CLIMATE CHANGE PERCEPTIONS AND ADAPTATION STRATEGIES OF SMALL HOLDER FARMERS ON MAIZE (*Zea mays* L.) PRODUCTION IN GUTO GIDA WOREDA, WESTERN ETHIOPIA

MSC THESIS

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DECLARATION

I Getahun Minase Amanuel declare that this Msc. thesis work entitled "Climate Change Perceptions and Adaptation Strategies of Smallholder Farmers on Maize (*Zea mays* L.) Production in Guto Gida Woreda, Western Ethiopia" is my original work and has not been submitted for a degree of award in any other university and all sources of material used in this thesis have been properly acknowledged.

Getahun Minase Amanuel	____________________	____________________
Name of Student	**Signature**	**Date**

APPROVAL SHEET I

This is to certify that the thesis work entitled "Climate Change Perception and Adaptation Strategies of Smallholder Farmers on Maize (*Zea mays* L.) Production in Guto Gida Woreda, Western Ethiopia" submitted in partial fulfillment of the requirements for the degree of Master of Science in Climate Smart Agriculture Landscape Assessment, the graduate program of the Department of Agro forestry, and has been carried out by Getahun Minase Amanuel, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Dr. Demelash Kafale	__________________________	____________________
Name of Main Advisor	**Signature**	**Date**

APPROVAL SHEET II

We, the Undersigned, members of the board of examiners of the final open defense by Getahun Minase have read and evaluated his thesis work entitled "**Climate Change Perception And Adaptations Strategies Of Small Holder Farmers On Maize (*Zea mays* L.) Production In Guto Gida Woreda, Western Ethiopia**" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Climate Smart Agriculture Landscape Assessment.

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Postgraduate Approval	**Signature**	**Date**

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LIST OF ABBREVIATIONS AND ACRONYMS

CSA	Central Statistics Authority
DA	Development Agents
ENSO	El-Niño Southern Oscillation
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GGA&NO	Guto Gida Agricultural and Natural Resource Office
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
JJA	June July August
JJAS	June- July – August- September
MAM	March April May
MEDC	Ministry of Economic Development and Cooperation
MLND	Maize Lethal Necrosis Disease
Mo A	Ministry of Agriculture
NGO	Non-Governmental Organization
NMA	National Meteorological Agency
PA	Peasant Association
RSCZ	Red Sea Convergence Zone
SON	September, October and November
SPI	Standard Precipitation Index
SSA	Sub Saharan Africa
TEJ	Tropical Easterly Jet
UNFCCC	Unite Nation Framework Convention on Climate Change
USD	United States Dollar
STJ	Sub-Tropical Jet
ITCZ	Inter Tropical Convergence Zone
RSCZ	Read Sea Convergence Zone,
TEJ	Tropical Easterly Jet

CLIMATE CHANGE PERCEPTION AND ADAPTATION STRATEGIES OF SMALL HOLDER FARMERS ON MAIZE (*Zea Mays* L.) PRODUCTION IN GUTO GIDA WOREDA, WESTERN ETHIOPIA

By: Getahun Minase Amanuel
Advisor: Demelash Kefale (PhD)

ABSTRACT

The impact of climate change on crop production system, particularly on maize producing smallholders is considered to be strong in our country in which maize is source of food and income. Therefore, a better understanding of small holder farmers' perception on climate change and adaptation strategies of maize producer is essential to develop proper measures that will avert its adverse effects. This study was thus conducted to assess long term climate change trends, farmers' perceptions on climate change and its effect on maze production, identify the existing adaptation strategies used by farmers as well as determinant factors that influence farmers' adaptation strategies to the changing climate in Guto Gida Woreda. Thirty four years meteorological data were accessed from NMA and field survey was conducted on 342 maize producing smallholder farmers using multistage random sampling technique in three kebeles. Descriptive statistics such as percentage and frequency, Logit and MNL models, were used to analyze the data. SPI, MK trend test and CV were also used to evaluate the long term climate especially rainfall and temperature trends in the study area. The results showed that, the rainfall amount is in decreasing trend at a rate of 5.77mm annually along with 23.5% of variability, despite the variability during maize planting period (MAM) is about 36.3%. Moreover, about 75% of the wet years were recorded before 2000, while 71% of the dry years occurred after 2000, confirming that the occurrence of wet years is declining whereas drought incidence is increasing. Although, the annual amount of rainfall showed declining trend, maize productivity continued to increase in the woreda, since the rainfall during maize growing period was relatively stable. The annual mean temperature showed increasing trend at a rate of 0.037°C annually, The increasing trend was consistent and less variable as expressed by the CV values of 16.8%,. Descriptive statistics on the perception level of the sample households indicated that 85% of them perceive that late rainfall onset is the major indicator of climate variability followed by early offset 84%, leading to reduction of maize growing period and yield reduction. The main adaptation practice being exercised by the farmers in response to climate change was maize crop rotation with pulses implemented by 82%, followed by using different maize varieties practiced by 77% of the respondents. The results also indicated that, the determining factors for their choice of adaptation strategies are related to; sex, education, family size, farm size, membership of local organization, access to extension services, credit, market, climate observation and weather information. Additionally, the study identified bottlenecks of adaptation measures to climate change to be; land degradation, lack agricultural technologies, limited farm land, and market opportunities. Thus, there is a need to focus on addressing the major determinant factors and alleviating bottlenecks to promote the implementation of suitable adaptation measures and climate smart agriculture practices among the smallholder farmers.

Key words*:* Climate Variability, Maize Yield, Adaptation Barriers, Smallholders, Climate Change Impact

1. INTRODUCTION

1.1. General Background

Globally the climate has been changing in the past and may continue to change in the future. The striking increase in temperature of our planet has been affected the agricultural Production and also the livelihood of farm households around the globe. Unless some important measures are taken to control emissions, accumulation of the greenhouse gases in the atmosphere is expected to substantially increase over the coming decades (Mendelsohn, 2008). This trend may observably continue causing many impacts on different sectors especially on agriculture that could withhold the world's economy. The effect of climate change on crop production is also likely to be increasing through time (Mendelsohn, 2008 and Salvatore, *et al.*, 2011).

The negative effects of climate change especially on the agriculture of developing countries are expected to be even harder. Accordingly, climate change would cause more negative effects on crop yields of low-income countries where adaptive capacity is low (IPCC, 2011). According to IPCC projections, the negative effects of climate change on food crops would be most serious in drought-prone areas of sub Saharan Africa (SSA). In this part of Africa, climate change could reduce agriculturally suitable land area and rain-fed crop yields as much as 50 percent by 2020 (IPCC, 2007).

In SSA, agriculture is practiced by millions of small scale and poor farmers that produce food crops for subsistence. Low land productivity and harsh weather conditions due to high average temperature, and scarce and erratic rainfall are the main futures that hinder the agricultural productivity of the Region. Because of the low level of economic diversification and reliance on rain-fed agriculture, development prospects in this part of Africa are closely associated with climate change and projected to further food insecurity (Cline, 2007).

Ethiopian agricultural sector is considered as a pillar of the economy and remains playing the leading role in the country's economy for many reasons (MOA, 2010). The sector directly supports about 83% of the population; contributes over 40% of the country's gross domestic product (GDP). It generates about 85% of export earnings and supplies around 73% of the raw materials for the country's agro processing (ADB, 2011). On the other hand the sector is dominated by small-scale farmers, who are dependent on rain-fed mixed farming system and use traditional technologies with low inputs.

Research evidences discovered that agricultural sector of the country has been highly affected by climate related hazards (Deressa, 2007). The long-term climatic change related to changes in precipitation patterns, rainfall variability, and temperature is most likely to increase the frequency of droughts, floods and food insecurity in Ethiopia. The country's heavy dependence on rain-fed and subsistence agriculture increases its vulnerability to the adverse effects of these changes (Gissila *et al*., 2004).

1.2. Statement of the Problem

Climate change is a major challenge for crop production in Ethiopia particularly for maize production, since it is predominantly produced by rain-fed agricultural system. Perhaps, maize is the single most important crop in terms of both number of farmers engaged in cultivation and consumption in Ethiopia specifically it covers about 65% of the cultivated land in the study area.

Adaptation to climate change requires farmers' first notice and better understanding about the changing climate in order to identify potentially useful adaptation strategies and implement them. Hence there is the need to understand how farmers perceive about climate change and adaptation in order to steer future strategies. Some studies indicate the importance of farmers' perception on climate change reduce its negative impacts (David *et al.*, 2007). Also studies (Maddison, 2006; Hassan and Nhemachena, 2008) further showed that, perception or awareness of the farming community about climate change and respective adaptive measures are influenced by different socio-economic, institutional and environmental factors. Therefore, Climate change perception and adaptation strategies are believed as important mechanisms to reduce the negative effect of climate change.

Maize is one of the major food crops in Ethiopia particularly in Guto Gida district of East Wollega zone and copping the negative effects of climate change on maize productivity and livelihood of maize producing smallholder is crucial. Therefore, the study was designed to investigate long term climate trends and the relationship with maize yields, as well as to assess the perceptions on climate change and adaptation strategies of maize producing farmers thereby suggest possible course of action in the study area by setting the following specific objectives:

1.2 Specific Objective of the study's

- ✍ Assess long term rainfall and temperature trends in the study area
- ✍ Investigate farmers' perceptions on the climate status and its effect on maze production
- ✍ Evaluate the existing adaptation strategies used by maize producing farmers in response to climate variability and change
- ✍ Identify determinant factors that influence farmers' the adoption of important adaptation strategies to the changing climate

1.3. Research Questions

- ✍ Were there changes in climatic condition in the last three decades in the study area?
- ✍ Are small holder maize producing farmers perceived climate change and its adverse effect on their maize production or yield?
- ✍ What are the potential effects of climate variability on maize yield at the study area?
- ✍ What kind of adaptation strategies are used by small holder maize producing farmers in the study area in response to climate variability and change?
- ✍ What are the challenges of current adaptation strategies to climate variability in study area?

1.4. Significance of the Study

As a whole, this study can be taken as an assessment of the climate change perception of farmers' and their adaptations options for their maize production, in order to provide a meaningful contribution to efforts aimed at ensuring sustainable development of the country particularly for the small holder maize producing farmers. Therefore, the study was conducted on the basis of samples in Guto Gida, that can be superimposed to all districts in the adjacent woreda's of the western part of Ethiopia in general and Oromia in particular, and can be extended to other maize producing woredas of similar agro ecological environment that are under the impact of climate change and play significant roles on farmers livelihood and adaptation strategies.

1.5. Scope of the Study

This study was depending only on maize producing small holder farmers of Guto Gida district. While it is desirable to include in more wide areas, the research was conducted in restricted three kebeles of Guto Gida district based on the agro ecology and extent of maize production of the kebeles due to the shortage of time, financial and lack of necessary logistics.

2. REVIEWS OF RELATED LITERATURES

2.1. Concepts of Climate Change and Adaptation Strategies

Climate is usually defined as the average weather or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time from months to thousands or millions of years. Climate change refers any change in climate over time through natural variability or as a result of human activities (IPCC 2007). Climate change refers a change of climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable time period (UNFCCC Article 1, 1992).

Adaptation is defined in different ways. For instance, (IPCC, 2012) defined adaptation as the process of adjustment of human systems to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. IPCC (2001) also defined adaptation as 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). 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. Adaptation to climate change is generally defined as the process of adjusting or intervening in natural or human systems intending to respond to actual or anticipated climate change or its effects. It is the process of improving society's ability to cope with climate change and its effects across time scales, from short term. It is a mechanism that helps in managing the losses or exploiting beneficial opportunities presented by climate change. Adaptive capacity is defined as the ability of a system to adjust to climate change and its effects, to moderate potential damages and to take advantage of opportunities (IPCC, 2001).

Adaptation in agriculture is identified as one of the policy options to reduce the negative impact of climate change on agricultural productions (Kurukulasuriya, *et al., 2006*). Adaptation in agriculture occurs at two main scales: household-level (micro) and national level (macro). Micro-level analysis of adaptation in agriculture focuses on tactical decisions that farmers make in response to seasonal variations in climatic, economic, and other factors. The most common micro-level adaptation options in crop agriculture include crop diversification, using irrigation, mixed crop livestock farming systems, using different and new crop varieties that are better suited to drier conditions, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops (Temesgen, *et al*.,2008).

Different factors can affect climate change adaptation options in crop production at household. These factors can generally be classified as climate variables, household and farm characteristics, infrastructure, and institutional variables. The most commonly cited climatic variables include change in temperature, precipitation level and rainfall patterns.

Household characteristics include age, education, farming experience, marital status, and gender of the head of household and household income. Farm characteristics include farm size, fertility, and slope; institutional factors include access to extension and credit; and infrastructure includes distance to input and output markets (Temesgen, *et al*., 2008). Constrains that can limit the capacity of households to respond to climate change in crop agriculture include lack of information, lack of education, lack of money, shortage of labor, Shortage of land, poor potential for irrigation, lack of market access for inputs and out puts and health factors (Temesgen, *et al*.,2008; Nhemachena, *et al*.,2007). Information concerning climate change forecasting, adaptation options and other agricultural production activities is an important factor affecting use of various adaptation measures for most farmers. Lack of information (about seasonal and long-term climate changes and agricultural production) can increase high downside risks from failure associated with uptake of new technologies and adaptation measures (Salvatore, *et al*. 2011; Nhemachena, *et al*.,2007; Jones, 2003 and Kandlinkar, *et al*., 2000). Lack of money and other resource limitations and poor infrastructure are likely to limit the adaptive capacity of most rural farmers. Shortage of Labor is also deemed as an important input constraint. Households with more labor are believed to be better able to take adaptation measures in response to changes in climatic conditions compared to those with limited labor (Temesgen, *et al*., 2008). Farmers with lack of money and limited resources will fail to cover costs necessary to take adaptation measures and thus may not make beneficial use of the information they might have (Kandlinkar, *et al*., 2000).

2.2. Climate Characteristics of Ethiopia

2.2.1. Seasonal classification

There is an accumulating body of evidence regarding the climate of Ethiopia or of certain region of the country (Gissila *et al, 2004*; Segele and Lamb, 2005; Korecha and Barnston, 2007). Due to variation in topography and it geographic proximity to the equator and Indian ocean, the country experiences large spatial as well as temporal variation in temperature and precipitation (Fazzini *et al*, 2016). The country's climate system is largely influenced by a range of factors, including complex topography and migration of atmospheric circulations. The country's climate has distinct seasonal characteristics. According to national meteorological agency of Ethiopia (NMA, 1996), cited in (Fazzini *et al*, 2016) the three distinct seasons are, the dry season-locally called bega (October – January), the small rainy seasons-locally called belg (February – May), and the main rainy season-locally called kiremt (June – September). A brief description of each season and the mechanisms for rainfall formation are given below.

2.2.2. Kiremt season

During kiremt season, moist air flow is mainly dominated by zone of convergence in low pressure systems, which is usually accompanied by north-south-north oscillatory of inter tropical convergence zone (ITCZ). Major Rain-producing systems during kiremt include the north ward migration of the ITCZ, development, and persistence of the Arabian and the Sudan thermal lows, development of quasi-permanent high-pressure systems over the South Atlantic and South Indian Oceans, development of tropical easterly jet (TEJ) and its persistence, and generation of low-level jet (Somali Jet). The Somali Jet is widely popular for both East African and Southeast Asia monsoon as it enhances low level southwesterly moisture flow towards the regions where JJAS is the main rainy season. It is to be noted that Kiremt rainfall covers most of the country with the exception of some part of south and southeast of Ethiopia (Fazzini *et al*, 2016).

2.2.3. Bega Season

As indicated again by Fazzini *et al*, (2016) during bega season, the country predominantly falls under the influence of dry and cool north easterly winds. These dry air masses originate either from the Saharan anticyclone and/or from the ridge of high pressure extending into Arabia from a large high pressure over Siberia, central Asia. However, very occasionally, northeasterly winds get interrupted when migratory low-pressure systems originating in the Mediterranean area move eastward and interact with the equatorial/tropical systems, resulting in rainfall over parts of central Ethiopia. In addition to this, occasional development of the Red Sea convergence zone (RSCZ) affects coastal areas. In bega, most of the country is generally dry; the exception is the south and southeast of Ethiopia, which receives its second important seasonal rainfall in this period (Korecha and Barnston, 2007).

2.2.4. Belg season

The belg season coincides with the domination of the Arabian high as it moves towards the north Arabian Sea. Major systems during the belg are the development of a thermal low (cyclone) over the south of Sudan, and winds from the Gulf of Aden and the Indian Ocean highs that are drawn towards this center and blow across central and southern Ethiopia,

These moist, easterly and southeasterly winds produce the main rains in Southern and Southeastern Ethiopia and the belg rains to the east-central part of the northwestern highlands (Fazzini *et al*, 2016).

2.3. Impact of climate change in Ethiopia

Ethiopia is one of the most vulnerable countries in the world to the impact of climate variability, change and with least capacity to respond (IPCC, 2007; Zegeye Haileab, 2018). Climate change causes wide-ranging effects on the environment, socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity (Gebeyehu Getaneh and Zerga Belay, 2016; Zegeye Haileab, 2018). Similarly, the mainstay of the Ethiopian economy is rain-fed agriculture, which is heavily sensitive to climate variability and change. In addition, many species with limited geographical opportunities, restricted habitat requirements and small populations are typically the most vulnerable (IPCC, 2014); Zegeye Haileab, 2018). Ethiopia is experiencing the impacts of both climate variability and change.

Climate change has led to recurrent droughts and famines, flooding, expansion of desertification, loss of wetlands, loss of biodiversity, decline in agricultural production and productivity, scarcity of water, and increased incidence of pests and diseases.

Climate change is likely to aggravate environmental degradation, food insecurity, water scarcity, disease epidemics and poverty in Ethiopia (Kidanu Aklilu *et al*., 2009; EPA, 2012; Zeray Negussie and Demie Ashebir, 2015; Zegeye Haileab, 2018). Practical evidences also shows that farmers perceived climate change in terms of changes in rainfall and temperature, increase in drought condition, crop pests and diseases had significant impact on farmers' households whose income depends on rain fed farming. According to H. Daba Mekonnen (2018) finding discovered that the impacts of climate in rural areas include reduced in crop yield (49%); increase in pest and disease (34%) and soil erosion (98%). At national level, World Bank (2010) suggests that climate change may reduce Ethiopia's GDP compared to a baseline scenario by 2-6% by 2015, and by up to 10% by 2045.

2.4. Climate Change and its Impacts on Agriculture in Ethiopia

Climate change in the country is mainly manifested through the variability and decreasing trend in rainfall and increasing trend in temperature (Addisu Solomon *et al*., 2015). Besides, rainfall and temperature patterns show large regional differences.

For the IPCC mid-range emission scenario, the mean annual temperature will increase in the range of 0.9 -1.1 °C by 2030, in the range of 1.7 - 2.1 °C by 2050 and in the range of 2.7-3.4 °C by 2080 over Ethiopia compared to the 1961-1990 normal (Asaminew Emerta, 2013 ; EPA, 2012). Average annual temperature nationwide is expected to rise 3.1°C by 2060 and 5.1°C by 2090. In addition, precipitation is projected to decrease from an annual average of 2.04 mm/day (1961-1990) to 1.97 mm/day (2070-2099) for a cumulative decline in rain fall

25.5 mm/year (Kidanu Aklilu *et al*., 2009). In addition to climate projections suggest an increase in rain fall variability with a rising frequency of both severe flooding and drought due to global warming (World Bank, 2010).

2.4.1. Rainfall variability

The rainfall is highly variable both in amount and distribution across regions and seasons (Tilahun, 1999; Mersha, 1999). The seasonal and annual rainfall variations are results of the macro-scale pressure systems and moisture flows which are related to the changes in the pressure systems (Haile, 1986; Beltrando and Camberlin, 1993). The most important weather systems that cause rain over Ethiopia include Sub-Tropical Jet (STJ), Inter Tropical Convergence Zone (ITCZ), Read Sea Convergence Zone (RSCZ), Tropical Easterly Jet (TEJ) and Somalia Jet. The spatial variation of the rainfall is, thus, influenced by the changes in the intensity, position, and direction of movement of these rain-producing systems over the country (Taddesse, 2000). Moreover, the spatial distribution of rainfall in Ethiopia is significantly influenced by topography which also has many abrupt changes in the Rift Valley. He showed that, the highest mean of annual rainfall over 2,400mm, is in the south-western high lands of Oromia region. However, the amount of rainfall gradually decreased to about 600mm in the north, less than100mm in the north-east in Afar depression and to round 200mm in the south-east Ogaden desert. The studies of Daba (2018) on Agro Climatic Characterization in western Oromia identified that, the highest rainfall is recorded in kiremt and the lowest is in bega. Furthermore, annual rainfall is highest over the Ilu Aba Bora, Jimma and Easts Wellega, while the West Shewa and the Qelem Wellega receive less rainfall. However, the detail spatial and temporal variability of rainfall over the horn of Africa in general and Ethiopia in particular is highly complex and not well known yet. This variability of the rainfall and recurrent droughts in the country affects the lives of millions of people whose livelihood is mainly dependent on subsistence agriculture.

2.4.2. Onset and Cessation of Seasonal rainfall

Different Studies have shown that the number of rainy days serves as a marker that can be used to verify the distribution of rainfall. During the length of growing season of crops, farmers expect a balance between the distributions of rain days and moderation in rainfall amounts per rain days throughout the season. A fall in the number of rain days associated with an increase rainfall per rainy day signifies an increased in the intensity of rainfall (Fraser *et al*., 1999). An increase in the intensity of rainfall may result in potential serious risk of an increased flood frequency and severity for most region of the world (Gordon *et al*, 1992; Flower *et al*., 1995). High daily rainfall may be responsible for potentially destructive to agriculture in sensitive areas that are prone to flood. This situation could compound the problem of food shortages and led to unprecedented food price increases. The study of Fraser *et al*., (1999) also revealed that increase in the number of rain days does not depict high amount of rainfall.

The onset of rains, which is defined as the first occasion after a selected date when the rain accumulated over three consecutive rainy days is at least 20mm and no dry spells of more than 7 days in the next 30 days was used as a successful planting data (Sivakumar, 1988). The onset of rainy season is a very important event for farmers in Sub-Sahara Africa. The onset of rains mark the beginning of three main activities; planting, weeding and Harvesting (Omotosho, 1990). This enables to determine the socio-economic life and survival of the farming household. The importance of farming in the lives of these households also affect other activities, Planting that depends and is influenced directly by the onset of the rainy season is the first activity, which the other two activities are based. Significant shifts in the onset of rains will therefore affect both agriculture and many other non-agricultural activities of small-scale farmers. Several researchers have reported how variability of the onset and cessation of the rainy season in tropical region pose a serious challenge in the process of determining when the rainy season/planting season begins (Oladipo *et al*., 1993). The cessation of the rainy season, which is defined as a decadal rainfall amount is less than half of the corresponding reference evapo transpiration at the end of rainy season and length of growing, is the difference between cessation and onset of rainfall. Studies in Ethiopia revealed that rainfall variability, unreliable occurrences in sufficient amount and delay in onset dates caused significant reduction in crop yield with reasonable amount almost all parts of the country (Godswill *et al*., 2007). According to Feyissa (2009), in prolonged drought spell and belg rain failure over Siraro district in 2007/2008 were caused the loss of 862,400 quintals of yield and the household suggested that erratic rainfall period has increased an opportunity for crop pest. Similarly, shortage of the belg rain was accounted for crop production reduction in 2003, 2004 and 2008 in Shashemene.

2.4.3. Impact of rainfall variability on agricultural

According to several literatures, most of the time agricultural planning in Ethiopia is difficult during small rainy season due to erratic nature of the rains. Moreover, in relation to El Niño-Southern Oscillation (ENSO) phenomena, significant year to year variation in the performance of the rainy season has favored the agricultural activities of the country mainly due to the eastward moving mid latitude troughs facilitate the interaction between the mid latitude cold air with tropical warm and moist air so that unstable conditions often produce abundant rains during the small rainy season (February to May). Studies in Ethiopia have shown that rainfall variability usually result in reduction of 20% production and 25% raise in poverty rates in Ethiopia (Hagos *et al*., 2009; Osman and Sauerborn, 2002). Moreover, a 10% of decrease in seasonal rainfall from the long term average generally translates in to a 4.4% decrease in the countries food production. Rainfall in much of the country is erratic and variable and the associated drought have historically been the major cause of food shortage and famine (Wood, 1997; Pankhart and Johnson, 1998). Economic dependence of agricultural sector in Ethiopia on natural rainfall makes the production projected to be widen variation of yields and spatially and temporary. In line with this, the recorded famine in Ethiopia in 1973 and 1984 mainly due to severe drought and hence caused crop damage and decline of food availability in the country (Degefe and Nega, 2000).

In Ethiopia, Lemi (2005) analyzed crop yield and rainfall data found out that crop yields are negatively affected by rain. The results in his study further showed a positive correlation between meher season rainfall and crop yield. For instance, meher (JJAS) rain (r = -0.218 and r = -0.359) had low to moderate negative correlation with yield in Gojjam and Gondor province in Ethiopia, respectively. On the other hand, meher rain (r =-0.191 and (r =0.160) had low negative and positive correlation with maize yield at both location in the country. However, belg rain (r = 0.034) and (r =-0.187) had low positive and negative correlation with maize at both location. Another study by Beweket (2009) showed that, results of correlation analysis between monthly, seasonal and annual areal average rainfalls and production of teff, barley and wheat production, for example show considerably high correlations with the kiremt rainfall. Similar, a study by Admassu (2004), using climate and crop data for the period 1994-2001 stated that, total annual rainfall does not show strong correlation with the production of cereal crops such as teff, barely, wheat and maize in the study areas except for annual rainfall with wheat production in the second study area (South Wolo, Oromia and North Shoa Zones). Total belg rainfall does not also show significant correlation with production of cereals of teff, barely, wheat and maize in the study areas except for belg rainfall with barley and wheat production in the third study area (West and East Welega).

2.4.4. Temperature Variability in Ethiopia

According to its topography, Ethiopia had been experiencing different amount of temperatures under different years. (NMSA, 1989) cited in (Senait *et al*., 2010) explained that, the highest mean maximum temperatures is about 45^{o}C from April to September and 40^{o}C from October to March are recorded from Afar depression in north east Ethiopia. The north western lowlands experience mean maximum temperature of 40^{o}C in June and the western and south eastern lowlands with mean maximum temperatures 35^{o}C to 40^{o}C during April. The lowest mean temperatures, of 4^{o}C or lower are recorded at night in highland areas between November and February. According to Senait *et al*. (2010), based on poverty, vulnerability and climate variability, the mean annual temperature of Ethiopia also varies widely, from lower than 15°C over the highlands to above 25°C in the lowlands. Several sources indicate that temperatures are rising: Between 1951 and 2006, the annual minimum temperature in Ethiopia increased by about 0.37°C every decade. Between 1960 and 2006, the mean annual temperature increased by 1.3°C, at an average rate of 0.28°C per decade.

Some sources assert that “the past 10 years have been substantially warmer than the 1986 – 1999 average (World Bank, 2011; Mc Sweeney and Lizcano, 2008). According to USAID (2015), the technical report on climate variability and change in Ethiopia reported that, maximum temperatures during kiremt season varies between 0.4 - 0.6 ^{o} C/decade in Amhara, Oromia, Afar and Tigray region

2.4.5. Impacts of Temperature variability on Agriculture in Ethiopia

Air temperature is the most important climatic variable that affects growth, development and survival of plants (Mavi and Tupper, 2004). Growth of higher plants is restricted to temperature between 0C^{o} and 60C^{o} and crop plants are further restricted to a narrower range of 10 to 40 C^{o}. However, each species and variety of plants and each age group of plant has its own upper and lower temperature limits. Beyond these limits, plants become considerably damaged and may even be killed. It is therefore the amplitude of variations in temperature, rather than its mean value, that is more important to plant growth. Rise in temperature, particularly in low and mid-latitudes, causes variation in crop production by inducing early flowering and shorten the grain filling period, which in turn reduces productivity per unit area. In general, higher temperatures as a result of climate change and variability could cause greater stress to crops in tropical areas as higher temperature can be enhance evaporation of water from soil. A recent meta-analysis of fully fertilized maize experiments in southern and eastern Africa showed that an increase in the temperature during the growing season can lead to a significant decrease of 3% in maize grain production (Lobell *et al*., 2011).Hence the optimum temperature for germination is 18oC- 21C^{o}; below 13 C^{o} it is greatly reduced and fails below 10C^{o}.

2.5. Farmers' perception on climate variability and change in Ethiopia

Understanding of local people's perception on environmental conditions is crucial to design and implement appropriate adaptation strategies to climate change and variability (Bewket Woldeamlak, 2012). Different studies in different part of Ethiopia shows that small holder farmers' perceived the occurrence of climate variability and change in terms of increase in temperature, decrease in rain fall and change in time of rain, change in the onset of rains, erratic rain fall patterns (Bewket Woldeamlak, 2012). The indicators for what they perceived from studies is weather related to problems such as soil erosion, loss of soil fertility, reduction in agricultural production, high rate of disease occurrence and frequent occurrence of drought (Mengistu Dejene K., 2011 ; Alem Kidanu et al., 2016 ; Wolka Kebede and Zeleke Gizachew, 2016 ; Yayeh Desalegn and Leal Filho, 2017 and Hameso Seyoum, 2018).

Studies also compares the farmers perception on climate change against climatological data shows that there is no evidence of reduction in the amount of rain fall data due to high inter annual variability(Amadou *et al*., 2015). According to Mekasha Aklilu *et al*. (2016) indicates that household across the three eco-environments(pastoral, agro pastoral and mixed crop-livestock high land perceived increasing number of extreme warm days and warm nights and decreasing number of extreme cool days and cool nights. This house hold perception agreed with the record extreme temperature. Deressa Temesgen *et al*. (2011) indicates that farmers' perception of climate change is significantly related to the age of the head of house hold, wealth and knowledge of climate change, social capital and agro ecological setting.

2.6. Adaptation strategy to climate variability and change in Ethiopia

Climate change as a global community agenda based on intergovernmental panel on climate change is created by Kyoto protocol (IPCC, 2007). In Ethiopia, through the National Adaptation Program of Action (NAPA) process, priority activities are identified that address immediate climate change adaptation needs of the country. These activities broadly focus in the areas of human and institutional capacity building, improving natural resource management, enhancing irrigation agriculture and water harvesting, strengthening early warning systems and awareness raising quite relevant areas in improving Dry lands livelihood systems (Kidanu Aklilu *et al*., 2009). Ethiopia has prepared its Intended Nationally

Determined Contribution (INDC) document to implement both mitigation and adaptation initiatives. To reduce the vulnerability of the population, environment and economy to the adverse effect of climate change, The Ethiopian Government has already put in place a number of policies, strategies and programs aimed at enhancing the adaptive capacity and reducing climate variability and change.

Thus, the country's Climate-Resilient Green Economy (CRGE) focuses on four pillars (namely agriculture, forestry, renewable energy, and advanced technologies) that will support Ethiopia's developing green economy. Due to this Ethiopia has planned to achieve middle income status in 2025 by climate resilient green economy through a green growth path that fosters development and sustainability (FDRE, 2011).

2.6.1. Challenges of adaptation strategies

Many challenges can exist at local and national level that weakens the power to overcome negative impacts of climate change. Ngigi, (2009) stated poor infrastructure and associated lack of financial resources restricts the availability of adaptation options, especially for smallholder farmers, whose investment decisions depend on good prices for their product and expected economic returns. In addition lack of technology has the potential to seriously impede communities' ability to implement adaptation options by limiting the range of possible responses and interventions. This document showed that, poverty is directly related to vulnerability, and is therefore a rough indicator of the ability to cope and adapt. In addition, this study provided that, adaptation and adoption of new technology costs money and because poor communities have less diverse and more restricted entitlements, they lack the empowerment to adapt, locking them into a vulnerable situation. Similar study by (Ngigi, 2009) affirmed that, although awareness of and sensitization to the development and utilization of new technologies are a key to strengthening adaptive capacity; technology choices are limited by inadequate financial resources and knowledge. He has also mentioned that, lack of access to land, information, and credit are the main challenges of adaptation strategies in Ethiopia. On the other hand, (Ngigi, 2009) has explained poor governance as a major hindrance to socioeconomic development and adaptation to climate variability. Indeed, poor governance not conducive to addressing climate risks and easing the hardship of the people.

2.6.2. Farmers' Adaptation Effort in Ethiopia

Climate change adversely affects Ethiopian economy due to heavy dependence of the agricultural sector on rainfall (Gashaw Temesgen *et al*., 2014). A decrease of rainfall and rise in temperature has been increasing the exposure of the country to frequent drought. According to Deressa Temesgen *et al*. (2011); Mengistu Dejene K. (2011); Alem Kidanu *et al*. (2016); Asrat Paulos and Simane Belay (2018) and H. Daba Mekonnen (2018) discussed in their line different adaptation measures are practiced by small holder farmers such as soil and water conservation, crop rotation, change crop variety, changing planting date, diversification of crop type and variety which differs from area to area. Those adaptation measures is highly affected by level of household education, agro-ecology, livestock owned, farm income and credit services, lack of information, lack of capital ,shortage of labor ,lack of access to water and poor potential for irrigation.

For the IPCC mid-range emission scenario, the mean annual temperature will increase in the range of 0.9 -1.1 °C by 2030, in the range of 1.7 - 2.1 °C by 2050 and in the range of 2.7-3.4 °C by 2080 over Ethiopia compared to the 1961-1990 normal (Asaminew Emerta, 2013 ; EPA, 2012). Average annual temperature nationwide is expected to rise 3.1°C by 2060 and

5.1°C by 2090. In addition, precipitation is projected to decrease from an annual average of 2.04 mm/day (1961-1990) to 1.97 mm/day (2070-2099) for a cumulative decline in rain fall 25.5 mm/year (Kidanu Aklilu *et al*., 2009). In addition to climate projections suggest an increase in rain fall variability with a rising frequency of both severe flooding and drought due to global warming (World Bank, 2010).

2.7. Maize production and Climate Change impact in Ethiopia

Maize is the most widely distributed cereal crops in the world. According to The World Bank Group (2011), in developed countries 70 % of maize is destined for feed, 3 % is consumed directly by humans and the remaining is used for bio-fuels, industrial products and seed. While in SSA outside of South Africa, 77 % of maize is used as food and only 12 % serves as a feed. Maize covers 25 million ha in SSA, largely by smallholder farmers that produced 38 million tons in 2008, primarily for food as an instance. Despite the importance of maize in SSA, yields remain low (Shiferaw *et al.*, 2011). While maize yields in the top five maize producing countries in the world (USA, China, Brazil, Mexico and Indonesia) have increased three-fold since 1961 (from 1.84 t ha -1 to 6.10 t ha-1), maize yields in SSA have stagnated at less than 2 t ha-1(Cairns *et al.*, 2013).

In Ethiopia, maize accounts for the largest share of production by volume and is produced by more farms than any other crop. CSA (2012a) indicated that about nine million smallholders were involved in maize production in the 2011/12 production season. Same source also indicated that maize covered about 2.05 million ha of land at the national level that is equivalent to 21.43 % of the total area covered by all cereals. Out of this area, 30.64 % of the land was covered by improved seed varieties and 23.3 % and 27.7 % of the land had utilized organic and inorganic fertilizer, respectively. The total output of maize in the same year at national level was 60.7 million qt that is 32.3 % of the total cereal production in the same year.

However, maize is more susceptible to climate change compared to other crops. About 40 % of Africa's maize producing areas face irregular drought stress in which yield losses are 10 – 25 % and 25 % of the maize crop suffers recurrent drought, with losses of up to half the harvest (CIMMYT, 2013). It also indicated that maize crops tend to have the highest water requirement when the maximum leaf area index combines with the highest evaporative demand. Thus, maize crop is very susceptible to water shortfall during its critical period for two reasons: high water requirement in terms of evapo transpiration and high physiological sensitivity when determining its principal yield components such as the number of ears per plant and number of kernels per ear (Omoyo *et al.*, 2015). Specifically, in Africa, under non-drought conditions 65 % of the area that is under maize cultivation would experience yield losses from a uniform 1°C warming. Under drought conditions, this figure will increase to 100 %, with 75 % of this area suffering yield losses of at least 20 % (Lobell *et al.*, 2011a).

Other studies carried out on the relationship between rainfall characteristics and maize yield in Gboko, Nigeria indicated that the amount of annual rainfall had a strong positive correlation ($r = 0.599$) with maize yield; duration ($r = 0.306$) and dates of cessation ($r = 0.219$) had weak positive correlation with maize yield; while dates of onset ($r =-0.269$) had weak negative correlations with maize yield (Adamgbe and Ujoh 2013). This shows that amount of rainfall received during growing season of maize is the strongest determinant factor of its yield. Maize yields will decline as the amount of rainfall below 200mm and 450mm to 600mm is preferable; in tropics maize does best with 600mm-900mm. A good distribution of rainfall and a sufficient amount to maintain steady growth are essential during growth critical growth period. Much water is needed during this period because of plant's rapid growth rate and the high rate of evaporation from the soil and transpiration from the leaves (Normal et al., 1995). In general, inter annual rainfall variability impose greatest effect on maize yield as optimum spread of rain throughout the rainy season enhance yield of maize per hectare (Bewket, 2009).

2.7.1. Perception of Farmers on Effects of Climate Variability on Maize Yield

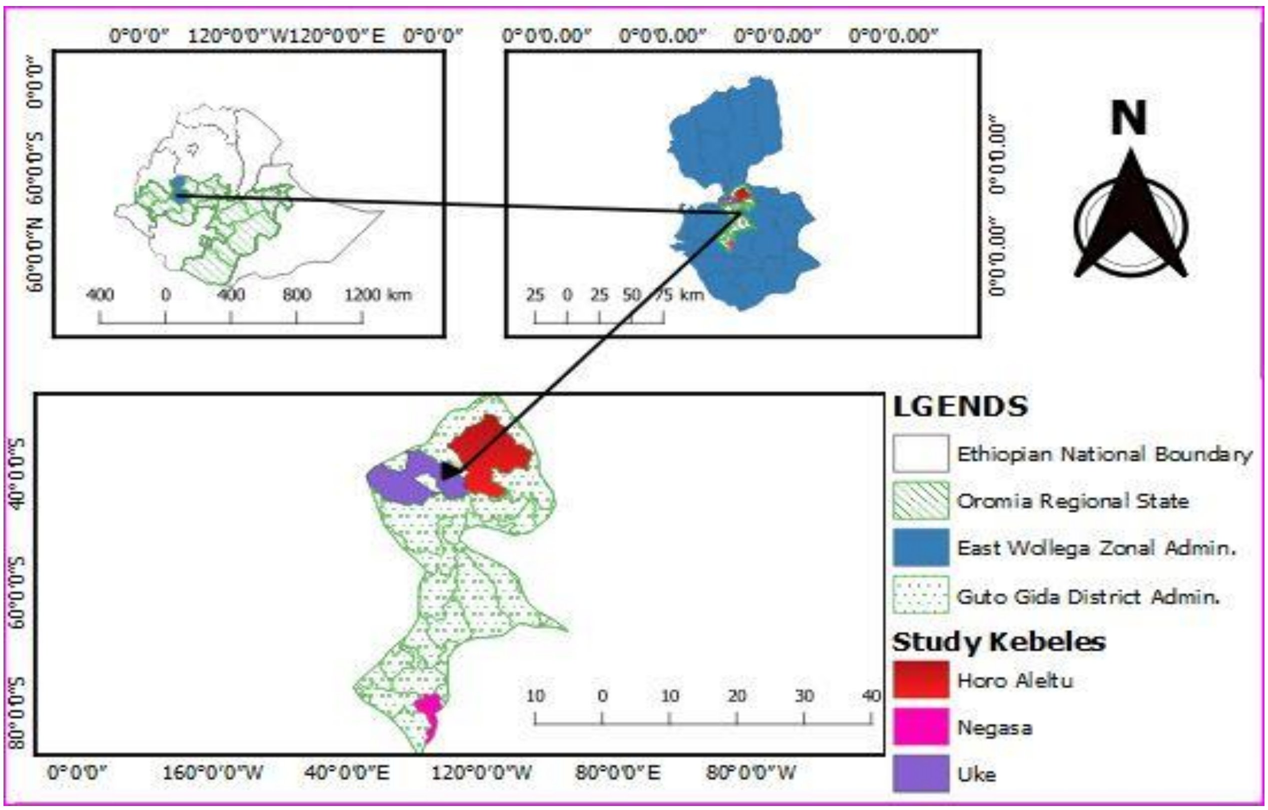
Perceptions of peoples are very crucial in identifying effects of climate variability. Climate affects many aspects of agricultural sectors such as crop and animal production, degrades natural resources thus influence the normal functioning of ecosystems. The study by Worku, (2018) attempted to assess only the effect of climate variability on maize yield which is staple crop for his study area Guto Gida. In the study area, people perceived the effect of climate variability on maize yield through a gradual change in the amount of yield harvested per hectare annually. From his survey half of the respondent perceives an increase in maize yield but Development Agents pointed out this increment of maize yield, with the main reasons, such as adaptation practices adopted by the farmers like using to maize varieties, mulching, irrigation, and changing planting date to match early onset of rain. The other little study by Bedeke *et al*., (2018) tries to discuss the issues of climate variability on maize by relating it to rain fall and temperature change as manifestation to perceive by small holders in Wolaita Zone.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The research was conducted in Guto Gida woreda of Oromia Regional State, western Ethiopia, located at 328 km west of Addis Ababa. Geographically the study area is located between 8^0 59' and 9. 06'N latitude and 36^0 51'and 37 09'E longitude, at an altitude range of 1650-2,450 meters above sea level (m a s l).

Figure: 1. Map of the Study Area



Source: (CSA, 2013)

Climate and agro ecology

The study area is characterized by uni-modal rainfall pattern the rainy season starts during March/April and continues until June to September followed by extended dry season until the next rain (World Bank, 2006).The farmers cultivate both long and short cycle crops. The annual rainfall of the District ranges from 1145mm to 2588 mm and the annual average minimum and maximum temperatures appeared to be 11^{o}C and 27.8^{o}C respectively.

According to East Wollega Zone Finance and Economic development office data the district is composed of 20 rural and 3 urban PA's covering a total area of about 109,150 hectares and bordered with Wayu-tuka in the east, Sasiga and Diga in the west, Gida Ayana and Gudaya Bila in the north & Leka Dulacha in the south. It has three agro ecological zones with different climatic proportions. The high land, midland and the lowland covering about 2.80 %, 56.0 % and 41.20 % of the total area of the district with mean altitudes 1350, 2080 and 2450 m a s l respectively. The district is characterized by undulating landforms with prominent hills with altitudes ranging between 1350 and 2450 meters above sea level. It experiences mean annual temperature of about 18^{0}c and mean annual rainfall ranging from 1600 to 2000mm.

Major crops grown in the area includes maize, sorghum, haricot bean, Niger seed, soya bean, sesame, tomato, onion, pepper, head cabbage, carrot, potatoes, sweet potato, mango, banana, papaya, avocado and etc. Additionally, the major livestock reared in the district were cattle, goats, sheep and poultry. Out of twenty rural kebeles found in the District, twelve are maize producing kebeles. Most of the crops in the study area are produced for commercial purposes while maize is the staple food and as well as commercial. It covers more than 65% of productive land of each kebele in the district, especially in the 12 maize producing kebeles (GGA&NRO, 2019).

Populations

According to the 2007 national census, this district has a total population of 102,276, of whom 52,846 were men and 49,430 were women. None of the population was urban dwellers, and the majority of the inhabitants observed are Protestant Christians, with 60.11% while 25.72% practice Ethiopian Orthodox Christianity, and 14.17% are Muslims. Out of the total populations, 14560 and 1781 are male and female household heads, respectively.

Most of the people in the area are engaged in mixed agriculture (i.e., crop cultivation and livestock production). Crop production is entirely rain fed, except in very specific and small areas where vegetables are cultivated under traditional and small-scale irrigation.

3.2. Sample Size and Sampling Technique

The study applied a multi- stage sampling technique to select sample households. In the first stage, the study area, Guto Gida district, was purposively selected based on the extent of maize production in the woreda and its high vulnerability to climate variability and change. In the second stage, among the total 20 rural and 3 urban kebeles of the district, three rural kebeles (Negasa, Uke and Horo Aleltu) were selected purposively depending on the degree to which they were exposed to climate variability, their agro-ecology and level of maize production. In the third stage simple random sampling was used to get optimum representatives of sample out of the three selected kebeles household heads.

According to G/G/A/N/R Office data, the current total households of the three kebeles were 2333. To determine the total households sample size as representatives from each kebeles, the following sample determining formula was used:

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

Where n =is the sample size, N= is population size and e =is the level of precision (Yemane, 2001, Belay, 2012; Getachew *et al.,* 2014). For the selected kebeles, N =2333 at ±5% precision level the sample size was computed as equation above, with confidence level of

95% and p=0.05 (maximum variability). Therefore, to get the total sample size for the selected kebeles:

$$n = \frac{2333}{1+2333(0.05)^2} = 342$$

Generally, out of 2,333 households, 342 (which were 15% of the total households) were selected from the three kebeles for the interview. In addition, development agents and local elders have participated. These selected households were engaged in providing information related to the past and present climate changes and current adaptation strategies to climate variability in their respective area.

Table: 1: Total sample size of selected households

No	Kebeles	Total House Holds	Sample Size
1.	Ukke	902	135
2.	Horo Aleltu	810	122
3.	Negasa	621	95
Total		**2,333**	**342**

Source: (GGA&NRO, 2019).

3.3. Data Type and Source

The Data was collected from both primary and secondary sources. The primary data was collected through questionnaire, scheduled or Key informant interview, observation and focus group discussion.

3.3.1. Primary Data

Close and open ended format questions was prepared and distributed to the selected households to get information about climate change perception and adaptations strategies of maize producing small holder farmers.

The observations were made as supportive or supplementary technique to collect data that can complement or set in perspective data obtained by other means (NRC, 1995). Hence, various environmental changes (agro-ecology, vegetation covers, and other topographic features was observed in study area.

Group discussions were held to get more information on relevant or similar ideas raised and concentrated points got at the end. At each selected Kebele, focus group discussions were held with the community regarding the climate change and strategies of adaptation among them.

In order to gather information, elders of the study area village was used as they were assumed to be more experienced in traditionally forecasting climate condition and response to it. And also they know the area's background very well.

3.3.1.1. Key Informant Interview

Key informants (KIs) are those people who are knowledgeable about the area and the major issues of the study (Elder, 2009). For this study, KIs were peoples who are knowledgeable and understanding about the existing trend of climate change, the socioeconomic status of small holder farmers, livelihood activities of the communities and climate change adaptation in the area and have certainly lived in the area long enough to clarify the issue of interest. The key informants were selected by snow ball method (Bernard, 2011). This is done by asking a randomly selected three farmers from each kebele to give the names of key informants based on the above criteria. Then the mentioned key informants are ranked and the most frequently appeared top three farmers were assigned as the key informants in each kebele. In general, 9 (nine) KIs was selected in order to obtain information for a sort of data triangulation. The key informants were individually interviewed on the overall information that has risen as criteria.

Like most qualitative data collection, key informants were asked repeatedly in order to explore issues in-depth based on open-ended questions.

3.3.1.2. Focused Group Discussion

Focused group discussion helps to generate data on group dynamics, and allows a small group of respondents guided by skilled moderators, focusing on key issues of the research topic (Kanire, 2012). In a focus group discussion, a group of people having similar concerns and experience regarding a subject was encouraged in the focus group discussions (FGD) with development agents, district agricultural and rural development office experts and farmers and relevant qualitative data was gathered. The FGD were considering 6-12 individuals per kebele (Elder, 2009). Therefore, one FGD in each sampled kebeles that made up a total of 3 FGDs which had 30 participants. The discussion was facilitated by the researcher together with the enumerators based on the designed check list.

3.3.1.3. Household Survey

A household survey was used to collect both qualitative and quantitative information. Sample household heads should be the unit of analysis from whom quantitative and qualitative data be collected. In this regard, carefully designed, open and close-ended questionnaires consisting of interrelated issues was administered by trained expert enumerators under the supervision of the researchers and the development agents of the selected kebele. To convey the questions effectively to the rural interviewees, the questionnaires were translated into the local language (Afaan Oromoo). For the sake of checking the reliability, a pre-test was administered for a few randomly selected households. Based on the feedback obtained, some possible adjustments and modifications were made.

3.3.1.4. Observation

In order to handle the most pertinent information, transect walks with the researchers, Development agents (DAs), model farmers and kebele leaders across the study area was conducted. During the transect walks, informal discussions with households and elderly people was conducted to gather useful and detailed information which difficult to collect through the questionnaire.

3.3.2. Secondary Data

Secondary data was collected from available sources of information such as published and unpublished documents. Long term climatic data regarding rainfall and temperature was obtained from National Meteorology Agency (NMA) to estimate the trends. Data on annual maize production and productivity in the study area was collected from Guto Gida district Agriculture and Natural resource office as well as from central statistical agency (CSA).

3.4. Data Analysis

The collected data, both qualitative and quantitative were summarized, statistically processed, and interpreted. Tabular presentation including graphs and maps and figures were used to characterize farmer's perceptions on climate changes as well as various adaptation measures being used by farmers

To compute the data, statistical analysis software, XLSTAT 2019 and MAKESENS_1_0 software were used for analyzing trend in annual rainfall and temperature. Stata16 was also used for regression analysis of quantitative and qualitative data that were collected on climate change perception and adaptation strategies.

3.4.1. Mann-Kendall Trend Test

Trend analysis of a time series consists of magnitude of trend and its statistical significance. Mann-Kendall method, a non-parametric test was used to test trends in precipitation and temperature of an area. It is the most frequently used non-parametric test as it is less affected by presence of outliers, which is a common trait of meteorological and hydrologic data. This technique is a non-parametric test based on the detection of trends and change point and attaching to it a probability significance level in a time series estimator. Mann-Kendall is complemented with Sen's slope estimation to determine the magnitude of the trend: The magnitude of the trend is predicted by Theil (1950) and Sen (1968) slope estimator methods as

$$Ti = \frac{xj-xk}{j-k} \text{Xj-Xk} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where Ti is slope, xj and xk are data values at time j and k (j > k) respectively

The total score for the time-series data is the Mann-Kendall statistic, which is then compared to a critical value, to test whether the trend in rainfall is increasing, decreasing or if no trend in rainfall can be determined;

$$S = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \text{sign (Xj-Xk)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Sign (Xj-Xi) = +1 if X_j - X_k>0, 0 if X_j - X_k = 0, -1 if X_j - X_k < 0

Where N is number of data points

A normalized test statistics (Z score) was used to check the statistical significance of the increasing or decreasing trend of mean precipitation and temperature values. Furthermore, Mann-Kendall trend test was used to detect the trend and normalized p-value for significant test.

$$ZMK = \frac{s-1}{\sqrt{var(s)}},\ \text{if } S > 0$$

$$ZMK = \{0 \text{ if } S = 0\}$$

$$ZMK = \frac{s+1}{\sqrt{var(s)}},\ S < 0$$

3.4.2. Coefficient of Variation Analysis

Rainfall variability was determined by coefficient of variation (CV %).

It is denoted as;

$$CV = \frac{SD}{\bar{X}} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Where CV= is Coefficient of variation, SD =is the standard deviation, $\bar{X}$= is long year mean

The decision rule will be when;

- ✓ CV value < 20% it is less variable,
- ✓ CV value from 20% to 30% is moderately variable and
- ✓ CV value >30% is highly variable.

3.4.3. Standard Precipitation Index Analysis

The SPI computation in this research was following the method which proposed by McKee *et al.*, (1993). SPI was computed based on the observed rainfall from the study woreda in the year 1983-2016 (34 years of data). Then, in order to obtain the SPI value, the function was normalized and standardized. It could be said that z-score of the distribution function to represent the deviation event from the mean of rainfall data as the SPI value. Drought severity was estimated by Standard Precipitation index (SPI) with the following formula.

$$\boxed{SPI = \frac{X-\bar{X}}{SD}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Where; X is discrete precipitation data, $\bar{X}$ is mean data, SD is Standard Deviation, SPI is drought index which is a powerful, flexible and simple to calculate. The decision rule will be if the SPI value of a given season is as in the following table.

Table: 2: The decision rule will be if the SPI value

SPI Values	Season
Greater than 2.00	Extremely wet
1.5 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderately dry
-1.5 to -1.99	Very dry
Less than -2.00	Extremely dry

Source (McKee *et al*, 1993)

3.4.4. Regression Trend Analysis

Multiple linear regression methods were used to establish and analyze, cause and effect relationships of rainfall and temperature on maize yields of smallholder farmers. Maize crop production and productivity trends were also analyzed by regression along with time series, after which it was correlated with rainfall and temperature trends of the study area. The effect of maximum and minimum temperature was also estimated by regression trend analysis. The regression equation used for the study was:

$$Y = a+b1x1+b2x2+b3x3\ldots bnxn +e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where; Y = the value of the dependent variable (maize yield in qt or qt/ha); a = Y intercept and b1, b2, b3, b4, ⋯bn = regression coefficients, x1, x2, x3, x4, ⋯ xn = the independent variables, e = the error of estimate or residuals of the regression.

3.4.5. Analysis of Perception and Adaptation Strategies

It is strongly argued by (Madison, 2006) that adaptation to climate change is a two-step process which involves perceiving that climate is changing in the first step and then responding to the changes through adaptation in the second step. To analyze these two steps he suggests applying binary logistic model. The advantage of this is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Madalla, 1983) and it is also computationally simple (Tse, 1987).

Depending on the aims of this study as an initial points, hypothesized independent variables were; age, sex, education, family size, access to extension, access to credit, size of farm land, access to market, membership of local organizations, temperature variability, RF variability, Onset of RF, Offset of RF, frequent crop failure, maize disease occurrences and access to weather information; while the dependent variables; feeling to climate change and adaptation strategies of small holder farmer were proposed to identify the perception of farmers on climate change and adaptation strategies.

Additionally, the climate change research community has identified different adaptation methods. The adaptation methods most commonly cited in literature include: use of new crop varieties and livestock species that are more suited to climate change, irrigation, crop diversification, mixed crop livestock farming systems, changing planting dates, diversifying from farm to non-farm activities, increased use of water and soil conservation techniques, changed use of capital and labor and shading and sheltering/tree planting (Kurukulasuriya and Mendelsohn, 2006; Maddison, 2006; Nhemachena and Hassan, 2007). However, this study focused on the adaptation strategies of maize producing small holding farmers to cope with the climate change impact that were faced in the study area. Those strategies were diversification of crop variety, using different type of maize cultivars, applying short season growing and drought, diseases and pest tolerance maize variety, maize rotation with other pulses, changing planting dates, shifting from farm to non-farm activities, increased use of soil and water conservation techniques and applying other types of adapting mechanisms such as cattle fattening and using small scale irrigation that can be determined by one or more of the above independent factors in the study area.

For statistical analysis of these proposed dependent and independent variables , the Logit and MNL models were employed due to the nature of the decision variable; whether farmers perceived climate change and have adapted or otherwise. For such a dichotomous outcome, the logit model is the most appropriate analysis tool. The Logit model considers the relationship between a binary dependent variable and a set of independent variables that mentioned above, whether binary or continuous. The Logit model for 'k' independent variables (X1, X2, X3…….. Xk) is given by;

$$P(x) = \alpha + \sum_{i=1}^{\mathrm{ki}} \beta i Xi \text{--} (6)$$

(Exp) (βi) indicates the odds ratio for a person having characteristics i versus not having i, while βi is the regression coefficient, and α is a constant. Thus the estimated regression coefficient associated with 1 or 0 coded dichotomous predictor was the natural log of the perception of farmers and demographic data associated with climate change. The logistic model also can be written;

$$ln\left(\frac{P(y|x)}{1-P(y|x)}\right) = \; ln\left(\frac{P}{1-P}\right) = \beta_o + \beta_1 x_1 \text{ ------------------------------ } (7)$$

This implies that the odds for success can be expressed as $\left(\frac{P}{1-P}\right) = e^{\beta o + \beta_1 x_1}$ ------------ (8)

This relationship is the key to interpreting the coefficients in a logistic regression model (logit model). The Models relationship between set of variables Xi dichotomous (yes/no) (Kurukulasurya, P and Mendelson, R, 2006) is illustrated as follows;

$$\left(P("success"|X)\right) = \frac{e^{\beta o + \beta_1 x_1}}{1 + e^{\beta o + \beta_1 x_1}} \text{ -- } (9)$$

In this analysis before estimating the model, it was necessary to check the existence of multi co linearity among the hypothesized explanatory variables. Multi co linearity problem arises when at least one of the independent variables is a linear combination of the others; with the rest that we have too few independent normal equations and, hence, cannot derive estimators for our entire coefficient. VIF shows how the variance of an estimator is inflated by the presence of multi co linearity (Gujarati, 2004). The speed with which variances and covariance increase can be seen with the variance-inflating factor (VIF), which is defined as;

$$VIF_j = \frac{1}{R_j^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10),$$

where, R_j^2 is coefficient of determination in the regression outcomes.

The larger the value of VIF_j, the more niggling or collinear the explanatory variables is (Gujarati, 2004). The model was checked and ignored the problem.

4. RESULTS AND DISCUSSION

4.1. Climate Trend

In order to assess the long term climate change trends of the study area, 34 years of precipitation and temperature data were accessed from National Meteorology Agency (NMA) along with survey conducted to evaluate farmers' perception on climate variables and their respective consequences. The long term rainfall trends were evaluated on both annual and seasonal bases. The seasons included those months which are expected to have impact on maize production and were categorized as; March April May (MAM), June July August (JJA) and September, October November (SON). Trends of annual minimum, maximum and average temperatures were also regressed following the required steps.

4.1.1. Rainfall Trends and MK trend Analisis

According to the results of long term NMA data analysis, the annual rainfall in the study area is declining by an average of 10.28 mm per year during the last three decades (Figure 4). The coefficient of determination also confirmed that, the contribution of time series with in the specified duration was 16.61%. Similarly the JJA rainfall which is expected to have determinant effect on maize productivity is decreasing by an average of 6.15mm annually. However the long term rainfall during the months of MAM and SON was relatively stable despite still with declining trend.

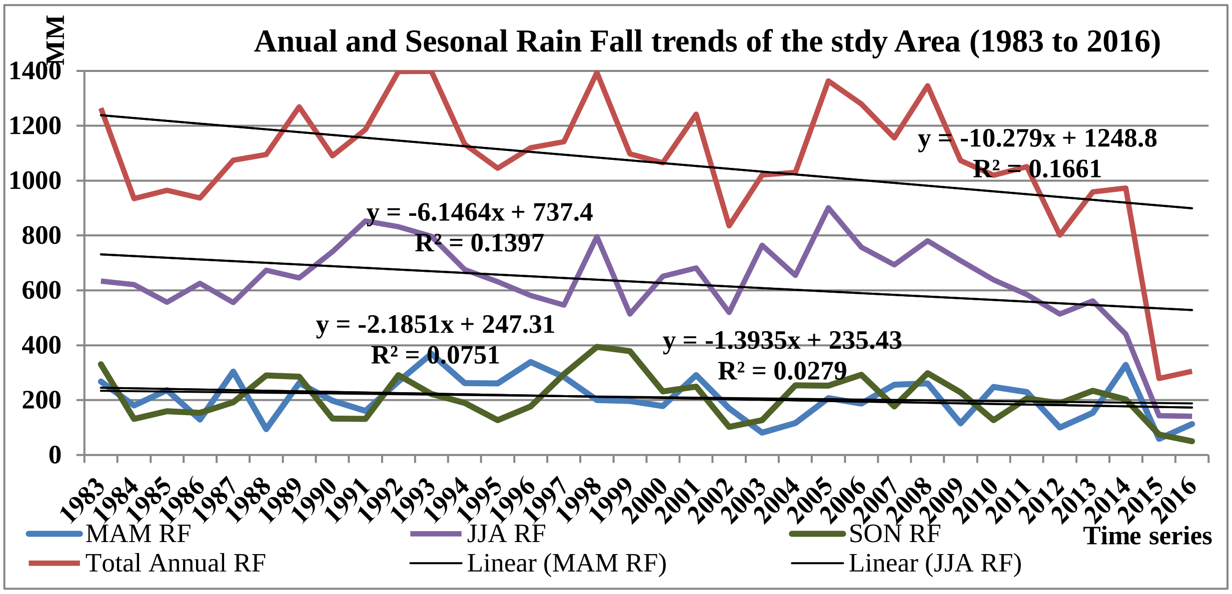


Figure: 4 Annual and seasonal RF trends of the study Area (1983 - 2016)

The Mann-Kendall (MK) trend test and Sen's slope estimator result also showed significant decreasing trend in the long term inter-annual rainfall (Table 7). The declining trend was statistically significant in amount at a rate of 5. 77 mm and (MAM), (JJA) and (SON) were 1.46, 1.41 and 2.51mm annually (Table 7) and this partly agrees with farmer's perception. The overall result is in agreement with the national rainfall trend (NMA, 2007). This was in full agreement with FGD and KI results obtained from the survey data. This result is also in line with the findings of (Daba, 2018) that elaborated average annual rainfall has been decreasing in western Oromia.

Table 7: Trends of rainfall in the study district for the period 1983-2016.

Time series	Mann-Kendall tau	Sen's slope	P- value
Annual rain fall	0.99	-5.77	0.000***
March April May (MAM),	0.33	-1.46	0.0058**
June July August (JJA),	0.51	-1.41	0.0019***
September, October November (SON)	0.65	-2.51	0.008*

Source: NMA (2020).

Sen's slope is the annual change (mm), *, **, ***: significant trend at 0.00, 0.05 and 0.01 levels.

Variability of Rainfall

The maximum 1397 mm rainfall was record for the area in 1993, while the minimum 278.95 mm amount of rainfall was received in 2015 (Table 7). This longer term rainfall variation analysis in the study area indicated that, there is inter-annual rainfall variability and the distribution pattern was also expressed in CV values. In this regard the CV result of the annual rainfall in the study area was 23.5% indicating the existence of less inter-annual variability. Whereas the CV values of the long term rainfall variability for the months of JJA and SON were 22.1 and 20%. However the CV value for MAM was 36.3% indicating that the rainfall was highly variable which creates difficulty to decide the planting time (Table 8), since March, April and May are months for maize field land preparation and planting time in the study area. This was further confirmed by members of the focus group discussion and key informants participants. This agrees with the inter-annual rainfall variability in Ethiopia that varies from 10% to 70% (NMA, 1996b).

Table 8: Descriptive statistics of annual rainfall in Guto Gida district (1983-2016)

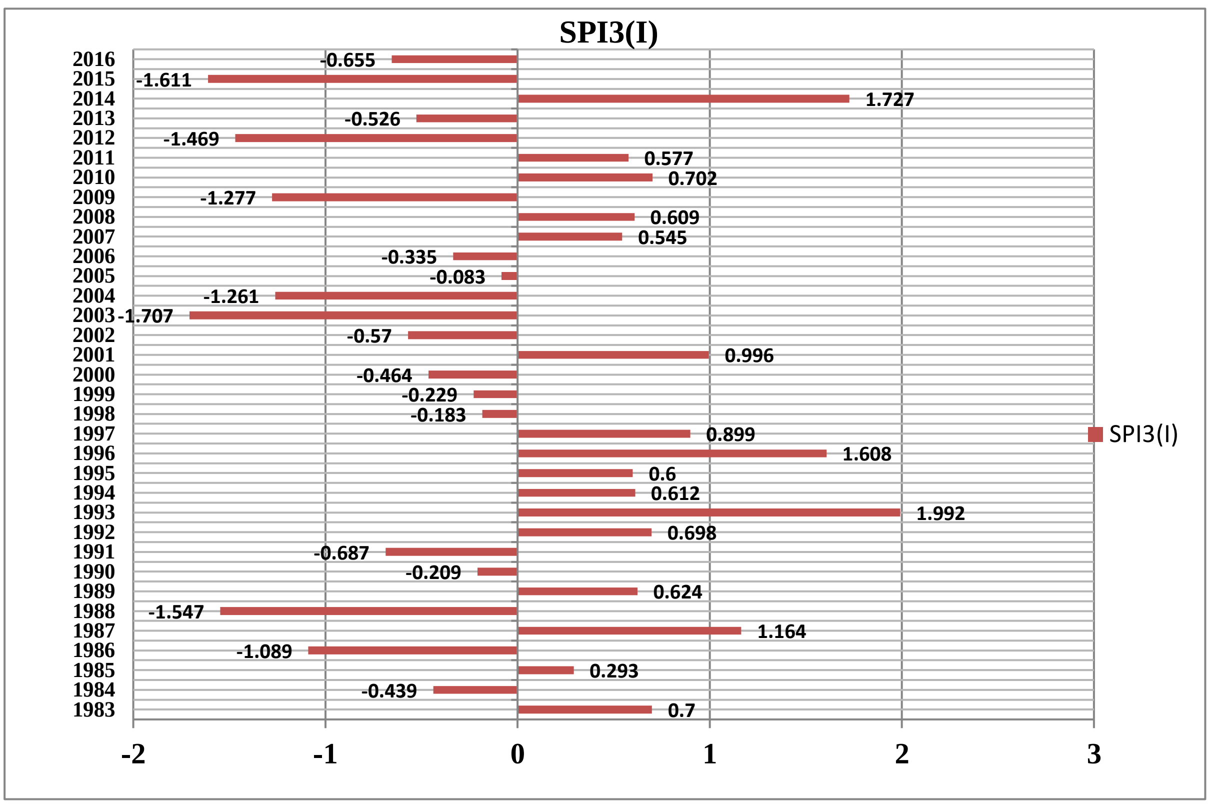
Time series	Obs.	Mean	CV	SD	Min	Max
Annual rain fall	34	1068.94	**23.5**	251.13	278.95	1397.96
March April May (MAM),	34	214.07	**36.3**	77.76	81.307	368.95
June July August (JJA),	34	646.60	**22.1**	143.12	193.255	901.105
Sept, October November (SON)	34	860.67	**20.0**	172.48	282.034	1166.17

Source: NMA (2020)

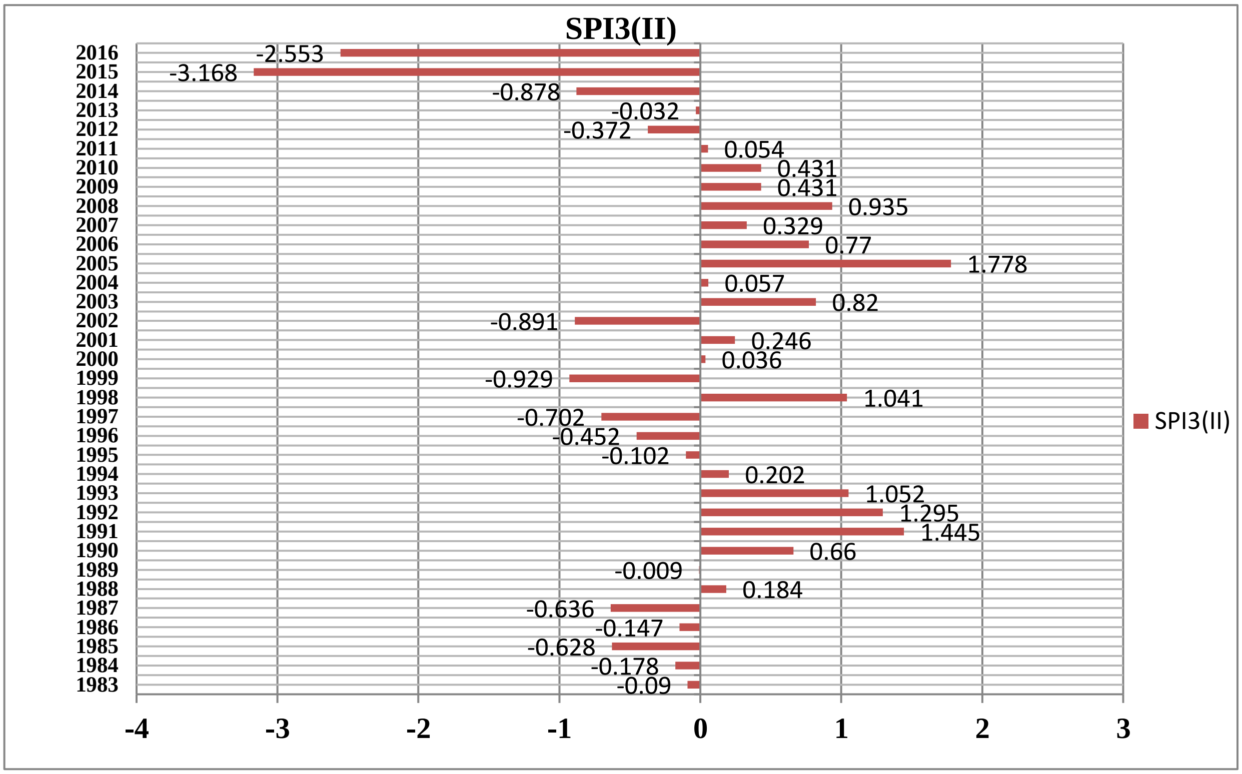
4.1.3. Standard Precipitation Index Analysis

The results of SPI analysis of all periods showed from moderate to severe drought conditions characterizing climatic condition of the study area. Drought years during the 1st three month SPI3 (I) were 1988, 2003 and 2015 with SPI value of (-1.55), (-1.71) and (-1.61) respectively (Figure 5a), whereas only two extreme droughts occurred during the 2nd three month SPI3 (II) period with the value of drought index (-3.17) and (-2.55) in 2015 and 2016 respectively (Figure 5b). Similar two severe droughts were recorded during 3rd six month SPI6 period with values of drought index (-3.36) and (-2.41) in 2015 and 2016 respectively (Figure 5c). Severe droughts were also observed two times in 4th nine month SPI9 period with the value of drought index of (-2.55) in 2015 and (-2.10) in 2016 (Figure 5d). The 5th twelve month SPI-12 period shows the overall year comparisons of the 34 years of drought occurrence. In this regard the SPI-12 values showed that, 2015 and 2016 were extremely drought years with SPI value of (-2.72) and (-2.26) respectively, while the extreme wet years were 1992 and 1993 with (1.02) SPI-12 value (Figure 5e).

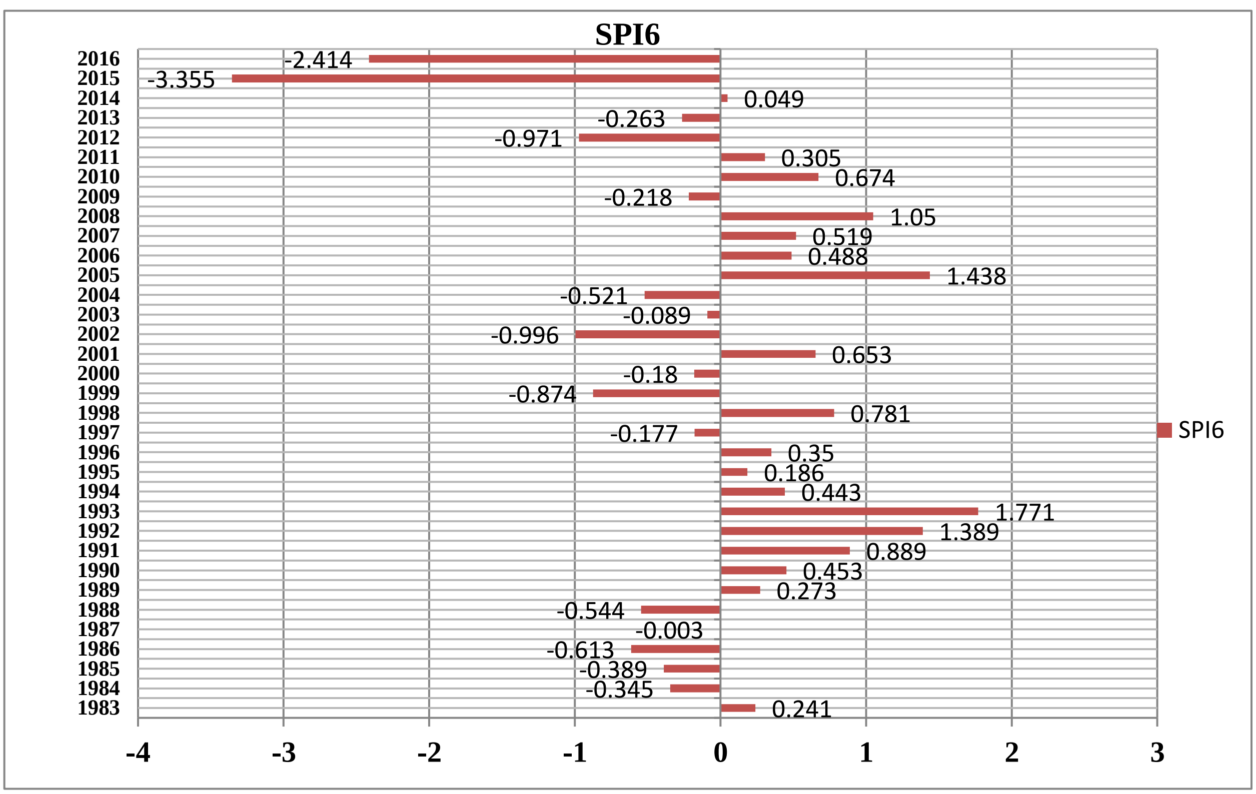
Figure: 5. SPI of different period (SPI3 (I), SPI3 (II), SPI6, SPI9, and SPI12) of the woreda



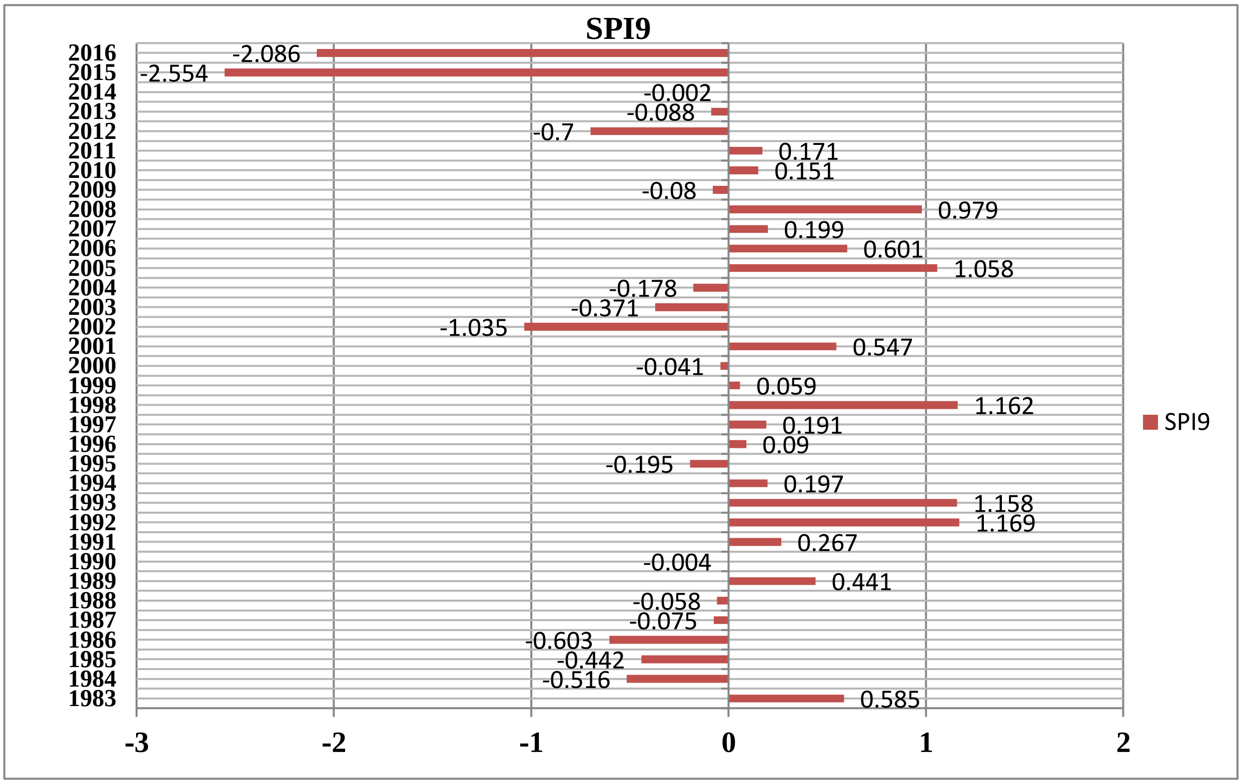
a). 1st SPI3 (I) for March, April and May



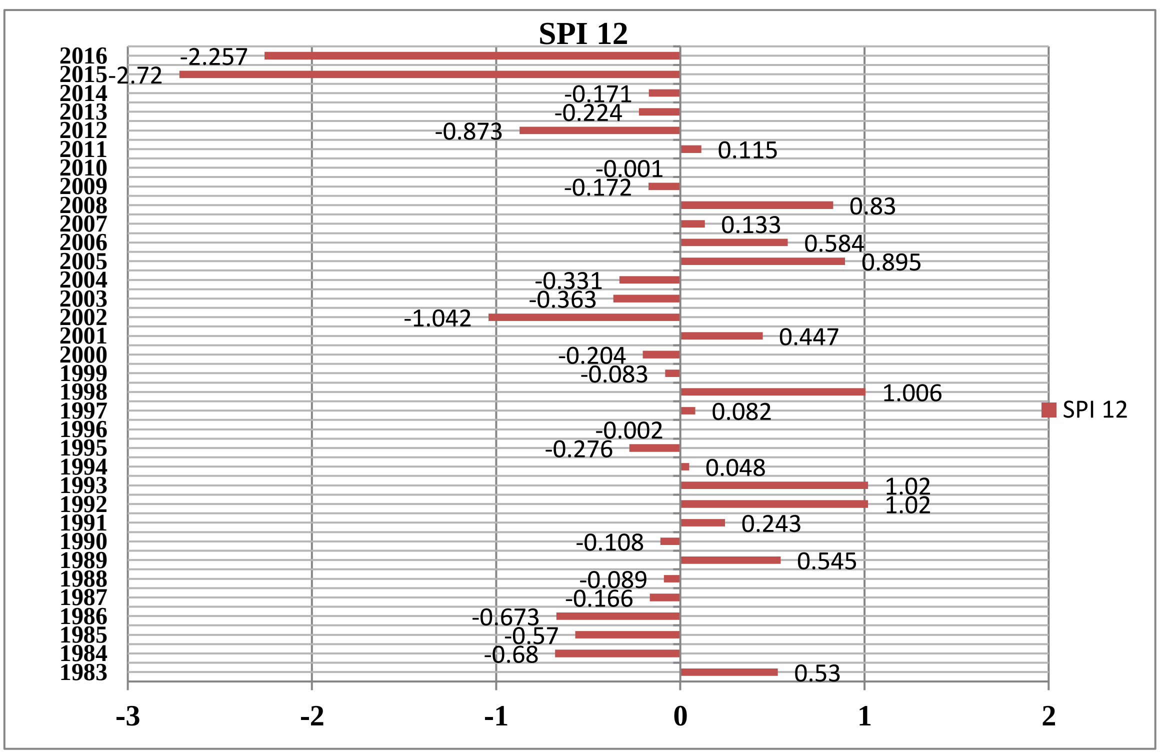
b). 2nd SPI3 (II) for June, July and August



c). 3rd SPI6 for March to August



d). 4th SPI9 for March to November



e). 5th SPI12 for March to Feburuary

(Source NMA 2019)

Generally, the results of the SPI values indicated the existence of rainfall irregularity at the study area within the past 34 years. On the other hand the two extreme wet years (1992 & 1993) being in the first half of the observed period, while the extreme drought years (2015 & 2016) occurring at the end of the second half shows the shifting trend of the rainfall towards drought in the study area. Moreover, about 75% of the wet years were recorded before 2000, while 71% of the dry years occurred after 2000 on maize sowing time, confirming that the occurrence of wet years is declining whereas drought incidence is increasing.

This result was in line with findings of Daba, (2018) which states that, the average dry periods in western Oromia shows increasing while the wet periods are declining over the last three decades. The result is also consistent with several findings that show both frequency and spatial coverage of dry spells and drought conditions in Ethiopia have increased significantly (Adimassu *et al.,* 2014, Abate *et al.,* 2015). Analysis of long-term extreme climate events reported by the NMA (2015) over several decades in Ethiopia indicates shortening of inter-drought periods at an exponential rate. In general, the long term climate data showed the existence of climate variability in the study area. And the result is consistent with the reports of Asaminew Emerta (2013) and EPA (2012) on their works of climate projections at different parts of Ethiopia stating that, some parts of the country experiencing drought and flooding more than ever.

4.1.4. Mann-Kendall Temperature trends

Temperature is important climate variable that influences the climate, that restrains moisture of a given area and even rainfall amount is highly influenced by intensity and magnitude of its temperature (Onoz *et al*, 2012). Thus, trends of maximum, minimum and mean annual temperature data were analyzed and summarized over time series for the study area.

The results indicated that, the annual mean temperature ranges from 16.22°C in 2006 to 19.59°C in 2005 with mean value of 17.78°C (Table 5). The annual maximum temperature ranges from 28.21°C in 2005 to 24.38°C in 1985, while the annual minimum temperature ranges from 6.07°C in 1995 to 11.75°C in 2010. It was observed that the minimum temperature with cv value of 16.80% was found to be more variable than the annual mean temperature and maximum temperature over the analyses period (Table 5). This agrees with the result of Muluken Mekuria, (2017) doctoral thesis who analyzed temperature data of Amibara and Gewane districts in Afar region.

Table 5: Descriptive statistics of annual temperature of the study Area (1983- 2016)

Variable	Obs.	Mean	Std. Dev.	Min	Max	CV%
Annual minimum temperature	34	9.05	1.52	6.07	11.75	16.80
Annual maximum temperature	34	26.52	0.79	24.38	28.21	2.98
Annual average temperature	34	17.78	0.97	16.22	19.57	5.46

Source: NMA (2020).

The result of trend analysis for the minimum, maximum and mean temperatures showed a consistent increasing inter-annual trend, with low variability that indicates the existence of significant warming tendency in the study area (Figure 3).

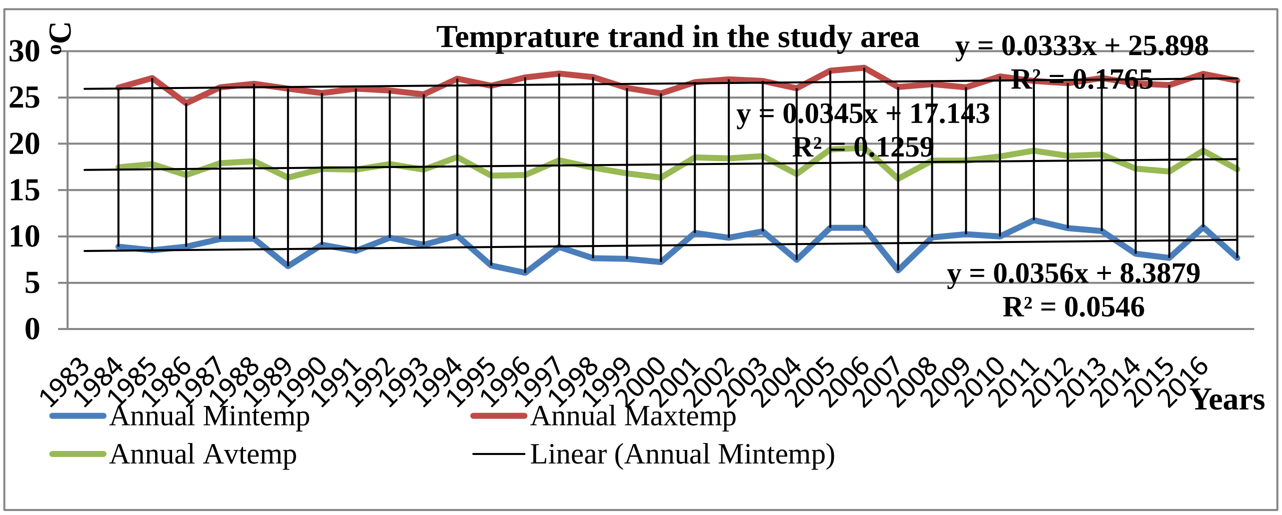


Figure: 3 Annual temperature trends of the study Area (1983- 2016)

Source: NMA (2020)

The highest mean increase was observed in the minimum temperature which accounted for an annual average increase of 0.035°C. Whereas, the annual mean and the maximum temperatures increased by 0.034 and 0.033°C per year respectively (Table 6). These results have been found to be higher than the national rate of increase of 0.028°C in the annual mean temperature during 1960 to 2006 (Mc Sweeney *et al*. 2010), despite all the trends still indicate the existence of a warming trend in the country.

Table 6: Trends of annual temperature in the Woreda (1983-2016)

Annual temperature	Mann-Kendall tau	Sen's slope	P- value
Annual Maximum temperature	0.30	0.032	< 0.01
Annual Minimum temperature	0.99	0.045	< 0.01
Annual Mean temperature	0.79	0.037	< 0.01

Source: NMA (2020).

Similarly it is good to see the variability of temperature in the woreda and in general, temperature was found less variable as compared to other parts of Ethiopia. The increasing trend was consistent with less variability as expressed by the CV values of; 16.80, 2.98, and 5.46% for annual min, max, and average temperatures respectively, despite the variability in the annual minimum temperature (CV=16.80%) much higher than the annual maximum and annual average temperatures (Table 4).

4.1.5. Maize productivity Trends in Guto Gida Woreda

Trends in maize productivity in the study area during the last twenty years (1997-2016) were correlated with rainfall patterns. The analysis result revealed that, maize productivity showed an increasing trend by 1.99 qt/ha annually, despite the rainfall is decreases with an average of 30.80 mm annually (Figure 2). This could be mainly associated with the increasing tendency of farmers to use improved technologies and agricultural inputs, which could have been overriding the negative impacts of the declining annual rainfall in the study area. The values for coefficient of determination also showed that, the contribution of time series for the observed increase in maize yield is about 76.47%, while 37.69% for the decline of annual rainfall (Figure 2).

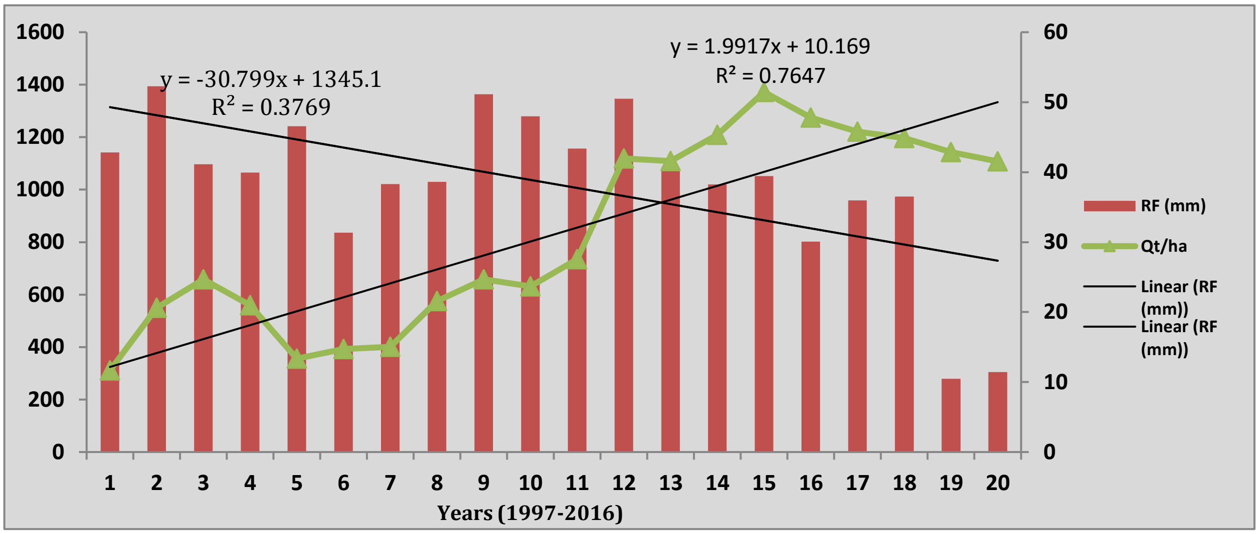


Figure 2, Rainfall and Maize productivity trends over the last twenty years

Moreover, the impacts of the total annual as well as seasonal rainfall trends on maize productivity were also analyzed focusing on the important months for maize production from land preparation up to harvesting in the study area including; March-April-May (MAM), June-July-August (JJA) and September-October-November (SON).

The results from the regression analysis showed that, the total annual rainfall had about 19.0% negative contribution to maize productivity in the study area (Table 3). However the positive impact of seasonal rains of; MAM, JJR and SON contributing to the maize yield by 16.7% 20.9 and 20.8% respectively, maintained the increasing trend of maize productivity during the sampled twenty years.

Table: 3. Effect of Rainfall and tempe. on maize yield during 1983-2016 in Guto Gida woreda

Rainfall	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
MAM RF	0.167	0.0437	3.83	0.002	0.0729	0.2619
JJA RF	0.209	0.0505	4.14	0.001	0.1000	0.3182
SON RF	0.208	0.0567	3.67	0.003	0.0857	0.3307
Annual RF	-0.190	0.0404	-4.71	0.000	-0.2777	-0.1032
Min temp	3.377	1.6372	2.06	0.060	-0.1595	6.9143
Max temp	-6.452	3.8544	-1.67	0.118	-14.7794	1.8747
_cons	156.497	97.4402	1.61	0.132	-54.0103	367.0034

Source: (NMA and GGANRO, 2020).

The current result reveals the importance of seasonal rainfalls during the critical growth in maize production than the overall total amount of annual rainfall. This result in line with (Adamgbe and Ujoh 2013) found that amount of rainfall received during growing season of maize is the strongest determinant factor of its yield. In addition this finding is supported by (Worku, 2018) pronouncement that elaborated the increase in kiremt rain fall increases maize yield. The result is in line with (Lemi, 2005) in his study in Ethiopia, analyzed crop yield and rainfall data found out that crop yields are negatively affected by rain.

Table: 4. Correlation of MAM, JJA, SON RF & Annual Min, Max and Av. temp on maize yield

Time series	______	Yield per Ha	MAM RF	JJA RF	SON RF	An. Min.tem	An. Max.tem	An. Ave.tem
Yield per Ha	Pearson Correlation							
	Sig. (2-tailed)							
MAM RF	Pearson Correlation	0.014						
	Sig. (2-tailed)	0.954						
JJA RF	Pearson Correlation	-0.247	0.188					
	Sig. (2-tailed)	0.293	0.428					
SON RF	Pearson Correlation	-0.292	0.272	0.499				
	Sig. (2-tailed)	0.212	0.245	0.025				
Annual Minimum temp	Pearson Correlation	0.273	-0.077	0.051	-0.344			
	Sig. (2-tailed)	0.245	0.747	0.831	0.138			
Annual Maximum temp	Pearson Correlation	0.019	-0.223	-0.079	-0.290	0.594		
	Sig. (2-tailed)	0.937	0.345	0.740	0.215	0.006		
Annual Average temp	Pearson Correlation	0.217	-0.129	0.013	-0.359	0.967	0.780	
	Sig. (2-tailed)	0.357	0.586	0.956	0.120	0.000	0.000	
Annual RF	Pearson Correlation	-0.389	0.435	0.897	0.756	-0.110	-0.216	-0.155
	Sig. (2-tailed)	0.090	0.056	0.000	0.000	0.645	0.360	0.515
	N	20	20	20	20	20	20	20

Source: (NMA and GGANRO, 2020).

In addition, the increasing temperature in the study didn't show significant impact on maize production, despite a positive trend from the minimum and negative tendency from the maximum temperatures were observed (Table 4).

4.2. Farmers' Perceptions on the Climatic Trends and Adaptation Strategies

4.2.1. Socio-Economic Characteristics of the Respondents

The result of this study showed that, the age of respondents was ranging from 22 to 70 years with the average of 41.6 years. About 96.2%, of them were within the working age (22 to 63 years), of which 27.7% were youths. This indicates the existence of potential active labor force participating in the agricultural sector in the study area. From the sampled farmers in this study 80% were male. A noticeable fact about the low participation of the females was the extreme dominance of males as the household head. Among the respondents, 98% were married, while the average family size of the respondents was about 5 members and they have been living in the area for very long period of time (Appendix 3).

Regarding education level of the total respondents, 77.5% had a 1st cycle education, 3.5% of them 2nd cycle and above, whereas only 19% respondents have no formal education level (Appendix 3). Almost of all farmers in the study area stated agriculture as their major occupation. The average land holdings of farmers was 2.8 ha, of which the average maize growing land was 1.85 ha (Appendix 3). This shows that, 66% of their land allotted for maize production and thereby they can be considered as maize dependant farmers.

4.2.2. Perceptions of farmers on Climate Change

This study found out that, about 80% of the maize producing smallholder households have heard of and talked about as well as felt the negative effects of climate change on their maize production (Appendix 3). As a result, production of maize in the study area has already been impacted by such climatic variations. This shows that a majority of these smallholder farmers are facing the problems associated with the changes in temperature and rainfall patterns previously observed during the climatic analysis. However the farmers' perception on the specific contribution of the annual and seasonal rainfall differed according to the different sources. But the general trend results agreed with the obtained perception of the FGD and KI participants in the current survey. This result is also consistent with the results of SPI in different duration in figure 5 a, b, c, d and e and logistic regression analysis in table 3.

4.2.3.Perceptions on the Reasons for Climate Change

Sampled households were asked to verify the most important indicators for climate change/ variability in their area. Accordingly 85% out of the total respondents believe that, climate change in their area is manifested mainly by frequent delays in onset of rainfall, while 84% consider early offset of rainfall being the main indicators of climate change in the study area (Table 9). In both cases the rainfall duration is affected resulting in shortening of maize growing period and ultimate yield reduction since maize is a crop with relatively longer duration. In addition, temperature and rainfall variations, frequent crop failure and increasing maize disease occurrences were also mentioned among the main reasons to perceive the existence of climate change in their area (Table 9).

Table: 9. Main reasons of Farmers for Perceiving the Existence of Climate Change in Guto Gida woreda, Oromia Region, western Ethiopia in 2020

Main reason	Frequency	Percent	Rank
Temperature Variability	276	81	4^{th}
Rain Fall Variability	299	73	5^{th}
Delays on Onset of RF,	319	85	1^{st}
Early Offset of RF,	320	84	2^{nd}
Facing frequent crop failure,	241	61	6^{th}
Maize disease occurrence	278	82	3^{rd}
Total	**342**		

Source (Own survey, 2020)

The logit model results in examining the factors influencing the smallholder maize producing farmers' perceptions on climate change reviled that, sex of household head, access to extension service, membership of local organizations, rainfall onset variability, frequent maize crop failure and access to weather information have significant positive relationship with farmers' perception to climate change (Table 10).

Accordingly, sex of household has been observed positively and significantly affecting their perception on climate change in the study area with 0.036 P value, coefficients of variation 10.14% and odds ratio 2.76 at α 0.005, which indicates that, being male-headed household increases by 10.14% and has 2.76 times probability of perceiving on climate change incidence than being female-headed house hold.. This relation implies that the perception of male household toward climate change is stronger than female headed house hold due to their direct exposure to day-to-day maize production activities and its impacts on their maize field. Accordingly, the study by Asfaw and Admassie (2004) stated that, male-headed households are often considered to be more likely to get information about new technologies and take risky than female-headed households.

Access to extension serves has also positive and significant (P< 0.001) impact on the perception of maize producing farmers on climate change in the study area with coefficients of variation 16.9% and odds ratio 5.4 at α 0.005 (Table 10). This result indicates that, as the access to extension serves of the farmers increases by one unit their perception to climate change increases by 16.9% and has 5.4 times higher probability to perceive climate change than those not accessed. The result is in line with the finding of (Asrat Paulos and Simane Belay, 2018), elaborating significant difference on climate change perception between households who received extension services to those who did not take the extension services.

Table: 10. Logit model Explanatory Perception of Respondents on Climate Change

Variables	Coef.	Odd/R	S/ Er.	z	P>z	95% Con. Interval	
Sex	1.014	2.756	0.482	2.10	0.036	0.069	1.959
Age	0.681	1.975	0.555	1.23	0.220	-0.408	1.769
Education	-0.615	0.540	0.547	-1.13	0.260	-1.687	0.456
Access to extension services	1.685	5.391	0.529	3.19	0.001	0.648	2.721
Membership of local organ.	1.795	6.021	0.496	3.62	0.000	0.823	2.768
Temperature variability	-0.351	0.704	0.533	-0.66	0.510	-1.396	0.693
RF Variability	1.073	2.923	0.503	2.13	0.033	0.087	2.058
Onset of RF	3.100	22.21	1.401	2.21	0.027	0.355	5.846
Offset of RF	-0.239	0.788	1.376	-0.17	0.862	-2.935	2.457
Frequent maize crop failure	1.028	2.796	0.461	2.23	0.026	0.125	1.931
Maize disease occurrence	0.545	1.724	0.531	1.03	0.305	-0.496	1.585
Access to weather information	1.428	4.172	0.550	2.60	0.009	0.350	2.506
_cons	-6.780	0.001	1.264	-5.36	0.000	-9.258	-4.301

Source: (Own survey, 2020)

Similarly, being membership to different local organizations has got positive and significant ($P< 0.001$) effect on the knowledge of maize producer farmers in the area about the climatic status of their area with coefficients of variation of 18% and odds ratio 6 at α 0.005 (Table 10). This shows that, as the smallholding maize producing farmers being member of a given organization in their locality, their perception to climate change increases by 18% and has 6 times probability than their counter play to perceive climate change due to exposure and experience sharing among and within different members of local organizations in the study area. This result is also in line with Tilahun and Bedemo (2014) who reported that being member of a given local organization had positive and significant relationship with perception of climate change.

Rainfall variability's shown positive and significant ($P< 0.05$) effect on knowing of farmers about climate condition of their local area with coefficients of variation 11% and odds ratio 3.0 at α 0.005 too (Table 10). This result implies that, the respondents of the study area experienced variability of rainfall for more than 30 years in their life and as variability of rainfall increases the perception on climate change also increases by 11 % and 3.0 times probability to perceive about climate change occurrence, which is supported by the SPI result of rainfall data (Appendix: 3) on maize producing small holder Farmers of study area. This finding was in agreement with several studies that had shown farmers perception with regard to climate variability and change (Feleke, 2015 and Negash, 2016). The variability of rainfall onset at the study area has positive effect on climate change perception of the respondents (Table 10), since the inconsistency is part of the climate change itself. The result is in line with the study by Bedeke *et al.,* (2018) realize the issues of climate variability on maize by relating it to rain fall and temperature change as manifestation to perceive by small holders in Wolaita Zone.

On the other hand frequent maize crop failure in study area has also positive effect on the perception of the respondents, since an increase in experiencing crop failure enhances the perception of the farmers on climate change. This result was supported by FGD participants who confirmed the occurrence of frequent maize crop failure due to harshly and marshy environment. This statement was also supported by SPI value of the current study area (Figure 5 a, b, c, d and e). The result of this study is consistent with the study report on weather related problems such as; soil erosion, reduction in agricultural production, high rate of disease occurrence and frequent occurrence of drought occurring in different parts of Ethiopia (Yayeh Desalegn and Leal Filho, 2017 and Hameso Seyoum, 2018).

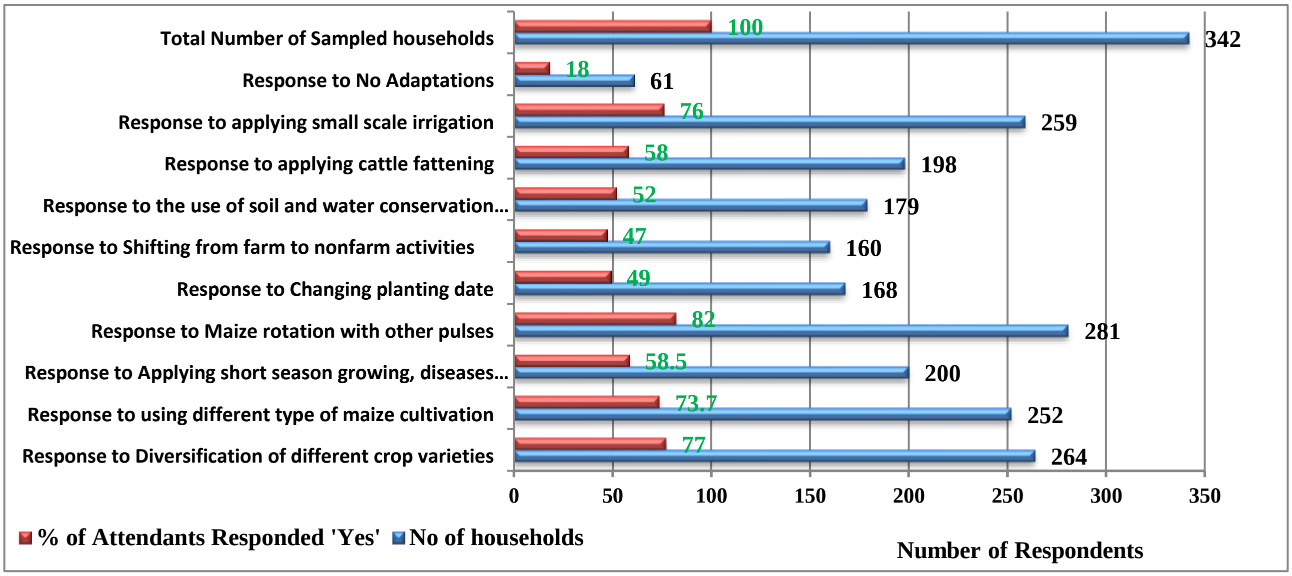
The other important climate change perception variable was access to whether information which has significant positive impact on farmers' climate change perception (Table: 10).This impalas as access to whether information increases the perception of small holder maize producing farmers increases by 14.3 % and 4.2. The result is in line with (Wolka Kebede and Zeleke Gizachew, 2016), who stated that access to whether information significantly increase the likelihood of farmers' perception of climate change at ($P < 0.01$).

4.2.4. Adaptation strategies in Maize Producing Small holder Farmers of the Study Area

The current study generally revealed that, maize producing smallholder farmers of the study area have a sufficient knowledge of climate change and its impact on their farmland (Table 9). From the total of the respondents more than 81% of the households believe that climate change and variability can negatively affect their maize production and could hamper maize production. Therefore, this study also focused on the determinants of adaptation strategies of smallholder maize producing farmers to cope with the climate change impacts on their local area particularly with their maize production. As hypothesized earlier in this study potential strategies included were; diversification of crop variety, using different type of maize cultivars, short season growing, drought, diseases and pest tolerance maize variety, maize rotation with other pulses, changing planting dates, shifting from farm to non-farm activities, increased use of soil and water conservation techniques and applying other types of adapting mechanisms such as cattle fattening and using small scale irrigation.

Consequently, the study result revealed that only 18% of the respondents have no any adaptation strategies, although every farmer was expected to practice (Figure 6). This result shows the adaptation strategies are well practiced in the study area to struggle climate change impacts in their maize production. The highest adaptation practice being exercised by the farmers in response to climate change was found to be maize crop rotation with pulses implemented by 82.0% followed by crop diversification practiced by 77.0% of the respondents (Figure 6). Small scale irrigation and use of different maize cultivation methods practices were also practiced by 76.0 and 73.7% of the respondents in the study area. Other strategies were practiced moderately as illustrated in the figure below.

Figure: 6. Main adaptation practices of Small holder Maize producers in the study area.



Source (Own survey, 2020)

4.2.5. Determinant Factors that Influence Farmers' Adaptation Strategies

A MNL model was employed to estimate the determinant factors of farmers' adaptation practices to reduce the impacts of climate change on their maize production activities. The parameter estimates of the MNL model were used to provide the direction of the effect of the independent variables on the dependent (response) variable, whereas estimates represent neither the actual magnitude of change nor the probabilities (Table 11). In this regard, only factor variables that were statistically significant at $\alpha = 0.05$ were interpreted and discussed.

Table: 11. Determinant factors on the choice of Adaptation strategies in Guto Gida woreda, Oromia Region, Western Ethiopia during the study conducted in 2020

Response Variables	---	Sex	Edu.	Fam. size	Access to ext. services	Access to credit	Memb. of local org.	Size of farm land	Access to market	Temp Variability	RF Variability	Onset of RF	Offset of RF	Freq. maize fail	Maize dis. occur	Acce. to weath. info	_cons
		Determinant Factor Variables															
Diversification of crop variety																	
	Coef.	-0.182	0.071	0.028	0.057	0.038	0.033	0.127	-0.166	0.067	0.170	0.089	0.064	0.108	-0.117	0.186	0.202
	sig	0.001	0.138	0.538	0.375	0.532	0.566	0.003	0.005	0.250	0.001	0.583	0.689	0.022	0.085	0.010	0.184
Applying short season growing Diseases and pest tolerance maize varieties																	
	Coef.	0.056	0.138	-0.105	0.197	0.045	0.115	0.049	-0.131	-0.098	0.213	0.295	0.193	0.071	0.184	-0.124	-0.186
	sig	0.253	0.001	0.011	0.001	0.402	0.025	0.205	0.013	0.060	0.000	0.044	0.182	0.095	0.003	0.055	0.173
Maize rotation with other repulses																	
	Coef.	0.012	0.228	-0.009	-0.002	-0.015	-0.014	0.115	0.185	-0.014	0.036	0.011	-0.027	0.049	0.177	0.101	-0.096
	sig	0.861	0.000	0.873	0.984	0.841	0.849	0.034	0.013	0.852	0.580	0.959	0.894	0.408	0.040	0.267	0.617
Changing planting dates																	
	Coef.	-0.043	-0.033	0.037	0.038	-0.053	0.089	-0.022	0.007	-0.040	0.027	0.268	0.282	0.038	-0.030	0.238	0.147
	sig	0.290	0.367	0.286	0.426	0.241	0.038	0.496	0.871	0.361	0.495	0.029	0.020	0.281	0.560	0.000	0.196
Shifting from farm to nonfarm																	
	Coef.	-0.046	0.018	0.133	-0.063	-0.075	0.075	0.060	-0.019	-0.033	-0.059	0.055	-0.026	0.128	0.150	0.066	-0.031
	sig	0.527	0.775	0.027	0.453	0.345	0.317	0.287	0.802	0.671	0.389	0.797	0.903	0.041	0.096	0.483	0.876
Increased use of soil and water																	
	Coef.	-0.140	0.247	0.036	0.268	0.116	0.067	0.242	0.041	-0.215	0.208	-0.122	0.125	-0.081	-0.203	0.070	-0.170
	sig	0.194	0.009	0.688	0.033	0.330	0.546	0.004	0.725	0.060	0.042	0.704	0.694	0.382	0.130	0.619	0.569
Applying cattle fattening																	
	Coef.	-0.007	-0.004	0.100	-0.093	0.085	-0.132	0.035	0.283	0.113	0.135	0.091	-0.217	0.170	0.015	-0.015	0.128
	sig	0.919	0.951	0.082	0.250	0.268	0.066	0.520	0.000	0.126	0.042	0.662	0.287	0.005	0.860	0.873	0.507
Applying small scale irrigation																	
	Coef.	0.178	-0.001	0.132	-0.151	0.131	0.006	0.127	0.298	0.035	0.128	-0.034	-0.047	0.005	0.077	-0.119	-0.132
	sig	0.010	0.982	0.021	0.059	0.083	0.937	0.018	0.000	0.633	0.051	0.869	0.817	0.938	0.366	0.186	0.489

Source (Own survey, 2020)

i. Sex of Household Heads

The results of this study showed that, sex of household has significant negative impact on diversification of crop variety and positive on small scale irrigation as adaptation strategies with coefficient of variation and P value (-18.2% , 0.001) and (17.8% , 0.01) respectively. The results show that being a male- or female-headed household significantly changes the probability of diversifying crop variety by 18.2% and applying small scale irrigation by 17.8% as climate change adaptation strategies (Table 11). Hence, female-headed households had better opportunities to practice adaptation measures than the male-headed households, in the case of diversifying crop varieties while male-headed households have higher chance of applying small scale irrigation. This finding is similar to a study by (Deressa *et al.*, 2011) done in another part of Ethiopia that analyzed farmer's choices of climate change adaptation methods on applying small scale irrigation, which showed that male headed households could be more likely to have access to technologies and climate change information than female-headed households but argued on crop diversification. As a result, male headed household were in a better position to practice diverse adaptation strategies than the female-headed ones because males have more exposure for different training program by several development promoters in the study area but female prefers more diversified crop than male in the study area.

ii. Education level of Household

The other significantly determining factor was education of household head which had a positive effect on farmers' adaptation strategies like applying short season growing cultivars, diseases and pest tolerance maize varieties, maize rotation with other repulses and increased use of soil and water conservation. The result showed that being educated could increase the probability of adopting applying short season growing diseases and pest tolerance maize varieties by 13.8%, maize rotation with other pulses by 22.8% and use of soil and water conservation by 24.7% as adaptation measures. This is because educated farmers are expected to better adopt new technologies based on their awareness of the potential benefits from the proposed climate change adaptation measures. The result is supported by the findings of the study by Asrat Paulos and Simane Belay (2018) in Dabus water shade stating that, as education of a farmer increases the adoption of new technology including different adaptation measures in their farming activities also increases.

iii. Family Size

Family size of the household head also impacted on the decision of farmers to practice some of the adaptation strategies (Table 11). In this regard, family size has found to be negatively related with the decision to applying short season growing diseases and pest tolerant maize varieties with coefficient of variation -10.5% and 0.011 P value. While the impact of family size on shifting to nonfarm and applying small scale irrigation was positive with coefficient of variation and 13.3% and P value 0.027, 13.2% and P value 0.021 respectively.

This means as household family size increases by one person, the probability of the households applying short season growing diseases and pest tolerance maize varieties decrease by 10.5%. This can be understood as family size increases financial resource to pay in applying short season growing diseases and pest tolerance maize varieties decreases. On the other hand, the increase in household family size increases the probability of the household adapting to climate change by shifting to nonfarm or to small scale irrigation by 13.3% and 13.2% respectively. This result can also be explained that, having more family members can lead households to shift to nonfarm activities in addition to farm activity to get immediate income to feed the family and cop up with the impacts of climate change in short period. Similarly having larger family size preferably encourages households to practice small scale irrigation since it requires more lobar to apply as an adaptation strategy. According to Kurukulasuriya and Mendelsohn, (2006) stated that, larger family size especially productive household member increases agricultural production since it is associated with labor-intensive sector.

iv. Extension Access

The result of the current study also indicates that having access to extension is positively and significantly related with the probability of implementing short season growing diseases and pest tolerance maize varieties and soil and water conservation in increasing by 19.7%, and 26.8% with significant levels of 0.001 and 0.033 respectively. The possible reason behind the result would be the strong belief on improved varieties and recent time mass mobilization on water shade development in the study area. According to H. Daba Mekonnen (2018), better access to extension services has a strong and positive impact on adoption of climate adaptation strategies.

v. Being Member of Local Organizations

Being member of local organizations has significant positive association with applying short season growing diseases and pest tolerance maize varieties and changing planting dates. The result indicated that being the member of different local organization increases the probability of applying short season growing diseases and pest tolerance maize varieties and changing planting dates by 11.5% and 9.0% (Table 11). This could be due to experience sharing among different members of the local organization with diversified experiences. This is consistent with earlier research findings in Ghana that showed farmers belonging to cooperative organizations have higher likelihood of using adaptation practices due to their capacity to share information - discuss problems, share ideas and take collaborative decisions (Ndamani and Watanabe, 2015).

vi. Size of Farmland

Size of farmland has a positive and significant association with most of the adaptation strategies. That is, as the size of farmland increases by one hectare, the probability of diversifying crop variety, rotating maize farm with different pulse crop, applying soil and water conservation measures on maize field and using small scale irrigation increases by 12.7%, 11.5%, 24.2% and 12.7% respectively (Table 11). Because, larger farm sizes provide an opportunity for diversification of their crop, getting more space to rotate maize with appropriate pulse crop, can have enough space to practice soil and water conservation technology and getting irrigable land, and it can help to distribute risks associated with unpredictable weather condition. This result is in line with the findings of Asrat Paulos and Simane Belay (2018); H. Daba Mekonnen (2018) who claimed in their work at different parts Ethiopia indicating that, having larger farm size increases the application of crop diversification and irrigation possibilities.

vii. Access to Farm inputs and Output Market

Access to farm inputs and output markets have also positive and significant effect on diversification of crop variety, maize rotation with other pulses, cattle fattening and applying small scale irrigation and negative effect on using short season growing maize varieties (Table

11). Easy access to market increases the likelihood of practicing crop diversification by 16.6%, applying maize rotation with other pulses by 18.5%, cattle fattening by 28.3% and applying small scale irrigation by 30%. This is due to the fact that, market access could help farmers to buy fertilizers, pesticides, and improved crop varieties and sell their maize product with good prices. On the other hand, the negative relationship between market access and using short season growing maize varieties could be associated with the exponential increase of cost of seed and inherent low yielding nature of early maturing maize varieties that reduces the market benefit of maize producing farmers. This result is line with the result of Maddison (2006); Nhemachena and Hassan (2007) that showed the distance to market center will affect the access to get new technologies and information on farm technologies.

viii. Climate Observation

Observing rainfall variability has significant positive associations with diversification of crop variety, applying short season growing diseases and pest tolerance maize varieties, increased use of soil and water conservation practices and cattle fattening. The result indicated as observed rainfall variability in the study area increases by one unit the probability of applying diversification of crop variety, short season growing diseases and pest tolerance maize varieties, increased use of soil and water conservation practices and cattle fattening increases by 17%, 21.3%, 21% and 13.5% respectively. This result confirm the study conducted by Bedeke *et al.,* (2018) which discussed the issues of climate variability on maize by relating it to rain fall and temperature change in Wolaita Zone stating that most farmers had shifted from a sole maize production to both maize-tuber and maize-legume mixed systems to respond to drought stress. Crop production by combining maize with legumes, notably either pigeon peas Pisum sativum or common beans Phaseolus vulgaris, were largely applied to build up soil fertility and prevent nutrient losses. Although changes in disease spread and severity are uncertain under climate change farmers suggest that greater crop diversity across space and time could potentially help to improve yields. At the same time, farmers acknowledge that crop diversity can protect against climate change risks because it is possible to plant specific crop varieties when other varieties fail.

Observed onset and offset of rainfall had positive impact on applying short season growing diseases and pest tolerance maize varieties and changing planting dates. The result indicates that, experiencing let or early onset and offset of rainfall in the study area increases the likelihood of adopting short season growing diseases and pest tolerance maize varieties and changing planting dates as adaptation strategy for maize producing farmers in the study area. This result is consistent with the finding of Habtemariam *et al.*, (2016), who showed seasonal rainfall duration in Ethiopia has become much shorter than the regular rainy season. Similarly, Simelton *et al.*, (2011), analyzed farmers' perception of rainfall variability patterns in Malawi, and stated that households often explain unpredictable seasonal rainfall in terms of its duration and proposed certain adaptation strategies.

ix. Maize Production Observation

The frequent occurrence of maize crop failures in the study area was found to be a positive determinant factor for certain adaptation options in the area. As the frequency of maize crop failure increases in the study area the probability of diversifying crop variety increases by 11% to share risks over diversified crop. Shifting to nonfarm activities as adaptation strategy was also increased by 13% along with increase of cattle fattening by 17% in the study area, since they have to adjust their livelihood with the condition. Similarly, Adimassu *et al.*,

(2014) revealed that crop diversification is one of the preferred strategies by farmers to deal with adverse climate change impacts like crop failure.

Maize disease occurrence in the study area also affects the respondents and forcing them to apply short season growing diseases and pest tolerance maize varieties and maize rotation with pulses. As the MNL model result indicated, recently emerging pests and disease increase the likelihoods of using short season growing, diseases and pest tolerant maize varieties and maize rotation with pulses by 18.4% and 18% respectively which was also supported by focus group members and key informant participants. Accordingly, most maize producing farmers had shifted from maize mono-cropping to both improved maize varieties and other legume mixed systems in order to respond to disease and pest stress. These results are consistent with findings of Kassie *et al.,* (2013) and Adimassu *et al., (*2014), who explored changes in crop varieties and types as major crop management adaptation strategies to climate change among small farming households in north-central Ethiopia.

x. Access to weather information

Access to weather information is also another important variable that affects adaptation options of smallholder farmers. The results showed that, access to weather information as expected had positively impacted adaptation to climate change. That is, farmers who had better access to weather information (i.e., Rainfall cassation and occasion) and seasonal or mid-term forecasting, had a higher probability of implementing climate change adaptation strategies such as diversifying crop variety, applying short season growing, diseases and pest tolerance maize varieties and changing planting dates. Being informed about weather condition increased the likelihood of diversifying crop variety 18.6% and making planting date adjustments by 24%. These findings are similar to the findings from various studies

(Asrat Paulos and Simane Belay 2018; H. Daba Mekonnen 2018) stating the importance of weather information in their respective finding.

Figure: 7. Some of adaptation practices of Small holder farmers in the study area.

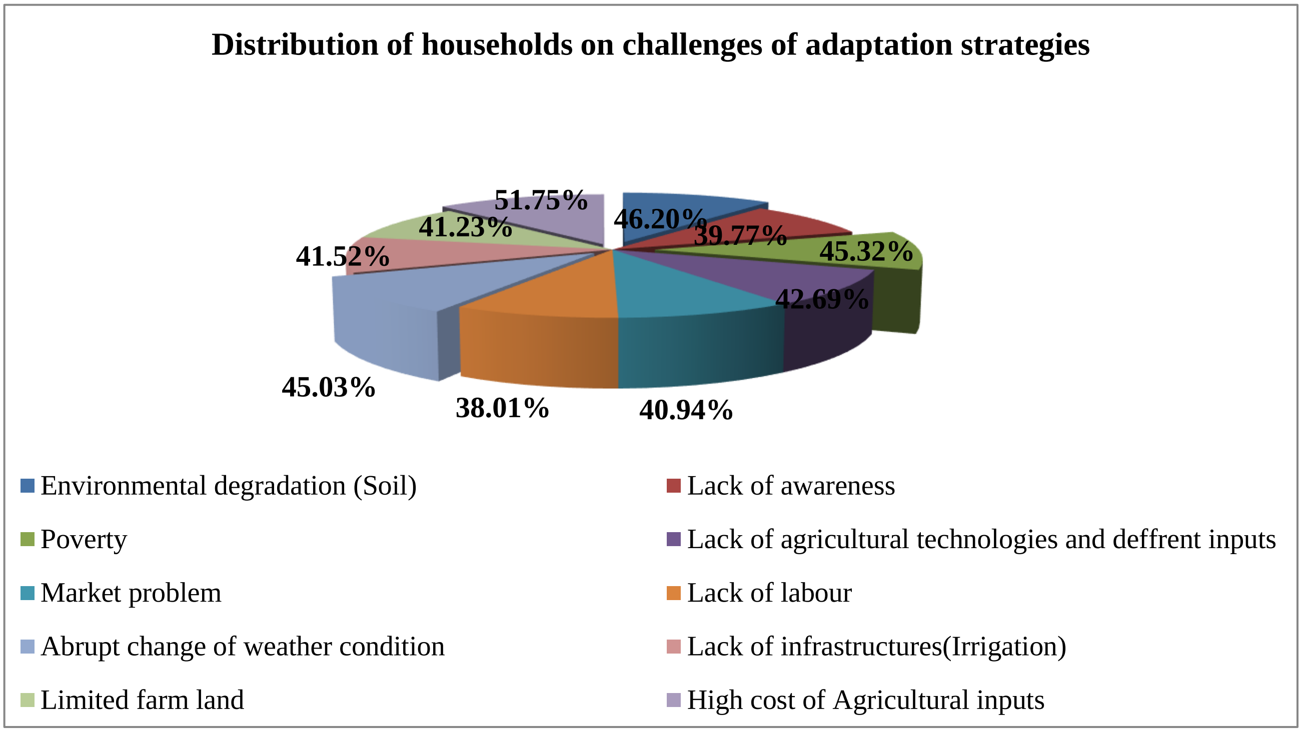
Source (Own photo, 2020)

4.3. Barriers and challenges of Adaptation Strategies in the Study Area

Barriers of adaptation can be defined as factors, conditions or obstacles that are believed to reduce the effectiveness of the farmers' adaptation strategies (Van *et al,,* 2015). The major farmer adaptation barriers are socio-ecological factors, psychological factors and resource constraints, which arise due to poverty levels, lack of information and communication on adaptive measures, lack of access to credit, and the perception of the importance of climate change and adaptation. Such barriers can be overcome with creative management, critical thinking and concerned effort (Gbetibouo, 2009)

Accordingly, maize producing small holding farmers was asked to state the factors that hinder them from applying available adaptation options. Among the main barrier factors; Environmental degradation (land and Soil), Lack of awareness, Poverty, Lack of agricultural technologies and deferent inputs, Market problem, Lack of labor, Unexpected change of weather condition, Lack of infrastructures(Irrigation), and Limited farm land, High cost of Agricultural inputs were the mains among others (Figure 8) .

Figure: 8. Barriers for Maize producing farmers when coping with a changing climate.



Source (Own survey, 2020)

As shown the survey result of the current study, maize producers in the study area are well aware of the climate variability and its impacts on their maize production in numerous aspects. However they have experiencing many challenges to practice different adaptation strategies to fight against the effects of climate variability. Accordingly, the respondents, FGD participants and key informants identified the challenges that have been hindering their adaptation capacity to climate variability in the study area are discussed below.

i.***Environmental Degradation****:*

About 46.2 % of the households reported that, environmental degradation is a bottle neck to adapt to climate variability-related hazards (Table 12). Furthermore, these households have mentioned environmental degradation is due to miss uses of the natural resources and over population. Land degradation is the popularly reported by households and has impacts on their livelihood by causing decline of crop productions through soil erosion, water logging, depletion of soil nutrients and creation of soil acidity. These perceptions are in line with World Bank, (2007) that stated, serious land degradation leading to decline in crop yields and reduced the effectiveness of fertilizer use to raise farm productivity.

ii. Lack of awareness:

Awareness creation on development and utilization of new technologies are keys to strengthening adaptive capacity (Ngigi, 2009). However, 39.77 % of the interviewed households' lacks awareness on utilization of available land based existing and projected climate change variability to exercise appropriate adaptation strategy. This result gives a clue of the importance of land based climate projection data availability for proper choice.

iii. Poverty:

About 45.32 % of households consider poverty as the bottle neck that has been weakening their capacity to overcome the problems encountered them from climate variability (Table: 12). Poverty as perceived by households is caused by and consequences of scarcity of land, climate related hazards (soil erosion and flood), lack of assets to recover from impacts of climate variability. These problems have forced the households to leave their original residences and seeking for other livelihood options. IPCC, (2001) also manifested that, poverty is directly related to vulnerability, and is therefore a rough indicator of the ability to of a community to cope and adapt stress conditions.

Table: 12. Ranks of challenges to Farmers' adaptation strategies to climate variability

Challenges of adaptation strategies	No of Respondents	Frequency of Respondents	Percent	Rank
Environmental degradation (land and Soil)	342	158	46.20	2
Lack of awareness	342	136	39.77	9
Poverty	342	155	45.32	3
Lack of agricultural technologies and deferent inputs	342	146	42.69	5
Market problem	342	140	40.94	8
Lack of labor	342	130	38.01	10
Unexpected change of weather condition	342	154	45.03	4
Lack of infrastructures(Irrigation)	342	142	41.52	6
Limited farm land	342	141	41.23	7
High cost of Agricultural inputs	342	177	51.75	1
Total	342	342	100.00	

Source: (Own survey, 2020)

***iv. Lack of agricultural technologies and input**:*

About 42.7% of interviewed households indicated the lack of agricultural technologies and input as the most important challenge to adaptation to climate variability (Table 12). The interviewed households have also indentified lack of irrigation access and required fertilizers on time as well as shortage of improved seeds which could give better output in short period of time are among the challenges. In spite of all these challenges the respondent farmers expressed that, diversifying agricultural activity is the most excellent option for their livelihood compared to other activities.

***v. Market problem**:*

Some challenges to farmers' adaptation strategies, related to market access were observed in the study area (Table 12). According to the responses of 41% of the households, problems of market (market function, such as exchange of goods , time, marketing information that facilitate marketing, as well as distance of market from their residences and from agricultural productions field and supplying similar goods, have been enforcing households to sell their production cheaply and to buy inputs expensively. The mentioned market's problems joined with other infrastructures have deteriorating impact on households to adapt climate variability.

vi. Lack of labor:

About 38% of the respondents expressed that family size presents challenge to adaptation practices that are applied in the field (Table 12). Family size imposes additional pressure on family's resources. Thus some of the working forces would be migrating to nearby towns seeking for job opportunity and create socioeconomic instability. Since most households have large family size, they cannot produce surplus to earn income by using advanced useful technologies and adapt to climate change related risks. Although some argue that large family size provides additional labor to implement some adaptation practices (Ali and Erenstein 2017), it might not be the best idea to have large family for farmers with very small land area to operate.

vii. Unexpected change of weather condition:

About 45% of the sampled smallholder maize producers responded that abrupt change in the weather condition has affected their economy by triggering unexpected diseases and pests on crops and animals. They also have indicated that, abrupt change of weather condition has exposed them in frustration of future plan and thereby adaption strategies in the study area have been ineffective**.** It is evident that, particularly crops could be impeded by; rusts, weeds, worms, cutworms, termite, root rotting and other disease causing pathogens as a result of the changing climate *(*Ahimed *et al.,* 2011)

viii. Lack of Irrigation infrastructures:

In this study about 41.5% of households have indicated that, lack of irrigation infrastructure is a major challenge resulted in ineffective adaptation strategies in study area. When rainfall becomes variable and scant to cause crop failure, there would be a need of irrigation infrastructure to reduce the expected drought damage on the crop yield.

ix. Limited farm land*:*

Besides, 41% of the respondents think that, the existing shortage of farm land limits their adaptation choice. Although the mean household land size in the area is about 2.8 ha is better than the national average (≤ 2.5ha), the application of some adaptation measures such soil and water conservation and diversifying crop types take larger area and thus discouraging them to implement as adaptation strategies.

x. Higher cost of Agricultural inputs*:*

Most of the adaptations options were related to price, which is again related to capital and thus, 52% of respondents mentioned that, the higher cost of fertilizers and other agricultural inputs along with the lack of credit access hinder their adaptation capacity. Similarly, IPCC (2001) explained that, adaptation of new technology costs money and poor communities have less diverse and more restricted entitlements, they lack to adapt, locking them into a vulnerable situation.

5. SUMMARY AND CONCLUSION

5.1. Summary

The impact of climate change on crop production is considered to be strong and affecting food security and especially livelihood of smallholder farmers. Thus, a better understanding about climate change and developing the right perception and adaptation strategies of farmers is essential to propose proper measures that will avert its adverse effects. The aim of the current study was therefore to evaluate long term climate trends and investigate perception of smallholder farmers about climate change and adaptation strategies in maize production in Guto Gida woreda using both quantitative and qualitative data analysis.

The results revealed that, the annual rainfall is in a declining trend by 5.77mm per year, with inter-annual variability of 23.5% CV value which is considered as moderately variable. Similarly, rainfall variability's for the months of JJA and SON were 22.1 and 20% respectively, while the long term variability during months of MAM was 36.3% which is highly variable that would create significant challenge to decide the planting time, since these months are for land preparation and maize planting in the study area.

The overall comparisons of rainfall indices showed that, 2015 and 2016 were extremely drought years with SPI value of (-2.72) and (-2.26) respectively, while the two extreme wet years were 1992 and 1993 with SPI values of 1.02 for both and about 75% of the wet years were recorded before 2000, while 71% of the dry years occurred after 2000, confirming that the occurrence of wet years is declining whereas drought incidence is increasing.

On the other hand, the study discovered that, the mean temperature of the study area is significantly increasing with annually rate of 0.033^0C in the maximum, and 0.035^0C in the minimum temperatures, while the mean annual variability in the minimum temperature was 16.80% which was much higher than the annual maximum of 2.98%. These results show that, the annual minimum temperature is much higher than the annual maximum in both rate of increase and level of variability in the study area. Generally, the analyzed rainfall and temperature trends in the study area during the past 20 to 30 years were further confirmed by 80% of the respondent farmers in the study area.

The results from the binomial logit model on specified variables like sex, access to extension service, membership of local organizations, RF variability, Onset of RF, frequent maize crop failure and access to weather information were the only significantly influenced the perception of the respondent on climate change.

Additionally, the study also revealed climate change impacts on crop production particularly on maize. Especially the rainfall of months of JJA and SON had significantly negative (-0.58 and -0.45) impact on maize yield on the long term, as a result, the farming community was pushed to practice various adaptation measures. The most frequently practiced adaptation measures were crop rotation of maize with pulses which was implemented by 82% of respondents followed by crop diversification practiced by 77% of the respondent farmers. Small scale irrigation and use of different maize cultivars were also practiced by 76 and 73.7% of the respondents to overcome the shock posed by climate changes in the study area.

According to the result from MNL regression, the level of significance of the variables differs with type of adaptation measures in the study area, indicating that, all adaptation options ware not influenced by the same variables. But all hypothesized adaptation strategies were determined at least by one of these variables; sex, education, family size, access to extension services, access to credit, access to market, access to weather information, membership of local organization, size of farmland, temperature variability, RF variability, onset of RF, offset of RF, frequent maize failure and disease occurrence significantly either positively or negatively at α 0.05.

This study also identified the major barriers for the implementation of climate change adaptation strategies of maize producing farmers in the study area. The barriers based on the prioritization by the respondents include; Higher cost of Agricultural inputs, Environmental degradation (land and Soil), Poverty, Unexpected change of weather condition, Lack of agricultural technologies and inputs, Lack of infrastructures (Irrigation), Limited farm land, Market problem, Lack of awareness, shortage of labor.

5.2. Conclusion

As climate change perception is one of the most important factors determining the willingness of farmers to implement adaptation options, it is considered as the first step in the process of farmer’s adaptation to climate change impact. Therefore a joint policy intervention between government policy makers and development practitioners is required to improve the climate change perceptions and thereby enhance the adaptation capacity of smallholder farmers. The author suggests the task of improving the level of perception of smallholder farmers on climate change and adaptation strategies in crop production in the study area and similar agro ecology to be done in four ways.

First, this joint policy intervention should focus on encouraging informal social networks that can promote group discussions and better information flows and experience sharing to enhance smallholder farmer’s climate change perceptions that could help to improve the capacity of smallholder farmers to reduce negative impacts of climate change on the already weak agriculture and the livelihoods of smallholder farmers.

Second, to improve the capacity of the farmers to adapt to climate change at all, government policy makers and development practitioners should focus on improving market information flow, access to input and output market and credit facility that could help improve the capacity of smallholder farmers to use any one of the adaptation strategies identified in this study.

Third, government policy makers and development practitioners can identify the most appropriate climate change adaptation strategy and tackle determinant factors that affect the decision of farmers to use that strategy based on environmental context of the districts. For instance, the study area mostly exposed to flood, maize mono cropping and frequent maize failure due to unexpected change of weather condition they can work on tackling determinant factors that affect the decision of farmers to counter act for climate adverse impact on their crop yields.

Fourth, in general joint policy intervention may focus on improving climate - agriculture relation through climate smart agriculture strategies proposed by FAO through boxing in all climate smart agricultural activities and out other wise to reduce climate change impact on the livelihoods.

REFERENCE

Abate T, Shiferaw B, Menkir A, Wegary D and others, 2015. Factors that transformed maize productivity in Ethiopia. Food Security 7, 965-981.

Adamgbe, E. M and Ujoh, F. 2013. Effect of variability in rainfall characteristics on maize yield inGboko, Nigeria. Journal of Environmental Protection,4(09), 881.

Addisu Solomon, G.Selassie Yihenew, Fissha Getachew and Gedif Birhanu. 2015. Time series trend analysis of temperature and rainfall in lake Tana Sub-basin, Ethiopia. Environmental Systems Research 4(1): 12.

Admassu S.,2004. Rainfall Variation and its Effect on Crop Production in Ethiopia. Thesis submitted to School of Graduate Studies, Addis Ababa University.

Adimassu Z, Kessler A, Stroosnijder L., 2014. Farmers' strategies to perceived trends of rainfall and crop productivity in the Central Rift Valley of Ethiopia. Environ Dev 11, 123-140.

AfDB (African Development Bank), 2011. Federal Democratic Republic of Ethiopia, Country Strategy Paper 2011-15.

Ahimed Hussen, Dejene Biru and Bona Yadessa, 2011. Oromia National Regional State Program of plan on Adaptation to climate change Document. Finfinne.

Alem Kidanu, Kibebew Kibret, Jemma Hajji, Muktar Mohammed and Yosef Ameha, 2016. Farmers perception towards climate change and their adaptation measures in Dire Dawa Administration, Eastern Ethiopia. Journal of Agricultural Extension and Rural Development 8(12), 269–283.

Ali, A and Erenstein, O., 2017. Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Climate Risk Management, 16, 183-194.

Amadou, M.L., Villamor, G.B., Attua, E.M., Traoré, S.B., 2015. Comparing farmers' perception of climate change and variability with historical climate data in the Upper East Region of Ghana. Ghana Journal of Geography 7(1), 47-74

Asaminew Emerta, 2013. Climate Change, Growth and Poverty in Ethiopia.Working paper 03.

Asfaw, A. and A. Admassie, 2004. The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. Agricultural Economics, 30 (3), 215-228.

Asrat Paulos and Simane Belay, 2018. Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. Ecological Processes 7(1), 7.

Bedeke, S., Vanhove, W., Wordofa, M., Natarajan, K., Van Damme, P., 2018. Perception of and response to climate change by maize-dependent smallholders. Clim. Res. 75, 261–275.

Belay Abraham, 2012. Analysis of climate variability and its economic impact on agricultural crops: the case of Arsi Negele district, central rift valley of Ethiopia. MSc. thesis, Hawassa University.

Beltrando G. and Camberlin P., 1993. International variability of rainfall in the eastern horn of Africa and indicators of atmospheric circulation. International Journal of Climatology 13, 533-546.

Bernard, H.R., 2011. Research Methods in Anthropology: Qualitative and Quantitative Approaches. (4^{th} ed.). Alta Mira Press, Lanham, MD., 198-203.

Beweket Waldeamlak, 2009. Rainfall variability and crop production in Ethiopia Case study in the Amhara region. Department of Geography & Environmental Studies, Addis Ababa University.

Bewket Woldeamlak, 2012. Climate change perceptions and adaptive responses of smallholder farmers in central highlands of Ethiopia. International Journal of Environmental Studies 69,507 – 523.

Bryan, E., Deressa T., T., Gbetibouo, G.A. and Ringler C., 2009. Adaptation to Climate Change in Ethiopia and South Africa: Options and Constraints. Env. Science & Policy, 12, 413-426.

Burton and I., 1996. The growth of adaptation capacity: practice and policy. In Adapting to climate Change: An International Perspective. Springer - Verlag, New York, NY, USA, 55 – 67.

Cairns, J. E., Hellin, J., Sonder, K., Araus, J. L., MacRobert, J. F., Thierfelder, C., Prasanna, B., M., 2013. Adapting maize production to climate change in sub-Saharan Africa. Food Security, 5 (3), 345 – 360.

Camberlin, P., 1997. Rain fall anomalies in the source region of the Nile and their connection with the Indian summer monsoon. Journal of Climate, 10, 1380 – 1392.

CIMMYT, 2013. The drought tolerant maize for Africa project. DTMA Brief. URL, http://dtma.cimmyt. org.

CSA, 2012a. Statistical report on area and crop production. Addis Ababa, Ethiopia. Central Statistical Agency.

Daba, M. H., 2018. Agro - Climatic Characterization in the Selected Woreda's of Western Oromia, Ethiopia. Journal of Earth Science and Climatic Change, 9(3), 79 – 95.

David, S., Thomas G., Twyman C., Osbahr H., Hewitson B., 2007. Adaptation to climate change and variability: farmer responses to intra-seasonal precipitation trends in South Africa. Climatic change 83, 301-322.

Deressa,T., 2007. Measuring the economic impact of climate change on Ethiopian agriculture. World Bank Policy Research Paper No. 4342. Washington D.C. World Bank.

Deressa, 2010. Factors affecting the choices of coping strategies for climate extremes: The case of farmers in the Nile Basin of Ethiopia.

Deressa Temesgen, Hassan R. M., Ringler, C., 2011. Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. The Journal of Agricultural Science 149, 23–31.

Elder, S., 2009. Sampling methodology. A Methodological Guide, Module 3, International Labor Organization, Geneva.

Environmental Protection Authority, 2012. National Report of Ethiopia, the United Nations Conference on Sustainable Development. Addis Ababa: Federal Democratic Republic of Ethiopia, EPA publications, 73.

F. Ndamani1and T. Watanabe, 2007. Determinants of farmers' adaptation to climate change: A micro level analysis in Ghana. Kochi University of Technology, 185 - 782.

FAO, 1978. Report on the Agro-Ecological zone project vol.1. Rome.

Fazzini, M., Bisci, C., Billi, P., 2015. The Climate of Ethiopia. https://doi.org/10.1007/978-94 017-8026-1_3

FDRE (Federal Democratic Republic of Ethiopia), 2011. Ethiopia's Climate-Resilient Green economy strategy (CRGE). Adis Ababa.

Feleke H. G., 2015. Assessing Weather Forecasting Needs of Smallholder Farmers for Climate Change Adaptation in the Central Rift Valley of Ethiopia. Journal of Earth Science 6, 312.

Feyissa, A., 2009. Climate Change Impact on Livelihood, Vulnerability and Coping Mechanisms: A Case Study of West-Arsi Zone, Ethiopia. MSc. Thesis, Lund, Sweden.

Fowler, A.M and Hennesy KJ., 1995. Potential impacts of global warming on the frequency and magnitude of heavy precipitation natural hazards.

Fraser A. I, Hazard T. R., Harrad, T. R., Haygarth P. M., 1999. The effect of rainfall intensity on soil erosion and particulate phosphorus transfer from Arable Soils. Water scie. and tech. 39, 12, 41

Gashaw Temesgen, Mebrat Wondie, Hagos Daniel and Nigussie Abeba, 2014. Climate Change Adaptation and Mitigation Measures in Ethiopia. Journal of Biology 4(15): 7.

Gbetibouo, G.A., 2009. Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. IFPRI Discussion Paper No. 00849.

Gebeyehu Getaneh and Zerga Belay, 2016. Climate Change in Ethiopia Variability, Impact, Mitigation, and Adaptation. Journal of Social Science and Humanities research 2, 20.

Getachew. S, Tilahun. T, Teshager M., 2014. Determinants of agro pastoralist climate change adaptation strategies. Research Journal of Environmental Sciences 8(6), 300 - 317.

Gissila, T., E. Black, D.I.F. Grimes and J. M. Slingo, 2004. Seasonal forecasting of the Ethiopian Summer rains. International Journal of Climatology, 24, 1345-1358

Gods will M, Dawit K. and Dejene A, 2007. A comparative analysis of rainfed and irrigated agricultural production in Ethiopia. Journal of Irrigation and Drainage 21, 1.

Gordon, H. B, Whetton, P. H, Pittock A. B, Fowler, A. M, Haylock, M. R., 1992. Simulated changes in daily rainfall intensity due to the enhanced green house effect: implications for extreme rainfall events Climate Dynamics 8, 83-102.

Gujarati DN, 2004. Basic Econometrics, Fourth Edition. The Mc Graw − Hill Companies.

Guto Gida Woreda Agricultural and Natural Resource Office, 2019. Unpublished socioeconomic document.

H. Daba Mekonnen, 2018. Assessing Local Community Perceptions on Climate Change and Variability and its Effects on Crop Production in Selected Districts of Western Oromia, Ethiopia. Journal of Climatology and Weather Forecasting 6(1), 1 - 8.

Habtemariam L T, Gandorfer M, Kassa G A, Heissenhuber A., 2016. Factors influencing smallholder farmers' climate change perceptions: a study from farmers in Ethiopia. Journal of Environment Management 58, 343-358.

Hagos F, Makombe G, Namara R E, Awulachew S B., 2009. Importance of irrigated agriculture to the Ethiopian economy: Capturing the direct net benefits of irrigation. Colombo, Sri Lanka. International Water Management Institute, 37.

Haile T., 1986. Climatic Variability and Support Feedback Mechanisms in Relation to the Sahel International Research Institute for Climate and Society.

Hameso Seyoum, 2018. Farmers and Policy-makers' Perceptions of climate change in Ethiopia. Journal of Climate and Development 10(4), 347–359.

Hassan R. and Nhemachena C., 2008. Determinants of African farmers strategies for adapting to climate change: multinomial choice analysis. African Journal of Agricultural and Resource Economics 2 (1), 83–104.

IPCC, 2001. Climate Change Vulnerability, Impacts and Adaptation to Climate Change, Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press, 675–77.

IPCC, 2007. The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

IPCC, 2014. Climate Change Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland, 151.

IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Am Special Report of Working Groups I and II of the IPCC, Edited by C.B., V. Barros, T.F. Stocker, D in, D.J. Dokken, K.L. Ebi, M. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley. Cambridge, UK, and New York, USA. 582.

Kandlinkar, M and Risbey, J, 2000. Agricultural impacts of climate change: If adaptation is the answer, what is the question? Climatic Change 45, 529 – 39.

Kassahun B, 1987. Weather systems over Ethiopia Proc. First Tech. Conf. Eastern and Southern Africa. Nairobi, Kenya, UCAR, 5357.

Kassie B T, Hengsdijk H, Rötter R, Kahiluoto H, Asseng S, van Ittersum M., 2013. Adapting to climate variability and change: experiences from cereal - based farming in the Central Rift and Kobo valleys, Ethiopia. Journal of Environment Management 52, 1115-1131.

Kanire, G., 2012. Social Science Research Methodology: Concepts, Methods and …URL https://www.grin.com/document/203950 (accessed 8.20.19).

Kidanu Aklilu, Rovin, K. and Hardee, K., 2009. Linking Population, Fertility and Family Planning with Adaptation to Climate Change: Views from Ethiopia. 36.

Korecha, D and A.G.Barnston, 2007. Predictability of June-September Rainfall in Ethiopia. Monthly Weather Review 135(2): 628 – 650.

Kurukulasuriya, P and Mendelsohn, R, 2006. A Ricardian analysis of the impact of climate change on African cropland. CEEPA Discussion Paper No. 8. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Lemi A., 2005. Rainfall probability and agricultural yield in Ethiopia. East Africa. Social. Science. Research 21(1): 57–96.

Lobell, D. B., Bänziger, M., Magorokosho, C., Vivek, B., 2011a. Nonlinear heat effects on African maize as evidenced by historical yield trials. Nature Climate Change 1, 42 – 45.

Lobell, D. B., Schlenker, W. and Costa - Roberts, J., 2011. Climate trends and global crop production since 1980. Science, 333(6042): 616 - 620.

Madalla, G., 1983. Limited dependent and qualitative variables in econometrics. Cambridge: Cambridge University Press.

Madison, D., 2006. The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No.10. Cent. for Environmental Economics and Policy in Africa, University of Pretoria.

Mavi H. S., Tupper G. J., 2004. Agro-meteorology: Principles and Applications of Climate Studies in Agriculture. Haworth Press 50 – 64.

McSweeney, C., New, M., and Lizcano, G., 2008. United Nation Development Program (UNDP) Climate Change Country Profiles Ethiopia Available at http://countryprofiles.geog.o ac.uk.

McSweeney, C., New, M., Lizcano, G. and Lu, X., 2010. The UNDP Climate Change Country Profiles: Improving the Accessibility of Observed and Projected Climate Information for Studies of Climate Change in Developing Countries. Bulletin of the American Meteorological Society 91(2): 157 – 166.

MEDaC (Ministry of Economic Development and Co-operation), 1999. Survey of the Ethiopian Economy: Review of Post-Reform Developments, 1992/93 - 1997/98. Addis Ababa, MEDaC.

Mekasha Aklilu, Chillot Yirga, Tesfaye Kindie, Lisanework Nigatu and Alan, J. D., 2016. Perception of climate extreme trends over three Ethiopian eco-environments: Comparison with records and analysis of determinants. Journal of Agricultural Biotechnology and Sustainable Development 8, 53 – 66.

Mendelsohn, R., 2008. The Impact of Climate Change on Agriculture in Developing Countries. Journal of Natural Resources Policy Research, Yale University. New Haven, USA.

Mengistu Dejene K., 2011. Farmers' perception and knowledge on climate change and their coping strategies to the related hazards: case study from Adiha, central Tigray, Ethiopia. Agricultural Sciences 2, 138 – 145.

Mersha, E., 1999. Annual Rain Fall and Potential Evapo-Transpiration in Ethiopia. Ethiopian Journal of Natural Resources 1, 137 – 154.

Mc Kee T B, Doesken N D and Kleist J., 1993. The Relationship of Drought Frequency and Duration of Time Scales Conf. Eighth Conference on Applied Climatology, American Meteorological Society (Anaheim CA) 179-186.

MoA, 2010. Ethiopia's agriculture sector policy and investment framework: Ten Years Road Map (2010-2020).

NDMC, 2020. Monitoring drought, The Standardized Precipitation Index, Interpretation of SPI Maps. National Climatic Data Center, http://www.drought.unl.edu/monitor/interp.html, Date Accessed: 22-5- 2020

Muluken Mekuyie Fenta, 2017. Understanding Resilience of Pastoralists to Climate Change and Variability in a Changing Rangeland Environment in the Afar region, Ethiopia. Doctoral degree desertion.

NAPA, 2007. Climate Change National Adaptation Program of Action, Ethiopia, Addis Ababa.

Negash Wolde, 2016. Analysis of Rainfall Variability and Farmers' Perception towards it in Agrarian Community of Southern Ethiopia. Journal of Environment and Earth Science 6.

Ngigi, S. N., 2009. Climate change adaptation strategies: Water Resources Management Options for Smallholder Farming Systems in Sub-Saharan Africa. The MDG Centre, East and Southern Africa. The Earth Institute at Columbia University.

Nhemachena C. and Hassan R, 2007. Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute. Washington DC.

NMSA, 1996. Climate and agro climate resources of Ethiopia. NMSA Meteorological Research Report Series 1(1).

National Meteorology Agency, 2015. Weather records: National Meteorology Agency (NMA), Addis Ababa, Ethiopia.

Norman, M.J.T., Searle, P.G.E., 1995. Maize (Zea mays L.) In The Ecology of Tropical Food Crops. Cambridge University Press, 126-144.

NRC, 1995. Natural climate variability on decadeto century times scales.Washington, D.C, National Academy Press.

Oladipo, E. O and Kyari K. D., 1993. Fluctuations in the onset, termination and length of the growing season in Northern Nigeria. Theory and Application of climatology, 47(4), 241250.

Omotosho. J., 1990. Onset of thunderstorms and precipitation over Northern Nigeria. International Journal of Climatology 10, 849 - 860.

Omoyo, N. N., Wakhungu, J. and Oteng'i, S., 2015. Effects of climate variability on maize yield in the arid and semi arid lands of lower eastern Kenya. Agriculture and Food Security, 4, 8.

Onoz, B., Bayazit, M., 2012. The Power of Statistical Tests for Trend Detection. Turkish Journal of Engineering & Environmental Sciences 27, 247 – 251.

Osman. M and Sauerborn. P, 2002. A preliminary assessment of characteristics and long term variability of rainfall in Ethiopia basis for sustainable land use and resources management. Conference on International Agricultural Research for Developm ent, Deutscher Tropentag Witzenhausen, Germany.

Pankhurst R, Johnson D H., 1988. The great drought and famine of 1888 - 92 in north east Africa. Inter. Journal. The ecology of survival: case studies from northeast African history 47 - 72.

Paulo A., A. and Pereira L, S., 2006. Drought concepts and characterization: comparing drought indices applied at local and regional scales *Water Int.* 31**,** 37-49.

Paulo A., A, Rosa R. D. and Pereira L., S., 2012. Climate trends and behavior of drought indices based on precipitation and evapotranspiration in Portugal. *Natural Hazards and Earth System Science* 12**,** 1481-1491.

Pedgley, D., E., 1966. The Red Sea Convergence Zone: Weather 21, 350 - 358 and 394 - 406.

Salvatore, Di Falco, Mahmud Y, Gunnar K and Claudia R., 2011. Estimating the Impact of Climate Change on Agriculture in Low-Income Countries: Household Level Evidence from the Nile Basin, Ethiopia.

Segele, Z. T. and P. J. Lamb, 2005. Characterization and variability of Kiremt rainy season over Ethiopia. Meteorology and Atmospheric Physics 89(1): 153 – 180.

Senait Regassa, Christina Givey, and Gina E. Castillo, 2010. Poverty, Vulnerability and Climate variability in Ethiopia. Oxfam international journal 14-16.

Shiferaw, B., Prasanna, B. M., Hellin, J. and Bänziger, M., 2011. Crops that feed the world Past successes and future challenges to the role played by maize in global food security. Food Security, 3 (3), 307 – 327.

Simelton E, Quinn C H, Antwi - Agyei P, Batisani N and others, 2011. African farmers' perceptions of erratic rainfall. Sustainability Research Institute 27.

Sivakumar, M. V. K., 1988. Predicting rainy season potential from the onset of rains in southern Sahelian and Sudanian climatic zones of West Africa. Agric.For. Meteorology 42, 295 - 305.

Taddesse, T., 2000. Drought and its predictability in Ethiopia. In Wilhite, D. A. (Ed.), A Global Drought Assessment 1, 135-142.

Temesgen, D, Hassan R. M, Alemu,T., Mahmud Y. and Ringler C., 2008. Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia 260-284.

Temesgen. D., 2008. Measuring Ethiopian Farmers Vulnerability to Climate Change across regional States. International Food Policy Institute.

Tilahun, K., 1999. Test of homogeneity, frequency analysis of rainfall data and estimate of drought probabilities in Dire Dawa, eastern Ethiopia. Ethiopian journal of Natural Res. 1, 125-136

Tilahun U, Bedemo T., 2014. Farmers' Perceptions and adaptations to climate change through conservation Agriculture: The case of Guto Gida and Sasiga Districts, Western Ethiopia. Acad. J. Agric. Res. 2(10), 207-224.

Tse, Y. K., 1987. A diagnostic test for the multinomial logit model. Journal of Business and Economic Statistics 5 (2), 283 – 286.

UNFCCC, 2011. United Nations Framework Convention on Climate Change: Fact sheet: Climate Change science – the status of Climate Change science today. 7.

USAID, 2015. Climate variability and change in Ethiopia. Summary of findings technical report Washington, DC.

Van, S. T., Byod, W. and Van, M. T., 2015. Perception of Climate Change Farmer's Adaptation: A Case Study of Poor and Non-Poor Farmers in Northern Central Coast of Vietnam. Journal of Basic and Applied Sciences, 11, 323-342.

Venkataramanan, M., 2011. Causes and effects of global warming. Indian Journal of Science and Technology 4(3). 4.

Wolde Georgis T., 1997. The Use of El Nino Information as Drought Early Warning in Ethiopia. International Journal of Agriculture Science, 1, 2.

Wolka Kebede and Zeleke Gizachew, 2016. Understanding Farmers' Perception on Climate Change and Adaptation Strategies in Karetha Watershed, Omo-gibe Basin, Ethiopia. Asian Journal of Earth Sciences 10, 22 – 32.

Wood A., 1997. A preliminary chronology of Ethiopian droughts, Drought in Africa, 2 68-73.

Worku, D., 2018. Yield and challenges of adaptation strategies in Guto Gida district, East Wollega, Ethiopia.

World Bank, 2011. Vulnerability, risk reduction and adaptation to climate change. Climate risk and adaptation country profile.

World Bank, 2006. Managing water resources to maximize sustainable growth: A country water resources assistance strategy for Ethiopia. World Bank, Washington on, DC.

World Bank, 2010. Economics of Adaptation to Climate Change , Ethiopia .World Bank Group 1818 H Street, NW Washington.

Yamane, T., 2001. Basic Sampling Methods. Literature Publishing, Istanbul, Turkey.

Yayeh Desalegn and Leal Filho, W., 2017. Farmers' perceptions of climate variability and its adverse impacts on crop and livestock production in Ethiopia. Journal of Arid Environ. 140, 20-28.

Yusuf, M, D, Salvatore, Temesgene Deressa, R. Claudia and K. Gunnar, 2008. The Impact of Climate Change and Adaptation on Food Production in Low income Countries. IFPRI Discussion paper.

Zargar A, Sadiq R, and Naser B. and Khan F., 2011. A review of drought indices. *Rev.* 19333 - 349.

Zegeye Haileab, 2018. Climate change in Ethiopia: Impacts, Mitigation and Adaptation. International Environmental studies 5, 18 - 35.

Zeray Negussie and Demie Ashebir, 2015. Climate change, Impact, vulnerability and Adaptation in Ethiopia: Review. Journal of Environment and Earth Science 5(21), 12.

APPENDIXES

1. House hold semi-structured Questionnaires

Hello Dear Respondents!

My Name is Getahun Minase. I am a student at Hawassa University Wondo Genet College of Forestry and Natural resources, doing my MSC Degree in Climate Smart agricultural Landscape assessment. I am conducting my master's thesis on Climate change Perception and adaptation strategies of small holder Maize producing farmers in Guto Gida District, East Wollega, Oromia Regional State, Western Ethiopia particularly in this area. I will explain to you consciously the aims of the research and the procedures to be used. Consequently, your involvement by giving authentic information will have better significance for the accomplishment of this thesis and make more fruitful my study. Perhaps, you can ask the researcher any questions that make you confusion about the study and expected to attain adequate answers regarding the research.

Thank you in advance for your contribution!

Part I. Personal Information

- Questionnaire No: ___________________
- Area:
- Region:__________Zone:__________District:__________Village:________
- Date of interview: ____________________
- Code of respondent: __________________
- Age: _______________ Sex: __________
- Marital status: Married ☐ Single ☐ Other specify ☐ ☐
- Education level: Illiterate Primary school ☐
- Other specify ---------------- ☐
- Number of family members________________

Part II. Perception of Households on Climate Variability

1. For how long did you live here? ____________________________
2. What was your major livelihood activity?
    - ○ ____
    - ○ ____
    - ○ ____
    - ○ ____

3.What are your major crops under cultivation?

- ○ ___________________Size in ha.________ Yield/ha in quintal______________
- ○ ___________________Size in ha.________ Yield/ha in quintal______________
- ○ ____________________Size in ha. ________Yield/ha in quintal_____________
- ○ ____________________Size in ha.________ Yield/ha in quintal_____________
- ○ ____________________Size in ha.________ Yield/ha in quintal_____________

4.Size of Farmland_________________________

5.Number of farming Oxen____________________________________

6.Number of Cattle_______________________________________

7.Number of ruminant animals (goat, sheep)_____________________________

8.Number of pack animal (ass, mule, horse)______________________________

9.Do you have access to credit from any sources? a/yes b/no

10. Do you have extra income other than farming? a/ yes b/ no If yes please specify____

11. Are you accessed to market? a/yes b/no

If yes, have you get good price for your commodity?

12. Have you ever notice maize disease or pest?

If yes, please list any.

a. __________________________________
b. __________________________________
c. __________________________________
d. __________________________________
e. __________________________________

13. Have you perceived crop failure? If yes, what types of crop?

List any;

________________,___________________,_________________

14. Based on #13 can you guess the cause of the crop failure?

15.	Do you have an access to climate change information?	Yes ☐	No ☐
	If yes, what were the sources of your climatic information? A) Mass media B) Extension agent C) Climate change forum D) Indigenous knowledge E) Other		
16.	What was the indigenous knowledge that helped you to identify the change in climate?		
	A) Counting local calendar B) using to proxy (remarkable events C) sharing information from parents.		
17.	Have you ever observed climate variability in your locality?	Yes ☐	No ☐
	If yes, which climatic parameters? A) Rain fall B) Temperature C) Other----------------		
18.	In which season, the variability revealed mostly? (based on #5		
	A) *Belg* season B) *kiremt* season C) *Bega* season		
19.	Have you ever observed any change in onset, cessation and length of growing period over the past 30 years?	Yes ☐	No ☐
20.	Based on # 7, if yes, how did you notice?		
	A)Due to change of sowing date B) due to change of harvesting time C) due to increased rainfall trend D) due to decreased rainfall trend E) all F) others------------------------------		
9	Have you noticed any effect of precipitation (rainfall) and temperature on crops in your locality over the past years?	Yes ☐	No ☐
	If yes, what were the effects? ____		

Part III. Opinion of Households on Adaptation Strategies

10. What were the adaptation strategies you have employed against climate variability?
    a. Crop variety diversification
    b. Growing short maturing crops and drought tolerance varieties
    c. Being selective in crop variety in diseases and pest tolerance crop variety
    d. Changing planting dates
    e. Using small scale irrigation
    f. Shifting from farm to non-farm activities
    g. Increased use of soil and water conservation techniques
    h. Cattle fattening
    i. Using different type of crop cultivation
    j. Others ------if others please specify
11. How did you practice to defend /to make adaptation strategies effective? ---------------------

    ----

Part IV. Perception of Households on Challenges of Adaptation Strategies

12. What are the major constraints (challenges) you have that hinders your adaptation strategies

Challenges of your adaptation strategies? Mark as Yes or No	Yes	No
Environmental degradation		
Lack of awareness		
Poverty		
Lack of agricultural technologies and input		
Market problem		
Lack of family planning/family size.		
unexpected change of weather condition		
Lack of infrastructures		

Any Other?

13. ____

____

____

14. What will happen if you fail to adapt the climate variability on your crop and livelihood?

List what you think

____

____

____

____

15. Who is responsible for the challenges of adaptation as you think?

____

____

____

____

16. Who should do what to overcome the challenges?

---

2. Check List for Focus Group Discussion

1. Had you any climatic information? , from where did you get climatic information?

____

____

2. Have you ever affected by rainfall variability in your locality which altered your Production? Yes------------- No-----------
3. If yes, what type of climate related hazard? A) Excess Rainfall B) Drought C) Erratic Rainfall D) all E) Others--
4. Based on #2, when did you observe? A) Belg season B) Meher season C) Bega season)
5. Have you affected by change in temperature in your locality over the past years?

   Yes ☐ No ☐
6. Based on question #4, if yes, how could you identify the variability? ____

   ____
7. What were the adaptation strategies you have employed against climate variability?____

   ____
8. Have you understood any challenges of adaption strategies in your local area? ____

   ____

   ____

3. Check Lists for Key Informants Interview

Name _________________________Profession/ Position ________________________

1. For how long time did you work here**?**
2. Have noticed any climate change?
3. Were there climate variability and its effect in your area? If you have noticed, what are the cause and consequences?
4. Have noticed the preferable adaptation strategies that are effectively used? Do you think is there other options in to assist the maize producing farmers to overcome the adverse effect of climate variability?
5. What are the current challenges that make adaptation strategies ineffectively used?

Appendix: 2

SPI Value of different period (SPI3 (I), SPI3 (II), SPI6, SPI9, and SPI12) of study Area

Years	SPI3(I)	SPI3(II)	SPI6	SPI9	SPI 12
1983	0.700	-0.090	0.241	0.585	0.530
1984	-0.439	-0.178	-0.345	-0.516	-0.680
1985	0.293	-0.628	-0.389	-0.442	-0.570
1986	-1.089	-0.147	-0.613	-0.603	-0.673
1987	1.164	-0.636	-0.003	-0.075	-0.166
1988	-1.547	0.184	-0.544	-0.058	-0.089
1989	0.624	-0.009	0.273	0.441	0.545
1990	-0.209	0.660	0.453	-0.004	-0.108
1991	-0.687	1.445	0.889	0.267	0.243
1992	0.698	1.295	1.389	1.169	1.020
1993	1.992	1.052	1.771	1.158	1.020
1994	0.612	0.202	0.443	0.197	0.048
1995	0.600	-0.102	0.186	-0.195	-0.276
1996	1.608	-0.452	0.350	0.090	-0.002
1997	0.899	-0.702	-0.177	0.191	0.082
1998	-0.183	1.041	0.781	1.162	1.006
1999	-0.229	-0.929	-0.874	0.059	-0.083
2000	-0.464	0.036	-0.180	-0.041	-0.204
2001	0.996	0.246	0.653	0.547	0.447
2002	-0.570	-0.891	-0.996	-1.035	-1.042
2003	-1.707	0.820	-0.089	-0.371	-0.363
2004	-1.261	0.057	-0.521	-0.178	-0.331
2005	-0.083	1.778	1.438	1.058	0.895
2006	-0.335	0.770	0.488	0.601	0.584
2007	0.545	0.329	0.519	0.199	0.133
2008	0.609	0.935	1.050	0.979	0.830
2009	-1.277	0.431	-0.218	-0.080	-0.172
2010	0.702	0.431	0.674	0.151	-0.001
2011	0.577	0.054	0.305	0.171	0.115
2012	-1.469	-0.372	-0.971	-0.700	-0.873
2013	-0.526	-0.032	-0.263	-0.088	-0.224
2014	1.727	-0.878	0.049	-0.002	-0.171
2015	-1.611	-3.168	-3.355	-2.554	-2.720
2016	-0.655	-2.553	-2.414	-2.086	-2.257

Appendix: 3

1. **Summary statistics for continuous variables used in the study**

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	342	41.582	11.105	22	70
Family size	342	5.228	1.730	2	9
Size of farm Land	342	2.791	2.536	0.5	20

2. **Summary statistics for Dummy variables used in the study**

Variable	Obs	Mean	Std. Dev.
Sex	342	0.8304	0.3758
Education	342	1.0585	0.6738
Accesstoex~s	342	0.8947	0.3073
Accesstocr~t	342	0.9327	0.2508
Membership~n	342	0.8977	0.3035
Accesstoma~t	342	0.9006	0.2997
Changeintemp	342	0.8070	0.3952
ChangeinRF	342	0.8743	0.3320
OnsetofRF	342	0.9327	0.2508
OffsetofRF	342	0.9357	0.2457
Frequentma~e	342	0.7047	0.4569
Maizedisea~e	342	0.8129	0.3906
Accesstowe~n	342	0.8743	0.3320
Perception~e	342	0.8538	0.3538
Diversific~y	342	0.4708	0.4999
Usingdiffe~c	342	0.3713	0.4839
Applyingsh~D	342	0.3509	0.4779
Maizerotat~s	342	0.4181	0.4940
Changingpl~s	342	0.1404	0.3479
Shiftingfr~a	342	0.1754	0.3809
Increasedu~r	342	0.4064	0.4919
Applyingca~g	342	0.3684	0.4831
Applyingsm~n	342	0.2778	0.4486
No Addaptat~n	342	0.9327	0.2508

Appendix: 4 Co linearity and regression Statistics

Model	Coef.	O/R	S/ E.	z	P>z	Co linearity Statistics	
						Tolerance	VIF
(Constant)	2.215	9.164	0.787	2.820	0.005		
Sex	0.057	1.058	0.033	1.740	0.081	0.785	1.274
Age	1.226	3.407	0.577	2.120	0.034	0.757	13.20
Education	-0.895	0.409	1.013	-0.880	0.377	0.892	1.121
Access to extension services	1.994	7.345	0.830	2.400	0.016	0.624	1.603
Membership of local organizations	-0.087	0.917	0.729	-0.120	0.905	0.904	1.106
Change in temp	3.145	23.209	0.892	3.520	0.000	0.701	1.427
Change in RF	3.848	46.885	1.082	3.560	0.000	0.625	1.600
Onset of RF	2.618	13.711	1.223	2.140	0.032	0.646	1.549
Offset of RF	-1.716	0.180	0.860	-2.000	0.046	0.696	1.438
Frequent maize crop failure	2.754	15.702	0.708	3.890	0.000	0.860	1.163
Maize disease occurrence	3.102	22.237	0.763	4.070	0.000	0.556	1.798
Access to weather information	-15.015	0.000	2.809	-5.350	0.000	0.696	1.437

Models fit

R	R Square	Adjusted R Square	Std. Error
0.78946	0.623243923	0.60950206	0.22110347

Appendix: 5; Long Term Rainfall Data Accessed from NMA

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1983	0	32.0	71.5	32.0	165.0	155.9	256.3	221.5	165.6	111.2	53.5	0.0	**1264.5**
1984	0.5	0	6.8	18.3	154.8	204.7	241.8	174.7	119.9	1.5	9.9	1.9	**934.8**
1985	10.7	0	9.8	100.1	127.0	126.7	192.6	237.4	108.8	47.0	3.3	1.3	**964.6**
1986	5.0	17.7	42.1	61.6	25.7	261.1	207.3	157.2	126.6	25.1	2.0	5.4	**936.7**
1987	2.3	6.8	109.0	39.5	156.1	215.0	172.3	168.4	121.8	67.5	3.0	13.1	**1074.7**
1988	11.8	26.9	4.1	0.0	89.7	191.3	273.5	208.2	198.9	88.0	3.3	0.0	**1095.8**
1989	0.8	6.2	91.7	87.3	83.5	160.9	249.3	235.0	255.2	30.0	0.0	68.3	**1268.5**
1990	3.8	14.8	65.9	41.7	90.2	261.1	244.1	235.9	107.2	16.0	9.9	0.0	**1090.5**
1991	6.6	26.5	47.2	31.3	82.2	220.9	346.0	286.4	121.1	10.6	0.0	7.3	**1186.1**
1992	3.0	3.6	48.5	87.5	132.4	291.6	241.1	299.2	146.5	110.8	33.7	0.0	**1398.0**
1993	3.5	5.8	40.1	171.8	157.1	196.4	287.6	313.3	137.8	84.0	0.6	0.0	**1397.9**
1994	6.5	0.0	17.7	83.8	160.2	135.1	269.1	271.3	169.5	11.5	8.3	0.0	**1133.0**
1995	0.0	1.1	65.5	83.3	112.0	159.4	211.1	261.5	93.3	24.1	9.5	24.1	**1044.8**
1996	17.9	3.3	94.2	72.3	172.6	219.4	232.9	129.7	144.4	8.7	23.4	0.6	**1119.3**
1997	13.5	0.0	12.4	109.9	161.7	195.5	199.1	151.6	111.4	151.6	31.9	3.9	**1142.4**
1998	4.6	0.0	41.6	20.8	137.4	263.0	276.9	255.7	169.6	210.2	14.3	0.0	**1394.2**
1999	3.4	0.0	2.0	48.7	145.5	166.4	158.8	188.4	178.2	200.1	0.7	4.9	**1097.2**
2000	0.0	0.0	0.0	72.3	105.6	249.0	187.2	215.5	113.5	91.6	27.1	2.7	**1064.5**
2001	0.0	14.3	50.1	32.6	208.8	190.2	208.7	282.9	103.6	143.5	1.5	5.4	**1241.8**
2002	18.1	0.0	64.7	63.8	41.3	183.8	184.9	150.4	97.7	4.0	0.2	27.1	**836.0**
2003	3.7	39.3	38.1	40.5	2.7	192.9	306.8	264.3	108.9	5.3	12.4	6.3	**1021.1**
2004	2.1	0.0	8.9	26.0	81.1	212.6	199.4	242.8	192.6	59.6	1.5	3.3	**1029.8**
2005	2.7	0.0	77.6	25.2	104.8	319.7	313.6	267.9	171.3	27.6	53.5	0.0	**1363.8**
2006	0.0	3.5	61.1	14.0	112.9	219.5	251.8	285.6	195.9	91.2	4.7	38.8	**1279.0**
2007	4.7	24.4	26.1	61.8	168.6	251.4	238.4	203.9	150.9	26.1	0.0	0.0	**1156.2**
2008	4.9	0.0	0.0	58.4	202.9	305.2	313.6	161.6	148.9	73.8	75.4	1.5	**1346.1**
2009	7.2	3.1	42.0	45.9	26.9	241.4	223.3	243.6	130.5	91.4	6.0	11.9	**1073.1**
2010	3.8	1.9	6.3	18.0	224.4	212.9	213.3	212.1	107.2	8.6	11.4	0.0	**1019.8**
2011	27.3	4.1	24.4	40.9	163.7	164.1	154.2	266.1	113.5	34.4	58.5	0.2	**1051.2**
2012	0.0	0.0	12.5	19.9	67.5	162.7	153.4	197.2	154.0	27.9	7.1	0.0	**802.1**
2013	10.1	0.0	3.2	8.0	142.0	182.7	198.8	180.6	155.9	74.6	3.2	0.0	**959.1**
2014	0.8	0.3	27.2	138.9	162.2	161.3	163.4	116.2	132.1	67.1	4.0	0.0	**973.5**
2015	0.0	0.0	8.1	4.4	46.3	25.2	15.0	103.1	50.4	2.8	21.8	1.9	**279.0**
2016	0.1	0.7	2.8	66.4	43.9	18.8	67.0	55.3	34.0	5.8	10.3	0.0	**305.1**
Mean	**5.28**	**6.95**	**36.0**	**53.7**	**119.4**	**197.6**	**219.2**	**213.1**	**136.4**	**59.8**	**14.9**	**6.8**	**1068.9**