ASSESSMENT OF CLIMATE VARIABILITY AND ADAPTION STRATAGY ON MAIZE PRODUCTION IN ABOBO DISTRICT GAMBELLA REGION. ETHOPIA

MASTERS THESIS

BY ATEY ABOWALLA ACHAMO

HAWASSA UNIVERSITY.

WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES

JUNE, 2020

WONDO GENET ETHIOPIA

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ATHESIS SUBMITTED TO SCHOOL OF NATUR A RESOURCE AND ENVERONMENTALSTUDIES, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES HAWASSA UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CLIMATE SMART AGRICULTUER AND LAND SCAPE

JUNE, 2020

ADVISORS APPROVAL SHEET 1

This is certifying that the thesis entitled Assessment of climate variability and adaption strategy on maize production in Abobo district Gambella region Ethiopia, Submitted in partial fulfillment of the requirement for the degree of masters with specialization in climate smart agriculture and land scape assessment and has carried out Atey Abowalla Id No, Roo6/10

Therefore two advisers recommend that the student has fulfilled the requirement and hence here by can submit the thesis to the department

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EXAMINERS APPROVAL SHEET 2

The undersigned members of the board of Examiners of the final open defiance, by Atey Abowalla have read and evaluated his /her thesis entitle Assessment of climate variability and adaption strategy on maize production in Abobo district Gambella region Ethiopia and examined the candidate

This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirement for the degree of master of Science in Climate Smart Agriculture and Land scape

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Name of the External Examiner	Signature	Date

DECLARATION

I, Atey Abowalla hereby declare that this thesis entitled ‘‘Assessment of the effects of climate variability on maize production and adaptation strategies in Abobo district Gambella region’’ submitted for the partial fulfillment of the requirements for the Masters of Science in Climate Smart agricultural and Land scape assessment is the original work done by me under the supervision of Amare Tesfaye (Ph.D) and Damelash Kefale (Ph.D) and this thesis has not been published or submitted elsewhere for the requirement of a degree program to the best of my knowledge and belief. Materials or ideas of other authors used in this thesis have been duly acknowledged and references are listed at the end of the main text.

Name: ___________________________________

Signature: __________________

Date______________________

ACKNOWLEDGMENT

First of all, I would like to thank a God for all his guidance and promises in my life. Then, special gratitude goes to my major advisor, Dr. Amare Tesfaye and co-advisor, Dr. Damelah Kefale for their welcoming face, guidance, unlimited support and critical review of this thesis. I am grateful to farmers of Abobo district who participated in and gave necessary information for this research work. I would also like to thank staff of Abobo development worker Agent ,Gambella Meteorological Agency, Gambella Central Statistics branches and , agriculture and natural resource office, for providing me with all the relevant secondary information. Data, finally, my greatest gratitude goes to my parents and Friends

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ABBREVIATION

CRGE………… Climate Resilient Green Economy

CSA………… Central statistics Agency

CV…………… Coefficient of variation

DA…………… Development agents

FAO………… Food and Agriculture Organization of united nation

FDRE……… Federal democratic Republic of Ethiopia

FGD………… Focus group discussion

GANRB …….Gambella Agriculture and Natural Resources Bureau

GCM……… Global Climate Model

GDP……… Gross Domestic Product

GMSA…… Gambella Metrology Station Agency

HA………… Hectare

HH……….. Household

HHH ……. Household head

IFAD……… International Fund for Agriculture development

IPCC……… Intergovernmental panel on climate change

KG……… Kilo gram

LGP……… Length of growing period

MM……… Mile meter

MOA…………Mister of Agriculture

NAPA……… National Adaption programmer Action

NGOs……… None governmental Organization

NMSA………National Metrology Station Agency

QT………… Quintal

SHH……… Sample household

SPI………… Standard precipitation index

SSA…………Sub Saharan Africa

THH…………Total household

UNDP…..……United nation development programmer

UNFCCC……United nation Frame work Convention on Climate Change

USAID………United states Agency for International development

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ABSTRACT

Climate change refer to the increase of earth temperature due to the release of gases such as Carbon Dioxide ,Nitrous oxide, Methane and Ozone into the earth's atmosphere, Climate change and Climate variability present a challenge for researchers attempting to quantify its local impact due to the global scale of likely impact and the diversity of agricultural systems Similarly, the effect of climate change on vegetation can be dramatic, due to variations in the amount of CO available for photosynthesis. This study was to assess effect of the climate variability on maize production and investigate adaptation strategy of small holder farmers in the study area five kebeles was Selected for household Sampling and the Sampling procedure was both Systematics and purposive Selection. The total household Sampling was 92 respondents and different data was collected from primary and secondary data it includes quaternary, individual interview and focused group discussion The study shows that farmers have experienced of Climate variability mainly increased temperature and deceasing rainfall in the district ,Climate variability Affecting maize production reduction Food Shortage was experienced mostly by farmers in the district. Adoption of drought resistances maize variety, as well as mixed cropping was found to be the most option adaptation strategies to Climate variability. The possibilities of farmers to practice adaptation strategies effectively were mainly limited by low financial and lack of agricultural based skills and technology. Government should enhance sustainable adaptive strategies for reducing the impacts of Climate variability , particularly for the most vulnerable district and household farmers

Keywords: Climate Change, adaptation, Maize, Impact, .Smallholder farmers

1, INTRODUCTION

1.1 Back ground

Climate change refer to the increase of earth temperature due to the release of gases such as Carbon Dioxide ,Nitrous oxide, Methane and Ozone into the earth's atmosphere, Climate change present a challenge for researchers attempting to quantify its local impact due to the global scale of likely impact and the diversity of agricultural systems Similarly, the effect of climate change on vegetation can be dramatic, due to variations in the amount of CO available for photosynthesis. In addition, climatic factors such as temperature, precipitation, moisture and pressure affect the development of plants, either alone or by interacting with other factors considerable research works have been carried out on the effects of weather/climate on agricultural production the effects of climate variability on maize production It has been reported by Chi-Chung that precipitation and temperature have opposite effects on yield levels and variability of corn (maize) in his study on the influence of climate variability on maize production in the district. Respondent reported that in order to counter the adverse effects of climate variability in maize production, it might be necessary to use early maturing cultivars and practice late planting. Studies have indicated that 1°C increase in global temperature will lead to reduced productivity in some cultivated plants, such as 17% in maize Climate Variability and Food Shortage: Various studies by IPCC have pinpointed Africa to be one of the most exposed continents to suffer the devastating effects of climate change and climate variability, with colossal economic impacts because it often lacks adaptive capacity. The African rain-fed agriculture is viewed by many observers to be the most vulnerable sector to climate variability and the potential impacts of climate change on agriculture are highly uncertain.

According to reports of IPCC, factors such as endemic poverty, bureaucracy, lack of physical and financial capital, frequent social unrest and ecosystem degradation contribute to Africa's vulnerability to climate variability. Almost 80% of the Africa population is rural-based with livelihoods predominantly dependent on subsistence crop farming and/or livestock rearing.

Over the past years, multiple interrelated factors such as small fragmented landholdings and Lack of access agricultural inputs, poor extension services, lack credit finical have contributed to chronic food insecurity and gradually weakening livelihoods

In addition, the agricultural system is dominated by a single crop, which is maize, coupled with the extensive dependence on rain-fed agriculture which will further increase households' vulnerability due to erratic rainfall and weather variability. Minimal shocks to agriculture therefore have a potential risks and impacts of climate change and variability on human society has been identified at global and regional levels (IPCC 2007; Jacobsen et al. 2009). Despite global coverage of climate change, there is global variation in climate variability manifestations based on geographic location and environmental factors

The Global warming is rising because of anthropogenic activities (e.g. change forest to Agricultural, release of greenhouse gases, Urbanization and Industrialization Expansion) and natural phenomena's and climate change It also affected Agriculture sector and other sector like , health, water and tourism sectors and most common characteristic of climate change is variability of rain fall from season to season by causing dry spell or drought that lead to highly decrease yield or crop production and finally cause food insecurity (Mandleni, et al, 2010) According to IPCC projection after ten decade the mean temperature on the earth will increase from 1.1°C to 6.4°C by 2100, which is likely to cause natural disaster and, increase temperature, rise sea level because of melting ice sheet and snow near the coastal areas(IPCC, 2007a).Climate change has become one of the great challenges to the development of countries. It is now affecting agriculture sector and Agriculture production worldwide. There is evidence of declining crop yield due to climate change in many countries (Muamba and Kraybill, 2010; Orindi *et al.*, 2006 and Stige *et al.*, 2006).

1.2 Statement of the problem

Agriculture is the most important Sector in sub-Saharan Africa (SSA) and it is largely affected by Climate Change .Ethiopia which is dependent on rain fed agriculture together with its low level of socioeconomic development is high venerable to climate change since it affects agriculture .water and energy supply as well as poverty reduction and sustainable development efforts. Resulting in natural resources degradation and natural disaster confirmed in several studies (Hassan et.al 2008 Deressa et al 2009 MoFED) .

Maize is one of the most important staple food crop and very common in all parts of abobo distract and is predominantly produced by smallholder farmers on a small farm plot (often more than 2 ha) using family labor (Abate et .al 2015.) soil degradation is being further accelerated by removing topsoil from cultivated lands and causing agricultural productivity decline from time to time . The acceleration of environmental degradation and climate change induced flooding .erratic rain fall. Crop pest and disease.

Small size landholdings among other factors have direct effects on maize yield reduction shortage of food availability.

Similarly maize producer farmers in the study area are particularly vulnerable to multiple environmental challenges .since they produce under uncertain climatic conditions constraining maize crop production in study area .As site specific issues require site specific knowledge .it is therefore very important to undertake extensive study at local level to forward possible solutions.

Even though several researches have been carried out in the study area on socio economic aspects there is no in depth study conducted on farmer’s perception of climate change variability assessing impacts specially on maize production and efforts of adaption choices in accordance with maize crop at community and local level .

Hence this study was intended to inquire site specific information on climate change on maize production of small holder farmers and asses' major adaption strategies to cope with the adverse effects climate change in abobo distract Gambella region.

Objectives of the study

1.2.3 **General objectives**

The general objective of the study was to assess effect of the climate variability on maize production and investigate adaptation strategy of small holder farmers in the study area

.1.2.3 **Specific objective**

The specific objective of the study was

- To analyze 30 years climate trends focusing on rainfall and temperature in the study area
- To investigate effects of climate variability on maize production
- To identify the major adaption strategies for maize crop production at farmer level in response to climate variability of rain fall

1.3.3. **Research questions**

- How do the trend and variability of rain fall and temperature parameter that are important for rain fed of maize crop production in the study area for the past 30 years?
- What is the effect of climate change and variability on maize production?
- What type adaption strategies for maize crop production at Farmers level to response climate variability and change in the study area?

1.3.**4 Significance of the study**

The present study was conducted to assess the effect of climate variability and to understand of local scale trend and variability of agriculturally-relevant rainfall indices and thereby help to option of locally specific maize based adaptation strategies .the results of study can be uses by the local development agents and model farmers to improve the knowledge and adaptive capacity of farmers of the study area by reinforcing and/or correcting their perception. Besides, the results can also be used as a base for further and detail study on maize specific responses and adaptation alternatives to observed and projected rainfall trend and variability.

1.3.5 Scope of the study

This study was attempt to the impact of key climatic variables such as rainfall and temperature, zone.

In addition, the study used village level rainfall data obtained from Gambella region Meteorological Agency. Hence, one of the limitations of this and most common adaptation strategies at local farmer on maize production. Besides, it utilizes cross-sectional data generated from limited farmers selected from five rural villages of Abobo woreda in Agnwa study was lack of significant spatial variation in at farmer level rainfall data. This was because only few rain gauge stations might set to cover wide geographic areas in the study area. To partially solve this problem at farmer level data on rainfall, qualitative information on plot specific observed rainfall condition experience of the farmers was collected to develop as rainfall variability that the results of this study was provide important information on the trends and frequency of drought and others disasters risks that related to climate variability and its impacts as well as adaption mechanisms/ strategies for the farmers of the study area. So, this study more or less extends to the farmers of Agnwa zone Abobo woreda.

2. LITERATURE REVIEW

2.1. Concepts and terminologies

Climate _is defined as 'the average weather' condition as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years.; .The relevant quantities often are surface variables such as temperature, precipitation, and wind.

Climate change is a Global worming or increasing temperature for Long period of time (say 30 years) or It is also the long term summary of the weather conditions taking in account the average (IPCC 2007)

Climate variability is the short term weather conditions. Or Cyclical up and down over short time scale (IPCC 2007) , Only over a sufficient period and within a large number of recorded extreme events scientist can claim if a specific climatic event is within a normal historical variation or is attributed to other factors such climate change ((UNISDR, 2008). The concerns over human activities that may affect the global climate system have led to the establishment of the Intergovernmental Panel on Climate Change (IPCC in 1988). Consequently, the United Nations' Framework Convention on Climate Change (UNFCCC) was developed in 1992 and entered into force in 1994.

It is an international treaty aims at reducing the greenhouse gas emissions that cause climate change to level that would prevent anthropogenic interference with climate system. States that are parties to the convention agreed to common but differentiated responsibilities in achieving this global objective. Mitigation; can be defined as Reduce or Remove (GHGs) greenhouse gas emission from the atmosphere (IPCC 2014)

Impacts are the Effects on natural and human systems. In this report, the term impact is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and **of** climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system (IPCC, 2012). Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts. **Adaptation**: Can be define as to reduce exposure of farmer to short term risk or the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC, 2014). Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation: Anticipatory adaptation (also referred to as proactive adaptation) – adaptation that takes place before impacts of climate change are observed. Autonomous adaptation (also referred to as spontaneous adaptation) – adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.

Planned adaptation – adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Sensitivity: is The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, rang or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC 2014) .

Adaptive capacity: The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014), or the combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities (IPCC, 2012)..

Yield gaps: yield gaps can be defined as the difference between what is attainable and what is theoretically conceived by scientists and what is attained at experimental stations. The second

\type of yield gap is the difference between yield at the experimental station and potential yield at farmers' field, perhaps due to environmental conditions and technological differences between experimental stations and farms. The third (last) type is the difference between potential on farm yield and actual farmers' yields. This study considered the third type of yield gap in our analysis.

Crops: are in generally includes cereals, pulses, oilseeds, vegetables, root crops, fruits, coffee etc. produced for food, making drinks, stimulation and making fabrics or clothing.

Vulnerability: is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

Exposure: is the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014).

Perception: is a process by which individuals organize and interpret their sensory impressions in order to give meaning to their environment. Understanding the perception of farmers towards factors affecting the performance of their crop yield including climate change and/or variability is an important step in designing locally specific adaptation strategies. This is because farmers' decision making on crop production strategies to adapt climate change and/or variability is shaped more by their perception of climate change and climate risk, rather than by the actual climate patterns as measured by scientific methods (Adger et al., 2009; Mertz et al., 2009)

Trend: A trend is a significant change over time exhibited by a random variable, detectable by statistical parametric and non-parametric procedures

Resilience: can be described as the capability of ecological ,social systems, to support and build up communities, households or individuals to prevent, mitigate or cope with risk and recover from shocks. (Holling 2002)

2.2. Climate Change and Agriculture

Agriculture is inherently sensitive to climatic conditions. It is a sector vulnerable to current and anticipated global climate change. Consequently, livelihood of the people leading agriculture dependent life is highly vulnerable to climatic shocks which result in food insecurity. This is evidenced by the United Nations Food and Agriculture Organization report on World Agriculture toward 2015/2030.These people live in 98 countries mostly concentrated in South Asia and Sub-Saharan Africa. They also argued that the greenhouse gas induced climate change would further worsen the food security situation, especially in the tropics by reducing agricultural productivity.

This situation is pervasive in case of Africa. Despite a good performance with high economic growth rates over the last decade, Africa has not made significant progress on some of its major challenges, especially food security and employment for the growing youth population (UNECA, 2012). Climate change has affected agriculture negatively and triggered food security problem in various regions of Africa. Higher temperatures, reduced rainfall and increased rainfall variability reduce crop productivity in many tropical areas. This affects food security in low income and agriculture-based poor economies.

Thus, the impact of climate change is detrimental to countries in which people depend on agriculture as their main means of livelihood like Ethhiopia (Jones et al. 2009). Many African countries which have economies largely based on weather-sensitive agricultural production systems are particularly vulnerable to climate change.

From the African region, countries in the Horn are among the most vulnerable but least prepared for adverse global environmental change in the word (Aklilu and Alebachew, 2008). In the Horn of Africa, food insecurity has increased in drought-affected pastoral areas of Somalia, Kenya, Djibouti and Ethiopia. The recent drought of 2011-2012 has been qualified as the worst drought in 60 years, caused by a prolonged lack of rain and resulting dry conditions. South-eastern Ethiopia, northern and eastern Kenya, and southern Somalia, are the worst affected areas. The severity and scale of the drought has raised concerns because 80 per cent of the population in this sub-region depend on crops and livestock for their livelihoods and food security, while only about 1 per cent of arable land is irrigated (GIEWS, 2012). Among the horn countries, Ethiopia is one of the most poverty stricken, ecologically vulnerable country whose growing population and economy are heavily impacted by climatic change and variability

In Ethiopia, agriculture is important for food security in three ways. Firstly, it produces the food people eat and contributes about 45 percent of Gross Domestic Product (GDP). Secondly, it provides the primary source of livelihood for about 80 percent of the country's total workforce. Thirdly, it can provide income through generating about 60% of export earnings from the exports (MoFED, 2010).

This implies that climate change can affect food security mostly through affecting agriculture. As Ethiopian agriculture is predominantly rain-fed and its economy is dependent on primary commodities, any irregularities in weather and climate conditions have adverse welfare implications.

Studies show that rainfall in Ethiopia is expected to be irregular and affects food production negatively. Von Braun (1991) has confirmed that a 10% decline in the amount of rainfall below the long run average leads to a 4.4% reduction in the country‟s national food production. According to Funk et al. (2005), rainfall is expected to decline in the future and also become more irregular. Drought has been an increasing occurrence in Ethiopia over the last decades affecting a significant proportion of the population. Food shortage and famine associated with rainfall variability cause a situation of high dependency on international food aid. Consequently, Ethiopia has become one of the biggest food aid recipient countries in Africa that accounts for 20-30% of all food aid to Sub-Saharan Africa (Bezu and Holden, 2008).

According to African Development Bank report in September 2010, there is a strong correlation between weather conditions and Ethiopia‟s economic growth performance. A change of 1 percent in average annual rainfall is associated with a change of 0.3 percent in real GDP in the following year. This has a clear implication for the impact of climatic conditions on smallholders‟ food security in the country. Above all, climate change has the potential to undermine sustainable development, increase poverty, and delay or prevent the realization of the Millennium Development Goals (IPCC, 2007).

An effective way to address the impacts of climate change is by integrating adaptation measures into sustainable development strategies so as to reduce the pressure on natural resources, improve environmental risk management, and increase the social well-being of the poor. Furthermore, climate change will have impact on all four dimensions of food security such as food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns (FAO, 2008). Therefore, the potential impacts of climate change on food security must be viewed within the larger and multidimensional framework encompassing all of the indicators under changing earth system dynamics and observable changes in multiple socio-economic and environmental variables.

2.3. Concept of Adaptations to Climate Variability

The vulnerability of agricultural sector to long-term changes in climatic variables such as temperature and precipitation is greatly influenced by its adaptive capacity. Adaptation is generally described as those responses by individuals, groups and governments to climatic change or other stimuli that are used to reduce their vulnerability or susceptibility to adverse impacts or damage potential. It has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions (Kandlinkar and Risbey, 2000). According to IPCC (2001), adaptations are adjustments or interventions which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate. It is the process of improving society‟s ability to cope with changes in climatic conditions across time scales, from short term (e.g. seasonal to annual) to the long term (e.g. decades to centuries). The IPCC (2001) also defines adaptive capacity as the ability of a system to adjust to climate change including climate variability and extremes to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or change.

Adaptation to climate change can occur at two main scales. First, it can be at farm-level that focuses on micro-analysis of farmer decision making. Second, adaptation can take place at the national level or macro-level that is concerned about agricultural production at the national and regional scales and its relationships with domestic and international policy (Kandlinkar and Risbey 2000). Micro-level analysis of adaptation focuses on tactical decisions farmers make in response to seasonal variations in climatic, economic, and other factors. Farm-level decision making occurs over a very short time period usually influenced by seasonal climatic variations, local agricultural cycle, and other socio-economic factors. According to Kandlinkar and Risbey (2000), macro-level analysis on the other hand focuses on strategic national decisions and policies on local to regional scales taking into account long term changes in climatic, market and other conditions over longtime periods.

Adaptation to climate change is critical in developing countries particularly in Africa where vulnerability is high partly due to low ability to adapt. In this circumstance, adaptation helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socioeconomic conditions including climate variability, extreme weather conditions such as droughts and floods, and volatile short-term changes in local and international markets (Kandlinkar & Risbey, 2000). Farmers can reduce the potential damage pertaining to climate change and variability by making tactical responses to these changes. Therefore, analyzing climate change adaptation and its effectiveness is of great importance for identifying ways to help poor farmers in agriculture dominant economies like Ethiopia. Africa is one of the most vulnerable continents to climate change and climate variability. This is a result of the interaction of 'multiple stresses' including land degradation and desertification, run-off from water catchments, high dependence on subsistence agriculture, HIV/AIDS prevalence, and low adaptive capacity due to factors such as extreme poverty, frequent natural disasters i.e. droughts and floods, and Rainfall dependent agriculture (Boko *et al* 2007). With increased climate change, the amount of effective rainfall (soil moisture) available will likely to decrease. Heat stress on crops; increased pest, disease and weeds and livestock diseases may also be prevalent. Such changes would result in reduced yields and increased overall vulnerability.

The region is situated in sub humid and arid zone with mean temperature 37.250c and mean annual rainfall ranging from 300 to 900mm. According to the climatic resources report of the (LUP 2003) the different lengths of growing period of the region have been grouped into 5 LGP classes where each class has 30 days.

Growing period is not the part of the year in which neither water nor temperature are limiting to agricultural production. Growing period length and onset dates can be estimated for different planting months, and by comparison the best planting can be selected, maximizing the available growing period. Matching of crop duration with growing period is the key to consistent yields, in particular in areas with deficient rainfall. It is important to select crop Variety with cycles to maturities that are in the same range as the dependable growing period. In all cases the choice of cropping patterns will need to be based on a thoughtful consideration of the reliability of growing period length and onset.

Agro ecological zone classification is based on thermal and moisture regimes describe the broad temperature, moisture and elevation conditions. Agro ecology of the Gambella regional state classified into two major (mid land and low land . In the last three decade the region faced with frequent climatic variability and agro ecological change. It is evident that the agronomic calendar of the region pushed forward with one month duration. (Sowing date for Maize was April The average annual temperature of Gambella and Abobo district was relatively high the current annual temperature. These trends increase in alarming rate from time to time synergic with the current climatic change.
These change brought about low production and productivity in economy and social aspect of community. These urge a need to harmonize live with the climate change impact by designing different environment friendly coping mechanisms.

In the study area most of farmer are growing cereals crops specially maize the period of growing of maize in the study area Early Kermit season form April up to May and Late Kiremt season form June and Planting time for kermit season crops form April up to May and Kiremt crops season Harvested September up to August. In the study area majority farmers 90 % are growing maize production. (sources Gambella Agriculture Bureau).

2.6. Amount of rainfall: Annual and seasonal

The total amount of rainfall is one of agriculturally-relevant rainfall characteristics in rain-fed crop production system as it determines, with other rainfall characteristics, types of crops grown in a given area (Yengoh et al., 2010; Hadgu et al., 2013). Thus, understanding the trend and variability of the total amount of rainfall of a given area, especially in growing seasons, is crucial for agricultural planning and adaptation of the sector for rainfall variability (Tesfaye and Walker, 2004). In Ethiopia, main crop producing areas receives most of their rain between March and September (Segele and Lamb, 2005).

The main rainy season of crop produce in the study areas of the country is Kiremt rain and occurs between April and September (Korecha and Barston, 2007)

2.7. Distribution of rainfall

The distribution of rainfall throughout cropping season, besides the amount, is critical in affecting maize crop growth and yield (Simane and Struik, 1993; Yengoh et al., 2010), as uneven seasonal distribution of rainfall can expose maize crops to different degrees of dry season without significant reductions in total rainfall (Barron et al., 2003; Yengoh et al., 2010).

A season with high total rainfall amount but poorly distributed cannot promote high crop yields. On the other hand, fairly good yields can be obtained with well distributed seasonal rainfall that may not be high in terms of total amount

Furthermore, a reasonable knowledge of trend and variability of rainfall cessation date enable to understand change in length of growing period of rainy season (Omotosho et al., 2000). Besides, unwelcomed rain just before harvesting brings spoilage to standing crops through damaging physically, making seeds to germinate, or proliferating crop diseases and pests.

Therefore, understanding trend of the start and end of rainy season is crucial to the success of crop production activities (Sivakumar, 1992; Segele and Lamb, 2005). It assists on-time preparation of farm lands, mobilization of seeds and fertilizers, man power and equipment and will also reduce risks associated with planting/sowing too early or too late.
A variety of techniques to estimate rainfall onset and cessation date have been developed, including precipitation-only based models, e.g., (Sivakumar, 1998; Segele and Lamb, 2005; Hadgu et al., 2013) and precipitation- potential evapotranspiration (PET) models e.g., (FAO, 1986). Precipitation-only models define the growing season(s) using precipitation threshold criteria that can vary regionally, and are useful because rainfall observations are generally available (Stern and Coe, 1982). An alternative approach uses a water balance model that compares precipitation to PET, with growing season onset defined when precipitation exceeds one half of the PET (FAO, 1978).

2.8. Impact of Climate Variability on Maize Crop Production

The impact of rainfall on maize crop production can be related to its total seasonal amount or its intra-seasonal distribution. In the extreme case of droughts, with very low total seasonal amounts, crop production suffers the most. But more intra-seasonal variations in rainfall distribution during crop growing periods, without a change in the total seasonal amount, can also cause substantial reductions in yields. This means that the number of rainy days during the growing period is as important, if not more, as that of the seasonal total. Generally, the effect of rainfall variability on crop production varies with types of crops cultivated, types and properties of soils and climatic conditions of a given area.

In addition to its bio-physical impact, studies also indicated that uncertainties due to rainfall variability and the subsequent potential risk of crop failure influence the decision of smallholder by making them not willing to invest on improved seeds and fertilizer to avert the financial risks and hence harvest low output (Rockströma et al., 2002).The severity of the bio-physical impact of rainfall variability on maize crop yield of a given area depends on the time of crops grown and the growth stage of the crops (Brouwer et al., 1989) mainly especially maize is very in sensitivity to the erratic rain fall and growing stage of the crop.

2.9. Maize crops sensitive to impacts of moisture stress

The Maize crop can be sensitive to moisture stress at the initial stage of crop; the crop development stage and the mid-season stage (including flowering and grain setting or yield formation).

In general the initial stage and mid-season stage – i.e. flowering and grain setting or yield formation stage is most sensitive to water shortages because it is the period of the highest crop water needs (Brouwer et al., 1989). If dry spells or water shortage occur during this stage, the negative effect on the yield will be pronounced For instance, water stress at flowering stage of maize reduces yields by 60%, even if water is adequate throughout the crop season (Seckler and Amarasinghe, 2000) that is about 145 days for long cycle maize variety (MoA, 2012).

The least sensitive to water shortages is the late season stage. This stage includes ripening and harvest. Water shortages in this stage have - especially if the crop is harvested dry - only a slight effect on the yield. Care should, however, be taken even during this stage with crops which are harvested fresh. Fresh harvested crops are also sensitive to water shortages during the late season stage. The initial and crop development stages are between the mid-season and late season stages with respect to sensitivity to water shortages. Some crops react favorably to water shortage during the crop development stage: they react by developing a deeper root system, which is helpful during the later stages.

The main adaption management practices in the study area was selection of crop varieties, diversifying cropping, inter cropping. And mixed crops.

Farmers have indigenous technical knowledge in selection of crops that resist drought and other adverse weather shocks from the locally available varieties. Planting crops that are drought tolerant and/or resistant to temperature stresses,

CHAPTER THERE

3. METHODOLOGY

3.1 Description of the Study Area

Abobo District Agnwa Zone,Gambella regional state is one of the regional state in Ethiopia that has been affected by drought and flood .

3.2 Geographical Location

Gambella, the regional capital is about 776 kilometers South-West of Addis Ababa, The Capital of Ethiopia it is geographical located 7^o to $8^{o'}$ North and 33^o to 35^o East It is bordered in the east and north by Oromiya National regional State, in the west and south by the Republic of South Sudan and in the south-east direction by the Southern Nations, Nationalities and People's Regional State. The region has an area of 25,800 km2. Estimated total population of 580,000. The Region is sub-divided into three administrative zones and one special woreda; the administrational demarcation is considering the majority of the ethnic group living in the area. These are Agnwak, Nuer and MajangZones as well as Itang Special woreda, which is out of these three Zones. The Gambella region contains Thirteen (13) woredas (districts) and one twon (kentiba) Adimistrative It has also 265 kebeles, which are the smallest administrative units. in the government structure

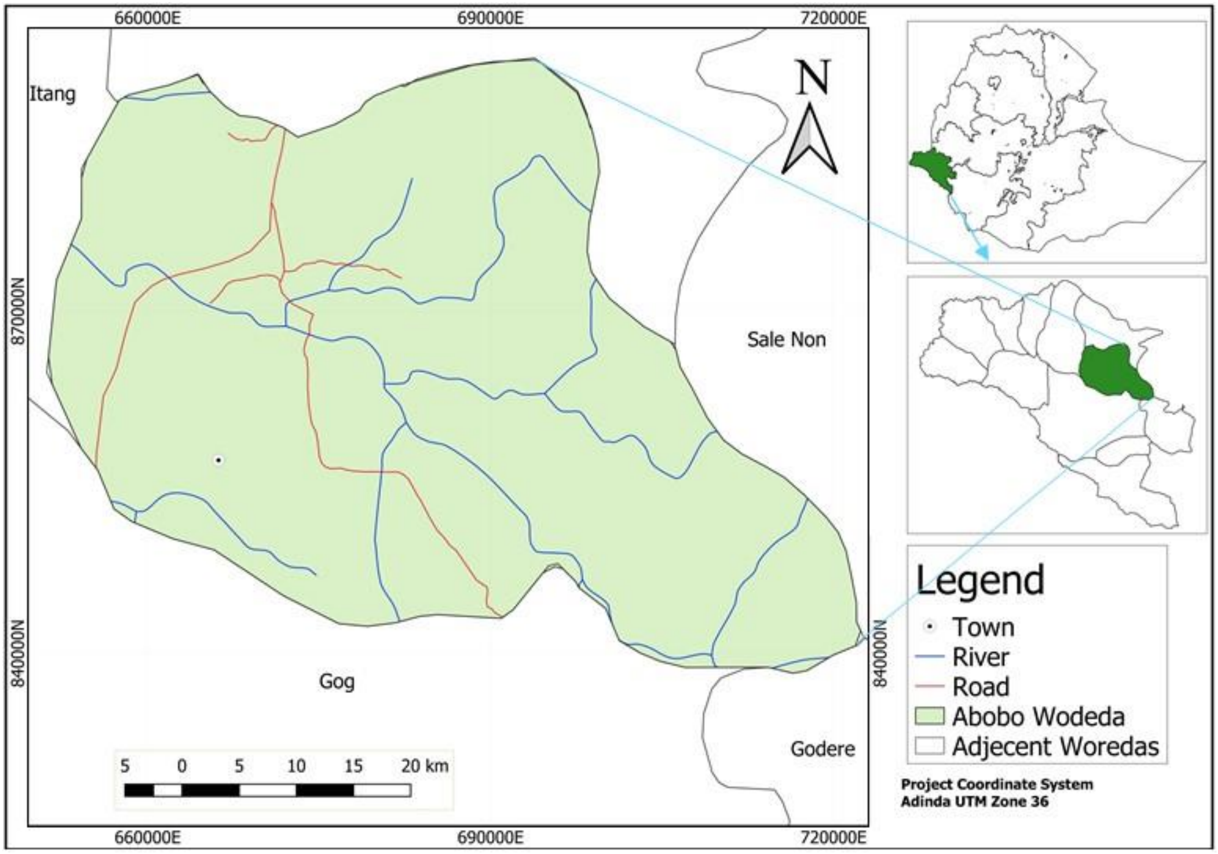


Figure 1 . Map of the study area

Source Done by Researcher Using ARC GIS Software (2019)

The study was conducted in five kebeles of Abobo Woredas, The five kebeles namely Shubo kier, Okuna ,Dumbang, Tanye, and Perbango are mainly crop producer Kebeles and the livelihoods of farmers in those kebeles are dependent on maize production and rain-fed agricultural system a

In addition the farmer in the area produces fruits and vegetables around Home garden. Abobo woreda is one of the woredas in the Agnwa Zone of Gambela Region producing maize.

Elevations in Gambella region range from400–600 meters above sea level; the Rivers found the region include Baro. Gillo, Alewro, and Akobo . The distance of abobo woreda (Study aera) form Gambella town is about 45 Kilometers. Although Abobo woreda is the most economically developed woreda in the Region, its economy is predominantly by agriculture.Specally Maize and other sector like fishing, mining etc.

3.3. Climate and weather condition

Since the region is located at lower altitude, it characterizes with hot climatic condition. Thus, the average annual minimum and maximum temperature for the region is 17 and .45C respectively. The absolute maximum temperature occurs in March and February it was about 45C and the absolute minimum temperature occurs in July and August it was about 17C. The annual rainfall of the Region in the lower altitudes varies from 900-1,500mm.

3.4. Demographics characteristic

Based on the 2018 national Census conducted by the CSA, this woreda has a total population of 20,590, of which 9,469 are men and 11,121 women having an area of 5,118.79 square kilometers, Gambela region has a population density of 340 000, which is less than the Zone average . While 1,096 or 10.35% are urban inhabitants, a further 264 or 2.49% are pastoralists.

A total of 2,595 households were counted in this woreda, which results in an average of 4.1 persons to a household, and 2,528 housing units. The majority of the inhabitants said they were Protestant, with 75.72% of the population reporting they observed this belief, while 9.28% of the population practiced Ethiopian Orthodox Christianity, 5.19% were Catholic, 1.79% practiced traditional religions, and 1.48% were Muslim

3.5. Land use and Natural Resources

Each farm household head owns a plot of land for crop cultivation, and each household head has full controlling right over the use of land and vegetation covers including perennial trees on his/her farm plot, there are no restrictions on movement and use of land for crop production as well as for grazing except the plot of land along the river banks. Unlike the rest few regional state, landowner ship certificate has not still issued for the rural households of the region.

The perennial rivers of crossing the region such as; Baro, Gilo, Alewro and Akobo have an immense potential for irrigation development. Excluding the water logging areas about 631,000 ha of land, a total of 1.1 million hectare of land has a potential for agricultural production. Out of which a net area of 480,000 hectares of land are suitable of irrigation. However insignificant hectares of land around Bonga, Gilo pocal and Baro pinkew become operational in the past recent years as small-scale irrigation projects for the local farmers (Alemseged Tamiru et.al, 2014). However, in Abobo wareda no small-scale irrigation projects that have been constructed to the local farmers.

Table 1 : Land use type Cover of the study area

Land use type	Area coverage km^2)	Percent (%)	
Arable land	4 .226	11.05	
Grazing land	10.125	26.48	
Forest	13,124	34.32	
Potentially cultivable	5,654	14.78	
Wetted land	934	24.42	
Total	38.243	100	

Sources: Abobo Woreada Agriculture office (2016)

3.6. Agricultural activities of the study area

Agriculture in the study area depends on rainfall to a very large extent and the activities in winter season are less affected by climate variability than in summer. Since the 1990s, crop production in the country especially of maize has faced the negative impacts of climate events which are believed to be manifestations of short-term climate variability.

The district has experienced some of its worst droughts and floods in the last two decades whilst significant rainfall deficits/cessation at critical stages of crop growth has frequently led to a serious short rain fall in crop production especially maize. According to 2004/2005 crop and food supply assessment of the FAO/ WFP, the production of the country's staple food, maize was on a long term decline, dropping by 70% over a period of five years in most areas.

This was due to non-cultivation of the arable lands due to delayed rainfall and the high risk of making loss from agriculture as well as shortage of seeds for alternative crops among other.kebles has suffered below average and declining cereal production as a result of erratic rainfall patterns, which are exacerbating the impact of rising unemployment and increased poverty .The purpose of this study is to analyze the impacts of climate change on maize production and yields and to examine the implications of climatic variability and change on household food security in woreada

In rain fed agriculture, the farmers producing Maize, improved seed varieties specially for low land warm climate such as maize (Abobako , and Gusawo) varieties, are well adapted crop varieties for the region. In the region the dominantly crops are maize crop. The Gambella Agricultural and Natural Resources Bureau provided improved seeds varieties and distributed to the rural farmers in the region through various extension packages in coordination with the woreda agricultural office.

Those efforts made by government development practitioner to increasing the productivity of the farmers; however the accessibilities of these improved seeds are limited due to scarcity of resources to multiply in sufficient amount for those farmers aspire it. In the cases insufficiencies of the improved varieties; the native peoples in the region saw their local maize seed known by Amara and utterly, which have undesirable characters of logging sensitivity and low productivity respectively (GARI).

Rural farmers in study district are engaged in Rain-fed agriculture and farming activities are considered as a primary livelihood strategy. Shifting cultivation, use of hand hoe, small-scale framings are major features of the study area's crop production system is common practice in rural parts of the district as secondary livelihood of the society in the selected study area

(Abobo woreda District) next to crop production. The main crops produced in the district are maize, sorghum, rice; sesame and ground nut from the total cultivated land maize is the dominant in the district.

The study area has improved the livelihoods of marginalized farmer using rain fed agriculture; however the primitive agricultural system and erratic rain are the main constraints. The productivity of crop without any input for maize is very low. It is a major crops used for daily consumption and could provide 8-13 quintals per hectare in remote and inaccessible areas; but recently in relation to expansion of extension packages ,availability of rain and use of improved seeds the productivities of these crops have reached to 30-40 quintals per hectare (HA)

3.7. Livelihood System

Rain-fed agriculture, mainly cereal cropping Like Maize along with Fruit and Root , crops and Fish are the mainstays of livelihoods of the rural population of the district. Farmers in the area cultivate Meher maize crops; the latter contributes more than 90% of the total production (HARDO, 2014). Maize (Zea mays), are common crops grown in the area. Maize (long cycle crop) maize is the leading cereal crop grown in area under cultivation and total production followed by the Region

3.8. Design of the study and sources of data

The study design includes both quantitative and qualitative type. Five kebeles was purposively selected because it was the high potential of maize production in those kebeles. From Which primary data about age, sex, education level, model farmers and major source of income of respondent; how long she/he has been living in the area; types of disasters risks that related to climate variability and , frequency and impacts; on the maize production which is highly affected by climate variability; the Model farmer were collected.

The kebele registers containing names of all the people and all households in each kebele was used to select sample households for interview. With the assistance of kebele local governments, DA (development agency) and 92 farmer of households was systematically selected from each study kebele (Stern et al., 2004) Climate related data from those highly affected by the impacts of climate variability on locally farmers, Like how or the indicators that they using to forecast climate variability; the mechanisms/strategies that they are using to cope up or adapt with those challenges; what practical activities that governmental and non-governmental organization have been acting on the issue to minimize the risks and related important information for the study was collected from sampled households through Semi structured questionnaire with closed and open ended option questions, focus group discussion, key informant interview, more over secondary data about the climatic and demographic information; maximum yield per heater of maize crop production in the study area; types and the major disasters risks that related to climate variability and its trend, frequency and impacts; on the maize crop production that are highly affected by climate variability and change; the major strive that her/his office have been doing on the issue to minimize risk and related information which important for the study was collected from the woreda Agriculture and Natural Resources office, local none government organization(NGOs) and governmental organization , The open ended questions was used to the key informants.i.e model farmer ,DA development agent ,Locally government , none government (NGO) and responsible experts to give their own opinion and closed questions was presented with a series of choices and allowed the respondents to choose their answer.

3.9. Sample size determination

The sample size for collecting quantitative data for this research is determined by using the formula provided by (Yamane, 1967 as cited in Israel, 1992).

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

= (1156/(1+1156*0.1*0.1)=1156/3.89=92)

Where: n =designate the sample size of the research use; N=designates total number of households in five kebeles; e = designates maximum variability or margin of error 10% (0.1); l = designates the probability of the event occurring.

The selection of the kebeles is based on the past record of maize production the effect of climate change and variability on maize production in the study area.

The wereda has seventeen (17) kebeles. Selection of the sample kebeles was done by using a district map and identification more affected kebeles by climate variability and change with location of the kebeles in the district and are purposive selected. The population number and list of farmers for each kebele was obtained from the kebele register

Table 1 Design of household Sample Size of study area

		total population			HH			
No,	Kebeles	M	F	Total	m	F	Total	selected HH
1	Shubo kier	258	411	669	63	80	143	
2	Okuna	173	243	416	56	102	158	
3	Dumbang	640	1241	1881	196	189	385	
4	Tanye	118	123	241	30	17	47	
5	Perbango	725	782	1507	291	132	423	
	Total	1914	2800	4714	636	520	1156	92

Table 2: Design of household sample size for study area

The sample design with respect to number of households to be selected from each sample kebele.

Total sampled households

$$\mathbf{n = \frac{N}{1 + N(e^2)} \qquad = \frac{1156}{1 + 1156(0.1)} = 92}$$

4. Sampling Method

Systematic sampling technique was conducted in selection of household head farmers for the study in these kebeles. A household head farmer was used as a sample unit and it was composed of a husband, wife, or any, individuals and dependents living in the family. Household heads identified by kebele authorities (both women and men) was interviewed. Field surveys was carried out in five (5) kebeles (Shubo kier, Okuna, Perbango, Tanye and Dumbang, .A total sample of 100 households was obtained. The study was conducted in Five kebeles.

4.2. Primary Data Collection

A primary data source was collected from sampled household. The sources were informal and formal interviews conducted with individual household head farmers and key informants. Reconnaissance surveys and direct observations were used to supplement the interview data. Both qualitative and quantitative research approaches was used in primary data collection to provide the historical and current information on the effect of climate variability and community response to such effects.

4.**3 Secondary Data**

The Secondary data (meteorological and maize agronomic data) used in this study were Collected from Gambella Meteorological Station Agency, CSA and Gambella regional of Agriculture Bureau and Woreada agricultural office. The meteorological and maize agronomic data included average monthly and annual rainfall as well as the average annual output per hectare of maize in the study area. The time series data (1990-2009) covered 20 years.

The climatic data specifically rainfall and temperature was accessed from Abobo Meteorological Agency branch and maize production and productivity trends was collected from the regional agriculture office and CSA (2015)

4.2. 1. Household Survey

At the household head level 92 % was interview by using semi structured questionnaire was made, to capture information on local perceptions on climate change and variability, including their influence on maize crop production at local farmers' level.. Data collection at household head level was done self-introduction to household head farmers' members by informing about the objective of study. A household head farmer is the basic unit of production and consumption in the kebeles and hence was used as a unit of analysis preferably with household head farmers as the main informant.

4.2.2 Focus Group Discussions (FGD).

Agroup discussions were conducted in the five selected kebeles, with selected participants based on various demographic factors (example sex, age, wealth, and level of education). These discussions was aim at obtaining general overview of experiences with the effect of climate change and variability on maize crop production and community based adaptation strategies used by the community, and the local perceptions on maize crop production vulnerabilities and adaptation mechanisms (autonomous and planned). Essentially, this exercise will help to identify indigenous knowledge on effects in local communities, and climate change factors associated with vulnerability, and adaptation to such effects. The research team will facilitate the discussions, but participants will have equal chance to express their opinions. Notes will be taken on issues once consensus will be reached among the participants. To generate the information needed, the discussion will begin with an introduction on the survey and criteria used to classify them.

4.2.3 Key Informant Interview (KII)

A key informant interview was a closely structured conversation with people who have specialized knowledge about the topic of interest. Information regarding about variability of rainfall and temperature its impact on crop production, and changes made by farmers on their crop farms in the past 30 years to adapt. Variability in rainfall, were collected from the key informants. The interviews were conducted with different individuals at different levels.

The interviews were conducted with farmers who have sufficient knowledge about the area and be able to memorize well its historical climate variability. Experts with early warning and crop production backgrounds in the district and kebele were also interviewed. key informant people who have level of specialized knowledge about the trend and climate variability of rainfall and temperature its impact on maize crop production, key informant including model farmer, development agent (DA) kebele leaders

4.4. Method of data Analysis

The data was collected from the survey entered into a computer for analysis mainly using micro soft Excel and Statistical Package for Social Sciences (SPSS version 16). Before running the analysis, some internal consistency checks were made to assess the quality of data. The analysis part consists of descriptive statistics (diagrams, charts, ratios, percentages, means, minimum, maximum, variances and standard deviations, frequency, tables and graphs) and inferential statistics was used to describe the socio-economic, demographic and institutional characteristics of the sample households.

In order to test the strength of the relationship between each predictor (independent variable) and dependent variable, after selecting the important variables data interpretation and analysis was employed to fit the data with best explaining variables. Whereas data collected through open-ended questionnaire, in depth interview, FGDs and documents was narrated following the quantitative data results. Long-term climatic data was analyzed and estimated variability by; Person's correlation, simple regression methods as well as coefficient of variability (CV).

4.4.1. Meteorological data diagnosis

Estimation of missing data: The raw data set obtained from GMSA had only 0.63% missing daily rainfall data (the whole Jan and Feb of 1989, and Dec 2019 with in the study area. These missing observations were reconstructed using the normal ratio method as described in Das (2009).

Quality controlled daily rainfall and temperature data of Abobo woreada station were summarized and analyzed to detect trends and variability of rainfall of the past three decades. The data summary was done using statistical software and the analysis was processed using an Excel macro named (SPSS version 16) created by Finnish Meteorological Institute (Salmi, 2002).

4.4.1.1 Rainfall based determination of Meher season rainfall indices

This study employed precipitation based model and defined onset date as the date when the 3 day accumulated rainfall is greater than 20 mm after a specified date (in this study the beginning of Meher: June 1st) provided that there were no dry spells longer than 7 days within the next 30 days (Tesfaye and Walker, 2004; Hadgu et al., 2013).

Off set date - is defined basically as the first day of a dry-spell (<1mmd-1) of at least 20 days duration that occurred after onset. However, if extended dry periods of more than 20 days occurred in mid-season and after which persistent rains returned, this definition might be modified (Segele and Lamb, 2005; Biazin and Sterk, 2013). The length of growing period - (in days) for a particular season was calculated as the difference between the Julian date numbers of the determined cessation date and the determined onset date for that season (Mugalavai et al., 2008; Hadgu et al., 2013).

Number of rainy days: Based on the definition of NMSA of Ethiopia, a day is considered as a rainy day if it accumulates 1mm or more rainfall per day (NMSA, 1996). The number of rainy days was, therefore, counted starting from the first day of June to September 30 (Kiremt season) in each year (Seleshi and Zanke, 2004). 51 Dry spell length: maximum numbers of consecutive dry days (<1 mm per day) were counted to determine dry spell length in Kiremt season (Hadgu et al., 2013; Muluneh et al., 2016). INSTAT+ v3.36 statistical software was used to summarize the daily data into annual, seasonal and monthly totals rain fall.

4.4.1. Trend Analysis

A variety of statistical methods have been applied to detect trends and other changes in hydrologic and climatic variables. These methods can be broadly categorized as parametric and non-parametric methods; parametric methods assume an underlying distribution (typically Normal) for the variables of interest, whereas non-parametric methods do not. As many hydrologic time series data are not normally distributed and with positive skewness, most researchers advocated the use of non-parametric trend detection methods over parametric (Karpouzos et al., 2010; Ayalew et al., 2012; Hadgu et al., 2013; Muluneh et al., 2016).

4.4.2. Variability analysis

The Coefficient of Variation (CV), the Precipitation Concentration Index (PCI), and the Standardized Rainfall anomaly (SRA) were used as statistical descriptors of rainfall variability (Bewket and Conway, 2007; Ayalew et al., 2012; Hadgu et al., 2013). Coefficient of variation gives an estimate of the degree to which rainfall important for agriculture is either stable or changing. It was calculated as indicated the equation.

According to Hare (1983) cited in Gebremichel et al.(2014), CV is used to classify the degree of variability of rainfall events as less, moderate and high. When 20<ي% it is less variable, between 20% and 30% is moderately variable, and greater than 30% is highly variable.

Inter Seasonal rain fall variability was analysis using the coefficient of variation (CV) According to Hare (1983). CV (%) valu are classified as the follows degree.

- <20% it is less variable
- between 20% and 30% is moderately variable
- greater than 30% is highly variable

4. CHAPTER FOUR

4. RESULTS AND DISCUSSION

Age of the household head (Age) The mean age of the respondents was 48.4 year and The results also indicated that average farming experience of the respondents was 30.56 years, and 78.9% of the respondents had farming experience of more than 20 years, implying that majority of them have first-hand experience of rainfall variability and its impact on Maize crop production at least for the last two decades. Studies indicated that age and farming experience often have significant effect on adopting climate change adaptation options ,although the direction of the effect varies across studies (Shiferaw and Holden, 1998; Deressa et al., 2009).

Farm size the average farmland size of interviewed households was 1.15 hectares per household that is slightly above the national average land holding of 1.02 hectares, implying that relatively better landholding in the area. The maximum and minimum landholding of the households was 2 and 0.5 hectares.

Family Size; the result indicated that the family size of the respondents varied from 2 to 10 with Maximum and minimum household size per HH, which is Large member of family size can adapt Climate Variability easily. Therefore.it was expected that household size has positive sign for the farmer who used adaptation method to Climate Variability.

Education Back ground educational status of the respondents was assessed and found that the 60 % of respondents did not attend formal education, whereas 40 % attended formal education. The result indicates that the household heads interviewed had low educational status. Educational status of HH head determine positively on access to information and subsequently to the adoption of adaptation technologies (Deressa et al., 2009). Thus, the low educational status of the majority of HHs had likely been limited them from access to and adoption of improved adaptation technologies and practices

.4.1. **Meteorological Data Analysis of study area**

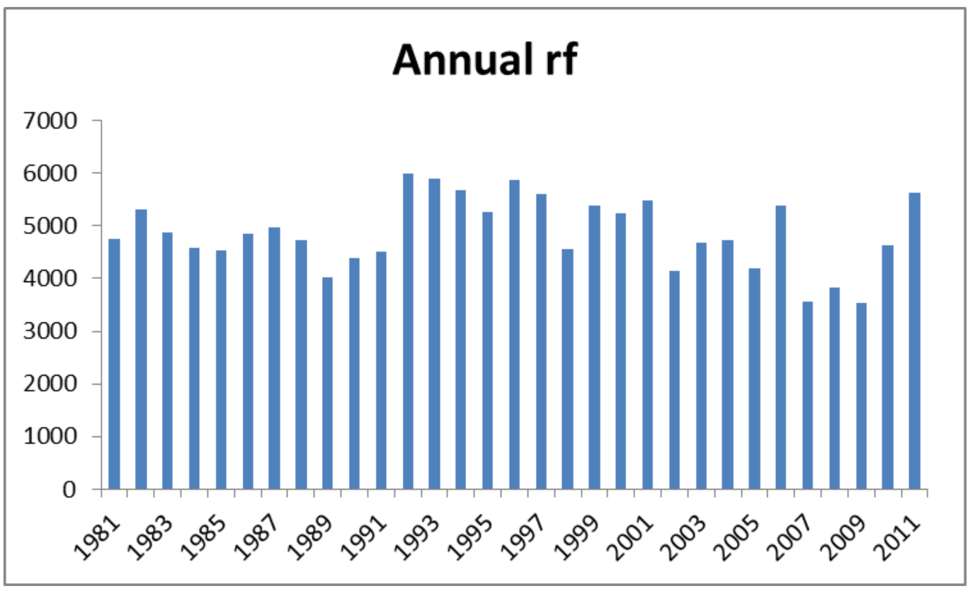
4.1.1 Inter annual variation trend of rainfall

The average Annual rainfall of the study area years 1981-2011 range from 300mm-900mm The minimum rain fall was 240mm and maximum 1146mm the rain fall analysis in study area showed that correlation significant was 0.05 and 0,01to maize production. The mean annual fall of those years the Coefficient of Variation (CV) 23.14 and standard division (SD) 612.49 are respectively. The Coefficient of Variation (CV) of rain fall of the study area was 23.14% the result showed that it was moderate rain fall variation.

Rain fall distribution is below in the years 1989-1991 it was dry land and wettest land years from1981-1988 it was Heavy rain fall in the study area

The annual rainfall distribution period of the study area was onset from April and offset at the end September over 80% of annual rainfall in the district occurring during this period. Heavy rainfall occurring in July and August are often not able to support high yield of maize crop as a result of late planting which is usually carried out during the second and third week of April and first week of May According to the Regional Meteorological Service of district, there was enough moisture during the rainfall amounts that were well above the previous planting season rainfall on maize production years' averages, as shown or indicating significant reduction in maize production. Rain fall throughout the growing season will have a cultivatable area which may in turn affect the household damaging impact on the maize crop yields especially in the food security.

Figure 1 Annual rainfall in the study area period (1981-2011)



Sources; Gambella metrology agency (2011)

In the study area the result forecast trend in crop yield in relation to moderate rain fall variability in Effects of Climate Variability on Maize production. Rainfall Coefficient of variation analysis showed that Climate variability on maize are most affects during planting season Development stage of crop and Flowering stage. Rainfall variability was relatively Moderate in yield and the various crop processes and activities in maize production. There has been a significant fluctuation and, there was negative coefficient variation on maize yield and production trends in the study area.

The dramatic variations in both maize yield and cultivatable areas both with significant down ward trend. The occurrence of climate variability such as may be characterized by a prolonged dry period or heavy rainfall spell or erratic rain fall coinciding with the critical stages of crop growth and development may lead to significantly reduced crop yields and extensive crop losses. Maize production in the study area has been on steady decline due to erratic rainfall variability like of Improved crop Varity. Like of chemical fertilizer and poor extension services.

Climatic variability: almost 80% of the district population is rural-based with livelihoods predominantly dependent on on rain fed agriculture Over the past years, multiple interrelated factors such as small fragmented land holdings and poor access to agricultural inputs, poor extension services, lack of market opportunity lack of access technology, lack of information of climate, lack of finance, poverty and high HIV/AIDS prevalence have contributed to chronic food insecurity and gradually weakening livelihoods .the agricultural system which is dominated by a single crop, maize, which is largely dependent on rain-fed agriculture has declined over the years due to rainfall variability and drought and flooding subsequently increasing households' vulnerability to erratic weather and food insecurity.

SEASONAL RAIN FALL(mm)

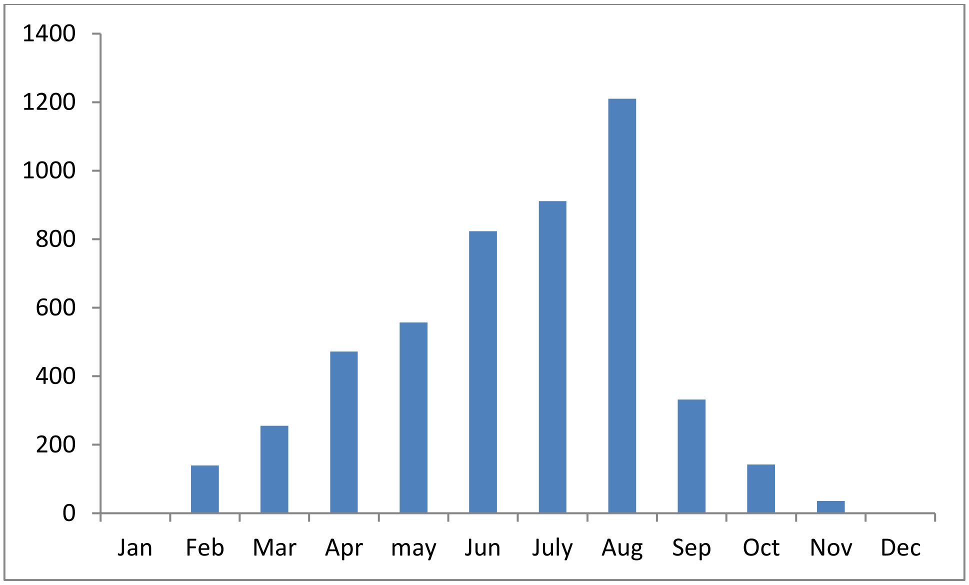


Figure 2. Average Meonthly rain fall distribution of the study area

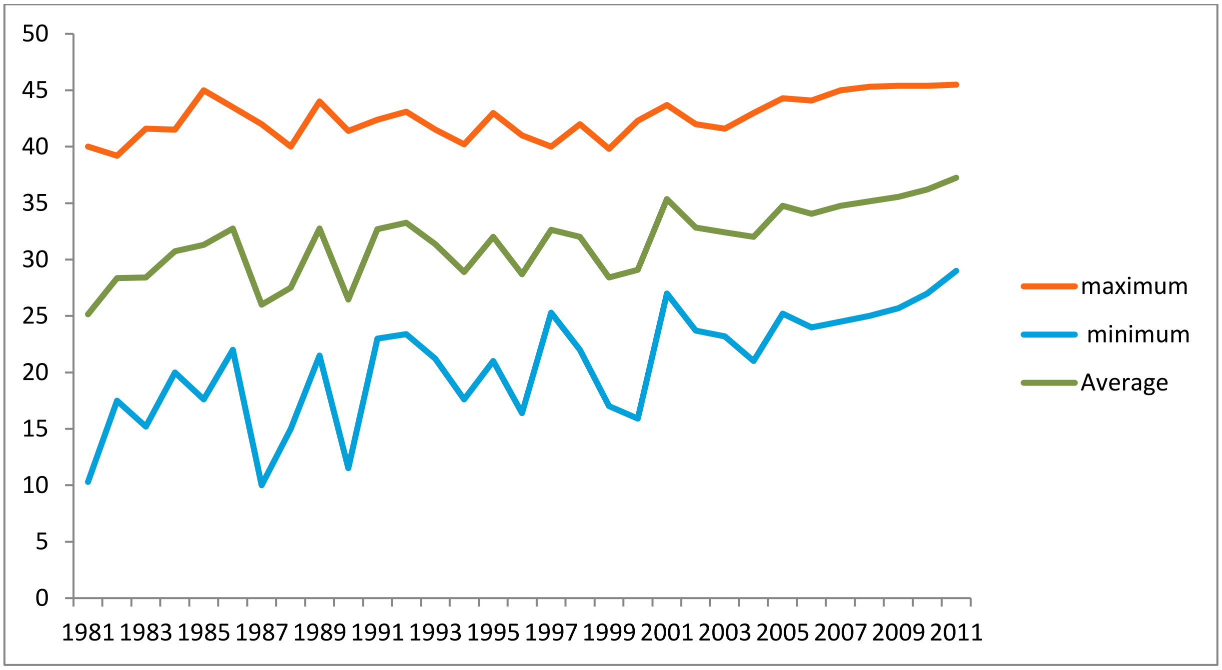
sources ;Gambella meteorology agency (2011)

In the study area the main annual rain fall season starts from (April to September) .the results indicated that the seasonal rainfall variation was started from February to November. Therefore it was high seasonal rainfall variation in the study area during the period (2011)

4.1.2. Inter annual variation trend of Temperature

The results of the current study showed that there was an increasing temperature. Inter annual temperature was observed in the study area. The average yearly maximum temperature of the study area was 37.25 while the minimum average temperature was 25.15and the (SD) 317.12 Coefficient of variant (CV) 10.05 the temperature over the past 30 years are increased.

Figure 3. Average Annual temperature of the study area Years 1981-2011



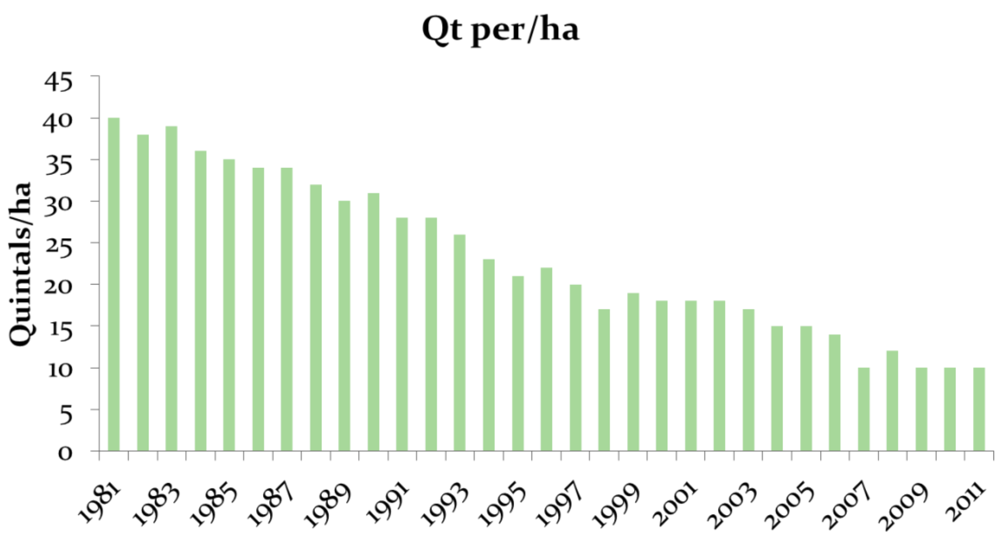
Sources Gambella metrology agency (20110

4.2. Effect of climate variability on maize production

4.2.1. Maize production of the study area for the year 1981-2011

The production of maize crop for the 30 years form 1981-2011 the maximum production of maize was (40 qt. /ha) are obtained during 1981 and the minimum production was (10 qt /ha) are obtained during 2009-2011 in the study area. And the maximum production was obtained Form 1981-1990 and the minimum or low production also obtained form2000-2011. Results indicated that the Coefficient of variation of maize production was (CV) 41.20 % it was high variation. The main reason for high variation or for the Declining of maize production in the study area was the main cause are irregular rain fall or erratic rain fall distribution, lack of input or improved maize variety, planting only maize crop variety though out the years and poor Extension services in the study area and declining soil fertility. . The indicators of Climate variability are Flooding and Drought .unseasonal pest and disease and the low in come farmers are more variable or more affected by climate variability than the other farmers. The total cropping land by maize 1225 hectare in 2010-2011 and beneficiary are 1156 Household male 636 and female 520 total 1156 beneficiary farmers for each farmer from 0.5-2 hectare the maximum is 2 hectare and the minimum is also 0.5 the average is 1.06 hectare

Figure 5; TREND OF MAIZE PRODUCTION



Sources Abobo **wareada agriculture offices(2011)**

4.3. Adaptive strategies

4.1.3 Crop-based Climate Variability Adaptation Strategies

Small holder farmer who perceived change in rainfall patterns were interviewed whether they made any adjustment in their crop production system to minimize the impact and/or optimize opportunities of the change in agriculturally-relevant rainfall indices. Accordingly, a large proportion of respondents (95.1%) reported that they were practicing at least one crop-based adaptation strategy in response to the perceived change. Among those farmers who practiced the adaptation strategies, the most common crop-based adaptation strategies identified were soil and water conservation practices, and use of resistance crop varieties, planting date adjustment, and crop diversification, Table 14 ,Deressa et al.(2009) also reported that planting trees, soil conservation, use of different crop varieties, changing planting dates and irrigation were commonly used climate Variability and change adaptation methods by the farming community level.

In the study area the main adaption was use crop resistance variety .Inter cropping and mixed crops.

The factor affect maize production in the study area according to the respondent the main factor are erratic rain fall (irregular rain fall) was 40 % ,lack of input 30% , lack of finical credit 10%and other decaling soil fertility 20%.

Table 2 Factor Affecting Maize production in the study area

Factors affecting maize production	% affected
Irregular rain fall	40%
Lack of input	30%
Lack of Credit	10%
Land degradation and pest	20%

Sources; Gambella agriculture office (2011)

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study attempted the impact of Climate variability of rainfall dependent on maize production. Climatic trend and farmers' perception adaptation strategy in abobo distract. The meteorological data confirmed that the rain fall of the study area is Characterized by greater inter-annual and seasonal variability with several empirical research finding conducted in gambella. The results is also described by alteration of wet and dry years in a periodic pattern over the past 30 years (1981-2011) Annual Temperature in the study area showed increasing trend over the past years (1981-2011) The study was confirmed that abobo distract found to be increasingly venerable to the risk of climate change and variability associated extreme weather events like drought and flood.

Maize production on the study area depends on natural precipitation. Rain fall variability affects its production. The results have shown that the less the rain fall variability. the less maize yield anomalies thus the more reliable the rain is needed for the maize production in the study area. Maize production showed considerably very high and significant correlation with the short season rain fall. whereas it showed a weak and non-significant correlation with main season rain fall even if it showed positive correlation. Warming temperature speed maize development so does it decreases growth period. It has also a negative relationship with maize production indicating that temperature decreases the yield of maize by shortening its growth period. Mean maximum temperature had the strongest (significant) positive correlation value with maize yield. Rather than mean minimum temperature in the study area.

The most common adaptation option in response to climate change and variability impact on maize production and farmer's adaption strategy in study area include crop diversification (diversifying maize verities with other crops) changing planting date .inter cropping and mixed cropping .

The results also confirmed that age of the farmers. educational level of the household head. Farm size. Farming experience. Frequency of extension contact. Credit utilization and having weather change information significantly affected farmers' choice of climate change adaptation measures. With this respect family size and gender household were not impose significant impact on farmers' choice of adaption.

5.2 Recommendations

To facilitate adaption option in response to maize production towards to climate variability stake holders should;

- Invest more in education because education households are more alert than non-educated and yield increasing technology. Packages that increase farm income in rural areas should be underlined as policy option to reduce the negative impact of climate change and variability.
- Install meteorological station in the woreada to full fill the information gap on climate/weather variability and monitoring of crop-climate relationship in the area in order to achieve improved maize yield.
- Encourage the farmer with improved agriculture inputs and draft power to insure rain fall risks .especially for smallholder farmers as they adopt improved agriculture production technologies to benefit from potentially unusually increase and decrease rain fall;
- Promote new crop variety such as adapted to drought. Nutritionally enhanced maize variety as well as drought tolerant like sorghum. Cassava and market-preferred common been variety and promote farming of dairy goats and poultry in appropriate.
- Integrate indigenous local technical knowledge with science-based knowledge in order to support adaption to climate change and variability.
- Integrate efficient agricultural water management practices with productivity enhancing intervention Irrigation to supplement crop water requirement should be promoted in abobo woreada.

6.REFERENCES

Aklilu A. and Alebachew A. 2008. Assessment of Climate Change-induced Hazards, Impacts and Responses in the Southern Lowlands of Ethiopia. Forum for Social Studies (FSS). Addis Ababa, Ethiopia

ATA, 2012. Maize Sector Development Strategy (Working Document 2013-2017) , Addis Ababa, Ethiopia: ATA

Barron, J., Rockström, J., Gichuki, F. and Hatibu, N., 2003. Dry spell analysis and maize yields for two semi-arid locations in East Africa. Agricultural and Forest Meteorology, 117(1-2), pp. 23-37

Berhanu, Y., Tesfa, M. and Bekele, M., 2015. Assessment of Climate Variability Context and Local Farmers' Adaptation Strategies in Halaba Special Woreda, Ethiopia.

Bradshaw, B., Dolan, H. and Smit, B., 2004. Farm-Level Adaptation to Climatic

Deressa, T. T. and Hassan, R. M., 2009. Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from Cross-section Measures. Journal of African Economies, pp. 1-26..

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T. and Yesuf, M., 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global environmental change, 19(2), pp. 248-255.

FAO, 1986. Early agro meteorological crop yield assessment. Plant production and protection. Paper 73, Rome, Italy: FAO.

International Journal of Environmental Monitoring and Protection, 2(5), pp. 84-93.

IPCC (Intergovernmental Panel on Climate Change). 2007. Mitigation of Climate Change: The Working Group III Contribution to the IPCC. Fourth Assessment Report

Jones E., Plassmann G., York H., Hounsome B., Jones D. and Canals L. 2009. Vulnerability of Exporting Nations to the Development of a Carbon Label in the United Kingdom. Environmental Science and Policy

Kandlinkar, M. and J. Risbey. 2000. Agricultural Impacts of Climate Change: If Adaptation is the Answer, What is the Question? Climatic Change 45: 529-539

CSA, 2015. National statistical abstract. [Online] Available at: http://www.csa.gov.et/images/documents/pdf_files/nationalstatisticsabstract/2006/total.pdf

Das, G., 2009. Hydrology and Soil Conservation Engineering including Watershed v Management. Second edition. New Delhi: PHI Learning Private Limited.

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T. and Yesuf, M., 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global environmental change, 19(2), pp. 248-255.

Deressa, T. T. and Hassan, R. M., 2009. Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from Cross-section Measures. Journal of African Economies, pp. 1-26.

FAO, 1986. Early agro meteorological crop yield assessment. Plant production and protection. Paper 73, Rome, Italy: FAO.pp. 982-1000.

APPENDIX

Appendix 1: Questionnaire for household survey

The objective of this questionnaire was to collect information which would be used for the study

on "trend and vulnerability of Climate changes and farmers' adaptive response on maize crop production in Abobo district". This study is going to be conducted for

the partial fulfillment of MSc degree in 'Climate Smart Agricultural and Land Scape Assessment at Hawassa University, Wondo Genet college of Forestry and Natural resource. Your full support and willingness to respond to the question is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and give appropriate and reliable information on the issues. Be sure that the information you provide is only for the purpose of this study.

Instruction to Enumerators

Greet the respondents in locally accepted style and introduce your self

Provide sufficient information on the objective of the survey and the importance of the data they are going to provide

Fill the information as stated by the respondent (don't put your own opinion)

Make the respondents feel free and ease of the communication by avoiding technical terms

Create friendly atmosphere of trust and confidence, so that respondents may feel at ease while talking to and discussing with the interviewer.

General Information

Date of Interview ---------------------- Name of Enumerator ------------------------
-

Name of the Kebele----------------- Mobile -----------------------------

Name of the village----------------- Signature----------------------

A. Household Demographic and Socio-economic Characteristics

1. Name of the HHH: ----------------------

2. Sex?

i. Male

ii Female

3. Age (years)? ------------------

4. Marital Statuses:

i. Single

ii. Married

iii. Divorced

iv. Widowed

5, Education

i. Did not attend formal education (cannot read and write)

ii. Did not attend formal education (can read and write)

iii. Elementary (grade 1-4)

iv. Junior (grade 5-8)

v. High school (grade 9-10)

vi. Above high school

6. Family size ------------

i. Male ---------------------

ii. Female ------------------

7. What is/are your main source/s of livelihood?

i. On-farm activities only

ii. Off-farm activities only

iii. Both on-farm and off-farm activities

8. Farm land size and allocation in ‘timed’ last year (2010 E.C)

B. Crop Production System of the HH

9. Do you produce or grow maize crops?

i. Yes

ii. No

10. How long have you been growing maize crops (years)? _________________

11. What type of verity of maize crop production did you practice with regards to water supply?

i. Rain-fed maize crop production

ii. Irrigated crop production

iii. Both rain-fed and irrigated

12. If field irrigated, source of water:

i. River

ii. Rainwater harvesting pond

i. Ground water pond

iv. Other, specify____________

13. In which season/s do you produce maize crops?

i. Bega season only

ii. Meher season only

iii. Both in Bega and Meher season

14. Major meher season crops

i. Haricot bean

ii. Maize

iii. Pepper seedlings

iv. Others, specify__________

15. Major Meher season crops and their cropping calendar during normal season:

Appendix 2 : Checklist for Focus Group Discussion

1. What are agriculturally-relevant to Climate Change and how they affect the performance of crop production?

2. Trends of these agriculturally important rainfall characteristics?

3. What are the impacts of these trends on crop production of your area?

4. How do farmers respond to adapt to these trends with regards to crop production?

5. What are the major barriers of adaptation in your area?

7. Cropping calendar of maize crops grown in the area?

8. In which growing stage do you think rainfall is critical for yield? And why?

9. How do farmers decide planting time of maize crops?

Appendix 3: Checklist for key informant interview

1. Name ______________________ Position/profession _____________________

2. What are the major crops grown in the area?

3. Crop yield trend in the past 30 years?

4. What are the major limiting factors in crop production system in the area?

5. What are agriculturally-relevant to climate characteristics and their trend in the past 30 years?

6. What are the impacts of climate trend and variability on crop production in the area?

7. What are the major crop-based adaptation strategies practiced by farmers in response to the change in trends and variability of climate?

8. Which periods in the growing season are the most critical to have climate for crop failure?

9. How do farmers decide sowing or planting date or how they judge when climate is sufficient for planting?

10. Do farmers in the area practice dry planting or do they wait for onset of rainfall?

12. Which kebeles are the most vulnerable to climate variability and why?

Appendix 3 Month rain fall distribution with stander division of 30 year(1981-192011) of abobo station

year	Jan	Feb	Mar	Apr	may	Jun	July	Aug	Sep	Oct
1981	0	40	350	500	600	700	850	900	750	45
1982	0	35.5	400	450	500	705	680	950	800	760
1983	0	0	250	0	500	800	850	1000	700	350
1984	0	0	250	300	600	650	750	1500	500	15
1985	0	54.14	265	400	550	780	850	1350	250	24.7
1986	0	200	250	500	700	760	900	1200	250	100.5
1987	0	34.6	200	400	600	650	850	1500	560	150
1988	0	0	250	350	500	780	900	1200	540	170
1989	0	50	200	250	600	700	100	1500	400	200
1990	0	100	130	300	450	550	900	1400	250	250
1991	0	150	200	450	500	620	750	1350	350	120
1992	0	300	360	500	450	1200	1200	1500	400	80
1993	0	238	350	400	450	1000	1250	1400	540	90
1994	0	230	400	550	600	1100	950	1400	320	100

1995	0	200	250	600	500	900	920	1420	400	75
1996	0	150	300	660	420	1200	1400	1200	450	77
1997	0	170	250	700	475	1350	1100	1200	250	82
1998	0	145	75	580	700	850	1000	900	200	98
1999	0	180	280	540	720	875	1300	1100	275	95
2000	0	160	350	600	800	900	900	1300	150	72
2001	0	150	380	640	810	950	960	1400	120	65
2002	0	54	250	380	450	1200	110	1500	160	32.3
2003	0	30.3	200	400	510	900	1200	1250	120	45
2004	0	120	220	250	560	720	1450	1300	72.6	25.9
2005		100	160	375	400	800	1000	1200	65.5	60
2006	0	1200	150	400	540	650	1350	1000	13.2	45.11
2007	0	100	160	450	400	540	920	960	16.21	10.12
2008	0	45	100	520	430	800	800	1100	11.6	9.5
2009	0	34.5	800	850	650	650	810	1200	22	120
2010	0	30.3	75	700	700	600	650	750	700	550
2011	0	24.5	67.4	650	600	650	600	570	650	500

Appendix 4 Annual temperature of the study area (1981-2011)

Years	maximum temperature	minimum temperature,	,
1981	40	10.3	
1982	39.2	17.5	
1983	41.6	15.2	
1984	41.5	20	
1985	45	17.6	
1986	43.5	22	
1987	42	10	
1988	40	15	
1989	44	21.5	
1990	41.4	11.5	
1991	42.4	23	
1992	43.1	23.4	
1993	41.5	21.2	
1994	40.2	17.6	

1995	43	21
1996	41	16.4
1997	40	25.3
1998	42	22
1999	39.8	17
2000	42.3	15.9
2001	43.7	27
2002	42	23.7
2003	41.6	23.2
2004	43	21
2005	44.3	25.2
2006	44.1	24
2007	45	24.5
2008	45.3	25
2009	45.4	25.7
2010	45.4	27
2011	45.5	29

Appendix 5 . Maize Crop production QT/Ha Obtained of the study area

Years QT no of Hectare, production (tones)

Years	QT	no of Heaters	maize production (tones)
1981	40	2100	
1982	38	2000	
1983	39	2000	
1984	36	1900	
1985	35	1920	
1986	34	1986	
1987	34	1987	
1988	32	1988	
1989	30	1989	
1990	31	1990	
1991	28	1991	
1992	28	1992	

1993	26	1993
1994	23	1994
1995	21	1995
1996	22	1996
1997	20	1997
1998	17	1998
1999	19	1560
2000	18	1500
2001	18	155
2002	18	1450
2003	17	1400
2004	15	1410
2005	15	1321
2006	14.5	1721
2007	10	1720
2008	12	1500
2009	10	1450
2010	10	1320
2011	10	1225

BIOGRAPHY

Atey Abowalla, the author, was born in Pynundo district, Gambella Region Ethiopia in September 10 1971 E,C. He attended his primary education at Pynundo primary schools. He completed his junior and high school education at Gambella Secondery School Comprehensive senior secondary school and then joined the Haramaya University, In 2000 E,C by Program of B.Sc. degree in Plant Sciences in July 2003 graduate, now I, worked in Gambella bearearu of Agricultural and Natural Resources.

I, pursued his graduate studies in Climate Smart and Agricultural Land Scape Assessment stream at Hawassa University Wondo Genet College of Forestry and Natural Resources in the Regulare program

	Maximum	Minimum	Avarage
2008	40	10.3	25.15
2009	39.2	17.5	28.3

2010	41.6	15.2	28.4
2011	41.5	20	30.7
2012	45	17.6	31.3
2013	43.5	22	32.7
2014	42	10	26
2015	40	15	27.5
2016	44	21.5	27.7
2017	41.4	11.5	26.4
2018	42.4	23	32.7

2008	40	10.3	25.15
2009	39.2	17.5	28.3
2010	41.6	15.2	28.4
2011	41.5	20	30.7
2012	45	17.6	31.3

2013	43.5	22	32.7
2014	42	10	26
2015	40	15	27.5
2016	44	21.5	27.7
2017	41.4	11.5	26.4
2018	42.4	23	32.7

Temparture data at long term in abobo station

	Maximum	Minimum	Avarage
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2010	41.6	15.2	28.4
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2018	42.4	23	32.7

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2016	44	21.5	27.7
2017	41.4	11.5	26.4
2018	42.4	23	32.7