DETERMINANTS OF FARMERS' ADAPTATION STRATEGIES TO THE IMPACT OF CLIMATE VARIABILITY ON MAIZE [Zea Mays L] YIELD IN ADAMI TULLU JIDO KOMBOLCHA WOREDA, EAST SHOA ZONE, OROMIA REGIONAL STATE, ETHIOPIA

MA THESIS

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Determinants of Farmers' Adaptation Strategies to the Impact of Climate Variability on Maize [Zea Mays L] Yield in Adami Tullu Jido Kombolcha Woreda, East Shoa Zone, Oromia Regional State, Ethiopia

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APPROVAL SHEET

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I hereby certify that I have read and evaluated this Thesis entitled "Determinants of Farmers' Adaptation Strategies to the Impact of Climate Variability on Maize [Zea Mays L] Yield in Adami Tullu Jido Kombolcha Woreda, East Shoa Zone, Oromia Regional State, Ethiopia prepared under my guidance by Kuba Negash Wake. I recommend that it to be submitted as fulfilling the thesis requirement.

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As members of the Board of Examiner of the MA Thesis open defense examination, I certify that I have read and evaluated the thesis prepared by Kuba Negash Wake and examined the candidate. I recommend that the thesis be accepted as fulfilling the Thesis requirements for the Degree of Master of Geography and Environmental Studies**.**

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Final approval and acceptance of the Thesis is contingent upon the submission of its final copy to the Council Graduate Studies (CGS) through the candidate's department or School Graduate Committee (DGC or SGC).

DEDICATION

I dedicate this thesis manuscript to my beloved family and friends who contribute even a piece of advice throughout my life to reach in this level.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an MA degree at the Haramaya University and deposited at the University Library to be made available to borrowers under rules of the Library.

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BIOGRAPHICAL SKETCH

The author Kuba Negash Wake was born on August 10, 1978 in Adaba Woreda, West Arsi Zone Oromia Region, Ethiopia. He attended his elementary at Lenca Wosha Primary and secondary education at Adaba Secondary School from 1984 -1994. He completed his preparatory school at Dodola Preparatory School from 1995 - 1996. After successful completion of his preparatory school education, he joined Addis Abeba University in 1997 and graduated with a Bachelor degree in Geography and Environmental Studies in June 1999. After graduation he worked as a Teacher for sixteen successive years at different senior secondary schools in Adami Tullu Jido Kombolcha Woreda, East Shoa Zone, Oromia Regional state. He joined the postgraduate program of Haramaya University in 2010 to pursue his MA study in Geography and Environmental Studies.

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ACRONYMS AND ABBREVIATIONS

DA	Development Agent
EMI	Ethiopian Meteorological Institution
ENSO	El Niño
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GDP	Growth Domestic Product
HHH	Household Head
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
MNL	Multinomial logit model
MOA	Minister of Agricultural
MoFED	Ministry of Finance and Economy Development
NMA	National Metrological Agency
SPSS	Statistical Product and service solution
SSA	Sub Saharan Africa
UNDP	United Nations Development Program
UNFCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WMO	World Meteorology Organization
WOA	Woreda Agricultural Office

TABLE OF CONTENTS

Continues……

Continues……

LIST OF TABLES

LIST OF FIGURES

LISTS OF TABLES IN THE APPENDIXCES

Determinants of Farmers' Adaptation Strategies to the Impact of Climate Variability on Maize [*Zea Mays L*] Yield inAdamiTulluJidoKombolchaWoreda, East Shoa Zone, Oromia Regional State, Ethiopia

Kuba Negash Wake

ABSTRACT

Climate variability directly and indirectly affect cultivation of maize yield, these condition impacting the smallholder farmer living in the Ethiopia specially whose life is dependent on rain fed agriculture. The objective of this study is to assess Determinants of Farmers' Adaptation Strategies to the Impact of Climate Variability on Maize [Zea Mays L] Yield in Adami Tullu Jido Kombolcha Woreda. Data was collected from 330 sample smallholder farmers' were selected purposely from three kebeles through survey questioner, interviews and focus group discussions. Quantitative and Qualitative data were collected from both primary and secondary sources. The quantitative data includes long-term climatic data and maize outputs for 30 years (1994 – 2023) that were obtained from the Ethiopian Meteorological Institute (EMI) of Ethiopia Asela branch and Adami Tulu Jido Kombolcha Agricultural Office, respectively. Data from different sources were analyzed using descriptive and inferential statistics including coefficient correlation, multivariate regression and multinomial logit models (MNL). The result of the study shows that the annual maximum and minimum temperature significantly increased by a factor of 0.144 ^{0}C and 0.148 ^{0}C respectively. In the study area, there was a positive correlation between maize yield and annual rainfall(r= 0.981).Due to climatic factors, about 98.1% of maize yield variation was observed in the study area. The regression result shows that climate variables significantly affect maize yields. Regarding the factors affecting the farmer's choice of adaptation strategies to climate variability sex, age, family size, level of education, experience, income and others are significant affecting by level of confidence, respectively the choices of adaptation strategies to climate variability. Hence, these findings suggested a need to encourage smallholder farmers' adaptive capacity.

Key Words: -Adami Tullu Jido Kombolcha, Adaptation Strategies, Climate variability, Small holder farmers', Maize yield.

1. INTRODUCTION

1.1. Background of the Study

Nowadays, Climate variability is recognized as one of the greatest challenges of our world. It is predicted to have adverse consequences on world's ecosystems, economies and societies (IPCC, 2012).Climate variability has always been identified as a challenge for African farmers. Specifically, the hazards on access climate information relevant to agricultural activities that enable the farmers to make prior decision about which crops to plant, where and when, will increase the ability of agricultural sector to make informed decision (Zermoglio, 2011). But, the adverse affects vary across countries, regions and socio demographic groups due to differences in exposures, sensitivities and adaptive capacities (Betelhem, 2014).

Africa has one of the continents that-have been seriously hit by the impacts of climate change. However, the continent represents only 3.6percent of emissions (Conway and Schipper, 2012). Sub Saharan Africa (SSA), in particular, is the most vulnerable region in the world to climate variability and climate change (Michael, 2012). Sub-Saharan Africa (SSA) is arguably the most affected region by the impacts of climate variability due to a very high dependence on rain-fed agriculture (Datta, 2013). Thus, impacts of climate variability and change are likely to fall unreasonably on poorer nations and on poorer households.

Climate variability has historically been found as a major cause of food insecurity and famine in the country (Beweket, 2012). This is clearly due to the fact that the agricultural sector is facing increased and continued risks of climate change. It is apparent that maize yield primarily depends on weather conditions, diseases and pests, planning of harvest operation etc. Even if agricultural yields are extremely sensitive to fluctuations in precipitation, and there is a fundamental concern that traditional farming practices may not be suited to produce sufficient maize yields under emerging climate contexts. The application of adaptation strategies varies from farmers to farmers depending on type of maize, soil and resources available to them. Beside farmer's efforts to adapt to changing climate, governments' through its institutions are also seeking ways of fashioning out policies to adapt the impacts and to prevent food insecurity. The development and implementation of adaptation strategies will go a long way to help offset erratic nature of

climate in order to sustain maize production. Changes in regional rainfall will affect water intensity, availability and may lead to decreased agricultural production and potentially widespread food shortage (Ayalaw, 2012).Ethiopian agriculture is one of the most vulnerable sectors to current climatic variability, potentially exposing millions of people to recurrent food shortages and periodic famines. With climatic shocks vulnerable population susceptible to crisis that force millions of people to turn to the government for emergency assistance and safety net benefits each year to enhance their own production and copying strategies (World Bank, 2013).

Agricultural sector is a pillar for the Economy of Ethiopian (MOA, 2013). This sector, which is rain-fed by its nature, is highly sensitive to climate change and variability (NMA, 2013).According to World Bank (2013), close linkage between climate and Ethiopian economy is demonstrated by close pattern of rainfall variability and GDP growth. The trends in the contribution of agriculture to the countries total GDP clearly explain the presence of strong relationship between the performance of agriculture and climatic conditions.

The economy of Oromia Regional State is predominantly dependent on agriculture; hence, agriculture forms the major livelihood for the majority of the population of the region. The performance and nature of agriculture in the region is more of traditional which has low productivity. In Adami Tullu Jido Kombolcha Woreda, farming patterns are gradually changing and faced with perceived climate variability and its negative consequences on the maize productivity in the location. Further, rural people are reporting famine and maize crop failures have become is current feature of their life. Maize production has been quite variable and declining due to the problem of rainfall pattern and variability of temperature in the study area.

1.2. Statement of the Problem

Climate variability has direct impact on agricultural productivity and indirect impact through by pests on maize, reducing water availability and increasing natural resources degradation. Due to this adaptation to climate change has to intend at providing adaptation strategies through agro ecology based research (Temesgen *et al,* 2014). According to Ababe (2014), the climate of Ethiopia is characterized high variability annually, seasonally and geographically. Especially the amount and seasonal distribution of rain are varying annually and difficult to predict while the temporal distribution of rainfall during the growing season is an important factor influencing maize yield. However, increasing temperature and rainfall variability in different part of Ethiopia adversely influence the agricultural production of household head farmers. To minimize the shock of climate change on household head farmers' adaptation strategy is essential instrument (Temesgen *et al*., 2014).

Adaptive capacity building is increasingly embraced by governments and other institutions as a means to improve economic and ecological resilience, sustainable development and will require action across multiple sectors at all levels (Bishaw*et al.*, 2013). In the study area, which is dependent on rain fed agriculture, climate variability is the main factor determining maize yield types. Peoples must build the resilience, including adopting appropriate technologies while making most of local knowledge, and diversifying their livelihoods to cope the climate stress. These local knowledge and local adaptation strategies need to be used in collaboration with government and local interventions (UNFCCC, 2014).Adaptation to climate change requires that farmers first perceive that the climate is changing, and then identify useful adaptation measures to cope with the problems and implement them effectively and efficiently (Temesgen, 2014).

In Adami Tullu Jido-Kombolcha Woreda, farming patterns are gradually changing and faced with perceived climate variability and its negative consequences on the maize productivity in the location. For decades Adami TulluJido-Kombolcha Woreda has been suffering from the problem of persistent food insecurity and poverty (Adami Tullu Agricultural Office, 2010). It is one of the most Vulnerable Woreda's with livelihood and the safety net program. When usual frequency of climatic shocks happens, the humanitarian and government agencies have

been supporting the people of the Woreda. Further, rural people are reporting famine and maize yield failures have become current feature of their life. Maize production has been quite variable and declining due to the problem of rainfall pattern and variability of temperature in the study area.

Additionally, due to the lack of information and knowledge of farmers about variation of temperature and rainfall, the farmers deforests tree for expansions of agricultural land is the major problem in the study area again. So knowledge and perception of household head farmers about climate variability are vital to improve productivity and environmental condition.

Previous studies on the impact of climate variability and change in Ethiopia are often at broader scale (country level), (Degefu and Bewket, 2014; Wodaje, 2016). However, no detailed studies were conducted on the impact of climate change and variability on maize yield as well as farmer's perception in Adami Tullu Jido-Kombolcha Woreda. Therefore, this study aims to fill information gap regarding how recent changes in rainfall and temperature affect maize production. Specifically, the study assessed on the impacts of climate variability on maize yield and determinants of farmers' adaptation strategies in the study area**.**

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study is to assess determinants of farmers' adaptation strategies to the impact of climate variability on maize [*Zea Mays L*] Yield in Adami Tullu Jido Kombolcha Woreda**,** East Shoa Zone, Oromia Regional state, Ethiopia.

1.3.2. Specific Objectives

The study addresses the following specific objectives:-

1. To identify the trends of climate variability in the past 30 years in the study area.
2. To examine the impact of climate variability on maize yield in the study area.
3. To identify Farmers adaptation strategies to the impact of climate variability on maize production in the study area.

4. To analyze the major factors that determines the adaptation strategies to climate variability in the study area.

1.4. Research Questions

1. What are the trends of climate variability in the past 30 years in the study area?

2. What is the impact of climate variability on maize yield in the study area?

3. What are the adaptation strategies to the impact of climate variability on maize production in the study area?

4. What are the major factors that determine the adaptation strategies to climate variability in the study area?

1.5. Scope of the Study

This particular study was conducted in Adami Tullu Jido-Kombolcha Woreda. The study focused on climate variability impact on maize yield and determinants of farmers' adaptation strategies in the study area. The researcher decided to select three Kebeles from 43 rural Kebeles. The selected Kebeles are Chitu, Adansho-Borannota and Barra-Hubbicho. The sample kebeles are selected on the basis that they are found in similar geographical locations, which are highly affected by climate variability from 43 Kebeles due to the relative homogeneity of the Kebeles within the specific agro climatic zone in terms of rainfall variability and Maize Yield. The study was also being delimited to the impacts of climate variability on maize yield in Adami Tullu Jido-Kombolcha Woreda.

1.6. Significance of the Study

The study is conducted to assess climate variability impacts on maize yield and determinants of farmers' adaptation strategies. The results of study can be used by the local development agents and model farmers to improve the knowledge and adaptive capacity of farmers of the study area by reinforcing and correcting their perception. Besides, the results could be served as a base for further and detail study on maize specific responses and adaptation alternatives to observed and projected rainfall trend and variability. Finally, findings of this research can play significant role to enhance and facilitate exchange climate knowledge and information among local communities, field experts, policy makers, researchers and other development practitioners to deliver right policy and programs in required areas on time. In this perspective

the study was try to develop bench mark to assess on impacts of climate variability and maize production and farmers adaptation strategies that can be used as insight for future studies on the issue.

1.7. Limitation of the study

There was some limitation that affects the quality of this study. Such as, Unwillingness of some officials to provide the required data, as well as shortage of time, Lack of related literature because of these limitations the researcher focused small geographical areas of three kebeles of Adami Tullu Jido-Kombolcha Woreda.The study have challenges had occurred when conducting this study. The first and the most challenging event was that there searcher faced has, the data reliability. Some of the respondents hide their data and some of them had put them self under frustration when he/she selected for questioner and then, there searcher made clarity by saying that, this study used only for academicals purpose only. The problems that there searcher faced was clash of programs held with developmental agents to use the enumerators and key informants with that of Woreda's seasonal trainings and works. However, it adjusted by postponing the held program to appropriate days. The other challenge had collecting the data from women was not very easy due to the background (socio-cultural conditions) of the local people in the study area. This is also solved by the researcher.

1.8. Definition of key Terms

Adaptation: is an adjustment in natural or human systems in response to expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2014).

Climate variability: refer to deviation of climate statistics about an established average over a given period of time such as specific month, season or year from a longer period mean of the same variables (WMO, 2016).

Impact-effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system (IPCC, 2012)

Kebele-is the smallest administrative unit of Ethiopia. (https://www.collinsdictionary.com)

Strategies – is the science or art of employing the political, economic, psychological, and military forces of a nation or group of nations to afford the maximum support to adopted policies in peace or war. **(**https://www.dictionary.com/browse/strategies)

Woreda-is the third-level of the administrative division of Ethiopia after zones and the regional state. (https://en.wiktionary.org)

Yield – is the production of a certain amount earned on a security, over a particular period of time. It refers to the interest or dividend earned on debt or equity, respectively, and is conventionally expressed annually as a percentage based on the current market value or face value of the security. (https://economictimes.indiatimes.com)

Zone- is the area or stretch of land having a particular characteristic, purpose to particular restrictions. (https://www.google.com)

1.9. Organization of the Thesis

This thesis has five chapters. Chapter one presents the introductory parts of the thesis which includes the background of the study, the statement the problem, objectives of the study, research questions, significance of the study, scope ,limitation of the study as well as definitions of key terms. In chapter two literature reviews was presented which briefly discuss empirical literatures and conceptual framework related to the study. Chapter three focuses on research methodology which comprises description of the study area, study design, data types and sources, sample size and techniques, as well as methods of data collection and analysis. Chapter four presents the results and discussions part of the research and chapter five present summary, conclusion and recommendations of the thesis.

2. LITERATURE REVIEW

2.1. Theoretical Review of Climate Variability and Adaptation Strategies

2.1.1. Overview of Global climate variability

Climate variability acknowledged by many research outputs undertaken at larger geographical scale. From these, IPCCs (2012) investigations found as one of the prominent findings that tried to show variability in global temperature and rainfall variability with underlying causes through instrumentation of appropriate statistical techniques.

According to FAO (2016), there are six most widely grown crops in the world. These are wheat (Tiriticumvulgare), rice (Oriza sativa), Maize (Zea mays), soybeans (Glycine max), barley (Horeumvulgare) and sorghum (ghumbicolor). Production of these crops accounts for over 40 percent of global cropland area, 5% of non-meat calories and over 70% of animal feeds.

European Commission (2012) also indicates that, from five crops, wheat, grain maize, barley, potato and sugar beet farm income reflects both direct effects of climate on maize yields as well as any variability made in adapting to a changing or variable climate. Based on this concern, results showed that prevailing climatic conditions significantly influence farming. It also suggests that regions with similar climates adapt in similar ways. The influence of climate on variability of maize yields and incomes is more significant at regional level than farm type level. At farm type level, farm characteristics play a greater role; and temperature has significant influence on trends in crop across regions.

The case in Africa is not unique from the prevailing global state of climate variability affects certainty condition. One of investigations undertaken 3 decades before by Hansen (2012)shows that, dominantly African precipitation pattern is featured by high spatial coherence of rainfall anomalies within continent that were interlinked with ENSO events. Similar study undertaken by Conway (2012) sates that on decadal time scales, SSA experiences drying across Sahel after early 1970s; relative stability marked by extreme wet years in Eastern Africa; and periodic behavior underlying high inter annual variability in southern Africa. The study also predicted the likelihood of substantial variability in rainfall and river flows ranging up to the order of 14-51% deviations of reduction. Contrary to claims of Hansen (2012), observed significant trends were not result of variations in the ENSO

connections but rather study suspected case to whether natural variability of climate and/or may be a result of human activity. Moreover, analysis of Manyatsi (2016), carried out by utilization of different climate variability scenarios, has reported an outstanding surface heating and declining pattern in hydrological cycle over most of tropical Africa, resulting in enhanced heat stress and extended dry spells.

Maize (*Zea mays* L.) is one of the most important cereals worldwide and cultivated globally leading in total yield and the third most important food crop after wheat and rice (FAOSTAT, 2014). Only 3% of maize yield may be consumed directly by humans in developed countries whereas, in SSA, more than 80% is used as a food and also provides at least 30% of the total calorie intake of people (Nuss and Tanumihardjo, 2017). Maize is one of the major cereal crops that serve as food source in Ethiopia. According to CSA (2012), maize stands second in terms of production area (over 2.05 million ha) and supports about 10 million households in the country.

2.1.2. Impact of Climate Variability on Agriculture

According to (MoFED, 2012) Climate variability profile for Ethiopia, mean annual temperature has increased by $1.3C^0$. At an average rate of $0.28C^0$per decade. The temperature increase has been most rapid from July to September ($0.32C^0$ per decade). It is reported that the average number of hot days per year has increased by 73(an additional 20% of days) and the number of hot nights has increased by 137(an additional 37.5% of night) between 1960 and 2006.Currently, climate variability has already imposed significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and Sustainable development effort. Furthermore, extreme weather events, such as drought, floods, or landslide, may cause death to domestic animals (MoFED, 2012).

The adverse impact of climate variability are not only these, particularly According to World Bank (2013), agriculture is extremely vulnerable to climate variability. Higher temperature eventually reduces yields of maize while encouraging weeds and pests proliferation. Variability in rainfall pattern increased livelihoods of short run maize failures and long run production declines. Climate variability also has significant impact on rain fed agriculture. The overall impacts of climate variability on agriculture expected to be negative. Agriculture plays a dominant role in economy of Ethiopia, contributing about half of GDP, provides

employment opportunity for majority working force and generates considerable foreign invariability earnings (MoFED, 2012).

Despite its contribution to overall economy, this sector is challenged by many factors, of which climate related disasters like drought and flood (often causing famine), are major ones (Temesgen, 2017). It has also a fragile high Land ecosystem, which is currently under stress due to population pressure (Alemneh, 2018) argued that, climate variability affects agriculture and its effect pronounced on subsistence farmers, which have low adaptive capacity. Climate variability most likely increased poverty and long-term trends toward reduce rainfall and drought; have played a role in weakening of economy (USAID, 2014).

2.2. Concepts of Climate Variability and Adaptation Strategies

Climate Variability is the short term shift in weather patterns in specific region or globally (IPCC, 2014), it refers to changes in regions, including precipitation, and temperature and cloud cover and so on. Climate variability as the way climate fluctuates yearly above or below a long term average value (Keely, 2012). It is also as a change in the state of the climate that can be identified by changes in the mean and the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2014).While it refers as variation in the climatic parameter of a region from its long term mean. Every year in a specific time period, the climate of a location is different. Some years have below average rainfall, some have average or above average rainfall (FAO, 2014). One of the widespread anthropogenic challenges affecting agricultural production is climate change and climate variability (Torquebiau, 2016).

Intergovernmental Panel on Climate Change (IPCC (2014) define climate change as the change in the state of the climate that can be identified by changes in the mean and the variability of its proportions and that persists for an extended period. Typically, longer climate change affects agriculture in a number of ways including through changes in average temperature, rainfall and climate extremes with an important impact on soil erosion (Yohannis, 2016).Climate variability refers to variations in mean state and other statistics such as standard deviations, statistics of extremes of climate on all temporal and spatial scales beyond that of individual weather events.

UNFCCC 2014 stated climate change refers to long-term changes in average weather conditions, all changes in the climate system, counting drivers of change, changes themselves and their sound effects only human-induced changes in the climate system.

According to Belay and Getaneh (2016) climate change is a change of climate which is attributed directly or indirectly to human activity. It alters the composition of the global and regional atmosphere and natural climate variability observed over comparable time periods. Climatic variability is the type of changes in temperature, rainfall, occurrence of extremes changes in physical and socio-economic system have been identified in many regions.

According to UNFCCC, 2014 global average surface temperature is likely to rise by 1.8degrees to 4.0 degrees Celsius. These a level may raise by 30 to 60cm. Climate variability will increase almost everywhere. Climate variability represents variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (WMO, 2014). The term is often used to denote deviations of climatic statistics over a given period of time from the long-term statistics related to the corresponding calendar period (Belay, 2014). Variability may be due to natural internal Processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability).

Adaptation is a process by which strategies to moderate, cope with and take advantages of the consequences of climatic events are enhanced, developed, and implemented (UNDP, 2016).According to Bowyer *et al.*, (2014) also defined adaptation as process or outcome of a process that leads to a reduction in harm or risk of harm, or realization of benefits associated with climate variability and climate change. According to Adger *et al*., (2016) adaptation to climate change is defined as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Adaptation options are key things that farmers individually or collectively undertake to respond to climate change hazards (e.g., tree planting, soil conservation, migration, and planting early maturing crops) (Mequanite, 2016). Generally, Farmer's perspective increasing time to time towards to adaptation options including, choosing heat and drought stress-tolerant varieties, intensification, diversification, expansion, increased off-farm income, exit from

agriculture, adjusting cropping calendar, in-situ moisture conservation, (Jallow, 2012; Hellin*et al.*, 2012; Schaeffer, 2014; Singh *et al.*, 2019; Amanuel*et al.*, 2019).

2.3. Impact of Climate Variability on Maize Productivity

Agriculture is a means to feed ever growing world population and agricultural activities often harm environment by deteriorating quality and quantity of locally available natural resources (Tunde, 2011). Many countries in tropical and subtropical parts of Africa expected to be vulnerable to impact of global climate variability. The problem of sustainable water supply is a major challenge for African countries and climate variability exacerbates problem of watering rural areas. In addition climate variability aggravates impact and as a result, countries face semi-arid and arid conditions that make agriculture challenging (Alemayehu, 2012).A large number of studies and research evidences of variability of climate and its impact besides, impacts of climate variability on agricultural production, it also has an impact on various physical, human and capital aspects of country, which indirectly disable the economic social and political factors of government, above all rural people access to food is threatened (FAO,2016). Predominantly, smallholders and subsistence agriculture are more vulnerable to impact of climate variability. Ethiopia has experienced a worsening food insecurity problem for several years.

In the Central Rift Valley of Ethiopia, climate change and variability is manifest through frequent droughts and loads, erratic rainfall, and fluctuating mean temperature (Gizachew, 2014). The study of Belay *et al.* (2017) revealed that the annual and seasonal rainfall variability is between 50 and 80%, the average temperature has been increasing at a rate of 0.37 °C every ten years, and the maximum daily temperature has increased by a cumulative 1.5 °C since 1900. Small-holder farmers are highly dependent on rain fed agriculture which is very sensitive to climate variability and change. Changes in the distribution and amount of rain-fall which have resulted in low precipitation and frequent drought have been affecting agriculture (Kassie, 2013).

The study of Nega*et al.,* (2015) revealed that nearly all participants perceived climatic change and its negative impact on agriculture and regarded global climate change as a salient risk to their future livelihoods and economic development. Different levels of perception were expressed in terms of world temperature change and also the impact on traditional rain-fed

agriculture. Age, education level, livestock wealth, access to climate information, and extension services meaningfully impacted perception levels. Solomon *et al.* (2016) also undertook an exploration of perception and adaptation models of natural processes by the agricultural people of lake Sub-basin, Ethiopia by employing Heckman probity and MNL models. The farmer's perceptions of global climate change were found to be statistically and significantly related to factors like status, farm size, global temperature change information access, and also the extent of income generations.

2.4. Major characteristics of climate variability and Adaptation strategies

2.4.1. Temperature Variability and Maize Productivity

Temperature is one of the most predominant and very vital elements of climate for itsvery observable and has invaluable effect on life and livelihood of human beings (Solomon, 2015). The year to year variation of annual minimum temperatures expressed in terms of temperature differences from the mean and averaged very high.

Globally, especially in developing countries, climate variability causes yield declines for their most important maize yield. Rainfall and temperature is an important element that limits growth of plants and maize yield. Some level of relationship, therefore, seems to exist between rainfall and temperature, and yields obtain from cultivation of maize yield. The study of Temesgen (2014) reveals that, a marginal increase in temperature in summer and winter season used a reduction in maize yield and revenue per hectare. The reduction in the yield and income of household head has significant impact on the livelihoods of the household head as well as some of socio-economic roles they play in the family. In addition, high temperatures and extreme events are predicting to increase in SSA with a resultant effect on growth and yield of most agricultural maize yield in these regions, which activate serious concerns about food security (Datta, 2013).

Conversely, Welch, (2014) exemplifies in his study that higher minimum temperatures reduce yields, while higher maximum temperature increases yields. However, it is important to note that impact of high and low temperatures on maize yield depend on the type of crop under consideration. Similarly, Atta (2013) emphasized fact that high temperature can influence significantly on maize and cause a reduction in yield.

2.4.2. Rainfall Variability and Maize Productivity

Ethiopia has diverse climates, ranging from semi-arid desert in the lowlands to humid and warm (temperate) in the southwest. Mean annual rainfall distribution ranges from a maximum of more than 2,000mm over the Southwestern highlands to a minimum of less than 300mm over the Southeastern and Northwestern lowlands (Tsega, 2013).

The IPCCs uniform climate scenarios show that, a decrease in rainfall of a place will cause a reduction in yield with household head losing their entire net revenue from maize if rainfall decreases by 14 percent. While an increase in rainfall causes increases in maize yield, reduction in rainfall causes a decline in net yield of crops especially; maize that need considerable amount of water to survive (IPCC, 2012).Therefore, there is a direct relationship between rainfall and maize yields. In event of low rainfall, there is need to resort irrigation to ensure that maize get needed amount of water for their growth. It is important to recognize fact that, notwithstanding above impacts climate variability has on maize production, there positive effects as well. It also avers that high temperatures and very high rainfall in summer increases maize production (Traore, 2013).

2.5. Major characteristics of Adaptation Strategies and Determinants

2.5.1. Major characteristics of Adaptation Strategy

Agricultural sector is adversely affected by climate change and variability. This negative impact can minimize by using adaptation strategies like adjustment of planting and crop variety, crop relocation, improved land management (e.g. erosion control and soil protection through tree planting) (ibid).Farmers use different adaptation strategies that fit with the types of the problems caused by climate change they faced. This is due to the fact that impact of the climate change is unevenly distributed over different geographic areas and hence the adaptation mechanisms also vary with types and level of the impact of climate change (IPCC, 2014). The extent to which adaptation strategies are implemented varies among individual farmers depending on their capacity and willingness to adopt (Crimp *et al.*, 2012).The common adaptation practices included diversifying crops, changing varieties and planting dates, using irrigation, and supplementing livestock feed Gbetibouo *et al*. (2012).

According to Mengistu *et al*.(2011) different crop varieties, changing planting dates, planting trees, adoption of drought tolerant and early maturing crop varieties, changing cropping

densities, water harvesting techniques, increased use of soil and water conservation techniques or soil erosion prevention programs, increased use of irrigation and use of irrigation techniques, changing fertilizer application, pesticide application, applying different feed techniques, the pastoral system or the herd composition, improvement or rehabilitation of terraces, home-garden agriculture are among the common adaptation strategies farmers carry out in response to climate change. The degree of farmer's perception on climate change also depends on its impact on farmers' livelihood, their social, institutional and economic background. It is different and depends mainly on level of education, livelihood activity, location and age. Crop varieties, changing planting dates, planting of shade trees and changing fertilizers were the main adaptation methods implemented by farm households Abid *et al*. (2015). Crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock, and tree planting are the practices that farmers made attempted to adapt climate variability and change Abrham *et al*. (2017). Smallholder farmers used different adaptation strategies to reduce the effect of climate variability and change on crop production system Buni et al, (2019). In this regard, the rural community who perceived climate variability and change has used crop diversification, mixed farming, changing crop varieties, irrigation farming, adjusting planting time, soil and water conservation practices as climate variability and change adaptation strategies.

According to Paulos Asrat and Belay Simane (2018) the most used adaptation measures include soil and water conservation and agronomic practices such crop rotation, intercropping, adjusting planting dates, diversifying crop types, use of fertilizer, use of improved crop varieties, application of manure, and irrigation practices.

2.5.2. Major Determinant Factors

Climate variability already has, and will further, result in environmental unrests that increase the vulnerability of agricultural systems of Africa. Further changes are predicted to occur earlier than in other areas of the world and hence adaptation is urgent (Gebremichaell et al.(2014). According to Hassan and Nhemachena (2012) generalized the farmers' adaptation Options in Africa in two aspects: increased diversification, and protecting sensitive stage of

crops through managing the crop to ensure not to overlap the critical stage with harsh conditions.

According to Pettengell, (2014) the concept of adaptation to climate is not a new phenomenon. Throughout human history, societies have adapted to natural climate variability by altering settlement and agricultural patterns and other facets of their economies and lifestyles. Adaptation could be defined as initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate variability effects.

According to Butler, and Huybers, (2013) the term "adaptation measures" covers eight categories: bearing losses (doing nothing), sharing losses, modifying the threat and thus preventing effects, changing use, changing location, accessing new research based technologies, disseminating knowledge through education to change behavior, and restoration. Others have classified the different forms of adaptation as anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

According to Bowyer et al., (2014) defined adaptive capacity as the potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with consequences. The capacity to adapt to climate change varies across countries, social groups and regions over time. These capacities will depend to a large extent on the availability of natural resources, their level of development, their resource base, technological knowhow and level of information about climate change, and their scientific and technical capacity.

Greater economic resource availability increases adaptive capacity while the lack of it limits adaptation options. Hence, adaptation measures are very much related to socio-economic conditions of the country and community given basic forms of adaptations including micro-level adaptations such as diversification and strengthening of crop and livestock production, changing land use, irrigation and altering the timing of operations, market responses, institutional changes and technological developments (Butler, and Huybers, 2013). According to Getachew et al., (2014) farmer's mainly employed changing of planting dates, planting trees, soil conservation and changing of crop varieties as adaptation method for climate change. In addition to these, fertilizer application, increasing farm land and mulching also used as adaptation options against climate variability.

2.6. Conceptual Framework

Figure 1 shows the interrelationships that do exist between different factors that have assumed to affect agriculture production due to climate, farmers Adaptation Strategies of climate variability. Studies focused on assessment of impacts of climate variability on Maize yield and household farmers' adaptation measures plays the important roles in addressing the level of climate variability impacts on Maize yield. The conceptual framework for this study was indicate that climate variability brought the changes in the amount of temperature and rainfall, drought, flooding and spreading of disease and pests, among others. This led for effects on environments such as forests, soil resources, water resources and socio-economic effects like agriculture and human health. However, the changes happening as a result of climate variability leads to vulnerability of the people especially in rural household.

The vulnerable groups devise different strategies including the accumulative, adaptive and coping strategically goals to minimize the effects of climate variability. Each of those developments is reflected back on the feature of household's head farmers. Among these accumulative, coping and adaptive strategies together with other devices lead to climate resilient and sustainable development. Conversely, survival strategies would derive vulnerable groups to migration that end to unsustainable livelihood. Therefore, enhancing farmers' adaptation through creating awareness to climate adaptation measures at community level was help to reduce the impacts of climate variability in area under the study. This is briefly sketched in (Figure 1).

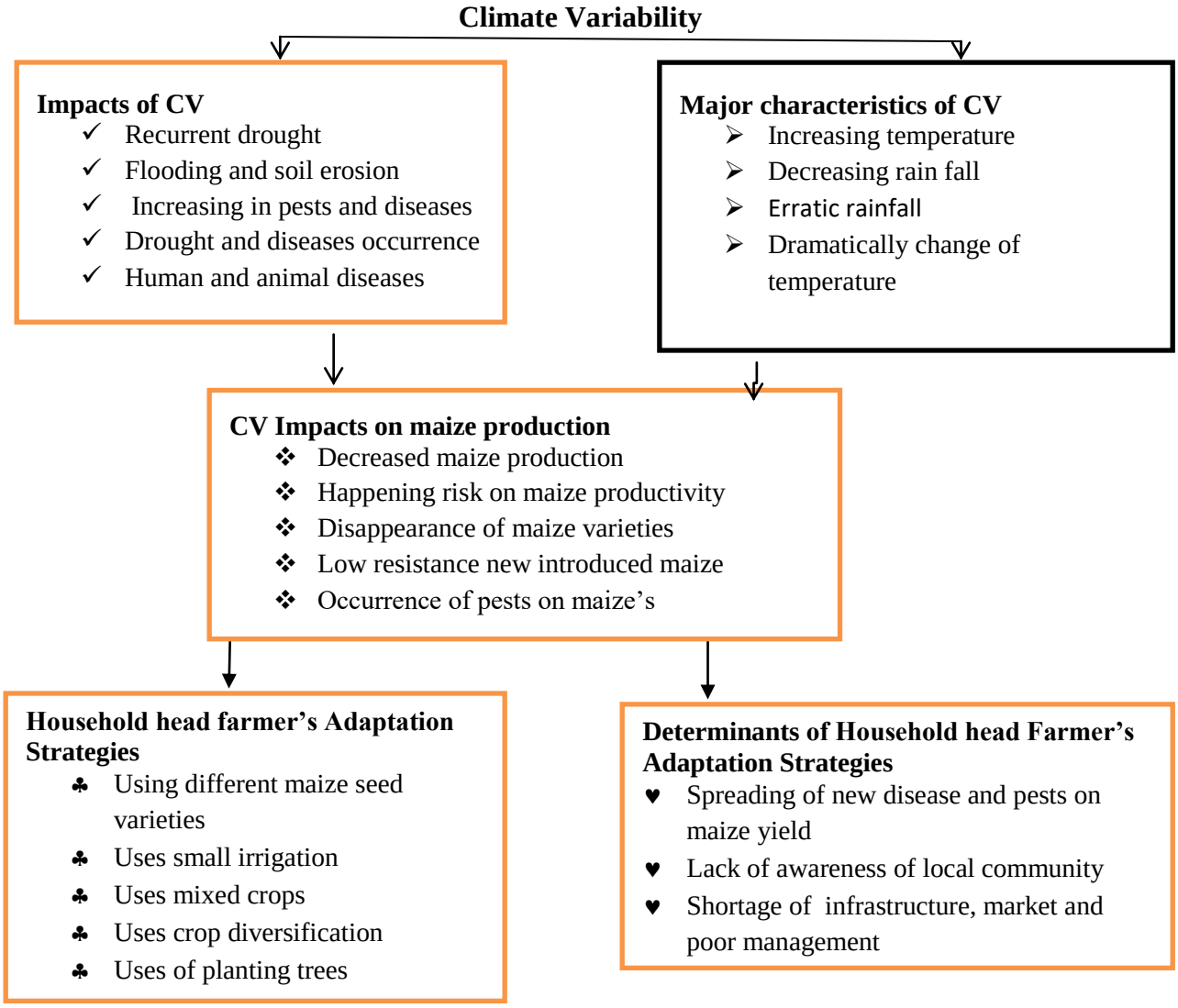

Figure 1. Conceptual framework

Source: developed by investigator in 2024(Adapted from Portier *et al*. (2010)

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location and Area

This study was conducted at Adami Tullu Jido-Kombolcha Woreda. It is located between $7^0$40′0″-$8^0$10′0″ N and $38^0$30′0″-38^0 50′0″ E. (Figure 2) It is bordered by Butajira in the west and northwest, Dugda-Bora Woreda in the north, Arsi zone in the east and Negele Arsi Woreda of WestArsi in the south. It is situated at 167 km in the Southeast direction from the national Capital, Addis Ababa.

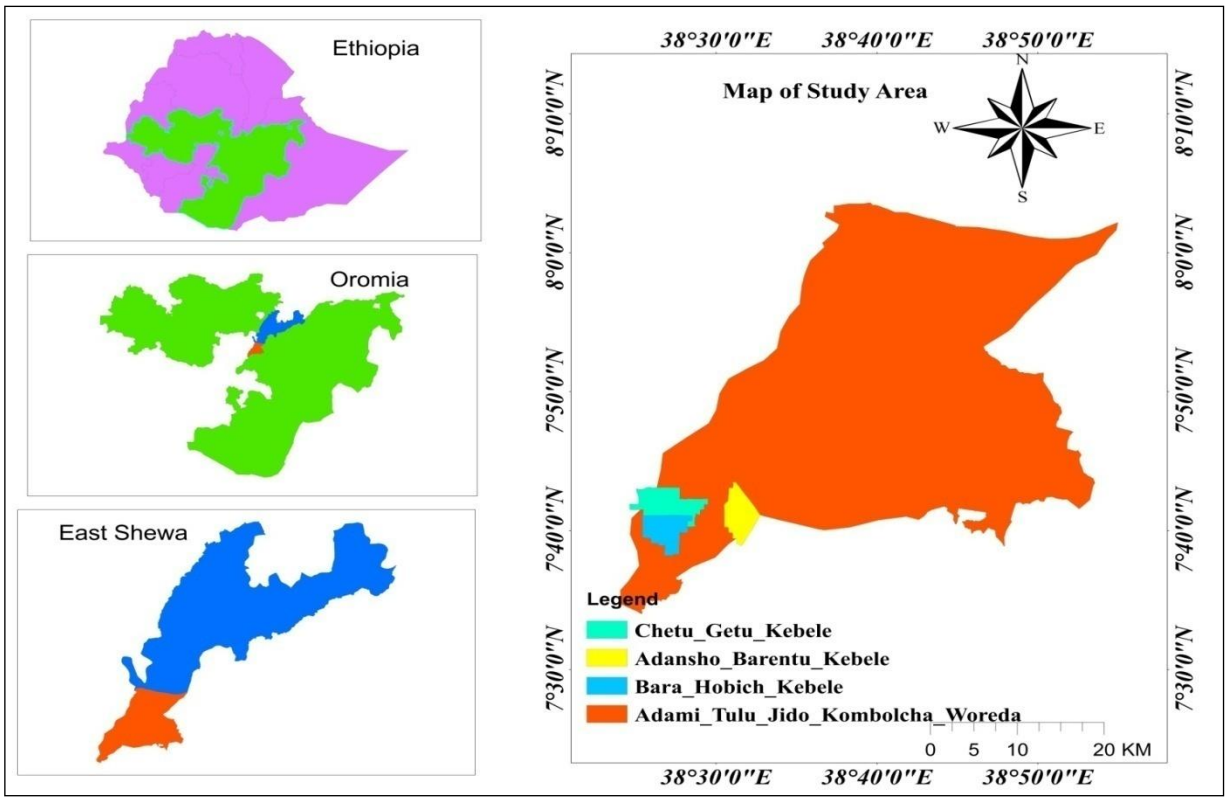

Figure 2.Location Map of Study Area

Source: Own construction using Ethio, Arc Map (GIS)

3.1.2. Topography and Soil

The elevation of the Woreda ranges from 1500 to about 2300masl with mountain Aluto as highest peak of 2335m above mean sea level. Its area is 1403.3 km^2 (OLEP, 2007). There are 43 administrative Kebeles covering about 80% of the total Woreda area; towns, military

camps, private investors and other companies occupy the remaining 20%. From the total area 45% is cultivated, about 30% is used for grazing and woodlands, 7% is classified as marginal land and other land uses account for about 18% (OESPO, 2003). The soil in the area is formed from the weathering of the very young pyroclastic rocks and mainly gray soil with low fertility (Commercial Bank of Ethiopia, 2007).

3.1.3. Climate and Drainage

Adami Tullu Jido-Kombolcha Woreda has a semi-arid and arid climate. The average annual Precipitation is about 700mm of which 42% falls in the period from June to September (OESPO, 2003). The driest months are November and December. The mean annual temperature is $20C^0$ at Zway and Adami Tullu station (OESPO, 2003). May is the hottest month with a mean maximum temperature of $28C^0$ and coolest month is December with a mean minimum temperature of $10c^0$. Rainfall is characterized by fluctuation in amount and periodicity from year to year in the study area. Accordingly, it has two rainy seasons, *Belg* and *Kiremt. Belg* is the short rainy season and lasts between March and May. The *Kiremt* season, which is the longest rainy season, lasts between June and September.

The drainage system of the Woreda mainly includes rift valley drainage system. The rift valley drainage includes Lake Zway, Langano, Abijata and surrounding streams draining to them. The lakes have great potential for fishery and transportation. Beyond that the lakes and lower parts of the rivers are habitats for fishes and birds. The water and forest resources of Adami Tulu Woreda have provided a wide range of environments for supporting great varieties of fauna and floras.

3.1.4 Vegetation and Wildlife

The study area has been covered by sparse indigenous forest species. The vegetation is characterized by stunted trees, shrubs and short grasses. Most common trees in the kola part of *Adami Tullu Jido-Kombolcha Woreda* consist of drought and fire resistant trees such as the Shea, baobab and acacia. However, the vegetation cover has been removed partly for cultivation and it has also been replaced by some exotic species such as eucalyptus tree. Major reason for this rapid decline of forest coverage was extensive deforestation due to the population growth and expansion of cultivation land. Thus, like other parts of the country, natural vegetation of the area has been influenced by human activities. Like forestland,

grassland and bush land is also overgrazed and then gradually changed into farm land. At this time these types of vegetation are mostly destroyed because of rapid increase of number of population, trees serve as source of income for the population of the Woreda. And some of the major types of wild animals in the Woreda include jackal, hyena, tiger, monkey, apes, and leopard.

3.1.5. Socio-economic Condition

3.1.5.1 Demography

Adami Tullu Jido-Kombolcha Woreda has 43 kebeles and five small towns (Bulbula, Oitu, Jido, Adami Tulu and Abosa towns).Its total area is 1403.3km^2 and the Total Population of this Woreda is 331,004 in 2016 estimation from 1994(111,926) and 2007(141,405) national census reported. Age and sex structure of the population is the most important demographic variable which has a major influence on labor, socio-economic structure and productivity of the society. The majorities of the population are men and followed by women population.

3.1.5.2. Social Setting

Adami Tullu Jido Kombolcha has an estimated population 3311,004. In the Woreda there are five largest ethnic groups such as Oromo, Amhara, Soddo Gurage, Silte and Sebat Bet Gurage. The majorities of the inhabitants were Muslim with 82.7% of the followers' while 11.6% of population was a follower of Orthodox Christianity, and 5.1% of the population was Protestant.

3.1.5.3. Economic Setting

The livelihoods of the local farmers mainly depend on mixed farming of crops and livestock (OESPO, 2003). Land use in Adam Tullu Jido Kombolcha Woreda was characterized by open Wood-land, annual crops, livestock grazing and some irrigated agriculture (OESPO, 2003).Livestock, crops and forest products are the main sources of income for farmers in Adami Tulu Jido Kombolcha resource poor farmers (landless, few oxen and female headed households) earn money mainly from sales of firewood and charcoal (OESPO, 2003). During years with maize yield failure, most households depend on income from tree resources, livestock and food aid. The majority of the households sell firewood and /or charcoal during the food shortage months (June-September) (OESPO, 2003). Farm size, number of livestock

and draught animals (oxen) are the main criteria which determine the wealth status of farmers, Farm holding size ranges from 0.75-3ha with an average size of 1.5 ha, (OESPO, 2003). Horticultural maize production is becoming the main source of income for farmers living around Lake Zway and Bulbula River.

Maize, haricot bean, Teff and wheat are mainly grown under rain fed conditions. The greatest proportion of land covered with maize and haricot bean. The land allocated to maize production has increased from 32,030-63,015 ha between 1995 and 2000 (OESPO, 2003). However, average maize yield remained very low (OESPO, 2003). In addition to low and erratic distribution of rainfall, most farmers in the Woreda are significantly constrained by limited availability of resources such as draught power and other agricultural inputs. The frequent droughts and high costs of technologies (improved seeds, fertilizers and pesticides) caused that farmers are risk-aversive and reluctant to adopt new technologies developed for rain-fed conditions.

3.2. Research Design

The Researcher used sequential explanatory research design with mixed method research design. Because the method was believed to be more appropriate to investigate the climate variability and its impact on maize yields and existing adaptation strategies. Both qualitative and quantitative data gathering tools was employed to assess the impacts of climate variability on Maize Yield and determinants of farmers' Adaptation Strategies in the study area. Mixed method research design helps to gather a large variety of data related to a problem under study and it is also effective for providing a snapshot of the current behaviors, attitudes, and beliefs in a population. Moreover, the mixed method research design also helps to provide adequate information that enables the researcher to suggest some valuable alternatives. Therefore, to have a clear picture on the existing problems and to accomplish the objectives stated above a mixed method research design become appropriate.

3.3. Types and Sources of data

In order to collect the required data in the study area, both primary and secondary data sources was used. Primary data (both qualitative and quantitative) was collected directly from the respondents who are selected from maize farmer production in the selected Kebele. It was collected through questionnaire, KII and FGD.

Secondary data was collected from available sources such as published and unpublished documents, from National Metrological Agency (NMA) Rainfall and Temperature data was used. The other data was obtained from governmental, non-governmental organization and Adami Tullu Jido Kombolcha Woreda Agricultural Office. Moreover, the study also used the record of temperature and rainfall for 30 years and Maize Yield data for 30 consecutive years.

3.4. Sampling Techniques

The main objective of this research was to analyze the impact of climate variability on Maize yield and determinants of Farmers' Adaptation Strategies in Adami Tullu Jido Kombolcha Woreda. In order to select the respondents a three-stage sampling approach were employed. First, three *Kebeles* were selected out of 43 *Kebeles* in the district purposively for being main producers of maize in study area (dependent on rain fed maize production) and the intensity of the impact of the climate variability as well as potentials of different adaptation strategies. Accordingly, the four *kebeles* were Chitu, Adansho-Borannota and Barra-Hubbicho. The total farmer's households of three *Kebeles* were 1894 from these samples of 330 households were selected based on Yamane (1967) simplified formula. Secondly, using stratified sampling method households were selected from each of the three *Kebeles* proportionally. Therefore, the total farmers" of selected *Kebeles* were 1894 then arranged in four strata such as N_1, N_2, N_3 are 532, 919, and 443 respectively. So n_i=sample size (N_i/total house hold of selected *Kebele*) that means n_i=330(Ni/1894) where n_i is sample size of house hold in each *Kebele*, N_i is the strata number of each *Kebeles*. Finally, systematic sampling methods used to select farmers from each *Kebeles*. The use of this particular sampling method involved three steps. In first step, sample interval (k^{th}) was determined by dividing farming population of various *Kebeles* by the irrespective sample sizes. The second step involved a random sampling of respondents from various *Kebeles*. To begin random process, first number was picked between 1 and k^{th} number using simple random sampling technique through lottery method. Here, first number to k^{th} number were written on pieces of papers and folded in a bowl. Afterwards, ablind folded person asked to pick first number from bowl, which served as basis for selecting rest of respondents using sample interval. Finally, k^{th} term selected successively from list until total number of sample obtained (Kothari, 2004).

3.5. Sample Size Determination

The sample size determination was done using a simplified formula of Yamane (1967). The formula was used to determine the required sample size at 95% confidence or risk level, 5% degree of variability, or 0.05 level of precision. A total of 330 maize producer households were selected for this study. The sample size was calculated as follows:

$\mathbf{n=} \frac{N}{1+N(e)^2}$ Where: n= Sample size to be taken

N = Total study population

e = margin of error/Level of precision accordingly,

n = $1894/1+1894(0.05)^2$

= 1894/1+1894(0.0025)

= 1894/1+4.735

=1894/5.735= 330

Table 1. Sample size Determination

No	List of Kebele	Total Household	Sample Household	%
1	Chitu	532	93	28
2	Adansho-Borannota	919	160	49
3	Barra-Hubbicho	443	77	23
4	Total	1894	330	100

Source: - Adami Tullu Jido Kombolcha Woreda Administration office (2024)

3.6. Methods of Data Collection

The primary data source is the key component under data collection for this study. Due to this household head survey collection and interview methods were used as major primary data collection tools. Closed and open-ended survey questions about socio-economic issues, the impact of climate variability on maize yield, and determinants of farmers' adaptation to climate variability in the area.

Tools used for gathering data were designed on the basis of review of related literature and basic research questions. To make the study successful the researcher made a face to face contact with kebeles leaders to establish better study atmosphere, introduce the purpose of the study and to secure cooperation for collecting data using the tool. Next the researcher

distributed the questionnaires for the respondents selected for the study.

To avoid barriers of understandings regarding to Kebele leaders the researcher himself communicate and read the item for them. The researcher was collecting the questionnaire from the household head farmers, Development Agency (DA) workers, Experts of agricultural office and target individuals. The collected data was analyzed, presented and interpreted quantitatively. Finally, the study was summarized and concluded; the recommendations was also be forwarded.

3.6.1. Questionnaire

The researcher was use questionnaire as it is the most important method to collect quantitative data from the respondents. Koul (2014) suggested that questionnaire is widely used in research to obtain information about certain conditions and practices and to inquire into opinions and attitudes of individuals and groups. It was allow individual adequate time and privacy to complete the responses and it is easy to administer. The items were presented in respondents' mother tongue (Afan Oromo) to avoid language barriers. The translation was made by the researcher independently. The questionnaire was designed to gather relevant data from all respondents, that is, household head farmers, DAs, experts and the coordinator of the office.

The validity and reliability test of the questionnaires was conducted in this study. According to Ann et al., (2012), the concept of validity is used to judge whether the data collection instrument used in any research accurately measures what it intended to measure. Checking the validity of data collecting before providing for the actual study subject is the core to assure the quality of the data (Singh, 2012).Checking the reliability of the questionnaire using a pilot test was carried out. Reliability refers to random error in measurement. Reliability indicates the accuracy or precision of the measuring instrument (Norland, 2011). The pilot test seeks to answer the questions, does the questionnaire consistently measured. The items in questionnaire were pilot tested. The questionnaire was distributed to 9 farmers with better performance, 6 DA workers, 6 experts of agricultural development office and (4) target individuals from Adami Tullu Jido Kombolcha Woreda Agricultural Office. In pre-testing questionnaire, the main concern is to detect problems which might cause confusion to the respondents. It is also useful to improve the format of the questionnaire to be clear.

The pilot survey is used to determine whether the words in each question were properly

understood. The designed questionnaire will be distributed for respondents in pilot test. After two days the respondents return the questionnaire and depending on their response, analysis will be made. Any common errors identified on the item were improved. Reliability will be established using a pilot test by collecting data from the sample. Data collected from the pilot test will be analyzed using SPSS that provides information, reliability coefficient (alpha). A reliability coefficient (alpha) of 0.70 or higher will be considered as acceptable reliability.

3.6.2. Key Informant Interview

The researcher was use semi structured interview because of its flexibility and to make clarifications when there is ambiguity. Interview was hold with key informants who are purposively selected from the community that have different responsibilities and knowledge believing that they have relevant information.

The interviews were conduct with respondents who have sufficient knowledge about the area and be able to memorize well its historical climate variability. A total of fifteen key informants, four in each kebele (one chairman, one Model Farmers and two Development Agents(DAs)) and three from woreda officials (one from Local leaders and two from the Adami Tullu Jido Kombolcha Agricultural Office was interviewed. Elders (experienced and well known individuals), Kebele Administrators and Development Agents was members of key informant interview. Moreover, the woreda agriculture and rural development officials was interviewed, about the impact of climate variability in the study area(Appendix II).Checklist containing different guiding questions was prepared and used. This was made to have an overall picture of the *Kebeles* to generate general information on the main research problem.

3.6.3. Focus Group Discussion

The focus group discussion was constructing to collect the qualitative information from the selected three *kebele* administrations. The individual participants of the focus group discussion are purposively selected based on the information obtained from the DAs working in the sites, their interest of participation in group discussion and their backgrounds knowledge about the usage of both climate variability and status of Maize Yield in the study area. For, focus group discussions the investigator selected six respondents based on socially respected within society and are known to have better knowledge on the present and past about the impact of climate

variability on environmental, social and economic status of the study area. In each Kebele two FGDs of household farmer groups was conducted. Accordingly, different open- ended questions were prepared and present to the selected individuals to express their responses regarding the current research under investigation. This condition in turn, enabled the researcher to confirm and justify the results of the questionnaires distributed to the participants in the study area (Appendix III).

3.7. Methods of Data Analysis

In this Research, the data collected through questionnaire, FGDs as well as interview were analyzed by using both qualitative and quantitative data analyses. Before analyzing the data, raw data were processed (coded, edited, ordered and organized) to generate relevant information. Data were analyzed using both descriptive statistics like frequency distribution, mean, and ratio using Statistical Product and Service Solution (SPSS) version 24 and Microsoft Excel. Multiple linear regression models are widely used and offer an important set of tools for understanding the association (significance and strength of their relationship) between two or more independent variables and dependent variable. In this study, the amount of maize in three kebele measured by kuntal was considered as dependent variable and the effect of temperature variability and rainfall variability was studied using multiple linear regression analysis since the dependent variable (amount of maize in kuntal) is continuous (it is neither discrete nor count) random variable and it satisfies the basic assumption of the regression model.

3.7.1. Descriptive Statistics

Descriptive statistics was one of the techniques used to summarize data collected from sample. It was employed to explain the demographic and socio-economic behaviour of household characteristics. By applying descriptive statistics such as mean, standard deviation, frequency of appearance etc. one can compare and contrast different categories of sample households with respect to desired characters so as to draw some important conclusions. The qualitative information gathered using focus group discussion and interview of respondents was analysed and transcribed using qualitative techniques.

3.7.2. Inferential Statistics

Inferential statistics tools such as multiple regressions, time series trend, Correlation, and other

tests were employed. Quantitative data collected through questionnaires was carefully coded and checked for consistency and entered into the (SPSS) Statistical Product and Service Solution. Inferential statistics such as correlation and regression analyses was employed with the help of Microsoft Excel and Statistical Product and Service Solution (SPSS) version 24.0 to assess the effect of meteorological variables on maize yield. The relationship between climate variability and maize production were analyzed through regressing of climate variables (rainfall and temperature) with maize yields. The Microsoft Excel function of linear trend, Mann-Kendall trend test as well as line chart was used to analyze the trend of climate variability over past 30 year period (1994 to 2023) in the area. Multinomial logit model (MNL) was used to identify factors influencing choice of adaptation strategies by sample households to climate variability.

3.8. Ethical Consideration

The researcher should be informed the respondents about the purpose of the study. Additionally, they should be informed their participation in the study was being based on their interest and argument. The research was not be personalized any of the respondents response during data presentation, analysis and interpretation. According to Best and Khan (2011) involving participant work is important considering the ethical principles lay down to protect them. To make the research process professional, ethical consideration was made. Furthermore, the information they give was not be used for anything other than research purpose in education.

4. RESULTS AND DISCUSSION

4.1 Demographic and Socio-economic Characteristics of Sample Households

One of the proposed objectives of this study was to assess adaptation methods being practiced by farmers along with community based adaptation strategies in response to negative impacts of climate variability and demographic factors that affects them. Age compositions of smallholder farmer are important demographic variables. As stated earlier; the size of sample respondents for this study was 330. As indicated in Table 2 the age of the sample household heads is categorized in Three stages; 18 - 35, 36 – 45 and >47 age populations. Out of the total household age group 39.4% of respondents between the age category of 36 -45 years followed by 34.8 % who are in age group of ≥47 years and 25.8% are in age group of 18 - 35 respectively. This reveals that the majority of populations belong to 36 - 45 age groups and that accounted for 39.4% that is working/productive age group which indicated that the respondents were very active and may informed to current climate-related challenges on agriculture and other socio-economic activity in the study area. With regard to sex out of the total 330 households /respondent 78.8% were males while 21.2% were females. Relatively female headed households are may vulnerable to climate variability risks than male headed households because they have a lot of burden to solely carry out livelihood engaging issues and to involve off-farm activity than male headed households.

The survey data on Table 2. Shows that among the entire respondents 60.6 % were married, 12.1% were divorced, 18.2% were widowed and 9.1 were Single. Therefore, it is evident that, the majority of the respondents in the study area were married. With regard to Family Size more than half about 54.5 % of the respondents had family size between 6 to 10 and 30.3% of them had family size between 1 – 58 and the remaining 15.2% of the respondents had family size of greater than >11. This implies that the study area is among those that represent highest family size. It shows that, the differentiation of social status and family size affects their livelihood bases and adaptation to climate variability. With regard to Education out of the total number of the respondents, the majority of households were Primary school level that accounts about 45.5 %.Education level has its own influence on the introduction of modern technology to the modernization of local knowledge and innovation under western influence educational systems. With regard to Farming Experiences about 45.5% had between 16 – 30 years, 30.3% had between 0 -15 and about 24.2% had more than 30 years farming experiences.

Land was one of the most important factors of agricultural production. In the survey they responded

as about 89.4% had their own land that most of them inherited from parents and got from Kebele by government allocation. With regard to land size of sample respondents out of the total number of the respondents, the majority of households have 4 hector that accounts about 39.4% in the study area. With regard to source of income out of the total respondents' Livestock rearing 18.2%, single Crop production 27.3%, mixed farming 51.5% and other 3.0%. Therefore, the majority of Households of the study area farmers are highly dependent on both crop production and Livestock rising (Mixed) it accounts 51.5%, which is sensitive to climate variability (shortage fodder and scarcity of water).

Table 2. Demographic and Socio-economic characteristics of respondents

Variables	Category	Frequency	Percent
Age of Respondent	20 -35	85	25.8
	36 – 45	130	39.4
	>46	115	34.8
	Total	330	100.0
Sex of Respondent	Male	260	78.8
	Female	70	21.2
	Total	330	100.0
Family Size	1 – 5	100	30.3
	6 – 10	180	54.5
	>11	50	15.2
	Total	330	100.0
Marital Status of Respondent	Married	200	60.6
	Divorced	40	12.1
	Widowed	60	18.2
	Single	30	9.1
	Total	330	100.0
Level of Education of Respondent	not read and writes	30	9.1
	Primary school	150	45.5
	Secondary School	100	30.3

	Above grade 12	50	15.2
	Total	330	100.0
Farming Experiences	0 – 15 yrs	100	30.3
	16 - 30 yrs	150	45.5
	>30 yrs	80	24.2
	Total	330	100.0
Hold land	Yes	295	89.4
	No	35	10.6
	Total	330	100.0
Farm Land size in Hectare	0	35	10.6
	1	45	13.6
	2	70	21.2
	3	50	15.2
	4	130	39.4
	Total	330	100.0
Means of livelihoods	Livestock rearing	60	18.2
	Crop production	90	27.3
	Mixed	170	51.5
	Others	10	3.0
	Total	330	100.0

Source: Own Survey, 2024

4.2 Trends and Variability of Climate

4.2.1. Trends and Variability of Temperature

The researcher presented the trends of temperature with data obtained from the Ethiopian Meteorological Institute Asela branch for the last 30 years (1994-2023) in the study area. The result indicated that the maximum annual temperature increased by 0.144 as well as on seasonal scale temperature indicates that summer, autumn, winter and spring increased by 0.124,0.150,0.163 and 0.138 respectively. In the research area, the annual mean maximum temperature ranged from 27 ^{0}**c**

to 32^{0}c, with a mean of 29.42^{0}C (Table 2). Overall, annual mean maximum temperature showed a statistically significant increasing trend having the rate of change of 0.144per years (Figure 2). This result is very close with finding of Lomiso (2020) and Belay et al. (2017) in Southern Ethiopia. This is show irregular variability of temperature in study area over the period of 1994-2023. This result in line with the finding of Solomon (2015), the pattern of temperature variability was irregular in different part of Ethiopia.

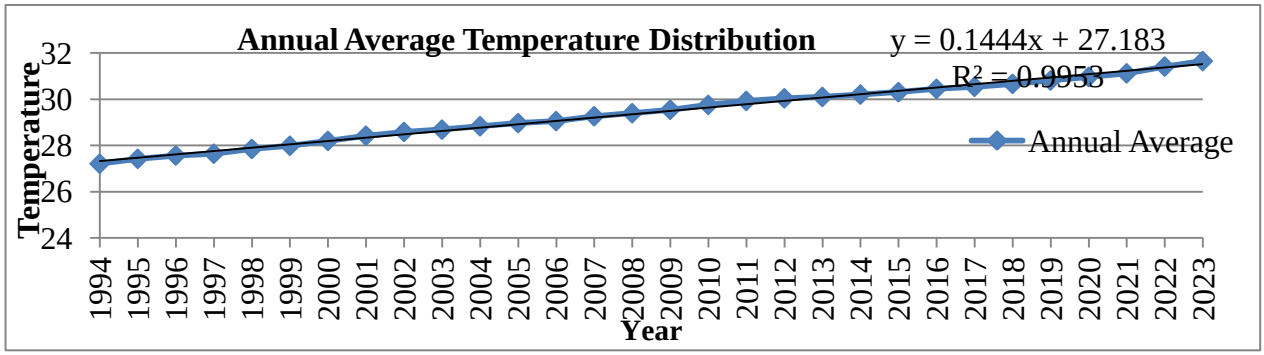

Figure 2. Trends of annual Average maximum temperature during the study period

Source: Computed based on data obtained from EMI (1994-2023)

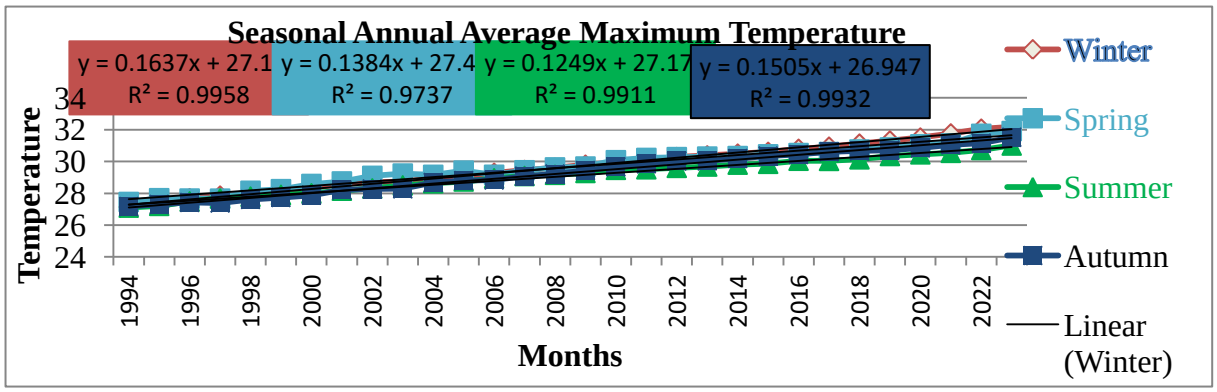

Figure 3. Seasonal Trend of Average Maximum Temperature of Adami Tullu Jido

Source: Computed based on data obtained from EMI (1994 -2023)

In the study area the average maximum temperature observed 28.35^{0}C once in four years (25% probability), 29.45^{0}C twice in four years (50% probability) and 30.50^{0}C three times in four years (75% probability) (Table 2).On the other hand summer season maximum temperature ranged between 27^{0}C to 31^{0}C with mean 29.10^{0}C, whereas autumn season maximum temperature ranged between 27^{0}C to 32^{0}C with mean 29.28^{0}C, winter ranged from 27^{0}C to 32^{0}C with mean 29.66^{0}C and spring season maximum temperature ranged between 28^{0}C to 32^{0}C with mean 29.64^{0}C in the study area (Table.2).In the study area the summer season average maximum temperature observed

28.15^{0}C once in four years (25% probability),29.25^{0}C twice in four years (50% probability) and 30.0^{0}C three times in four years (75% probability), autumn season mean maximum observed 28.13^{0}C once in four years,29.30^{0}C twice in four years and 30.45^{0}C, winter season mean maximum observed 28.53^{0}C once in four years, 29.70^{0}C and 30.83^{0}C three times in four years, spring season mean maximum temperature observed 28.68^{0}C once in four years, 29.65^{0}C twice in four years' time and 30.53^{0}C in three out of four years(Table.2).

Table 3. Annual and Seasonal Average Temperature

		Maximum Temperature	Minimum Temperature	Summer maximum	Summer Minimum	Autumn Maximum	Autumn Minimum	Winter Maximum	Winter Minimum	Spring Maximum	Spring Minimum
Mean		29.42	13.24	29.10	12.90	29.28	13.53	29.66	13.36	29.64	13.20
Median		29.45	13.30	29.25	13.00	29.30	13.70	29.70	13.35	29.65	13.20
Std. Deviation		1.276	1.319	1.094	1.345	1.324	1.314	1.450	1.295	1.219	1.311
CV		4.34	9.96	3.76	10.43	4.52	9.71	4.89	9.69	4.11	9.93
Minimum		27	11	27	10	27	11	27	11	28	11
Maximum		32	15	31	15	32	15	32	15	32	15
Sum		883	397	873	387	878	406	890	401	889	396
Percentiles	25	28.35	12.25	28.15	11.85	28.13	12.55	28.53	12.40	28.68	12.08
	50	29.45	13.30	29.25	13.00	29.30	13.70	29.70	13.35	29.65	13.20
	75	30.50	14.43	30.00	14.03	30.45	14.60	30.83	14.45	30.53	14.43

Source: Computed based on data obtained from EMI (1994-2023)

Coefficient of variation (CV) of Annual and Seasonal Average maximum Temperature of the Study area was also calculated. Accordingly, the result indicate that coefficient variation (CV) of Summer, autumn, winter and spring temperature was 3.76**%,** 4.52**%,** 4.89**%**and **4.11**% respectively. Coefficient variation (CV) of temperature of the average annual maximum temperature was 4.34% (Table.2).

During the study area the annual Average minimum temperature increased by 0.148 as well as on seasonal scale temperature indicates that summer, autumn, winter and spring increased by 0.151,

0.145, 0.146 and 0.148 respectively.

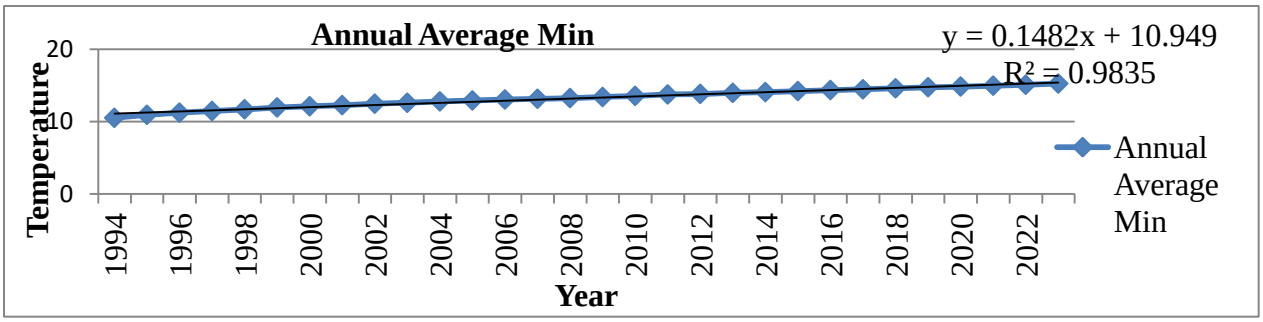

Figure 2. Annual Trends of Minimum Temperature of Adami Tullu Jido Kombolcha

Source: Computed based on data obtained from EMI (1994-2023)

During the research period, the annual Average minimum temperature ranged from 11^0C to 15^0C, with a mean of 13.24^0C (Table.2). The annual mean minimum temperature in the study area was increasing at a rate of 0.148^0C per years (Figure.2.).This result is corroborates with report of Gemeda (2019) who reported annual mean minimum temperature increased significantly in southern Ethiopia. In the study area the mean minimum temperature observed 12.25^0C once in four years (25% probability),13.30^0C twice in four years (50% probability) and 14.43^0C three times in four years (75% probability) (Table.2).

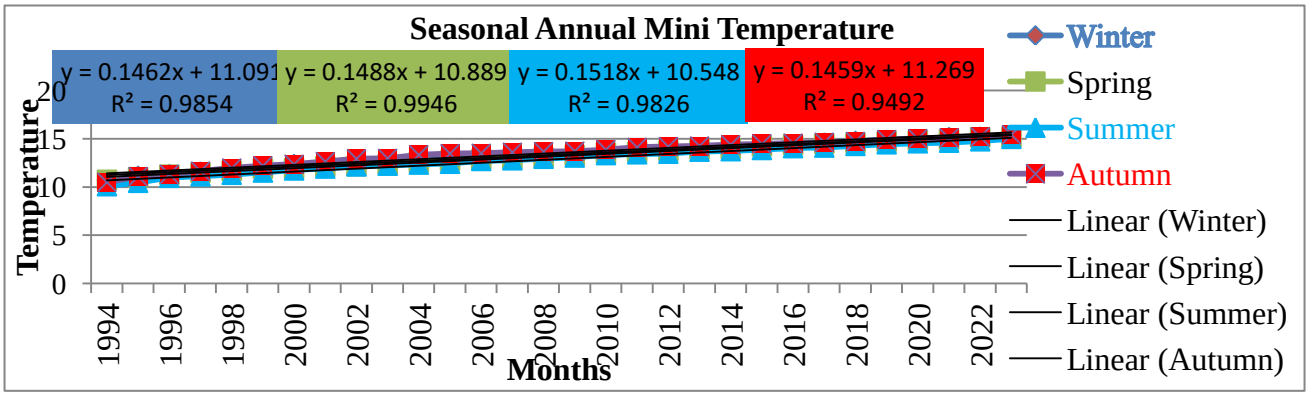

Figure 3. Seasonal Trends of Minimum Temperature of Adami Tullu Jido Kombolcha Woreda

Source: Computed based on data obtained from EMI (1994-2023)

In the study area the minimum temperature of summer season ranged from 10^0C to 15^0C with average of 12.90^0C, autumn ranged from 11^0C to 15^0C with mean 13.53^0C, winter ranged from 11^0C to 15^0C with 13.36^0C and spring season average minimum temperature ranged between 11^0C to 15^0C with mean of 13.20^0C in the study area, during the study period (Table 3). In the research area the summer season average minimum temperature observed 11.85°C once every four years(25%),13.0^0C twice in four years(50%) and 14.03^0C three times in four years(75%), autumn

season average minimum temperature observed 12.55^{0}C once in four years, 13.70^{0}C twice in four years and 14.60^{0}C three times in four years, winter season average minimum temperature observed 12.40^{0}C once in four years, 13.35^{0}C twice in four years and 14.45^{0}C three times in four years, spring season average minimum temperature observed 12.08^{0}C once in four year,13.20^{0}C twice in four years' time and 14.43^{0}C in three out of four years(Table.2).

Coefficient of variation (CV) of Annual and Seasonal average minimum Temperature of the study area was also calculated. Accordingly, the result indicate that coefficient variation of summer, autumn, winter and spring temperature was 10.43%,9.71%,9.69% and 9.93% respectively. Coefficient variation of temperature of the mean annual minimum temperature was 9.96% (Table.3).As presented in Figures and Tables the mean maximum and minimum temperature revealed that increasing trends observed in both cases over all but the magnitude of the trend varies in the study area. Annual minimum temperature is increasing faster than the annual maximum temperature during the study period. This finding is in line with others from the Central Rift Valley Region of Ethiopia by Muluneh et al. (2016) and Matewos and Tefera (2020) in Sidama, whose research found minimum annual temperature to increase faster than the maximum. During these years, maize output in the research area decrease in yield.

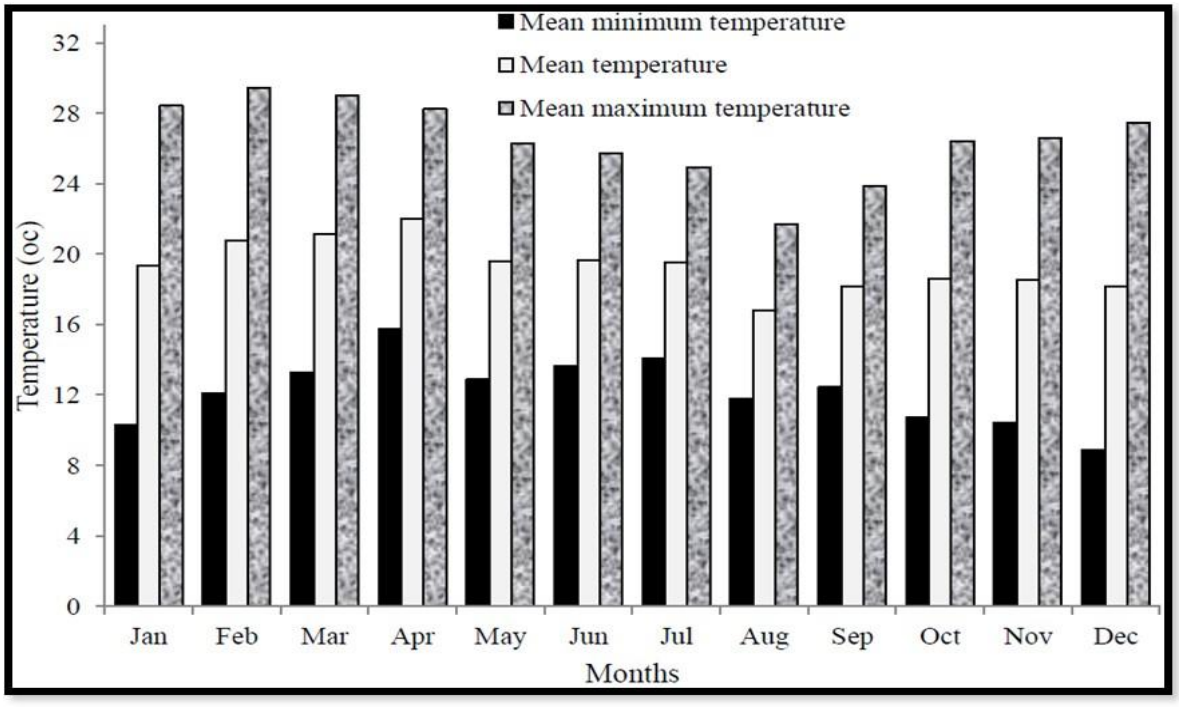

Figure 4. Monthly Maximum and Minimum Trends of Temperature of Adami Tullu

Source: Computed based on data obtained from EMI (1994-2023)

As indicated in the above figure the monthly maximum and minimum temperatures distribution in the last 30 years in the study area vary from month to month. Maize is planted in June, when the appropriate temperature is reached for germination. June, July and August corresponds to the key-growing season in the Woreda. This suggested that rising temperatures have gradually pushed the sowing period in the research area.

4.2.2 Trends and Variability of Rainfall

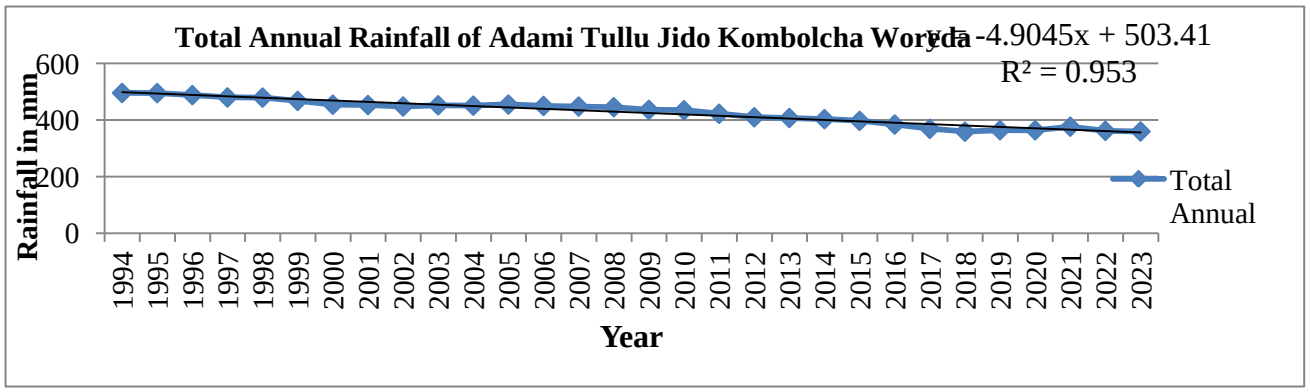

Figure 5. Total Annual Rainfall of Adami Tullu Jido Kombolcha Woreda

Source: Computed based on data obtained from EMI (1994-2023)

The total rainfall ranged from359 to 496mm. As indicated in Figure.5. the total annual rainfall pattern over 30 years for Adami Tullu Jido Kombolcha Woreda has been decreased by -4.904mm per year. The average annual rainfall for 30 years (1994 to 2023) was 427.4mm. The variability of the Total annual rainfall for these years ranged from 359mm (2018) to 496mm (1994), with high variation over the year 1994 to 2023. The standard deviation and coefficient of variation (CV) were 44.231%, and 10.35%, respectively.

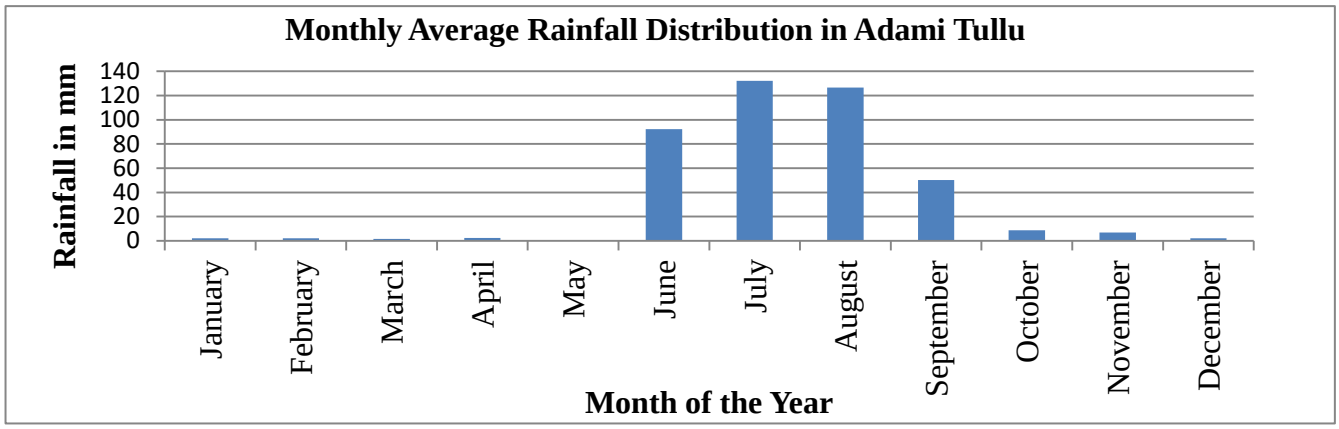

Figure 6. Monthly Average Rainfall Distribution of Adami Tullu Jido Kombolcha Woreda

Source: Source; computed based on data obtained from EMI (1994 -2023)

As indicated in figure.6. the monthly rainfall distribution in the last 30 years indicates prevalence of high rainfall record from June to September, constituting about above half of the total amount of rainfall in the study area. The monthly pattern of rainfall distribution depicts rainfall decline from October until May that clearly reflects the prevalence of seasonality of rainfall in the study area as it is also true to some of such areas in the country. The computed descriptive statistics of rainfall including mean, coefficient of variation (CV) and standard deviation (SD) of rainfall distribution over the study area for the period 1994 -2023 were presented in Table 4. In the study area, the rainfall condition was highly variable for all months, which indicated unpredictability and vulnerable to drought condition. The three months with highest maximum monthly rainfall were June (92.23mm), July (132.25mm) and August (126.68mm) the average annual rainfall.

Table 4. Descriptive statistics for monthly rainfall

	Minimum	Maximum	Mean	Std. Deviation	CV
January	0	9	2.04	2.518	123.43
February	0	15	2.03	3.267	160.94
March	0	7	1.51	1.746	115.63
April	0	9	2.42	3.301	136.41
May	0	1	.31	.329	106.13
June	41	173	92.23	29.157	31.61
July	85	188	132.25	29.325	22.17
August	83	194	126.68	29.176	23.03
September	1	90	50.19	25.099	50.01
October	0	42	8.72	8.286	95.02
November	0	29	6.86	8.111	118.24
December	0	9	2.14	2.643	123.51

Source: computed based on data obtained from EMI (1994 -2023)

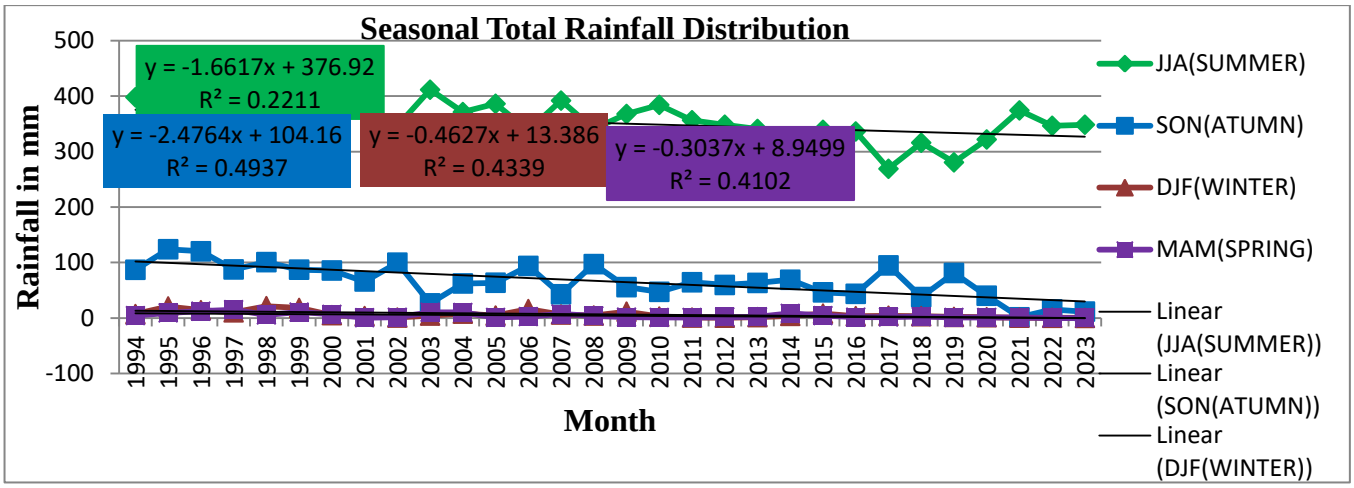

Figure 3. Seasonal Rainfall Distribution of Adami Tullu Jido Kombolcha Woreda

Source; computed based on data obtained from EMI (1994 -2023)

As indicated in Figure 3. Rainfall was decreased during summer by -1.661, during winter by -0.462, during autumn by -2.47 and during spring by -0.303. Hence, the seasonal precipitation in the study period matches with the previous finding which means rainfall is the major climate parameter with the highest degree of temporal variability in all the time scale in months, years, and in seasonal scales shows variations in Adami Tullu Jido Kombolcha in general. Seasonal rainfall analysis showed had high variability during all seasons.

Coefficient of variation (CV) of rainfall of the study area was also calculated. Accordingly, the rainy season coefficient of variation of summer, autumn, winter and spring rain shows 8.860%, 47.17%, 99.502% and 98.443% respectively (Table.5). However, coefficient variation of Total annual rainfall was 10.349%. The mean, standard deviation and coefficient of variation of seasonal and annual rainfall of the study area has been illustrated in the (Table.5)

Table 5. Annual and Seasonal Trends of Rainfall of Adami Tullu Jido Kombolcha Woreda

	Total Annual Rainfall	JJA(Summer Rain)	SON(Autumn Rain)	DJF(Winter Rain)	MAM(Spring Rain)
Mean	427.39	351.16	65.77	6.22	4.24
Std. Deviation	44.231	31.114	31.028	6.189	4.174
CV	10.349	8.860	47.17	99.502	98.443
Minimum	359	269	1	0	0
Maximum	496	412	124	21	15

Source; computed based on data obtained from EMI (1994 -2023)

4.3 Trends and Variability of Maize Yield in Adami Tullu Jido Kombolcha Woreda from 1994 to 2023

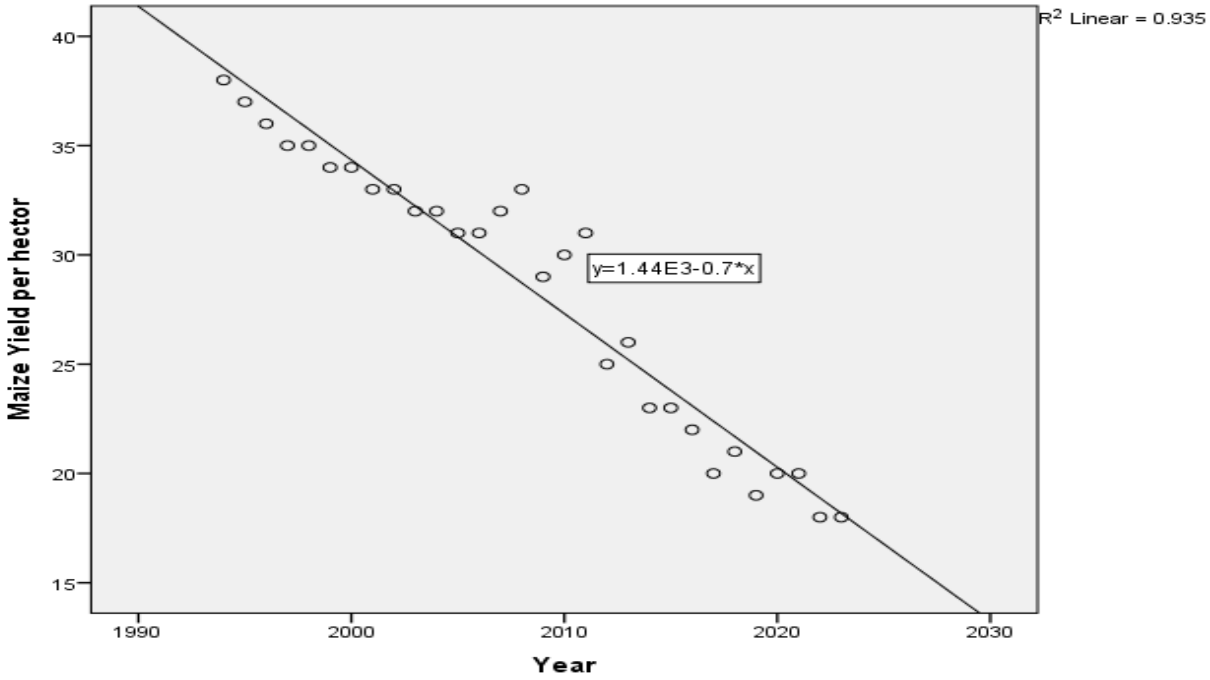

Figure 4. Maize Yield Trends in study area.

Table 6. Descriptive Statistics of Maize Data

	Minimum	Maximum	Mean	Std. Deviation	CV
Maize Yield per hectare	18	38	28.37	6.398	22.55

Source; computed based on data obtained from Adami Tullu Jido Kombolcha Agricultural office

As indicate in Figure 4 and Table 6. There is statistical significant change per year. The yearly Average Maize production of the past 30 years was 28.37quintal with the minimum value 18 and Maximum value 38. Coefficient of variation (CV) of Maze year of the study area was 22.55. In generally Maize yields of the Adami Tullu Jido Kombolcha Woreda over the last 30 years are fluctuated. I can conclude that the amount of maize production has highly variable in the last 30 years. The possible reasons might be due to climate variability and may be poor fertilizer access, miss management of farm land, land fragmentation etc. Here all the combined effects are responsible to yield decreasing but the most decisive cause in the study area was climate related hazards. The results were in line with the findings of Balcha (2009); crop production capacity can be weaken because of climatic variability.

4.4 Correlation Analysis of the Climatic Variables and Maize Yield

To determine the relationship between climatic variability and maize yields (kg/ha) a correlation analysis was performed. The correlation coefficient computed between maize yield, rainfall features, maximum and minimum temperature is shown in Table.7. The results reveal that there was a significant relationship between the climatic variability and the maize. While testing the impacts of seasonal minimum and maximum temperatures, a significant relationship was observed in the production of maize yield. There was a negative correlation between maize and the maximum temperature (r = -0.954), and negative correlation with minimum temperature (r = -0.950). There was a positive correlation between maize and the Total annual rainfall (0.981).

Table 7. Pearson's correlation matrix of maize yield and rainfall and temperature features

	Maize Yield per hector	Maximum Temperature	Minimum Temperature	Total Annual Rainfall
Maize Yield per hector per year	1	-.954**	-.950**	.981**
Maximum Temperature per year	-.954**	1	.993**	-.967**
Minimum Temperature per year	-.950**	.993**	1	-.966**
Total Annual Rainfall	.981**	-.967**	-.966**	1
**. Correlation is significant at the 0.01 level (2-tailed).				

Source: Computed based on data obtained from EMI (1994 -2023).

4.5 Regressive Relationship between Climatic Variables and Maize Yield

Under this subsection the actual impacts of climate parameters (spring and Summer Rainfall, and Maximum and Minimum Temperature) on maize were analyzed by using multiple regression models. The model also revealed to what extent the independent variables explains Yield. So the below table indicates the impacts of climate variability on maize yield in the study area. A multivariate regression model was used to confirm the impact of variation in climate variables on maize yield. Linear association between variable yield in Adami Tullu Jido Kombolcha and meteorological data in climate variables, like temperature and rainfall, were developed to assess the maize yield variation due to variability in climate variables during the study period. The estimate result from multivariate regression model is presented in the table below.

Table 8. Coefficient of regression for rainfall and temperature features in the study area.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	11.777	38.780		.304	.764	-68.445	91.999
	Maximum Temperature	-2.006	1.651	-.400	-1.215	.237	-5.422	1.409
	Minimum Temperature	1.339	1.484	.276	.902	.376	-1.731	4.410
	JJA(Summer Rain)	.137	.021	.666	6.577	.000	.094	.180
	SON(Autumn Rain)	.143	.026	.693	5.445	.000	.089	.197
	DJF(Winter Rain)	.028	.053	.027	.524	.605	-.082	.138
	MAM(Spring Rain)	.051	.082	.033	.625	.538	-.118	.220
a. Dependent Variable: Maize Yield per hector per year								

Source: Computed based on data obtained from EMI (1994-2023)

Table 9. Regression Values for Predictors

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.986[a]	.973	.965	1.188	.973	136.260	6	23	.000
a. Predictors: (Constant), MAM(Spring Rain), JJA(Summer Rain), SON(Autumn Rain), DJF(Winter Rain), Minimum Temperature, Maximum Temperature									

Source: Computed based on data obtained from EMI (1994-2023)

The result of regression coefficient analysis showed that different rainfall and temperature features impact the maize yield in different changing values. The season of spring date changes maize yields .051qt/ha. This means the late starting of the season in the study area challenges the yield of maize production than early. Late rain triggers late plantings which favor disease; as result yield decrease. In the study area maximum highly a negative impact on maize yields (-2.006qt/ha) and minimum temperature positive impacts (1.339qt/ha) respectively.

The computed value for the coefficient of determination (R^2) is 0.973 in Table.9. This indicates that 97.3% of the variance on maize yield per hectare in the study area last 30 years. This value of variation on maize yield was the combination of the start of the season, end of the season, number of rainy days, summer and spring rainy season, maximum and minimum temperature with others the rest non-climatic factors in the study area.

4.6. Determinant Factors that Influence Choice/Preference of Adaptation Strategies

The results of MNL model evaluate factors that determine the preference/ choice of adaptation strategies to climate variability and showed most significant levels of the parameters estimates. During the survey, the farmers explained number factors to adaptation strategies from diverse socioeconomic, demographic and institutional situations. Results of the multinomial logit (MNL) model indicated that different socio economic, environmental and institutional factors impacts the probability of selecting mutually exclusive adaptation strategies to climate variability. Accordingly, results presented show that Age, sex, level of Education, and other have significant influence on practices. Some of explanatory variables are highly significant to impacts the decision for a particular strategy and may be insignificant for the other strategy groups. Thus, the multinomial logit analysis results revealed that the decision of each class of climate variability and adaptation strategy is influenced by different factors and at different levels of significance by the same factor.

Table 10. Parameter estimates of multinomial logit model

Adaptation Strategies to Climate Variability[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Soil and water conservation	Intercept	108.899	675.979	.026	1	.872			
	Age	-52.354	248.911	.044	1	.833	1.832E-23	2.450E-235	1.370E+189
	Education	-12.366	39.849	.096	1	.756	4.259E-6	5.127E-40	3538139822000000000000000000.000
	Sex	-54.480	624.136	.008	1	.930	2.187E-24	.000	.[b]
Use of crop varieties	Intercept	-38.672	582.449	.004	1	.947			
	Age	14.220	246.960	.003	1	.954	1498132.184	9.176E-205	2.446E+216
	Education	15.616	117.135	.018	1	.894	6050337.681	1.191E-93	3.073E+106
	Sex of	-2.887	409.825	.000	1	.994	.056	.000	.[b]
Use of Afforestation	Intercept	-24.773	1265.190	.000	1	.984			
	Age	13.776	209.354	.004	1	.948	960967.149	6.024E-173	1.533E+184
	Education	-9.484	62.822	.023	1	.880	7.603E-5	2.552E-58	2.265E+49

	Sex	20.993	1249.006	.000	1	.987	1309437607.000	.000	.[b]
Use of improving crops and livestock	Intercept	-72.113	1751.188	.002	1	.967			
	Age	38.212	617.640	.004	1	.951	393936941300000.000	.000	.[b]
	Education	16.586	578.764	.001	1	.977	15964084.740	.000	.[b]
	Sex of	-7.864	123.645	.004	1	.949	.000	2.178E-109	6.779E+101
Irrigation	Intercept	59.523	273.866	.047	1	.828			
	Age	-19.749	245.714	.006	1	.936	2.648E-9	1.865E-218	3.760E+200
	Education	-1.073	41.141	.001	1	.979	.342	3.272E-36	3577480998000000400000000000000000.000
	Sex	-48.238	79.440	.369	1	.544	1.124E-21	2.701E-89	4.674E+46
Mixing Farming	Intercept	84.509	255.596	.109	1	.741			
	Age	-32.589	241.031	.018	1	.892	7.030E-15	4.796E-220	1.031E+191
	Education	-7.635	38.077	.040	1	.841	.000	1.877E-36	1245256384000000000000000000.000

	Sex	-44.691	.000	.	1	.	3.899E-20	3.899E-20	3.899E-20
a. The reference category is: Other.									

Source: Own, survey, 2024

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Climate variability is causing the greatest environmental, social and economic threats to allof mankind and across borders in many nations. The study was conducted in Adami Tullu Jido Kombolcha Woreda, East Shoa Zone, Oromia Regional State, Ethiopia. This study was conducted to assess the climate variability, impacts on maize Yield and determinants of farmers' adaptation strategies. In this study Out of 43Kebelesin the Woreda, three Kebeles (namely Chitu, Adansho-Borannota and Barra-Hubbicho) were selected using purposively due to the fact that the kebeles are frequently susceptible to climate related. For this study 330 sample respondents were selected randomly from 1894 sample frame. It was also both primary and secondary data were used to address the objective of the study.

The primary data was collected using questionnaire, key informant interview, focus group discussion and observation. Secondary data were also obtained from published and unpublished documents governmental and nongovernmental reports, and internet sources. Descriptive statistics as well as qualitative analysis, multivariate and MNL models were used to analyze data collected from different sources. Descriptive statistics was used to present demographic and socio economic characteristics of sample respondent. The meteorological data for 30 years (1994-2023) of Adami Tullu Jido Kombolcha station obtained from EMI, Asela branch was calculated by Microsoft excels. Quantitative data generated though questionnaire about impacts of climate variability and smallholder farmers' perception of climate variability was analyzed by using SPSS software version 24. Smallholder farmers perceived climate variability and analysis of the study showed that the majority of respondents experienced that there was climate variability in decreased rainfall and increased trend of temperature in their area. Besides, smallholder farmers have been observed the manifestations of temperature variation. Multivariate regression models were used to analyze the impacts of climate variation (Rainfall and Temperature) on maize yields over the last 30 years (1994 to 2023) using software. The regression results showed a significant relationship between maize yield and climate variation. Among the climate variables rainfall in spring seasons negatively and significantly impact the maize yield. Similarly, maximum temperature has negatively association and significantly impact maize yield.

5.2. Conclusions

This section provides conclusion based on research findings on climate variability impacts on maize yield and small farmers' adaptation strategies in Adami Tullu Jido Kombolcha Woreda, East shoa, Oromia Regional State, Ethiopia. This study was undertaken to investigate the impacts of climate variability on maize yield.As above mentioned the dominant climate elements were rainfall and temperature fluctuation that was posed major impact in the study area. As a study result household in the area mainly dependent on crop and livestock production that is dependent on rain-fed agriculture. The study objective is to identify impacts of climate variability on maize (zea mays l.)Yield and adaptation strategies in the study area; households were relied on rain-fed agriculture that is more sensitive to climate variability. As a result the rainfall and temperature trend in the study area, as long- term meteorological data shows there is high concentration of rainfall that is erratic in nature and there is high fluctuation of temperature with increasing trend.

Contrary to the expected direction of climate trends and variability, this study found significant variation in the amount and distribution of monthly, annual and seasonal rainfall as well as temperature. The calculated standardized rainfall coefficient of variation showed good agreement indicating there was high variation of rainfall in the area. As a result of rainfall variations the Woreda become vulnerable to recurrent drought. El-nino and topographical setting may be the main factor for its variation. Concurrently, at 5% level of significance, by the coefficient of regression line the Total annual Rainfall and mean temperature has increased for Woreda from time to time. Statistical models, based on indicators of climate have been developed to anticipate shifts in Rainfall, temperature and maize yield in Adami Tullu Jido Kombolcha Woreda. Thus, a medium term future pattern of mean annual temperature is found significantly greater in the amount for future than the previous monthly, annual and seasonal temperature. On the Other side, rainfall and maize yield showed mixed result.

Regarding the implications of climate variability on maize yields in the study area there is significant linear relationship between maize yields and climate variability. Hence, maize yields are significantly fluctuation of productivity is associated with Total annual rainfall and mean annual temperature. Therefore, increasing climatic trends and seasonal variations led to a

conclusion that the yield of maize in the study area has been negatively impacted by decreasing of annual rainfall rather than mean temperatures and seasonal precipitation variation. The observed climate variation patterns and impacts which were diverse temporally and impose their impacts on crop development and production have become significant in Adami Tullu Jido Kombolcha Woreda.

Climatic variability makes it essential to develop adaptation strategies at local level. Success on adaptation to climate variation is largely a function of a multitude of interacting factors including technological, institutional and economic endowments. Analysis of response of smallholder farmers on adoption options practiced to withstand climatic variability showed that many have expressed their efforts to Soil and water conservation, Use of crop varieties, Use of Afforestation, Use of improving crops and livestock, Irrigation, Mixing Farming and other. In generally the Majority of Households uses Use of crop varieties for climate variability related.

Although farmers response and discussions on Adaptation strategies with focus group, experts and key informants revealed lack of knowledge, shortage of farmland, high cost of Agricultural inputs, lack of access to information, financial constraint, especially high cost of Agricultural inputs and financial constraint in the study area respectively have remained as factors impacts to adaptation with the adverse impact of climate change.

The most important conclusions to be drawn from the study are that most of the farmers have been using traditional Adopt crop rotation and mixed which is not supported by Technology. Therefore, it is recommended that, the office of agriculture in collaboration with Oromia agricultural enterprise Adami Tullu Jido Kombolcha Woreda branch should encourage farmers to better adapt to future climate condition, by providing new breeds that can stand with climatic change, genetic improvements to identify more drought resistant maize varieties in addition to link farmers to relevant research institutions to promote access to certified seeds of these varieties. Again government institutional coping strategies should be incorporated for the sustainability of farmers coping strategies; in addition to integration and effective collaboration of all sectors of stakeholders for conservation of water and natural resources.

5.3. Recommendations

Based on findings and conclusion of this study the following recommendations are forwarded:

- Extension workers and expert of agriculture should give Information about climate variability to adapt the impacts of climatic variability through awareness creation to smallholder farmers in their local area.
- Farmers and the Woreda agricultural sector should take care and attention on date and length of growing season, also about types of maize because these parameters directly impacts maize yields.
- District leaders should enforce green laws by encouraging peoples' tree plantation that enable to regulate the local climate through carbon sequestration and reducing flood risks of heavy rainfall events.
- Allocating high yielding improved maize crop varieties to user farmers and Promoting use of early maturing seeds that can resist the impact of climate change or variability.
- Support the smallholders to improve their adaptation capacity and also enforce the use of adaptation technologies whenever needed.
- More focus should be made in restoring degraded ecosystem in which the local farmers depend for their livelihoods, by applying various rehabilitation mechanisms.
- Future studies on the effects of climate variability on the production of crops should consider both the intra and inter seasonal variations of climate variables in the study area. This will enable determination of individual contribution of climate variables to crop production process.
- This research can be used as an input; however, more research is needed to analyze both short and long-term climate variability in maize and other crops in the study area.
- Last but not list, for more confidence further studies by including additional climate models, farmer's perception and additional stations is recommended.

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7. APPENDICES

7.1. Appendix A. Household Survey Questionnaires

My name is KubaNegash Wake. I am a postgraduate student at Haramaya University,in Geography and Environmental Studies. Currently I am conducting a research on the"***Climate Variability Impacts on Maize Yield, and Determinants of Adaptation Strategie sin Adami Tullu Jido Kombolcha Woreda"***You selected randomly from the respondents to provide proper information that would hold at most confidentiality, and would use only for the analysis of this study. You are free to refuse to respond to any questions you do not feel comfortable answering or to withdraw from the research all together**.**

General characteristics of respondents

Name of the Kebele---------- Date of interview----------

Enumerator's name..... Signature..... Checked by..... signature.....

Part I. Socio-economic and demographic characteristics

1. Age of household A.20-35B. 36-45 C.>46

2. Sex of household: Male ---------- Female ----------

3. Family size_____

4. Marital status Single --------- married ------- Divorced -------- widowed ------

5. What is your educational level?

A. Primary school B. Secondary School C. not read and writes D. above grade 12

6. What is your Farming Experiences? A.0–15yrs B.16-30yrs C.>30yrs

7. What is your means of livelihoods or how do you get your livelihoods?

A. Livestock rearing B . Renting out land C. Crop production

D. working as daily laborer E. Petty trade F. Others

8. Do you hold land? A. Yes B. No

9. If your answer for question, NO.8,is, yes", how much is the total size of your land? Hectare_____

10. How do you perceive the productivity of your land?

A. Increasing B. Decreasing C. Constant D. Do not know

11. If the yield from your farmland is decreasing, what could be the reason behind?(More than one answer is allowed)

A. Absence of fallowing B. Poor access to chemical fertilizers C. Unreliable rainfall

D. Erosion/runoff E. Over cultivation F. Pests H. Moisture stress

G. Other reasons_____

B. Perception of variability in Rainfall and Temperature between 1994 and 2023

12. From your own experience, how have rainfall and temperature changed between 1994 and 2023?

Rainfall: - A. Increased B. Decreased C. No change

Temperature: - A. Increased B. Decreased C. No change

13. for the last 30 years (1994-2023) which years did you experience severe;

A. Heavy rains B. Drought

14. In the above situation of severity, did you experience loss of crops?

A. Yes B. No Kindly

15. Does the rainfall coming on time? A. On time B. Too early C. Too late

16. Is there enough rain on your field sat the beginning of the rainy seasons?

A. Enough B. Too little C. Too much

17. Is there enough rain on your fields during the growing seasons? A. Yes B. No

18. Does the rains stopping on time on your fields? A. On time B. Too early C. Too late

19. Is training during the harvest time? A. Yes B. No

20. What is your perception about temperature variability after twenty (20) years?

A. The temperature is decreased B. The temperature is increased

C. The temperature is no change

21. If your answer to question number is the temperature show variability, what kind of Indicators do you use to evaluate the temperature trends in the area?

A. Dry up of river and streams B. Decrease crops and livestock production

C. Prevalence of newly introduced human and animal disease D. Decrease in rainfall amount

E. Change in wearing style (dressing light close) F. Extinction of indigenous habitat

G. Deteriorated vegetation cover

22. Are you heard about climate variability before? A. Yes B. No

23. Do you know what the term“climate variability” is meant? A. Yes B. No

24. What do you say the main cause of climate variability?

A. Natural factors B. Human and natural factors C. Human factors C. Other (specify)

25. If your answer on question number 26 is “Human factors” which of the following do you think is the major causes of climate variability?

A. Over Cultivation B. Deforestation C. Population pressure D. Air pollution

26. What is the trend of maize productivity in your Kebele?

A. Decreasing B. The same C. Increasing

27. How was/is the amount of maize yield productivity before a decade compared with this time? A. Has no change B. Decreased in crop yield

C. Increased in crop yield D. Standard crop growth.

28. Is there any possible relationship between climate variability and maize production?

A. Yes B. No If yes, which types of relationship exist? A. Positive B. Negative C. No idea

29. Does rainfall/temperature variability affect maize yield? A. Yes B. No

30. If yes, what is the level impact? A. High B. Moderate C. Low

31. Have you heard about the issue of climate variability? A. Yes B. No

32. If yes, what problems you have faced due to the change of climate? (More than one choice is possible). A. Fluctuation of rainfall B. Disease incidence like malaria C. Increased temperature D. Deforestation E. Cold temperature G. More flooding H. Hail storm I. Drought

33. Did you notice changes in the amount of rainfall in your area in last 30 years? A. Yes B. No

34. Did you notice changes in the amount of temperature in the last30years? A. Yes B. No

35. What happened to pattern of rainfall on set and cessation in your area in the last 20 years? A. decreased B. increased C. Time of onset became late

D. Time of cessation became earlier or late E. Rarely season become shorter

36. In the past 30 years, how would you describe the climate variability in terms?

A. Rainfall on-set and Cessation B. Rainfall amount C. Rainfall seasonal distribution

D. Temperature E. Extreme climatic condition

37. How do you perceive the effect of climate variability on agriculture?

A. Shortage of food supply B. Poor crop yields

C. Incidence of crop pests D. Impacts on livelihoods

38. Does rainfall and temperature variability affect maize yield? A. Yes B. No

39. What extent it affect maize? A. high B. moderate C. low

40. To what extent would you agree or disagree that the options indicated in the table below apply as possible reasons to responses by your household to the climate trend or variability impact on maize yield?(Mark the appropriate box)

Options	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
Maize production failures due to late/early Cessation of rainfall.					
Crop destruction by floods, pest, insects & weeds					
Maize yield is the same as before30 years					
Severity of food shortage in drought is high.					

Part II. To identify existing climate variability adaptation strategies by household farmers in Adami Tullu Jido Kombolcha Woreda

41. Do you practice any climate variability adaptation? A. Yes B. No

42. If no adaptation method used why?_____

43. If your response is yes, which of the following is the most important adaptation mechanism? And often used?

A. Soil and water conservation B. Use of crop varieties /early or late planting

C. Use of Afforestation D. Use of improving crops and livestock

E. Irrigation F. Mixing Farming G. other specifies_____

44. Which adaptation practice you can use with related to improve crop productivity

A. use new variety of seed B. intercropping C. use of irrigation D. SWC

45. Have you heard about climate variability or change adaptation options? A. Yes B. No

46. If yes, how did you know about climate variability adaptation? Through:

A. Development agent B. Local leader C. Radio D. Woreda Expert E. others (specify)

47. What major changes in weather have you observed in your community over the last 30Years? A. Unpredictable rains B. prolonged drought C. Very hot seasons

D. Very wet Seasons E. doesn't know F. others (specify)

48. What is the main impact of this variability on the local community?

A. Crop failure B. Flooding C. Human disease out breaks

D. Livestock disease outbreak E. Famine F. Others(specify) _____

49. What changes would you associate with climate variability on each of the following?

A. Crop production B. Livestock production C. Human health D. Water sources

50. Are you interested in using adaptation mechanism? A. Yes B. No

51. If yes, why? _____

52. Do you have planned to use adaptation practice in the future? A. Yes B. No

53. If no, why? _____

54. Adaptation strategies, you used to overcome climate variability effects related with crop production? A. Receiving aid from safety net B. Using new varieties of crops

C. Inter-cropping system D. wise storage of crops (saving) E. Intensive irrigation F. Others

55. How do you manage to adapt with some of your problems related with climate variability?

A. Reducing number of meals B. By getting remittance from relatives C. Through loan D. sells of livestock E. Renting of land

F. By membership social institutions G. by getting aid H. Others (multiple responses are possible).

7.2. Appendix B Guiding Question for Key Informants Interviews (KIIs)

My name is Kuba Negash Wake. I am a postgraduate student at Haramaya University,in Geography and Environmental Studies**. Currently I am conducting a research on: "*Climate Variability Impacts on Maize Yield and Determinants of Adaptation Strategies in Adami Tullu Jido Kombolcha Woreda"*.**You have selected purposively from different experts in ***Adami Tullu JidoK ombolcha Woreda***.There sponses you give are valuable will be held in ultimate confidentiality and will be used only for the analysis of this study. You are free to refuse to respond to any questions you do not feel comfortable answering or to withdraw from the research all together.

Name_____ Position/occupation_____

Organization_____Code of interviews _____

BACKGROUND OF KEY INFORMANT INTERVIEW

1. Sex___

2. Age___

3. Marital Status_____

4. How many years are you living in this area?_____

5. What is your level of education?_____

6. Is there any form of climate variability in your region or woreda? A. Yes B. No

7. If yes, please give details the extent of climate variability effects on crop yield of your woreda /Kebele _____

8. What is the impact of climate variability on livelihood in terms of crop production especially on maize productivity in your area?_____

9. What is the local adaptation mechanisms used to reduce the negative effects of climate variability?_____

10.What are the main challenges and how do you think they can been changed?

11. How do you know (understand) the impacts of climate variability on your livelihood?

12. Did you take any community based measure to overcome the observed climatevariabilityeffects?A. YesB. No.

13. If yes, what is that measure you have taken to overcome climate variability problem? A. planting trees (afforestation) B. protecting water reservoirs C. constructing roads D. Building flood protection features (ditches) E. Others(multiple responses a responsible)

14. What is your view on climate variability in the Woreda over the past 20 years?

15. In your own opinion, what has been the variation of temperature and rainfall pattern over the past 20 years?_____

16. Is the amount of rainfall increasing or decreasing over 20 years? What do you think there as on for this?_____

17. In your own opinion, how does temperature and rainfall variability affect crop production? 18. In your opinion, how have extreme climatic events (e.g. drought, high t e m p e r a t u r e , floods, etc) affected maize productivity in the Kebele?

19. Based on your experience, what look like its implication and trend on maize yield output in the district for last20years?_____

20. What concerns do you have about adopting and implementing climate variability options in this area? Identify any challenges. _____

21. is there a change in the cropping calendar (sowing and harvesting time) compared to the past 20 years? What methods the smallholders use to cope with the existing changes of cropping calendar?_____

22. How does your office help smallholders in their attempt to responding to the variability in climate?_____

23. Does your office provide any training programmers to smallholders to enhance their adaptive capacity in response to climate variability? A. Yes B. No. If yes how?

24.What are the major factors affecting the crop production in Adami Tullu Jido Kombolcha Woreda in terms of climate variability?_____

7.3 Appendix C Guiding Questions for Focus Group Discussion (FGD)

My name is Kuba Negash Wake. I am a postgraduate student at Haramaya University,in Geography and Environmental Studies**. Currently I am conducting a research on: "*Climate Variability Impacts on Maize Yield and Determinants of Adaptation Strategies in Adami Tullu Jido Kombolcha Woreda"*.**You have selected purposively from different experts in ***Adami Tullu Jido Kombolcha Woreda***.The responses you give are valuable will be held in ultimate confidentiality and will be used only for the analysis of this study. You are free to refuse to respond to any questions you do not feel comfortable answering or to withdraw from the research all together.

Name_____ Position/occupation_____

Organization_____Code of interviews _____

BACKGROUND OF KEY INFORMANT INTERVIEW

1. Sex___

2. Age___

3. Marital Status_____

4. How many years are you living in this area?_____

5. What is your level of education?_____

6. Is there any form of climate variability in your region or Woreda? A. Yes B. No

7. If yes, please give details the extent of climate variability effects on crop yield of your Woreda /*Kebele*_____

8. What is the impact of climate variability on livelihood in terms of crop production especially on maize productivity in your area?_____

9.What is the local adaptation mechanisms used to reduce the negative effects of climate variability?_____

10. What are the main challenges and how do you think they can been changed

11. How do you know (understand) the impacts of climate variability on your livelihood?

12. Did you take any community based measure to overcome the observed climate variability effects? A. Yes B. No.

13. If yes, what is that measure you have taken to overcome climate variability problem? A. planting trees (afforestation) B. protecting water reservoirs C. constructing roads D. Building flood protection features(ditches) E. Others (multiple responses are possible)

14. What is your view on climate variability in the Woreda over the past 30 years?

15. In your own opinion, what has been the variation of temperature and rainfall pattern over the past 30 years?_____

16. Is the amount of rainfall increasing or decreasing over 30 years? What do you think there as on for this?_____

17. In your own opinion, how does temperature and rainfall variability affect crop

production? _____

18. In your opinion, how have extreme climatic events (e.g. drought, high t e m p e r a t u r e , floods, etc) affected maize productivity in the Kebele?

19. Based on your experience, what look like its implication and trend on maize yield output in the district for last 30 years?_____

20. What concerns do you have about adopting and implementing climate variability options in this area? Identify any challenges. _____

21. is there a change in the cropping calendar (sowing and harvesting time) compared to the past 20 years? What methods the smallholders use to cope with the existing changes of cropping calendar?_____

22. How does your office help smallholders in their attempt to responding to the variability in climate?_____

23. Does your office provide any training programmers to smallholders to enhance their adaptive capacity in response to climate variability? A. Yes B. No. If yes how?

24. What are the major factors affecting the crop production in Adami Tullu Jido Kombolcha Woreda interms of climate variability?

Appendix Table: 1. Adami Tullu Jido Kombolcha Woreda Annual Maximum Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Average
1994	27	27.4	27.5	27.6	27.3	27.0	27.3	27.0	27.1	27.2	27.3	27.0	27.2
1995	27.4	27.8	27.8	27.7	27.6	27.0	27.5	27.2	27.1	27.4	27.4	27.3	27.4
1996	27.6	27.9	27.9	27.4	27.8	27.4	27.7	27.4	27.2	27.6	27.5	27.6	27.6
1997	27.7	28.0	28.1	27.0	27.8	27.6	27.7	27.8	27.2	27.6	27.4	27.8	27.6
1998	27.9	28.2	28.5	28.0	28.0	27.7	27.8	27.9	27.4	27.9	27.6	27.5	27.9
1999	28	28.2	28.9	27.8	28.0	27.8	27.8	28.2	27.4	28.2	27.6	28.0	28.0
2000	28.3	28.5	28.9	28.6	28.2	27.9	27.9	28.2	27.7	28.2	27.8	28.2	28.2
2001	28.3	28.6	29.0	28.9	28.4	28.1	28.1	28.3	28.1	28.5	28.0	28.8	28.4
2002	28.5	28.7	29.2	29.6	28.5	28.3	28.2	28.5	28.1	28.5	28.2	28.8	28.6
2003	28.7	28.8	29.4	29.6	28.7	28.4	28.2	28.9	28.2	28.5	28.2	28.7	28.7
2004	28.8	28.9	29.5	29.2	28.8	28.5	28.5	28.9	28.6	28.8	28.6	29.0	28.8
2005	28.9	28.9	29.6	29.7	29.0	28.7	28.5	29.1	28.7	28.9	28.7	29.0	29.0
2006	28.9	29.3	29.9	29.3	28.3	28.9	28.5	29.4	28.8	29.0	28.7	29.6	29.1
2007	29.2	29.5	30.0	29.6	28.7	29.2	28.6	29.5	29.2	29.3	28.8	29.7	29.3
2008	29.3	29.7	30.0	30.1	28.8	29.2	28.7	29.6	29.4	29.3	28.9	29.8	29.4
2009	29.6	29.9	30.0	30.3	28.8	29.5	28.7	29.7	29.9	29.4	29.0	29.9	29.5
2010	29.6	30.0	30.3	30.5	29.4	29.7	28.9	29.8	29.9	29.7	29.4	29.9	29.8
2011	29.7	30.4	30.4	30.7	29.6	29.9	28.9	29.8	30.2	29.8	29.6	30.3	29.9
2012	29.8	30.7	30.5	30.7	29.6	29.9	29.0	29.9	30.4	29.8	29.9	30.3	30.0
2013	29.9	30.8	30.5	30.8	29.7	30.0	29.2	29.9	30.4	29.8	29.9	30.5	30.1
2014	29.9	30.9	30.6	30.8	29.7	30.0	29.3	30.1	30.6	29.9	30.1	30.7	30.2
2015	30.2	30.9	30.6	30.8	29.9	30.2	29.3	30.2	30.7	30.0	30.3	30.7	30.3
2016	30.3	31.3	30.8	30.9	29.9	30.2	29.5	30.4	30.8	30.0	30.5	30.8	30.5
2017	30.5	31.5	30.8	30.9	30.1	30.2	29.5	30.5	30.9	30.3	30.7	30.8	30.5
2018	30.8	31.7	31.0	31.1	30.2	30.3	29.7	30.5	30.9	30.3	30.7	30.9	30.7
2019	30.9	31.9	31.1	31.2	30.3	30.5	29.9	30.7	30.9	30.6	30.7	31.2	30.8
2020	31	32.0	31.8	31.2	30.3	30.5	30.0	30.8	31.1	30.7	30.8	31.5	31.0
2021	31.3	32.4	31.9	31.4	30.1	30.7	30.2	30.8	31.5	30.8	30.9	31.6	31.1
2022	31.6	32.7	32.1	31.9	31.2	30.9	30.4	30.9	31.7	30.8	30.9	31.8	31.4
2023	31.9	32.8	32.1	32.2	31.5	31.4	30.5	31.1	31.9	31.2	31.4	31.9	31.7

Appendix Table: 2. Adami Tullu Jido Kombolch Woreda Annual Minimum Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Average
1994	10	10.6	10.5	10.6	11.2	10.0	10.3	10.0	10.1	10.2	11.3	11.5	10.5
1995	10.4	10.8	10.8	10.7	11.6	10.3	10.5	10.6	10.5	10.4	12.4	12.3	10.9
1996	10.6	10.9	10.9	11.2	11.8	11.3	10.7	10.9	10.9	10.6	12.5	12.6	11.2
1997	10.9	11.0	11.1	11.5	11.8	11.6	10.7	11.1	11.2	10.9	12.9	12.8	11.5
1998	11	11.2	11.5	11.7	11.9	11.7	10.8	11.4	11.4	11.2	13.4	13.4	11.7
1999	11.3	11.6	11.9	11.8	12.0	11.8	11.2	11.6	11.5	11.5	13.6	13.6	11.9
2000	11.4	11.9	11.9	11.8	12.2	11.9	11.4	11.9	11.7	11.6	13.8	13.8	12.1
2001	11.4	11.9	12.0	11.9	12.5	11.9	11.6	12.3	11.9	12.0	14.0	13.8	12.3
2002	11.7	12.2	12.2	11.9	12.5	12.3	11.7	12.5	12.1	12.5	14.2	13.9	12.5
2003	11.8	12.4	12.4	12.1	12.7	12.4	11.8	12.5	12.2	12.6	14.2	14.1	12.6
2004	11.9	12.4	12.5	12.5	12.8	12.6	11.8	12.7	12.6	12.8	14.6	14.3	12.8
2005	12	12.6	12.6	12.7	12.9	12.6	12.0	12.7	12.7	12.9	14.7	14.4	12.9
2006	12	12.6	12.9	12.9	12.9	12.9	12.4	12.9	12.8	13.0	14.7	14.6	13.0
2007	12.2	12.8	12.9	12.9	13.1	12.9	12.6	12.9	12.8	13.3	14.8	14.7	13.1
2008	12.3	12.8	13.0	13.2	13.1	13.1	12.7	13.0	12.8	13.3	14.9	14.8	13.2
2009	12.6	12.9	13.4	13.3	13.3	13.5	12.7	13.1	12.9	13.4	14.9	14.9	13.4
2010	12.6	12.9	13.8	13.5	13.4	13.7	12.9	13.4	13.1	13.4	15.2	14.9	13.5
2011	12.7	13.4	13.9	13.7	13.4	13.9	12.9	13.5	13.2	13.8	15.4	15.3	13.7
2012	12.8	13.4	13.9	13.7	13.7	13.9	13.0	13.5	13.4	13.8	15.4	15.3	13.8
2013	12.9	13.6	14.2	13.8	13.9	14.0	13.2	13.9	13.4	13.8	15.6	15.5	14.0
2014	12.9	13.9	14.4	13.8	13.9	14.0	13.3	13.9	13.6	13.9	15.7	15.7	14.1
2015	13.2	13.9	14.6	13.9	14.2	14.2	13.3	14.2	13.7	14.0	15.7	15.7	14.2
2016	13.3	14.2	14.8	13.9	14.5	14.2	13.5	14.4	13.8	14.0	15.8	15.8	14.4
2017	13.5	14.5	14.8	14.2	14.5	14.4	13.5	14.5	13.9	14.3	15.8	15.8	14.5
2018	13.8	14.7	14.9	14.3	14.6	14.7	13.7	14.5	13.9	14.3	15.9	15.9	14.6
2019	13.9	14.8	14.9	14.5	14.8	14.8	13.9	14.7	14.3	14.6	15.9	15.9	14.7
2020	13.9	14.8	15.1	14.5	14.9	14.9	13.9	14.8	14.5	14.7	15.9	16.2	14.8
2021	14.3	14.9	15.4	14.6	14.9	14.9	14.2	14.8	14.5	14.8	16.0	16.3	15.0
2022	14.5	14.9	15.5	14.9	15.0	15.0	14.4	14.9	14.7	14.8	16.1	16.3	15.1
2023	14.6	15.1	15.5	14.9	15.2	15.4	14.5	15.1	15.0	14.9	16.4	16.5	15.2

Appendix Table: 3. Adami Tullu Jido Kombolcha Woreda Annual Total rainfall

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1994	0.1	1.0	3.5	0.0	0.7	78.5	134.6	184.9	75.6	10.0	1.3	5.9	496.1
1995	8.9	8.2	0.2	8.6	0.4	83.8	126.4	131.5	88.3	21.8	13.8	3.7	495.6
1996	8.1	5.9	3.2	8.2	0.8	70.5	135.1	136.5	84.3	19.6	16.3	0.0	488.5
1997	8.0	0.1	6.7	8.2	0.1	63.2	170.2	134.1	67.1	11.6	8.8	2.1	480.2
1998	2.4	15.3	3.0	2.4	0.0	96.2	117.0	139.1	86.6	11.3	2.8	3.6	479.7
1999	4.7	6.8	1.9	8.6	0.0	89.0	158.2	105.1	55.5	12.2	19.4	6.6	468.0
2000	5.1	0.0	4.5	1.4	0.6	124.1	150.4	82.8	13.9	42.3	29.4	0.0	454.5
2001	0.6	2.8	0.2	0.0	0.3	101.9	121.5	160.3	62.4	3.4	0.0	0.0	453.4
2002	0.7	0.0	0.5	0.0	0.7	105.8	121.1	119.8	90.0	9.7	0.0	0.0	448.3
2003	0.3	0.0	0.5	9.1	0.7	93.8	150.8	167.0	23.9	0.0	2.4	4.0	452.5
2004	2.1	0.5	0.9	8.3	0.7	88.4	135.8	147.1	33.0	14.5	14.7	5.2	451.2
2005	2.0	1.7	0.1	0.3	0.7	138.0	89.9	158.4	54.7	8.8	0.0	0.6	455.2
2006	3.1	3.7	0.1	1.6	0.8	161.2	84.8	92.0	65.0	6.7	22.1	9.2	450.3
2007	3.1	1.6	0.6	5.8	0.7	173.4	128.6	90.0	35.1	5.1	2.5	1.5	448.0
2008	1.5	2.9	2.0	0.9	0.7	123.7	92.7	124.2	78.4	8.0	10.7	0.0	445.7
2009	1.8	2.2	0.9	0.1	0.5	89.6	186.2	92.1	37.3	8.8	9.5	7.4	436.4
2010	1.2	1.3	0.0	0.5	0.5	40.8	149.7	193.8	46.2	0.9	0.0	0.0	434.9
2011	0.0	0.5	0.0	0.4	0.5	103.2	145.0	108.4	47.7	10.6	6.1	0.2	422.6
2012	0.4	0.0	0.9	0.8	0.0	52.2	188.0	108.3	48.4	8.9	2.2	0.1	410.2
2013	0.8	0.0	1.3	0.7	0.0	82.9	120.1	137.9	54.1	8.7	0.4	0.7	407.6
2014	0.1	0.4	5.7	2.6	0.0	80.3	114.8	127.7	64.5	1.2	3.1	3.2	403.6
2015	2.1	0.5	2.9	1.3	0.0	86.4	135.8	117.1	43.0	1.5	1.7	5.2	397.5
2016	2.0	0.7	0.1	1.3	0.0	88.0	89.9	158.4	34.7	8.8	0.0	0.6	384.5
2017	0.1	1.7	1.1	0.6	0.0	86.2	84.8	98.0	66.0	6.7	22.1	2.2	369.5
2018	0.1	1.6	1.6	0.8	0.0	88.4	128.6	99.0	30.1	5.1	2.5	1.5	359.3
2019	1.0	0.9	1.0	0.0	0.0	63.7	92.7	124.2	68.4	8.0	4.7	0.0	364.6
2020	0.8	0.2	0.9	0.1	0.0	89.6	140.2	92.1	37.3	1.8	1.0	0.4	364.4
2021	0.2	0.3	1.0	0.0	0.0	78.8	141.7	153.8	1.2	0.0	0.0	0.0	377.0
2022	0.0	0.1	0.0	0.0	0.0	93.2	145.0	108.4	7.7	1.6	6.1	0.2	362.3
2023	0.0	0.0	0.0	0.0	0.0	52.2	188.0	108.3	5.4	3.9	2.2	0.1	360.1