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Centre for Food Security Studies College of Development Studies

CLIMATE CHANGE ADAPTION RESPONSE AND ITS IMPACT ON HOUSEHOLD FOOD SECURITY THE CASE OF BASONA WERANA WOREDA, NORTH SHEWA ZONE ANRS ETHIOPIA

BY

FIKER HILEMELEKOT

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

JUNE, 2020

ADDIS ABABA, ETHIOPIA

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COLLEGE OF DEVELOPMENT STUDIES
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DECLARATION

This thesis is my original work and has not been presented for MSc. degree in any other University and that all the sources and materials used for the thesis have been properly acknowledged.

Declared By: Fiker Hilemelekot

Signature: _____

Date: _____

Place: Addis Ababa University College of Development Studies, Center for Food Security Studies

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

Dr. Desalegn Yayeh _____ _____
(Advisor) Signature Date

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This is to certify that the thesis prepared by Fiker Hilemelekot Gizaw entitled 'Climate change adaption response and its impact on household food security the case of Basona Werana *woreda*, North Shewa Zone ANRS 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.

Signed by the examining committee:

External Examiner: _____Signature _____Date _____

Internal Examiner: _____ Signature _____ Date _____

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Name of Chairman _____ Signature _____ Date_____

ACKNOWLEDGEMENT

This thesis work wouldn't have been realized without the help of the following persons. First and for most, I would like to thank my advisor Dr. Desalegn Yayeh for his consistent support in critical comments, and advises right from title selection to completion of the research; and always having opened hands and door for me despite his responsibility. I would like to thank the entire study participants for their willingness and the Basona Werena *Woreda* office of agriculture for their assistance. I want to thank all staffs at center of food security studies at Addis Ababa University for their kind support. My special thanks also go to my beloved family for their love and support in all path of this thesis I want to say great thanks to you all.

Acronyms and Abbreviation

AWD	Acute Water-borne Diarrhea
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
IPCC	Intergovernmental Panel for Climate Change
NAPA	National Adaptation Programs of Action
OCC	Office of Climate Change
PANE	Poverty Action Network of civil society organizations in Ethiopia
SSA	Sub-Saharan Africa
SWC	Soil and Water Conservation
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
IASC	International Agency Standing Committee
NAPA	National Adaptation program of Action of Ethiopia
WMO	World Meteorological Organization
WWF	World Wide Fund for Nature

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Abstract

Ethiopia is predominantly dependent on rain-fed mixed farming with traditional technologies, and it is the backbone of the country's economy, but the most vulnerable sector to climate change and variability. The objective of this study was to assess climate change adaption response and its impact on household food security in Basona Werana Woreda Amhara region, Ethiopia. From the cross-sectional survey of 138 farm households from Wayou Kebeles and time-series climate data from metrological satellite data was employed. The primary and secondary data were analyzed by using both qualitative and quantitative methods of data analysis. Both descriptive and inferential statistics were used to analyze farmers' food security status and adaptation options to climate change and variability. To assess household food security status of the respondent's household food consumption score and household food insecurity access scale was used, tobit model was used to examine climate change adaptation option and ordered logistic regression was employed to examine the contribution of climate change adaptation on the food insecurity status of households. The result showed frequency of extension service, training access, farm size, and gender of the household head, frequency of flood and access for credit showed a significant impact for adaption. The ordered logistic regression model showed that household food security status were significantly influenced by cultivated land procession, Crop failure, soil and water conservation participation, small scale irrigation use, diversification of new crop varieties, diversification of sources of livelihood, agro-forestry, fertilizer application. Therefore Policies and implementation on climate change adaption strategies should emphasized on a collaborated action climate smart approach to reduce the impact of climate change on agricultural sector across the national level and local levels to enhancing household food security.

Key words: *Food security Climate change adaption, FCS, HFIAS*

1. INTRODUCTION

1.1. Background

Climate change and variability are the most unconvincing challenges facing people and environment of the world (SNV, 2012). Climate change is any change in the state of climate that can be identified by changes in mean and/or the variability of its properties over long time at least above three decades, weather due to natural variability or as a result of human activities (IPCC, 2014). Climate variability is the variation in the mean and other statistics of the climate on all temporal and spatial scales beyond that individual weather event (IPCC, 2007). Climate change it may be due to natural internal operation or external factors such as persistent changes to the atmosphere or persistent changes of the atmosphere or change in land utilization (Mario, 2010). Climate change attribute directly or indirectly to human activity. It changes the composition of the global and regional atmosphere and natural climate variability noticed over comparable time periods (UNFCCC, 2007).

Climate variability is defined as variations in the mean state and other statistical of the climate on all temporal and spatial scales, beyond individual weather events. The term "Climate variability" connote deviations of climate statistics over a given time in a month, season or year, some scientist are of the opinion that this period can transcend to decades (30 years). Climate variability assessed by these deviations, which are usually termed anomalies. Variability may be due to natural internal processes within the climate system internal variability or to variation in natural or anthropogenic external factors external variability. But climate variability is more affiliated to the internal variability unlike climate change (Mario, 2010). Climate variability is the types of changes temperature, rainfall, occurrence of extremes; magnitude and rate of the climate change that causes the impacts on the area of public health, agriculture, food security, forest hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services. Changes in physical and socio-economic system have been identified in many regions (UNFCCC, 2007).

According to UNFCCC and IPCC report over the next decades, it is predicted that billions of people, particularly those in developing countries, face shortages of water and food and greater risks to health and life as a result of climate change concerted global action is needed to enable developing countries to adapt to the effects of climate change that are happening now and will worsen in the future. The urgency for adaptation is highlighted by intergovernmental Panel for Climate Change in 2007 (IPCC 2007). Ethiopia is frequently depicted as a drought stricken country for so long. Hence, the estimation of the severity, spatial extent, frequency of droughts, lack of resources planning and management cause the country chronically food insecure for decades. Adaptation is an adjustment of a human and natural system to expected impact of climate change (Bethel, 2018). Drought is the main concern in North Shewa Zone, Ethiopia like *Basona Werana Woreda,* recent high frequency and larger area coverage is also becoming drought prone.

According to Basona Werana Woreda agricultural office report Wayous *Kebele* is one of frequently face climate change hazards in the area this cause soil erosion and degradation this result the *Kebele* become one of frequent food aided *Kebele*. As large the zone belongs to one of the most vulnerable places to climate variability in the country a lot of population is already food insecure in Amhara Regional State the state has been reported that only nearly 20% of the households cover their food requirements from their own production for three months only in many areas of the region, mainly due to natural hazards, uneven distribution of rainfall, land degradation and pest damage which all are related to climate variability. Overall, 2-3 million people are chronically food insecure in the region accounting for one third of the chronically food insecure and vulnerable people in the country (BoARD, 2006).

1.2. Statement of the problem

Ethiopia agricultural sector dominate by small scale farmers who are relay on low input and low production rain fed mixed farming with traditional technologies. Government of Ethiopia has given top priority to the sector and has taken steps to enlarge productivity. However, various obstacles are grasp back the main causes of inadequate production or less than expected production due to disaster like drought, which frequently causes famine, and floods. As follows climate connected disasters makes the nation dependent on food aid.

The tendency of the contribution of agriculture to total GDP of the country understandably describes the connection between the impact of climate change on agriculture and economy. After the 1991, the federal and regional government launched different types of interventions or adaptation measures to rehabilitate the degraded land and to increase agricultural productivity to enhance food secured. These involvements too happen on ground through voluntary community mobilization and productive safety net program intervention at community level and at individual farmers. After implementation of these program different studies shown that there is gradual change most of the changes are slow from the expected outcome. The agriculture sector is still practice traditional way of farming system most of the farmers are surplus farmers. Farmers who are using adaptation technology are very small percent.

According to FAO 95% annual gross total agricultural output of the country come from smallholder agriculture and only 5% commercial farms contribute to gross total agricultural output (FAO, 2016). These large scales of smallholder farmers need more intervention than ever this intervention to cope up with different calamities include climate change impact. Climate change impact differs with different land formation the intervention also differ because it dependent on the agrological and land formation of the area to bring sustainable solution for climate change impact and effect on food security local adaption mechanizes are need for proper implementation locally and current studies are needed due to variability of climate change events still excising problem. Therefore, the purpose of the study is to assess farmers' perception, adaptation strategies, and analyze determinant factors that affect farmers' choices of adaptation strategies and analyze contribution to food security in the study *Woreda*.

Even though researches are done on climate change and variability in the country and the region, people who live in varies parts of the country/ region could not use similar adaptation strategies and face similar situation for adoption options. Climate change and variability adaptation options can be very in time and places. Because climate change adaptation is local base and control by the local environmental factors. Despite sustained economic growth and increased domestic cereal production, there has yet to be realized any substantial decrease in the size of the needy population.

Rather climatic shocks render already vulnerable population susceptible to livelihood crises that force millions of people to turn to the government for emergency assistance and safety net benefit each year to augment their own productive and coping strategies (NCCF, 2009). The country is extremely vulnerable to the least change in climate. If the rain is late, does not arrive or irregular, it immediately result in an increase in the number of people who need help because they are already living on the margins of life. The food security status of the Amhara region, as indicated by the regional Disaster Prevention and Preparedness Bureau the region becomes severe even before about 42% of the total population and 52 *Woreda* are recognized as food insecure and drought-prone respectively. North Shewa administrative zone, which are surplus-producing areas before the two decades, became food insecure and livelihood vulnerability trap (Bethel, 2018).

Community perception regarding to climate change is the root for the necessary replay mechanisms to cope with climate disaster the degree of awareness within the community control the extent of execution that require to tackles the problem. Lack of awareness can cause arbitration to misappropriate understanding. As indicated local communities have their own coping mechanism in traditional method integrated to traditional coping mechanism researched need to support and implement climate change adaption option to tackle problem. Therefore, they may minimize future damage of climate change and decrease impact on food security. Different studies shown that climate change has potential to have several negative impacts on human welfare, public health, natural resources and development activities in the country. However, most of these studies have been carried out at the nationwide. There are very few studies dealing with the empirical status at the local level and their lack of identifying determinate factors of climate adoption option without this the intervention become incomplete identifying determinate factors will help for sustainable solution Unless, the impacts of climate change are known and describe at the local level and determinate factors understood terms of local people and established the right perception, it would impossible for adaptation actions. To fill this gap, this research were carried out with a focus on understanding the perceptions of people, assessing climate change adaptation strategies and identifying determinate factors, contribution on food security status of the people in *Basona Werana Woreda in Wayou Kebele.*

1.3. Objective of the study

1.3.1. General objective

The general objective of the study is to assess the contribution of climate change adaptation response on household food security in Basona Werana *Woreda*

1.3.2. Specific objective

The specific objectives of this thesis are to:

1. Characterize temperature and rainfall trends and variability (1984-2014) in Basona Werana *Woreda*
2. Assess farmers' perception of climate change and variability in *Basona Werana Woreda*
3. Examine farmers' adaptation response to climate change and variability contribution to food security in Basona Werana *Woreda* and
4. Analyze the determinants of climate change adaptation strategies on food security in Basona Werana *Woreda*

1.4. Research question

1. Does the level of perception of the people about the existence of climate variability or change?
2. What are the effects of climate change on food security?
3. What adaptation strategies are adopted by different farmers of the study area to cope with climate change?
4. What is the major determinates of different adaptation strategies on household food security?

1.5. Significance of the study

Ethiopia is one of the poorest nations of the world which has been vulnerable to the impacts of climate variability and change. The limited economic, institutional and logistic capacity to mitigate and adapt to climate change exacerbated the vulnerability of many peoples and communities to climate change induced-hazards that are occurring through global climatic change and land use transformation. The problem is more serious on communities who heavily depend on climate sensitive livelihoods. One of the major contributions of climate variability and change is agriculture sector.

Agriculture remains by far the most important sector in the Ethiopian economy about eighty-five percent of the population in terms of employment and livelihood directly support by agriculture; it contribute about fifty percent of the country's gross domestic product (GDP); it generates about eighty-eight percent of the export earnings; and it supplies around seventy- three percent of the raw material requirement of agro-based domestic industries. It is also the major source of food for the population and hence the prime contributing sector to food security. In addition, agriculture is expected to play a key role in generating surplus capital to speed up the country's overall socio-economic development.

Facing climate change-induced hazards may not be new for the Ethiopian peoples. The challenges, however, are both diversified and frequent hazards in the current climate system. Now a day the magnitude and number of hazards are beyond the control of local people. In addition, the mitigation plans have been reactive rather than preventive. The practical measure expected from Ethiopia is, however, developing adaptation strategies and enhancing adaptive capacities of different stakeholders. This shows that the need to review of climate change response mechanism to enhance food security. However, there is lack of adequate research generated data on perception of people about climate change and their adaptation response strategies determinate factors, impact to household food security to asses those this study employed on the study area. These results of the study were used as an input for the government and other stakeholders working on the area of climate change adaptation impact on household food security.

1.6. Scope of the study the

The study was focused on Basona Werana *Woreda as* the area is drought prone. The study area was selected according to national disaster risk management commission report out of thirty one *kebele* Wayou *kebele* were select based on the report of national disaster risk management commission *Wayou kebele* as food insecurity *kebele* and considering the *kebele* is frequently exposure to drought for the last four consecutive years due to the drought the national meteorology agency state that degree of exposure to climate variability and impact and physical accessibility in the *kebele* is high .

1.7. Limitation of the study

The prevalence of the problem and its scopes was limited to the assessment of perception on climate change adaptation, their adaptation response strategies determinate factors, contribution to household food security status on *Basona Werana Woreda* North Shewa Ethiopia.

The study has much more interested had it been possible to include more *kebeles* in North Shewa and beyond. However, for practical reasons such as time and financial limitations, the study relied on selected *Basona Werana Woreda Wayou Kebele.*

1.8. Organization of the thesis

Organization of the Study this report is organized into five chapters. Chapter one introduces and sets out the background information, statement of the problem, research objectives, research questions, significance, scope and limitation and organization of the study; chapter two talks about review of related literature. Chapter three tries to introduce description of the study area and research methods which discusses location, demographic and socio-economic profile of the study area; research design and approach; types and sources of data; sampling techniques and data collection tools; and techniques of data collection. Chapter four deals with result reporting and the related discussions chapter five summarize the finding and suggest recommendation according to significant findings.

1.9. Ethical consideration

The ethical approval and clearance was obtained from the ethical committee of Addis Ababa University. Permission was obtained from the concerned bodies of Amhara national regional state bureau of agriculture and rural development administration. Prior to interview data collectors was requested consent, and study subjects was registered to participate after they obtain enough information about the aim of the study.

2. LITERATURE REVIEW

2.1. Climate change and variability

Currently, climate change is increasingly in realized way as a critical challenge to ecological health, human well-being and future development (IPCC, 2007). It is one of the greatest censorious of humanity, affecting both present-day and future generations. The world community took initial steps in 1992 (United Nations Framework Convention on Climate Change-UNFCCC), in 1997 (Kyoto Protocol) and then again in 2009 (the Copenhagen Climate Change Conference) to curb global greenhouse gas emissions. Nevertheless these efforts obtain handful countries only. The consequence of emission reductions are nowhere near, what they should be sequence to halt or slow the pace of climate change (GLCA, 2009).

In addition, local community- based adaptation implementation is a critical issue especially in developing countries. However, some is known about local community perception of climate change and adaptation worldwide. Climate change is the worldwide environmental warning that severely influences agricultural productivity and it affects mankind in many ways, including its direct influence on food security. Although Climate change is global issue developing countries are the one seriously affect specially developing country like Africa due to lack of adaptive capacities their livelihoods of millions of people who are poor and vulnerable by climate change which altering the natural and physical resources they depend in generally and agricultural production particularly. The agricultural sectors are the most influenced due to the contribution to livelihood, production and enrollment to the economy is highly impacted by climate variation existing affect a sensitive sector such as agricultural sectors (Aragie EA, 2013). Sub-sequent, poor countries can obtain extremely large costs from a small diversion in climate, particularly due to their poor adaptive capacity, lack of technology, and lack of resources to accord with climate change.

2.1. Climate change impact on food security

The role of long-term mean climate change impacts on global food production is significant and may require ongoing adaptation; greater risks to food security may be created by changes in year-to-year variability and extreme weather events. Historically, crop productivity fall in large amount due to low precipitation it contributes for faller largely. However on productivity small changes in mean annual rainfall have an impact.

Climate response task showed that between 36% and 44% % of the losses for the entire continent this damage represent losses between 42% and 60% of agricultural GDP in this region West Africa whereas, the Sahara countries suffers the lowest absolute damages because of agriculture in the Sahara has low value (Mendelsohn, et al., 2000). At the World Food Summit (WFS) in November 1996 the Food and Agriculture Organization (FAO), defined food security as a situation which ‘‘exists when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life’’. From this definition, food security consists of four key dimensions: food availability (production, distribution, trade and exchange), food accessibility (affordability, allocation and preference), food utilization (nutritional and societal values and safety) and food stability (Ericksen et.al, 2008).

It is however imperative to note that food insecurity is a more complex problem. In addition to climate change, food security is influence by many of factors including wider spread of poverty, natural resource imbalance, poor or corrupted governance, poor infrastructure, disagreement, lack of markets access, finance, high disease burden such as HIV/AIDS malaria and under five child death, unequal global trading postponing and inequity within countries, and so on (Ericksen et.al, 2008). Nevertheless, according to the Inter-Agency Standing Committee (IASC) groups report climate change act as redoubling of existing threats to food security (IASC, 2009). Globally, food system performance currently depends more on climate than it did 200 years ago. The risks climate change creates on food security are especially critical at a time of high oil prices, at levels surpassing $130 a barrel in May 2008. High fuel prices make agricultural production more expensive by raising the cost of fertilizers, irrigation, and transportation. In SSA climate variability and extreme weather events such as droughts, excessive rains and floods are among the most risks affecting agricultural productivity and consequently affect rural household food security. A decrease of the rainy season is directly linked to agricultural production reduction; food availability at household level as well as restrict rural employment possibilities. Climate change and extreme weather events impact all elements of food security in several ways vary from direct effects on crop production (for example, change rainfall pattern cause frequent drought or flooding, or warmer or cooler temperatures leading to changes in the length of the season), to changes in markets can influence food prices and supply chain structure.

Specifically, climate change will reduce food availability, because it will negatively impact on the basic dimension of food production soil, water and biodiversity. Agricultural demand will affect indirectly food availability through economic growth of the country as large (Ericksen, 2008). Researchers predict that without climate change influence calorie availability in African expected to increase in the range 2000 in 2050 but with climate change food availability in the region average 500 calories less per person 500 calories in 2050 it show 21% decline(IFPRI 2009). This result clearly show adaptation measure for climate change in Africa region Is not option but it is a matter of sustainability issue for the people survival when the calorie intake decrease it major cause of malnutrition, retardation both affect the young generation due to vulnerability if the young generation in majority why thinking tomorrow for Africa become loss. On this scenario the continent can expect to have additional people at the risk of hunger around 55 and 65 million people by the 2080s. Under the climate scenario the impact is even more severe, producing an estimated additional 70 million people at risk of hunger in Africa this scenario indicate that not only food availability also become a question it bring together the malnutrition double burden of disease scenario in health system after some non-communicable disease burden become serious issue in the health system focus diverted to solve this adequate food availability and balanced diet are highly associated climate change impact is not one way direct effect on human activity(Parry et al., 1999). Macro economy and GDP directly affected because climate change directly linked to agricultural production reduction in terms of incomes, employment opportunities also linked this lead to effect on food access which form livelihoods in several direction, as well as shape social protection (Boko et al. 2007).

Prevalence of undernourishment currently become highest 32% of the total population deprived of access to food is in danger (Shah et al., 2008). Agricultural incomes reductions most suffer countries strongest impact of climate change and poorest economic growth will face food insecurity in their region. (Schmidhuber and Tubiello 2007). While by 2080, climate change will reduce Asia's agricultural GDP by 4% that of SSA will decline by up to 8% (Shah et al. 2008).

If prediction increases in weather variability occur, that leads to increases in the frequency and magnitude of food emergencies for which neither the global food system nor affected local food systems are adequately prepared for upcoming emergence at head. In addition, physical, economic, and social access to food will be severely compromise by climate change and

variability because as agricultural production decrease, food prices increase, and purchasing power decreases. In many developing countries, between 10 and 40% of cereal consumption will have to be covered by imports that make the local agricultural sector fall gradually due capacity of local farmers imports are advantageous for supply agricultural product while the local community and farmer suffer for several due to lack of input and output and availability of market access . Many of these countries face lack the foreign exchange to finance food imports, thus putting them at risk of increased food insecurity among the population.Currently, the SSA region's net cereal imports amount to approximately 7 million tons, but the impact of climate change may result in a net import of roughly 143 million tons of cereal by if not intervention happen especially in climate change adaptation and post-harvest to reduce the loss 2080 (Shah et al. 2008).

Food stability is viewed in relations to stability of crop yields and food supplies which will be negatively affected by variable weather conditions and influenced by the temporal availability of, and access to, food. Recent studies suggest in upcoming years the world food supply does not appear to be seriously threatened by the projected global changes in climate, food insecurity in Africa will worsen and the population at the risk of hunger will increase both in terms of percentage and absolute numbers. Finally, climate change create problem to food utilization through its impacts on human, including the spread of diseases such as malaria, HIV/AIDS, as general communicable and non-communicable disease and unsustainable livelihood capability and food security at different sectors (Boko et al. 2007). According to IPCC fourth assessment report causal contribution of climate to food insecurity in Africa is still not fully understood, particularly the play of other multiple stresses that enhance the impacts of droughts and floods and possible future climate change (IPCC 2007). Climate change could cause by 2080; result in an additional 30–170 million people suffering from malnutrition or under-nutrition globally, of whom three-quarters will live in Africa. These pictures tell for the African continue to determine different adaptation mechanism to cope with devastative damage.

2.2. Global responses to climate change

Climate change is a global issue that requires immediate international response. Governments, industries, communities and organizations across the globe are coming together to develop and implement measures to reduce greenhouse gas (GHG) emissions and avoid dangerous climate change (office of climate change (OCC), 2010).

Several international conferences, seminars, symposia and workshops were held. Some of them were the first World Climate Summit (1979) in Geneva, Conference on Industries and Climate (1980 in Vienna), Vienna convention (1985, in Austria), Montreal Protocol constitution of IPCC by UNEP and WMO in 1988 and Paris agreement in 2015 First Earth Summit (1992 Brazil), Kyoto Protocol (1997, Japan) and so on (Singh and Sweta, 2008). The united Nation Framework convention on climate change (UNFCCC) is an international environmental treaty produced at United Nations Conference on Environment and Development (UNCED) held in Riode Janeiro in 1992. The objective of the Summit to reduce greenhouse gas concentrations in the atmosphere to avert the dangerous anthropogenic intrusion within the climate system the framework consider as non-binding which have no mandatory restriction of GHG emissions for individual nations and contained no enforcement provisions. Rather, the treaty includes provisions for updates (called "protocols") that would set mandatory emission limits. The principal update is the Kyoto protocols that can give more unrestricting this directly influence the developing nation. (Aklilu and Alebachew., 2009).

In December 1997 Kyoto Protocol, adopted as an international agreement, which builds on the UNFCCC and sets legally binding targets for cutting GHG emissions of industrialized or developed countries. Like the UNFCCC, the Kyoto Protocol aims to stabilize GHG emissions in the atmosphere. The major distinction between the two documents is that while the convention encouraged developed countries to stabilize GHG emissions, the protocol commits them to apply. The protocol sets out emission reduction targets for developed countries because they have been responsible for the vast majority of the world's human-induced GHG emissions (OCC, 2010).

The protocol was entered in to force on 16 February 2005. After 1997 in the year of November 2009, 187 states agreed and signed the protocol. Copenhagen Accord was forged at the 15th Conference of the Parties, held in Copenhagen in December 2009, towards a new agreement beyond the Kyoto Protocol (UNFCCC, 2009). First global agreement on climate change, include the major developed and developing countries that makes significant agreement on this agreement developing economies countries like China, Brazil and India, played a significant role for the first time (OCC, 2010). The accord is significant because it is the first global agreement on climate change, involving the major developed and developing countries.

The United States and major developing economies, such as China, Brazil and India, played a key role for the first time (OCC, 2010). The UNFCCC and the Kyoto protocol have faced many obstacles to fulfill their first goal to reducing emissions. For example, in spite of the Kyoto protocol's progressively countries start leading avocation countries like Canada Japan and member of the European Union had not able to meet their targeted reductions of emissions ambitious goals, even countries that have shown to be its leading advocates, such as Japan, Canada, and the members of the European Union had not able to meet their targeted reductions of emissions. Additionally, Australian government still not accepts the agreement and United States of America remain the only countries of the United Nations Convention on Climate Change to not ratify the Protocol (CamWalker, 2006). After all currently recent agreement is Paris agreement in 2015 the Paris Agreement need both developed and developing countries to make significant dedication to inscription climate change. Countries in charge of 97 percent of global emissions have so far committed their Nationally Determined Contributions (NDCs) for how they will address climate change. Countries will readdress their present-day committed by 2020 and, in a perfect world, nourish their emissions reduction targets for 2030.

The Paris Agreement incorporate a powerful stronger transparency and accountability system for all countries needed reporting on greenhouse gas emission and projections that are subject matter will pass to a technical expert review and a multidimensional analysis. On this agreement climate finance will provide to help for the most vulnerable developing countries because the emission is release by the developed or industrialized nation but the impact is faced by developing nation due their vulnerability and lack of adapt to climate change and build low-carbon economies and build their adaption capacity.

Still Paris Agreement does not "solve" climate change; it allows us to start the next significant signal of global climate steps, generate an upright cycle for more aggressive steps in the decades to come (NRDC, 2017).

2.3. Climate change impacts and responses in Ethiopia

Ethiopia one of highly vulnerable to climate variability and change one of the cause is the agriculture system is depend on rain fed agriculture, which is very sensitive to climate variability and change, Ethiopian climate change impact also goes to under-development of water resources, lack health service to all community in rural and urban setting health service coverage still have a problem, rapid population growth rate, slow economic growth, lack of capacity, insufficient road infrastructure in drought prone areas, weak institutions and insufficient of awareness (NMSA, 2007). Vulnerability examine found on existing knowledge and quick information and rapid assessments conducted out under National Adaptation program of Action of Ethiopia (NAPA) has shown agriculture, water resources and human health mostly affected by climate variability and change (Temesgen, 2007). However, production and aggressiveness of this sector is increasingly unnatural by temporal and spatial variability of climate (NCCF, 2009) in addition, both droughts and floods are already common in Ethiopia. Most of the country is prone to drought (NMSA, 1996).

Droughts destroy farmlands and pastures; cause to land degradation, source crops to fail and livestock to destroy. Throughout the 1984 up to 1985 drought, the GDP decline by about 10 % and the 2002-3 drought effect over 3% decline. Drought severely affects the hydropower generation capacity, Ethiopia's main origin of electricity. Flooding causes significant damage to settlements and infrastructure, livestock and animal health, and the water-logging of productive land erode agriculture hold up planting, reducing yields, and compromising the quality of crops, especially if the rains occur around harvest time (WB, 2006). Changes in temperature and rainfall have had much negative impacts on human and livestock health. For instant, serious disease outbreaks including cholera, acute water-borne diarrhea (AWD), meningitis and malaria have been reported due to altered temperature and rainfall patterns the temperature change become suitable for the etiologic agent (NMSA 2007; Aklilu and Alebachew 2009). Collision of climate changes in Ethiopia makes various policy failing likewise climate change adversely affects the efforts to achieve Millennium Development Goals (MDGs). Decline of agricultural

outputs and worsening conditions of rural areas low economic growth caused by climate change will directly increase poverty of households in poor countries like Ethiopia (Diao, et al., 2005).

Current experience of extreme whether events underlines how devastating droughts and floods can be for household incomes. For example, in North Eastern Ethiopia drought induced losses in crop and livestock between 1998 and 2000 were estimated at dollar 266 per household (PANE, 2009). The Ethiopian government has recognized climate change has adverse impact on the country's Economic growth. As a result, the country ratified the UNFCCC (in May 1994), UNCCD (in June 1997) and Kyoto protocol (February 2005). Within these frameworks, Ethiopia prepared national adaptation programs of Action (NAPA) against the impacts of climate change and the gradual transformation of habitable land into desert; is usually caused destructive use of land (Aklilu and Alebachew, 2009).

The most important coping mechanisms generally used include: changes in cropping and planting implementation, reduction of consumption level, use of inter-household move and credit, collection of wild foods, grow petty commodity production, temporary and permanent migration of people and animals, hidden secure grain storage, sale of assets alike as livestock and agricultural implement, pledge of land/ proceeds credit from merchants and money lenders, use of early warning systems and appeals for food and other forms of aid (NMSA, 2006 cited in Aklilu &Dereje, 2010). Currently there is Ethiopia's climate resilient green economy national adaptation plan start implement by federal democratic republic of Ethiopia (NAP-ETH, 2019). Nevertheless by 2008, Ethiopia had no clear policy for dealing with climate change (Aklilu and Dereje, 2010).

2.2. Review of empirical studies

2.2.1. Determinants of climate change adaptation

In sustainable development goals major goal is end hunger, achieve food security and improve nutrition. Meanwhile, climate change is already influencing agriculture and food security does make the challenge of ending hunger and malnutrition even more hard. The impact of climate change on our ecosystems are been a critical and widespread, and contribution to food security in the face of climate change is among the most intimidating challenges facing humankind.

While some of the problems associated with climate change are emerging gradually, action is immediately required now in order to let enough time to build resilience into agricultural production systems.

2.2.2. Causes and impacts of climate change

Source and impacts of climate change is actuality; it has changed in the over, it is also changing at the current day, and it will change in the time to come (Burroughs, 2007). The change of climate could be slow and gradual, rapid and catastrophic, short-term or long term could be at local, regional and global scales; and it could be due to natural factors or anthropogenic factors. Majority of climate change studies attain the knowledge on decades of proof, modeling, and debate-that it is extremely likely that human activities are in charge of for the rising temperatures on Earth. Human component carry on with crucial factor in climate change (UN, 1992; NSF, 2009). One the contribution of human factor for climate change is form of greenhouse gas (GHG) emission and land-use change (Aklilu and Alebachew 2009; World Bank, 2008; FAO, 2008). Major greenhouse gases emitted are from electric power station, different industries and deforestation because of human activates due to these activities concentration of various greenhouse gases increase. Up to 1990 greenhouse gases emission were carbon dioxide, chlorofluorocarbons, methane and nitrous oxides 51%, 20% 16% and 16% respectively(Singh and Sweta, 2008). Global GHG emissions due to human activities have increase since pre-industrial period, with an increase of 70% between 1970 and 2004. Global atmospheric concentrations of carbon dioxide (CO2), methane (CH4), chlorofluorocarbons (CFC) and nitrous oxide (N2O) have grown significantly since 1750 due to human activities, and many thousands of years the pre-industrial years. The increment of fossil fuel use primarily concentrations of CO2 become global issue and land-use change. It noticed that increase in CH4 concentration is for the most part use of agriculture and fossil fuel use. The increase in N2O concentration is primarily due to agriculture (IPCC, 2007). Thus, the greenhouse contribution is intensified, resulting in spring up rising temperature on earth. Anthropogenic result on the physical and chemical effect the atmosphere has the possible impact on the quality of life. Weather and climate-connected disasters consequence in life lose, decrease in food production, pollution of waters and land surfaces, and the demolition of production dimensions and infrastructure the data received from many examination shown that that regional climate changes have already affected many physical and biological processes and systems (Anon, 2002).

Developing countries categorized under third world highly pronounced by climate change effect in their environment. The reasons are developing countries are most vulnerable; countries to the effects of climate change due to lack adopt capacity of these changes (IPCC, 2001and UNFCCC, 2007). According to IPCC (2007), Worldly low put costal and marine coral reefs are vulnerable ecosystems. Besides, agriculture, water resource, and human health are vulnerable zone. The same literature shows that Arctic, small islands, Asia, Latin America and Africa are the most vulnerable regions in the world. Within other areas, even those with high incomes, some people (such as the poor, young children and the elderly) can be particularly at risk, and also some areas and some activities.

The continent of Africa is primarily tropical or subtropical (National Research Council (NRC, 2010) which is one of the most vulnerable regions in the world to climate change. Africa's greatly vulnerability to the impacts of climate change is worsen by other factors such as extensive poverty, repeated droughts and floods, dependence on natural resources and biodiversity, the agriculture sector is depend on rain fed agriculture, massive communicable and non- communicable disease burden and conflicts that have immerse the continent. Economic growth of African may affect negatively by the change potential obstruct in time coming.

Water resource, food security and agriculture, natural resource management and human health become mainly impacted though climate change (Dinar, 2008). According to IPPC report millions of people in Africa their livelihoods dependent on agriculture. An average of 70% of the population lives by farming and 40% of all exports are earned from agricultural products (IPCC, 2001). In addition, 10% to 70% of gross domestic product (GDP) in Africa is generated by agriculture (Mendelsohn, et al. 2000). However, agricultural production is affected by climate change. The estimate for Africa is that 25% to 42% of species habitats could be lost, affecting both food and non-food crops (FAO, 2007). According to reports of the IPCC (2007), the projected yield reduction due to climate change in some poor countries could be as much as 50% by 2020. Under climate change, much agricultural land will be lost, with shorter growing seasons and lower yields. National communications report that climate change will cause a general decline in most of the livelihood crops, example sorghum in Sudan, Ethiopia, Eritrea and Zambia; maize in Ghana; Millet in Sudan; and groundnuts in Gambia (UNFCCC, 2007).

Tropical and sub-tropical regions are expected to be more vulnerable to climate change because additional climate change will have impact on their water resource and harm their agricultural sectors (Mendelsohn, et al., 2000). African countries were recognizing as having the highest vulnerability to drought. The Sahel situated at the southern fringe of the Sahara desert and stretching from the West African coast to the East African highlands are especially prone to drought. Droughts have particularly affected the Sahel, the Horn of Africa and Southern Africa since the end of the 1960s. Estimates suggest that one third of African people live in drought-prone areas and that around 220 million people are annually exposed to drought (Elasha, et al., 2006). Forest resource also affects with climate change.

Deforestation is a serious problem in Africa that cause extensive change in the area of forests this lead to raped climate change in the region. Changes in carbon dioxide emission, temperature or rainfall associated with climate change can have a major impact on the health or formation of forests that can lead to climate change. Forest resource also affects with climate change. Deforestation is a serious problem in Africa that cause extensive change in the area of forests this lead to raped climate change in the region. Changes in carbon dioxide emission, temperature or rainfall associated with climate change can have a major impact on the health or formation of forests that can lead to climate change (Houghton et al., 2012). Study done University of Lausanne, shown that climate change adaptation determines by age-related decline in extremely old age, accompanied by the fact that most domains of living are affected by loss, suggests that very old age is associated with an increasing risk for adaptation problems. However, the indicators of subjective well-being that are usually examined to explore the success of adaptation efforts remain unexpected stable during old and very old This "stability-despite-loss" phenomenon has been interpreted as proof that positive adaptation to these age-related restriction is feasible and that older people may be characterized by a high capacity to adapt However, research on well-being has also given some indication that the self-regulatory system may set off less efficient with advancing age (Daniela et al.,2006). Study done on Northern Ghana showed that various effects of the factors on farmer's option of adaptation strategies farming experience, farm income, access to phones, mixed farming, farmers' perception on decline in rainfall amount and access to meteorology information significantly and positively affects the choice of climate change adaptations agricultural extension service should be intensified nevertheless organization

of adult education programmers or field schools for farmers to educate them on some climate change adaptation strategies (Mabe et al., 2014).

2.3. Literature gap

From the above theoretical and empirical literature reviewed climate change adaptation more focus on developed nations, the practical measures expected from Ethiopia are to reduce the impact of climate change through the development of local adaptation estimate time. Most of the coping mechanisms are based on local knowledge and explain their determinate factor that are obstacle in developed nation contacts that cannot be able to cope with all of climate change effect due to climate change need local knowledge and intervention. Nevertheless, local community perception of people need be the foundation for the option of adaptation strategies. Even different researches done on the area of climate change adaptation and food security unfortunately on ground still there high effect and climate change damage in Ethiopia. Ethiopian food security status still dependent on aid until the identification on how deep the problem in local community it will continue as predicted the severity of climate change and food insecurity.

2.4. Conceptual framework

The framework is constructed based on reading of various literatures related to climate change adaptation technology in different time and place. The framework contains different factors that mainly determine the climate change adaptation option of rural households. These are institutional, socioeconomic, policy framework, environmental constrains and the socio demographic profiles. Socioeconomic factors that relate to social activities and capital of farmers like price of agricultural inputs, the household total livestock unit, labor availability for climate change adoption, land ownership, farming year of experience and engage with off-farm activities. Climate change effect together with risk factors influence household food security and decision-making processes over time, taking the role of gender and other vulnerable populations into account at the center of the households, where strategies are developed and decisions taken to develop and maintain household food security. Focusing on perspective of climate change could influence the bio-physical, agriculture, socio-cultural and socio-economic environments of households, impacting resources and assets, including social capital.

The resource management strategies and decision making potential of the population is also affected. According to Saboury at el., (2012) indicated that climate change adoption can be determine by different factors in Northern Senegal study on impact of adoption adaptation climate change on household food security incomes is one of factor inFerlo Semi-arid Area, Northern Senegal showed climate-change related threats, many adaptation strategies have been promoted widely for adoption by livestock owners in the Ferlo this result indicate having livestock influence adaption measure this is included in socioeconomic factor connected. On other hand old age, are highly challenged to adopt that makes negative influence conditions represent a serious challenge to their capacity to adapt and are likely to reduce the quality of life. By examining happiness and its determinants in centenarians, this study investigated the proposal that psychological resilience may come to an end in extremely old age this connected to the demographic factor gender also have impact on the climate change adaptation been female head household and male head household significant difference according to Ali, (2016). The conceptual framework of this study is describe and show (Figure1) based on the assumption of the adoption of climate change adoption option and its contribution on household food security in besides the determinant factors that affect adoption option. The climate change adaptation option strength influence by institutional, socioeconomic, and the demographic profile.

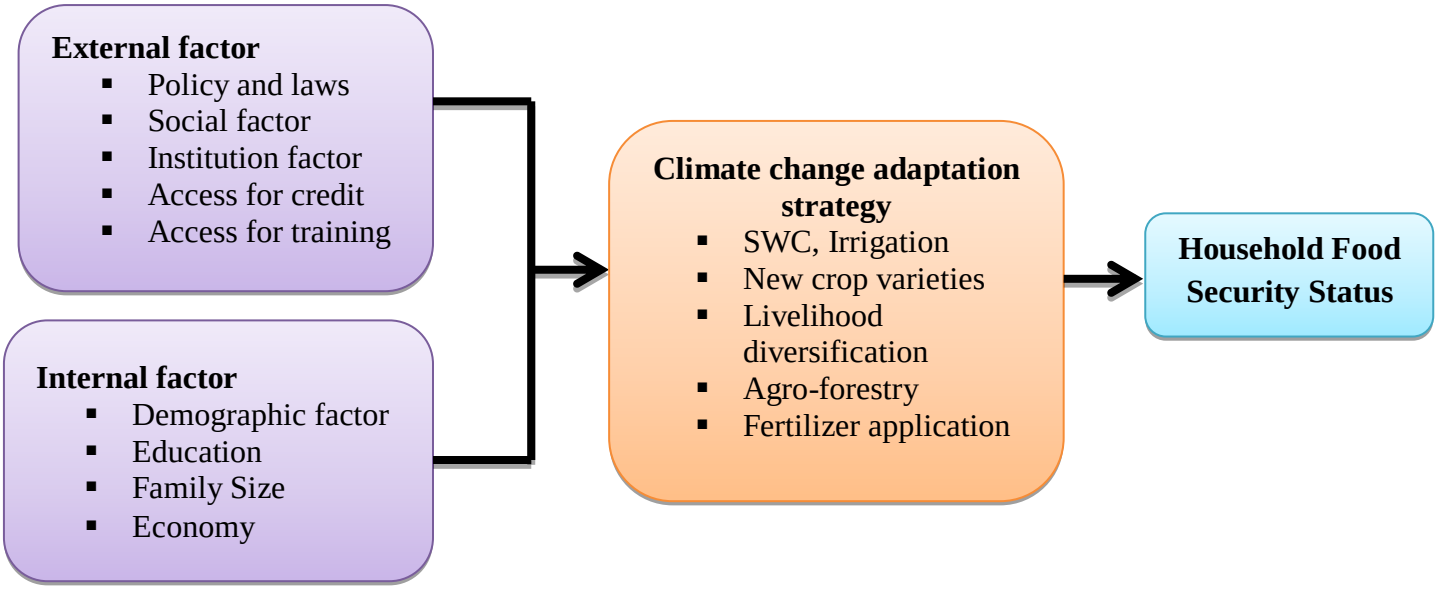

Figure 1: Conceptual framework contribution of climate change adoption respond on household food security.

(Source: Own construction based on the Selavarju, et al., 2006).

3. DESCRIPTION OF THE STUDY AREA AND RESEARCH METHODS

3.1.1. Location of Basona Worena *woreda*

This study was carried out in one *kebeles* in the *Woreda Basona Worena*. The woreda is one of the 10 *woreda* of the North Shewa Zone in Amhara National Regional State the *woreda* is located in the north at a distance of 130 km from Addis Ababa on the main road to Dessie. It is located between 9^0 38’00’’-$09^0$41’00” North Latitude and $39^0$30’00’-$39^0$32’00” East longitudes (MoA, 2016).

This study was conducted at *Wayou Kebele* depicted below.

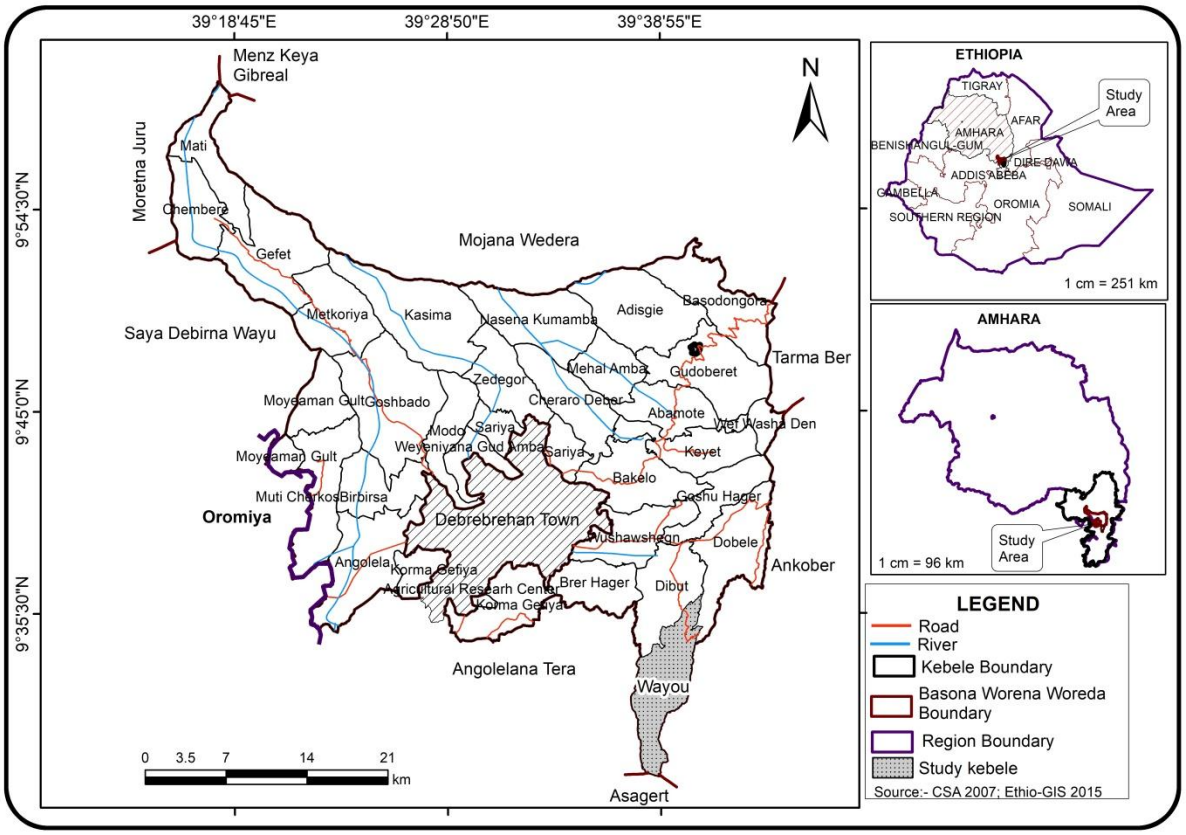

Figure 2: Map of the study area

Source: CSA 2007, Ethio-GIS 2015

3.1.2. Topography and climate

The *Woreda* has different agro ecological zones that vary from *dega, kola* and *Woyina dega*. In terms of the topography, most parts of the zone are hilly or mountainous, but there are some plains. The soil in most places is black and loam, however, there is clay loam in few areas. The area is known for its moderately good productivity and is considered to be self-sufficient in climate change impact with frequent flood farmers self-sufficiency is highly challenge. The average elevation of 2750 meter height above sea level (m.a.s.l) with an average maximum temperature of 16^{o}c and average minimum temperature of 19^{o}c, the town has got mean annual temperature of 13.3^{o}c (2008 to 2013), with mean annual rainfall of 900-1500mm between 2013 up to 2017 (NMA, 2017)

3.1.3. Demographic characteristics and major economic activities

According to CSA (2017), the total population of the *woreda* is 140,386 the total number of agricultural households is 138,264 of the total rural households, 71,439 are male and 68,947 are female headed and the selected *kebele* according to *woreda* administration office in *Wayou kebele* total number of population on the *kebele* is 4547. The total number of household on the *kebele* is 1267 household in the *kebele* from this 1030 of them were male hade household and 237 were female head households. The majority of the people resident on the *kebele* face frequent climate effect and that lead to from the total household in the *kebele* in the year of 2017/ 2018 budget year total of 1180 household were on government aid due climate change effect evens like flood, landslide that cause crop failure in the *kebele*. In 2019/2020 budget year 1252 household were receiving government food aids from administrative office. Generate their livelihood from agriculture and agriculture related activities dominantly their off farm activity was charcoal selling this indicate their high deformation in the *kebele.* Growing of cereal crops and pulses such as malt and food barley, wheat, Teff, Faba bean and Field pea are some of the crop production practiced in the area. More than half of the population engaged in agricultural activities based on the data found from *woreda* administrative office.

3.3. Research Methodology

This study was follow a cross-section and time-series climate data from satellite mixed method design; this is a procedure for collecting, analyzing and mixing both quantitative and qualitative data at some stage of the research process within a single study. The qualitative method focuses on key informant interview. Data collection trend and variability of temperature and rainfall distribution and its effect on household food security status while the quantitative method deals

Mainly with farmers' perceptions on climate situation, adaptations and responses to adverse situations, household food security status and determinates. In addition triangulation data collection method was applied to increase the validity and reliability of the findings.

3.4. Sample size and sampling Technique

For this study, both quantitative and qualitative types of data were employed (mixed research). With regard to data sources, both primary and secondary sources of data were used. The primary sources of data were collected from interviews (local elders and young farmers, *kebele*, and *Woreda* experts), and questionnaire for farmers.

The secondary data were collected from relevant books, archives, articles, research journals, reports, proceedings, and internet sources. Besides, the government reports, annual and semi-annual reports of related to farmers' adaptation strategies to climate change and variability were used as secondary sources. To analyze climate change and variability trends such as change in temperature, precipitation, drought, and other manifestations; both cross-sectional data and time-series data was collected. The time-series data, climate data were collected from satellite and it was analyses those how use adaptive measure for climate change and those how were not used the adaptive measure were compute their household food security by Food consumption score and Household Food Insecurity Access Scale.

3.4.1. Sampling Design and Procedure

In the North Shewa Zone *Basona Werana Woreda* there are thirty one *kebeles*. There as the report of *Woreda* administrators *Wayou Kebele* were selected due to frequently expose to climate change impact and persistent food insecurity. *Wayou Kebele* was 98% of total household dependent of government aid this due to climate change impact from the past many years this make the resident persistently food insecure and according to national disaster risk management commission and *Basona Werana Woreda* agricultural office report out of thirty one *kebeles Wayou kebele* is one of severely and frequently affect by climate change events and cause food insecurity on resident households. Reason for this *Wayou kebele* was selected purposive sampling method. *Wayou kebele* one of food insecure *Kebele* in North Shewa zone in Amhara regional state and frequently exposure to drought for the last four consecutive years due to climate change. National meteorology agency the degree of exposure to climate variability and impact and physical accessibility in the *kebele* is high (NMA, 2016).

The appropriate sample size for this study for household survey questionnaire, were used a Cochran (1977) formula at 95% confidence level.

$$n_o = \frac{pqZ^2}{d^2}$$

Where 'Z' is 95% confidence level/limit, 'P' is 0.1 proportions of the population to be include in the sample, i.e. 10%, 'q' is$1-p$, 'N' is the total population, 'd' is marginal error or degree of accuracy desired 0.05, was the desired sample size when the population greater than 10,000 and 'n' is number of sample size when the population is less than 10,000.

$$n_o = \frac{pqZ^2}{d^2} = 0.1 * 0.9 * 1.96^2 = \frac{0.1 * 0.9 * 1.96^2}{0.05^2} = 138$$

138 sample households were the sample size for the study.

Individual households from each selected by simple random sampling method were selected from *kebele* households head list were used, every K^{th}/P every 7thfarmers in the sample frame select after the first observation was pick randomly from 1030 male head household and 237 female head households. Total 138 households of the study area have equal and independent chance of being included for the sample. In addition, key informant interview was conducted to agricultural office leaders and agricultural and rural development experts. Moreover *kebele* agricultural and rural development experts and *kebele* administrators from *kebele* were participating through purposive sampling.

3.5. Data Collection Instruments and Procedures

To conduct the intended study data collection instruments such as questionnaire, interview, and document analysis were used to collect the require data. The questionnaire and key informant interview were addressed all the specific objectives of the study.

3.5.1. Key informant interview (KII)

Form Sample *kebeles* and *Woreda* some key administrative persons were interviewed to obtained relevant information. The in-depth interview was conducted for facilitating interaction between the participant and the researcher. Key informant interview were carried out with experts and administrators at *Woreda* and *Kebele* levels as well as the farmers, development agents.

3.5.2. Secondary data sources

In addition to the above mentioned data collection techniques and procedures, in-depth review of published and unpublished literatures such as books, journals, articles, reports and e-resources

were carried out. Documents from various Ministry of Agriculture, Annual, semi-annual, and quarter report of the *Woreda* related to climate change adaptations was analyze based on the climate analysis approach.

3.6. Techniques of data Analysis methods

The research was mixed research that combine both qualitative and quantitative methods of analysis.

Data collection was through open-ended questionnaires, interview, key informants interview and related documents were analyzed. Ordered logistic regression was employed to examine food insecurity status of households and impact of climate change adaptation on household food security and tobit regression model was used to examine determinants of climate change adaptation option. Descriptive Statistics: descriptive statistics summarizes, describes, and characterizes the value of the samples that was been studied. So, farmers' perception of climate change and variability, adaptation strategies and contribution to food security were analyzed by descriptive statistics (percentage, frequency and mean). Finally, the qualitative data recorded and presented with the quantitative data and empirical studies were triangulated.

.

$$\bar{X} = \frac{\sum fx}{n}$$

Where: $\bar{x}$ = mean

f = frequency of each class

x = Value of each observation

n = Number of observation

$\sum fx$ = sum of the products of mid- interval value and their corresponding frequency

3.6.1. Analysis of climate trend

The research was conduct on both quantitative and qualitative data the issues undertaken. Long term monthly mean rainfall distribution of *Basona Warana Woreda* Varies from 0.8mm for the driest month (January) to 243.00 mm the wettest month (August) The study *Woreda* rainfall, and almost all its rainfalls obtain during *Kiremt* (summer) season more concentrated in July and August. The rainy months are August and July; and March, April, May, June and September is the second level rainy months.

The study area major rainy season (*Kiremt)* from June up to September, Dray season (*Bega*) from October up to January and a short rain season (*Belg*) from February up to May. Mean rainfall of the study *woreda* is 596.6mm, with the maximum and minimum rainfall 984.00mm-304.8mm respectively concerning, to the month distribution of temperature of the study area; form maximum temperature, the warmest month is May (13.45^{o}c) and followed and the coldest month is December (8.10). Concerning mean monthly temperature (minimum and maximum) the warmest month is May (21.81^{o}c) and the coldest month is December (17.16^{o}c). Mean temperature of the study area is 19.54 with the maximum and minimum temperature 20.30^{o}c – 18.63^{o}c (NMA, 2016). The collected data were used Mice package in r to fill the missed data. Analysis of temperature and rainfall data was involved characterizing long term mean values, and calculations of indices of variability and trend at monthly, seasonal and annual time steps. Standard anomaly was calculated to assess rainfall and temperature variability (Sneyers, 1990).

$$SRA = P_{t-} P_{\mathrm{m}}/\sigma$$

Where:SRA = Standard Rainfall Anomaly

P_t = Annual (rainfall or temperature) in year t,

P_{m}= Long-term mean annual (rainfall or temperature),

σ = standard deviation of rainfall

A linear regression of annual and seasonal weather patterns was used. The significance levels of the slope were estimated for annual and seasonal rainfall (mm) distribution, standard deviation and coefficient of variation were used.

The Coefficient of variation is calculated with standard deviation over the mean that means long term mean precipitation according to NMA (1996).

$$CV = \frac{S}{\bar{x}} * 100$$

Where:

CV= Coefficient of variation

S= Standard Deviation

$\bar{x}$= Mean

The study was adopted Agnew and Chappell (1999) drought severity assessment method. This method provides a more elaborate classification of drought magnitudes. The model differentiated drought severity into four scales: extreme drought, severe drought, moderate drought and no drought ($S < -1.65$), ($-1.28 > S > -1.65$), ($-0.84 > S > -1.28$) and ($S > -0.84$) respectively.

3.7. Analysis of household food security

Household food security survey analysis survey

Interviewer administered questionnaire were conducted to sample farming households by using a questionnaire survey after obtaining consent form. The data collections tools were prepared in English and translate to Amharic with the intention that the respondents will understand it and provide an accurate response. Training was conducted for the data collectors. Data related to demography, socioeconomic, biophysical, farming adaptation practices and productivity, technology selection and adoption were collected.

Food Insecurity questionnaires usually employed a series of 9 to 15 questions that detect the level of concern and the lack of access to, variety and/or quantity of food. The questions retrospectively refer to a period between four weeks. The HFIAS occurrence questions ask whether or not a specific condition associated with the experience of food insecurity ever occurred during the previous four weeks (30 days) Each of one of the questions refers to a previous period of four weeks (30 days). The subject interviewed is first asked about the occurrence of food insecurity, in other words if the condition reflected in the question took place in the last four weeks (yes or no). If the subject answers affirmatively to this type of question, another question is asked about the frequency to determine if the condition has occurred a few times (once or twice), sometimes (between three to ten times) or frequently (more than 10 times) in the last four weeks. Above form this tool food consumption score were assess dietary diversity, food frequency, and relative nutritional importance of different food groups by using food consumption score is a composite score based on food items. Food items are grouped into eight standard food groups with a maximum value of seven days/week food groups and weights (Gemma et. al, 2015).

Food Insecurity Access Scale Score: the HFIAS score is a continuous measure of the degree of food insecurity (access) in the household in the past four weeks (30 days). First, a HFIAS score variable is calculated for each household by summing the codes for each frequency-of-occurrence question, before summing the frequency-of-occurrence codes. 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).The maximum score for a household is 27 (the household response to all nine frequency-of occurrence questions was often, coded with response code of 3); the minimum score is 0 (the household responded no to all occurrence questions, frequency-of-occurrence questions were skipped by the interviewer, and subsequently coded as 0 by the data analyst.) The higher the score, the more food insecurity (access) the household experienced. The lower the score, the less food insecurity (access) a household experienced.

Food Insecurity Access Prevalence: this indicator is used to report food insecurity (access) prevalence and make geographic targeting decisions through categorization of domain questions. The HFIAP indicator categorized into four levels of household food insecurity (access): food secure and mild, moderately 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.

Food Consumption Score

The FCS is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups. Food items are grouped into eight standard food groups with a maximum value of 7 days/week. To calculate FCS group food items in the specified food group, Sum all the consumption frequencies of food items within the same group, multiply the value of each food by it weight then sum the weighted food group scores to obtain FCS finally determine the household's food consumption status based on the following threholds:0-21:poor; 21.5-35: Borderline; >35: Acceptable.

Association between food security and adaptation response

Association between food security and adaptation response were asses using Chi-square, T-test, was used to test hypothesis and to show the association between variables that was collected through questionnaires.

T-test statistics Both demographic and socio-economic variables which are continues in nature like age, family size, educational status, livestock holding, farmland size, and so on were tested by t-test statistics. Chi-square test the remaining demographic and socio-economic dummy and categorical variables like sex, off farm income, adoption, and so on were tested by chi-square statistics. The formula to calculate chi-square test as follows (McDonald, 2014). Where (O), observed number and (E), expected number. The result of descriptive statistics was triangulate with the annual semi-annual government reports (region and *Woreda*); Climate data (temperature and rainfall) and Household food security status using interview. In order to maintain the quality of data, data filling, encoding, data entry and processing was used. Pre-test study was undertaken with the objective of checking estimate the time needed to complete the validity and appropriateness of the questions and implement it. The questionnaires were edited in the light of the results of the pre-test. Data cleaning was carried to check for the completeness, consistency and accuracy of data and to identify errors that may occur during data collection or coding process.

3.7.1. Statistical model specification

Ordered Logit Regression Model

Ordered logit regression model was used to econometrically identify factors affecting household level of dietary diversity, food frequency, and relative nutritional (Food consumption score) and food insecurity. The model is applied to perform analysis of ordinal and categorical variables. This model was selected because; the dependent variables are ordinal in nature as a result they fit to the model. Suppose that Y is an ordinal dependent variable with (c) categories, and ($y \leq j$) denotes the probability that the response on (Y) falls in category (j) or below (i.e., in category 1, 2… or j). This is called a cumulative probability. It equals the sum of the probabilities in category j and below:

$$(y \leq j) = pr(y = 1) + (pr(y = 2) + \cdots pr(y = j) \quad (1)$$

A category(c) and dependent (Y) variable" has cumulative probabilities(c): $pr(y = 1), pr(y \leq 2), \ldots pr(y \leq c)$the final cumulative probability uses the entire scale; as a consequence, therefore, $pr(y \leq c) = 1$ the order of forming the final cumulative probabilities reflects the ordering of the dependent variable scale, and those probabilities themselves satisfy:

$$(y \leq j) \leq pr(y = 2) \leq \cdots \leq (pr(y \leq c) = 1 \quad (2)$$

In an ordered logit model, an underlying probability score for an observation of being in the i^{th} response category is estimated as a linear function of the independent variables and a set of cut points. The probability of observing response category i corresponds to the probability that the estimated linear function, plus random error, is within the range of the cut points estimated for that response.

$$pr\ (Response\ category\ for\ t\square e\ jt\square\ outcome = i) = prki - 1$$
$$< b1x1j + b2x1j + bkxkj +$$

$$uj \leq kj \qquad (3)$$

It is necessary to estimate t $k1, k2, \ldots ki - 1$,he coefficients b_1, $b2\ldots$ $b_{k,}$ along with cut points K_1, $K_2 \ldots K_i$ where (i) is number of possible response categories of the dependent variable. The coefficients and cut points are estimated using maximum likelihood (Long and Freese, 2003).

Tobit Regression Model an econometric model known as tobit model was used to empirically identify the determinants of Climate change adoption status of farming households. This model is also recognized as censored regression model in the sense that a sample in which information on the regress and (adaptation) is censored. The tobit model was selected because climate change adoption variable were dummy. The value of the variable ranges between 0 and 1 this made it a more appropriate econometric model for this paper (Maddala, 1983; Gujarati, 2004). The structural equation of the tobit model is given as:

$$Y = xi\beta + \varepsilon i \qquad (1)$$

$$e \sim N[0, s]$$

Denoting Yi as the observed dependent (censored) variable

$$Yi = \begin{Bmatrix} Y = LifY^{\cdot} \leq L \\ X\beta + \varepsilon ifL < Y^{\cdot} < U \\ UifY^{\cdot} \geq U \end{Bmatrix} \qquad (2)$$

Where:

Yi = the observed variable, in our case climate change adaptation option

$Y^{\cdot}$= the latent variable (unobserved for values smaller than 0 and greater than 1)

xi = is a vector of variables influence climate change adaptation option.

β = are parameters associated with the variables to be estimated.

εi = Residuals that are identically normally distributed with mean zero and a common variance.

i= 1, 2…n (n is the number of observations). $Y^{\cdot}$

L = lower limit

U = upper limit

Data Quality Management

To ensure the quality of data, preceding data collection and training of the data collectors was carried out by the principal investigator on the objective, relevance of the study and confidentiality of information. The data collection tool was prepare in English and translate to Amharic with the intention that the respondents was understudied it and provide an accurate response. Two developmental agents were recruited and train to use the data collection tool before embarking on data collection. The research's data collection mechanisms was pre-test before proceeding to the research participants with the objective of checking the validity and appropriateness of the questions included there on. The pre-test was conduct on 5% of the sample size.

3.8. Definition variables and Hypothesis

Dependent variable is Household food security status. Household Food security status asses by Household food insecurity access score and food consumption score.

Explanatory variables affect the dependent variable Household food security status of the farmers. Explanatory variables are adaptation measure chosen by the farmers in a given period of time and place. Households' characteristics, socio-economic variables, institutional variables, attitudinal factors, environmental variables and seasonal climate variability was select every adaptation option represents by Y=1 if it is adapted by the farmer and y=0 if it is not adapted by the farmer. Climate resilient sustainable agriculture for adaptation to climate change identified forty adaptation options; but for this study the following six most common adaptation options that are more implemented in the study area and explanatory variable were used on the study listed below with their categories and variables. Those are

Table1: Explanatory variable description and Categories

Variable name	Category	Dependent	Independent
Age of the household head	Continuous		√
Gender of the household head	Dummy		√
Educational level of the household head	Categorical		√
Farm size	Continuous		√
family size/	Continuous		√

Income from off-farm activities	Continuous		√
Farming experience	Continuous		√
Market distance	Continuous		√
Soil and water conservation (SWC)	Dummy		√
Irrigation	Dummy		√
Diversification of new crop variety	Dummy		√
Livelihood diversification	Dummy		√
Appling fertilizers	Dummy		√
Agro-forestry	Dummy		√
FCS and HFIAS Score	Categorical	√	

4. RESULTS AND DISCUSSIONS

Introduction

This chapter discusses both results of descriptive and econometric analysis. Under descriptive analysis, household head characteristics, climate change adaptation and food security related variables were analysis by either t-test or chi-square and econometric analysis was carried out using ologit, tobit and normality, homoscedasticity (homogeneity of variance) and VIF test were conducted. Climate change and Variability trends of the study area from satellite data, drought severity and climate change adaption respond, farmers perception of climate change and variability of respondent were assed finally contribution Climate change adaption and determinate factors were examined.

4.1. Demographic and socioeconomic characteristics of sample respondents

Out of the total of 138 respondents, 26.1 % were food secure, 39.1% were mildly food insecure and 48.8% were moderately food insecure households. Result from agricultural households in *Basona Werena Woreda* of the *Wayou kebele* this section briefly summarizes farmers' adaptation options in response to climate variability and change. In this study adaptation options for climate variability and change farmers used includes using SWC, small-scale irrigation, crop diversification , agro-forestry, diversification of sources of livelihood, were used to measure adaptation status of sample households. Farmers who were applying one or more strategy it could be traditional or modern way consider to be adopter and those farmers in sample study doesn't apply all of them consider non-adopter. Result shows that 87 (63.04%) of the sample respondents are engaged in climate change adaptation strategies. Nevertheless, the number of farmers who did not adjust their farming practices in response to climate variability and change 51(37.96%) is found to be large in the study locality. However similar data collected the current study show slightly high result than study done however, this figure slightly high as compared to similar data collected from Ethiopia where 37 % of farm households did not adapt (Bryan *et al*. 2009).

Sex and marital status of respondents

Results showed that 114 (82.6%) of the sample households, were male-headed households, while 24 (17.4%) respondents were female-headed households. About the marital status of the households' head, majority of (118 (85.5%)) of the respondents were married households from both genders. While the remains 14.5 % were single, divorce, and widows.

Table 2: Sample household in the *WayouKebeles* by sex and marital status (n=138)

Variables	HH characteristics	Total	Percent
Sex	Male	114	82.6
	Female	24	17.4
Marital status	Single	9	6.5
	Married	118	85.5
	Divorced	4	2.9
	Windowed	7	5.1

Source: own survey, 2020

Age, Education level and family size of household head

The mean age of sampled household heads was the adopters is 46.62 while, it is 55.04 years for non-adopters. The mean age of the adopters is less than the mean age of the non-adopters in Climate change adoption option. The minimum and maximum ages of respondents were 20 and 76 years, respectively.

Table 3: Distribution of Sample Households by educational status and sex

Educational status	Frequency			Percent	
	Male	Female	Total	Male	Female
Illiterate	50	22	72	69.4	30.6
Formal education attended (Grade 1-4)	36	5	41	87.8	12.2
Formal education attended (Grade 5-8)	16	1	17	94.1	5.9
Formal education attended (Grade 9-12)	6	0	6	4.2	0.0
TVET and above	2	0	2	1.75	0.0
Total	114	24	138	82.6	17.4

Source: own survey, 2020

Farmland size, ownership and years of experience in farm

From the total respondent 128(92.8%) land owners and 10(7.2%) were have not had their own land. Generally, a majority of the farmers in the *Kebele* were owners of farm lands. The chi-square test value showed that there was no statistically significant relationship between farmland ownership and residence *kebele*. Therefore, there is no significant difference of land ownership and also no significant relationship between farmer experiences. These findings could be substantiated by qualitative data generated from interviews with key informants, as they explain: *"Land is already occupied by the old aged farmers; we are living without land. There has not been land redistribution. However, when those land holders passed away and there were also*

long term emigrant farmers in the Kebele there was no inherent relatives for them; their land holdings would be redistributed. Our critical problem is lack of land."

Table 4: Land possession and farm land size of household heads (n=138)

Variables	Option	Frequency (%)	Chi^2
Land holders	Land holder	128 (92.8)	df =2 p(.060)
	Non-holder	10(7.2%)	

Sex	Farm size in Ha.			Farm Experience in years		
	0.25-1.00	1.01-1.5	>1.5	1-10	11-20	>20
Male	86	16	12	17	31	66
Female	20	3	1	0	7	17
Total	106	19	13	17	38	83

Source: own survey data, 2020, 1timad = 1/4hectare.

4.2. Climate change and variability trends of the study area

This section makes a brief summary of the situation of climate change and variability in the *Basona Werena Woreda*, North Shewa, Zone Amhara region which are important for this study.

Table 5: Slope and significant level of trends in annual and seasonal climate parameters

Climate Parameters	**Season**	**Slope**	**P-value**	**Mean**	**Min**	**Max**
Maximum temperature (^{0}C)	Summer	0.006	0.581	19.65	18.68	21.27
	Autumn	0.032	0.003***	18.86	17.37	19.90
	Winter	0.029	0.006***	19.77	18.50	20.63
	Spring	0.034	0.025**	21.03	19.43	22.25
Minimum temperature (^{0}C)	Summer	0.019	0.031**	8.35	7.48	9.25
	Autumn	0.014	0.38	4.37	3.13	5.83
	Winter	0.012	0.662	4.60	1.80	7.13
	Spring	0.013	0.447	7.68	5.65	9.56
Rainfall (MM)	Summer	5.851	0.006***	626.0647	341.8	817.7
	Autumn	-0.115	0.887	107.1529	27.3	175.8
	Winter	-0.555	0.298	36.24706	0.8	90.8
	Spring	-0.139	0.888	145.6853	40.3	300.6

Source: own design based on the satellite data, 2020

Temperature and Rainfall trend analysis

Annual mean Maximum temperature trends of the study area

The annual maximum temperature is the average of afternoon maximum air temperature over a year. The average annual maximum temperature of the study *Woreda* was 20.26^{0}C; the highest and lowest temperatures were 20.45^{0}C and 18.93 ^{0}C respectively. There is a significant increase in maximum temperature at annual time scale at a rate of change 0.025 ^{0}C per year or 0.75^{0}Cper decade over the last 30 years (1984-2014). The p-value implies that there is significant increasing change of trend over the last 30 years at ($p<0.01$) significant level.

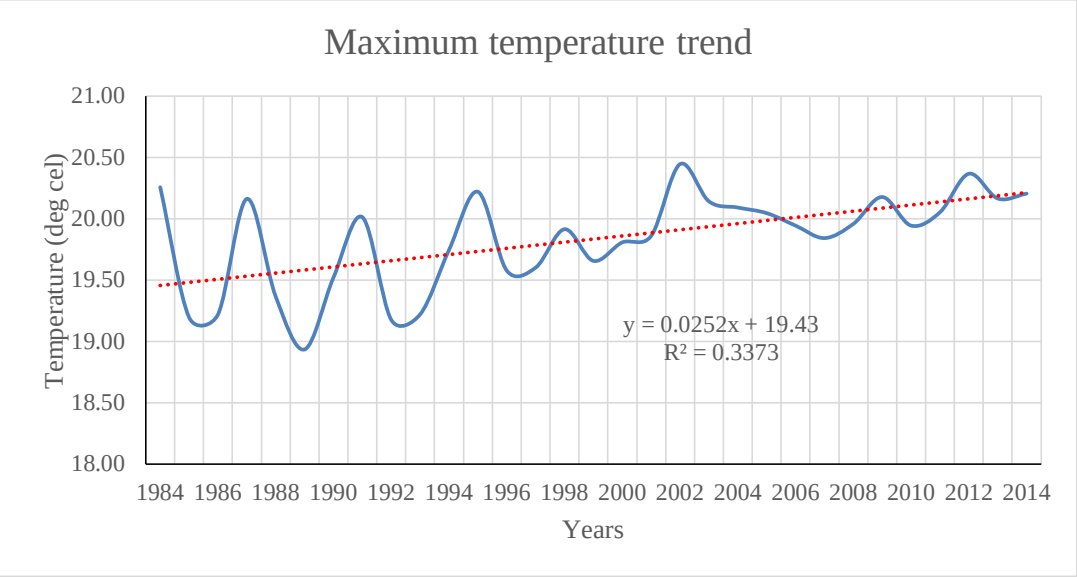

Figure 3: Annual mean maximum temperature trends of BasonaWeranaWoreda from 1984-2014
Source: own design based on the satellite data, 2020

Annual mean Minimum temperature trends of the study area

The annual minimum temperature is an average of night time low air temperature over the year. The average annual mean minimum temperature of the study *Woreda* was 5.76^{0}C, and 4.79 ^{0}C and 7.45^{0}C are the highest and the lowest annual mean minimum temperature over the 30 years in the study *Woreda*. The p-value showed that a positive trend in the annual minimum temperature and the increasing trends also significant at ($p<0.01$) significant level over the last 30 years in the Study *Woreda*. There is a significant variability in minimum temperature at annual time scale at a rate of change 0.0148^{0}C per year or 0.44^{0}C per decade over the last 30 years (1984-2014)

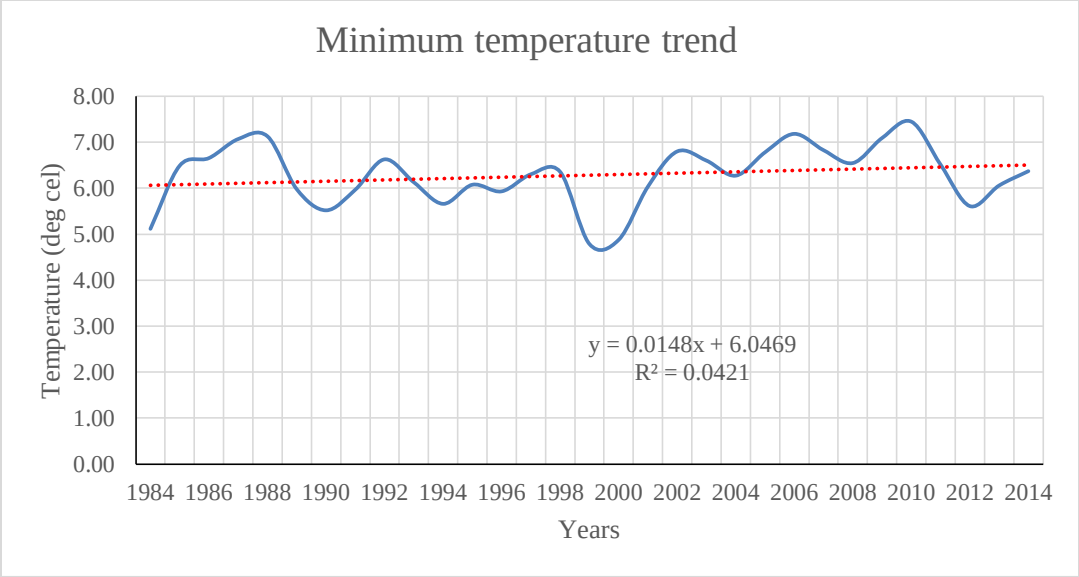

Figure 4: Annual mean minimum temperature trends of Basona Werana Woreda from 1984-2014
Source: own design based on the satellite data, 2020

Annual Rainfall trends of the study area

The annual rainfall shows positive trends with 5mm/year rate of variation in the last 30 years. Data analysis result shows annual rainfall has an increase in the past 30 years. As Figure 5, indicate amount of rainfall fluctuated yearly between 1984and 2014. The p-value implies that increase in annual rainfall variation were found to be significant at ($p<0.01$) significant level over the past 30 years in the study *Woreda*. The annual rainfall of the study *Woreda* varied between 649.9 mm and 1083.5mm with 433.6mm range of difference and the mean rainfall of the 30 years was 916.12mm.

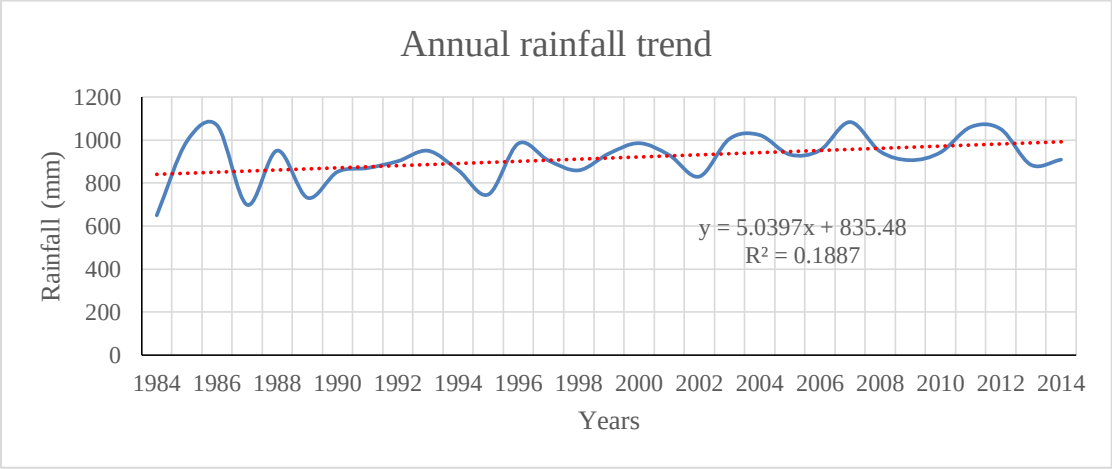

Figure 5: Annual rainfall trends of Basona Werena Woreda from 1984-2014
Source: own design based on the satellite data, 2020

4.3. Seasonal rainfall Variability of the study area

Autumn rainfall trends, shows a -0.115mm variability per decade over the last 30 years, and the distribution is not statistically significant (p<0.887). On the other hand summer rainfall shows variability with 179.8mm per decade of increasing variation, the p-value implies that and the increased Variability showed statistically significant at (P<0.000) significant level. This inculcate that there a significant influence on the farming system. This implies that climate change and variability impact on the *Woreda* is increasing the past 30 years this also related that the study *kebele* is face repeated disaster like flood, landslide the local resident people are facing instability due to the disaster they are short or permanently displace from their local farm area this indicated by farmer perception and key informant interview the present problem also significant effect for household food security status of sample household those how were face climate change and variability effect repeatedly their household food security status were significantly affect also it statically significant (p<0.000). The maximum autumn rainfall the study *Woreda* in the past 30 years is 175.8 mm and the minimum also 27.3 mm and the average of rainfall was 107.15mmoverthe last 30 years.

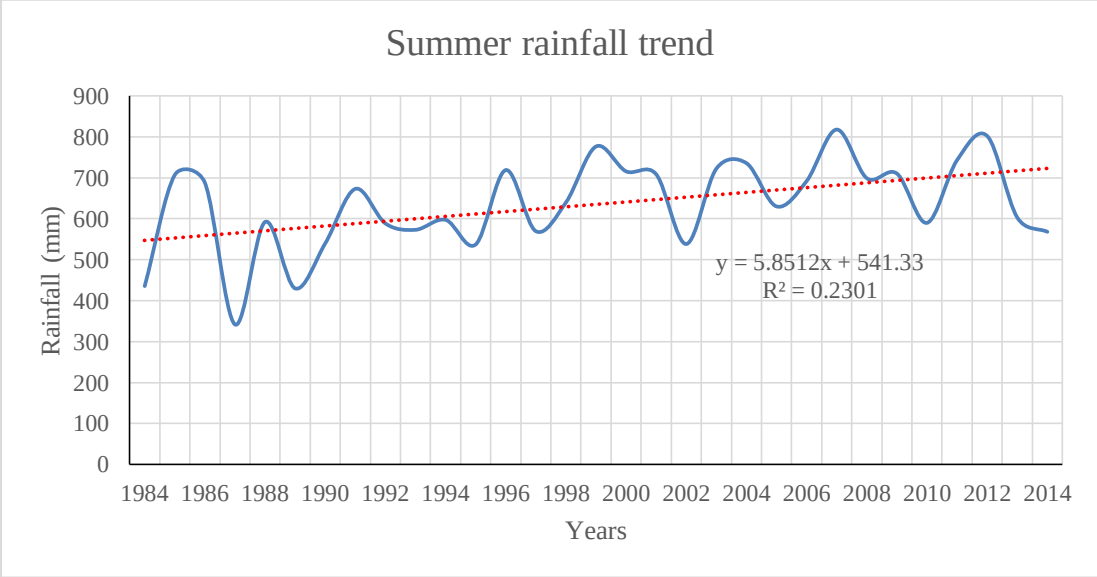

Figure 6: Trend Summer rainfall of Basona Werena Woreda1984-2014

Source: own design based on the satellite data 2020.

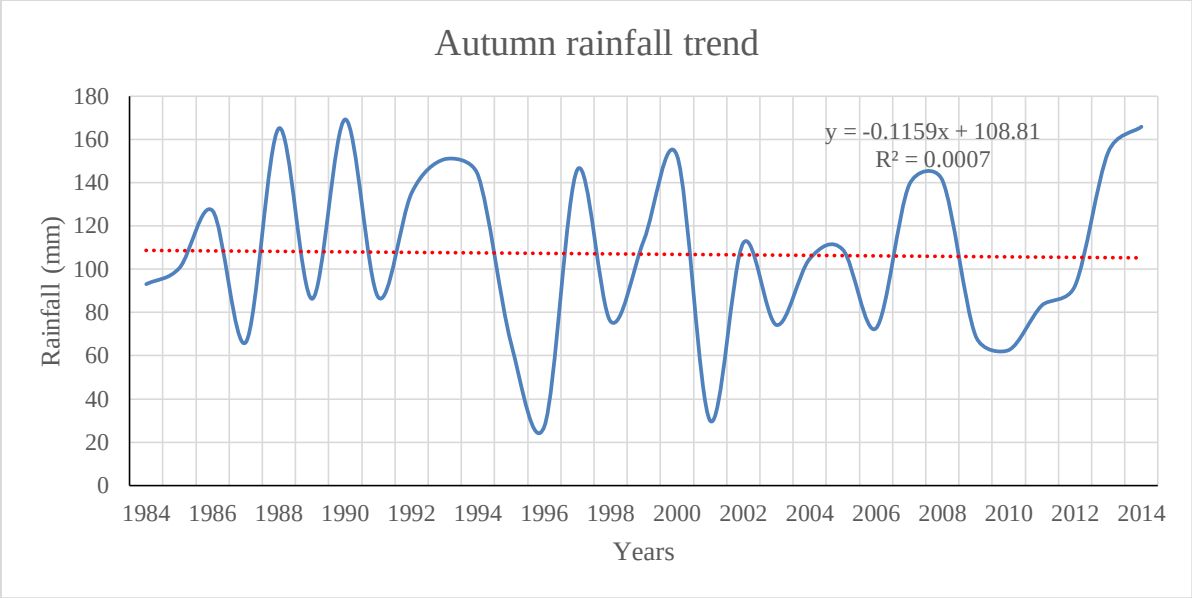

Figure 7: Trend Autumn rainfall of Basona Werena Woreda 1984-2014

Source: own design based on the satellite data 2020.

Winter rainfall trends, shown that -0.555mm variability per decade over the last 30 years, and the distribution is not statistically significant (p<0.298). On the other hand spring rainfall shows variability with 40.3mm and 300.6 mm minimum and maximum respectively in the past three decade the distribution is not statistically significant (p<0.888).

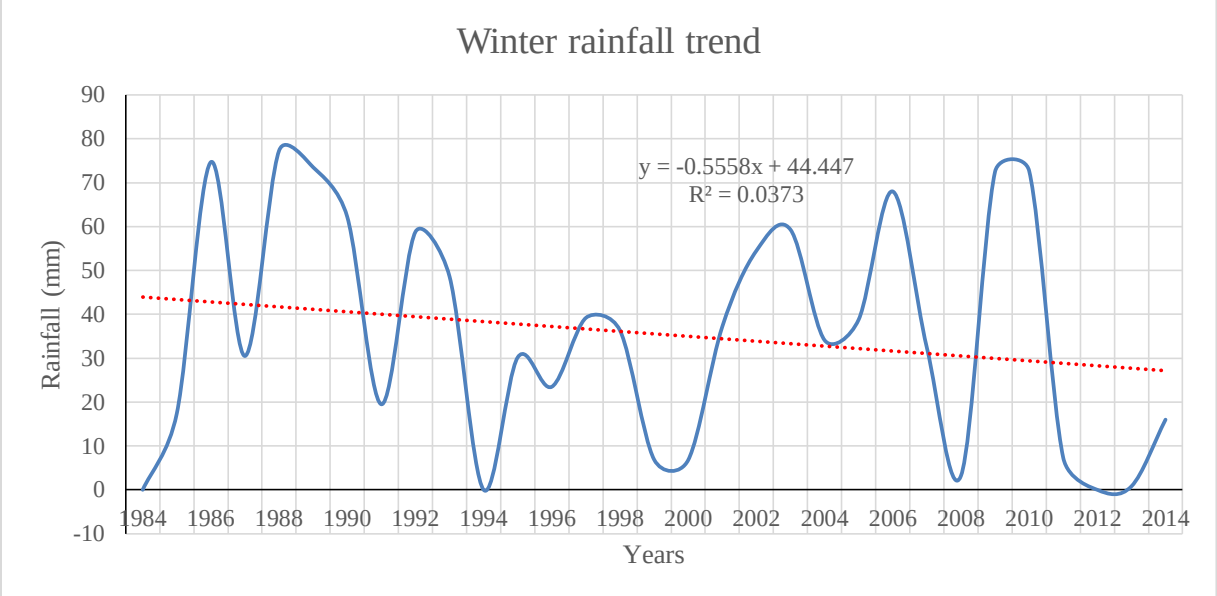

Figure 8: Trend winter rainfall of Basona Werena Woreda 1984-2014

Source: own design based on the satellite data 2020

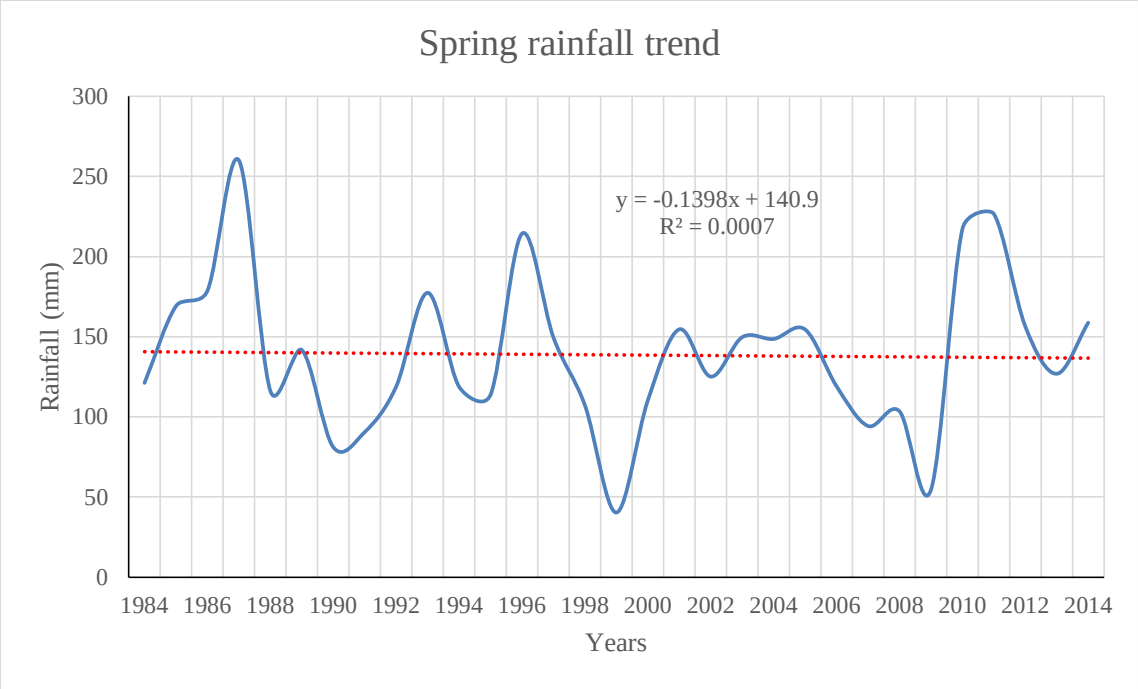

Figure 9: Trend of spring rainfall of Basona Werena Woreda 1984-2014

Source: own design based on the satellite data 2020

Average monthly rainfall and temperature distribution

The long term annual and seasonal rainfall variability shows in Table 6. Average mean for annual rainfall, small rainy season (autumn) rainfall, and main rainy season (summer) rainfall was computed as 916.12mm, 106.95 mm, and 634.95mm and occasional shower of rain season of spring 143.72 mm with standard deviation of 105.5, 39.77, 110.9 and55.55 respectively. Similarly, the coefficient of variation in annual, autumn, summer and spring season rainfall is 11.51%, 37.18%, 17.5% and 38.65% respectively, which means this much amount of rainfall is deviated from the mean.

Table 6: Annual and Seasonal rainfall (mm), standard deviation and Coefficient of variation, (1984-2014)

Rainfall	**Mean**	**Standard Deviation**	**Coefficient of Variation**
Annual	916.12	105.5	11.51
Autumn	106.95	39.77	37.18
Summer	634.95	110.9	17.5
Spring	143.72	55.55	38.65

Source: NMA (2020)

According to NMSA (1996) classified the rainfall variability of an area shown the coefficient of variation in annual rainfall variability is less than 20% (11.51%) which shows less variation. The coefficient of variability in Autumn season rainfall is greater than 30% (37.18%) which indicated highly variable, and in Summer season rainfall is less than 20% (17.5 %) indicated less variability in the past three decades.

4.3.1. Severity of drought

This study was focused on meteorological drought, which can be expressed by the so-called drought indices. According to Agnew and Chappel (1999) drought severity assessment method, shows that the drought severity scales in the study area between the years 1984-2014. Extreme droughts observed in the study area in the year 1991, 1992, 1994, 1997, 1998, 2009, 2013 and 2014 (-2.14632, -6.13027, -1.77513, -7.43661,-1.7602, -8.52684, -3.10865 and -10.5985 respectively). Severe drought appeared in 1995 (-1.582), moderate drought shows in the years 1984, 1987, 1989 and 2002 (-0.38966, -0.47571,-0.55933,-0.60912 and -1.18327 respectively). The rest year was not observed drought in the study area. Drought severity shows that the study area had sever climate change impact this gives evidence that the study *kebele* food security status highly impacted on climate change due to drought. Furthermore the meteorological drought indicate that severity of drought contribute directly to food security of household status.

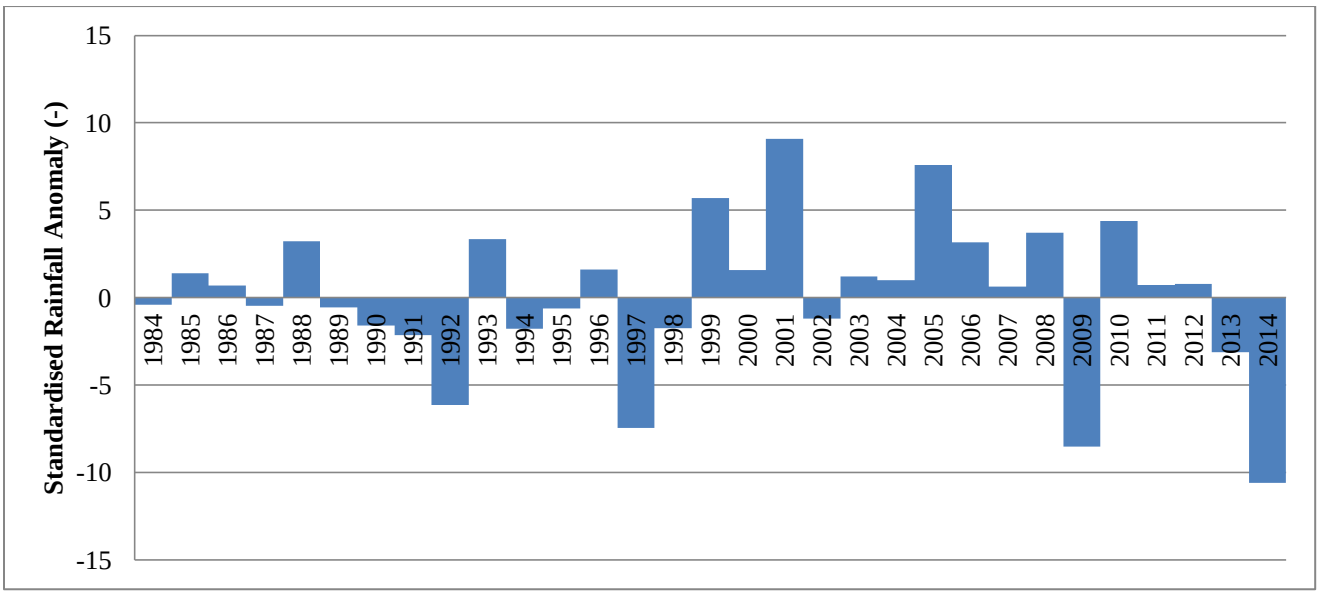

Figure 10: Drought severity source: NMA (2020)

Seasonal mean minimum temperature trends of the study area

Concerning, the seasonal trends of the minimum temperature, all summer, autumn, winter and spring shows a positive increase trend, but only summer have statistically significant at ($p<0.05$) significant level.

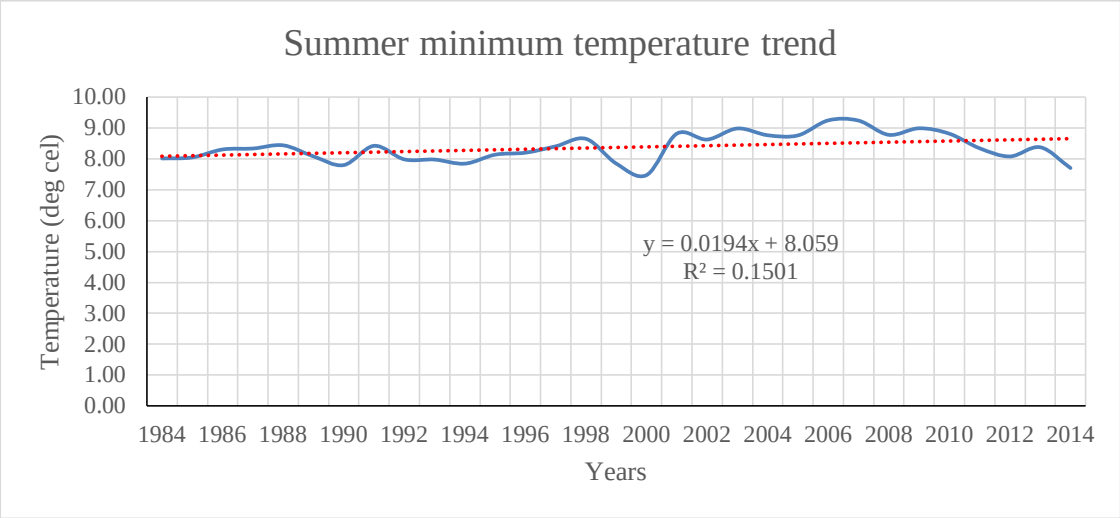

Figure 11: summer average minimum temperature trends of Basona Werena Woreda
Source: own design based on the satellite data 2020.

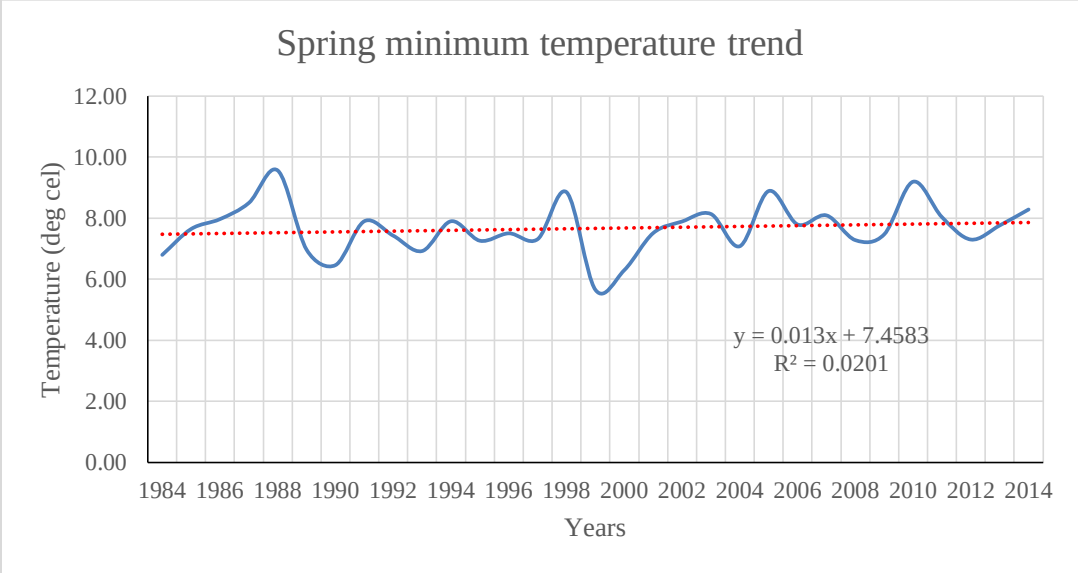

Figure 12: Spring average minimum temperature trends of Basona Werena Woreda
Source: own design based on the satellite data 2020.

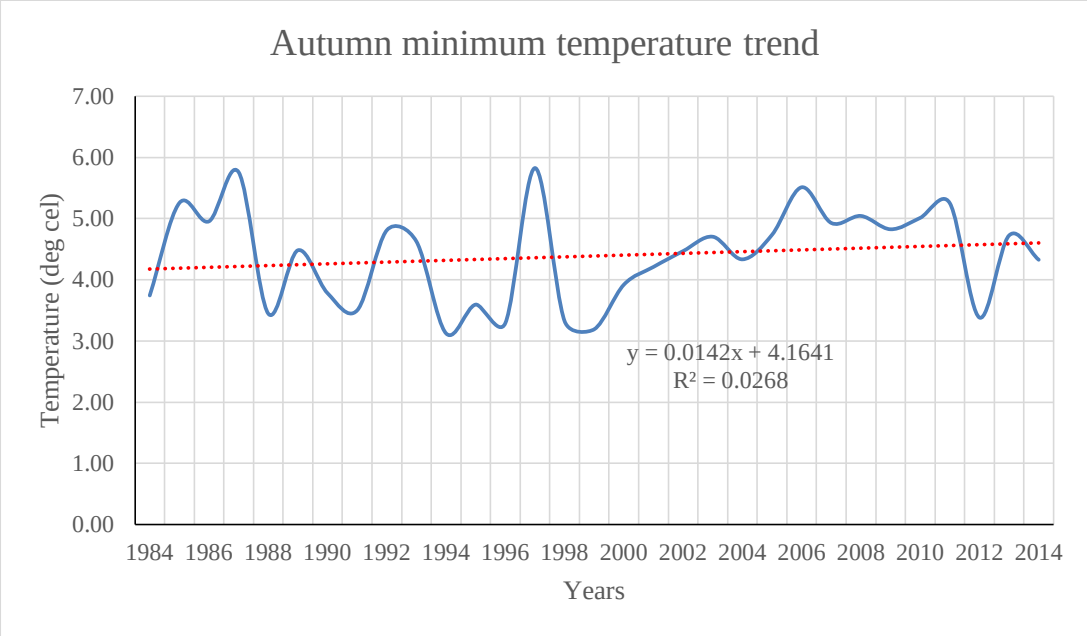

Figure 13: Autumn average minimum temperature trends of Basona Werena Woreda
Source: own design based on the satellite data 2020.

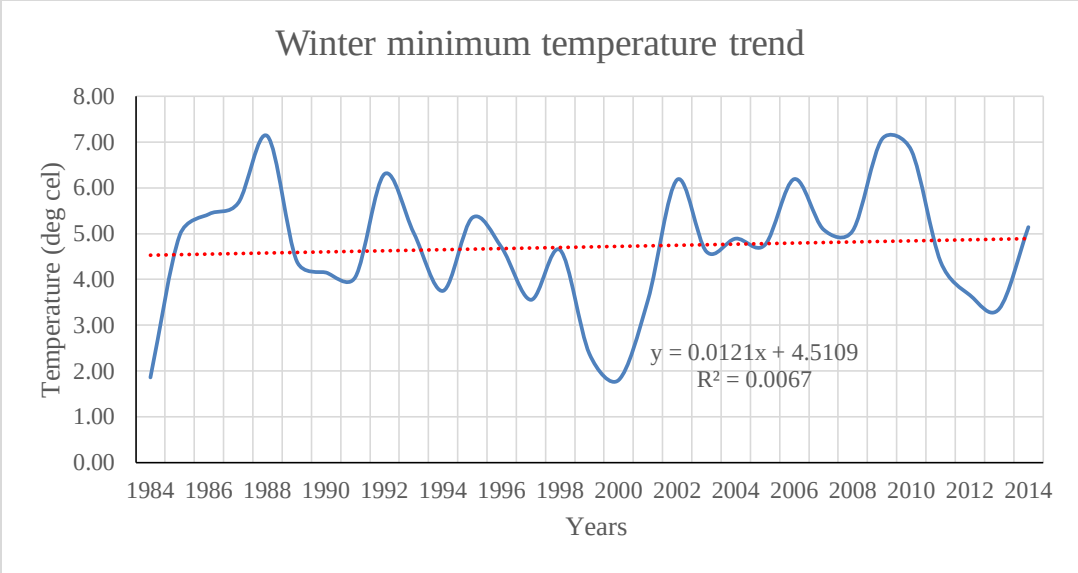

Figure 14: Winter average minimum temperature trends of Basona Werena Woreda
Source: own design based on the satellite data 2020.

Seasonal mean maximum temperature trends of the study area

Concerning, the seasonal trends of the maximum temperature, autumn, winter and spring shows a positive increase trend, except summer all have statistically significant ($p<0.05$) significant level.

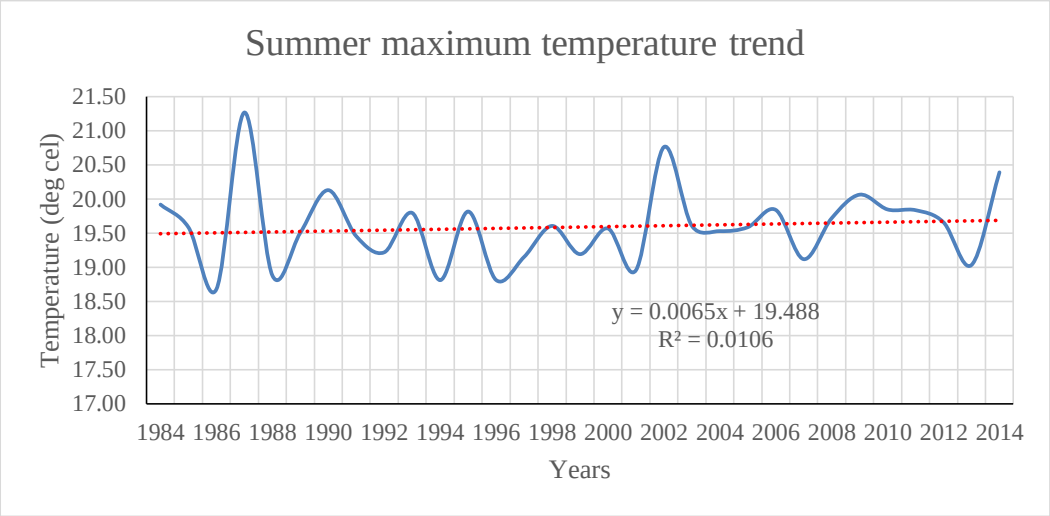

Figure 15: Summer average maximum temperature trends of Basona Werena Woreda
Source: own design based on the satellite data 2020.

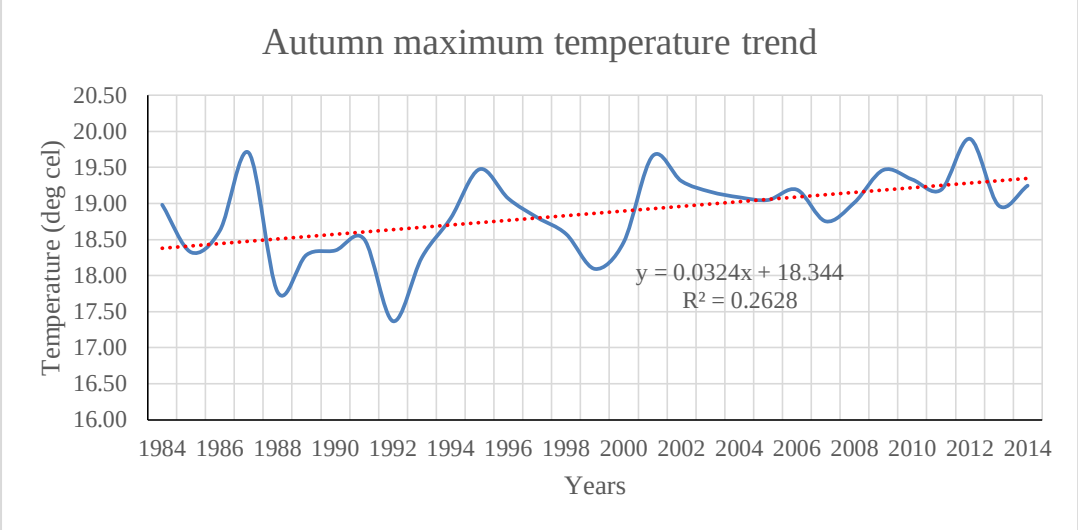

Figure 16: Autumn average maximum temperature trends of Basona Werena Woreda
Source: own design based on the satellite data 2020.

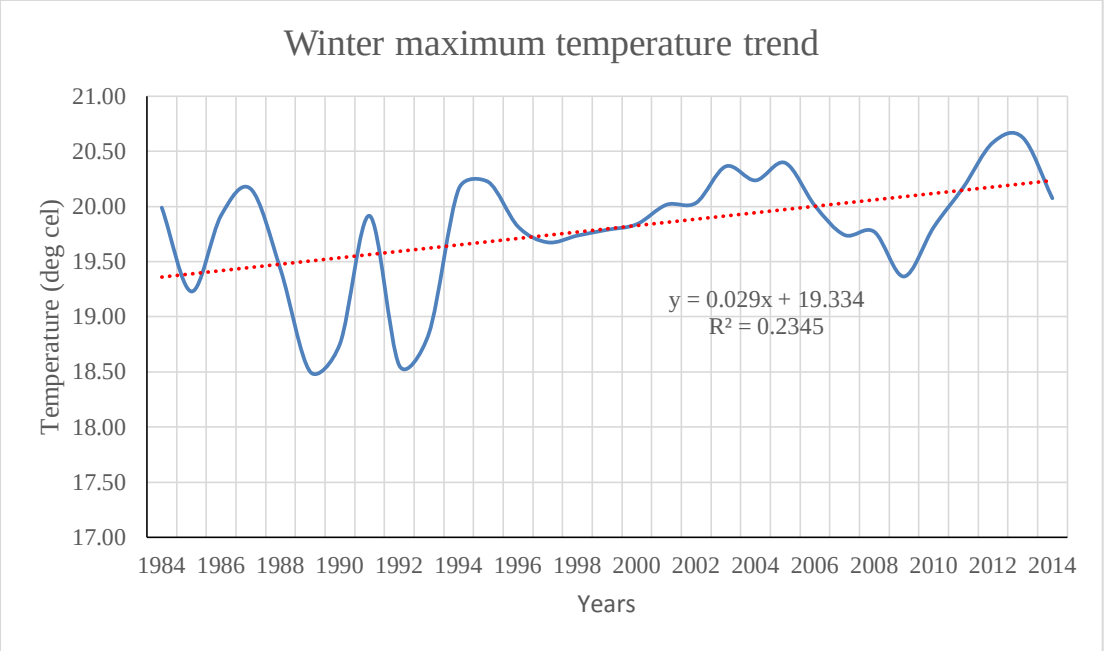

Figure 17: Winter average maximum temperature trends of Basona Werena Woreda
Source: own design based on the satellite data 2020.

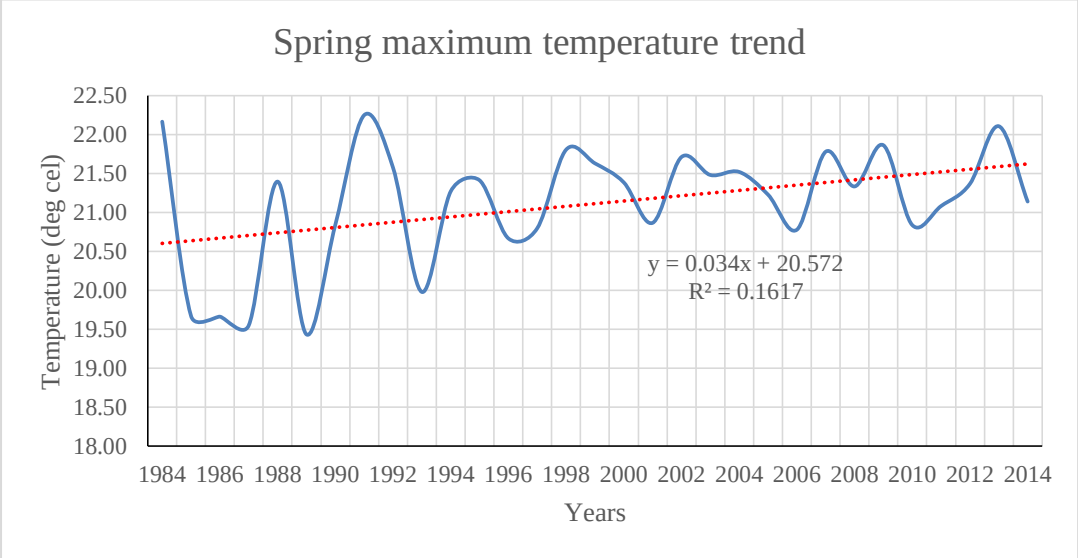

Figure 18: Spring average maximum temperature trends of Basona Werena Woreda from 1984-2014
Source: own design based on the satellite data 2020.

T-test distribution of variables by Climate change adoption status of respondents

Results showed that 114 (82.6%) of the sample households, were male-headed households, while 24(17.3%) respondents were female-headed households the result implies related to climate change adoption male-headed households more engage with adoption measure than female-headed households this have contribution on household food security status of the respondent. Marital status of the households' head, majority of (118 (85.5%)) of the respondents were married. While the remains 14.5 % were single, divorce, and widows.

This result indicate that when age increase practicing climate change adaptation option decrease among age group above 65 years old this result statistical significant in statistical difference at 5% significant level (p<076). Similarly study on Impact of Farm Households' Adaptations to Climate Change on Food Security: Evidence from Different Agro-ecologies of Pakistan. The Age of the farmers are considered to be more risk averse and hesitate to implement new ideas and innovations which make them less productive under the changing climate. The variables which are significantly negatively associated with the food security levels include age of the head of household (Ahmad, 2015). This idea support with difference psychological studies done related to adaptation when individual reach old age, accumulating negative conduction represents a serious challenge to their capacity to adapt and are likely to reduce the quality of life (Daniela, 2006).

This indicates that adaptation can influence by age as on factor. The result shown that the average educational levels of sampled household heads respondent was with minimum and maximum education level of illiterate and TVET, respectively. In this study majority of samples household heads respondent were illiterate how cannot read and write 72(52.2%), next to this respondent who attend first cycle formal education were the second highest result among sample households heads 41 (29.7%) comparing to those results respondent who attended TVET were less 2(1.45%). Average education level of sample respondents was 1.72 with adopters and non-adopters were 1.78 and 1.62, respectively with no statistically significant difference. Similar to this, no significant difference was identified by maximum education status of household members.

Another study showed that somehow similar find to the current studies, study done in Muger Sub-Basin of the Upper Blue-Nile Basin of Ethiopia educational level of households were not statically significant between adopter and non-adopters (Abayineh and Belay, 2017). Differently from the current and Muger Sub-Basin of the Upper Blue-Nile Basin, Ethiopia result study done in Pakistan, the results show that education of the male and female heads factors which raise the food security of farm households and their impacts are statistically significant. The female education turned out to be more pronounced and thus have important implications from policy point of view (Ahmad, 2015). These findings are consistent with the results of Li and Yu (2010). Even that result is different from the current study.

Family size of non-adopters was greater than from adopter without statistically significant between their mean values. The average family size of sample respondents was 5.80 with the minimum and maximum size of 2 and 10, respectively. According to Ethiopian demographic health survey 2016 report the average family household is 4.6 member in Ethiopia (EDHS, 2016) this result is greater from the above report by EDHS and also, average household size distribution of adopters and non-adopters were 5.27 and 6.67, respectively. Though, family size of non-adopters is greater than adopters, there is no statistically significant difference in their mean. Other research show a significant difference between adopter and non- adopter study done on determinates of farmers' decision on soil fertility management options for maize production in southern Ethiopia this study indicate that farm size on adoption of SWC. For example, a study on soil conservation measures and irrigation in Ethiopia found that farmers with large farm size were found to have more land to allocate for constructing soil bunds, stone bunds, check dams, and improved cut-off drains and motivated to use irrigation revealed that farm size is positively correlated with the probability of choosing irrigation as an adaptation option (Kassa*et al*. 2013). Based on this result and similar finding from different researches indicate when family size increase adaption measure and option can be increase in terms of labor household sizehas mixed impacts on farmers' adoption of agricultural technologies. Larger family size positively influence farmers to take up labor intensive adaptation measures like Soil and Water Conservation (SWC) and irrigation that demand labor which is a critical problem in a peak period of production and livestock rearing (Anley*et al*. 2007; Frito*et al.* 2006).

Alternatively, a large family might be forced to divert part of its labor force into non-farm activities to generate more income and reduce consumption demands (Tizale, 2007). Related to family size current study and other related studies shown that large family size have a negative impact on food security status on the household food security level. The agreements rise by other researcher family size help in terms of labor use but in the other hand family size have a negative impact on food security status. Similar find showed that study done Muger Sub-Basin of the Upper Blue-Nile Basin, Ethiopia family size is found to be negatively and significantly ($P < 0.05$) impacted to determine household food security in the study area implying that the probability of food security decreases with an increase in household family size. The odds ratio in favor of the probability of being food secure decreases with an increase in the family size with an increase in household size the odds ratio in favor of the probability of being food secure decreases with an increase in the family size and also study done in Pakistan the study showed that family size is found to be negatively and significantly contribution on food security status of sample households with this two different results in terms of family size current study indicate there is no statically significant with adopter and non-adapter household but there is a statically significant in food security household.

The result on the table 7 shows the average livestock holdings of sample respondents was 3.96 with the minimum and maximum size of 0 and 13 number of livestock, respectively at ($p<0.05$) significant level. This implies livestock possession has significant impact on Climate change adoption option. Those how have number of livestock has more chance to take adaption option than those how was not and less passion of number of livestock. The statistical significant show that having number of livestock has impact on the climate change adoption and also, average household livestock holdings distribution of adopters and non-adopters were 5.17 and 1.94, respectively, Households that adopt climate change adaption option tend to have livestock holdings higher than non-adopters. Different studies showed similar result with the current finding, study done in Northern Senegal on impact of adoption adaptation climate change on household food security and incomes in Ferlo Semi-arid Area, Northern Senegal showed climate-change related threats, many adaptation strategies have been promoted widely for adoption by livestock owners in the Ferlo. On this result showed livestock size is statically significant at ($P<0.02$) (Saboury et.al, 2012).

The average total farm income of sample respondents was 2127.10 birr with the minimum and maximum size of 700 and 11,000 birr, with no significant difference in their mean. Furthermore, average of household total farm income distribution of adopters and non-adopters were 2149.88 and 2089.42 birr, respectively there was no significant difference in their mean. Other global researches had done by world food program shown that Climate change adaptation option can effect of their income (WFP, 2012). This difference come in the current study income of the respondents in the study was not much difference between adopter and non-adopters the difference is very low 60.46 birr was the difference between the two group to identify the impact of income on adaptation option the gap is very low so that the climate change adaptation option cannot determine by income the current study.

The result further more the result indicate that availability of nearby for irrigation has significant impact on adopter and non-adopter those household respondent nearby water availability for irrigation has more change of adoption than those how was not nearby other constants were notices for lack of adaption like cost of adoption and other will explain below on other section. Availability of water nearby for irrigation is significant $P < 0.05$ significant level there mean variation between adopters and non-adopters. Sample household availability of water point from home less than 1 km become more adopter comparing those farmers water point availability greater than 5km the major reason difference indicated by the sample household between this group when the water availability become more far from their home the cost of adaption increase specifically to use irrigation indicated that farmland size shows statistical difference in terms technology adoption $P < 0.05$ significant level. The average mean variation was 3.81 and 4.00, for adopters and non-adopters respectively. Similar results reveal that adoption of adaptation options water resources options found to significantly and positively influence imperative to devise viable projects on soil conservation, irrigation and agronomic practices this influence household food security (Abayineh and Belay, 2017). On other study by Overseas Development Institute the impacts of climate change including predicted increases in extremes are likely to add to this stress, leading to additional pressure on water availability, accessibility, supply and demand. For Africa, it is estimated that 25% of the population (approximately 200 million people) currently experience water stress, with more countries expected to face high risks in the future.

This may, in turn, lead to increased food and water insecurity for at-risk populations, undermining growth (Ludi, 2009). Although, study done by the High Level Panel of Experts on food and Nutrition (HLPE) report say regional irrigation shortfalls tend to boost international agricultural trade and alter its geography. Adaptation to climate change needs to carefully consider competing water uses and their various implications for food security and nutrition (HLPE, 2015).

The mean difference of market distance in kilometer between adopters and non-adopters those have market access in five kilometer and more than ten kilometer distance for market access were statistically significant at ($p<000$) with the mean difference 2.76 and 2.96 between adopters and non-adopters, respectively. Study conducted in Muger Sub-Basin of the Upper Blue-Nile Basin, Ethiopia showed similar finding distance to the major market is found significantly and negatively related to food security in the study area. The odds ratio in favor of food security decreases by a factor of 0.6178 when the distance to the main market increased by one walking hour. The consensus on households nearer to market centers had better chances to be food secure than those who are away from market centers is due to the reason that households nearer to the market center have the probability of selling their produce and purchase food from the market (Abayineh and Belay, 2017).

In addition to this landslide and flood were significant impact on climate change adaptation those how were adopt climate change adoption option has face less climate change effect in the sample household the difference is the level of damage that they were facing between the two group was difference as the result indicate, the average mean difference between adopters and non-adopters were 1.38 and 1.58 for landslide and 2.48 and 2.53 for flood. The damage and the frequency between the groups were statistically significant at ($p<0.10$) significant level. Study on by Ziervogel from University of Cape Town showed increases in the frequency of droughts and floods are projected to affect local production negatively, especially in subsistence sectors at climate change adaption it cause temperature increases and reduced soil moisture availability (Ziervogel, at, el. 2010).

Table 7: T-test distribution of variables by Climate change adoption status

Variables	Adopters (N=86) Mean value	Non-adopters (N=52) Mean value	Total Mean	T-value	P-value
Age	46.62	55.04	1.72	-3.840	.076*
Sex of the household's head	1.31	1.14	1.20	-2.413	.000***
Family size	5.27	6.67	5.80	-4.398	.559
Educational level	1.78	1.62	1.72	.987	.175
HH Income	2149.88	2089.42	2127.10	.263	.205
Number of livestock	5.17	1.94	3.96	6.878	.000***
Availability of water	3.81	4.00	3.88	-1.977	.000***
Agricultural practice(Year)	2.47	2.50	2.48	-.280	.824
Visit agricultural extension agents	1.02	1.01	1.01	-.360	.473
Market distance (Km nearest situated market)	2.76	2.96	2.83	-2.165	.000***
Landslide	1.38	1.58	1.51	1.168	.054**
Flood	2.48	2.53	2.51	.174	.070**

Source: Field survey 2020 Note: ** and *** indicate the level of significance at 1, 5 and 10 percent CI, respectively.*

Chi-square distribution of variables by Climate change adoption status of respondent

There has been a significant difference between female household head and male household head in sample household. Both man and female participants involve in the study however male respondents were the majority on the sample household heads. Out of 138 sample household heads, male and female heads was 82.6% and 17.4%, respectively. Among Female Households 9(37.5%) and 15(62.5%) were adopters and non-adopters. The result shown that being a female household head have significant effect comparing to being male household the mean difference between male and female at $p<0.05$ significant level. This tells male household heads were more participating on climate change adaption option comparing to female household headed.

Similarly to the current study result study done in Ghana showed that there a significant difference in gender related to climate change adoption.

Female heads of farm households to deal with low food and income availability (due to impacts of climate change on their livelihood activities). Gender pattern to the coping measures adopted by households to counter the negative impacts of the climatic stressors (Assan, at el., 2018). According to food and agricultural organization studies on Climate change and food security risks and responses showed off-farm income sources from labor diversification is generally positively associated with welfare levels. For example, labor migration is a common strategy in the face of climate risk and environmental degradation, and remuneration from these migrants plays an important role in maintaining household resilience. Non-agriculture-based livelihoods are likely to play an increasingly important role in building resilience among agricultural populations due to projected population growth patterns as well as potential climate change impacts (FAO, 2016).

Similarly to the above result from the total sample of household heads, 59.4% earn off farm income, while 40.6% did not have off farm income and the result is significant at $p<0.01$. Most of the respondents engage in off farm activities to earn money. Among those who have off farm income, 75.6% were adopters and 24.4% were found to be non-adopters. About 40.6% did not engage on off farm active among them 57.1% of those who confirmed having no off farm income were found to be non-adopters. This shows that adopters earn more off farm income than non-adopters. Household heads who have taken adaptation training and those who do not take 71.73% and 34.1% of the total respondents, respectively. Out of 71.73 % of trainers 88.3% and 11.7% of households with climate change adoption option were found to be adopters and non-adopters, respectively. While out of34.1% of households with not taken adaptation training 17.0% and 83.0% do not adopt climate change adoption option was found to be adopters and non-adopters, respectively. Statistical difference between adopters and non- adopters was observed among those how taken adaption training and not at $p<0.01$ significant level. This shows that taking adaptation training was a significant to apply adoption options. Based on the credit access report of table (8), out of the total respondent 64.5% and 35.5% were have access for credit and have no access respectively. The majority of the sample households have access for credit out that 89.5% of the respondents were adopters of climate change adaptation option.

Household heads were access for credit 10.5% were non-adopter. And also, out of 29.0% have no access for credit 71.0% of household heads were adopters and non-adopters, respectively. Statistical difference between adopters and non- adopters was observed in terms of credit access at p<0.01 significant level. Although study in Ghana indicate that adaption capacity- building resources and improved access to credit could enhance the adaptive capacity of farm households to mitigate projected climate change impacts on their livelihood and household well-being (Assan at el., 2018). Farmer's union membership or social capital is also another factor under consideration. Among the total respondents, 52.9% were found to have union membership, and the rest 47.1% do not. About 82.7% and 17.3% of those who have union membership were adopters and non-adopters, respectively. And also, about 38.1% and 61.9% of those who do not have membership were adopters and non-adopters, respectively. The result indicates significant difference in terms of adoption status at p<0.01 significant level. This shows adopters were dominated by household heads with union membership. The current findings align with other studies association membership was all positively associated adaptation methods, likely denoting the role of access to information and other resource which empower the farm household to adopt such climate-risk coping strategies (Ali, 2017).

Table 8: Chi-square distribution of variables by Climate change adoption status

Variables	**Categories**	**% of sample Proportion**	**Percentage distribution**		**Chi-square**
			Adopters	**Non-Adopters**	
Sex of HH	Male	82.6	67.5	32.5	.028*
	Female	17.4	37.5	62.5	
Off farm income	Yes	59.4	75.6	24.4	.000***
	No	40.6	42.9	57.1	
Adaptation Training	Yes	71.73	88.3	11.7	.000***
	No	34.1	17.0	83.0	
Social capital (association)	Yes	52.9	82.7	17.3	.000***
	No	47.1	38.1	61.9	
Credit used	Yes	64.5	89.5	10.5	.000***
	No	35.5	29.0	71.0	

*Source: Field survey 2020 Note: * and *** indicate the level of significance at 1and 10 percent, respectively*

4.4. Household Food Security Analysis

Chi-square distribution of food consumption score and household food insecurity access scale in climate change adaption status

Out of the total number of respondents who adopt Climate change adaptation option 39.1% of the respondents food secure, 3.90% of non adopter were food secure and 49.40% adopter were found mildly food insecure and 21.60% non-adopter.74.50% non adopter their household food security status were moderately food insecure, and 11.50% adopter were moderately food insecure among sample household. Beside out of the total sample household respondent who did not adopt climate change adaption option, there dietary diversity, food frequency, and relative nutritional importance was significantly different according to food consumption score of the respondents from the total of climate change adaptation option adopters 50.6% of them their food consumption score fail in to acceptable category the significant level is ($p<0.000$). On the other hand out non adopters only 5.9% of them their food consumption categorized to acceptable. Majority of non-adopters there categories of dietary diversity, food frequency, and relative nutritional score implies that there food consumption score categorized with borderline (35.3%) and Poor (58.8%). According to this result climate change adaptation option have direct impact on dietary diversity, food frequency, and relative nutritional status of the sample households. Addition to food consumption score household food insecurity access scale was taken to examine access component of household food insecurity the result shown that non-adopter sample household their food access is less than comparing to those how were adopt climate change adaptation option. Therefore, based on the outcome using climate change adaptation option ensure household food security status taking action on climate change adaptation option can be one way for sustainable household food security status among food insecure population.

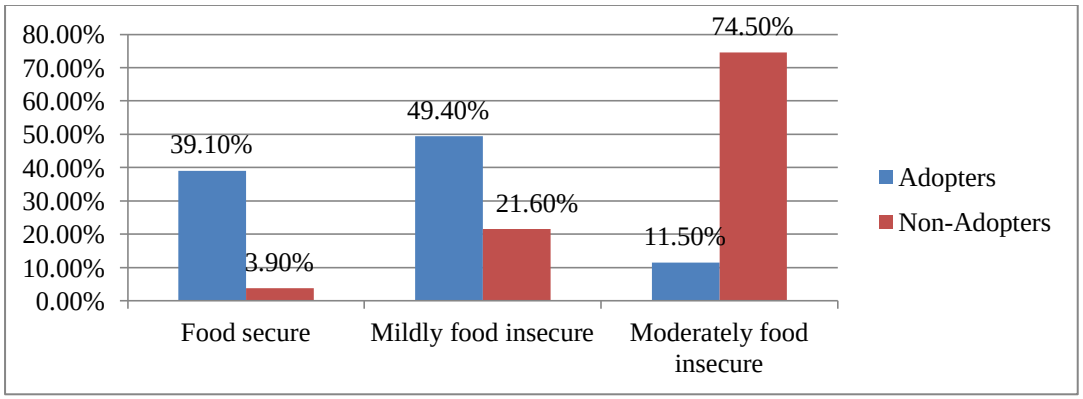

Figure 19: Household HFIAS

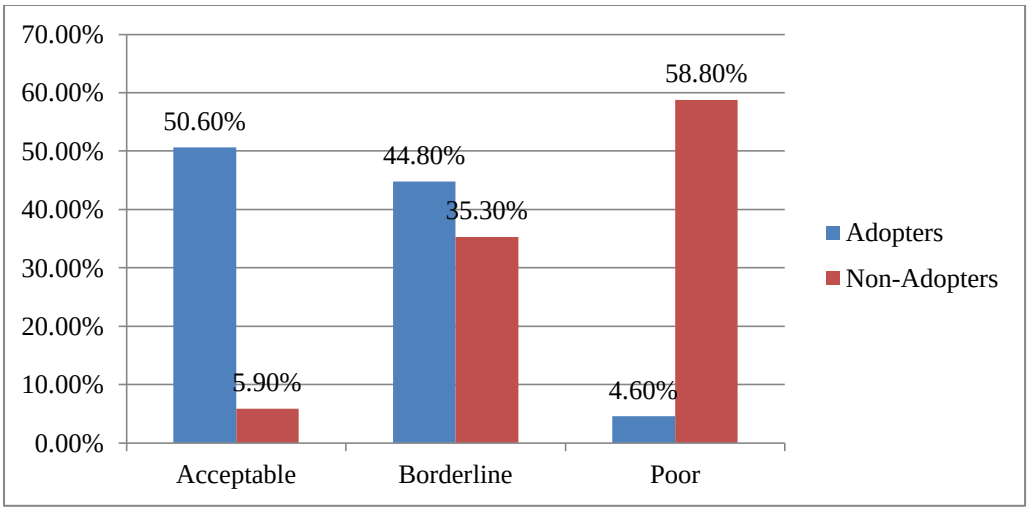

Figure 20: Household FCS

4.5. Households Food Accessibility

Food Insecurity Access Prevalence showed that 26.1% of the households in *Wayou Kebele* were food secure, 39.1% were mildly food insecure and 34.8%, moderately food insecure. However, there was no severely food insecure household in *Wayou kebele* sample households. This showed that over 70% of the study population was in a state of some degree of food insecurity. This showed survey was made immediately after harvest (November, December and January), when food was relatively abundant, the level of food insecurity was telling of what could happen in the months (July, August and September). Similarly study done on Muger Sub-Basin of the Upper Blue-Nile Basin, Ethiopia results showed that 57.8% of the households are food secure, while the remaining 42.2% of the households are food insecure (Abayineh and Belay, 2017).

Table 9: Food Insecurity Access Prevalence in Basona Werena *Woreda Wayou Kebele*, 2020

FIAP Prevalence	Frequency	Percent
Food secure	36	26.1
Mildly food insecure	54	39.1
Moderately food insecure	48	34.8
Severely food insecure	0	0

Source: own survey, 2020

According to Global Hanger index report Ethiopia faces high levels of food insecurity, ranking as one of the hungriest countries in the world. Ethiopia was ranked 104 in the world in Global Hunger Index in 2017(GHI, 2018). To assess household food security status respondent was measured by using Household Food Insecurity Access Scale (HFIAS) according to (Coates et al., 2007). The HFIAS occurrence questions ask whether or not a specific condition associated with the experience of food insecurity ever occurred during the previous 4 weeks (30 days).

Table 10: HFIAS in the past four weeks in Wayou *Kebele*, 2020

No	Occurrence Questions of HFIAS	Occurrence		Frequency		
		Yes	No	Rarely	Sometimes	Often
1	In the past four weeks, have you been worried that you would not have enough food?	103	35	70	0	0
2	In the past four weeks, is there a situation that you was not able to eat the kinds of foods you preferred because of a lack of resources?	97	41	67	30	0
3	In the past four weeks, did you have to eat a limited variety of foods due to a lack of resources?	105	33	44	59	2
4	In the past four weeks, did you have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	95	43	61	34	0
5	In the past four weeks, did you have to eat a smaller meal than you felt you needed because there was not enough food?	100	38	94	6	0
6	In the past four weeks, did you have to eat fewer meals in a day because there was not enough food?	81	57	81	0	0
7	In the past four weeks, was there ever no food to eat of any kind because of lack of resources to get food?	48	90	48	0	0
8	In the past four weeks, did you go to sleep at night hungry because there was not enough food?	45	93	45	0	0
9	In the past four weeks, did you go a whole day and night without eating anything because there was not enough food?	29	109	29	0	0

Source: own survey, 2020

4.6. Food Consumption Score (FCS) of the respondents

In practice, food security correlates with food frequency and dietary diversity proxy indicators with regard to access and availability of sufficient quality food (Hoddinott and Yohannes, 2002). Food security as developed by the WFP covered food frequency and dietary diversity in the food consumption analysis. FCS analysis examine the household consumption through using Food Frequency questionnaires and a given food group weight (WFP, 2016). Therefore, applying food consumption score is used to assess food security of the household. The highest weight was attached to the household with food relatively high energy, good quality protein, and micronutrient. Food consumption score data obtained from food consumption score analysis of the households and categorized in to three food consumption groups (FCG) to determine the food security level of the households. FCS categorized in to (1) "poor" if the household food consumption group falls below 21; (2) "borderline" if the household food consumption group ranges from 21 to 35 and (3) "acceptable" if the FCG is above 35. Based on the FCG, the food security level was divided into two groups: (1) "food insecure" if the FCG is categorized in the borderline or poor groups and (2) "food secure" if the FCG is categorized in the acceptable group (WFP, 2016).

The result indicated that, from the total sampled household, 34.1% of the household food consumption found to be acceptable, for 41.3% of the household frequency of food group consumption lies in the borderline food consumption categories and the rest of 24.6% of the households are in the poor consumption condition. Food consumption score clear indicate that there is a statically significant $p<0.01$ difference between adopter and non-adopters. Current findings align with other studies in Pakistan on Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan explore positive relation between climate-change adaptation strategy and food security (Ali, 2017).

Table 11: Food security status of respondents on climate change adaption (Using FCS)

Food Consumption Score (FCS)	**Adopters** 63.04%	**Non-Adopters** 37.96%	**Total**	**Mean of adopters**	**Mean of non-adopters**	**P-value**
Acceptable	44 (50.6%)	3 (5.9%)	47 (34.1%)			
Borderline	39 (44.8%)	18 (35.3%)	57 (41.3%)			
Poor	4 (4.6%)	30 (58.8%)	34 (24.6%)	1.53	1.06	.000***

Source: own survey, 2020

4.7. Farmers' perception of climate change and variability

Farmers' awareness to climate change and variability in terms of long term change in temperature and precipitation plays a great role in adapting to the change. Perception of climate change affects how a farmer responds and adapts to its multiple impacts. Perception affected the activity of farmers' responses to his/her perceived impact of climate change and variability. But this does not mean that those farmers' who did not perceive of climate change and variability, and their impacts are not adapters. Farmers' perceptions about climate change, therefore, strongly affects how they understand and deal with climate induced risks and uncertainties, and undertake specific measures to mitigate the adverse impact of climate change on agriculture Adaptation is not only for the impact response, but it may be to maximize utility as well (Aslamat el.,2018).

Farmers' perception of climate change and variability

From 138 of the total interviewed farm household heads of *Wayou Woreda,* the majority of the respondents 123 (89.1%) perceived local climate was changed. Out of those who perceived 123 respondents, 57(47.3%) were illiterate and 66(53.7%) literate. The chi-square test value showed that there was a statistically significant relationship between education and climate change perception ($p<0.1$). Generally, literate and illiterate farmers of the study *Woreda* have significant differences in perceiving the change in climate.

Farmers' perception of long term temperature change

From the interviewed household heads, 123 (89.1%) perceived long term change in temperature in *Wayou Woreda* in the past 30 years. The remaining 15(10.9%) did not perceive long term change in temperature. With regarding to the perception of the farmers to patterns of temperature majority 117(84.8%) of the farm household heads observed increase in temperature in the past 30 years. Generally, the majority of the respondents perceived change in temperature and expressed in terms of increasing and decrease temperature 126 (91.3%) of the respondents perceived frequent occurrence of drought in the past 30 years.

Table 12: Farmers' perception of long term change in temperature over the last 30 years

Climate parameters	Option	Frequency	Percent (%)	Chi-square
Temperature	Increase	117	84.8	3.091 p(.139) df=1
	Decrease	9	6.5	
	No change	7	5.1	
	Unsure	5	3.6	
Frequent occurrence of drought	Increase	104	75.4	4.262 p(0.235) df=3
	Decrease	28	20.3	
	No change	5	3.6	
	Unsure	1	.7	

Source: own survey data, 2020

Farmers' perception of long term precipitation

Concerning to the long term change in the amount and distribution patterns of rainfall in the last 30 years in *Basona Woreda*; 133 (96.3%) respondents perceived the change it has either increase decrease. From the perceived respondents 120(87.0%), 118(85.5%), 122(88.4%) were observed decrease in rainfall amount, length of Kiremt and length of Belg respectively in the study *Woreda*. From qualitative survey *"The Woreda was characterized by Kiremt and Belg rainfall distribution. But now days the rainfall patterns changed and the amount of rainfall also reduced. Kiremt start late almost middle of July and offset middle of August. Its volume also decreased from time to time with high variability. The Belg season also became uncertain, and we cannot be sure regarding the time and the amount of rainfall."*

Table 13: Farmers' perception of rainfall patterns Wayou *Kebele* of the household heads

Climate parameters	Option	Frequency	Percent (%)	Chi-square
Precipitation	Increase	13	9.4	1.416 df=3 P(.811)
	Decrease	120	87.0	
	No change	4	2.9	
	Unsure	1	.7	
Length of kiremt	Increase	13	9.4	1.290 df=3 p(.744)
	Decrease	118	85.5	
	No change	5	3.6	
	Unsure	2	1.4	
Length of Belg	Increase	9	6.5	3.333 df=3 P(.280)
	Decrease	122	88.4	
	No change	4	2.9	
	Unsure	3	2.2	

Source: own survey, 2020

Farmers' perception of the causes of climate change and variability

Farmers' perceived causes to change and variation in climate of the earth 66.9% of total perceived the combination both man-made and super-natural forces are the cause for the change. 15.25% and 12.34 % respondents perceived the cause is only natural cause, and only man-made cause respectively. The remains 5.52% of the respondents are they did not know the cause of the climate change and variability key informants of the *Wayou Kebele* of listed activities like deforestation, limiting knowledge on how to use natural resources, land degradation and soil erosion, frequent agricultural flow without rest, over-population and other related issues as the man made cause to climate change and variability.

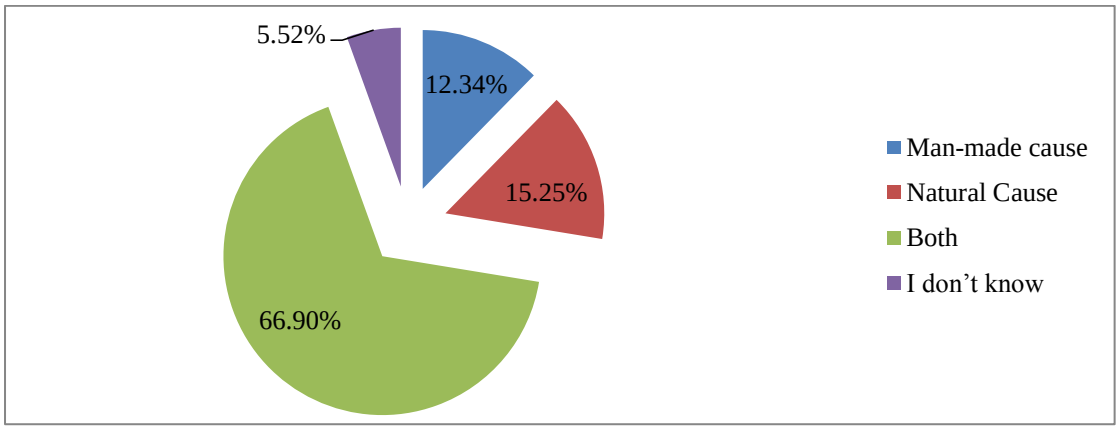

Figure 21: Perceived cause of climate change and variability,
Source: own survey data, 2020

Frequent occurrences of climate hazards in the last 30 years

Based on the survey data 2020, 91.3 % of household heads of the respondents were experienced Unusual climate extreme events over the last 30 years regarding drought occurrence, above half of the farm household head 78 (73.6%) from 126 (household heads experienced climate related hazards in the last 30 years) household heads faced from 1-3 times in the past 30 years. 63 (67%) and 29(30.9%) of the respondents experienced flood from 1-3 and 4-6 times in the last 30 years regarding famine 76(74.51%) of the respondents experienced from 1-3 times in the last 30 years 56(57.73%) and 30(30.92%) of respondents experienced 1-3 times and 4-6 times snow/intensive rainfall respectively. 96(76.19%) of from the interviewed household heads experienced land slide from 1-3 times in the last 30 years. Regarding crop production failure in the study *Woreda,* 65 (73.03%) of the respondents faced from 1-3 times in the last 30 years. 17 (19.1%) of the respondents faced from 4-6 times in the last 30 years in the study *Woreda*.

Table 14: Frequent occurrence of climate hazards by household heads' Wayou *Kebele*

Climate extreme events/hazards	**Low (1-3 times) F (%)**	**Medium (4-6 times) F (%)**	**High (7-9 times) F (%)**	**Very high (10 times & Above) F (%)**	**Total F (%)**	**Chi square**
Drought N=106	78 (73.6)	21(19.8)	6(5.7)	1(0.9)	106 (100)	18.125 df=8 P(.020**)
Flood N=94	63 (67)	29(30.9)	2(2.1)	0(0)	94(100)	6.369 df=6 P(.383)
Famine N=102	76 (74.51)	15(14.71)	8(7.84)	3(2.94)	102 (100)	21.676 df=8 P(.006***)
Intensive heavy N=97	56 (57.73)	30(30.92)	8 (8.25)	3 (3.1)	97(100)	8.154 df=8 p(.419)
Land slide N=100	96 (76.19)	23(18.21)	6 (4.8)	1 (.8)	126 (100)	7.744 df=8 p(.459)
Crop failures N=89	65 (73.03)	17 (19.1)	3 (3.37)	4 (4.5)	89 (100)	36.387 df=8 P(000***)

*Source: own survey data, 2020, **, ***significant at 1%, and 5% respectively*

Farmers' sources of information to climate change and variability

In a developing country like Ethiopia's access to information is not well developed, especially in the remote areas. From the total interviewed 138 household heads, 112 (81.2%) has access to information related to climate change and variability (climate information), while 18.8% have not. The chi-square indicated that there is a statistical significant difference in access to climate information across the adopters and non-adopters ($p < 0.1$) From the 112 household heads who have access to climate information 26 household heads could not decide regarding to their sources of information. From the 112 household heads decided their sources of information, 83(60.1%), 20(14.5%), their source of information was from friends and neighbors and extension workers, media/radio 9(8.0%) acquired climate information from radio, television and extension workers respectively. In general, farmers of *Wayou Kebeles* have different accessibility of climate related information and their sources of information were non-electronic sources.

Table 15: Access to information on climate change and variability

Variable	Information access on climate change		Total	Chi2
	Yes	No		
Adopters	74	13	87	2.339 df=0 P(.097**)
	85.1%	14.9%	100.0%	
Non- adopters	38	13	51	
	74.5%	25.5%	100.0%	
Total	112	26	138	
	81.2%	18.8%	100.0%	

*Source: own survey data, 2020, ** Significant at 5%*

Farmers Adaptation strategies to climate change and variability

Copy Mechanisms of *Basona Werana Woreda Wayou kebele* farmers to climate shocks

Copy mechanisms are short term responses to climate impact when the farm households shocked by climate extremes like drought, flood, crop failures, and soil erosion and others. Copy mechanisms are a short term and either planned or spontaneous response to climate shocks. As the study *Kebele* is vulnerable to drought and erratic rainfall Farmers of *Wayou kebele* adapted a wide response's measure to climate shocks either in a planned / organized or spontaneous response the most common copy mechanisms in the study *Kebele* were, reducing the consumption level 92 respondents, selling livestock and other personal assets 101 respondents, food aid/relief or government assistants 81 of respondents, migration to search daily labor 84 respondents, borrowed/loans from government, and relative friends and neighboring 82 respondents, and 55 of respondents by other copy mechanisms out of the above listed such as like selling forest product (charcoal and wood), either at community level, or individual level were the major coping mechanisms applied by farmers of *Wayou Kebele*.

Table 16: Food coping mechanisms of Basona Werana *Woreda* farmers

Cope mechanisms adopted by Basona Werana *Woreda Wayou kebele* farmers	Frequency	Percent
Reducing of consumption amount	92	66.7
Selling livestock and other assets	101	73.2
Food aid/relief/government assistance	81	58.7
Daily labor/migration to search employment	84	60.9
Loans (government, friends and nearby)	82	59.4
Others (crop insurance, grain storage, selling forest Product...)	55	39.8

Source: own survey, 2020

4.8. Model diagnosis test results

The study was conducted Multicollinearity, normality, homoscedasticity (homogeneity of variance) and VIF test were conducted. The explanatory variables were analysis and check for multicollinearity between the dependent variable to identify determining factors that has effect on climate change adoption options. The result shows chi^2 (12) =186.57 Prob > chi^2 = 0.0000 this signifies that the model is found to be to carry out the regression analysis VIF result show that there was no multicollinearity between explanatory and dependent variables was tested using variance inflation factor (VIF (1.33)) identified the model specification error occur when the relevant variables are omitted from the model. Accordingly, the result revealed that there is no problem of multicollinearity observed. All the statistics in the table above indicates that there less problem multicollinearity in the independent variables. According to SPSS user manual when several Eigen values are close to zero the variables are highly inter-correlated and small changes in the data values may lead to large changes in the estimates of the coefficients. Also according to SPSS user manual when condition index greater than 15 indicates a possible problem and an index greater than 30 suggest a serious problem with co linearity. With this perspective only variables (Fertilizer applied, Market access nearby, Credit Service obtained, frequency of flood, frequency of famine) are somewhat interrelated and all the rest have less problem of multicollinearity. Besides, many of the variables have condition index less than 15 indicating that the relationships among these variables is insignificant. Tolerance (1- R^2) and VIF (Variance Inflation Factor = reciprocal of tolerance) are another multicollinearity statistics which are used to determine how much the independent variables are related to one another (multi-collinear). According to SPSS Manual, a variable with low tolerance (large VIF) contributes little information to a model. Most of the variables have large tolerance values which are close to 1 indicating that there is little multicollinearity among the independent variables in the model and thus they have significant contribution to the model (see appendix 8).

Normality test

The normality of each of the variables was tested using the ***P-P plot*** and basic statistics of its derivatives is given in Table.(17) The observed points are more or less aligned to the diagonal line indicating that the distribution of scores in the logistic model of customer preference against brand the independent variables is close to normal. Some of variables (Age, family size of household, number of livestock, total cultivated land size, soil and water conservation, irrigation use of household, new Crop variety use Household Head, agro-forestry practices, livelihood

source diversification, fertilizer applied no. of oxen, farm-size) are neutrally positively skewed and these variables were transformed to normal distribution by applying non-equal classification. To numerically test whether or not each of the variables in the model is normal or not Kolmogorov-*Siminirov and Shapiro-Wilk* ***tests*** of normality were applied.

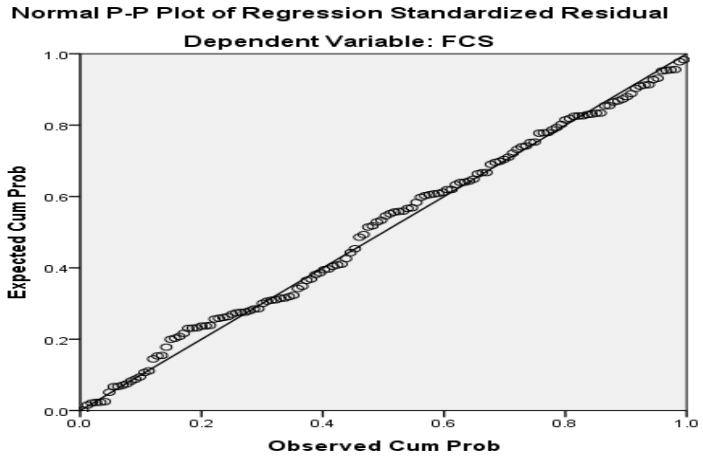

Figure 22: Normality test

Table 17: Test of normality

Variables	**Kolmogorov-Smirnov test**			**Shapiro-Wilk test**		
	Statistic	df	Sig.	Statistic	df	Sig.
X_1: Age of the household head	.071	138	.083*	.979	138	.031*
X_2: Family Household size	.160	138	.000***	.955	138	.000***
X_3: Total Livestock Unit per household	.192	138	.000***	.871	138	.000***
X_4: Soil and water conservation used Household	.352	138	.000***	.636	138	.000***
X_5: Irrigation used Household headed	.415	138	.000***	.605	138	.000***
X_6: New Crop variety use Household Head	.473	138	.000***	.529	138	.000***
X_7: Agro-forestry practices	.479	138	.000***	.515	138	.000***
X_8: Livelihood source diversification	.389	138	.000***	.623	138	.000***
X_9: Fertilizer applied	.476	138	.000***	.522	138	.000***

4.9. Adaptation strategies of *Basona Werana Woreda Wayou Kebele* Farmers of Long Term Change in Temperature and Rainfall and food security status of respondents

Based on the data collected from the farm households of *Basona Werana Woreda, Wayou Kebele* this sub-topic investigated whether farm households made some adjustments in their farming practices in response to the long term changes in temperature and rainfall variability by adapting some particular strategies. Adaptation is well-planned and applied for long term response climate change and induced shock. Climate change accounts for a significant reduction in renewable surface water and ground water storage in most dry regions. Climate variability in relation to water scarcity results in serious environmental and social consequences that not only threaten agricultural production. To cope with these risks, farmers decided to perform their adaptation response by adjusting or adapting their farming practices. More specifically, adaptation is pressing to reduce the vulnerability to the adverse impacts of climate change, maintain the rural livelihood of poor communities, and ensure food security.

Table 18: Farmers Adaptation strategies adopters and non-adopters and food security status

Climate change adaptation measure		**Food Consumption Score (%)**			**Total**	**Chi-square**	**P-value**
		Acceptable	**Borderline**	**Poor**			
Soil and water conservation	Adopters	38 (80.9)	31 (54.4)	3 (8.8)	72 (52.2)	41.208	.000***
	Non-adopters	9 (19.1)	26 (45.6)	31 (91.2)	66 (47.8)		
Irrigation	Adopters	40 (85.1)	41 (71.9)	8 (23.5)	89 (64.5)	35.012	.000***
	Non-adopters	7 (14.9)	16 (28.1)	26 (76.5)	49 (35.5)		
Different crop varieties	Adopters	44 (93.6)	45 (78.9)	16 (47.1)	105 (76.1)	23.941	.000***
	Non-adopters	3 (6.4)	12 (21.1)	18 (52.9)	33 (23.9)		
Agro-forestry	Adopters	16 (34.0)	10 (17.5)	5 (14.7)	31 (22.5)	5.585	.061**
	Non-adopters	31 (66.0)	47 (82.5)	29 (85.3)	107 (77.5)		
Livelihood diversification	Adopters	37 (78.7)	35 (61.4)	10 (29.4)	82 (59.4)	20.054	.000***

	Non-adopters	10 (21.3)	22 (38.6)	24 (70.6)	56 (40.6)		
Appling fertilizer	Adopters	45 (95.7)	42 (73.7)	19 (55.9)	106 (76.8)	18.134	.000***
	Non-adopters	2 (4.3)	15 (26.8)	15 (44.1)	32 (23.2)		

*Source: own survey data, 2020, **, ***significant at 1%, and 5% respectively*

Farmers Adaptation strategies by *Basona Werana Woreda Wayou Kebele*

SWC is the biological (Mulching, Area closure, strip cropping and crop rotation) and physical (contour and check dam) measures to counter balance the effect of soil erosion. SWC practice is not a new concept either formally and informally farmers use to protect their farmland from floods. It is not only to preserve the soil but also to maintain the land productive capacity. According to key informants of the study *Woreda* SWC is the key and base of all adaptation strategies.

Accelerating soil erosion and decline soil fertility was the major challenges of agricultural production in the *Wayou kebele*. They adopted SWC to solve soil erosion and decline in land fertility, and to recover the depletion natural/ land resources. The chi-square has statistical significant difference practicing of SWC across the adopters and non-adopters of climate change adaptation strategies ($p<0.000$) there is significant relation between those how were using soil and water conservation and food security status of sample household than those how are not using.

In key informant interview *Basona Werena* administrator asked an informal question what is the reason farmer of the *kebel*e practiced SWC at the communal land and what is the major problem to on climate change adaption? He answered *"The kebele was vulnerable to climate hazard like floods, decline land fertility, deforestation, erratic rainfall, frequent drought, land degradation, and other climate related hazards. For this reason the farmers presented in the communal land every day is to check which or where part of the kebele is affected by the hazard and always ready to give a response to the hazard. The major adaption problem on the kebele is the cost of climate change adaption the technologies have high cost as the woreda budget is one of the problem most of the budget is applying for food aid there is sever climate change hazard in the kebele due there is frequent crop failure in the kebele so more budget need to address household*

food security the food security didn't give us time so we apply the budget more for food aid that is the major problem."

Irrigation

Irrigation means it is a process that supplying artificial water to the dry land during a dry season. It is used to assist in growing agricultural crop during a dry season. Its economic role is also important at the individual and national level. The water that is used for irrigation may be able to come from nearby rivers, underground water, and storage pond that depend upon the water availability in the surrounding environment. From 138 sample household farmers 89(64.5%) and 49(35.5) of respondents were user and nonuser of irrigation respectively. out of 89 irrigation users were there 40(85.1%) respondents their food consumption score were acceptable category on the other hand sample household those how were not users of irrigation out of 49 (35.5%) them 26 (76.5%) of respondent their food consumption score were fall on poor food consumption score category. The chi-square indicated there is statistically significant difference in adoption of irrigation across food security status of respondents ($p<0.000$). Generally, irrigation applies make difference in food secure and insecure households.

Diversification of New Crop Varieties

Crop diversification is not a new concept/phenomenon for subsistence small holder farmers of Ethiopian even did not support by policy and technology option. Crop diversification is a wider choice for the production of a variety of crops in a given area to expand production related activities on various crops and also a lesson to risk. According to the agricultural experts of the study *Woreda*, crop diversification does not focus on numbers of crops applied by a given farmer in a given area and year rather it is, a shift from low value to high value crop, emphasized on drought resilience and focusing on climate resilience and high yield crops. Regarding to diversification of new crop variety, 105(76.1%) respondents from 138 sample households adapted with significant difference between food secure households and food insecure households ($p <0.000$) This implies farmers of household food security status affect by diversified new crop varieties differently. According to data collected from key informants, Tomato and Pepper from vegetables and Sorghum, Wheat, Maize, Teff, and Barley from cereals was the most common produced/adopted by farmers in *Wayou kebele* during normal rainfall during a shortage of rainfall whereas, farmers of *Wayou*, predominantly adopter from bean Pulses, Onion and Tomato from vegetable and produced by irrigation during normal rainfall.

Diversification of Sources of Livelihood

Shifting sources of livelihood from climate sensitive sectors to less climates sensitive sector is one way to adapt the change in long term in temperature and rainfall one of the solution to tackle climate change impact on food insecurity is livelihood diversification. From the 138 sample households 82 (59.4%) farmers diversified their sources of livelihood with statistically significant differences between food secure and food insecure sample households ($p < 0.000$). Diversification of livelihood may be on-farm or off-farm activities. *Wayou* farmers diversified their source of livelihood in both on-farm and off-farm activities as a source of income generation. From 138 sample household heads, 82(59.4%) farmers participate in off-farm activities while 56(40.6%) were not participating in off-farm activities. The chi-square value did show a statistical significant difference off-farm activity between food secure and food insecure at ($p<0.000$).

Agro-forestry

Agro-forestry/on-farm conservation concerning to agro-forestry, from 138 sample households 31(22.5%) of respondents were adopted. From the 31 adopter of agro-forestry, 16 farmers were there food consumption score were acceptable farmers how are not adopt agro-forestry 107 (77.5%) majority of sample household there food consumption score categorized under borderline and poor food consumption score 47(82.5%) and 29(85.3%) respectively. The chi-square value indicated agro-forestry conservation has a statistically significant different across food secure and food insecure household at the ($p < 0.000$).

Fertilizer application

Concerning fertilizer application of farmers of *Wayou Kebele*, 106 (76.8%) out of the total sample farmers was adapters with statistically significant differences across food secure and food insecure sample households ($p <0.000$). Out of the adapters of fertilizers 45 (95.7%) was food secure their food consumption score acceptable categories and from those how are not apply fertilizer 32(23.2%) of them 15(44.1%) their food consumption score were categorized on poor food consumption score. According to the *Woreda* agricultural office DAP distribution showed an increasing rate 1175.5 quintal per year and UREA 579.12 quintal per year in the last 10 years. The sums of both DAP and UREA showed an increasing rate 1754.6 quintal per year in the last 10 years. Farmers of the study *Woreda* were users of both organic and inorganic fertilizers. 70(66.04%) of the responding farmers were users of Dap, Urea, compost and manure; whereas

36(33.96%) of farmers were users of all the above listed except compost to enhancing their agricultural product by using organic and inorganic fertilizers.

4.10. Determinants of household's food security status

On this section the main part of the discussion is the competing factor explain here is analysis of contribution of climate change adaption strategies on household food security status. Ordered logistic regression due to the dependent variable the estimated results of the model of the maximum likelihood of the result and the marginal effects are analyzed. On food consumption score analysis a total of 12 explanatory variables were used to compute the econometric model in order to identify determinate factor that were contribution on food consumption of the sample household the result show that food consumption score is affect by cultivated land hectare increase food consumption score increase that means their significant difference in the three categories of food consumption score the contribution were positive and significant at ($p<0.1$) level of significant. The result also indicate that a with a history of increases crop failure were odds of 0.60 times more likely decease food consumption score among sample households the significant at ($p<0.01$) level of significant. As well as household food consumption score were determine by use of climate change adaption measure. Sample households that were used soil and water conservation odds of 3.25 times more likely to have better food consumption score comparing those how are not using at significant ($p<0.05$) level of significant. Similar to this sample household were used small scale irrigation odds of 3.00 times more likely improved food consumption score than those not using small scale irrigation the significant at ($p<0.05$) level of significant marginal effect indicate that those farmers households not practice small scale irrigation their household food security status were negatively affected. The result further shown that sample household who were more active in agro- forestry in their land and beyond odds of 2.4 times more likely increase their food consumption score than not much active sample household the significant at ($p<0.1$) level of significant and diversification of new crop variety significantly influence sample household food security status those how were diversifying new crop varieties odds of 3.03 times more like to household food security status than those how were not diversified new crop at significant of ($p<0.05$) significant level. Addition to this the measured result show sample households they were diversified their livelihood odds of 3.06 times more like to have acceptable level of household food consumption score comparing with those how were not diversified their livelihood the significant at ($p<0.05$) level of significant.

Table 19: Ordinal logistic regression of household's food consumption score

FCS	Odds Ratio	Marginal effect dy/dx	Std. Err	z	P>|z|
SEX	.9264545	.0132362	.4898444	-0.14	0.885
AGEHH	.9868767	.0022889	.0151842	-0.86	0.391
FAMSIZ	1.012492	-.002151	.108616	0.12	0.908
NLIVESTO	.9361454	.0114332	.0604283	-1.02	0.307
CULAND	.6057197	.0868671	.1625856	-1.87	0.062**
CROPFAI0	.6099925	.0856491	.0727549	-4.14	0.000***
SWC	3.25961	-.2047377	1.608966	2.39	0.017**
IRRIGATI	3.007288	-.1907775	1.354172	2.45	0.014**
DIFFCROP	3.038033	-.1925399	1.532456	2.20	0.028**
AGRO	2.464026	-.1562547	1.16427	1.91	0.056**
LIVELIHO	3.061773	-.1938886	1.357554	2.52	0.012**
FERTILIZ	1.69722	-.0916586	.8402726	1.07	0.285
cut1	4.538259	1.865815			
cut2	7.673522	1.978119			

*y = Pr (FCS==1) (predict) = .22299906 Notes: **, ***, show significance level*
Source: Computed from own survey (2020)

4.11. Determinants of Climate change adoption

Factors affecting decision of climate change adoption option

Since the values of Climate change adoption falls in between 0 and 1, Tobit model has been used. The estimated results of the model of the maximum likelihood shown below a total of 12 explanatory variables were used to compute the econometric model in order to identify factors that determine household's food security status and climate change adoption option participation level computed. The study also tried to assess factors related to climate change adaption strategies to improve household food security. Based on the result presented below, households climate change adoption option status were negatively affected by extension worker visit, market access, frequency of drought at 5% , 5% and 1% significant level respectively. It was positively influenced by sex of household head, family size, adaption related training, credit, flood and household food security status at 10%, 1%, 1%, 1%, 1% and 1% significant level respectively.

Table 20: Estimated result using Tobit model

Variable	Coef.	Std. Err	t	P-value
SEX	.1873944	.1110758	1.69	0.094**
AGEHH	.0038536	.0034744	1.11	0.269
FAMSIZ	.1089978	.0266019	4.10	0.000***
LIVESTOC	.0841468	.1738468	0.48	0.629
EXTSERV	-.9372407	.3093225	-3.03	0.003***
TRAINING	.8003806	.108209	7.40	0.000***
MARACC	-.194229	.1081717	-1.80	0.075**
CREDIT	.477214	.1180542	4.04	0.000***
EFFECTCC	.3036796	.0799906	3.80	0.000***
EVENTS	-.0806514	.0389864	-2.07	0.041**
FLOODC	.080059	.0294985	2.71	0.008***
HFIAS	.4052512	.0766013	5.29	0.000***

Number of obs =138, LR chi2 (12) = 186.57, Pseudo R = 0.7145 Prob> chi2 =0.0000, Log likelihood = -37.275025, Obs. summary: 87 left-censored observations at ADAPUSED<=1
51 uncensored observations 0 right-censored observations
*Note: ***, **, show significance at p<0.01 and p<0.05 respectively*
Source: Computed from own survey (2020)

Sex of the household head - sex of the household head expected to have either negative or positive significant correlation with agricultural adaptation technology as a response to climate change. Male-headed households are more ready to adapt climate change than female headed (Temesgen Deresssa et al., 2008). Study conducted in 11 African countries, indicated that male headed households are more probably adapters of climate change than female-headed households (Hassen and Nhemachena, 2008). The result of this study indicated that male-headed households and female household head were statically significant ($p<0.1$) male household head increase the probability of using, climate adaptation measure than female head household heads. On the other hand male headed households, decrease the probability of a diversified way of livelihood compared to female headed households, holding other variables constant. Female-headed households are more participants in charcoal, petty trade rearing activities than male households.

Family size of the household – according to the result of the study, family size has positive correlation climate change adoption with irrigation, diversification of new crop variety, livelihood diversification and SWC.

Age of the household head - is one of the insignificant explanatory variable. But the mean age of respondents of adopter is lesser than non- adopter age not significant in tobit model in chi square result indicate that adopter mean age have significant effect on adopted and easily to be familiar to new technology than old age group the current finding is differ from similar study done by Temesgen Deressa et al. (2008), and Hassen and Nhemachena (2008) idea that the more experienced old age farmers are more probably adaptor of climate change and variability than farmers less experienced age group.

Distance of the market from the nearest to the household head– market distances expected to have a significant and negative effect with agricultural adaptation technology as a response to climate change. Farmers far away from the market access are challenged to get easily agricultural input and to sell agricultural output. The result of the model did show a significant level at ($p<0.05$) relation of market distance with either of the adaptation options. Similarly study done on linking vulnerability, adaptation and food Security in a changing climate: evidence from Muger Sub-Basin of the Upper Blue-Nile Basin of Ethiopia noted that adoption of different technologies is thriving in areas with developed rural infrastructure and markets, and also where commercial agriculture prevails. As hypothesized, distance from the home of a household to the main market is found to have a significant ($p< 0.05$) negative impact on the likelihood of choosing different agronomic practices. A unit increase in walking hour from the home of a household to the main market would decrease the likelihood of using agronomic practice/s by 3.9% (Abayineh and Belay, 2017).

Access to extension advisory services of the household head from extension agriculture workers - is one of the significant explanatory variable and farm household heads have access to extension advisory services from agricultural extension experts have a positive significant relation with climate change adaptation. The result of the model indicated farmers have not access to extension advisory services; the probability of using adaptation is affected and decrease ($p< 0.01$) compared with to farmers could have access. Farmers have best access to institutional support (access to extension advisory services) have better opportunity to get information on climate change conditions. This in line with the study conducted by Negash Mulatu (2011) in

North Shewa that farmers have access to the extension services better adapter than could not have.

Access to agricultural and non-agricultural credit services of the household head - is one of the significant explanatory variables access to farm and off-farm credit is expected to have a significant positive with climate change adaptation. Access to farm and off-farm credit has a significant positive with climate change adoption option. Credit for livelihood diversification adoption of agro-forestry to improve cash crop production farmers have access credit services, the probability of diversifying the way of livelihood and agro-forestry increase as compared with farm households have no access to credit services, holding other things constant. This result is in line with Abid,et al., (2015) and Temessgen Deressa et al., (2008).

Based on the current result of this study the study reject the null hypothesis and conclude that the alternative hypothesis is true at 95% confidence interval because the alternative hypothesis stated that household food security status will be better or improved for those farmers how were using climate change adaptive measure comparing with those how were not using adaptive measure. The current study prove this sample household engaged with climate change adoption measure their food consumption score and household food security status were improve than comparing with non-adopter of climate change adaption measure.

Then the null hypothesis is rejected because the null hypothesis state that household food security status will be no difference between farmers how are using adaptive measure and farmers how are not using adaptive measure. However the study revealed that there was a significant difference with those farmers how was engaged with climate change adoption and not in other word there was a statistical significant difference within adopter and non-adopters household food security status of sample households.

5. Conclusion and recommendation

In conclusion the study revealed that climate change adoption strategies have direct contribution on household food security status of respondents. The majority of respondents, who adopt climate change adaptation, option their household food security status, exceed comparing with non-adopters. The farmers perceived that climate change in their *Woreda* this accordance with the satellite climate data results. Temperature and drought severity in *Wordea* showed there is a change; maximum temperature change is statistically significant.

Various adaptation measure take on by farm household of *Basona Werena Woreda Wayou kebele*. SWC, irrigation, diversification of new crop variety, livelihood diversification, agro forestry, and applying fertilizers identified as the major adaptation option in the study *kebele*. Farmers of the *kebele* faced various constraints when they are making effort to adapt the long term temperature and rainfall variability and change these constraints also influence their household food security status of the respondents.

Recommendation

Based on the findings and results of the study, the following recommendation forwarded to improve farmers of *Basona Werena Woreda Wayou Kebele* adaptation to climate change and variability for enhancing household food security status.

- Institutional service improvement should be implemented to Providing information regarding a seasonal, daily, and monthly weather condition to farmers spent the whole time in agricultural practices, especially in irrigation through template, special individual contacts, and other possible alternatives training.
- Gender equity should consider female head households should get institution service, credit access as male head household.
- In order to easily adapt climate change and variability, farmers should have accessibility of agricultural inputs such as water technology (water pump), improved seeds, and access to credit, to minimize the effect on household food insecurity status of the respondents.

- The barriers of adaptation indicate institutional, environmental, and economic constraints. So, regarding to the institutional problems, the *Woreda* administrators should give attention is worth effect with farmer-center participation to bring impact on household food security status.
- Agricultural extension workers shall encourage farmers on diversification of new crop variety to the Topographic feature of the *kebele* is higher slope area and expose for soil erosion if they Agricultural extension workers focus on drought resistance crop, cash crops, fruit and vegetable they can address the climate change adaptation option like livelihood diversification this directly connect to household food security status.
- One of the factors that determine climate change adaptation and household food security is family size. Family size have a positive effect on climate change adaptation in terms of labor availability this positive effect had another face family size have negative effect for household food security so then to sustainable household food security status family planning should apply if not family planning consider as nation level this become a significant problem every year population density continue increasing. Sustainable food security is a multi-dimensional. Agricultural extension worker and health extension worker should coming together for sustainable change of negative effect of household food insecurity because the human labor can be replace with technology outcomes and handle than human labor.
- For academic Researchers on the current studies only six major adaptation strategies in the study area assessed because of different limitations. However, further assessment should be taken from the remains indigenous and modern adaptation strategies are advisable and
- New crop variety those are suitable for topographic and biophysical textures need further investigation for successful implementation.
- Related to gender issue to bring equity between female head household and male households in term of service access future study need to empower women head household and to identify factor affecting women head household identification can help for better outcome to address the gap between female head households.

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Appendixes

Appendix 1: Variable and description

Name of variables	Description
AGEHH	Age of the household head
SEX	Sex of the household head
FAMSIZ	Family size of household
LIVESTOC	Having Livestock Unit
EXTSERV	Extension service
TRAINING	Training service
MARACC	Market distance
CREDIT	Credit use
EEFECTCC	Effect of climate change on Livelihood
EVENTS	Frequency of climate change events
FLOOD	Flood due to extreme climate change effect
CROPFAIO	Crop failure
SWC	Soil and water conservation
IRRIGATION	Use of small scale irrigation
DIFFCROP	Diversification of New Crop Varieties
AGRO	Agro-forestry
LIVELIHO	Diversification of Sources of Livelihood
FERTILIZ	Fertilizer application

Appendix 2: Likelihood ration of level of food Consumption score for ordered logistic regression model

```
. ologit FCS SEX AGEHH FAMSIZ NLIVESTO CULAND CROPFAI0 SWC  IRRIGATI DIFFCROP AGRO  LIVELIHO FERTILIZ, or

Iteration 0:   log likelihood = -148.65389
Iteration 1:   log likelihood = -102.03171
Iteration 2:   log likelihood =  -99.86088
Iteration 3:   log likelihood =  -99.84145
Iteration 4:   log likelihood = -99.841449

Ordered logistic regression                     Number of obs   =        138
                                                LR chi2(12)     =      97.62
                                                Prob > chi2     =     0.0000
Log likelihood = -99.841449                     Pseudo R2       =     0.3284
```

FCS	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	.9264545	.4898444	-0.14	0.885	.3286762	2.611439
AGEHH	.9868767	.0151842	-0.86	0.391	.9575605	1.01709
FAMSIZ	1.012492	.108616	0.12	0.908	.820499	1.24941
NLIVESTO	.9361454	.0604283	-1.02	0.307	.8248941	1.062401
CULAND	.6057197	.1625856	-1.87	0.062	.3579271	1.025059
CROPFAI0	.6099925	.0727549	-4.14	0.000	.4828365	.7706352
SWC	3.25961	1.608966	2.39	0.017	1.238816	8.576785
IRRIGATI	3.007288	1.354172	2.45	0.014	1.244176	7.268893
DIFFCROP	3.038033	1.532456	2.20	0.028	1.130385	8.165047
AGRO	2.464026	1.16427	1.91	0.056	.975992	6.220771
LIVELIHO	3.061773	1.357554	2.52	0.012	1.283986	7.301054
FERTILIZ	1.69722	.8402726	1.07	0.285	.6431596	4.478757
/cut1	4.538259	1.865815			.8813277	8.19519
/cut2	7.673522	1.978119			3.796481	11.55056

Appendix 3: Multicollinearity of level of food insecurity experience score for ordered logistic regression model

```
. estat vif
```

Variable	VIF	1/VIF
SWC	1.87	0.533395
IRRIGATI	1.47	0.681198
FERTILIZ	1.42	0.705549
DIFFCROP	1.38	0.722497
LIVELIHO	1.35	0.742282
CULAND	1.32	0.756401
SEX	1.27	0.788026
NLIVESTO	1.24	0.803707
AGEHH	1.21	0.829394
CROPFAI0	1.17	0.853230
FAMSIZ	1.10	0.909155
AGRO	1.05	0.956648
Mean VIF	1.32	

Appendix 4: Regression estimation result of food insecurity experience score (marginal effect)

```
. mfx

Marginal effects after ologit
      y  = Pr(FCS==1) (predict)
         =  .22299906
```

variable	dy/dx	Std. Err.	z	P>|z|	[	95% C.I.	]	X
SEX	.0132362	.09166	0.14	0.885	-.166414	.192887		1.2029
AGEHH	.0022889	.00268	0.85	0.393	-.002963	.007541		49.7899
FAMSIZ	-.002151	.01856	-0.12	0.908	-.03853	.034228		5.7971
NLIVESTO	.0114332	.01127	1.01	0.310	-.010655	.033521		3.94928
CULAND	.0868671	.04768	1.82	0.068	-.006592	.180327		.73913
CROPFAI0	.0856491	.02308	3.71	0.000	.040411	.130887		2.67391
SWC	-.2047377	.08581	-2.39	0.017	-.372923	-.036552		1.47826
IRRIGATI	-.1907775	.07842	-2.43	0.015	-.344472	-.037083		1.35507
DIFFCROP	-.1925399	.08761	-2.20	0.028	-.364252	-.020828		1.23913
AGRO	-.1562547	.0836	-1.87	0.062	-.320115	.007606		1.77536
LIVELIHO	-.1938886	.07711	-2.51	0.012	-.345025	-.042752		1.38406
FERTILIZ	-.0916586	.08607	-1.06	0.287	-.260356	.077039		1.23188

Appendix 5: Likelihood ration of climate change adaption for Tobit regression model

```
. tobit ADAPUSED SEX AGEHH FAMSIZ LIVESTOC EXTSERV TRAINING MARACC CREDIT EFFECTCC EVENTS FLOODC HFIAS, ll

Tobit regression                                  Number of obs   =        138
                                                  LR chi2(12)     =     186.57
                                                  Prob > chi2     =     0.0000
Log likelihood = -37.275025                       Pseudo R2       =     0.7145
```

ADAPUSED	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
SEX	.1873944	.1110758	1.69	0.094	-.0324214	.4072102
AGEHH	.0038536	.0034744	1.11	0.269	-.0030222	.0107294
FAMSIZ	.1089978	.0266019	4.10	0.000	.0563535	.1616422
LIVESTOC	.0841468	.1738468	0.48	0.629	-.259891	.4281845
EXTSERV	-.9372407	.3093225	-3.03	0.003	-1.549381	-.3251006
TRAINING	.8003806	.108209	7.40	0.000	.5862382	1.014523
MARACC	-.194229	.1081717	-1.80	0.075	-.4082976	.0198397
CREDIT	.477214	.1180542	4.04	0.000	.2435882	.7108398
EFFECTCC	.3036796	.0799906	3.80	0.000	.1453805	.4619786
EVENTS	-.0806514	.0389864	-2.07	0.041	-.1578043	-.0034985
FLOODC	.080059	.0294985	2.71	0.008	.0216823	.1384358
HFIAS	.4052512	.0766013	5.29	0.000	.2536594	.556843
_cons	-1.632362	.5045802	-3.24	0.002	-2.630911	-.6338126
/sigma	.3591312	.0386311			.2826813	.435581

```
  Obs. summary:         87  left-censored observations at ADAPUSED<=1
                        51     uncensored observations
                         0 right-censored observations
```

Appendix 6: Multicollinearity of climate change adaption for tobit regression model

```
. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
      CREDIT |      1.89    0.528892
    TRAINING |      1.85    0.541349
      MARACC |      1.54    0.647335
       HFIAS |      1.47    0.680869
         SEX |      1.20    0.834301
     EXTSERV |      1.19    0.842261
      EVENTS |      1.15    0.868327
      FLOODC |      1.15    0.869093
      FAMSIZ |      1.15    0.870163
    LIVESTOC |      1.15    0.873120
       AGEHH |      1.13    0.884627
    EFFECTCC |      1.10    0.907692
-------------+----------------------
    Mean VIF |      1.33

.
```

Appendix 7: Food consumption Score and weight

Food group	**Weight**
Main Staples	2
Pulses	3
Vegetables	1
Fruit	1
Meat/Fish	4
Milk	4
Sugar	0.5
oil	0.5

Source: INDDEX Project (2018)

Appendix 8: Collinearity Diagnostics

Parameters		Collinearity Statistics			
		Eigenvalue	**Condition Index**	**Tolerance**	**VIF**
	(Constant)	13.070	1.000		
X_1:	Age of the household head	.347	6.137	.791	1.264
X_2:	Family Household size	.314	6.449	.888	1.125
X_3:	Total Livestock Unit per household	.123	10.291	.741	1.349
X_4:	Soil and water conservation	.110	10.885	.607	1.648
X_5:	Have you user of irrigation?	.097	11.600	.571	1.751
X_6:	New Crop variety use Household Head	.085	12.433	.686	1.457
X_7:	Agro-forestry	.073	13.340	.924	1.083
X_8:	Livelihood source diversification	.061	14.651	.813	1.230
X_9:	Fertilizer applied	.055	15.379	.622	1.608
X_{10}:	Market access nearby	.050	16.193	.609	1.643
X_{11}:	Credit Service obtained	.010	35.598	.479	2.088
X_{12}:	Flood	.046	16.870	.870	1.150
X_{13}:	Famine	.031	20.512	.859	1.164

Appendix 9: HOUSEHOLD FOOD INSECURITY ACCESS SCALE (HFIAS)

No	Occurrence Questions	If Yes how often did this happen?		
1	In the past four weeks, have you been worried that you would not have enough food? 0 = No (skip to Q2) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often
2	In the past four weeks, is there a situation that you was not able to eat the kinds of foods you preferred because of a lack of resources? 0 = No (skip to Q3) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often
3	In the past four weeks, did you have to eat a limited variety of foods due to a lack of resources? 0 = No (skip to Q4) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often
4	In the past four weeks, did you have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? 0 = No (skip to Q5) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often
5	In the past four weeks, did you have to eat a smaller meal than you felt you needed because there was not enough food? 0 = No (skip to Q6) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often
6	In the past four weeks, did you have to eat fewer	1 = Rarely	2 = Sometimes	3 = Often

	meals in a day because there was not enough food? 0 = No (skip to Q7) 1 = Yes			
7	In the past four weeks, was there ever no food to eat of any kind because of lack of resources to get food? 0 = No (skip to Q8) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often
8	In the past four weeks, did you go to sleep at night hungry because there was not enough food? 0 = No (skip to Q9) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often
9	In the past four weeks, did you go a whole day and night without eating anything because there was not enough food? 0 = No (skip to Q10) 1 = Yes	1 = Rarely	2 = Sometimes	3 = Often

Source: FANTA, (2006)

Appendix 10: Household questionnaires

Addis Ababa University

College Of Development Studies

Center for Food security and Development studies

Questionnaire for the Respondents

Dear respondent! Good morning/ afternoon, my name Fiker Hilemelekot. Presently, I am conducting a research in order to fulfill the requirements for Master of Science (MS.c.) Degree in Food Security and Development at the center for Food security and Development Studies of the College of Development Studies, Addis Ababa University. This questionnaire is designed for data collection to undertake research entitled "climate change adaption response and its impact on household food security the case of Basona Werana Woreda Amhara region, Ethiopia" The information you provide me will be used only for academic purposes and your personal information will be also kept confidential. Accordingly, the result of the research will not have any consequence on your personality in any ways. I would further like to thank you in advance for giving me your precious time and for cooperating me to share your views and experience regarding the issues under investigation.

Dear Respondents:-

Please answer the following question sincerely and honestly Use √ in the box and circle the letter for choices given Please, give your answer for the interviewer please put their answer in the space provide for the open ended questions

Questionnaire number _____

Date of interview_____

Part one **Section one: Socio-demographic Characteristics of respondents**				
Resident	101	Resident Kebele	_____	
Sex	102	Sex of the household's head	1, Male 2,Female	
Age	103	Age of the household head	_____	
Marital Status	104	Marital status of the household head	1, single 2, married 3, divorces 4, windows 5, others (specify) _____	
Family Size	105	Family size in the Household	Male _____ Female_____ (Total)_____	
Education level	106	Education level of the household head	1.Illiterate 2.Formal education attended (Grade 1-4) 3.Formal education attended (Grade 5-8) 4.Formal education attended (Grade 9-12) 5.TVET and above	
Status	107	What is your status in your locality?	1, Model farmer 2, Ordinary farmer	
Agricultural practice	108	For how long have you been involving in agricultural practice?	_____ years	
Section Two: **Economic factors**				
Income	201	How much money you earn per year?	(ETB)_____	
Livestock	202	Do you own livestock?	1, Yes 2, No	
No. of livestock	203	If your answer for Q-202 is 'yes' Please, list livestock you own in terms of their numbers and in types?	Types / No. Oxen Goats Camel Beehive Cows Sheep Donkey Horse Hen/poultry Mule Other specify	
Cultivated land	204	Do you own cultivated land?	1, Yes 2, No	
Size of	205	If yes to Q-204, the size of cultivated land	_____ timad	

cultivated		owned by the household is		
Off- farm	206	Do you earn income from off- farm activities?	1, Yes 2, No	
Types of activities	207	Yes to Q-206, in which types of activities have you been engaged?	1, Petty trade 2, Daily labor 3, Selling fire woods 4, Hand craft 5, Remittance 6, Others (please, specify)_____	
Section three: Environmental factors				
Fertility	301	In which of the classification of land fertility your cultivated land is categorized? (The Perception of the farmer to his/her land level of fertility)	1.Infertile, 2. Medium, 3.Fertile	
Soil texture	302	Tick the type of soil texture in your farm (multiple answer is possible).	1, Sandy 2, Loam 3, Clay 4, others (please, specify) _____	
Slope of your cultivated land	304	What is the slope of your cultivated land?	1, Higher slope 2, Medium slope 3, Lower slope	
Water availability	305	Do you have water availability of for irrigation	1.Yes 2. No	
Availability of water point	306	How far is the availability of water point from your home?	1, Less than 2, 2. Km From 2-3 Km , 3, From 4-5 Km, 4. Greater than 5 Km	
Section Four: Institutional factors				
Agricultural extension	401	Do you get advisory services from agricultural extension agents?	1, Yes 2, No	
Agents visit	402	If yes to Q-401, how frequent do the extension agents visit you in 2012 E.C year?	_____.	
Time of visit	403	If yes, to Q-401 when do the extension agents' visit you? (Multiple answers are Allowed)?	1, During land preparation 2, During plantation 3, During harvesting 4, Post harvesting process 5,During input provision 6, Any time when there is technical problem 7, Other (please, specify) _____	
Training	404	Have you ever received training on the farmers' extension services?	1, Yes 2, No	

How many Times	405	If yes to Q-404, how many times have you taken training in the past five years?	_____	
Market access	406	Do you have market access which nearby?	1, Yes 2, No	
Far	407	If your answer is yes to Q-406, how far is it	_____km (For the nearest situated market to you)	
Credit service	408	Have you obtained any credit service	1, Yes 2, No	
Use the credit	409	If yes to Q-408, for what purpose do you use the credit?	_____	
Amount of Money	410	If yes to Q-408, How much birr did you have borrow in the past five year	_____	
Financial institutions	411	If yes to Q-408, from which financial institutions obtain the credit services?	1, Formal institutions 2, Friends neighboring 3, Non-formal institutions 3, others (please, specify) _____.	
Modern financial	412	Are you user of modern financial institution?	1, Yes 2, No	
	413	If your answer to Q-412 is "yes" in which financial institutions do you save your money?	1, Dedebit Micro-Finance Institutions 2, Commercial Bank of Ethiopia 3, Private bank 4, Micro-Finance Institutions 5, others (please, specify)_____	
Community association	414	Are you a member of any community association (Edir, Iqub, etc.)?	1,Yes 2, No	
kind of support	415	, if yes to Q-414, what kind of support do you get from your association?	(Please, mention)_____	
Type of associations	416	In which social associations are you a member?	1, Women Association 2, Youth Association 3, Farmers Association 4, Others (specify) _____	
Position	417	To Q-416, what is your position in the Association you are associated?	1, member 2, advisory 3, leader 4, others (please, specify)_____	
Participation	418	In which case you are participating in your local community's issue?	1 , As advisory 2, As idea deliberator 3, As receivers	
Decision	419	Who is a decision maker on farmers' related	1, Woreda expert and	

maker		issues in you kebele?				administer 2, Kebele expert and administer 3, farm community of the Kebele 4, special/model farmers 5, other (specify) __		
Section Five: Farmers' perception on climate change and variability								
Climate change	501	Do you think that the climate of the earth has changed over the past 30 years?				1, yes 2, No		
Perceive	502	Do you think that there change in Woreda climate conduction				_____		
Climate variability	503	If yes to Q-501, how do you perceive climate variability?				_____		
Local indicators	504	If Yes to Q-501, for perceiving climate change and variability what is your reason? Put your local indicators to justify your observation?				1,_____ 2,_____ 3,_____ 4,_____ 5,_____ 6,_____		
Parameters	505	Do you perceived the following climate parameters are change in the last 30 years in local area				Parameters / Yes / No Temperature Precipitation Intensity of Soil erosion		
Indicator climate parameter	506	Please make a "√ " mark on the respective space provided against each indicator about the following climate parameter for the past 30 years)						
	Climate Parameter		Increase	Decrease	No Change	I don't know		
	Temperature							
	Precipitation							
	Length of kiremt							
	Length of belg							
	Floods							
	Drought							
	Soil erosion							
	Failures crop production							
Effect of climate change	507	Has the local community's livelihood been affected by climate change and variability?				1, Yes 2, No, 3, Do not have idea		
Cause	508	What do you think the cause of climate change and variability?				1.Man-made cause 2. Natural cause/supernatural forces 3, both 4, I have no idea		
List of Cause	509	Please, fill in the following table the cause of climate change and variability.				1.Man-made causes_____ 2. Natural		

		causes_____	
Extreme events	510	Have you experienced any extreme/unusual weather events in your locality for the last 30 years?	1, Yes 2, No 3, I cannot remember	
	511	If your answer is yes toQ-510, please, fill in the following table		

Events of climate change	Frequency of climate extreme events experienced in her/ his life experience					
	1-3 times	4-6 times	7-9 Times	10 and above	Magnitude Use, 1=High, 2=medium 3= low	When did you face hazard?
Drought						
Flood						
Famine						
Intensive heavy rainfall/snow fall						
Land slid						
Crop failure						

Organization	512	Which organization (NGO) helps you when you have faced with hazards?	1, Government 2, NGOs 3, Community-based 4, No one 5, others (please, specify)	
Administration officials	513	The Woreda extension expert is doing things to help you to adapt climate change and Variability.	1. Yes 2. No	
Frequency		If your response is yes for Q513 How frequent they come?	1.Weekly base 2. In two weeks 3.Monthly 4.once time in a year 5.Two times in a year	
Information	514	Do you have access to information on climate	1, Yes 2, No	
Heard	515	Have you heard of the word "climate change and variability" before?	1, Yes 2, No	
Source	516	If yes to Q-515, what is/are your source of information about climate change and Variability?	1, Friends/ neighbors 2, Indigenous indicators 3, Radio 4, Television 5, Extension workers 6, Printed media/newspapers 7, others (please, specify)	
Indigenous knowledge	517	Are you user of indigenous knowledge to predict weather condition?	1, Yes 2, No	
Predict weather condition	518	If you are user of indigenous knowledge to predict weather condition, (please specify them)	-For rainfall _____ -For temperature _____	

Cope up	519	How did you cope up the problem of climate change and variability?	_____	
Section Six: Farmers' adaptation strategies to climate change and variability				
Faced climate impacts	601	When you faced climate impacts, how can you minimize/survive the problem in short time? Please, try to put your answer on the following tables.		

Copy mechanisms adopted by farmers	Yes	No
Reducing of consumption level		
Selling livestock and other assets		
Food aid/relief/government assistance		
Daily labor/migration to search employment		
Migration (to save the whole family life)		
Loans (government, friends and nearby)		
Others (crop insurance, grain storage, selling forest product.....)		

Adoption	602	Every adaptation option represent by "√" if it is adopted by the farmer and "X" if it is not adopted by the farmer.

List of adaptation technologies climate change and variability

No.	Types of Adaptation	Adopt options
1.	Soil and water conservation	
2.	Irrigation	
3.	Diversification new Crop Variety	
4.	Agro-forestry	
5.	Livelihoods diversification	
6.	Appling fertilizers	

Adaptation	603	What types of Climate change adaptation (farm adjustment have been taken) you have been used?	1.During shortage of rainfall_____ 2.During normal rainfall _____	
Interventions	604	What types of climate change adaptation strategies (farm adjustment have been taken) Have you use before and after the interventions?	1.Before and _____ 2. After the interventions? _____	
Agriculture do you practice	605	What types of agriculture do you practice?	1, Rain fed 2, Irrigated 3, Mixed (rain fed and irrigated)	
Irrigation	606	Have you user of irrigation?	1, Yes 2, No	
Types of irrigation	607	If yes to Q-606, which types of irrigation have you applied? (Multiple answers are possible)?	1, communal 2, drip 3, small scale irrigation , 4,home and rain water harvesting 4, other (please, specify) _____	
Total irrigable area	608	If yes to Q-608 what is the total irrigable area	_____ in timad.	

Reason for not applying	609	3If your answer to Q-609 no, what is your reason? Reason for not applying irrigation agriculture			1, shortage of capital 2,lack of water pump 3, lack of experiences 4, lack of water availability 5, lack of labor forces 6, others (please specify)	
Willingness to participate	610	Do you have a willingness to participate in water and soil conservation practices? (At community level).			1, Yes 2, No	
Reasons	611	If no to Q-610, what is/are your reason?			_____	
Soil Conservation	612	Do you apply water and soil conservation in your farming practices? (At household Level).			1, Yes 2, No	
Apply	613	If yes to Q-612, please, fill in the following table				
Types of activities		At individual level	At community level	Measure		
				Hectare	Km	
Hill side Trace and Channel						
Hill side Trace						
Stone Bund						
Soil Bund						
Channel Diversion						
Stone Channel Diversion						
Check Dam K.M						
Others (specific)						
Conservation structure	614	2If yes to Q- 612, please put in meter or km water and soil conservation structure			Which have been construct in your own land? _____.	
Reduce the problem	615	Which of the following types of soil and water conservation measures are efficient to reduce the problem of soil erosion?			1, stone bund 2, soil bund 3, cut off drain 4, water way 5,planting of different trees 6,others (specify)_____	
Family member(s) participated	616	Which family member(s) participated in water and soil conservation work?			1,Father(household head) 2, woman/wife 3, Able-bodied children 4, all of them 5, others (please, specify)_____	
Apply different crop	617	Do you apply different crop varieties that are smart to climate change and varieties to increase your production?			1, Yes 2, No	
Types of crop varieties	618	If yes to Q-617, what types of crop varieties do you apply? (Multiple answers is possible).			1, Drought-tolerant crop or variety 2, Early –maturing crop variety	

			3, Disease –resistant crop or variety 4, High-yielding varieties of a crop 5,Others (please, specify) _____	
Diversified your crop varieties	619	If you are diversified your crop varieties, please fill in the following table Types of crop/vegetables you have produced How many quintals produce in one year? (1 quintal = 1000kg)		

Types of Crop/Vegetables you have produced	How many quintals produce in one year? (1 quintal =1000kg)	Irrigation practice	Rain fed practice	What factors constraint you to diversify your crop production (use the given below)

Remark, Belg (February, March, April, and May); Meher (October, November, December, and January) and Kiremt (June, July, August, and September)
Code for Constraints; 1=shortage of land, 2=shortage of labor, 3=shortage of oxen, 4=declining soil fertility, 5=drought,6= crop pest and diseases, 7=soil erosion, 8=erratic rainfall, 9= lack of Availability of water, 10= lack of knowledge, 11=lack of availability of agricultural input, 12=other (please, specify)

Improved seeds	620	If you are user of improved seeds, what types of improved seeds do you use?	Please list them _____.	
Diversified livelihood	621	Have you diversified your livelihood sources?	1, Yes 2, No	
Source of livelihood diversified	622	1If yes to Q-621, what types of source of livelihood diversified? (multiple answer is allowed	1, Hen production 2, Livestock production 3, bee keeping production 4, other (please, specify) _____	
Diversifying your sources of income	623	If no to Q-622, what your reason, for not diversifying your sources of income	_____ _____ _____	
Apply fertilizer	624	Did you apply fertilizer(s) in your farming practices to increase production?	1, Yes 2, No	
kind of fertilizer	625	1If your answer is yes to Q-53, which kind of fertilizer did you apply (multiple answer is possible)?	1, DAP 2, Urea 3, manure 4, compost 5, All 6, Others (please, specify)_____.	
Quantity	626	If you apply DAP or Urea fertilizer in your farm production what quantity of /kg/ fertilizer do you apply per hectare**?**	DAP_____ Urea_____	

Food Insecurity questionnaires usually employ a series of 9 to 15 questions that detect the level of concern and the lack of access to, variety and/or quantity of food. In the past four weeks, did you worry that your household would not have enough food?

0= Never

1= Rarely (Once or twice in the past 30 days)

2=Sometimes (three to ten times in the past 30 days)

3=Often (more than 10 times in the past 30 days

Part Two **Section one: Household Food Insecurity Access Scale (HFIAS)**			
No.	Occurrence Questions	Respond option	Code
101.	In the past four weeks did you worry that your household would not have enough food?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____
102	In the past four weeks were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____
103.	In the past four weeks did you or any household member have to eat a limited variety of foods due to a lack of resources?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____
104.	In the past four weeks did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____
105.	In the past four weeks In the past four weeks did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____
106.	In the past four weeks did you or any household member have to eat fewer meals in a day because there was not enough food?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____

107.	In the past four weeks was there ever no food to eat of any kind in your household because of lack of resources to get food?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____
108.	In the past four weeks did you or any household member go to sleep at night hungry because there was not enough food?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____
109.	In the past four weeks did you or any household member go a whole day and night without eating anything because there was not enough food?	0= Never 1=Rarely (Once or twice in the past 30 days) 2=Sometimes (three to ten times in the past 30 days) 3=Often (more than 10 times in the past 30 days)	_____

Appendix 11: The household food consumption score (FSC)

WFP's recommended cut-offs to the food consumption score.

0-21	Poor
21.5 – 35	Borderline
> 35	Acceptable

Section two: The household food consumption score (FSC)								
No.	Food Items	Days						
		1	2	3	4	5	6	7
201	Maize , maize porridge, rice, sorghum, millet pasta, bread and other cereals							
202	Cassava, potatoes and sweet potatoes							
203	Beans. Peas, groundnuts and cashew nuts							
204	Vegetables and leaves							
205	Fruits							
206	Beef, goat, poultry, pork, eggs and fish							
207	Sugar and sugar products							
208	Oils, fats and butter							

Appendix 12: Rainfall and temperature distribution

Monthly Minimum Temperature distribution in *BasonaWerenaWoreda*

Year	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	0.89	0.92	6.81	5.65	7.94	7.85	8.39	7.79	6.77	0.98	3.49	3.77	5.12
1985	5.28	4.76	6.97	7.89	8.07	7.35	8.35	8.44	6.97	4.53	4.27	4.85	6.49
1986	3.83	7.39	7.61	8.63	7.68	8.65	8.29	7.97	6.07	4.48	4.31	5.05	6.66
1987	4.97	6.85	8.8	8.05	8.65	7.66	8.49	8.85	7.59	5.49	4.19	5.19	7.07
1988	6.82	13.64	13.54	8.19	6.95	6.61	9.66	9.05	7.61	3.92	-1.19	0.91	7.13
1989	0.29	6.24	7.40	8.04	5.45	6.27	8.75	9.22	9.39	3.30	0.75	6.66	5.98
1990	3.11	9.15	7.12	6.75	5.52	5.88	8.6	8.91	7.25	2.03	2.06	0.18	5.52
1991	5.27	6.05	8.36	7.66	7.69	7.38	9.03	8.85	7.12	1.64	1.75	0.82	5.97
1992	6.83	7.913	8.49	7.27	6.52	6.87	8.07	9.01	6.99	3.55	3.89	4.15	6.63
1993	5.62	6.9	5.85	8.15	6.77	6.62	8.68	8.63	7.75	4.61	1.52	2.51	6.13
1994	3.64	5.07	8.66	7.96	7.08	7.14	8.61	7.78	6.69	1.85	0.83	2.53	5.66
1995	2.77	7.48	6.68	8.65	6.45	6.71	8.53	9.18	6.96	2.67	1.15	5.79	6.08
1996	6.3	4.57	7.39	7.11	8.01	7.86	8.22	8.52	6.35	1.39	2.14	3.23	5.93
1997	6.12	2.21	8.25	7.02	6.67	8.54	8.59	8.08	7.11	6.07	4.3	2.32	6.30
1998	7.69	8.37	9.29	9.61	7.65	7.19	9.29	9.46	7.28	3.7	-1.01	-2.14	6.36
1999	2.22	3.09	5.91	5.23	5.82	6.31	8.63	8.6	6.24	4.57	-1.24	1.81	4.79
2000	1.01	3.43	4.78	7.02	7.09	5.68	8.64	8.11	6.82	3.29	1.66	0.95	4.88
2001	1.48	4.51	8.32	6.02	8.19	7.98	9.25	9.22	6.43	3.35	2.86	4.64	6.04
2002	5.01	6.27	8.42	7.59	7.69	7.58	9.15	9.15	7.52	3.12	2.77	7.25	6.8
2003	5.33	6.85	7.92	9.47	7.02	7.99	9.39	9.56	8.11	3.07	2.94	1.64	6.60
2004	5.02	4.39	5.62	8.92	6.71	8.13	9.21	8.95	7.01	3.35	2.65	5.25	6.27
2005	5.32	7.26	8.26	9.19	9.22	7.81	9.25	9.21	8.33	3.89	1.99	1.68	6.78
2006	5.87	7.95	7.54	8.49	7.36	8.17	9.78	9.79	7.34	5.36	3.83	4.75	7.18
2007	6.63	7.52	7.67	8.47	8.13	8.98	9.55	9.18	7.49	3.35	3.95	1.11	6.83
2008	5.60	5.03	5.54	7.72	8.59	8.53	8.61	9.18	7.04	4.13	3.96	4.55	6.55
2009	6.28	7.59	8.09	7.36	6.96	8.39	9.26	9.32	6.48	4.93	3.07	7.33	7.09
2010	6.29	9.34	9.23	9.16	9.19	8.09	9.08	9.27	7.24	3.67	4.13	4.82	7.45
2011	6.53	4.58	7.40	8.75	7.95	7.64	8.66	8.72	7.5	3.44	4.82	2.04	6.51
2012	3.81	3.48	5.96	8.39	7.55	7.55	8.75	7.94	6.49	1.8	1.86	3.68	5.61
2013	3.61	5.19	8.56	7.48	7.25	7.92	8.73	8.48	6.29	4.23	3.65	1.25	6.06
2014	5.78	7.09	8.26	8.34	8.26	7.11	8.5	7.49	6.32	3.88	2.78	2.55	6.37
Total	4.56	6.05	7.72	7.89	7.42	7.46	8.79	8.79	7.11	3.49	2.51	3.17	6.25

Appendix13: Monthly Maximum Temperature distribution in *BasonaWerenaWoreda*

Year	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	19.99	21.34	21.98	23.46	21.06	20.25	19.33	20.17	18.37	19.13	19.45	18.64	20.26
1985	19.43	19.78	20.45	18.91	19.68	21.67	18.66	18.42	18.21	18.15	18.61	18.48	19.19
1986	20.37	19.87	19.06	19.03	20.89	19.35	18.6	18.09	18.31	18.52	19.04	19.52	19.22
1987	19.48	20.92	19.50	19.67	19.48	21.95	22.41	19.45	19.78	19.52	19.8	20.07	20.16
1988	20.32	19.71	21.53	20.58	22.07	22.13	16.95	17.55	17.98	17.38	17.94	18.27	19.36
1989	18.99	18.46	19.72	18.14	20.44	21.35	18.82	18.35	18.17	18.01	18.67	18.04	18.93
1990	18.97	18.45	19.87	20.09	22.55	22.96	18.56	18.88	18.38	18.18	18.48	18.84	19.52
1991	19.89	21.58	22.74	22.12	21.89	22.52	18.04	17.8	18.79	18.16	18.56	18.27	20.01
1992	18.05	18.92	21.67	21.48	21.56	22.63	18.42	16.60	17.54	17.29	17.31	18.70	19.17
1993	18.95	18.69	20.61	19.39	19.94	21.91	18.63	18.85	18.49	18	18.26	18.95	19.22
1994	19.72	20.91	20.38	21.45	21.99	21.45	17.36	17.63	18.12	18.97	19.29	19.85	19.75
1995	20.19	20.79	21.29	20.83	22.12	23.45	17.34	18.66	19.37	19.24	19.81	19.68	20.22
1996	19.15	21.93	20.69	21.22	20.09	19.37	18.46	18.61	19.59	18.93	18.68	18.37	19.58
1997	19.2	20.06	21.19	19.85	21.35	21.08	18.03	18.33	19.32	18.30	18.79	19.76	19.60
1998	19.85	20.95	20.87	22.17	22.37	23.31	17.79	17.71	18.73	18.56	18.43	18.41	19.91
1999	19.35	21.46	20.48	21.80	22.61	22.41	17.06	18.10	18.55	17.94	17.79	18.56	19.66
2000	19.69	20.47	21.54	20.78	21.84	22.72	18.32	17.67	18.49	18.39	18.52	19.35	19.81
2001	19.88	20.83	19.18	21.23	22.19	21.38	17.93	17.56	19.55	19.85	19.57	19.34	19.86
2002	19.52	21.23	20.68	21.43	23.03	22.82	21.53	17.94	18.56	19.59	19.77	19.35	20.45
2003	20.30	21.38	21.21	20.77	22.46	22.49	18.05	18.28	18.99	19.36	19.14	19.43	20.14
2004	20.73	20.42	21.03	20.44	23.09	21.23	18.71	18.65	19.13	18.6	19.52	19.56	20.09
2005	20.14	22.14	21.96	21.31	20.41	21.55	18.29	18.91	19.27	19.04	18.83	18.92	20.05
2006	19.97	20.98	20.47	19.99	21.87	22.57	18.99	17.96	18.58	19.55	19.44	19.07	19.94
2007	19.90	20.59	21.81	20.81	22.72	21.17	18.01	18.18	18.71	18.96	18.58	18.73	19.84
2008	19.96	20.25	21.95	20.79	21.25	21.22	18.92	19.02	19.41	19.2	18.43	19.10	19.96
2009	19.30	20.26	21.48	21.68	22.43	23.62	17.91	18.66	19.89	18.84	19.67	18.54	20.18
2010	19.30	20.89	20.41	20.83	21.28	22.73	18.68	18.12	18.98	19.81	19.21	19.25	19.94
2011	19.53	21.59	20.09	21.92	21.23	22.17	19.13	18.21	18.75	19.43	19.38	19.41	20.05
2012	20.26	21.33	22.07	20.63	21.41	22.29	18.40	18.28	19.41	19.83	20.45	20.17	20.37
2013	20.85	21.94	22.11	22.21	21.99	22.03	17.63	17.45	19.08	18.79	19.03	19.09	20.16
2014	19.72	20.93	21.28	20.87	21.28	22.77	19.99	18.42	18.69	19.05	20	19.58	20.20
Total	19.68	20.56	20.86	20.74	21.49	21.95	18.71	18.28	18.82	18.75	19.01	19.08	19.83

Appendix 14: Seasonal and annual rainfall distribution in *Basona Werena Woreda*

Year	Jan	Autumn				**Summer**				Winter			Annual
		Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
1984	32	4.7	113.6	57.9	129.1	29.3	241.1	312.6	72.4	1.6	0	0.5	994.8
1985	17.4	0	27.3	58.6	83.2	15.8	314.6	376.6	88.4	6.5	5.7	0	994.1
1986	0	74.7	99.2	52.5	27	141.9	271.3	274.7	115.7	11.3	0	0	1068.3
1987	5	19.2	108.1	51.7	100.2	0	32.3	309.5	47.5	18.7	0	6.3	698.5
1988	10.6	66.7	16.9	83.1	16.2	16	286.2	290	153.1	12.1	0	0	950.9
1989	2.3	40.5	97.6	42.7	1.4	41.1	211.4	177.4	67.7	18.6	0	30.7	731.4
1990	0	62.2	20.7	59.5	0.9	1.6	321	217.2	168.7	0.6	0	0	852.4
1991	4.8	8.3	64.6	21	4.9	63.7	218.4	390.8	80.5	6.4	0	6.4	869.8
1992	30.3	26.7	19.4	80.2	19.3	13.3	307.6	267.6	92.9	41.9	0.5	1.8	901.5
1993	4.3	43.2	0	116.9	60.5	9.1	395.5	168.4	107.7	43.2	0	1.1	949.9
1994	0	0	95.6	0	23.2	92.7	281.7	222.9	101.7	5.3	36.5	0	859.6
1995	0	28.5	19.1	68.4	26.3	23.3	280.1	233.8	60.4	5.1	0	1.7	746.7
1996	20.7	2.8	75.4	9.7	129.2	138	328.4	252.5	24.3	0	3	0	984
1997	29.5	4	41.2	82.4	25.9	96.9	272.1	200.6	34.8	89.7	21.7	5.7	904.5
1998	23.1	13.2	14.9	49.3	43	13.5	337.3	289	70.6	5.2	0	0	859.1
1999	6.9	0	26.5	2.8	11	48.9	362.4	365.1	52.4	59.6	1.4	0	937
2000	0	0	25.9	47.3	37.1	45.8	352.4	317.5	105.2	28.5	18.8	6.8	985.3
2001	0	33.8	71.2	18.8	64.6	49.2	417.8	241.4	25.8	4.1	0	3.4	930.1
2002	18.1	28	60.6	46.1	18.4	29.1	214.4	294.8	109.1	3.1	0	8.4	830.1
2003	15.6	36.3	60.2	85.7	3.8	99.5	334.1	288.7	74.2	0	0	7.4	1005.5
2004	24.4	9.7	29.7	113.3	5.6	99.7	334.7	301.3	78.9	14.1	11.8	0	1023.2
2005	34.3	4.5	28.6	49.5	76.4	91.1	310.7	228.3	106.8	0.7	1.5	0	932.4
2006	17.3	24.4	61	38.3	19.8	35.2	432.6	224.2	59.8	8.6	4.3	26.3	951.8
2007	2	30.4	8.9	71.8	13.6	93.2	309.9	414.6	128.5	4.9	5.7	0	1083.5
2008	0.3	1.7	0	34.6	68.9	66.4	397.7	234.8	76.6	9.9	54.6	1.2	946.7
2009	47.2	0	8.1	31.4	14.9	13.7	423.4	273.1	31.4	36.6	1.2	25.3	906.3
2010	47.2	21.6	55.7	119.3	42.2	35.4	242.3	312.2	53.8	0.3	8.5	3.9	942.4
2011	0.3	7	76.8	38.6	111.2	73.4	357.4	312.3	79	0	4.3	0	1060.3
2012	0	0	5.2	93.3	57.9	56	351.6	394.5	92.4	0	0	0	1050.9
2013	0.8	0	48.8	54.2	23.9	40.1	358.5	204.4	79.6	63.1	11.5	0	884.9
2014	0	16	67.7	44.1	46.9	16.8	260.3	291	110	55.9	0	0	908.7

Thank you.