



SMALLHOLDER FARMERS' STRATEGIES TOWARDS COPPING WITH THE EFFECT OF CLIMATE CHANGE ON MAIZE CROP PRODUCTION IN KEDIDA GAMELA WOREDA ,KEMBATA TEMBARO ZONE, SNNPR, ETHIOPIA.

MSC THESIS

BY

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THESIS SUBMITTED TO FACULTY OF ENVIRONMENT GENDER AND DEVELOPMENTSTUDIES,CLIMATE CHANGEAND SUSTAINABLE AGRICULTURE

COLLEGE OF AGRICULTURE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

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HAWASSA, ETHIOPIA

FEBRUARY, 2023

HAWASSA UNIVERSITY

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THESIS APPROVAL SHEET

As Thesis Research advisor, I hereby certify that I have read and evaluated this thesis entitled « Small holder farmers strategies towards coping with the effect of climate change on maize crop in Kedida Gamela Woreda ,Kembata Tembaro Zone, SNNPR, Ethiopia » prepared, under my guidance, by Meharu Geneto. I recommend that it can be submitted as fulfilling the thesis requirement of the University.

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Acknowledgment

Above all, my special thank deserved to almighty God without whose blessing, it would have been possible all my wishes to come in to reality.

I would like to extend my sincere and deepest thanks to my advisor Dr. ZenebeWorku for his skillful advice, enthusiastic encouragement and invaluable comments beginning from the inception of the proposal to the final write up of this thesis. I have also learnt many things from advisory time in addition to the concern of this thesis. I am grateful for all that he did for me and I would like to say may God bless him and live long peacefully!

My special gratefulness deserves to my special person, my wife FikreMarkosDogiso who is the base for all my achievements in my study life. She put the milestone and made untold sacrifices for today's success, making me strong, for my study. I am also highly indebted and acknowledged to my brothers Mr. KebedeMarkoswho helped me invaluable material support/computer/ during my study period their guidance, intimate follow up and encouragement.

I am very much grateful to my brothers and sisters mr.BirhanuGeneto, GirmaGeneto, TarekegnGeneto, Tariku Geneto, Meklit Geneto, TeketelMarkos and AlemuMarkos for their encouraging with resource support/financial support, love and care during my stay in the study. I am also special thanks to my father Ato GenetoSewore and my mother w/roTadelechwolde who has never been to school but brought me to this end.

I would also like to extend special thanks to Meteorological Agency, Hawassa Branch by giving meteorological data of rainfall and temperature of study area ,*Kembata Tembaro Zone Agriculture* office, special thanks to coffee, tea and spices department experts and coordinators who helped me by resource supporting/papers, printing of proposal documents, questionnaires, thesis copying and advising.

Special thanks also go to kedida Gamela woreda administration office who supported me with finance. I have no words to thank and appreciate the farmers of the study areas for their to answer the questionnaire. My appreciation goes to those development agents who were most helpful in collecting data.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical and technical principles of data collection, data analysis and compilation of the **thesis**. This **thesis** is submitted in partial fulfillment of the requirements for a Collaborative Master in climate change and sustainable agriculture in Hawassa University. **The thesis** is deposited in the Hawassa University Library and is made available to reader under the rules of the Library. I solemnly declare that this Thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate

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Biography

The author was born in Kedida Gamela Woreda, Kembata Tembaro Zone of Southern Nations, Nationalities and Peoples Region at a place called Aze DoboKebele, in 1978. He attended his elementary and junior school education at Aze Dobo and ZatoShodera elementary school, and Junior Secondary School, respectively. Then, he joined Durame senior secondary high school, in kembataTembaro Zone and completed his secondary education in 1999 at Durame Preparatory School. In 2000 E.C the author joined the then ArbaMinch University and graduated with B.sc. degree in plant Science department in July, 2002 Ec.

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LIST OF ACRONYMS

AEZs	Agro Ecological Zones
CRGE	Climate Resilient Green Economy
CSA	Central Statistical Agency
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focus Group Discussion
GHGs	Green House Gases
GO:	Governmental Organization
IGPCC	Inter Governmental Panel on Climate Change
IPCC	International Panel on Climate Change
KGWAO	Kedida Gamela Woreda Agriculture Office
KIIs	Key Informant Interview
MoFED	Ministry of Finance and Economic Development
NAPA	National Adaptation Program of Action
NGO:	Non-Governmental Organization
NMA	National Metrological Agency
NMSA	National Meteorology Service Agency
NOAA	National Oceanic and Atmospheric Administration
SNNPR	Southern Nation Nationality and Peoples Regional State
SSPSS	Statistical Package for Social Science
SSA	Sub Saharan Africa
UNFCCC	United Nations Framework Convention on Climate Change
UKCIP	United Kingdom Climate Impact Program
UK	United Kingdom

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ABSTRACT

This study was conducted Small holder farmers strategies towards coping with the effect of climate change on maize crop in Kedida Gamela Woreda ,Kembata Tembaro Zone, SNNPR, Ethiopia » Primary data were collected using key informant interviews, group discussions and household surveys with 164 sample respondent households. Both descriptive and inferential (multinomial logit model) statistics were used to analyze the collected data. According to the result shows about (85.4%) of the respondents have perceived high rainfall amount reduction while 11.6%respondents perceived moderate reduction of rainfall. such rainfall reduction perception by farmers has been confirmed by meteorological data record of the past 30 years. Average annual rainfall of the area has been declined by the rate of 2.269 mm annually. Similarly, 100 % of interviewed farmers said that temperature showed an increasing trend. According to the meteorological data for past 20 years showed that average temperature of the kedida GamelaWoreda was 20.63°C,with minimum temperature of 15.3 °C. And maximum temperature of 25.95°C.The same data confirmed that there is average mean annual temperature increment by 0.13°C. The multinomial logit model results reviled that he most common adaptation strategies practiced by farmers include planting of drought resistant maize crop variety, early maturing maize crop variety, early planting of maize crop variety, high yielding maize crop varieties implementing small scale irrigation practices, fertilizer application of animal manure. The result also indicates that ,age, family size, land size, education, farming experience and climate information are factors affecting household's choice of maize adaptations strategies in the study area. In the study area the amount of rainfall shows decreasing pattern and temperature increasing for last years. Therefore government should take responsibility for further plan and encourage an effective implementation of an alternative strategies that can minimize the dependency on limited variety of maize crops and take responsibility on appropriate climate change and variability adaptation strategies such as, using of drought resistant maize crop varieties, high yielding maize crop varieties, early maturing maize crop varieties, according to the season early planting of maize crop varieties, practicing water harvesting technology and irrigation practices. And government should provide farmers with extension services, moreover, ensuring credit facilities to enhance farmers' access to credit, which will increase their capability to adapt climate change.

Key words: Climate change, climate variability, perception, vulnerability, adaptation strategies

CHAPTER 1

1 INTRODUCTION

1.1 BACK GROUND

Globally, Climate change is one of the most serious environmental challenges facing the world at present. It refers to long-term change in the earth's atmospheric temperature, whether due to natural variability or as a result of human activity (kinyang, 2009). Global warming shows no signs of decreasing trend and is expected to bring about long term changes in weather conditions (FAO, 2018)Climate and agriculture are highly interlinked, and one affects the other in many ways. Agriculture contributes to climate change on a global scale through Emission of Greenhouse Gases (GHGs) while climate change affects agriculture through changes in average temperatures, rainfall, and climate extremes; changes in pests and diseases conditions (Nyang et al, 2011).

Climate change is already affecting agriculture and its effects are unevenly distributed across the world (poteretal 2014) .Climate change is the most urgent and complex challenge for societies and economies (corner et al 2012). It's magnitude and rate of climate change causes impacts on the areas of public health, agriculture, food security, forest, hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services (UNFCCC, 2007) .Global climate change is one of today's greatest challenges and it is crucial for all countries of the world to act now.Climate change and variability is increasing the frequency and intensity of climate related hazards and hence, the level and patterns of often inter related risks, particularly crop production and food security, exacerbate levels of vulnerability, mainly for rural households who mostly rely on rain fed agriculture. Climate change is most distressful event by posing tremendous negative impact on several sectors of the world (Inter Governmental Panel on Climate Change, IGPC 2014).

Rainfall variability has significant and negative impact on outputs of crop agriculture. What matters most in crop production is not per se the amount of rainfall but how that level diverges from the mean rainfall which is supposed to be the optimal level. When the rainfall diverge from the mean value (both upward and downward), the level of production has significantly diminished to all crop types unanimously. Other factors such as fertilizer, area,demands for crop production and labor force have significant impact in addition to rainfall variability in all crops. When rainfall diverges from its mean; fertilizer use has also a

negative impact on crop production. This is may be because in case of dry or excess rainfall conditions, fertilizer adoption may burn seeds and increase the probability of crop failure. Local temperature increases from time to time and negatively impacts the yields of key crops such as **Maize, Teff and Wheat**, resulting in the disruption of agricultural systems and production.

In developing countries where the majority of people reside in rural areas, the impacts of climate change on their livelihood are likely to be high because of high dependency, directly or indirectly, on rain-fed agriculture (Nyang et al, 2011) . and agriculture sector reported by several studies to be one of the most vulnerable and sensitive to climate change and weather conditions (Nelson , 2009).

Africa has been identified as one of the continent's most vulnerable to the impacts of climate change. The reasons are the exposure of its population to climate variations and extremes, people's dependency on natural resources and the underdevelopment of much of the region. Africa is already affected by climatic extremes such as floods and droughts, which will be exacerbated by climate change. Such events are having a negative impact on livelihoods, especially those of the poor. Given the degraded environments, crop production, food insecurity, poverty and HIV/AIDS already affecting large parts of Africa, climate change poses a monumental problem for the region (Jones et al, 2007). Assessments of regional impacts of climate change widely agree that the most vulnerable countries and societies are in Africa, especially south of the Sahara. The negative effects of climate change are threatening to reverse development gains in many parts of the world especially in Sub-Saharan Africa (SSA). It is now an accepted scientific phenomenon that the global climate is changing. Precipitation and temperature patterns are changing. In the Sub-Saharan region rainfall patterns have become less predictable, precipitation has decreased on average, and temperatures are rising. Evidence shows that the upward trend of the already high temperatures and the reduction of precipitation levels will increasingly result in reduced agricultural production in Sub-Saharan Africa (Mano & Nhamachina, 2007). Ethiopia is one of the agrarian countries whose main livelihood depends on agriculture as source of income. Farmers whose livelihoods depend largely on rain-fed agriculture were faces with different climate variability (Atinkut & Mabrat, 2016).

Ethiopia's agricultural sector, which is dominated by small scale, mixed crop and livestock farming, is the mainstay of the country's economy. Rural people, (Zerga&Gebeyehu, 2016) depend on agriculture in Ethiopia for sustenance and livelihood, are often vulnerable to the direct impacts of adverse weather, climate variations and change (Molnar, 2010). In Ethiopia the smallholder, low-input and rain-fed agriculture, and livelihood system in the arid and semiarid lowlands are more vulnerable to the adverse effects of climate variability and change because of dependence on climate-sensitive natural resource-based economic activities. The major factors responsible for low productivity include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complementary services such as extension, credit, marketing, infrastructure, and climatic factors such as drought and flood (Deressa, Hassan&Ringler, 2011). Climate change causes wide-ranging effects on the environment, and on socioeconomic and related sectors, including agriculture and food security, terrestrial ecosystems, and biodiversity (zerga&Gebeyehu, 2016).

Maize (*Zea mays* L.) is one of the major food crops in Ethiopia, both in terms of the area cover and the overall amount of production (Arega ,2017). According to study Maize is a long-cycle crop which is planted during the belg season between March and April and harvested between September and December.

Ethiopia's maize crop production is more vulnerable to climate change. Ethiopia's extreme vulnerability to the impacts of climate change is due to social, economic and environmental factors. In particular, high levels of poverty, rapid population growth, high level of reliance on rain-fed agriculture, high levels of environmental degradation, chronic food insecurity and frequent natural drought cycles increase climate change vulnerability in the country (Aklilu et al., 2009). Vulnerability assessment indicated that the most vulnerable sectors are agriculture, water and human health. In terms of livelihood approach smallholder rain-fed farmers and pastoralists are found to be the most vulnerable. The arid, semi-arid and the dry sub-humid parts of the country are affected most by drought (Kidane et al., 2009).

The Variability of rain fall and the increasing temperature were a cause for frequent drought and famine. At the national level, World Bank (2010) suggests that climate change may

reduce Ethiopia's GDP compared to a baseline scenario by 2-6% by 2015, and by up to 10% by 2045. Thus, adaptation measures are meaningful to cope up the effects of climate change.

In KedidaGamelaworeda, the impact of climate change and variability is affecting the small holders' crop production, small holder farmers and other social groups. Therefore, identifying adaptation strategy, identifying the constraints of climate change impact on small holders' farmers, local communities, is important to develop households' coping strategy to climate change impacts happening in the Woreda. Crop production in general and maize production in particular in KedidaGamelaworeda is affected by failure of rains or occurrence of successive dry spells during crops growing and flowering season. Even in good years, the one-time harvest of maize crop may be too little yield to meet the yearly household needs (Kedida Gamela woreda Agriculture Office ,KGWAO 2019).

Maize (*Zea Mays L*) is the most important cereal grain crop cultivated in the study area and it has a significant role in the livelihoods for instance: food, feed and income and consumption purpose for smallholder farmers (Kedida Gamela Woreda Agriculture Office, KGWAO, 2019).In general this study was aimed to understand Small holder farmers strategies towards coping with the effect of climate change on maize crop in Kedida Gamela Woreda ,Kembata Tembaro Zone, SNNPR, Ethiopia »

1.2.Statement of the problem

The impact of climate change on Ethiopian agriculture in general and crop production in particular has been the focus of research studies. To this end, according to [Aklilu et al., \(2009\)](#) reported that, vulnerability to climate change exacerbated due to high levels of poverty, rapid population growth, high level of reliance on rain-fed agriculture, high levels of environmental degradation, chronic food insecurity and frequent natural drought cycles. Another study by [Befikadu, \(2019\)](#), on Climate Variability and Farmers' Perception in Wolaita Zone, Southern Ethiopia attempted to better understanding of recent changes and variability in the rainfall and temperature data and factors affecting farm households' perception of climate variability.

However, the study overlooked answering what adaptation strategies farmers employ in response to reducing the impact of climate change and their variability.Similarly, there is another context based recent study by [Tafesse M.\(2019\)](#), on climate change-induced impacts

on smallholder farmers in selected districts of Sidama, Ethiopia. The study reported on the cause and effect relationship issues of rainfall condition and drought incidents, types of climate change-induced impacts, climate change and variability related epidemics, drought, harvest loss, climate change-induced hunger, flooding, and the attributing determinants to the prevailing effects. The study, however, also, limited to establishing the effect of climate change induced impacts on **small holder farmers but did not address the adaptation strategies by smallholder farmers**. Amare A, (2015) in his study focused on review on the impact of climate change on crop production in Ethiopia; mainly discussed on issues like evolution of climate change, direct and indirect impact of climate change on agriculture, vulnerable groups to climate and the macro policies on climate change. The above mentioned studies have **a gap in indicating households' adaptation strategies for the impacts of climate change**. In addition, there is a gap in terms of getting information and knowledge context specific to the study area. According to Kedida Gamela **Woreda** Agriculture and office (KGWAO, 2019) report, the district is one of the most vulnerable areas experiencing drought and food insecurity because of climate change impact. The same report, stated that higher temperature, reduced rainfall, and increased rainfall variability reduces crop yield are among the manifestations of the impact of climate change in the area, which particularly observed threatens food security of small holder farmers whose livelihood is / are dependent on low income subsistence agriculture (KGWAO, 2019). Smallholder farmers' of the district, have various important endogenous knowledge based traditional adaptation strategies to reduce risks like impact of climate change on crop production in general and maize production in particular (KGWAO, 2019). However, these indigenous knowledge based traditional adaptation strategies are not yet studied in a systematic and empirical manner, for documentation and possible integration with improved scientific knowledge based practices recommendations for the mitigation of climate change on smallholder agricultural production. **Therefore, this study has attempted to systematically and empirically assess the effect of climate change on context focused maize crop production**, which is among the dominantly grown and economically important crop in relation to the practical adaptation strategies of producing smallholder in the study area. The study thereby **has** generated new body of knowledge pertinent to the planning and implementation of development interventions in addressing the problem with locally workable and yet sustainable manner.

1.3 Objective of the study

1.3.1 General objective of the study

The general objective of the study was to. Small holder farmers strategies towards coping with the effect of climate change on maize crop in Kedida Gamela Woreda ,Kembata Tembaro Zone, SNNPR, Ethiopia »

1.3.2 Specific objectives of the study

-To assess small holder maize producers perception on climate variability and change and it's effect on maize production in the study area;

-To identify smallholder maize producers' adaptation strategies in response to effects of climate change and variability in the study area.

-To asses factors determining the smallholder maize producers' choice of adaptation strategies to climate variability and change on maize production in the study area.

1.3.3 Research Questions

1.How do small holder producers' perceive climate variability and change and its effect on maize production in the study area?

2. What are factors determining the smallholders' choice of adaptation strategies for climate variability on maize production in the study area?

3. What are smallholder maize producers' adaptation strategies in response to effects of climate change and variability in the study area?

1.4 Significance of the Study

The problem of climate change is more serious problems on smallholders' farmers' who heavily depend on climate sensitive crop production. Climate change and variability has become a serious challenging factor for the implementation of the country's development strategies especially on agriculture sector. As it has been already evidenced by Kedida Gamela **Woreda** Agriculture Office,(KGWAO 2019). Thus, the district is one of the most vulnerable areas experiencing drought and food insecurity because of climate change impact.

.More specifically, it would raise visibility of the actual and potential impacts of climate change on vulnerable groups in the **Woreda** .Thus, the outcomes of the study will help to understand the small holder farmers’ producers perception and their adaptation strategies to the effects of climate change on the crop production in general and maize production in particular. This will also support governmental and non-governmental actors working on the issues of developing program.Furthermore, the findings of this study may help the government and development partners, interested in issues of climate change such as researchers, extension workers, education institutions, GOs, NGOs, policy makers and planners of adaptation strategies to effects climate change by creating awareness and make understanding about issues of adapting to climate change, and helps to take appropriate actions needed to tackle the impacts of climate change.

More over since, this study is pioneering work in the study area, and it could pave ways for further research that would uncover in more facts about the areas -context specific new knowledge on climate change and impacts.

1.5 Scope& limitation of the Study

The scope of the study is limited to kedida Gamelaworeda, Kembata Tembaro Zone, and to assess smallholder farmers’ strategies towards coping up with the effect of climate change on maize crop production practiced at local level and to assess some of the smallholder farmers’ perception towards effect of climate change, variability and adaptation strategies. The study was conducted on rural kebeles of kedida Gamela by taking only three kebeles as a sample. And it focuses only on rural smallholder farmers and households’ efforts of adaptation and climate variability and its effects on small holders’ maize production. As limitation information determining factors such as age of households, sex of households, educational status, access to information, family size, farm experience, extension service,and climate information were taken into account for these studies. This is due to the assumption of shortage of time and budget constraints for further study of the rest of the factors.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURE

This chapter presents the review of pertinent literatures that make theoretical and conceptual foundation of the study and also contextualizes in the relation to previously conducted empirical study findings including their methodological approaches in relation to addressing the issues stated in the specific objective of this study. It describes basic concepts related with climate change, perceptions about climate change, and definitions, causes and manifestations of climate change, observed patterns and projections, the impacts of climate change in world, Africa, Ethiopia and Ethiopia's responses to climate change impacts

2.1 Theoretical and conceptual review

2.1.1 The concept of climate change and climate variability

The notion of climate change and variability has been narrated by different forms but fundamentally similar understanding. FAO (2018), reported that climate change is disproportionately affecting the world's poorest countries, which bear the brunt of its effects, and is among the most important environmental aspects that the human community is gifted with. Climate implies the long-term average of the individual weather conditions that communities experience every day FAO (2018).

According to (IPCC, 2015) Climate change, refers to any significant change in the measures of climate lasting for an extended period of time, (typically decades or longer) which includes major changes in temperature, rainfall, wind pattern and other climate variables that occur over decades or longer (IPCC, 2015). Climate change may be due to natural processes or external forces, or persistent changes in the composition of the atmosphere or in land-use due to anthropogenic factors (IPCC, 2014).

Climate is defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years (IPCC 2018). The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (Yohannes, 2019).

On the other hand, Climate variability (IPCC, 2015) refers to variations in the mean state and other statistics such as standard of deviations, the occurrence of extremes of the climate on temporal and spatial scales beyond that of individual weather events. Such 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). Moreover, as stated by National Oceanic and Atmospheric Administration (NOAA), 2009) it is ,the way climate fluctuates monthly, seasonally and yearly as above or below a long-term average value means the rise and fall that occurs from year to year and the statistic of extreme conditions such as severe storms or unusually hot seasons.

2.1.2. The concepts Vulnerability, impacts, impact assessment, Mitigation and Adaptation to climate change and variability

Adaptation: The IPCC (2007), defined adaptation 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 is;- a process by which strategies to moderate, cope with and reduce the risks of the consequences of climatic events are enhanced, developed, and implemented (UNDP, 2007)

Adaptation to Climate Change: According to United Nation Frame work Convention on Climate Change (UNFCCC, 2007) adaptation is defined as Practical steps to protect countries and communities from the likely disruption and damage that will result from effects of climate change. Adjustment in natural or human systems is response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptations can be distinguished such as anticipatory, autonomous and planned adaptation (IPCC, 2007).

Adaptationis 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 change. UK Climate Impact Programs (UKCIP, 2003).

Perception: -according to (Arsiso,et.al.2017), Perception is, in general, the process of attaining awareness or understanding of a phenomenon including climate change. In this regard, smallholder farmers ‘perception plays a big role for successful implementation of adaptation strategies to adapt climate change impacts as agricultural practices concerned.

Some scholars defined perceptions of farmers regarding the long-term changes in temperature and precipitation as farmers’ ability to understand climate change phenomena based on their own knowledge. Several studies pointed out some factors that influence farmers’ perceptions including farmers’ age, education, farming experience and sometimes access to climate information among others (Gbetibouo 2009) and (Ndambiri et al 2013)

As Ban and Hawkins (2000) define perception is the process by which we receive information or stimuli from our environment and transform it into psychological awareness. In general, the process of attaining awareness or understanding of a phenomenon including climate change.

Mitigation strategies:-Mitigation of climate change represents interventions to reduce anthropogenic forcing of climate system. It includes strategies to reduce greenhouse gases sources and emissions and enhancing greenhouse gases sinks. Carbon sink accumulates and stores carbon-containing chemical compounds. On the other hand, carbon sequestration is the process that removes carbon from the atmosphere. Community-level risk aversion and mitigation strategies include water harvesting, resource conservation and management, irrigating, partaking in voluntary resettlement programs, using household extension packages or agro ecological packages, and joining productive safety net programs.

Impacts. Consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts

Impact assessment. The study and quantification of potential consequences of climate change on natural and human systems at local, regional or global scales.

Small holder farmers: are farmers who own small plots of land on which they grow subsistence crops and one or two cash crops relying largely on family labor. Small holder farming is characterized by small land size, low technology and low capitalization. Farmers’

perception of climate change governance and adaptation is pivotal for future plans aiming to deal with challenges arising as result of climate change.

Climate phenomena (more specifically temperature and rainfall) variability is significantly challenging small scale farmers who directly depend on rain-fed agriculture in the developing countries (Moyo et al, 2012, Simelton et al, 2013).

2.1.3. Climate change ,impact on agriculture development

Climate change and **climate** variability has adverse impact that has been in general terms stated by different studies as potential consequences of climate change on natural and human systems at local, regional or global scales. Consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts.

Agriculture is the basis for the livelihood of billions of people in the developing world. However, changes in the normal pattern of climate affects agricultural production (crops and livestock) by reducing the length of growing periods and forcing marginal areas out of production. According to reports of the IPCC (2007), the projected yield reduction due to climate change in some poor countries could be as much as 50% by 2020. This is a burden that would aggravate the poverty situation in many of the food insecure and ecologically and geographically vulnerable countries

2.2. Global overview on Climate change

Climate change has been among the main **agendas** of global conferences across different part of the world. **Many** regional conferences have discussion sessions on climate change based on the recognition, that global climate change is increasing and this has become more evident in recent years (Aklilu and Alebachew, 2009)

According to the IPCC (2007) fourth assessment report, warming of the climate system is a real, as an evident, observations and meteorological data's shows that there is an increase in global average air and ocean temperatures, extensive melting of snow and ice and average sea level is rising in global level. The global average temperature has risen by 0.74°C and the global sea level has risen by 17cm during the 20th century because of melting of snow and ice from the mountains and Polar Regions.

On a global basis, climate variability and change may have an overall negligible effect on total crop production (Parry Rosenwieg, 2011); however, the regional impacts are likely to be substantial and variable, with some regions benefiting from an altered climate and other regions adversely affected. Generally, crop production is likely to decline in most critical regions (e.g. subtropical and tropical areas). The observed effects of past climate trends on crop production are evident in several regions of the world (Poter et al., 2014), with negative impacts more common than positive ones, including several periods of price spikes following climate extremes in key producing regions.

Agriculture is an economic activity that is highly dependent upon weather and climate in order to produce the food and fiber necessary to sustain human life. Not surprisingly, agriculture is deemed to be an economic activity that is expected to be vulnerable to climate variability and change. The vulnerability of agriculture to climate variability and change is an issue of major importance to the international scientific community, (UNFCCC, 2012).

Agriculture is inherently sensitive to climatic conditions. It is a sector vulnerable to current and anticipated global climate change. Consequently, livelihood of the people leading agriculture dependent life is highly vulnerable to climatic shocks which result in food insecurity. This is evidenced by the United Nations Food and Agriculture Organization report on World Agriculture toward 2015/2030. These people live in 98 countries mostly concentrated in South Asia and Sub-Saharan Africa. They also argued that the greenhouse gas induced climate change would further worsen the food security situation, especially in the tropics by reducing agricultural productivity. Climate change is expected to have adverse ecological, social and economic impacts. Climate change affects many institutions and productive sectors including agriculture, forestry, energy, and coastal zones, across the world. The economy of developing nations will be more affected by climate change, partly due to their greater exposure to climate shocks and also because of their limited adaptive capacity.

However, no country is immune (World Bank, 2009) and of the developing countries, many in Africa are seen as being the most vulnerable to climate variability and change (ACCRA, 2011). Poor agricultural productivity is one of many factors driving vulnerability of developing countries. Climate change will create large incremental risks (UNDP, 2007) and a small incremental risk of more droughts can lead to large human development setbacks.

Studies indicate that Africa's agriculture is negatively affected by climate change (Daniel Callo-Concha, 2018). Particularly sub-Saharan Africa is likely to face the most severe challenges on food security due to climate change and other pushing factors of global change (Easterling et al. 2007). Dry land farmers, especially the poorest ones, are expected to be severely affected. (Kurukulasuriya and Mendelssohn, 2006a) estimated that a 10% rise in temperature will lead to visible loss net incomes that could be gained per hectare; that is on average 8.2% for rain fed production. On the other hand, irrigated farmers are likely to have better gains in productivity (as higher temperatures support yield increment in most of Africa as long as sufficient water is available). This suggests that irrigation might be an effective adaptation strategy.

2.3 Review of Empirical study findings

2.3.1 Climate Change and impacts in Ethiopia

In Ethiopia, agriculture is important for food security in three ways. Firstly, it produces the food people eat and contributes about 50 percent of Gross Domestic Product (GDP). Secondly, it provides the primary source of livelihood for about 80 percent of the country's total workforce. Thirdly, it can provide income through generating about 60% of export earnings from the exports (MoFED, 2010). This implies that climate change can affect crop production and food security mostly through affecting agriculture. As Ethiopian agriculture is predominantly rain-fed and its economy is dependent on primary crop production and agricultural activities, any irregularities in weather and climate conditions have adverse welfare implications.

According to Funk et al. (2016), rainfall is expected to decline in the future and also become more irregular. Drought has been an increasing occurrence in Ethiopia over the last decades affecting a significant proportion of the population. Food shortage and famine associated with rainfall variability cause a situation of high dependency on international food aid. Consequently, Ethiopia has become one of the biggest food aid recipient countries in 16 Africa that accounts for 20-30% of all food aid to Sub-Saharan Africa (Bezu and Holden, 2008).

Ethiopia is experiencing the impacts of both climate variability and change. Climate change has led to recurrent droughts and famines, flooding, expansion of desertification, loss of biodiversity, decline in agricultural production and productivity, scarcity of water, and increased incidence of pests and diseases. Climate change is likely to aggravate environmental degradation, food insecurity, water scarcity, disease epidemics and poverty in Ethiopia.

According to Deressa and Hassan (2009) studies that have investigated impacts of climate change in the context of Ethiopia using a Ricardian approach, find that the climate variables have a significant impact on net crop revenue per hectare of farmers under Ethiopian conditions.

According to Muluneh et al(2016)Ethiopia's agriculture is mainly rainfed. However, the traditional/subsistence rain fed agriculture is highly vulnerable to the impacts of climate variability and change, particularly droughts, which occur due to increased temperature and reduced rainfall in a given year and cause human suffering. Climate change causes more erratic rainfall (both in amount and distribution), increased soil erosion (due to heavy rains), shifts in sowing and harvesting dates of crops (delayed onset and early ending of rainfall), changes in agricultural systems and increased incidence of pests and diseases. It affects crop production, including staple crops such as wheat and maize and cash crops such as coffee, leading to poor harvests and/or complete crop failures. It is likely to affect crop yields negatively and therefore food security

According to National Adaptation Program of Action (NAPA, 2007), rainfall variability greater than 30 is risky for farmers who depend on crop production which is prevalent in most parts of Ethiopia. Annual rainfall considerably decreases towards the eastern low lands which is source of low crop production. Rainfall is distributed differently in Ethiopia (NAPA, 2007)

Climate change increases the probability of extreme weather conditions such as drought and heavy precipitation (IPCC, 2013). Ethiopia is one of the sub-Saharan Africa countries, which have been suffering from frequent drought over the past decades (IPCC, 2013).

.Analysis of observed temperature data indicated that there has been an increase in seasonal mean temperature in many areas of Ethiopia over the last 50 years (Funk et al., 2008). Historical climate data (1951-2006) show that average temperature in Ethiopia has increased by 0.37°C in every ten years for the last fifty years (NMA, 2007)

Climate change increases the probability of extreme weather conditions such as drought and heavy precipitation (IPCC, 2013). Ethiopia is one of the sub-Saharan Africa countries, which have been suffering from frequent drought over the past decades (Araya and Stroosnijder, 2011; Araya et al., 2012). Analysis of observed temperature data indicated that there has been an increase in seasonal mean temperature in many areas of Ethiopia over the last 50 years (Funk et al., 2008). Historical climate data (1951-2006) show that average temperature in Ethiopia has increased by 0.37°C in every ten years for the last fifty years (NMA, 2007)

2.3.2 The impact of climate change on Ethiopia's Maize Production

According to Helen , Kindienigussie,tamado,Matthew ,2021,drought was perceived to be one major impact of climate variability and change on maize production by the majority of respondents in Gursum district, followed by those in Chiro and Haramaya districts as the climatic condition of the study districts are different. Farmers also lamented the limitation of water as a result of unpredictable weather caused by shortage or irregularity of rainfall and variability in temperature in the area. In line with the results of this study, studies have shown changes in precipitation combined with rising temperatures adversely influenced the availability of soil moisture and caused droughts.

2.3.3 Ethiopia's Climate changeadaptation /Responses and coping strategies

Climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities but mitigation refers to reducing climate change by reducing the GHG emissions (UNFCCC,2007).

As development strategy to climate change has two aspects. These are coping and mitigation

Coping strategies are actual responses to crises on livelihood systems in the face of unwelcome situation; therefore they are termed as short term responses. Generally, the local communities are already undertaking various coping and adaptation mechanisms in response to the adverse impacts of CC and variability. the main coping mechanisms are reducing the number of meals per a day, taking loan from relatives, remittance from relatives, sale of livestock ,sale of household a assets. Mitigationof climate change represents interventions to reduce anthropogenic forcing of climate system. It includes strategies to reduce greenhouse gases sources and emissions and enhancing greenhouse gases sinks (yohannes 2019)

The study conducted by Chinasho (2017), the adaptation and mitigation potential of developing countries to climate change are weakened as a result of poor building designs, agriculture, food in security, low income, deforestation, and conventional solid-waste management system. Adaptation to climate change impacts in general and to the agriculture sector in particular is an existing phenomenon. The agriculture sector has the capacity to adapt provided that technologies, resources, and management changes have been **undertaken relatively quickly**. The following are the common climate the change adaptation strategies been identified and implemented at different levels and areas.

Crop diversification: This strategy seeks to avoid risks of total crop failure rather than maximizing yields of one particular crop. In Ethiopia, crop diversification is widespread. Crop diversification is the most commonly used method to overcome climate changes in Ethiopia.

Greater use of different crop varieties in the same season could be associated with lower expenses and ease of access by farmers (Kristiansen, 2011). **Crop** diversification together with soil and water conservation and water harvesting practices were commonly used climate change adaptation strategies in eastern Ethiopia (Kristiansen, 2011).

Use of drought tolerant variety: It involves using varieties better fitting to the new climate such as the use of stress tolerant crops or varieties that have a shorter growing period and pest and disease resistance crops. It also includes cultivating crops which are suitable to the new climate and growing conditions. Elisha et al (2006) , mentioned planting of drought resistant varieties of crops as one of adaptation measures. World Bank (2010) also identified that planting disease and drought-resistant short period varieties is one measure of adaptation to climate change.

Mixing crop production with pastoralist Mixed species herds, widespread and seasonally available pastures, splitting animals into discrete herds, and mobility in response to seasonal variation in pasture productivity are key strategies in Ethiopia. Selling of livestock was a common coping strategy during drought periods amongst farmers in the Upper Awash Basin in Ethiopia (NAPA, 2007).

Soil and water conservation (SWC): In Ethiopia, they have often used different kinds of soil and water conservation strategies since around 1990, and soil and water conservation

strategies have probably developed much since that time. Soil and water conservation strategies are mainly used because of soil degradation and soil erosion, and because farmers due to this, want to rehabilitate their fields. These activities are increasingly important today because climate changes to some extents are accelerating these processes (Kristiansen, 2011).

Adjusting planting dates: It involves the adjustment of planting time better suit to the shifts in growing season by delaying or undertaking early planting/sowing (Bewuketu2017) also identified that changing planting dates is one among farmers' perceived adaptation strategies.

According to socio-economic development and combat climate change, Ethiopia developed a CRGE strategy in 2011. The CRGE strategy is based on four pillars:

- i) Improving crop and livestock production practices for higher food security and farmer income while reducing GHG emissions;
- ii) Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks;
- iii) Expanding electricity generation from renewable sources of energy for domestic and regional markets;

Adaptation and mitigation are two different policy responses to the issue of climate change. They are however inherently linked. Since mitigation measures alone will not be able to immediately avoid global warming, adaptive measurements are needed to avert the negative consequences of climate change at the short-term. On the long-term, mitigation measures will be able to avoid further warming or even reduce the effect (Parry et al., 2007).

Coping strategies are actual responses to crises on livelihood systems in the face of unwelcome situation; therefore they are termed as short term responses. Generally, the local communities are already undertaking various coping and adaptation mechanisms in response to the adverse impacts of CC and variability. The main coping mechanisms are reducing the number of meals per a day, taking loan from relatives, remittance from relatives, sale of livestock ,sale of household assets.

In Ethiopia both farm households and the government undertakes climate risk management through mitigation and coping practices to reduce the damages from climate change and variability. Risk mitigation strategies at the household level include diversifying crops, mixing crop and rearing of different livestock species, and accessing of rotating credit arrangements.

2.3.4 Small-holder farmers' adaptation strategies in climate change

According to Getachew, Melaku and Bereket (2017).studies revealed in KachaBiraWoreda, KembataTembaro Zone, and Southern region. The results of the study demonstrated that farm households applied a wide range of adaptation measures in response to the changes in climate. the most common adaptation measures were use of soil and water conservation practices (84.6%), different or new crop varieties (65.4%), planting drought tolerant crops (63.8%), use fertilizer application (59.2%), shifting planting date (57.7%), crop diversification (45.4%), involvement in off-farm activities (38.5%), livestock management (36.9%) .

In Ethiopia, Deressa et al. (2008) assess determinants of farmers' choice of adaptation strategies and perceptions of climate change in the Blue Nile Basin. They indicate that the common adaptation measure employed by farmers in the area are use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation.

According to a study conducted by Hadguet.al., (2014) in three districts situated at different agro-ecological zones of Tigray region, revealed that farmers use change in crop type and/or variety, soil and water conservation practices, crop diversification, change in planting date and irrigation practices as climate change adaptation options

2.3.5 Factors that determine Smallholder farmers Choice of climate change adaptation strategies in Ethiopia.

Different empirical findings innate that different demographic factors (such as gender, age of farmers, years of farming experience, household size and years of education) as well as institutional factors (such as access to credit and extension services and non farm income generating activities) were identified as significant determinants of climate change adaptation strategies (Kurukulasuriya and Mendelson, 2006, Madison, 2006, Deressa et al., 2008, Mertz

et al., 2009, Fosu-Mensah et al., 2010, Acquah-de Graft and Onumah, 2011, Mandleni and Anim, 2011, Badege et al., 2013, Abid et al., 2015, Weldlul 2016, Abrham et al., 2017, Bewuketu, 2017, Asrat and Simane, 2018a).

2.3.6. Factors affecting smallholders' choice of climate change and variability mitigation strategies

A research has been conducted by Abid et al. (2015) on farmers' perceptions of and adaptation strategies to climate change and their determinants in Punjab province of Pakistan. Changing crop varieties, changing planting dates, planting of shade trees and changing fertilizers were the main adaptation methods implemented by farm households in the study area. The results from the binary logistic model revealed that education, farm experience, household size, land area, tenancy status, ownership of a tube well, access to market information, information on weather forecasting and agricultural extension services influenced farmers' choices of adaptation measures. The results also indicated that adaptation to climate change is constrained by several factors such as lack of information, lack of money, resource constraints and shortage of irrigation water in the study area. A study by Adeoti et al. (2016) examined farmers' vulnerability, perception and adaptation to climate change in Kwara State using descriptive statistics and MNL model. The econometric investigation revealed that education of household head, farming experience, land ownership, rainfall and temperature were the most relevant and significant factors that determined the farmers' choice of adaptation strategies to climate change in the study area. The major barriers to adaptation include lack of information on adaptation methods, land tenure problem and inaccessibility to credit. As reported by researchers,

Buni, Tewodros and Deribe (2019), in Lokka Abaya district in Sidama farmers' adaptation strategies to climate change impact on crop production, accordingly, smallholder farmers used different adaptation strategies to reduce the impact of climate variability and change on crop production system. 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 household survey of the study result indicated that 37.4% of respondents' responded that mixed farming is one of the adaptation strategies

implemented to overcome impacts of climate variability and change on crop production. Results of focus group discussion and experts pointed out that, mixed farming is one of the effective adaptation mechanisms they use to overcome the impacts of climate variability and change on crop production.

According to Asrat and Simane (2018).studies revealed that the use of improved crop varieties, agro forestry practices, soil conservation practices, irrigation practices, and adjusting planting dates are the most important adaptation strategies by smallholder farmers. However, adaptation decision is location-specific and influenced by key drivers such as socioeconomic, environmental, and institutional factors.According to Getachew, Melaku and Bereket(2017).studies revealed Using multinomial logit model, their study finds that the level of education, gender, age, and wealth of the head of household, access to extension and credit, information on climate, social capital, agro-ecological **settings**, and temperature all influence farmers’ choice of adaptations. Their analysis also reveals that age of the household head, wealth, information on climate change, social capital, and agro-ecological **settings have**

significant effects on farmers’ perceptions of Climate change Moreover, the study also reports. lack of information on adaptation methods and **financial constraints** as **key constraints** to climate change adaptation.Astudy conducted by Belay et.al., (2017)in central rift valley of Ethiopia revealed that household demography, as well as positively by farm size, income, access to markets, access to climate information and extension, and livestock production are found the factors that shape smallholder farmers’ adaptation strategies...

2.4 Conceptual framework work of study

This study was aimed at assessing smallholder farmers' strategies towards coping with the effect of climate change on maize crop production. Communities and households face climate related stresses such as increased temperature, changes in the timing and amount of rainfall, hail storms, floods, droughts, wind instability (IPCC, 2007). The study used the following framework to conceptualize & understand factors which affects small holders maize producers adaptation strategy towards the impact of climate change and variability.

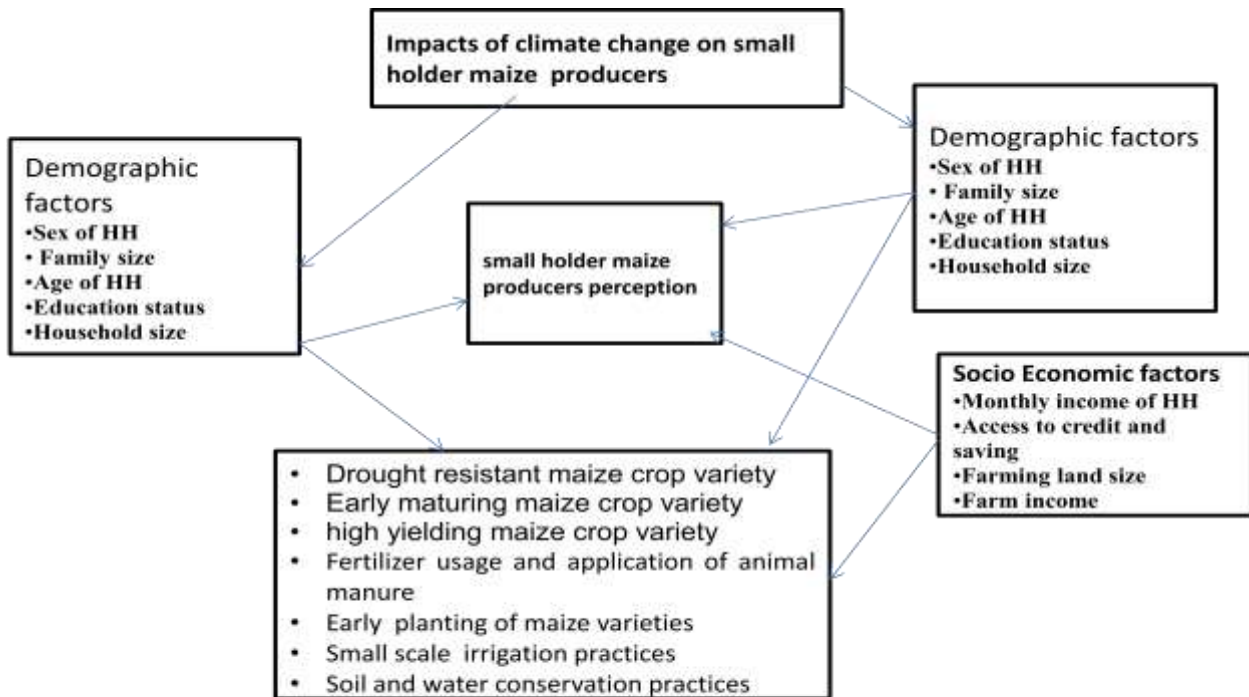


Figure 1 conceptual frame work of study

Source: Own construction based on literature reviews

CHAPTER THREE

3. METHODOLOGY

This chapter briefly describes the context based facts about the study area, and gives methodological overview on how the study population were defined, samples drawn, data collected and analyzed to answer the objectives of the study.

3.1 Description of the study area

The study area, KedidaGamelaworeda is located in Kembata Tembaro Zone at South Nations, Nationalities and People's Regional state. KedidaGamelaworeda is 277 km far from Addis Ababa which is a capital city of Ethiopia at south, 115.6 km far from Hawassa city at North West direction and located in Durame town which is a zonal city of Kembata Tembaro Zone

The Woreda is located between the latitude of 7° 11'N to 7° 19'N and 37°50' 30"E to 38° 4' 30"E longitude. The altitude of the Woreda ranges from 2550 to 2880 meters above sea level and maximum temperature of 25.95°C, minimum 15.3°C and average temp. Of 20.65°C (National Meteorological Agency Hawassa Branch, (NMA, 2021)

The topography of the woreda includes highlands and plains. About 28 % of the area is plain 35% high lands rough surface. Its area is divided into dega 4.5% and woyina dega 94.5% (Kedida Gamela Woreda Agricultural office (KGWAO, 2019).

KedidaGamelaWoreda has ten rural administrative kebeles and, one urban administrative kebeles and total of eleven kebeles. Kedida Gamela Woreda Agricultural and Natural Resource (KGDAO, 2019).

The total population of KedidaGamelaworeda is estimated to be 69645 (male 34717, and female 34928) Kedida Gamela Woreda. According to Kedida Gamela Woreda Agriculture office, extension users' male headed 8,210 and female headed extension users are 2044 and the total of 10254 with average family size of 5 persons per house. (Kedida Gamela Woreda Agricultural Office (KGWAO, 2019).

According to central statistical agency, average land holding is about 0.25-0.5 hectare per household (KedidaGamela Woreda Agriculture Office (KGDAO, 2020) maize is the most known annual crop in the area. Erratic rainfall, small landholding size, soil infertility, rapid

Population growth is the major causes of food insecurity problem in the Woreda (KGWAO, 2019). Agriculture is the main economic activity and livelihood source of the people of the study area. It is characterized by both crop production and livestock rearing. Crop production is one of the most important components of agricultural activities on which almost all rural farmers and other communities was depend on for their living and food security. The main crops grown widely in the area are maize, teff, wheat, haricot bean, inset and other vegetables in homestead but the most one crop is maize. The annual crops are mainly used for domestic use and source of income. The major constraints of crop production and food insecurity are impact of climate change and variability like erratic rain fall/unpredictable rainfall, increasing temperature, crop diseases and pests, land degradation, soil erosion, shortage of cultivated land, low level of modern agricultural technologies(Kedida Gamelaworeda Agricultural Office (KGWAO, 2020).The rainfall pattern of the area is bi-modal type in which the short rainy season was from May to June,while the main rainy season was from July to beginning of September. High temperature during dry seasons as well as erratic rainfall and moisture stress is the main climatic problem in the study area (Kedida Gamela Woreda Agricultural Office (KGWAO, 2019).

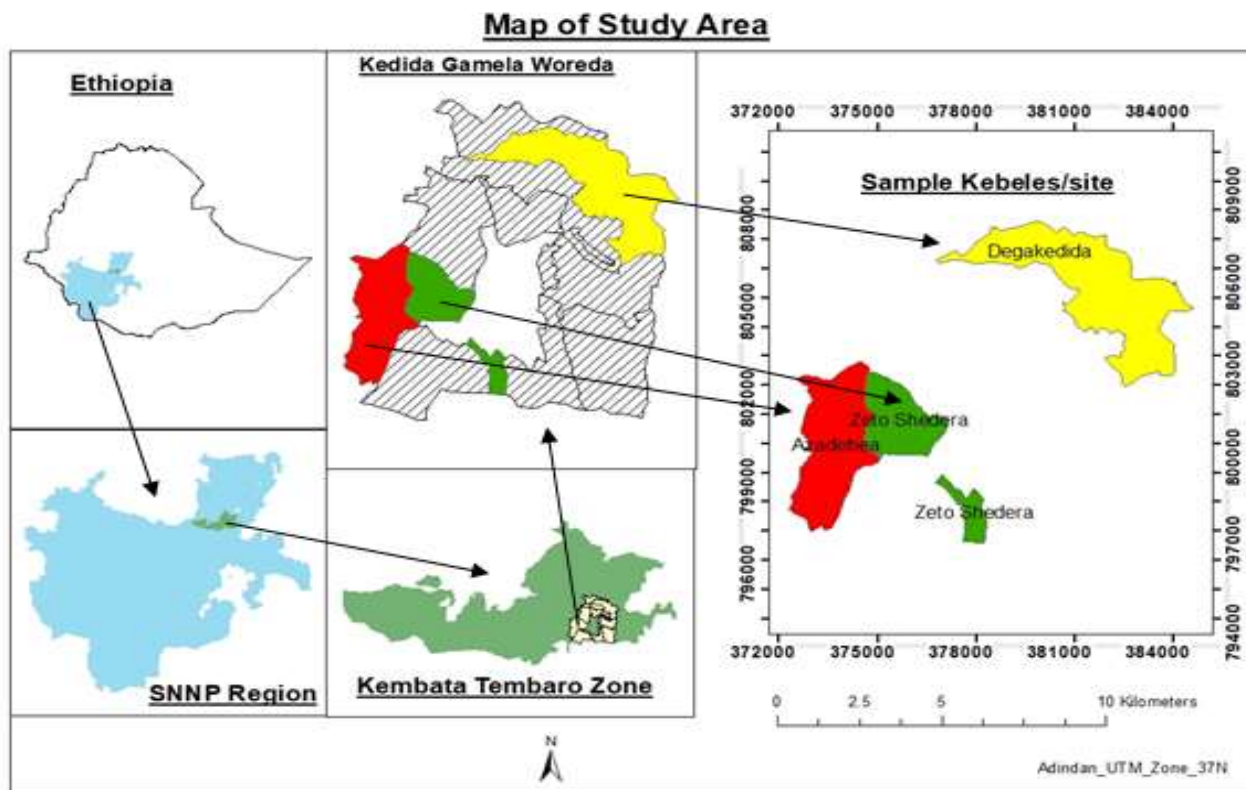


Figure 2. Map of the study area

Source:-kedida Gamela Woreda Agriculture office land resource department,2021

According to **climatic zone and seasons** in Kedida Gamela Woreda, including the study area, people classified agro climatic zone into two categories. These were locally called **Hansawi-qaala'a** (woyina-dega in Amharic) and **Hansawa** (dega in Amharic). From these, specific selected study sites belonged to **hansawi-qaala'a** with altitude ranges from 1700-2450 meter above sea level and **Hansawa** with altitude of 2450- 2850 meter above sea level and average rainfall distribution ranges from 632.1mm-1345.7mm(National Meteorological data 2021).

In addition, local people have reported that four different seasons. These are locally called as **Maxoaa** (kiremt in Amharic) indicated the season with heavy rainfall distribution and the duration to crop sowing mainly maize, haricot bean root, cereals like (wheat, barley, teff), pulses (faba bean, pea, chick-peas) and some root and tuber crops. The seasons occupied from June to August. **Oojja** (meher in Amharic ranges from September-November) refers to the season with moist and warm climatic condition in which moisture and temperature gets a mean value. This seasonal condition used to harvest and collect crops that planted through the

previous season including maize, **Haguaa**(bega in Amharic ranges from December-February) indicates that the season with cracking sun and the minimum or the least rainfall distribution and **Gilalo**(belg or tseday in Amharic) ranges from March to May which was the main season used to sow crops like maize, haricot beans rather than teff, wheat and other pulse crops like faba bean, field pea

3.2 Research Design

The study design employed for this study is cross-sectional, as it helps to provide explanation of perceptions, adaptation strategies and choice of adaptation strategies of smallholder farmers to climate change. Thus, data were collected from randomly selected rural households.

In this study, both qualitative and quantitative design approaches were used for identify the status of maize production, and rainfall and temperature data. In qualitative method, different knowledge claims, enquiry strategies, and data collection methods and analysis were employed (Creswell, 2009)

Qualitative method was applied to be familiar with the past and present conditions of the area, understanding households' perceptions on climate change and variability. In this case, interview and focus group discussion were employed.

3.3 Study population, sampling procedure and Sample size.

The study area **Kedida Gamela** were selected purposely, based on their vulnerability to climate change on crop production and food security. As a result of high temperature and erratic/irregular rainfall distribution; there is a reduction in the production and productivity of main crops like maize, teff and wheat crops, and increasing food insecurity and shortage (Kedida Gamela Woreda Agriculture office Report, 2019)

The study employed multi stage sampling techniques. In the first stage 11 kebeles of **Kedida Gamela woreda** stratified in to two climatic zones (**Woinadega** and **Dega**). Accordingly 3 kebeles found in the **Dega** agro-ecological zone and the remaining 8 are under the **Woinadega** agro-ecological zone.

In the second stage three sample kebeles two from (woineDega(Midhighlands) AzeDobo and ZatoShodera .One kebele DegaKedida Kebele fromDega/High lands) using stratified sampling.

In the third, list845 of HH heads were collected form kedida gamela woreda agriculture office tobeused as a sampling frame. Then the study employed Yemane (1967) formula to determine the study sample size of 164 respondent HH heads as follows

$$\frac{N}{1+N(e)^2} = n = \frac{845}{1+845(0.07)^2} = 164$$

.Where N =population size =845,

e is level of precision = 0.07 and n is sample size =

The study sample HH then distributed to each sample kebles(Table 2) in proportion to respective population size using Kothari (2004),

Finally, 164 sample household heads were selected randomly.

Table 1: Distribution Sample householdsby proportion of kebele(n=164)

no	Name of kebele	Agro-ecology of the study kebeles	*Total HHs of each kebele	**sample size of each kebeles
1	AzeDobo	WoyneDega	274	54
2	Zato- Shodera	WoyneDega	226	46
3	Degakedida	Dega	345	64
	Total		845	164

Source:*KedidaGamelaWoreda Agriculture Office, 2021

3.4. Methods of Data Collection

3.4.1 Data Type and Sources

In order to generate qualitative and quantities data for the research work, both primary and secondary sources of data were used.

Primary data:were collected from sample smaller households' surveys and key informant interview. Different groups of participants

with different socioeconomic groups such as female and male headed households were selected.

Secondary data: to get concrete information and to support the data obtained from primary sources, secondary data were collected from literatures/ written sources, were collected from different government offices and websites. Data on maize crop production were collected from District's (KedidaGamelaworeda) Agriculture and natural resource development office and selected three kebeles center by help of development agents. Precipitation and temperature values (data) was collected from (National Meteorological Agency from Hawassa Branch 2021), local communities survey to supplement analysis of households' perception on climate change and variability impacts on maize crop production, climate change adaptation strategies, and choice of coping strategies.

3.4.2 Data collection tools

The following primary data collection tools were employed to gather relevant information, such as focus group discussion, questioner, and interview.

House Hold survey (HHS): For this study, it was the major source of primary data collection techniques **from sampled respondents**. Structured questions (closed- ended or open- ended) were prepared to collect data on major research objective areas such as, small holder producers' perception on variability and their vulnerability status on the impact of climate change on their maize production, factors determining the climate variability and its induced impacts on small holder maize production, smallholder maize producers' adaptation strategies in response to effects of climate change and variability were included in the questionnaire

Focus Group Discussions (FGD)

The study employed Focus Group Discussion (FDG) as a method of data collection, as one data gathering that, is a highly efficient technique for data collection tool. The method is important that includes people who cannot read and write or other who have other specific difficulties is discriminated against (Robson, 2002). Focus group discussion (FGD) helps to generate data on group dynamics, and allows a small group of respondents to guide by a skilled moderator, to focus on key issue of the research topic. Focus group discussions were

conducted in all three kebeles with 18 selected model farmers. The researcher selected 6 respondents in each kebele based on socially respected within society and are known to have better knowledge on environmental, social and economic status of the study area. From Zato Shoderakebele 6 farmers, 5 men and 1 woman, Azedobo 6 farmers 5 men and 1 woman, Degakedidakebele 6 farmers 4 men and 2 women, total of 14 men and 4 women were selected from three kebeles. Focus group discussion or sometimes known as focus group interview, as one data gathering that, is a highly efficient technique for data collection since the amount and range of data increased by collecting from several people at the same time.

Key Informant Interview (KIIs)

The study applied Key Informant Interview (KIIs) as one of data collection methods which were carried out with experience rich experts from the woreda agricultural office (KGWAO) and Kebeles Development Agents (DAs). Accordingly, two experts from office and six (two from each kebele) DAs, and 3 model farmers (one from each kebele) total of 11 participants were interviewed.

3.5. Method of data analysis

The data collected from both primary and secondary sources were analyzed by using the SPSS20 software techniques. Qualitative data were analyzed through interpretation, conceptual generalization, suggestion and opinions narrative analysis of perceptions and feelings of FGD participants. The findings of the study were presented in tables, figures and charts.

For quantitative data, both descriptive statistics and econometric model were employed to analyze the relationship between the dependent and independent variables. While smallholder producers' characteristics were using descriptive statistics; econometric models were to study the relationship between variables

To assess small holder maize producers perception on climate variability and change and its effect on maize production in the study area a five point Likert scale measurements were applied. Farmers' perception were measured by summing up the reaction of positive and

negative response to a list of questions that seek knowledge, experience, and exposure of smallholder farmers about climate element variability, causes, consequences and adaptation measures. To ascertain perceived impact of climate change on maize crop production at farm-level, respondents were asked to rate the severity of climate change impacts on maize crop production in terms of climate change perception levels and using of a five point Likert scale measurement. The likert scale was as follows; 1.strongly disagree, 2. Disagree, 3. Somewhat agree 4. Agree, and 5. Strongly agree.

The study employed a multinomial logit (MNL) model to identify factors determining the smallholder maize producers' choice of adaptation strategies to the impact of climate variability and change on maize production and to determine factors affecting small-holder farmers choice of climate change adaptation strategies. The a multinomial logit (MNL) model specified as follows

The Multinomial logit model for the adaptation choice can be specified as in the following relationship between the probability of choosing option and a set of explanatory variables X Greene (2003

$$\text{Prob}(Y_i = j) = \frac{e^{B_j x_i}}{\sum_{k=0}^K e^{B_k x_i}}$$

Where Z is a dependent variable and X₁...X_n are explanatory variables, where b is the y intercept, b₀, b₁, b₂...b_n are partial regression coefficients associated with the independent variables. The logistic regression function is thus, given by: $p = \frac{e^z}{1+e^z}$ where p is the probability that an event occurs.

3.6 Definitions of Variables

3.6.1 Dependent Variables and hypothesization

Dependent variables: - The dependent variables for this study were: Small holder producers' choice of adaptation strategies in response to climate change and Perception of small holder producers' towards climate change and variability

Independent Variables

The study independent variables are defined and hypothesized as follow

Sex of Household:-Sex of household head determines access to information and perception of climate related problem, and willingness and ability of households to decide on use of adaptation measures (De Jonge, 2010).Which is a dummy variable that takes a value of 1 if the household head is male and 0 otherwise

Age of the household head AGE:-Age of household head, which represents experience, affected adaptation to climate change positively and significantly. Because as the age of the household head increases, the person is expected to acquire more experience in weather forecasting and that helps increase in likelihood of practicing different adaptation strategies to climate change. This is a continuous variable measured as the number of years of the farmer household.

Family size FSHH:-This is a discrete variable and the total family member of people in the household. It is assumed to represent the labour input to the farm. It was presumed that farm households with a large family size were better able to adapt to changes in climate

Farm experience FE:-According to Maddison (2006) reported that experienced farmers have a higher probability of perceiving climate change as they have been exposed to climatic conditions over a longer period of time. This is Continuous, number of years of farming experience of the household head.

Access to climate information ACI:-access to information from different sources has significant impact on the adaptation combination of improved maize crop variety and crop diversification. Indeed, it is an important precondition for farmers to take up adaptation measures (Madison 2006). 1 if household head get information about weather or climate from extension officer or any media and 0 otherwise

Extension service (ES):-Extension Service refers to a household's access to agricultural services. Extension services are a crucial source of information on agronomic practices as well as on climate. This is dummy, equals 1 if the household head get access and 0 if otherwise.

Access to training ATR: - It is a continuous variable measured by month/year

Which represents if the farmer has access to training related to the shock of climate change, weekly, monthly, twice a month, quarterly, yearly. Participation in climate variability and change related training programs enhances awareness of farmers about the impact of climate change.

House hold education status EDHH:-Education refers to the numbers of years of schooling of the head of the household. Education increases the ability of farmers to obtain and apply relevant information concerning the changing climate, which thereby increases farm level adaptation options. Thus, it is hypothesized to positively affect awareness of changes in climate.

Farm income FI:-refers to farm and non-farm income of the head of the household. Semenzaetal.(2008) indicated that higher income positively affects perception of climate change. On this basis we hypothesized that higher farm and non-farm incomes positively influence a farmers' perception of climate change. Income is continuous variable which is measured on (ETB). It is a return from investment of capital, labor, land and time to the farmer. This is a continuous variable and measures the amount of income the farmers make per year from investment in their farm.

Farmland SizeFLSrefers to a households' land holding size. Farmland holding size was expected to play a significant role in influencing farm households' choices in subsistence agriculture. It is hypothesized that farmers with large farm size would be more likely to adapt. Which is positively affects perception of climate change

Credit availability CA: -Access to Credit is an important determinant enhancing the adoption of various technologies (KandlinkarandRisbey 2000). Having access to financial sources enables farmers to make use of available information and improve their management practices in response to changes in the climate.

Agro-ecology:- refers to the agro-ecological setting of farmers. Farmers living in different agro ecological zones make use of different adaptation methods for climate change impact.

Rainfall: irregular & unseasonal rainfall will affect the cultivation of crops. Which cause a loss in crop & livestock production & productivity and has negative relationship with crop production.

Temperature: increasing temperature is creating many consequences; decreasing the period of maturation of crops, decreasing the time period of breeding of seed & widespread of

insects& disease. Therefore, the increasing temperature was affected maize crop production & has negative relationship with maize, teff&wheat, which is continuous variable (KGDAO, 2020)

Table 2. Summary of study variables

Variable label	Description and measurement	Variable type	Expected Sign
Independent variables			
Sex HH	1,if the household head is male; 0otherwise	Dummy	±
house hold education status EDHH	1, if the household head is literate 0= otherwise	Dummy	±
Family size FSHH	Number of people in the household	Continuous	±
Age of the household head AGE	Years	Continuous	+
Marital status	1 if married 0 if no	Dummy	+
Farming land size FLS	Hectar	Continuous	±
Farm income FI	Continuous (ETB)	Continuous	+
Extension service (ES)	Dummy, 1 = yes, 0 = no	Dummy	+
Access to climate information on ACI	1 if households get information 0= other wise	Dummy	+
Credit Access	Dummy, 1 = yes, 0 = no	Dummy	+
Temperature T	0c	Continuous	-
Rain fall R	mm	Continuous	-
Access to training ATR	Dummy, 1 = yes, 0 = no	Dummy	+
Dependant variables			
-Households perception on cc and variability	Binary outcomes: 1 if perceived and 0 otherwise		
-Choice of adaptation strategies			

CHAPTER FOUR

4. RESULTS AND DISCUSSION

This chapter presents the results and discussions of the main findings mainly characterization of respondent households, levels of smallholder farmers producers' perception on effect of climate change on their maize crop production, smallholder maize producers adaptation strategies in response to climate change and variability and identifying factors determining the choice of adaptation strategies on climate variability impacts on small holder maize production.

4.1. Characterization of respondent house holds'

4.1.1 Respondents' Demographic Characteristics

This study was based on quantitative and qualitative data collected from a total of 164 sampled households interviewed during the survey. As the sex composition of the survey indicates, from Zato Shodera 32(69.6%) were male and 14(30.43%) were female headed households. The remaining two kebeles, Aze Dobo'o and Dega Kedida took 41(75.9%) and 43(67.19%) of male and 13(24.07%) and 21(32.8%) of female household heads respectively. And Aze Dobo shared relatively the largest share of male headed households' and the smallest share of female headed households'. The result of the survey revealed that, age composition under 15 years, 16-50 years and >51 covered that 12(7.059%), 141(86%), 11(7.04%) respectively. This shows that, most of the Households were between the ages of 16-50 years. This entails most of surveyed HHs are economically active and it can be assumed that they are well aware of their area and prevailing environmental problems very well.

Like, other variables marital status determines household's access to information and use of adaptation measures in this study. As survey result indicated in (**Table 4**) from the total sampled households about 126(76.83%) of the respondents were married, 21(12.80%) were widowed, 9(5.49%) were divorced and the remaining 8(4.88%) were single. This result is in-line with the findings of Smit (2002), that agriculture is very much practiced by married people to make ends meet and cater for their children. This shows that majority of the household heads in the three kebeles were married. The result of this study revealed that in study area there were farmers in the sample have a minimum family size in number 1-3

were 16(9.75%), a maximum of 72(43.90%) were family size 7-9, the remaining 39(23.78%) and 37(22.56%) were 4-6 and 10-12 family size respectively. Farming experience may enable farmers to perceive and analyze problems appearing on the farm in general and climate change and variability in particular. Experienced farmers are capable of detecting climate variability related problem more than inexperienced farmers (Shiferaw, 2008). According to the result of this study, in study area illustrated that farmer in the sample have a minimum of 5 and a maximum of 42 years of experience. The average years of experience for the total sample household heads were found to be mean of 30 years with standard deviation of 0.932. There is general agreement that education is associated with a **greater** perception and understanding of certain problems that society faces in given environmental situations (De Jonge, 2010). Education increases farmers' ability to obtain process and use information and hence, this in turn motivate farmers to easily understand and use adaptation measures to climate change and variability. A number of studies (Temesgen et al, 2008) for example, reported that education increases the probability of adapting to climate change. This is because education is an indispensable tool to easily understand climate information to adjust and develop adaptive capacity to the changing climate. In relation to the educational status of sampled households, the survey result implied that from the total sampled household heads 29(18%), 82(50%), 40(24%), and 13(8%) were illiterate (unable read and write), able read and write, High school and above, college levels respectively. The average years of schooling, mean of 8 years for the total sampled household heads with standard deviation of 1.042. Thus, households with better education were more aware of existing climate variability related problems and more likely to practice adaptation measures than non-educated. Family Size: refers that the total number of family members who live with and work for the family. It can determine the number of the labor force in the households is expected to bring variation in decision behavior of households on climate variability related adaptation measures. That means house hold with larger work force may invest more in adaptation measures, which is consider more effective and efficient by households (Robson, 2002). Thus, use of adaptation measures by the household was Influenced by the number of household members who participate actively in adaptation measures for impact of climate variability. In short, households with large number of agricultural workers are more like to decide on use of adaptation measures. The survey results **confirmed** that the average family

size was 7 with the standard deviation of 2.2 for sampled households during the survey year. The maximum and minimum family size was 13 and 3 person, respectively. Out of the total sampled respondents 43.9 % of them have a householdSize of above 7-9 persons, 22.56% from respondents 10-12 persons, 23.78% from 4-6 persons (39), 9.76% from 1-3 numbers (16) (Table 4) below

Table 3 .Respondentsdemographic characteristics (n=164)

Variables		Respondents			
		Total			
Sex		n	%	mean	Sd
	Male	116	70.73		
	Female	48	29.27		
	Total	164	100		.46
	<15 yrs	12	7.06		
	16-50 yrs	141	86		
	>51 years	11	7.04		
Age	Total	164	100	33.3	0.37
	Single	8	4.88		
	Married	126	76.83		
	Divorced	9	5.49		
Marital status	Widowed	21	12.80		
	Total	164	100		
	1-3 no s	16	9.7561		
	4-6 no s	39	23.78		
	7-9nos	72	43.90		
	10-12 no s	37	22.561		
	>13 no s	0	0		
Family size in numbers	Total	164	100	7	2.2
	<20 yrs	23	14.02		
	21-30 yrs	36	21.95		
	31-40 yrs	75	45.73		
	>40 yrs	30	18.29		
Maize production farming experience	Total	164	100	30	0.932
	Illiterate	29	18		
	Able read and write	82	50		
	9-12	40	24	8	
Educational status	University	13			1.04
	Total	164	100		

Source: Survey result (2021) note yrs=years

4.1.2 Respondents economic characteristics

Total land size and land use:

According to the survey data , from (table 5) (67%) of respondents were dependent on crop production, from which maize production covers 57.7%teff covers 18.46 % from crop production, wheat covers 10.2%, haricot bean covers 13.611 %. But only 28.46% covered by perennial crops and 71.54% by crop production and farmers farm land sizes ranged from 0.125 to 1 hectare with the mean value of 0.1823 hectare.

Out of the 164 surveyed farms, 53(32.3%) had greater than 0.5 hectare and the highest percentages 98(59.8%) farmers had farm land 0.25-0.5 hectare land and the least percentages 13(7.9%) had less than 0.25 hectare (Table 5).This means that the highest percentages of farmers or households had relatively from 0.25hectare to 0.5 hectar.

The average size of farm plot for the total sample households were 0.34 hectares. According to (Table 5), the result indicates that there is a shortage of farm land in relation to the study

Population because of 98(59.8%) from total households had farm land size of 0.25-0.5 hectares.

. Table 4 Respondents total land size((plot size) and land use by crop types (n=164)

Crop type	Total land size in (ha)			Total land size in h/r
	AzeDoboKebeles	ZatoShodera	DegaKedida	
Annual crop production total	13.2	10	13.5345	36.7345
Teff	3.25	2.35	1.1845	6.7845
wheat	0.75	1	2	3.75
Maize	7.2	5.15	8.85	21.25
Haricot bean	2	1.5	1.5	5
Perennial crops production	4.575	2.5	7.5405	14.6155
Total land size in each kebelerespo.	17.775	12.5	21.075	51.35

Respondents average land holding (plot size) size (n=164)

Land holding size in ha	Total	%	Size of mean value In hectare
0.125-0.25 ha	4	3	6
0.25-0.5ha	30	23	45
0.5-0.75a	20	20	13
0.75-1ha	0	0	0
Total	54	46	64
			13
			98
			53
			0
			164
			100
			7.9
			59.8
			32.3
			0
			0.182
			0.342
			0.843
			0

Source: field survey 2021

Respondent's Total Livestock Holding by Types of Animals

In the respondents, (Table 6), 336 live stocks were recorded. Out of these, cattle have the highest number 227 (66.7%) and the least were donkeys with number of 18(5.4%). According to respondents' perception, in the study area because of impact of variability of climate elements in general and lack of animal feed resources in particular, from recent years the total number of livestock has decreased (Kedida Gamela Woreda Agriculture Office 2021)

The information collected from focus group discussion, key informant interviews and household respondents indicated that, due to impact of climate change and variability, high

temperature, frequent and erratic rainfall seasons, the districts respondents' livestock population of study area decreased as compared to the past years. According to office of agriculture and rural development experts, due to lack of feed resources and poor knowledge on improved feeding systems the districts livestock number is decreasing from time to time.

Table 5: Respondents Livestock holding by types of animals(n=164)

Type of animals	Respondents livestock quantity in numbers				
	Azedobo	ZatoShode	Degakedida	Total	%
Cattle	76	59	92	227	66.7%
Goats	4	6	13	23	6.7%
Sheep	11	9	9	29	9.7%
Chicken	13	11	15	39	11.5%
Donkeys	5	4	9	18	5.4%
Total	109	89	138	336	100%

Source: field survey result (2021)

Respondents estimate of average income during past production year by type of income sources (in ETB) :The study result (Table 7) revealed that Most of annual crops like Maize, Teff, Wheat, Haricot bean and others are mostly for households' consumption but some perennial crops like coffee, chat and other fruit crops are for market/cash(KedidaGamela District Agriculture Office 2021)

Table 6: Respondents average annual income by sources of types(n=164)

Source of Income	Amount (ETB) in year			
	Aze do	ZatoShodera	Degakedida	
Farm income	Sales of crop/perennial crops like coffee, chat	9500	6890	11000
	Sale of livestock	205000	147507	244321
Off farm income		20155	19105	27654
Total annual income		234655	173502	282975

Source: field survey result (2021)

Respondents DA advisory service by number/ frequency of contact

According to the (Table 8) showed the advisory service, most of the sampled households in week get service 1 times in a week. From AzeDobo respondents 50%, in number 27 respondents from total of 54 sampled hhs, from ZatoShodera 47.8%, in number 22 respondents from total of 46 sampled hhs, from DegaKedida respondents 48%, in number 31 respondents from total of 64 sampled hhs, this indicates that most of farmers get advisory service 1 times in a week. From total respondents in a week get advisory service 1 times in week that means 48.8% respondents and in number 80 respondents out of 164.

In monthly advisory service, the respondent households in a month got service 4 times in a month shows that from AzeDobo respondents 48 %, in number 26 respondents from total of 54 sampled hhs, from ZatoShodera 41%, in number 19 respondents from total of 46 sampled hhs, from DegaKedida respondents 51.6%, in number 33 respondents from total of 64 sampled hhs, this indicates that most of farmers got advisory service 4 times in a month, totally in a month 47.6% and in number 78 out of 164.

2.3.3 An overview Climate change/ variability trend and status in kedidaGamela Woreda

The climate change and variability is described by incidents of climate extremes, such as, rising temperature and irregular patterns of precipitation. According to KedidaGamela Woreda Agriculture Office (KGDAO, 2020) data indicate that temperature and precipitation have been changing over time, such that temperature is increasing, rainfall amount and distribution is highly varied. According to National Meteorological Agency (NMA, 2021) data minimum and average temperature has been increasing and the average annual rainfall

of the woreda has recently shown a very high level of variability due to that the season is shifting from time to time. From the same source, the average annual rain fall of kedida Gamela woreda, ranges from 632.1mm -1345.7mm. The mean annual rain fall of those years is about 1058.704mm. The driest year in study area was 2015, which contains average rain fall i.e. (632.1mm), 2008, 2009, 2012 and the wettest year was 1998, 2001, 2005, 2013, 2014 which contains average rain fall of 1345.7mm, 1294.8mm, 1200.4 mm, 1301.1 mm, 1239.1 mm and 1211.3 mm respectively. Annual rain fall is below average in the years 2003, 2006, 2008, 2009, 2010, 2012, 2015, 2016, 2018, 2019 and 2021(National

Meteorological Agency,2021) .The rain fall of the woreda shown inter annual variability and erraticenes over the past years. This variability had also been indicated as a major problem to crop production by HHs in general and maize crop production in particular. More importantly, it is highly erratic in nature in its distribution from year to year and makes production of crop difficult. According to trends data in national meteorological agency, the annual rainfall pattern over the past years has been decreasing. A statistical analysis revealed that the decrease in annual rainfall was significant and an area characterized with large inter annual fluctuation of rainfall. The impact of rainfall on crop production can be related to its total seasonal amount or its intra seasonal distribution in our study area. The annual average rainfall of study area was decreased by 2.269mm yearly, .according to meteorological data

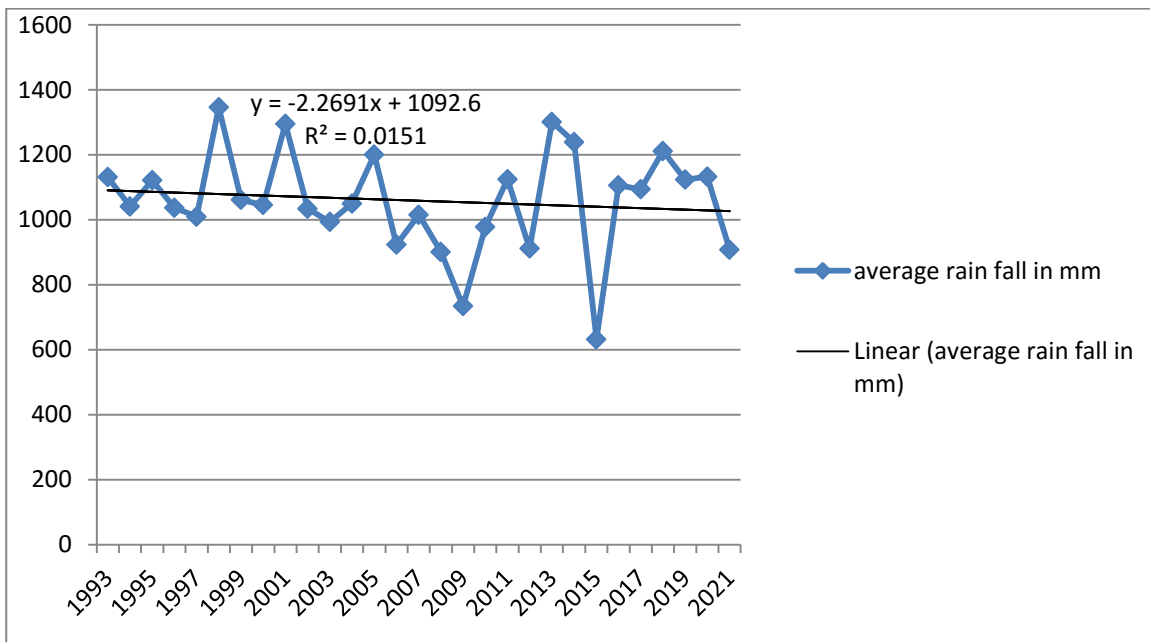


Figure 3. Trends of annual average Rainfall Pattern in Kedida Gamela Woreda

Source: National Meteorological Agency, Hawassa Branch

The trend analysis of annual temperature (minimum and maximum) shows statistically significant increase of the woreda. Based on the linear fitted line of average annual temperature on times in years, there is a general increase in the average annual temperature distribution in the study area. The meteorological data below showed that, 20 years average maximum temperature of the kedida Gamela Woreda was 25.95°C, while the average

minimum temperature was 15.3 °C. Average temperature of 20.63°C, average maximum temperature of the study area over the past 20 years increased by about coefficient of 0.128 °C annually, while average mean temperature was increased by 0.105°C and minimum average temperature was increased by 0.081 °c. Therefore, trend of temperature indicated that the maximum temperature, minimum temperature and average temperature of the district is increasing and will continue in its increasing trend in the future according to meteorological data. This is similar with the perceptions of most farmers towards temperature. According to meteorological data, the minimum and maximum temperature has varied over the past years in study area. The trend equation and trend line of the mean minimum temperature generally shows an increasing trend which means that the average minimum temperature over the years has been raising. Therefore, trend of temperature indicates that the maximum temperature, minimum temperature and average temperature of the study area was increased from past.

Hence, the trend equation and the trend line of the mean maximum temperature generally shows an increased trend, which means that the average maximum temperature over the years has been increased. Based on the linear fitted line of average annual temperature on times in years, there is a general increase in the average annual temperature distribution in the study area .

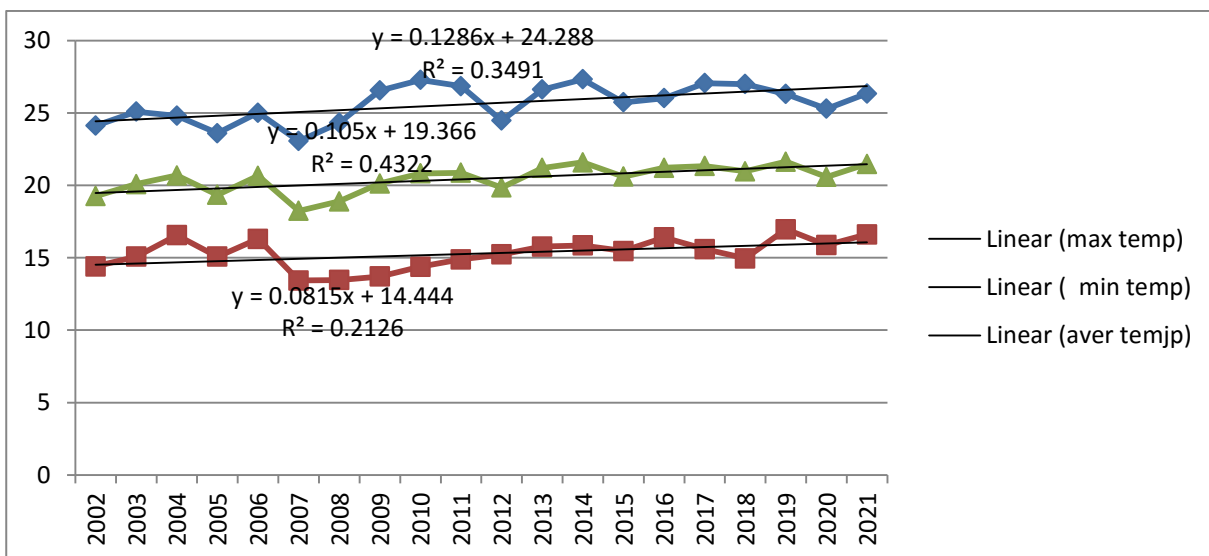


Figure 4 maximum temperature, minimum temp and average temperature of kedidaGamela worda

2.3.4. Maize production trend and status in kedida Gamela **Woreda**

According to Kedida Gamela Woreda Agriculture Office (2020) in the study area, crop production especially maize crop production is the main source of livelihoods, and has significantly been affected by climate variability and change. Among the major factors which affect rain fed crop production and productivity were the variability of two common elements of climate like unpredictable rainfall and increased temperature as the most important ones.

In Kedida Gamela Woreda, it is not only the variability and change in climate parameters but also its impacts have been perceived by smallholder farmers. The crop production mainly maize production has been severely affected and has led to food insecurity among smallholder farmers in study area.

In study area maize production was continuously decreasing because of climatic variability particularly irregularity of rainfall and rising of temperature that negatively impacts agricultural activities mainly maize crop production in our study area. Maize crop production is dominantly practiced in study area which is based on rain-fed agriculture. Hence, environmental problems in general and climate variability in particular highly harm the maize crop production of households'. The impacts of climate variability and change on crop production are more negative, but they can vary substantially between crops. Crop production in general and maize production in particular is highly vulnerable to climate variability and change. As a result, the annual variability in crop production is observed and the general trend of crop yield is declining. According to the maize yield trend of kedida Gamela Woreda Agriculture Office data,(2020), fifteen years maize area coverage, productivity per/ qt and production per area was collected and analyzed(KGDAO, 2020).

Increase in March-May temperature and June–August precipitation was found to have an adverse impact on maize production while increase in March-May precipitation was found to have a positive impact. The following table shows past and current maize production years average area coverage of maize, productivity and production of the crops, which indicates general decrease of productivity and production mainly due to unpredictable rainfall, seasonal rainfall fluctuation and shift of main maize crop season.

According to Kedida Gamela Woreda Agriculture Office 2021 data(table 1)indicates,area coverage of maize crop per hectar, total yield production in quintals and productivity per hectares of maize from the past 16 years.

Table 7 . Maize production area coverage, productivity by year by quintals

no	Production years	Area coverage of maize crop per hectare	Total production quintals	yield in quintals/ha
1	2007	1511	75550	50
2	2008	1500.5	69023	46
3	2009	1343.5	59449.88	44.25
4	2010	1561	71571.85	45.85
5	2011	1321	56803	43.00
6	2012	1334.45	50709.1	38.00
7	2013	1413	40977	29.00
8	2014	1409	52837.5	37.50
9	2015	1424.75	56348.86	39.55
10	2016	1387	45771	33
11	2017	1387	38836	28
12	2018	1276.45	37017.05	29.00
13	2019	1311	32775	25
14	2020	1389	37503	27
15	2021	1404	27378	19.50

Source: Kedida GamelaWoreda Agriculture Office 2022

According to evidence from small holder farmers and development agents in the study area, majority of the farmers use different types of adaptation strategies like, crop rotation, some farmers use crop diversification and early maturing crop variety like haricot bean, early sowing of crops was the common adaptation strategy used as compare to other adaptation mechanism to tackle the adverse impact of climate change and variability.

The crop production mainly maize production has been severely affected and has led to food insecurity among smallholder farmers in study area.In study area maize production was continuously deceasing because of climatic variability particularly irregularity of rainfall and rising of temperature that negatively impacts agricultural activities mainly maize crop production in our study area

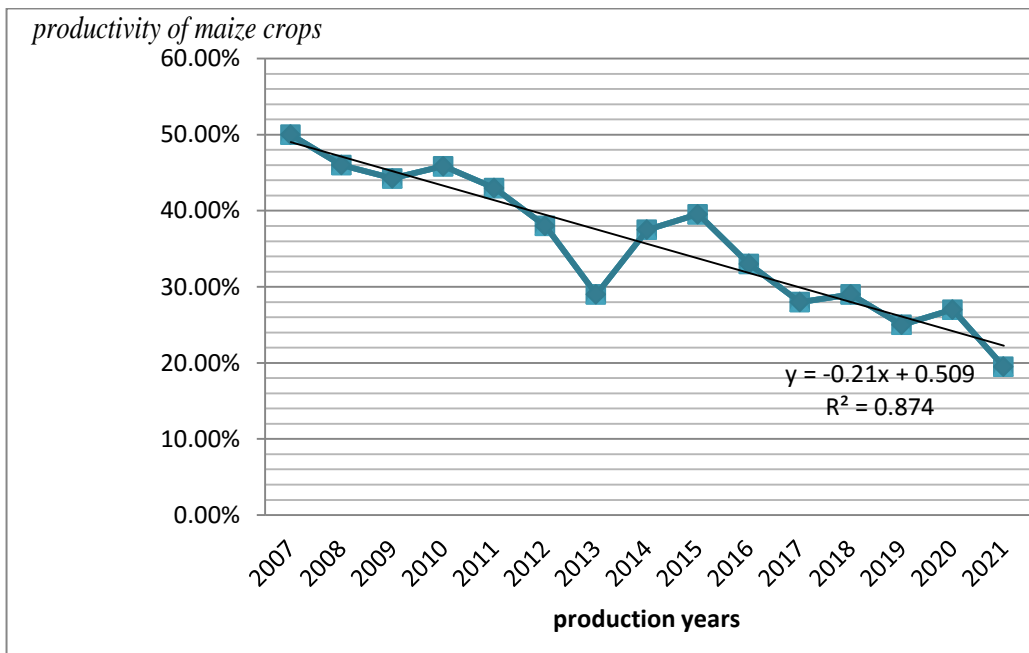


Figure 5. Maize crop productivity trends in kedidaGamelaWoreda,
Source: kedidaGamelaWoreda agriculture office, 2021

The maize productivity was decreased by the rate of 0.19qt/ha per annum. Regression line was fitted to determine evidence of trends in maize production; it depicted by 0.21qt/ha decreases in productivity in the meantime. The declining trend of maize yield (productivity) in the kedidaGamelaworeda is mainly due to variable onset, seasonal rainfall fluctuation and shift of main crop season.

2.3.5. Smallholder farmers’ perception towards climate change in Ethiopia

Smallholder farmers’ perception plays a big role for their reaction as implementing different coping strategies. Perception is, in general, according to (Arsiso, et.al., 2017) is the process of attaining awareness or understanding of a phenomenon including climate change.

In this regard, Some scholar for instance (Ndambiri 2013)s defined perceptions of farmers regarding the long-term changes in temperature and precipitation as farmers’ ability to understand climate change phenomena based on their own knowledge. Several studies pointed

out some factors that influence farmers' perceptions including farmers' age, education, farming experience and sometimes access to climate information among others.

Small holder farmers are farmers who own small plots of land on which they grow subsistence crops and one or two cash crops relying largely on family labor. Small holder farming is characterized by small land size, low technology and low capitalization

Smallholder farmers play a crucial role in ensuring food security in Ethiopia. Most of farms are occupied by smallholder farmers ((Africa Agriculture status, 2014). However low technology adoption and lack of credit access make the life of smallholder farmer's in difficulty.

smallholder farmers whose major source of livelihood is rain fed agriculture it is clear that climate change will carry about substantial welfare losses especially for smallholders whose main source of livelihood derives from agriculture" (Asrat and Simane, 2018,).

Smallholders' farmers in Ethiopia have been and are living in agreement with climate change. Many scholars has confirmed the information about climate change is a pre-condition for adapting to its adverse effects. Smallholder farmers plays a crucial role in ensuring food security in Ethiopia. Most of farms are occupied by smallholder farmers ((Africa Agriculture status, 2014). However low technology adoption and lack of credit access make the life of smallholder farmer's in difficulty. smallholder farmers whose major source of livelihood is

rain fed agriculture. It is clear that climate change will carry about substantial welfare losses especially for smallholders whose main source of livelihood derives from agriculture" (Asrat and Simane, 2018)

Table 8: DA advisory service of households (n=164)

frequency of contact/ DA advisory Service in week and months	study areas kebele							
	AzeDobore spondent		ZatoShod era		Degakedi da		Total numbers	
	n	%	n	%	n	%	n	%
Weekly advisory tim								
1 times in week	27	50	22	48	3	48	80	49
2 times in week	5	9.3	3	6	6	9.4	14	8.5
No advisory time in week	22	40.7	21	45	2	42.7	70	42.
Monthly advisory time								
1 times monthly	7	13	14	30	1	28	39	23.8
2 times monthly	1	22	6	13	1	15.0	28	17.1
3 times monthly	9	16.7	7	15	3	4.7	19	11.58
4 times monthly	2	48	19	41	3	51.3	78	47.56

Source: field survey result (2021)

4.2. Small holder producers' perception on variability and climate change effect on maize production.

4.2.1. Small holder producers' perception on variability and climate change

The study result (Table 9) indicate that smallholder farmers in the study area perceived that there were changes in the long-term average temperature and total rainfall over the past years and this is supported by the observed trends of temperature and precipitation levels of meteorological data. As indicated in table(11) ,from the total surveyed HHs, (100%) of the respondents perceived increased level of temperature, (85.37%) of HHs perceived decreased in rainfall amount, (90.85%)of HHs perceived Recurrent drought, 84.15% of HHs perceived Long and or short dry season,76.22% of HHs perceived Decreased vegetation composition and vegetation cover as an indicator, and this is followed by (73.5%) of HHs perceived and responded the unpredictable rainfall as the major indicator of climate change.

Table 9: Small holder producers' perception of climate change by perceived indicators (n=164).

Perceived indicator of climate change	perceived level of farmers							Mean %	Sd
	very high	Moderate		Low					
1. Change in local climatic features									
Change in rain season (setting and ending time)	143	87.2	21	12.8	0	0	50	0.52	
Decreased in rainfall amount	145	85.3	19	11.6	0	0	50	0.46	
Increased rainfall amount	11	6.7	19	11	1.3	8.2	34.34	0.58	
Long and or short dry season	138	84.1	24	14.6	2	1.2	33.33	0.40	
Change in temperature Recurrent drought	161	98.2	3	1.83	0	0	50.15	0.13	
Increased /high/ temperature	164	100	0	0	0	0	100		
Decreased/low/temperature	0	0	0	0	0	0			
Flooding	18	10.98	15	9.14	1.3	8.0	30.4	0.66	
Recurrent drought	149	90.85	15	9.14	0	0	49.995		
Unpredictable rainfall	141	86.6	14	20	9	5.5	37.4	0.51	

Source:- survey result of 2021

Note very high=1 moderate =2 low=3

All the respondent households' heads included in the survey perceived long-term changes in pattern of rainfall amount and distribution. The majority of the respondents in the study area noticed a change not in the total amount of rainfall but in the timing of rains, with rains coming later than expected time of rainfall and increased level of temperature. This was verified by all participants of Focus group discussions and key informant as there were changes in rainfall timing, amount and distribution in the area over the past years.

In general, we can conclude that majority of the smallholder farmers in the study area feel that there were changes in the long-term average temperature and total rainfall over the past years and this is supported by the observed trends of temperature and precipitation levels of meteorological data and respondents.

Moreover, the study result revealed that 100% of the respondents in the study area clearly indicated that climate change and variability has brought reduction in crop productivity especially maize production. They indicated that the reduction of crops yield is associated with many factors. First, the late start of the rainy season makes the smallholder farmers not to cultivate the crops that suit the particular season. The participants of FGD in study areas indicated and mentioned that there is frequent variation of rainfall distribution, affecting crop growth at the time of seed-bearing stage when in need of moisture. In study area farmers' perceptions and understanding of rainfall variability has significant importance in their livelihood's adjustments. Specifically, farmers in the FGD raised the occurrence of erratic rain distribution during Belg season has significantly reduced their production and affected their cash income seriously. Results from FGDs and KIIs revealed that recurrent drought, erratic, and uneven distribution of rainfall/ unpredictable rainfall are serious challenges that hinder most smallholder farmers' livelihood activities. This is serious especially in the mid land agro-ecologies of study areas, where crop failure and income loss led them to be poor and food insecure.

Respondents revealed that a decline in maize crop yield, crops yield reduction in both belg and meher season, recurrent drought, loss of assets, food insecurity were perceived impacts of climate-induced shocks. As a consequence, income from agriculture was decreased and made many households poor. Results showed that, from the sampled households, 100% per cent perceived changes in temperature (especially rise in average temperature), although there is no statistically significant difference among districts. About 85.4% per cent of the respondents perceived decrease in rainfall over the years. On the other hand, more than 86.6 percent of the respondents perceived that rainfall has become more unreliable and unpredictable

Some FGD participants in Zatoshoderakebele told and perceived that some years before, the Belg rainy season used to start in beginning of January and end of march, but now it

starts at end of may up to beginning of June , and the rain has no longer been reliable therefore maize cropping season and yield was affected with this variability of climate change especially rainfall unpredictability and high temperature. This also caused increasing frequency of drought and food insecurity. They perceived that main rainy season sometimes extends to first week of October, but now it stops in first week of September, existing crop types and it becomes difficult to live with our existing crop types. This showed the similar finding with previously described, Climate change has adversely affected the livelihood of people in developing countries where a large proportion of the population is heavily dependent on agriculture, and has exacerbated poverty, food insecurity and vulnerability of agro-pastoral community in sub-Saharan Africa (Bryan et al., 2009).

■ Rainfall and temperature are important meteorological variables that determine water availability, and production of crops and livestock rearing or food production processes in countries where agriculture is more dependent on rainfall, (Abebe, 2013).

According to FAO, (2018) prediction, the wet areas are expected to be wetter and the dry areas in the tropics are expected to be drier as a result of climate change. The intensity of rain storms could increase in some unpredictable.

The respondents' agreement with this prediction, almost all of the respondents reported that there was a change in the amount and timing of rain fall in the study area and it is adversely

Impacting maize crop production, during time of maize crop growing, flowering and harvesting especially cropping season

The result from the survey indicates that majority (85.4%) of the respondents highly perceived that there is a decrease in rainfall, 11.6% of respondents moderately perceived that there is increase of rainfall, and the remaining 3% of respondents perceived that there is no change of rainfall. Fosu-Mensah et al. (2012) found that 87% and 94% of respondents perceived the decrease in rainfall in their respective study areas.

However, according to rainfall data in study area, in addition to the decrease in rainfall, erratic nature of rainfall availability is the key climatic problem in study area. The study finding about farmers' perception on the decrease in rainfall availability is in line with above study

findings. The impact of rainfall on crop production generally and maize crop production particularly can be related to its total seasonal amount or its intra seasonal distribution. In the extreme case of droughts, with very low total seasonal amounts of rainfall, crop production suffers the most. But more subtle intra-seasonal variations in rainfall distribution during crop growing periods/maize growing periods, without a change in total seasonal amount, can also cause substantial reductions in maize yields.

The farmers' perception results indicates an increasing trend of temperature indicated that the maximum temperature, minimum temperature and average temperature of the district is increasing. This is similar with meteorological data report stating that during the past 16 years the district temperature has been increasing by about coefficient of 0.108 °C annually. with past 16 years increased past 16 years district temperature report.

The present study implies that an increase in temperature imposes stress on crop production, which may affect crop production in general and maize production particular, in many ways. For instance, increased temperature leads to surface drying and lack of moisture which increased duration of drought, thereby resulted in failure of maize crop production

According to EPA report on CRGE, Ethiopia has become warmer over the past century and human induced climate change will bring further warming over the next century at unprecedented rates. Climate models suggest that Ethiopia will see further warming in all seasons of between 0.7°C and 2.3°C by the 2020's and of between 1.4°C and 2.9°C by the 2050s. Similarly, increase in inter annual temperature is observed in the study area.

According to Deressa et al. (2011), Mengistu (2011), Tadesse (2011) and Tessema et al. (2013) reported that most farmers perceived an increasing trend of mean annual (76.0%) and summer season (79.5%) temperatures and most of the farmers in Ethiopia are aware of the

fact that temperature is increasing. On the other hand, the study reported that a chi-square test result, there was a significant at ($p < 0.01$) difference between farmers in their perception of annual, summer, and winter season temperature. The trend analysis of study area, annual temperature (minimum and maximum) shows statistically significant increase in the district.

4.2.2 Smallholder producers perception on effect of climate change and variability on maize production

According to the study areas focus group discussion, key informant interviewers, and households respondents of the survey result indicated that, the crop production in general and maize production in particular is highly vulnerable to climate variability and change. As a result, the annual variability in crop production is observed and the general trend in crop yield is declining. The impacts of climate variability and change on crop production are more negative, but they can vary substantially between crops Tewdros, Deribe(2019). The study of Anandh (2011), Tewdros, Deribe(2019) in revealed that, rising temperatures lead to crop failure through lowering crop water availability, causing heat stress in crops, and increasing pollen sterility. Maize crop production is dominantly practiced in study area which is based on rain-fed agriculture. Hence, environmental problems in generally and climate variability in particularly highly harm the maize crop production of households'.

According to (Aklilu k, 2009) most of the factors that influence crop production were associated with irregularity of rain fall (shortage of rain fall and heavy or intense rain). Almost all the respondents in the study area agreed that rain associated problems are the most severe problem that affects maize and crop production in the study area with accounts 93.3%

According to focus group discussion, key informant interviewers and respondents perception, in KedidaGamelaworeda, end of may and mainly beginning of June, is corresponding to the main growing season because may precipitation was found to have positive impact on maize crop production

According to Zerhun G.2020) in Halaba zone, Maize is planted under a single-cropping system in April, when the optimal soil temperature is reached for germination. According to the study June and July correspond to the key-growing season in Halaba zone. This indicated that the increasing temperatures have gradually shifted the sowing period from the historical third week of March to the last week of April and sometimes the first week of May which receive minimum optimal soil moisture amounts necessary for maize germination and growth in study area. The overall decrease of maize yield for the past 29 years was 0.2qt/ha.

Increase in March-May temperature and June–August precipitation was found to have an adverse impact on maize production while increase in March-May precipitation was found to have a positive impact...

According to result in (Table 10) below indicates that all respondent households (86%) regardless of their professional background reported that they have noticed climate is changing, while indicates the perception of respondents about climate related risks and consequences. According to FGD Participants in the study area, more than three-fourth of the respondents witnessed that the frequency of drought, rainfall variability /unpredictability and temperature were increased. About 100% of the respondents perceived increasing local temperature; while nearly half of respondents indicated forest cover is decreasing due to deforestation as one cause of climate change. Similarly, nearly three fourth of the respondents disclosed productivity and yield of crops have been declining due to climate variability and

Change. As a consequence, less food is directly available to the households. About 100% of them indicated frequency of Change in temperature and recurrent drought has been

increasing.inStudy area .DA experts also reported and perceived that income sources are declining due to climate induced risks. Moreover, the prevalence of conflict becomes an alarming problem of society these days.

According to the respondents perception indicated that over the last decades they realized early or late onset of rainy seasons, unexpected rainfall, declining rainfall, and extreme day and night temperature increasing. Most of farmers who perceive climate trends (i.e. increased temperature, declined precipitation and shortened seasonal rainfall duration was occurring as well as being caused by human action.

According to the respondents' perception in study area, the amount of rainfall at the beginning and end of the summer is changing from year to year. In this study, most farmers perceived increasing rainfall variability in terms of late-onset and early cessation of rainfall during the

main growing season. During the focus group discussion time, farmers mentioned that late-onset and early cessation of rainfall as a major factor that affects decisions on planting as well as harvesting dates of maize crops. FGD participants also stated that during the main rainy

season, in kedadagamela district general and study area particular, some farms were left uncultivated due to late-onset and low amounts of rainfall in previous years.

As focus group discussion (FGD) with selected farmers showed that before two and three decades, rainfall begins at around beginning of January and up to beginning of march and rainfall ends at the end of October and beginning of November. But now, this situation was changed and the rainfall begins in beginning of June and ends in the beginning of September. All of those and other sources indicate that since the past two decades the situation is worsened from time to time. This indicated that climate is changing from time to time according to the perception of focus group discussion.

The delay in the rainy season and the variation in seasonal distribution of rainfall was substantial impacts on agricultural production especially maize production season and

livelihoods. The change in rainfall has direct causal relationships with a decline in the production of food and fodder supply to the livestock dependent communities. Key Informant

Interviewees (KII) in the study area has already perceived that the climate is becoming hotter and the rains being unpredictable and shorter. There is an increasing trend for climate change

and rains do not come on the usual time and if they come, they are of short duration. In the study area, farmers underscored that there is climate variability and change increasingly being felt and responded in various degree of extent and forms.

The information from the FGD participants indicated that, in general, climate variability and change was broadly acknowledged across the study areas, though the degree of maize productivity change was perceived differently. All participants stated that these changes

affected their overall livelihood system, the climate seasonality especially impacts on yields of annual crops mainly maize crop production. FGD participants in AzeDoboKebele reported that, due to climate change and variability the farmers' indigenous maize variety was loosed. According to farmers perception, at now time we couldn't get indigenous variety in farmers' hand, because some farmers who had borende maize variety sold 1kg with 350 (three hundred fifty) Ethiopian birr. In another ways, the seeds of maize variety we get from

agriculture office didn't resist climatic conditions, it is too susceptible for climate change and, the seeds and fertilizer is very expensive which is more than our capacity From table below, we conclude that most of the sampled respondents in three kebeles study area FGDs and key informants were asked, there was climate change and variability or not. Their response shows that most of the people in number 141 (85.98%) informed that there is climate change and variability and remaining 23(14.02%) informed that there is no climate change and variability. According to each kebeles, respondents informed and perceived that , in Azedobo kebele respondents ,and others FGD groups 87% perceived that there is climate change and variability remaining 13% perceived that there is no climate change and variability ,which is existed before. In Zato Shoderakebele from respondents, and others FGD groups 84.8%perceived that there is climate change and variability remaining 15.2% perceived that there is no climate change and variability,which is existed before.In DegaKedidakebelefrom respondents, and others FGD groups 85.94 % perceived that there is climate change and variability remaining 14.06 % perceived that there is no climate change and variability,which is existed sometimes happen before and mean of 0.8598.

Also table showed respondents perception on climate change and variability, the respondents, focus group discussion and key informant interviewers in the study area, the level of perception is indicated according to the following table below

Table 10:Climate change and variability of households' perception (n=164)

Source: field survey data 2021

Climate change and variability perception of house holds	Azedobo		Zato		DegaKedida		Total	
	n	%	n	%	n	%	n	%
yes	47	87	39	84.8	55	85.94	141	85.98
no	7	13	7	15.2	9	14.06	23	14.02
Total	54	100	46	100	64	100	164	100

Chi-square tests for respondents* perception on climate change and variability (n=164)

There is climate change and variability/yes	47	39	55	141
There no is climate change and variability/no	7	7	9	23

Source Field Survey 2021

In order to confirm whether there is association between farmers' perception to CC and variability and the environment /kebeles/ chi-square test was employed. There is no significant difference of perception towards CC and variability and their living environment.

The chi-square test employed to analyze association between perception and living environment (kebeles), reveals that pvalue= .988, df=5 at 95% calculated **p**-value is more than the given **p**-value Therefore, it could be concluded that there is no significant difference of perception towards climate change and variability among farmers who are living at different environments (agro-ecological conditions, the kebeles). This implies the climate change and variability is becoming the problem of all environmental conditions in study area.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.610 ^a	5	.988
Likelihood Ratio	1.025	5	.961
N of Valid Cases	164		

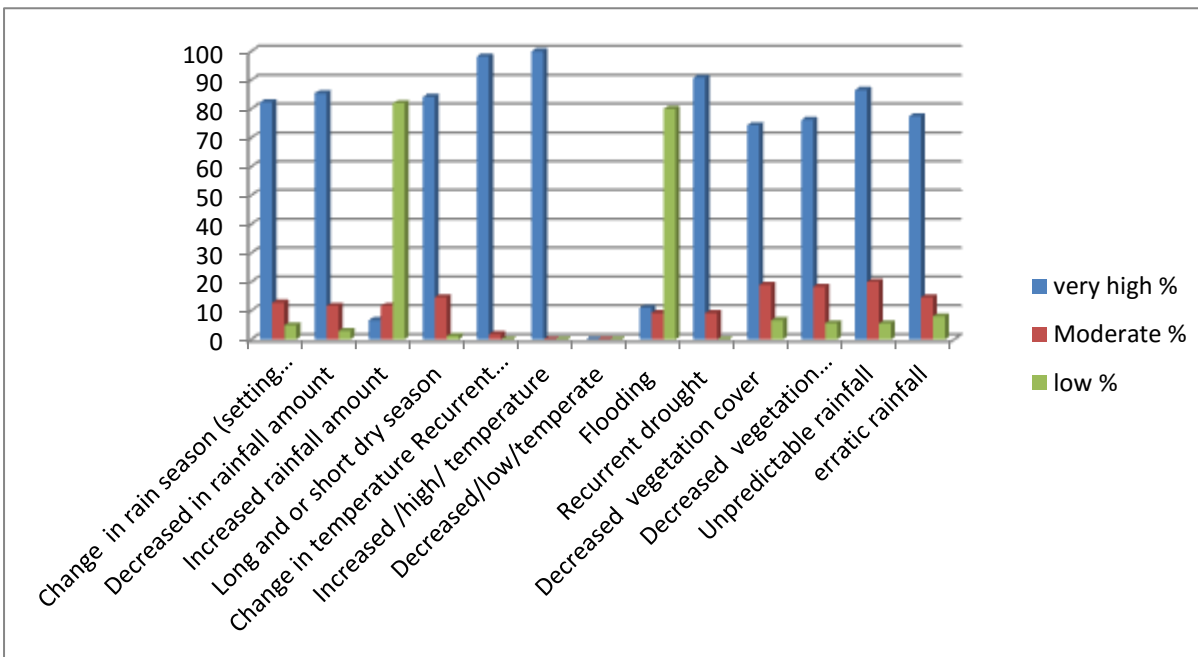


Figure 6. Local farmers perception indicator of climate change in graphically. From the result of Table 11 the chi square test of respondents' perception of climate change and variability indicates that $P_{calculated}$ p-value is > 0.05 w/c indicates no significant difference. Therefore decreased rainfall amount is the common problem in study area.

In case of increased rain fall calculated p value $< p_{val.0.05}$ w/c indicates Significant differences, therefore, increased in rainfall amount is not problem in agro- ecology of study area.

Respondents' perception on long and or short season in study area, respondents' perception on unpredictable rainfall condition, respondent's perception on change in rain season their p-value of the three perceptions is $p > p_{val.0.05}$ w/c indicate indicates no significant difference. Therefore respondents' perception on long and or short season in study area, respondents' perception on unpredictable rainfall condition, respondent's perception on change in rain season problem in study area.

Table 11 Chi-square tests of respondents' perception of climate change and variabilites

Chi-square tests of perception variables						
Respondents perception on	Value	df	Asymp . Sig. (2-sided)	P-value		
decreased rainfall amount in study area						
Pearson Chi-Square	19.817 ^a	15	.179			Pcal,0.179
Likelihood Ratio	24.980	15	.050			
N of Valid Cases	164					
Respondents perception on increased in rainfall amount in study area						Pcal,0.000
Pearson Chi-Square	43.897 ^a	10	.000			
Likelihood Ratio	18.503	10	.047			
N of Valid Cases	164					
Respondents perception on long and or short season in study area						Pcal,0.693
Pearson Chi-Square	7.342 ^a	10	.693			
Likelihood Ratio	7.999	10	.629			
N of Valid Cases	164					
Respondents perception on flooding study area						Pcal,0.003
Pearson Chi-Square	26.576 ^a	10	.003			
Likelihood Ratio	15.519	10	.114			
N of Valid Cases	164					
Respondents perception on unpredictable rainfall condition						Pcal,0.825
Pearson Chi-Square	2.169 ^a	5	.825			
Likelihood Ratio	2.634	5	.756			
N of Valid Cases	164					
Respondents perception on change in rain season						Pcal,0.993
Pearson Chi-Square	2.345 ^a	10	.993			
Likelihood Ratio	2.824	10	.985			
N of Valid Cases	164					
Kebeles respondents perception decreased vegetation cover and composition						Pcal,0.046
Pearson Chi-Square	18.582 ^a	10	.046			
Likelihood Ratio	22.679	10	.012			
N of Valid Cases	164					

The result of table 12, a five point Likert scale measurement was also used to measure the level of perception of sample respondents for some selected attributes of climate change. Farmers were asked to articulate their perception towards whether the level of rainfall is decreasing on study area from last years. According to respondents, the majority of the sample households strongly agree (82.3%), agree (15.85%) and undecided (1.8%). For other statement which says increased temperature of study area or not, about (87.8%) of sample households strongly agreed that increased temp. and (12.2) % tended to agree increased temperature.

For the third statement weather the rainfall is unpredictable, about (87.8%) of sample households strongly agreed, 9.14% of sample households agree and only (3%) are likely to undecided. For the fourth item: there is Long and or short dry season in study area, majority of sampled respondents (83.5%) tend to strongly agree, and (13.4%) respondents agreed, 1.8% of respondents tend to undecided, 1.2 % of respondents tend to disagree.

For the fifth statement, there is reduction in maize crop Production.in study area, majority of sampled respondents (93.9%) tend to strongly agree, and (6.09%) respondents agreed. For the Six statement, there is changed rain season.in study area, majority of sampled respondents (88.4%) tend to strongly agree, and (9.14%) respondents agreed, and 2.4% of respondents tend to undecided.

For the Eight statement, there is decreased vegetation cover and composition.in study area, majority of sampled respondents (80.5%) tend to strongly agree, and (15.85%) respondents agreed, 2.44% of respondents tend to undecided, and 1.2% respondents tend to disagree

Table 12 Distribution of Studied Households' local Perceptions indicator of climate change and Variability by using (5-point Likert- scale measurement).

	1		2		3		4		5	
	n	%	n	%	n	%	n	%	n	%
Decreased in rain fall amount in study area	135	82.3	26	15.85	3	1.8	-	-	-	-
Increased /high/ temperature in study area	144	87.8	20	12.2	-	-	-	-	-	-
Long and or short dry season	137	83.5	22	13.4	3	1.8	2	1.2		
Unpredictable rainfall	144	87.8	15	9.14	5	3				
Change in rain season	145	88.4	15	9.14	4	2.4				
There is reduction in maize crop Production.	154	93.9	10	6.09	-	-	-	-	-	-
Recurrent drought	143	87.2	17	10.4	4	2.44				
Decreased vegetation cover	132	80.5	26	15.8	4	2.44	2	1.2		

Note: 1=strongly agree 2=Agree 3=neutral 4=Disagree 5= strongly disagree

Source: Own survey result, 2022

According to Yohannes, (2019) discussion, the vulnerability mapping is an important tool that helps to take effective response actions to the adverse impacts of climate change through

Identification of vulnerable areas. The knowledge of vulnerability to climate change can assist decision makers in recommending adaptation measures and prioritizing resource allocation for specific areas as well as determining investments for adaptation to future impacts of climate change.

According to the **respondents the perception** of vulnerability level in Table (13) below, high perception level on reduction of maize crop yield, loose of indigenous maize varieties, HH food shortage, shortage of animal feed, reduction of livestock production, in number 144 (87.8%), 113 (67%), 133 (81.1%), 120 (73.2%), 115 (70.12%) respectively. moderately vulnerable level according to respondents like new emerging and Intensified crop pest on maize crops in number 70 out of 164 in percent 42.7%, reduction of soil fertility due to flooding of farm lands is less vulnerable which is from respondents answer in number 68 out of 164 in percent 41.5%.

Table 13 Perceived self-vulnerability level of climate change impact in study area (n=164)

variables	Perceived vulnerability level of impact in each study area in total							Mean	SD
	very high vuln.		Moderately vuln.		Less vulnerable				
	n	%	n	%	n	%			
Reduction of maize Crop yield	144	87.8	20	12.2	0	0	1.122	0.33	
Loos of indigenous maize verities	113	68.9	40	24.4	11	6.70	1.378	0.61	
HH food shortage	133	81.1	31	18.9	0	0	1.189	0.39	
Shortage of animal feed	120	73.2	33	20.1	11	6.707	1.335	0.59	
Reduction of livestock production	115	70.1	41	25	8	4.878	1.347	0.57	
Reduction of soil fertility due to flooding of farm lands a	44	26.8	52	31.7	68	41.46	2.14	0.81	
New emerging and Intensified crop pest on maize (insects and weed)	66	40.2	70	42.7	28	17.07	1.768	0.72	

Source: survey result of 2021

Vulnerability level of small-holder farmers in study area graphically, it indicates that reduction of maize crop yield, household food shortage, loose of indigenous maize varieties in farmers field, reduction of livestock production are highly vulnerable cases according to study area households and FGDs responses

4.3.Smallholder maize producers' adaptation strategies in response to effects of climate change and variability in the study area.

The most widely used adaptation strategies in study area in climate change related impact with maize crop production..Farmers existing adaptation Strategies are use of inter cropping, practicing crop rotation, crop diversification,mixed farming, Accordingly, the survey data obtained from HHs indicates that, (28.7%) of respondents were using new varieties of maize, intercropping(100%),Crop rotation(63.42%), Mixed farming (43.902%), Crop diversification (52.44%), The following mentioned adaptation strategies are the farmers selected maize crop adaptation strategies for the future to increase the yield of maize crops : drought resistant maize crop varieties(93.3%), high yielding maize crop varieties(93.3%),Fertilizer usage andapplication of animal manure(84.2%), Early maturing maize crop varieties(92.1%), Small scale irrigation practices(91.4%), Water harvesting techniques and increased use of irrigation(84.1%), application of agro-chemicals(79.8%), Early planting maize crop varieties (92.1%)This implies farmers in all agro ecologic conditions are already undertaking all types of adaptation strategies with more tendencies to **use new varieties of seeds**, to reduce the negative impact of climate change on maize crop production. From mentioned strategiesthe use of drought resistant maize crop varieties, early planting of maize varieties, high yielding maize crop varieties,Early maturing maize crop varieties practices was the most common response among the eight adaptation strategies for the future.

According to FGD participants, they are complaining of high costs of fertilizer and new varieties of maize seeds. It is above their capacity to pay, and they don't have other alternatives to sow their maize seeds. The land does not give yield without fertilizer. Especially the hybrid seeds in general and maize seeds in particular require fertilizer for production. The raising costs of fertilizer and seeds are problem for farmers' maize crop production in study area.Similarly, key informants from the woreda agriculture office and development agents, suggested that the government is supplying new varieties of crop seeds and inorganic fertilizer by using cooperatives and agriculture input department.

Nevertheless, the high price of seeds and fertilizer coupled with low awareness of farmers in the use of agricultural technologies is impeding the expected high yield per a plot in all parts of the districts

Table 14 Respondents household maize crop adaptation strategies (n=164)

Adaptation strategies on maize crop production	sample kebeles in %							
	AzeDobo		ZatoShodera		DegaKedida		Total	
	n	%	n	%	n	%	n	%
Droughtresistant maizecropvarieties(DRMC)	53	98.15	39	84.8	61	95.3	153	93.3
Highyieldingmaizecropvarieties(HY MCV)	52	96.3	41	89.1	60	93.75	153	93.3
Water harvesting techniques and increased use of irrigation (WHT and irri)	45	83.3	38	82.6	55	85.94	138	84.2
Fertilizer usage and application of animal manure(FAAM)	46	85.2	40	86.9	52	81.25	138	84.2
Early planting of maizevarieties(EP MV)	51	94.4	43	93.5	57	89.06	151	92.1
Smallscaleirrigationpractices(SSIP)	50	92.6	43	93.5	57	89.1	150	91.4
Early maturing maizecropvarieties(EMMCV)	51	94.4	39	84.8	58	90.62	148	90.2
Application of agro-chemicals	42	77.8	33	71.74	56	87.5	131	79.8

Source: -survey data 2021

This study shows that climate variability and change is happening, and there are societies implementing the necessary adaptation strategies to the impacts of climate variability and change. Similarly, Boko et al. (2007) reported that for poor countries like most African nations, practicing adaptation strategies is not an option; rather it is a necessity to survive in the changing climate. Accordingly, smallholder farmers used different adaptation strategies to reduce the effect of climate variability and change on crop production system. 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. As per surveyed data, results in times of less rain fall the most frequent adaptation strategies were growing short duration or early maturing varieties of maize crops, others responses for less rainfall is practicing small scale irrigation

Results from FGD showed that, in times of irregular rainfall, participants undertook water harvesting cultivation for maize and haricot beans crops. The use of chemical fertilizer is generally low reflecting broader pattern in study area.

FGD result on adaptive actions in times of increased temperature, were changing early maturing maize crop varieties, changing drought resistant maize crop variety, early maturing maize crop variety, changing planting dates (early planting of maize crop varieties). change in rainfall ,temperature and severe weather events are expected to reduce yield of crops in many parts of Ethiopia in general and study area particular.

Maize crop production is the most significantly influenced by climate variability from year to year even in high technology agriculture. Similarly, crop yield , can be increased with rainfall during growth period; meanwhile maize crop yield is more sensitive to rainfall than temperature. The growing period will reduce and planting date also needs to change for higher crop production with climate change. Climate change can decrease crop rotation period , so farmers of study area needs to consider, maize crop varieties, early maturing maize crop varieties, high yielding maize crop varieties, early sowing of maize crop varieties

Changing planting dates

This includes early and late planting options as strategies to the changing climate. This strategy helps to protect sensitive growth stages by managing the crops to ensure that these critical stages do not coincide with very harsh climatic conditions such as mid-season droughts.

Soil and water Conservation

The adaptation practices and technologies that enhance soil coverage and control soil erosion are crucial to ensuring greater resilience of production systems to increased rainfall events, extended intervals between rainfall events, and to potential soil loss from extreme climate events. Improving soil management and conservation techniques assist to restore the soil while also capturing soil carbon and limiting the oxidation of organic matter in the soil this follows increasing of crop production.

4.4 Factors determining the smallholder maize producers' choice of adaptation strategies.

The study result(**table 15**) indicates that, the farmers source of information about climate change is one of the most important factors that determine maize producers application of adaptation strategies ,during focus group discussion, farmers mentioned that our source of information for climate condition is always kebeles development agents(DAs) , which covers **67.1% their main source**. The table below shows information sources of the respondents on livelihood climate change and variability impact. In relation to this, FGD participants, key informants and HHs survey data**85.94% of the sample respondents already informed the existence of climate information**,the result indicated that **development agents (DAs) were indicated by majority (67.1%)** of the respondents as a most important source of information, **followed by media (radio 20.7 % and farmers to farmers 17.1%** others as important source of information. On the other hand about **9.75% of the respondents** used their mass media **and 10.5% households** use television program as a source of information.

Table15 Distribution of Studied Households by Sources of Information(n=164)

Information source	experience using the source															Sd	
	Azedobo kebele			Zato Shodera			dga Kedida			Total							
	1	2	3	1	2	3	1	2	3	1	%	2	%	3	%		
Mass media	3	4	47	3	5	38	5	7	52	1	6.1	1	9.6	13	83.7	2.7	0.56
Radio	14	7	33	1	5	30	9	1	42	3	20.4	2	15.5	10	64.0	2.4	0.82
TV	2	6	46	3	5	38	3	7	54	8	4.8	1	10.8	13	84.2	2.8	0.49
Development agent	39	1	0	3	1	0	4	2	0	1	67.0	5	32.1	0	0.9	1.3	0.47
(Colleagues) Farmers	14	1	27	9	8	29	5	1	48	2	17.1	3	19.5	10	63.4	2.5	0.77

Note that:- always = 1 most of the time=2, sometime=3

Source: -survey data 2021

4.4.1. Access to Credit by Sample Households: Access to credit service also plays a positive role for farmers to adopt climate change adaptation options.

Agricultural credit is one of institutional support rendered to farmers in a rural area. This service can be offered by government and non-government organizations (NGOs). However, in the study area Microfinance institutions, Women /Youth associations, Traders, and kebeles cooperatives are the main source of credit sources for some years.

Concerning credit access, it was indicated about 12% of the total households in three kebeles reported as they have access to credit, especially fertilizer in cooperatives and some money credits. However, there was no credit access for adaptation measures for climate variability in the past years. According to the survey data almost all (87.8%) of the HHs replied ‘NO’ and (12.2%) of them responded ‘Yes’ for the question which was stated “Do you have access to get credits from institutions to deal with climate related shocks or hazards. This clearly shows

that small-holder farmers' adaptation effort to the changing climate is being constrained by shortage of access to credit services in the district.

According to the (Table 16) 60.98 percent of small holder farmers didn't take awareness on appropriate technologies and or practices on impact of climate change on maize crop production in study area, the remaining 39.02 percent of respondents had awareness on technologies and practices.

In relation to farmers' perception on adaptation for impact of climate variability practices, farmers' contact with developmental agents (DA) has a role. Having good relation with developmental agents (DA) helps farmers in reducing crop yield associated like maize crop yield with environmental impact in general and climate variability in particular by providing relevant information. Among assessed farmers, 45.73 % have make contact with development agents. Along with evaluated farmers, 54.26% have no contact with development agents.. However, farmers who have no contact with development agents (DAs) and other experts and failed to practice the measures.

Table 16 factors affecting smallholder farmers strategy choice for dummy variables (n=164)

variables	AzeDobo kebele		ZatoShodera kebele		degakedida		Total		mean	Sd
	n	%	n	%	n	%	n	%		
small-holder farmers awareness	Yes	20	37	19	41.3	25	39.1	64	39.02	
	no	34	63	27	58.7	39	60.9	100	60.98	
Total		54	100	46	100	64	100	164	100	
on appropriate technologies										
DAs support of small holder farmers/ extension	Yes	29	53.7	19	41.3	27	42.19	75	45.73	
	no	25	46.3	27	58.7	37	57.81	89	54.26	
Total		54	100	46	100	64	100	164	100	
ice									0.4573	0.4997
access for credit from any sources	Yes	4	7.4	5	10.9	11	17.2	20	12.2	
	No	50	92.	41	89.1	53	82.8	144	87.8	
Total		54	100	46	100	64	100	164	100	
									1.878	0.3282
Smallholder farmers training on climate Change adaptation issues	Yes	34	.61	31	67.25	50	74	115	70.2	
	No	20	39	15	32.75	17	26	49	29.8	
Total		54		46		64		164		
									0.805	0.3975

Source :fieldSurvey 2021

Factors determining climate change and variability on maize crop production :are variables like, farmers credit sources, farmers extension service, sex of resp., family size of respondents, marital status of respondents., Education status of respondents , age of resp.

.Table 17 multinomial logit model results of factors affecting adaptation strategies for maize crop production

Explanatory variables	Adaptation strategies						
	DRMC coeff. p-value	HYMCV coeff. p-value	FAAM coeff. p-value	EPMV coeff. p-value	SSIP coeff. p-value	EMMCV coeff. p-value	AACH coeff. p-value
Sex	0.647 (0.7301)	0.541 (0.582)	0.67 (0.34)	0.24 (0.49)	0.55 (0.245)	0.99 (0.162)	0.81 (0.402)
Age	0.0048*** (0.078)	0.0539* (0.0043)	0.69 (0.351)	0.626 (0.431)	0.67 (0.142)	0.31 (0.223)	0.85 (0.712)
Family si	0.079*** (0.077)	0.0345* (0.0035)	0.087** (0.035)	0.028** (0.0401)	0.87 (0.13)	0.276 (0.6001)	0.9 (0.41)
Acces for credit	0.041* (0.008)	0.0251** (0.041)	0.289** (0.034)	0.0369 (0.27)	0.062 (1.021)	0.407* (0.0041)	0.34 (0.28)
Farm income	0.0903** (0.041)	0.021* (0.0042)	0.56 (0.31)	0.0904** (0.0401)	0.081*** (0.087)	1.04 (0.51)	1.21 (0.41)
Farmers ext. serv.	1.021* (0.0531)	0.0204* (0.008)	0.0743** (0.038)	0.037** (0.031)	0.0461*** (0.072)	1.04 (0.51)	1.21 (0.41)
Educational Status	0.073** (0.0321)	0.0331* (0.0091)	0.056** (0.031)	0.904 (0.401)	0.073*** (0.046)	1.04 (0.51)	1.031** (0.0404)
Marital status	0.054* (0.00506)	0.7031** (0.045)	0.063 (0.31)	0.0631*** (0.085)	1.003 (0.402)	0.0934 (0.15)	0.00901 (0.6)
Farmers' access to CI	0.0312* (0.0011)	0.021** (0.0381)	0.083** (0.023)	0.069** (0.027)	0.062 (0.0703)	0.0407* (0.00401)	0.34 (0.28)

Notes: *, **, *** = significant at 1%, 5%, and 10% probability level, respectively

Base category No adaptation

Number of observations 164

LR chi2(45) 135.41

Prob > chi2 0.0000

Pseudo R-Square 0.3193

Source: Own computation from survey data, 2022 Note 2:DRMC= Drought resistant maize crop varieties HYMCV= High yielding maize crop varieties, SWCP)=Soil and water conservation practices FAAM= Fertilizer usage and application of animal manure EPMV = Early planting of maize varieties SSIP= Small scale irrigation practices EMMCV= Early maturing maize crop

varieties AACH= Application of agro-chemicals, Exv=explanatory variables CI=climate Information

Age of the household head: - is one of a significant explanatory variable in which its coefficient has a positive sign. A one year increase in age of the household head, the probability of farmers' use drought resistant maize crop variety adaptation strategy increases by 0.48%, holding other variable constant. This means that the likelihood of taking up climate adaptation measures was higher among older farmers. Because as the age of the household head increases, the person is expected to acquire more experience and that helps increase in likelihood of practicing different adaptation strategies to combat climate change. This might be attributed to the experience of older farmers perceiving changes in climatic attributes. This result is in line with the findings of Deressa et al. (2008); Ajibefun and Fatuase (2011); Nhemachena and Hassan (2007); Maddison (2007).

Family Size: - family size also has significant and positive effect on adaptation strategies to climate change. A one unit increase in the family size, the probability of farmers use drought resistant maize variety, high yielding maize crop variety, fertilizer application of animal manure, early planting of maize variety adaptation methods increase by 7.9%, 3.45%, 8.7% and 2.8% respectively, keeping other variables constant. Because household size can influence adaptation, due to the fact that its association with labor endowment. It is argued that a larger household size enables the adoption of technologies by availing the necessary labour force in one hand and enabling the generation of additional income from extra labor invested in off farm activities (Yirga 2007). The finding of this study was similar with of the result of Tagel (2013).

Farm income: - Farm income of the household also a significant explanatory variables as shown in the above table. The result of this analysis reveals that farm income of a household had a positive and significant influence on drought resistant maize variety, high yielding maize variety, early planting maize variety, small scale irrigation practices adaptation methods in response to climate change. A one percent (ETB) increases in the income of the household from the farm, the probability of farmers' to use adaptation strategies drought resistant maize variety, high yielding maize variety, early planting maize variety, small scale irrigation practices increases by 9.03%, 2.01%, 9.04% and 8.1% respectively, holding other variables constant. The impact of income is a positive correlation (Franzel 1999; as cited in deressa et al., 2008). Higher income farmers may be less risk averse and

have more access to information and a longer term planning horizon. When the main source of income in farming would increase, farmers tend to invest on productivity smoothing options. This finding is consistent with studies of Tagel (2013); Deressa et al. (2009) and Mengistu et al. (2012).

Access to credit is also a significant variable. As compared to the farmer who has no access to credit, the probability of using drought resistant maize variety, high yielding maize variety, fertilizer application of animal manure, early maturing maize variety as adaptation strategies to climate change for the farmer who has credit access increases by 4.1%, 2.51%, 2.89% and 4.07% respectively, keeping other variables constant. Adaptation method to climate change needs

money to purchase improved inputs such as fertilizer and improved better seeds of maize. The result of this study is similar with the findings of Deressa et al. (2009); Di Falco et al. (2011); Tesso et al. (2012) as well as Aemro et al. (2012). It makes and enables farmers to change their management practices in response to changing climatic change and variability factors and to buy seeds of drought resistant maize crop variety, seeds of high yielding maize crop variety, fertilizers, and to buy other materials which is used for irrigation purpose and inputs which is used to increase the yield of maize and reduce the negative impact of climate change on maize crop production. This result is supported by work of Nhemachena and Hassan (2007) that strongly advocated the positive effect of access to credit on the probability of adopting irrigation, SWC practices, adjusting planting date, and using different crop variety in response to climate change by strengthening their financial capacity.

Access to climate information is also one of a significant explanatory variable. Getting information about seasonal forecasts and climate change, the probability of using adaptation of drought resistant maize variety, high yielding maize variety, fertilize application of animal manure, early planting maize variety, early maturing maize crop variety increase by 3.12%, 2.1%, 8.3%, 6.9%, 6.2%, 4.07% compared to not getting information, keeping other variables constant. Thus, access to information from different sources has significant impact on the

adaptation to climate variability. Indeed, it is an important precondition for farmers to take up adaptation measures (Madison 2006). access to climate information increases the likelihood of using short season and improved variety in response to climate change. It is also supported

in focus group discussion in study area confirmed that access to climate information increases. According to the focus group discussion in study area, development agents, radio

and farmer to farmer contact are the major source from which farmers obtain climate related information.

Farmers extension service is also among the significant explanatory variable in this model. As compared to the farmers who have no access to farmer's extension service, the probability of using drought resistant maize crop variety, high yielding maize crop variety, fertilizer application of animal manure, early planting maize crop variety, small scale irrigation practices adaption methods to climate change increases by 10.21%, 2.04%, 7.43%, 3.7% , 4.61% or farmers' who have access farmers-to-farmers' extension service, keeping other variables constant. Therefore, sharing of experience among farmers is very important to build up the knowledge of the farmers and will help them to take the adaptation measures. This result is also similar with the finding of Deressa et al. (2010) and Tessema et al. (2013).

Educational status . As hypothesized, educational level of household is positively correlated with all type of adaptation strategies of impact of climate variability. Here, the coefficient positive implying that education seems to have a strong influence on impact of climate variability adaptation strategies. As compared to the farmers who have no access to education , the probability of using drought resistant maize crop variety, high yielding maize crop variety, fertilizer application of animal manure, small scale irrigation practices, the adaption methods to climate change increases by 10.21%, 2.04%, 7.43%, 3.7% , 4.61% or than farmers' who have no access to education , keeping other variables constant. Therefore, this result might emanate from the fact that education improves farmers' capacity of obtaining and analyzing new information about climate change and variability impacts and adaptation strategies for maize crop production. Some studies also indicated that there is a strong positive relationship between education and using drought tolerant variety and Soil and Water Conservation practices). The result is in line with Gadédjisso-Tossou (2015) and Adeoti et al. (2016) that confirmed as the educational level of the household head increases, the level of understanding about climate change adaptation increases so that likelihood of using drought tolerant and short season variety increases. The possible explanation is that educated farmers better recognize the risk associated with climate variability and hence tend to use appropriate adaptation measure on their farm plot than non- educated.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The findings from this study showed that most of the districts small-holder farmers' perceived an increasing trend in temperature and decrease in rainfall amount and the pattern becoming unpredictable. Farmers' perceptions of climate change and variability is in line with the climatic records.

According to small-holder farmers evaluative trend perception of the climate situation which was complemented by focus group discussion, and key informant interviewers there has been a continuous climate change and variability in district.. Climate change and variability has negatively impacted rain fed crop production in general and maize production in particular. As a result, the annual variability in crop production is observed and the general trend in crop yield is declining.

Based on meteorological data of rainfall in study district, the total yearly rainfall pattern for the past 25 years shows the decreasing trends in amount and a change in the timing of rainfall. This is in accordance with the perceptions of most farmers towards rainfall.

According to focus group discussion, key informant interview and respondents perception, in KedidaGamelaworeda, end of May and mainly beginning of June, is corresponding to the main growing season because in May precipitation was found to have positive impact on maize crop production. Likert scale measurement and inferential statistics were also used to asses small holder farmers' perception on variability and climate change and its effect on maize crop production and binary regression model were used to analyze factors determining maize producers adaptation strategies

According to Descriptive statistics and Likert scale measurement, the results revealed that majority of the farmers were well aware of the increase in temperature and the decrease in rainfall. Decreased rainfall amount (hhs perceived level is 82.3% which is very high level of perception), change in rain season(setting and ending time, hhs perceived level is 85.37 % which is very high level of perception) , Increase(high) in temperature(hhs perceived level is 100% which is very high level of perception), unpredictable rain fall(hhs perceived level is

86.6% which is very high level of perception)), erratic rain fall(77.4%) and , recurrent drought(hhs perceived level is 90.85 % which is very high level of perception).

A five point Likert scale measure was also used to measure the level of perception of sample respondents for some selected attributes of climate change. According to the survey data, decreased rainfall, increased temperature, erratic rainfall, change of rain season, long and or short dry season, recurrent drought and decreased vegetation composition are the main drivers of vulnerability on smallholder farmers that respondents perceived.

The results of the study demonstrated that farm households applied a wide range of adaptation measures in response to the changes in climate. The most common adaptation measures/strategies selected by study district farmers for future maize crop production were use of drought resistant maize crop varieties, early planting of maize crop varieties, early maturing maize crop varieties, high yielding maize crop varieties, Water harvesting techniques and increased use of irrigation practices.

This implies that farmers in the study area noticed the change in climatic variables and have adopted various adaptations of maize production options to counteract the negative impact of climate change and variability in the area

.A multinomial logit model was used to identify factors affecting smallholder farmers choice of adaptation strategies to climate change. The study found out that there are five major adaptation strategies: early planting of maize crop variety, using drought resistant maize crop variety, early maturing maize crop variety , high yielding maize crop variety ,small scale irrigation practices. Accordingly, the result of multinomial logit model verified that , sex of the household head, age of households , education status of the households , farm income, access to credit, farmers extension service, access to climate information are statistically significant determinants and factors affecting of smallholder farmers' adaptation strategies. The strategy of drought resistant maize crop variety was positively related with sex of hhs, age of hhs, farm income, access to credit, farmers extension service, education status, climate information. Use of high yielding maize crop variety: was also positively related with sex of hhs, age of hhs, farm income, farmers extension service, education status, climate information .

Using early maturing maize crop variety was positively related with education level, farmers' extension service, farm size of hhs, and access to climate information. Early planting of maize crop practice was positively associated with sex of the household head, education status, farm income, access to credit, and farmer extension service and negatively associated with livestock ownership. Finally, the use of water harvesting techniques and irrigation practices was positively associated with education status of hhs, farm income, farmers extension service, marital status. The possible explanation is that educated farmers better recognize the risk associated with climate variability and hence tend to use appropriate adaptation measure on their farm plot than non-educated. According to the study result indicates that, the farmers source of information about climate change is one of the most important factors that determine maize producers choice and application of coping strategies, during focus group discussion, farmers mentioned that our source of climate information in order of importance were kebeles development agents (DAs) , which covers 67.1% ,Radio which covers 20.7%, farmers to farmers information 17.1%, mass media 9.75% and 10.5% households use television program as sources of information.

In the study area the amount of rainfall was decreasing and temperature increasing pattern for last years. The government should take responsibility for further plan and encourage an effective implementation of an alternative strategies that can minimize the farmers dependency on limited variety of maize crops .In this regard, an increased adaptive maize crop production technology has the potential to decrease the negative effects of climate change on maize crop production and productivity.

5.2 RECOMMENDATIONS

Based on the findings, the following recommendations are given

In terms of perceptions of climate change and variability, a need exists to narrow the gap between scientific knowledge on climate change and farmers' perceptions of the causes of climate change. Enhancing smallholder farmers' awareness about causes of climate change goes some way to address the gap. The level of perception of small holder farmers to climate change has a significant effect on the level of using adaptation strategies to lessen the effect of climate change. Therefore,

- emphasizing on awareness creation about the changing climate is crucial for enhancing farmers' resilience capacity
- In this regard, in the woreda increased adoption of adaptive agricultural technologies has the potential to decrease the negative effects of climate change on agricultural production and productivity specially maize crop production.
- the government should take responsibility on appropriate climate change and variability maize crop production adaptation strategies for smallholder farmers such as, using of drought resistant maize crop varieties, high yielding maize crop varieties, early maturing maize crop varieties, according to the season early planting of maize crop varieties, practicing water harvesting technology and irrigation

Adaptation to climate change requires credit provisions that are easily accessible to the poor farmers. Hence, availability of improved maize crop varieties, and expansion of maize crops production could help much in improving the districts small-holder maize producers.

Even though, the small holder farmers perceived there is Climate Change and variability in, their knowledge on how to adapt is not sufficient.

- Therefore, rising awareness about Climate Change effect on maize crop production and how to use modern agricultural technologies and farmers indigenous technologies is important to increase maize producers adaptation strategies of small-holder farmers in the woreda.

- In study area there were awareness gap on cause, consequence and its measurement, it is better creating and expanding awareness among the farmers about climate variability and change ,its causes and consequences by providing reliable and up to-date information to take appropriate adaptive measures.
- To this end Woreda, Zonal, Regional, and Federal governmental, Agriculture Sectors, NGOs should provide appropriate training for small-holder farmers, DA experts regarding dissemination, design, implementation and maintenance of climate change and variability related adaptation practices on a regular period based on crop production general and maize crop production particular.
- Woreda, Zonal, Regional, and Federal governments and NGOs should also aware farmers with using improved maize crop varieties, facilitating credit associations, and facilitating expansion of farmers extension service, introducing Water harvesting techniques and increased use of irrigation (WHT and irri).
- Promoting small-holder farmers“ access to credit is vital to secure immediate need of purchasing farm inputs and meet the costs associated with using various adaptation strategies: using drought tolerant maize varieties, using early maturing maize crop varieties, high yielding maize crop varieties , chemical fertilizer, water harvesting techniques and irrigation practices, and irrigation in response to climate change.
- Hence, future policies need to address barriers for the adoption of advanced adaptation measures at the farm level such as providing information and support, introducing climate smart maize varieties and promoting new adaptation measures for smallholder farmers based on different agro ecological zones
- Finally, further studies which could address the small-holders adaptation strategies and the existing challenges in various agro ecological conditions should be conducted so as to provide more options to policy formulation and enhance sustainability of livelihood of rural community in the face of climate change and variability in maize crop production.

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HAWASSA UNIVERSITY COLLEGE OF AGRICULTURE, FACULTY OF ENVIRONMENT GENDER AND DEVELOPMENTSTUDIES, MSC IN CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

I: Introduction

Dear Respondents, My name is Meharu Geneto, a graduate student in Hawassa University College of Agriculture, Faculty of Environment Gender and Development Studies, (Masters of Science in climate change and Sustainable Agriculture). I am conducting a research on: Small holder farmers strategies towards coping with the effect of climate change on maize crop in Kedida Gamela Woreda ,Kembata Tembaro Zone, SNNPR, Ethiopia » . Thus, I would like to express my appreciation in advance for your cooperation in giving me your time and being committed for the success of this work

INSTRUCTION TO ENUMERATORS

1. Make brief introduction to each interviewer before starting any question, get introduced to the interviewer (greet them in the local way), get his/her name, tell them
2. Yours, the institutions you are working for, and make clear the purpose and objective of your questions.
3. Please ask each question so clearly and patiently until the interviewer understands (gets your point).
4. Please fill up the questionnaire according to the interviewer reply (do not put own opinion).

Please do not try to use technical terms while discussing with interviewer and do not forget local unit.

Date of interview	
Time started at	
Questionnaire No.	
Interviewer's	Name:
	Cell phone:
Respondent's	
Cell phone	
Kebele	
Specific location (got)	

Section A- Respondent's Demographic and socio-economic characteristics

A1. Age (years) : _____

A2. Sex :a. female=0 b. male= 1

A3. Family size (No.) ;

A3a. Total family members: _____

A3b. Number of family members by age group

a. Under age 15 years b. 16- 50 years c. above 51 years _____

A4. Respondent's marital status:

a. Single=1.

b. Married=2

c. Widowed=3.

d. divorced=4

A5. Respondents Educational status

a. Unable read and write=1

b. Able read and write=2

c. Elementary=3

d. High school and above=4

A6. Respondents total land size and land use:

a. total holding (ha) : ____

b.for annual crop production _____

c. for perennial crop production ____

A7. Major crop types produced main purpose production in order of importance (during last two production seasons) by indicating :

mainly for HH consumption=1; mainly for market/cash= 2

.Crop type	Estimated average allocated land (ha)	Main Purpose of production
Annual crops		
Teff		
Wheat		
Maize		
Haricot bean		
Others (specify)		
Perennial crops		

A8.Respondent's livestock holding (No.)

Type of animal	Quantity
Cattle	
Small ruminants	
Chicken	
Aquins	

A9. Respondents estimate of average income during past production year by type of income sources (in ETB)

Source of Income		Amount (ETB)
Farm income	Yield of crop	
	Yield of livestock	
Off farm income		
Total annual income		

A10. Respondents maize production farming experience (in years)_____

A11. Respondents DA advisory service by number/ frequency of contact ,

A11 a. how many times in a week:-----

A11b. how many times in a month: -----

Section B To assess small holder producers perception on climate variability and change and it's effect on maize production in the study area;

B1. Do you think there is a climate change and variability in your area?

a. yes= 1 b. no= 0

B2. Have you observed climate change and variability in your area during the last from now?

B3. If your response for QB2 is "yes" what are the major indicators of climate change you observe in your locality ? Indicate your level of perception about the change as: very high =1; moderate=2; low=3

..no Perceived indicator climate change	perceived level of change		
	1	2	3
1. Change in local climatic features			
Change in rain season (setting and ending time)			
Short and or longer rain season			
Decreased in rainfall amount			
Increased rainfall amount			
Long and or short dry season			
Change in temperature Recurrent drought			
Increased /high/ temperature			
Decreased/low/ temperature			
Flooding			
Recurrent drought			
2. Change in agro ecology			
Decreased vegetation cover			
Decreased vegetation composition			
Others (specify)			

B4. How do you rate your HH level vulnerability to the impacts of climate change /variability impacts on?
By rating as : highly vulnerable =1; moderately vulnerable =2; less vulnerable=3

Type of impacts	Perceived self-vulnerability level of impact		
	1	2	3
Reduction of maize Crop yield			
Loos of indigenous maize varieties			
HH food shortage			
Shortage of animal feed			
Reduction of livestock production			
Reduction of soil fertility due to flooding of farm lands a			
New emerging and Intensified crop pest on maize (insects and weed)			
Others (specify)			

B5. If your response for QB1 is “yes” what are the major impacts of climate change you observe in your locality? Indicate your level of perception about the level impact on your maize production as : Very high =1; moderate=2 ; low=3

.Perceived/Observed impact of climate change	Perceived level of impact		
	1	2	3
Reduction of Crop yield			
Loss of indigenous varieties			
Shortage of food			
Shortage of animal feed			
Reduction of livestock production			
Reduction of soil fertility due to flooding of farm lands			
Intensified crop pest (insects and weed)			
Others (specify)			

C To identify factors determining the smallholders’ choice and application of adaptation strategies for the impact of climate variability on maize production in the study area.

C1. What is your source of information about the climate change? By level of importance as:a. always = 1; b. most of the time=2, c. sometime=3

Information source	Experience using the source		
	1	2	3
Mass media			
Radio			
TV			
Other (specify)			
Development agent			
(Colleagues) Farmers			

C2. Do you have access for credit from any sources? a) Yes =1 b) No=0

a. If YES, did you get credit for the past years? a) Yes =1 b) No=0

b. If “Yes”, how much money did you borrowed from any of the following sources during the past years? Total ofbirr

no	Credit Sources	yes	No	How often?	Total Amount borrowed (ETB)
1	Relatives				
2	neighbors				
3	Religious				
4	Farmers association or cooperative				
5	Commercial Banks				
6	Traders				
7	Saving and credit association				

C3. Did you get any training on climate change and variability related impact issues from any organization? a) Yes=1 b) No=0

C3a. Do you receive any support from agricultural extension workers (DAs) which could help improve your maize crop production? a) Yes=1 b) No=0

Section D: To identify smallholder maize producers’ adaptation strategies in response to effects of climate change and variability in the study area

D1. Are you aware of there are appropriate/adaptation strategies/ technologies to reduce the impact of climate change and variability on your maize production

a. Yes=1 ; b. No=0

Adaptation strategies	
Small scale irrigation practices	
Mulching	
Drought resistant maize crop varieties	
Early maturing maize crop varieties	
High yielding maize variety	
Early planting of maize varieties	
Crop diversification	
Mixed farming	
Application of agro-chemicals	
Fertilizer usage and application of animal manure	
Water harvesting techniques and increased use of irrigation	

A. Interview checklist for Focus group discussion

Date of Interview ____/____/____

Name of Kebele _____

Name / code FGD _____

1. Do you think there is a climate change and variability in your area?
2. Have you observed climate change and variability in your area during the last from now? explain
3. What are the local indicators of climate change you observe in your locality?
4. Explain the major impacts of climate change on maize you observe in your locality?
5. What are the main crops grown in your area? List in order of importance
6. Do you think climate change or variability posed negative effects on your maize crop production? If Yes, Please explain how.
7. How can you get information about the climate change and variability?/sources of information
9. Did you get any training on climate change and variability related impacts on crop production/maize crop production from any organization? Explain
10. How do you adapt the impacts of climate change and variability on maize crop production in your locality?
11. How do you explain technology or practice you have applied on your maize farm?

B. Check lists for Key Informant Interview

1. Name _____

Position/profession _____

2. What is the agro-ecology of your area/woreda/district?

3. Is there any form of climate change in your district? If your answer is yes, please explain

4. Explain local indicators of climate change and variability mainly on maize crop production?

5. Explain the major impacts of climate change you observed in your districts in crops production?

6. What do you think is the impacts of climate change & variability on the livelihoods of farmers?

7. Please explain how, climate change or variability posed negative effects on maize crop production in your woreda?

8. What are the main crops grown in your woreda/district? List in order of importance

9. What is the Productivity trend of maize crops in kedida Gamela Woreda/kebele?

10. How do you explain vulnerability of the impacts of climate change /variability impacts on maize crop production in your woreda?

11. How your woreda farmers/households get information about the climate change and variability?/sources of information

12. What is the role of institutions like GOs, NGOs, in facilitating adaptation to climate change in your woreda/district? Explain

. Linear Regression through the Origin

Model	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
sexof resp.	.099	.048	2.049	.042**
age of resp.	.042	.054	.779	.437**
family size of resp	-.038	.030	-1.243	.216
unpredictable rainfall condition	.044	.096	.455	.650
farmers credit sources	.154	.049	3.163	.002***
farmers exst.service	.003	.038	.084	.933
marital statusof rep.	.243	.044	5.525	.000***
Edu status of rep	.094	.038	2.451	.015**
change in rain season	.199	.053	3.775	.000***

30 years Average rainfall of kedida Gamela districts: from national meteorological Agency ,Hawassa Branch

Station Name	Class	Region	Zone	Wereda	Longitude	Latitude	Altitude (in M)	Element	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	1997	31.1	0.0	36.4	126.9	109.1	140.4	100.5	144.0	141.0	179.8	163.3	21.5
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	1998	31.8	73.6	103.6	164.4	183.1	96.9	182.4	197.4	107.7	204.8	90.9	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	1999	26.2	2.2	118.8	87.0	92.4	170.3	166.7	107.9	101.6	188.0	3.5	1.4
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2000	0.0	0.0	28.8	202.9	114.7	134.3	145.6	146.6	156.9	115.7	96.2	29.4
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2001	11.3	53.9	144.8	104.4	143.1	103.7	257.3	205.4	107.5	163.4	12.9	10.3
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2002	57.3	49.1	132.1	#NA	101.8	103.7	116.9	209.2	120.6	23.0	0.0	120.3
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2003	23.7	12.1	77.7	205.8	77.2	131.3	200.5	120.6	123.7	20.7	44.2	15.6
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2004	99.3	29.2	57.8	183.9	80.2	54.2	159.1	126.5	109.7	150.0	10.6	6.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2005	50.1	25.9	127.8	322.3	269.2	35.8	67.1	100.9	285.0	117.1	59.7	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2006	2.5	47.1	78.7	196.8	83.9	40.2	113.0	228.2	37.2	95.7	20.0	10.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2007	34.5	59.0	84.5	127.0	158.6	97.3	157.5	94.4	170.1	32.2	0.0	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2008	0.0	0.0	33.6	46.0	145.1	112.9	174.0	124.1	148.3	117.2	103.4	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2009	43.4	7.4	30.9	101.3	65.2	56.8	133.8	123.9	74.2	97.2	29.7	88.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2010	30.2	40.0	101.3	100.7	158.2	89.7	134.5	98.2	198.3	26.6	9.2	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2011	1.8	4.4	46.0	96.4	267.4	156.0	219.0	225.5	108.0	0.0	76.7	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2012	0.0	0.0	38.2	176.9	55.6	175.7	160.6	117.5	180.3	6.5	23.8	71.2
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2013	20.1	8.2	108.2	130.4	245.1	166.6	137.2	233.5	121.8	130.0	79.5	5.3
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2014	9.6	63.4	121.3	0.0	286.4	47.8	165.7	274.9	270.0	0.0	0.0	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2015	0.0	1.8	28.7	90.1	195.8	120.6	95.2	0.0	28.0	71.9	104.0	1.3
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2016	55.1	39.6	64.4	338.1	256.8	121.5	267.7	94.5	162.3	69.4	124.8	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2017	#NA	48.1	63.6	18.7	165.4	66.1	294.5	#NA	299.6	127.0	10.4	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2018	0.0	92.5	167.9	206.1	173.4	207.8	150.7	254.8	96.6	135.8	217.6	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2019	#NA	10.6	68.6	258.9	121.5	314.7	270.1	323.5	244.2	149.9	132.6	#NA
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2020	100.9	105.9	319.9	397.5	356.9	403.3	638.0	465.7	225.9	72.4	38.8	0.0
Durame	3 rd	SNPR	Karbata Terib.	Kedida Gamela	037° 53' 49.4" E	07° 14' 36.1" N	2116	Monthly Total PF	2021	0.0	69.9	3.4	0.0	202.3	19.1	680.4	293.7	177.0	178.9	#NA	#NA

20 years Average maximum temp.of kedida Gamela worda: from national meteorological Agency ,Hawassa Branch

Station Name	Class	Region	Zone	Wereda	Longitude	Latitude	Altitude (in M)	Element (in °C)	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2006	NA	NA	NA	NA	25.8	24.4	23.9	23.1	25.7	25.7	25.4	26.0
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2007	26.2	25.8	27.7	26.0	26.1	24.7	21.9	23.6	23.4	24.9	26.2	26.1
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2008	NA	28.1	28.3	26.4	24.3	23.3	20.4	21.1	23.6	24.1	23.4	24.4
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2009	25.4	26.8	28.5	26.5	26.1	26.4	25.1	26.0	25.0	27.7	28.1	26.9
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2010	29.8	31.6	29.7	28.3	26.5	27.3	24.3	25.6	24.6	25.8	26.5	NA
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2011	25.2	29.3	28.7	29.7	NA	28.2	25.8	24.4	25.0	25.7	26.4	26.9
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2012	29.3	30.5	31.2	25.6	26.4	25.2	23.2	23.6	24.4	26.5	27.6	27.5
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2013	28.5	NA	NA	NA	NA	24.0	22.9	23.5	25.6	27.9	29.9	30.7
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2014	29.8	29.4	29.1	NA	27.7	27.6	25.0	24.7	25.3	NA	NA	NA
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2015	29.2	30.6	28.9	28.7	27.2	25.5	26.2	29.1	30.4	26.2	26.7	28.8
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2016	27.9	29.1	29.7	24.6	25.2	24.1	22.6	23.6	24.3	27.2	27.9	NA
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2017	NA	28.7	30.3	28.6	24.6	25.3	21.8	NA	NA	25.3	28.6	30.4
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2018	NA	28.8	29.1	NA	27.6	NA	25.0	23.9	NA	26.9	26.0	28.7
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2019	NA	30.2	28.2	26.1	26.0	24.8	23.3	23.8	NA	25.2	27.0	28.4
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2020	29.1	27.9	26.4	25.9	25.5	23.9	22.1	22.0	24.0	25.1	26.4	NA
Durame	3 rd	SNWR	Kenbata Terib.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg.Max.Temp	2021	28.5	28.4	30.8	27.4	26.5	26.5	22.6	23.3	24.3	25.1	NA	NA

20 years Average minimum temp.of kedida Gamela woreda: from national meteorologicalAgency ,Hawassa Branch

Station Nam	Class	Region	Zone	Wereda	Longitude	Latitude	Altitude (in M)	Element (in °C)	Year	Ja	Fe	Mr	Ap	Mr	Ju	Ji	Ag	Se	Ok	Ne	De
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2006	NA	NA	NA	NA	13.6	14.7	17.5	17.6	18.1	NA	NA	NA
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2007	NA	NA	NA	NA	13.4	14.1	13.5	13.4	13.3	12.8	13.6	13.3
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2008	13.8	13.9	14.3	13.5	13.2	13.4	13.5	13.3	13.2	13.3	13.3	12.9
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2009	13.3	13.2	14.4	13.6	13.7	14.0	13.6	14.3	14.1	13.3	13.5	13.4
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2010	14.4	13.7	14.2	13.9	14.2	14.2	14.9	14.6	15.5	14.4	14.2	NA
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2011	15.2	13.8	14.1	14.6	15.4	14.7	15.2	15.9	15.3	14.4	15.1	15.0
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2012	14.6	14.6	14.3	15.6	14.9	15.8	16.8	16.4	15.3	14.6	14.9	14.9
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2013	15.4	NA	NA	NA	NA	17.0	17.1	17.0	15.5	14.8	14.6	14.8
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2014	14.8	15.0	15.0	NA	17.0	16.1	16.7	16.3	15.9	NA	NA	NA
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2015	15.1	14.8	15.8	15.9	16.1	16.0	15.9	15.0	15.1	15.4	15.4	15.0
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2016	15.6	15.2	15.7	17.3	16.8	16.8	18.0	17.7	16.7	14.9	15.7	NA
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2017	NA	15.3	15.0	15.7	17.2	15.9	16.9	NA	NA	16.5	14.2	13.7
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2018	NA	14.6	15.1	NA	14.7	NA	15.8	16.3	NA	14.9	14.2	14.0
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2019	NA	14.1	14.9	15.9	15.1	15.8	15.9	15.9	NA	15.1	15.0	15.0
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2020	14.6	15.0	15.7	16.9	15.8	16.8	17.7	15.5	16.3	14.9	15.4	NA
Durame	3 rd	SNPR	Kantata Tenb.	Kedida Gamela	037 ^o 53' 49.4" E	07 ^o 14' 36.1" N	2116	Avg. Min Temp.	2021	16.15	16.91	15.66	17.41	17.1	15.6	17.5	17.1	16.5	16.2	NA	NA