THE LIVELIHOOD VULNERABILITY AND ADAPTATION STRATEGIES OF SMALLHOLDER FARMERS TO CLIMATE CHANGE AND VARIABILTY IN MAREKA DISTRICT, DAWURO ZONE, SOUTH WEST ETHIOPIA

M.SC THESIS

GIRMA MITA ABDETA

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BY: - GIRMA MITA ABDETA

ADVISOR: Dr. MULUKEN MEKUYIE

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ADVISORS' APPROVAL SHEET

HAWASSA UNIVERSITY SCHOOL OF GRADUATE STUDIES

This is to certify that the thesis entitled "Livelihood Vulnerability and adaptation strategies of smallholder Farmers to the Climate Change and Variability in Mareka District, South West Region, Ethiopia" submitted in partial fulfilment of the requirements for the degree of Master of Science with specialization in Climate change and development in the Department of General Forestry, Wondo Genet College of Forestry and Natural Resources and has been carried out by Girma Mita Abdeta, ID. NO. GPCCDeR/003/14, under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the courses of this investigation have been duly requirements.

_____	_____	_____
Name of Major advisor	Signature	Date
_____	_____	_____
Head of department	Signature	Date

EXAMINERS' APPROVAL SHEET

We, the undersigned, members of the Board of Examiners of the final open defense by Girma Mita have read and evaluated his thesis entitled Livelihood Vulnerability and adaptation strategies of smallholder Farmers to the Climate Change and Variability in Mareka District, South West Region." and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science.

_____	_____	_____
Name of the Chairperson	Signature	Date
_____	_____	_____
Name of Internal Examiner	Signature	Date
_____	_____	_____
Name of External Examiner	Signature	Date
_____	_____	_____
SGS approval	Signature	Date

STATEMENT OF THE AUTHOR

First of all, I, Girma Mita, declare and state that this entitled **"Livelihood vulnerability and adaptation strategies of smallholder farmers to the climate change and variability"** in three kebeles in Mareka Wereda, South West Region, and Ethiopia in my work and that all the sources of material used for this thesis have been properly acknowledge. This thesis has been submitted in partial fulfillment of the requirement for a degree of MSC from the school of graduate studies at Hawassa University.

Name: Girma Mita

Signature: _____

Place: Hawassa University, Wondo Genet, Ethiopia

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LIST OF ABBREVIATIONS AND ACRONOMS

CSA Central Statistical Agency

GDP Gross Domestic Product

GHG Greenhouse Gas

IPCC Intergovernmental Panel on Climate Change

KII Key Informant Interview

LVI Livelihood Vulnerability Index

MoA Ministry of Agriculture

NMA National Meteorological Agency

NAPA National Adaptation Program of Action

FGD Focus Group Discussion

SPSS Statistical Package for social Science

SRS Simple Random Sampling

UNFCCC United Nation Framework Convention on Climate Change

UNCCD United Nation Conventions on Combating Desertification

USAID United States Agency for International Development

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ABSTRACT

Ethiopia is among the most susceptible countries in the world due to climatic variability and change, which can lead to flooding and drought. Climate change occurs by high temperature, scarce rainfall, and high amount of rainfall variability reduces crop yield and shortage of food security in low income and economies that based on agriculture. The main objective of this study was to explore and analyze Livelihood Vulnerability of smallholder Farmers to the Climate Change and Variability in Mareka District, South West Region, and Ethiopia. Both qualitative and quantitative methods were used for this research data collection and analysis. Primary data were collected from ***117*** *randomly selected farming households from three kebeles using structured questionnaires, interviews, focus group discussions and observations. Data on rainfall and temperature from 1992 to 2022 as well as Mann-Kendall test and regression analysis was used to detect trends and variability. A modified form of Sustainable Livelihoods Framework combined with Livelihood Vulnerability Index was employed to estimate livelihood vulnerability. According to the survey results, about 79.5% of the respondents perceive that the rainfall amount in the study area is decreasing. But the results are not supported by, long-term recorded rainfall data showed that the annual rainfall is increasing by the rate of* ***4.6206*** *mm annually over the past 31 years despite being statistically non-significant, the mean annual rainfall was* ***1316*** *mm with 25% of the coefficient of variation which is moderately variable based on the degree of variability. Similarly, 80% of interviewed farmers said that temperature is an increasing trend, which confirms the results from the analysis of long-term recorded data by NMA that indicated the mean average minimum and maximum temperatures are increasing by 0.069* ^{0}C *and 0.027* ^{0C} *per annum respectively. The result from the analysis of vulnerability to climate change indicated that about 22% of farmer's livelihoods were highly vulnerable to climate change and variability, 48% were medium vulnerable and 29.9% were least vulnerable to climate change and variability due to high exposure, low adaptive capacity, and high sensitivity in the study area. Furthermore, the study revealed that the farmers of mareka district took a number of measures to adapt to climate change within their capacity. These adaptation strategies include planting early maturing varieties, planting high-yielding varieties, changing crop variety, crop diversification, soil and water conservation, Emphasis on live stock keeping instead of crop cultivation, practicing crop rotation and practicing agro forestry. The main barriers to adaptation to climate change are the economic status of households, poor infra structural development, poor farming system, lack of credit access, low educational level of households, and lack of labor. Therefore, government should be trains and teach farmers on the issue of climate change to create awareness ,upscale the local adaptation strategies and support to overcome the vulnerability to climate change and constraints in which they face in using adaptation strategies to climate change and so that ensure sustainable livelihoods.*

Key words**: *Climate Change, Mareka district, Mann-Kendall, Livelihood Vulnerability, Adaptation.***

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the study

Climate change is the change in the events of climate lasting for an extended period of time. In other words, climate change refers to, among other things, changes in temperature, precipitation, patterns or wind speed that have occurred or are occurring over several decades or longer (IPCC, 2007). In the 21st c, climate change has assumed to be the environmental challenge, and it will continue across the world (Johannes 2012; IPCC 2014).The global impact of climate change on developed and developing countries is challenge for survival and livelihood of the global community (Tesso *et al*., 2012). The IPCC report showed that, the global mean surface temperature has been increased by 0.6 (0.4 to 0.8) over the last 100years.This increasing global mean surface temperature lead to changes in precipitation and atmospheric moisture (IPCC, 2001). Also increasing trend of the temperature and rainfall condition fluctuates from season to season and shows variations in climate. The global average temperature has shown a warming trend of 0.85^0c over the period 1880-2012 (IPCC 2014). The livelihood vulnerability of smallholder farmers to the climate change causes an adverse effect on their living conditions globally. The increasing rate (frequency) of disasters due to the impact of climate change has affected the livelihood systems of small farmers, especially in agrarian based developing countries (H. Guo *et al*., 2021).

Africa is highly vulnerable to climate change and variabilities (Bryan *et al*., 2010).In Africa, mean temperature levels have increased whereas precipitation levels have declined (IPCC, 2001). Temperature increase between 3 and 4 in Africa by the end of the 21st century (Bryan et al., 2010).This increase of temperature made Africa to be highly vulnerable to climate change and variability (Challinor *et al*., 2007). Majority of the livelihood of Africa is

vulnerable to the climate change since their economies are highly depend on climate sensitive agricultural production (Mohamud Yesuf *et al*., 2008)

Ethiopia is the second largest populous country in Africa with population of over 100 million. Its economy highly dependent on rain fed agriculture which supports more than 85% of the population and contributes about 50% of the country's gross domestic product (GDP) (GFDRR, 2011; Gizachew and Shimelis, (2014). Ethiopia is frequently mentioned as another nation that is extremely susceptible to changes in the climate. The prospective adverse effects of climate change on Ethiopia's agricultural production are the major concern of factors for the smallholder farmers' livelihood to be dwindling or decrease from time to time. Ethiopia is frequently ranked among the most vulnerable nations (Krishnamurthy *et al*., 2014) and is highly exposed to the effects of climate change (Conway and Schipper, 2011). Significant or major influence of current climate variability and extreme events are observed and expected to increase in the future (Daze, 2014). Agriculture is in general one of the most affected sector by climate change and variability (IPCC, 2014). In this regard, climate – sensitive agriculture always suffer because there is variability in temperature as well as rainfall. In case of these factors, small holder farmers' living standard becomes under the shadow of death and they lack livelihoods.

Like farmers elsewhere in Ethiopia, the mareka farming community in Dawuro zone is harmed by climatic changes that have become commonplace natural calamities in the nation. There has been more erratic rainfall from June to September ('Kiremt') and from February to May ('Belg') rainy seasons. These have been bringing drought and reduction in crop yields and plant varieties; the rainfall especially is destructive heavy downpours, bringing floods and soil erosion in the study area. Also, there has been an increase in temperature which influences the physiology of crops, the micro-climate and the soil system in which the

farmers cultivate. The present study was conducted in mareka wereda in Dawuro zone in South West Regional State (SWR).

1.2 statement of the problem

Ethiopia experienced10 wet and 11 dry years over the last 55 years, indicating the strong inter-annual climate variability (National Meteorology Agency 2007). This variability leads climate change impacts upon the livelihood of smallholder farmers and put them to be under the challenge of vulnerability. In Mareka district, climate change and variability has been leading adverse effects on the livelihood of farmers in the area (Mareka District, (2014). Agricultural and Natural Resource Management Office report).

Climate change is a major concern in Ethiopia because of its adverse effects on Ethiopia's agricultural sector, particularly given the country's dependence on agricultural production. In case of these the variation in temperature and rainfall results serious damage to the livelihood vulnerability of smallholder farmers (Mareka District, (2014). Agricultural and Natural Resource Management Office report).

Hence, in Mareka district, there were problems of hazards associated with climate change and variability such as recurrent drought, land degradation, erosion, and flooding which is caused by the variation in temperature and rainfall distribution (Mareka District, (2014). Agricultural and Natural Resource Management Office report).

The impact of climate change varies from place to place, regions to regions, sectors and social group and communities due to uneven distributions of resources. It is recognized that the impacts of climate change within the same regions, adaptive capacity and vulnerability will vary (IPCC, 2001).

This calls for the need to raise the livelihoods of farmers in systematic inquiry of analyzing the vulnerability of smallholder farmers to climate change and the adaptation strategies practiced by them. Hence, this study was designed to fill the existing research gap in mareka

district in Dawuro zone in South West Regional State of Ethiopia with respect to farmers' vulnerability and adaptation strategies to climate change and variability

1.3 Objectives

1.3.1 General objectives

- The general goal of the study is to clearly understand the vulnerability of small holders in the mareka district south west Ethiopia

1.3.2 Specific Objectives

- To analyze the trend of climate change over three decades (1992-2022 years) in the study area.
- To examine the magnitude of vulnerability on small holder farmers' livelihood in the study area.
- To identify the adaptation mechanism used by small holder farmers in the study area.

1.4 Research Questions

a. In what patterns of climate variability and change trends exist in the study area?

b. What is the status of smallholder farmers' vulnerability to climate change?

c. What adaptation mechanisms are employed by small holder farmers to adapt and cope with climate variability and change?

1.5 Significance of the Study

The study is significant as there is a gap of knowledge on the vulnerability and adaptive capacity and adaptation strategies of smallholder farmers to climate change based on livelihood approach in Ethiopia, in general, and Dawuro zone Mareka district in particular. Hence, analyzing grass-root level findings inform the government at different levels with more critical and accurate information to prioritize the support needs of the local communities. The findings of this study are likely to be relevant for other livelihood farmers with similar production systems, geographical profiles and socio-economic settings in Ethiopia. The findings of this study is also useful for academicians, stakeholders,

policymakers, and governmental and non-governmental organizations both at local, regional and federal levels to design location-specific, efficient and effective, flexible and responsive approaches for appropriately targeted vulnerable smallholder farmers for building their resilience capacity to climate change. Finally, this study would be focused on the support of reducing risk of climate change and to recognize the living condition of small holder farmers in the history and help all society should understand and to take care based on the searching solutions for the sustainable livelihood and investigating the major problems that causes climate change and its effects on the socio-economic aspects.

1.6 Scope of the Study

It is known that terms like climate change, vulnerability and adaptive capacity/resilience are becoming the recently catchy words in the developing world lexicon. Describing vulnerability and adaptive capacity, socio-economic and biophysical conditions of smallholder farmers in their local contexts is difficult as the concepts are dynamic and multidimensional, which deserves systematic exploration of contributing as well as hindering factors. The scope of this study is delimited by agro ecology, geography, farming system, and farmer's livelihood. With regards to geography, the study is undertaken in Mareka district, which is located in Dawuro zone. The study was focused on three kebeles based on community level, namely; (i) Gendo kebele, (ii) Gudumu kebele (iii) and Yamala kebele. Even though the study is limited to a specific area with different kebeles its findings will offer a useful understanding of similar contexts in other areas bordering administrative kebeles and zonal levels. In terms of response measures to climate change, the scope of the study was confined to coping and adaptation rather than mitigation to climate change and households were taken as units of analysis. Because mitigation attempts to reduce greenhouse gasses take time and are frequently challenging and subject to protracted international

negotiations, coping and adaptation should be prioritized as an urgent policy imperative and research focus.

1.7 Limitations of the study

The study uses the indicator method of livelihood vulnerability assessment due to its convenience to the objectives of the study. However, it may have limitations as a sense of subjectivity might be involved in the selection of indicators used to measure determinants of vulnerability and the overall vulnerability of farmers' livelihood. Hence, there might be other unselected indicators that may have increasing or decreasing effects on the vulnerability of farmers' livelihoods. Furthermore, during this study there were resource scarcity and time shortage for the data collection in all my carrier.

CHAPTER TWO

2. LITERATURE REVIEW

Definition of main words

Climate: In a limited sense, climate is typically defined as the typical weather, or more precisely, as the statistical description of important values over timescales ranging from months to hundreds of millions of years. The International Meteorological Organization specifies 30 years as the traditional time frame for averaging these variables. Most frequently, surface variables like temperature, precipitation, and wind are relevant values. The status of the climatic system, including a statistical description, is referred to as climate in a broader meaning (IPCC, 2018).

Climate change: - is defined as any change in the climate over time, whether brought on by human activity or natural variability. It can also be defined as alterations in the mean and variability of the climate's properties that last for a long time, usually decades or longer (Panthi *et al*., 2015).

Climate Variability: - refers to variations in the mean state of the climate on temporal and spatial scales beyond that of individual weather events. 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) (Fussel *et al*., 2006).

Smallholder farmers are farmers who own less than one-hectare plots of land on which they grow subsistence crops and one or two cash crops relying largely on family labor. In different countries, they are variously described as family farmers, subsistence farmers, poor farmers, and peasant farmers (Lowder *et al*., 2014).

Livelihood- is a means of securing the necessities of life and source of living subsistence and income.

Vulnerability- is the quality of being exposed to the possibility of being attacked or wounded either physically or emotionally susceptible to the impacts of hazards. According to IPCC (2001) vulnerability to climate change is defined as"the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the severity of climate change, the system's susceptibility to changes in climate, and the system's capacity for adaptation." Furthermore, a system that is very susceptible to even slight alterations in the environment and whose capacity for adaptation is severely limited is considered highly vulnerable (McCarthy *et al*., 2001).

Livelihood vulnerability- means living condition of the people damaged by the cause of climate change and the extent to which communities are exposed to physical effects. Vulnerabilities of livelihood for small holder farmers attacked from the long period of time due to the continuous change of climate variability and its articulated risks on agricultural productions of each individual household of livelihood damaged or dropped below the level of welfare. So that it would be incorporated and considered to change the extent of small holder farmers' livelihood under this study.

2.1. Evidence of Global climate change

Globally, there are records of the climate going back around 100 years. These 100 years have witnessed an increase of GHGs and change in the climate system. Both short-term and long-term climatic changes have had a significant impact on economic and social history. These days, the world's climate is growing more unpredictable due to the burning of fossil fuels and deforestation, endangering people's lives and means of subsistence everywhere (Ackerman, 2009). Both scientific evidence and human perception have been used to demonstrate the existence of climate variability and change. In the light of incontrovertible evidence of a more fundamental shift in the climate, research into how we could adapt to this would be paramount (Balling, 1997). On a global scale, the main cause of climate change is a growing

concentration of greenhouse gas (GHG) emissions of mainly carbon dioxide (70%), primarily coming from burning of fossil fuel(petroleum) imported from industrialized countries, while other sources GHG are methane and nitrous oxide which are caused by deforestation and agricultural activities particularly, the use of pesticides.

2.2. Climate Change and Developing Countries

The effects of climate change are substantial, particularly in the developing world. These countries are highly dependent on climate-sensitive natural resources. Agriculture is typically negatively impacted by sectors for livelihood and income as well as climate difficulties anticipated for the tropics and subtropics, home to the majority of developing nations (IPCC, 2007). In addition, low levels of human and economic development and high rates of poverty limit the ability of emerging nations to adjust to climatic changes.

The majority of the developing world is in a state of high sensitivity to climate change as a result of these factors working together. Poor nations are more susceptible to the effects of climate change as well as other stresses since they have a lower ability for adaptation. The poorest individuals have the worst form of this illness. IPCC (2007) many regions and countries will be capable of adapting to climate change but the poorer regions will have difficulties responding to climate change. There is no doubt that climate change will have a negative impact on many socio-economic sectors around the world, particularly those related to water resources, agriculture, forestry, fisheries, and human settlements, as well as ecological systems and human health, with developing nations being the most vulnerable (IPCC, 2001).

2.3. Climate Change and its Impacts in Africa

The IPCC report on the regional implications of climate change states that due to widespread poverty, Africa is the continent most susceptible to the effects of anticipated changes. Due to the importance of agriculture to the economy of the majority of African nations and the reliance of the farming sector on

rainfall during the rainy season, the region is particularly vulnerable to climate change. As a result, the rising frequency of drought poses a very serious danger to food security. It has been stated that the risks and susceptibility associated with drought in Africa are likely to be the most detrimental effects of climate change (Downing, 2001). Sufficient evidence shows that the average temperature rise in Africa is faster than the global average and is likely to persist in the future. The warming is definitely hazardous for agricultural activities in the continent as many of the crops are grown close to the thermal tolerance limits. The warming of a few degrees and increase in frequency of extreme weather will consequently strongly influence agricultural production and makes the society a victim of the events and decreases future adaptive capacities (Mendelssohn,1999). A recent study also shows that there was a dramatic decline in average rainfall conditions in all West African dry lands from the period 1960-1990. Some of the regions in the zone with semi arid conditions in 1930-1960 had become arid (on average) in the 1960-1990 period, considerable part of the sub-humid zone the period 1930-1960 had ended up semi parched in 1960-1990 with impressive dry spell dangers, certainly for crops which are less versatile to dry season stretch (maize, cotton) (Collier, 2008). Furthermore, Africa suffers from climate or water-related diseases, such as yellow fever, cholera, river blindness, bilharzias are malaria and tuberculosis.

2. 4. Climate change Impacts and Responses in Ethiopia

2.4.1 Climate change and variability in Ethiopia

Ethiopia is one of the developing nations specifically impacted by climate change. The climate information for 50 a long time (1951-2006) appears that temperature has expanded by 0.37^0c each ten a long time (MoWRNMA, 2007). Many industries and regions of the nation were directly impacted by the growth. The nation already struggles with a number of environmental issues, including desertification, deforestation, soil erosion, and loss of biodiversity (Deressa, 2010). Recurrent droughts, floods, starvation, and a lack of food security are the most obvious issues. High sensitivity to climatic risks is correlated with reliance on livelihoods that are climate-sensitive, low economic growth, low service coverage, underdeveloped water resources, poor road infrastructure, minimal capacity for

adaptation, and weak institutions. The economy is predominantly supported by rain-fed agriculture, which accounts for 80% of employment, 60% of foreign exchange revenues, and 45% of GDP (CSA, 2007; MO FED, 2010). Production is subject to variations in rainfall because it depends on undiversified livelihoods based on rain-fed agriculture. Such reliance continues to be the root cause of vulnerability to poverty, food insecurity, and their repercussions, such as malnutrition.

2.4.2 Local community perception on climate change and variability

Local community's perception to their environment is critical because their perception basically determine the socio-economic condition in their surroundings. Changes in the daily decisions made by billions of people are necessary for effectively mitigating and adapting to climate change (IPCC, 2007).That they collectively have a significant impact on Earth's climate, but very little is known about how local communities and other international parties feel about climate change (IPCC, 2001). Despite being the main guardians of natural resources, local people have little influence over policy development. Their exclusion from this process de-motivates them and this makes it difficult for local projects to achieve their goals. The lack of appropriate incentives for community involvement in Conservation is an important issue that needs to be considered. Furthermore, there is a lack of awareness on how daily personal actions contribute to the issue of climate change (Dumaru, 2010).

2.4.3 Impacts of climate change in Ethiopia

The Ethiopian climate is characterized by a history of climate extremes, such as droughts and floods; and increases and decreases in temperature and precipitation, respectively. The history of climate greatly extremes, especially drought is not a new phenomena in Ethiopia. The recorded history of droughts in Ethiopia dates back to 250BC. Since then, many sections of the nation have experienced droughts at various times. Even though there is a long history of droughts in Ethiopia, studies show that the frequency of droughts has increased over the

past few decades, especially in the lowlands (NMS, 2007). The environment has emerged as a major issue in Ethiopia in recent years. Land degradation, soil erosion, deforestation, biodiversity loss, desertification, periodic droughts, flooding, and air pollution are the nation's primary environmental issues. Their inadequate capacity for adaptation and the great susceptibility of their socioeconomic systems to climatic fluctuation and change are to blame for this. Within a nation, there are differences in sensitivity and adaptation ability based on sectors, geographical regions, time, and social, economic, and environmental factors. Ethiopia is already facing considerable challenges from the current climate variability, including natural disasters, resource degradation, impacts on food security, water and energy availability, poverty alleviation, and sustainable development initiatives (WRI, 2005).According to National Meteorological Station Agents (NMSA) (2010), the average annual minimum temperature over the country have increased by about 0.25 °c every 10 years, while the average annual maximum temperature increased 0.1^0c by every decade.

2.4.4 Adaptation mechanisms of climate change and variability in Ethiopia

Ethiopia has recognized climate change has adverse effects on the country's development agenda. As a result of this, the country ratified the UNFCCC (in May 1994), UNCCD (in June 1997) and Kyoto protocol (February, 2005). Within these frameworks, Ethiopia prepared a national adaptation program of Action (NAPA) against the impact of climate change and desertification. Unlike the case of developed nations, the practical measures expected from Ethiopia is to reduce the impact of climate change through the development of local adaptation measures while advocating for global solidarity, mitigation strategies, and climate justice (Alebachew, 2009). Ethiopians are battling the effects of changing climatic conditions. They have been facing the impacts in various forms over millennia and have developed a range of coping skills.

Household risk management strategies are ineffective mainly because they achieve partial insurance at a very high cost, they are localized, they are limited in scope, and informal insurances marginalize the most vulnerable and have very high hidden costs. The limitation of public risk management strategies includes; limitation of coverage, weak institutional linkages among stakeholders dealing with the risk management, poor early warning mechanisms, and dependence on foreign sources for food aid (World Bank, 2005).

2.4.5 Types of Adaptation

Adaptation is important since it can be used to assess the impact on and the vulnerability of a system and to develop and evaluate the response options. Different classification schemes have been used to distinguish between different kinds of adaptations.

Private or Public: The distinction is based on whether adaptation is motivated by private (individual households and companies) or public interest (government) (Spring Mann *et al*, 2016).

Reactive or Anticipatory: Reactive adaptation takes place after the initial impacts of climate change have occurred (Dendir and Simane, 2019). Anticipatory adaptation takes place before impacts become apparent (Alam, 2016).

Planned and Autonomous: Planned adaptation results from intentional policy choices made in the knowledge that circumstances have changed or are likely to change and that action is necessary to preserve the intended state (Dendir and Simane, 2009). For instance, intentional strategies for crop distribution and selection across various agro climatic zones, the replacement of older crops with new ones, and resource substitution brought on by scarcity (Addisu *et al.,* 2019).

2.5 Climate Change, Vulnerability and its Components

2.5.1. Concepts of Vulnerability

One of the catchy words in the scientific literature of climate change, but has no universally accepted definition is vulnerability. The recent IPCC, (2018) glossary defined vulnerability as the propensity or predisposition to be adversely affected. Climate change has traditionally been viewed as the primary cause of vulnerability in the literature on climate change and human vulnerability, which includes the vulnerability of individuals, communities, societies, and human systems. For instance, the Intergovernmental Panel on Climate Changes proposed definition makes this clear. According to the frequently used IPCC definition in the Fourth Assessment Report, "vulnerability is the degree to which a system is sensitive to, and unable to cope with, negative consequences of climate change, such as extremes and variability in the climate. Hence, the term vulnerability‘ is conceptualized to refer to (1) exposure to climate change, (2) sensitivity to climate change and (3) the capacity to cope and adapt with climate change that smallholder farmers confront in pursuit of their livelihoods.

2.5.2. Exposure to Climate Change

Climate change exposure is determined by the scope, nature, and pace of climate change in a particular region. In addition to how much a system is vulnerable to substantial climatic variations, exposure also refers to how much and how long these variations last. (Adger, 2006). Exposure is the nature and degree to which a system (People, property, or other elements present in hazard zones) is exposed to significant climatic variations and subject to potential losses today and in the future for the specific region or livelihood zone, in this research context. The Index for Risk Management rates Ethiopia as high risk due to its exposure to hazards such as increasing floods, earthquakes, and droughts, which would raise the danger of conflict and human exposure (Irish Aid, 18).

2.5.3 Sensitivity to Climate Change

The other component of vulnerability to climate change is sensitivity. It is the degree to which exposed people, places, institutions and sectors are impacted, either positively or negatively, by disaster today and the degree to which they could be impacted in the future. Communities 'sensitivity to climate change is the degree to which a community is adversely or beneficially affected by climate-related stimuli (IPCC, 2001b). It mostly depends on the community's primary livelihood activities (such as its reliance on livestock and rain-fed agriculture), its primary sources of subsistence, and the effects of climate risks on these primary sources. Together, exposure and sensitivity characterize the possible effects of climate change on a system.

2.5.4 Adaptive Capacity

A community's capability to adapt to climate change refers to its power to manage or cope with its effects as well as its capacity to seize opportunities. Income, literacy, institutional capacity, social networks, access to information, markets, technology, and services are just a few of the processes, structures, and circumstances that frequently affect an individual's potential for adaptation (IPCC, 2007). Access to and control over natural, human, social, physical, and financial resources is one of the most significant elements influencing how well-equipped people, families, and communities are to adapt. As the availability of these resources and services is limited in many developing countries, their adaptive capacity in the face of climate change is correspondingly low compared to developed countries. There are incidents of using coping capacity and adaptive capacity interchangeably in the climate change literature. However, there are differences for what capacity of condition, context and duration should be used. Literally, coping is the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning of people, institutions, organizations, short-to-medium-term and

short-term systems (IPCC, 2014). The ability of people, institutions, organizations, and systems to confront, manage, and overcome unfavorable circumstances in the short to medium term by utilizing their available resources, values, beliefs, and chances is known as coping capacity, according to IPCC (2018). Nelson, *et.al*., (2007) and Smit and Wandel, (2006) explained the difference between coping and adaptive actions Coping actions are not adaptive in the sense that they do not support transformative change, that is, complete reorganization or transformation of current management (Murphy, *et.al.*, 2015).

2.5.5. Approaches to Assess vulnerability

Vulnerability is made up of three parts: exposure, sensitivity, and adaptability. The first two determine the potential impact of climate based on its interaction with the system being considered. The third combines those impacts to determine overall vulnerability **(**Satapathy *et al*, 2014). The steps in a vulnerability assessment are:

- ✓ Frame the assessment: decide the scale and focus of the assessment
- ✓ Evaluate each component of vulnerability in turn: exposure, sensitivity, adaptive capacity
- ✓ Evaluate overall vulnerability
- ✓ Use results to inform risk assessment and adaptation planning.

2.5.5.1 Socioeconomic Approach

Literature on vulnerability argued that social vulnerability focuses primarily on the human determinants of vulnerability namely the social, political, and economic condition that makes exposure challenging (Belay, 2016). It is an approach that tries to analyze social vulnerability mainly focusing on the economic and political situation of an indvidual or social group known as socio-economic approach (Belay, 2016) and (Panthi et al., 2015). Social vulnerability is determined by factors such as poverty and in equality, marginalization, food entitlements, access to insurance, health, access to resources, and social status (Alam, 2016).

2.5.5.2 Biophysical Approach

The biophysical, or impact assessment, the approach is mainly concerned with the physical impact of climate change on different attributes, such as yield and income (Parker *et al*, 2019). Sesanaa *et al* (2019) referred to the biophysical approach as an end-point analysis responding to research Questions such as, "What is the extent of the climate change problem?" and " Do the costs of addressing climate change outweigh those of doing so?"Despite being incredible enlightening, it has its limitations. The major limitation is that the approach focuses mainly on bio-physical damages and sensitivity, such as a change in yield, health, income , and so on to climate change and disregards much of the adaptive capacity of individuals or social groups, which is more explained by their inherent or internal characteristics or by the architecture of entitlements as suggested by Gizachew and Shimelis (2014).

2.5.5.3 The Integrated Assessment Approach

The integrated assessment approach may be one of the most informative assessment approaches capturing diverse drivers (biophysical and socio-economic) of outcomes, system interactions and feed backs, and the evaluation of different adaptation decisions (Belay, 2016).The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability, assessing vulnerability in the Gurage administrative zone, Ethiopia by Dendir and Simane (2019) is a good example of this approach, in which both biophysical and socio-economic factors are combined to determine the vulnerability of the zone.

CHAPTER THREE

3. METHODS AND MATERIALS

3.1 Description of study area

The study was conducted in Mareka District, Dawuro Zone which is located in South West Regional States of Ethiopia. It is situated to the South West of Ethiopia at a distance of about 533 km from Addis Ababa across Butajira-Hosana and 510 km through Jimma-Tarcha. The astronomical location of Mareka district, extends from 6^0 09'00" to 7^0 01' 00" North and 37^0 01' 00" up to 37^0 03' 00" East (Mareka District Agricultural and Natural Resources Office, 2014). Its relative location, Mareka District is found south west of Gena Bosa, North West of Loma, North of Esera and East of Tocha districts. The total land surface area of Mareka district is about 46.724 square kilometres and its elevation ranges between 947 and 2546 meters above sea level.

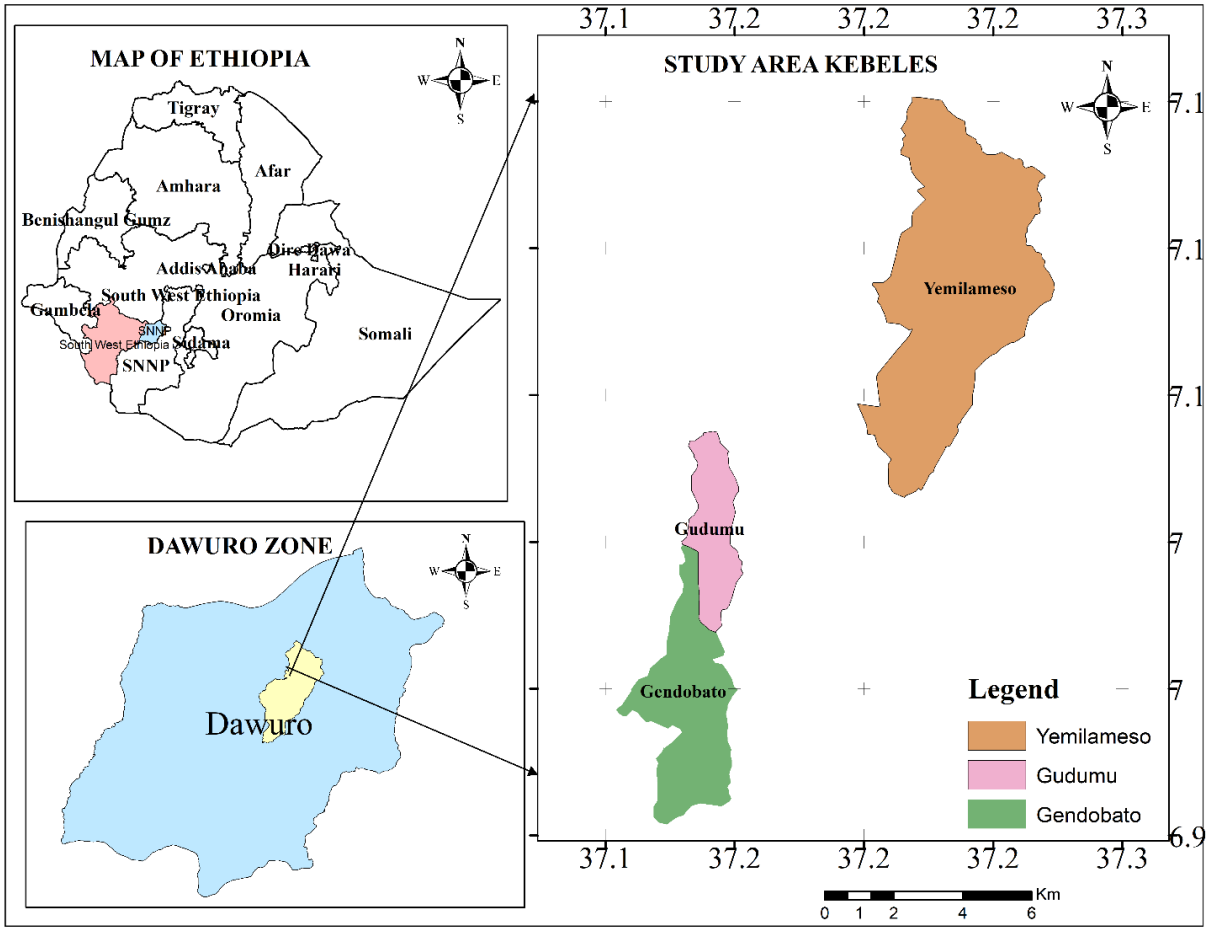

Figure 1 the study area mareka district

3.1.1. Climate of the study area

According to (MoA, 2000) traditional classification, agro-ecology of Ethiopia, the agro-ecology of Mareka District is classified as 8.23% is kolla (500-1500 meters above sea level), 50% is Woina dega (1500-2300 meters above sea level) and 41.77% Dega (>2300 m.a.s). The minimum and maximum temperature ranges between 16℃ to 23.4℃ and the minimum and maximum amount of rainfall is about 1314 mm to 1516 mm (MoA, 2000).The landscape of Mareka District is mostly mountains, plateaus and lowland plains.

3.1.2 Soil of the study area

The soil characteristics of the study area, is comfortable for agricultural activity and which has high fertility capacity. There are three types of soil characteristics. These are Sandy, silt and clay soils. Additionally, loam soil is the most fertile in Dawuro Zone, Mareka District, which gives an important advantage to the farmers to farm their land. Soils of the study area characterize also the practices of tillage, continuous cropping and removal crop residues (MWANRO, 2014).

3.1.3 Vegetation cover of the study area

The concentration of fresh air most of the time based on the existence of green vegetation coverage and the balance of ecology maintained by through it. Also it is relevant for the control of erosion, replenishment of ground water cycle. Mareka District, characterizes a big range of agro-ecological variations. The vegetation is almost warm and wet related vegetation of Tid, kosso, tikur enchet, and others. In this area, vegetation related problem is deforestation and wild fires, it depletes forest resources that create the weather condition to vary from time to time and then results climatic change and variability. People living in this area are farmers that they want to farm the land they try to cut the tree and deforestation due to housing and infrastructure and also energy consumption purposes. Vegetation’s are maize,

sorghum, vegetables from irrigations, mango, avocado, and fruit vegetables as, Mareka Wereda Forest and Environmental protection Office (MWFEPO, 2014).

3.1.4 Demographic characteristics of the study area

The Population of Mareka belongs to the omotic family. The language of the people is Dawurogna (Dawurot'uwa in Latin orthography).Since 1994/1995; Dawurogna has been serving as a medium of instruction in grade 1 up to grade 4 and of oral communication in the Zone's different government offices and all residents. Dawurogna, Amharic, Wolaytigna are the main languages spoken there. The total population of Mareka Wereda estimated to be 190,009 with this the number of male are 98,798 and female are 91,211.The district has 15 kebeles. Its land cover is 46,727 km and in 1km2 there is 406.6 densely populations (CSA, 2022). The population growth rate of the study area is 2.9%.

3.1.5 Socio-economic status

The socio-economic status any country determines the conditions of the life style and livelihood of the community. In our country Ethiopia, agriculture is the dominant economic activity that is exercised in general and Dawuro in particular. More than 93% of the population living in the Dawuro is engaged in agricultural activity. The production of cereal crops like maize, teff, barely, ground nut and wheat; root crops like yam/boyna, sweet potato, cassava, godere, and, vegetables are produced.

Enset (ventricosum) - is the predominant staple food crop and consumed by the community. Most of the small holder farmers' livelihood depends on enset productions which serve as delicious cultural food. Many quintals of unwashed coffee is produced from the Dawuro Zone and sent to export for central market. In this area, coffee consumption by the community is too high. Aforementioned socio-economic issues are the need of small holders' that they can survive their life and sustenance of living. Although climate change

variability adversely impacted the output of small holder farmers' livelihood sources, Mareka Wereda Agriculture and Natural Resource Development Office (MWANRDO, 2018).

3.2. RESEARCH DESIGN

In this study, a cross-sectional survey was used to understand the vulnerability and adaptation strategies of smallholder farmers to climate change. The study employed mixed methods (qualitative and quantitative) as the method is believed to be more appropriate to investigate the topic under discussion, encompassing comparative analysis of livelihood farmers at kebele levels. The approach further allows for triangulation across the results obtained from qualitative and quantitative (trend analysis, LVI,) sources.

Methodological triangulation; obtaining data from different sources, such as observations, documentation, household survey and interviews helps to connect diverse opinions about the same issue and assist in cross-checking the results and consequently helps to increase the validity and reliability of the findings and eases data analysis (Bryman, 2008). As one of the tools of empirical enquiry, the method is suitable for answering the how 'and why 'questions, on which this study is framed.

3.3 Sampling Techniques and Sampling Size determination

The study followed both the mixtures of purposive and random sampling techniques were employed for selecting the study area and sampling households. In the first stage, the study district was selected purposively because it is one of the vulnerable areas to the impacts of climate change and variability in the south west region (Dawuro Zone agricultural office, 2021). In the second stage, three rural kebeles were selected out of the Wereda by random sampling techniques to study the vulnerability and impacts of climate-related shocks on farmers' livelihood, and discussion with districts expert in the study area., to determine the sample size, the Yamane, 1967 Simplified formula was applied at 91% confidence level and 9% level of precision as shown below.

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

Where,

n-is the sample size.

N-is the total number of population of the households in three kebeles.

e- is allowable margin of error (level of precision) or (9%)

N=2400, e =0.09, then

n =2400/1+N (0.09)2 =2400/1+19.44=**117** households

3.4 Data source and Collection Methods

Both primary and secondary data sources were collected for the study. Instruments for primary data collection included a household survey, key informant interviews, focus group discussions and field observations. Overall, a cross-sectional household survey composed of both qualitative and quantitative methods was carried out using a structured questionnaire of both close and open-ended types of questions. Secondary data were obtained from statistical yearbooks, published and unpublished documents, and local and administrative records. Secondary sources include historical climate data on precipitation, maximum and minimum temperatures, and daily total rainfall from 1992 to 2022 from Ethiopian National Meteorological Agency (NMA) and were used to complement the findings from the household survey, FGD and KII. Seasonal and annual rainfall was derived from the daily data of the stations. With regard to vulnerability data sources, the Livelihood Vulnerability Index (LVI) analysis was carried out using primary data (household survey and FGD) and other secondary sources.

Field Observation

This is a method by which an individual or individuals gather first-hand data on programs, processes, or behaviour being studied. It provides evaluators with an opportunity to openly explore the relevant topics (Britha, 2002) suggested that observation provides important

information during all phases of the study. Field observation was started while writing the proposal and was continued throughout the whole process of data collection to make sure the validity of acquired information. It was aimed at understanding the local condition in terms of their culture, farm practices and traditional way of resource utilization and application of adaptation measures and others. During the transect walk such as east –west direction of walk has used and the researcher took notes on the climate variability impacts, existing adaptation measures, yield conditions, soil erosion severity, existing soil and water conservation, topography and land use and land cover.

Household survey

The structured questionnaire was developed based on information acquired from informal discussions with farmers and field observation, and literature. Two enumerators were trained and recruited to administer the questionnaire. Since farmers speak Dawurogna language, the enumerators are fluent in speaking Dawurogna and Amharic as well. Before carrying out the actual data collection (survey), the questionnaire was tested for its clarity and comprehensibility. Unclear, ambiguous and unrelated questions to local people and enumerators were modified and additional questions were included that are supposed to be necessary to capture relevant information. Hence the survey questionnaire included household characteristics, demographic, environmental, institutional, socio-economic conditions landholding, climate variability-related problems, and vulnerability and adaptation measures

Focus group Discussion (FGD)

It was performed to discuss the trends of climate change variability in the study area and how much it can affect their environment and declines their livelihood resources. FGD members include local elders, females, religious leaders and the vulnerable communities. The

selection was made on age, sex, work experience, vulnerability in the area. The members of FGDs are six (6) in each kebeles and totally eighteen members were participated.

Key Informant Interview

The key informant interviews purposely conducted to obtain additional and accurate information about the areas livelihood conditions. This interview was required key informant from wereda agricultural office, forest and environmental protection office, disaster prevention office, natural resource extensions (DA) professionals, site healthy extensions and kebele administrators are expected to interview in the study and the number of key informant participated and they are twelve (12) in number.

3.5 Methods of Data Analysis

3.5.1 Climate change trend analysis

The Mann-Kendall statistical test was used to analyze the seasonal and annual rainfall and temperature data trends at 1% and 5% levels of significance. Climate data trend analysis determines whether the measured values of a variable increase or decrease during a period. As reported by Guhathakurta and Rajeevan (2006) recent studies indicate that the most widely used method is the non-parametric Mann-Kendall test (Kendall, 1975; Mann, 1945).

The Mann-Kendall test statistics is using the following formula to determine:

$$S = \sum_{i=1}^{n-1} \sum_{j=i=1}^{n} sgn\left(x_{j-x_i}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

$$Sng(xj\text{-}xi) \begin{cases} 1 \text{ if } xj\text{-}xi > 0 \\ 0 \text{ if } xj\text{-}xi = 0 \\ -1 \text{ if } xj\text{-}xi < 0 \end{cases}$$

Where S is Mann–Kendall's test statistics, xi, and xj are the sequential data values of the time series in the years i and j (j > i), and N is the length of the time series. A positive value of S implies and "upward trend or increasing trends", while a negative value of S shows a

"downward trend or decreasing trends". It is necessary to calculate the probability related to S and the sample size, n, to statistically quantify the significance of the trend. The formula used to determine the variance related to S is (Mann 1945; Kendall, 1975).

This statistics represent the number of positive changes minus the number of negative differences for all the differences considered. The test is run using a normal distribution with the mean and variance as follows for big samples (N>10): E[S] = 0

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{k=1}^{m} t_k(t_{k-1})(2t_{k+5})}{18} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where t k is the amount of data points in group k and m is the number of tied groups.

In cases when the sample size n > 10, the test statistic Z(S) is calculated from (*Mann 1945, Kendall 1975).*

$$Z = \frac{S-1}{\sqrt{var(S)}} \; if \; S > 0$$

Z=0 if S=0…… ……..…..3

$$Z = \frac{S+1}{\sqrt{var(S)}} \; if \; S < 0$$

If Z is negative and the absolute value above the level of significance, the trend is considered to be declining; if Z is positive, the trend is considered to be advancing and greater than the level of significance. If the absolute value of Z is less than the level of significance, there is no trend, and the chosen value of α (taken as 0.05 in this study (Birhan, 2017).

3.5.2 Assessing the vulnerability of smallholder farmers to climate change

For vulnerability analysis, specific variables were used to capture the level of exposure to natural disasters and climate variability, adaptation capacity of households and their sensitivity to climate change. The formulation for LVI developed for this study is based on the livelihood vulnerability analysis technique developed by Hahn *et.al*, (2009), with replacements of some indicators to suit the local context of the study area. It uses nine key elements: Natural Catastrophe, Land and Water, Nutrition and Health, Skill and Knowledge, Socio-economic, Biophysical, Social and Institutional, and Finance and Income. Each profile

was defined by a set of indicators and a relationship with climate vulnerability. The selection of indicators was based on a review of related literature, household survey, FGD, key informant interviewers and my observation and experience in the study area. The components are further categorized under the five livelihood capitals; Human, Social, Natural, Physical and Financial. The indicators were developed based on a review of previous LVI studies conducted and the weights are given as their importance of involvement and in their influence in the households. The details of the descriptions are indicated as follows:

Table 1: Vulnerability factors livelihood capitals, profiles and indicator's used for LVI and Hypothetical relationship using IPCC frame work

Determinants of vulnerability	capitals	major components	sub indicators	Units	Hypothetical relation ship	Assigned weight for sub indicators (%)
Exposure	Natural disaster	Frequency of natural disaster and climate variability	Frequency of flood in 30yrs	Number of events	More frequency of flood occurrences higher exposure	20
			average daily max temperature between 1992-2021	Changes in Temperature	More increase in temperature higher exposure	20
			average monthly rainfall between1992-2021	Changes in rain fall	More decrease in rainfall higher exposure	40
			Vulnerability to the incidence of drought in 30 yrs.	Frequency	More frequency in incidence of drought higher exposure	20

Sensitivity	Natural	Crop Land and water	Land productivity	Percent	More percent of fertile land less sensitivity	25
			Access to grazing land	Percent	More percent of access to grazing land less sensitivity	15
			Access to animal forage	percent	More percent of access to animal forage less sensitivity	20
			Access to water	Percent	More percent of access to water less sensitivity	20
			Effect of post-harvest loss	Percent	Less effect of post-harvest loss less sensitivity	20
Adaptive capacity	Human	Nutrition and health status	Access to food	Percent	More access to food high adaptive capacity	50
			Health status	Percent	More percent of access to health facilities more adaptive capacity	50
		Skills and knowledge	Education attainment of household head	Percent	More education attainment of household head more adaptive capacity	30
			Technology adoption	Percent	More adoption of technology high adaptive capacity	70
		Socio-economic	Farming experience	Years	High farming experience high adaptive capacity	25
			Nonagricultural income	Number	High nonagricultural income less adaptive capacity	35

		Off farm activity	Birr	High off-farm activity income high adaptive capacity	40	
Natural	Biophysical environmental	Land protected from degradation	Percent	More protected land from degradation more adaptive Capacity	30	
		Vegetation cover	Percent	More vegetation cover more adaptive capacity	20	
		Slope or topography of cultivated land	Percent	High slope of cultivated land less adaptive capacity	25	
		Crop diversification	Percent	More crop diversification high adaptive capacity	25	
Social	Social and institutional	Access to social membership	percent	More access to social membership high adaptive capacity	25	
		Cultural connectivity	percent	High cultural connectivity high adaptive capacity	25	
		Local institutional support	percent	High local institutional support high adaptive capacity		20
		Access to indigenous knowledge	percent	High access to indigenous knowledge high adaptive capacity	15	
		Traditional weather prediction	percent	High traditional weather prediction high adaptive	15	

				capacity	
Financial	Finance and incomes	Access to credit	percent	High access to credit high adaptive capacity per HH	20
		Access to remittances	percent	High access to remittance high adaptive capacity per HH	10
		Access to saving	Percent	High access to saving high adaptive capacity per HH	15
		Access to money for emergency	Percent	High access to money for emergency high adaptive capacity per HH	10
		Economic gift	Frequency	High frequency subsidy from government high adaptive capacity per HH	10
		Farm income	Birr	Greater wealth greater adaptive capacity	35

Sources; Hahn et al. (2009)

Calculating the LVI

The indicator approach was used in the study to measure vulnerability. In indicator method, vulnerability is based on selecting indicators from the possible set of indicators and then combining them analytically to indentify the levels of vulnerability (Hahn *et al*., 2009). All vulnerability indicators are given similar weight in this study since it is thought that they are all equally important (Cutter *et al*. 2000). The method developed by Hahn *et al*. was used for the LVI calculation (2009). Several academics have applied a related strategy in various circumstances, including Simane *et al*., (2014), Panthi *et al.* (2015), Aryal *et al*., (2014), and Mohan and Sinha (2010). The LVI employs a balanced weighted average technique, as stated by Sullivan *et al*. (2002), where each indicator contributes equally to the total index despite each major profile consisting of a varying number of indicators or sub-components. Because each of the indicators or sub-components is measured on a separate scale, standardization is necessary for each index. The formula for calculating the life expectancy index, which is the ratio of the difference between the actual life expectancy and a predefined minimum, and the range of the predetermined maximum and minimum life expectancy, is taken from the Human Development Index for this conversion (UNDP 2007). First, each indicator is standardized to a common scale *(Eq.1)*

$$Iv = \frac{Ia - Imin}{Imax - Imin} \qquad (Eq.1)$$

Whereas, IV is the standard value, Ia is the value for the indicator I for particular component, Imin and Imax is the minimum value for the indicator across all the components. The inverse scoring technique is used in the standardization of values for each indicator based on ICRISAT for indicators where vulnerability is expected to have an inverse connection (2006). Maximum value minus observed values for indicator (Ia) / (maximum value minus minimum value) yields inversed index values (Iv). The following formula is used to calculate a profile average value:

$$Pa = \sum \frac{IV}{N} \qquad \textit{(Eq.2)}$$

IV is yields inversed index value

Where Pa is the value for one of the nine major profiles in components, and N is the number of variables in the profile. Values for each of the nine profiles were then combined to obtain the component level LVI:

$$LVI = \frac{\sum_{P=1}^{E} 1NpPa}{\sum_{P=1}^{E} 1Np} \qquad \textit{(Eq.3)}$$

Finally, the LVI-IPCC for livelihoods is calculated as follows:

LVI−IPCC= (Ea−Aa) *Sa *(Eq.4)*

Where E is exposure, A is adaptive capacity and S is sensitivity. It is better to think of the LVI-IPCC as a measure of the relative vulnerability of comparable populations because it scales from -1 (least vulnerable) to 1 (most vulnerable).

For the analysis of adaptation strategies to climate change descriptive statistics used for the analysis of small holder farmers adaptation measures and barriers to adaptation strategies to climate change.

For adaptation strategies farmers to climate change analysis including both qualitative and quantitative techniques were used. Qualitative techniques mainly include narrative analysis and content analysis of perceptions and feelings of FGD participants. Descriptive and inferential statistical techniques were employed to analyse data collected from both primary and secondary sources. Descriptive statistics was presented in the form of frequencies, cross tabulation, percentages, and tables.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Socio-economic profile of households

The study included 117 households, of which 96 (82%) were male and 21 (18%) female headed households (Table 2). The majority 93 (79.48 %) of the households were married. The family size varies from small to large groups, where the minimum and maximum family size in the study area were 2 and 12 members respectively and with an average of 5.48 slightly above the national average which is 5 (CSA, 2013).

The survey results in the study area revealed that 78.63% of the respondents engaged in farming activity only, whereas 21.37% engaged in farming activity and off-farm activities. Of the total respondents, 64.9%, 24.78% and 9.4% were categorized as poor, medium and rich respectively based on cattle's and land they own (Table 2). Also, the average monthly income was 1255 Ethiopian birr per household. Regarding education, 79.48 % farmers in sampled households can read and write (literate) whereas the rest 20.62 % Illiterate. The majority of responders 80.34% possessed less than 0.5 hectares of farmland, followed by 15.38% with 0.5–1 hectares, 2.56% with 1.0–1.5 hectares, and 1.7% with 1.5–2 hectares. Farming experience of respondents ranges from less than 20 years 39.31% to over 40 years 19.65%. In the study area, households pursue mixed agriculture in which crop and livestock production is an important component. Moreover, livestock are considered as a key source of livelihood and a symbol of wealth. Farmer's rear animals of different types for various purposes such as food (egg, milk, or meat), draft power, means of transport and source of cash for urgent needs. Cattle, goats, sheep, and donkeys are the major type of livestock rearing in study wereda. As far as the ownership of livestock is concerned, 67.52% the majority of the households possess 1-3 livestock followed by 23.07 % they own 4 -5 live stocks.

Table 2: Demographic profiles of sampled house holds

Variable	Frequency (%)	Survey sites		
		Gudumu	**Gendo**	**Yamala**
Sex				
Male	96 (82%)	20 (77.00%)	47(83.92%)	29(82.8%)
Female	21 (18%)	6(23.00%)	9 (13.18%)	6(17.2%)
Age				
25-40yrs	44(36.8)	8 (30.6)	23(41.00)	14(40.3)
41-55yrs	34(29.2)	7 (29)	20(36.1)	8(22.8)
56-70yrs	27(23.60	9 (32.71)	9 (16.00)	8(22.8)
71-85	12(10.4)	2 (7.69)	4 (7.00)	5(14.28)
Marital status				
Married	93 (79.48%)	21(80.76%)	48(85.70%)	24 (68.57%)
Single	9 (7.69%)	2(7.69%)	3(5.35%)	4(11.42%)
Divorced	2 (1.70%)	1(3.80%)	2(3.57%)	2(5.71%)
Widowed	13 (11.10%)	2 (7.69%)	3 (5.35%)	5 (14.28%)
Family size (group)				
Small (1-5)	64 (54.7%)	16 (61.5%)	21(37.5%)	20(57.14%)
Medium (6-8)	38(32.47%)	6(23.07 %)	29(51.78%)	7(20.00%)
Large (8-10)	10(8.5%)	2(7.69%)	2(3.5%)	6(17.00%)
Very large (11-15)	5(2.8%)	2(7.69%)	4(7.00%)	2(5.70%)
Total pop. In the study area	642 (100%)	102(15.88%)	374(58.25%)	166(25.80%)
Major occupation				
Farming	92(78.63%)	20(76.9%)	48(85.7%)	24 (68.57%)
Farming and off-farm activity	25 (21.27%)	6 (23.07%)	8 (14.30%)	9 (32.43%)
Wealth status				
Poor	76(64.9%)	17(65.38%)	35(62.50%)	24 (68.57%)
Medium	30(24.78%)	5 (19.23%)	17(30.35%)	8(22.85%)
Rich	11 (9.40%)	4(15.39%)	4(5.60%)	1 (2.85%)
Education				
Literate	93 (79.48%)	22(84.60%)	46 (82.14%)	24 (68.57%)
Illiterate	24 (20.62%)	4(15.40%)	10 (17.86%)	9 (32.43%)
Farm size				
Less than 0.5 hec	94(80.34%)	20(76.92%)	48(85.71%)	26 (74.28%)
0.51h-1 hec	18 (15.38%)	5 (19.23%)	7 (12.5%)	6(17.14%)
1.01h-1.5 hec	3 (2.56%)	1 (3.80%)	1 (1.78%)	1 (2.85%)
1.51-2 hectare	2(1.70%)	0(0.00%	(0.00%)	2(5.71%)
No livestock ownership				
1-3	79(67.52)	12(46.15%)	42(75)	25(71.42%)

4-5	27(23.07)	7(26.92%)	11(19.64%)	7(20%)
6-7	6(5.12)	2 (7.69%)	2(3.5%)	2(5.71%)
> 7	5(4.27)	5(19.23%)	1(1.78%)	1(2.85%)
Farming experience				
Less than 20 year	46 (39.31%)	10(38.46%)	26(46.42%)	10(28.57%)
21-30 year	29 (24.78%)	5 (19.23%)	17 (30.35%)	5(14.28%)
31-40 year	19 (16.23%)	5(19.23%)	6 (10.71%)	10 (28.57%)
Above 40 years	23 (19.65%)	6(23.00%)	7 (12.5%)	10 (28.57%)

4.2 Annual and seasonal rainfall trend analysis

4.2.1. Annual rainfall trend

The results revealed that the average annual rainfall ranges between 622 mm (2000G.c) registered low amount of rain fall year to in the wettest year 2114mm (2020G.c) in the area. Annual rainfall is showing increasing trend in amount. As it is shown in (Table 3), annual rainfall shows great fluctuation in its amount from year to year. Even though there is great fluctuation, rain fall is increasing with 4.6206 mm every year on average.

Table 3: Rainfall Mann-Kendall trend results (1992-2022)

Variables	Kendall's tau	p-value	Alpha	sens slope	Trend
Annual RF	0.064	0.513	0.05	4.6206	No significant
Kiremt RF	0.191	0.132	0.05	3.1442	No significant
Belg RF	-0.089	0.657	0.05	-0.0782	No significant

4.2.2. Belg season rainfall trend analysis

Accordingly, based on the analysis of secondary data obtained from the National Meteorological Agency it is possible to state that there is a great variation within 31 years, about 147 mm of rainfall was recorded during 2003G.c and maximum rainfall seen in belg season is in 1997G.c about 664 mm. As shown in (Table 3) In Belg season every year on average, there was 0.0782mm of rainfall reduction. At the same time, the trend of rainfall in the area shows a decreasing trend over the past 31 years (1992-2022) (Fig.2). The statistical analysis revealed a decreasing trend in rainfall was insignificant with large inter-annual

fluctuation. This result is in line with the findings of (Nicholson et al., 2000), who reported variability in rainfall in the semi-arid and sub-humid zones of West Africa.

4.2.3. Kiremt season rainfall trend analysis

In kiremt season, the maximum rainfall registered was about 711mm in 1996 and the minimum rainfall recorded was 116 mm in 2000 (1992-2022) (Table 4). In kiremt season there was an increase of rain fall seen last 31years on average every year 3.1442 mm. In general, from the trend analysis, it is possible to state that frequent variation in the distribution of kiremt rain from analysis of meteorological data.

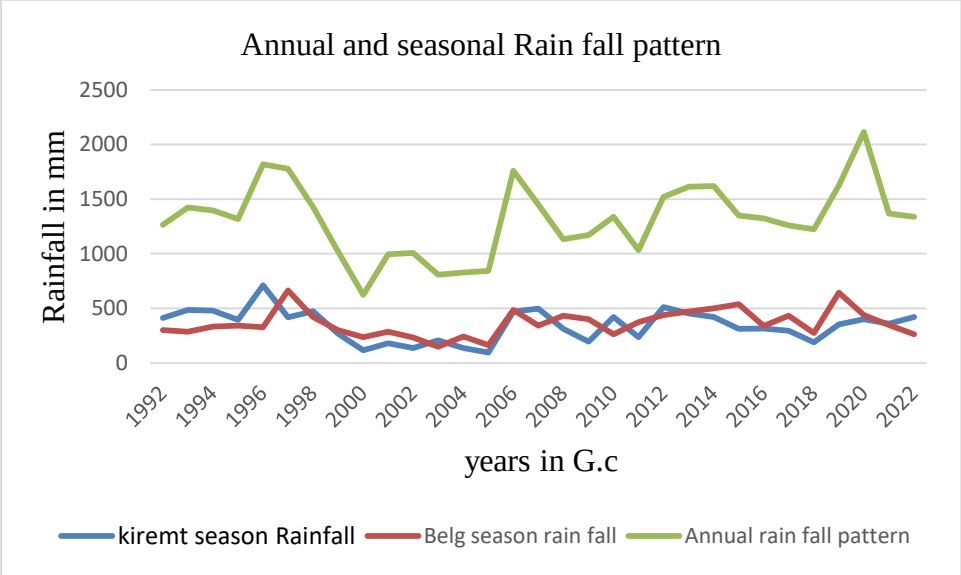

Figure 2: Average annual and seasonal rain fall trend (1992-2022)

Source: National Metrological Agency (NMA) of Ethiopia, 2023

Table 4: Annual rainfall trend analysis (1992-2022)

Variables in mm	Min	Max	Mean	Std	CV
Annual RF	622.26	2114.66	1316	331.95	25
Kiremt RF	94.91	711.91	344.46	143.51	41
Belg RF	147.66	664.46	363.32	123.34	33

Source: National Metrological Agency (NMA) of Ethiopia, 2023

The Coefficient of variation of the study area was 25%, 41%, and 33% for annual, kiremt, belg rainfall respectively, which indicates that there was moderately variable rainfall during the annual and there is high variation in kiremt and belg season between 1992- 2022 (Table 4).

Annual and kiremt rainfall shows increasing trend while belg rainfall shows decreasing trend from their average of 1316 mm, 344mm and 363mm respectively, during the three decades (1992-2022), (table 3). From the table above, kiremt season rainfall has big contribution to the annual rainfall because it is main rain season, even though it's huge role in livelihood security Belg season rainfall declined in the last three decades of year. The declining trend was not statistically significant because the computed p-value is greater than the significance level $\alpha = 0.05$ (table 3). The analysis results indicate that the annual rainfall found to be statistically insignificant annual and seasonal rainfall at the 5% level of significance. Belg season rainfall has considerably less contribution to the annual rainfall in the area because it characterizes seasonal variability.

4.3. Trends of average Maximum and Minimum temperature

The average max maximum temperature over the area recorded in 2003 was 31.825°C and average max minimum temperature was recorded in 2001 about 15.15 °C during 31 years.

The average max and min temperature in the study area was characterized by an increasing trend. As depicted in (Table 5), the average maximum temperature has increased by about 0.027°C every year and also average minimum temperature has increased by 0.069°C every year.

Table 5: Average temperature trend and variability (1992-2022)

Variables	Kendall's tau	p-value	alpha	sens slope	Trend
Average max temp	0.280	0.021	0.05	0.027	Sig
Average min temp	0.609	0.00013	0.05	0.069	sig

Source: National Metrological Agency (NMA) of Ethiopia, 2023

Table 6, this result is in line with the findings of the UNDP, 2008) report also revealed an increasing trend of the mean annual temperature of Ethiopia by 0.37°Cper decade. Similarly, according to (NMA, 2007), the average annual maximum temperature in the country has increased by 0.1°C per decade. This result is in line with (Conway and Schipper, 2011), who reported that an increase in minimum and maximum temperature in Ethiopia in the coming decades will affect farmers' production, like crop production mainly.

Table 6: Descriptive statistics for Max and Min Temperature in the study area (1992-2022)

Variables in	Min	Max	Mean	Std	CV
Max Temp	27.66	31.82	29.31	1.15	0.039
Min Temp	13.69	15.15	14.4	0.388	0.06

Source: National Meteorological Agency (NMA) of Ethiopia, 2023

As indicated in (Table 6) the minimum and maximum temperatures have fluctuated but not varied over the past 31 years. the results are in line with that of (Kassie *et al*., 2013) study, where the climate of the Central Rift Valley of Ethiopia will get warmer in the coming decades and the increasing rate in minimum temperature will be higher than the maximum temperature, particularly under the current emission scenarios. This finding is consistent with studies of Alebachew (2009) increasing trend of temperature by about 0.3 ^{o} C per decade in the Ethiopian highlands.

4.3.1 Farmers' Perceptions on temperature and rain fall

Majority respondents observed changes in rainfall patterns over the past two and three decades. Around 16% of the respondents noticed a change in timing of rains such as the late onset of rain during Belg season tended to extend the sowing dates for Meher crops (the main rainy season), affecting the post-harvest process as the rain tends to extend for extra weeks beyond the normal rainfall cessation calendar. , decrease in rainfall amount noticed by 79.5% of households, and about 4.2% of respondents have not seen any change. About 80%

of the respondents perceived an increase in temperature, while only 6.8 % noticed a decrease in temperature and 12.8% of the respondents did not perceive any temperature change (Table 7). The trend analysis depicted above also coincides with what the FGD participants in Gendo kebele. In the discussion, participants underscored that because of variability of rainfall, extreme rainfall conditions created the expansion of bacterial diseases, in maize and in cash crops such as Ginger and Coffee. Cognizant of this, farmers were requested whether they perceive long term changes in precipitation over the past thirty years which caused serious disruption of livelihoods, exposing many farmers to humanitarian assistance at wereda level (Mareka wereda Agriculture Office, 2018).

In the context of Gudumu kebele the participants of FGD have raised the main crops such as potato, sorghum, barley, bean, wheat and pea's production in the last ten years has seriously decreased in production, affecting their income Deressa *et al.* (2008) indicated that majority of contacted farmers in Ethiopia are aware of climate change and perceives an increased temperature. The FGD participants and interviews with key informants also confirmed that the presence of increased temperature, and also it affects their agricultural production.

Table 7: Perception of respondents on climate of the study area

Variables	frequencies	% of respondents
Change in rain fall timing	19	16
Decrease in rain fall amount	93	79.5
No change in rainfall	5	4.2
Increase in Temperature	94	80
decrease in temperature	8	6.8
no change in temperature	15	12.8

Source: House hold survey, 2023

4.4 Vulnerability of Smallholder Farmers to Climate Change

The vulnerability analysis results of all three kebeles are presented in two different steps.

The first steps, the result obtained from the assessment of individual profiles and contributions of indicator's to each of the profiles for each kebeles are presented with the overall LVI (Table 8). The second step, the LVI-IPCC vulnerability estimates done for kebeles based on vulnerability components (exposure, sensitivity, and adaptive capacity) of climate vulnerability index which are presented in Table 9 and Fig. 3. The LVI gives information about the components that determine vulnerability, and the LVI-IPCC shows that the three characteristics that have the most influence on a given kebeles' susceptibility are exposure, sensitivity, and adaptive capability.

Finally, interactions among vulnerability components (exposure, sensitivity, and adaptive capacity) in each kebeles were discussed. Livelihood vulnerability index results (Table 10, Fig.4) presented indexed indicators, profiles, and overall livelihood. Vulnerability Index (LVI) for Gendo, Gudumu and yamala kebeles. Elements of any of the five capital types (natural, financial, physical, human, and social) make up the key profiles or components that produce the LVI scores. These aspects are categorized into the contributing factors for exposure, sensitivity, and adaptation capacity in order to compute the LVI-IPCC (Table 8). Exposure includes the score of the one major profile such as natural disaster and climate variability. Sensitivity is composed of one major profile namely crop land and water. Adaptive capacity is made up of aggregated scores of six major profiles, they are nutrition and health, skills and knowledge, socio-economic, biophysical environment, social and institutional profiles, and finance and incomes.

Table 8: Vulnerability factors used for LVI analysis using the IPCC framework in the study area

Category	Major indicator	Sub components indicator	Units	yamala kebele	Gendo kebele	Gudumu kebele

	Frequency of natural disaster and climate variability	Frequency of flood occurrence in last 30yrs	Number of events	0.022	0.03	0.04
Exposure						
		average daily max temperature between 1992-2021	Changes over temperature	0.0488	0.062	0.0456
		Average monthly rainfall duration between 1992-2021	Changes over rain fall	0.172	0.18	0.16
		Vulnerability to the incidence of drought in 30 yrs.	Frequency	0.113	0.1087	0.1207
		Average		0.1377	0.1528	0.1536
Sensitivity	Crop Land and water	Land productivity	Percent	0.1675	0.2075	0.19
		Access to grazing land	Percent	0.0165	0.0345	0.042
		Access to animal forage	Percent	0.134	0.174	0.156
		Access to water	Percent	0.186	0.1	0.1
		Effect of post-harvest loss	Percent	0.14	0.024	0.028
		Average		0.1288	0.108	0.103
Adaptive capacity	Nutrition and health status	Access to Food	Percent	0.435	0.465	0.475
		Health status	Percent	0.39	0.425	0.46
		Average		0.4125	0.445	0.4675
	Skills and knowledge	Education attainment of house hold head	Percent	0.2565	0.2499	0.2088

	Technology adoption	Number	0.287	0.364	0.322
	Average		0.2717	0.3069	0.2654
Socio economic	Farming experience	Years	0.0525	0.0575	0.045
	Nonagricultural income	Number	0.07	0.084	0.098
	Agricultural income	Birr	0.044	0.052	0.0484
	Average		0.056	0.0645	0.0638
Bio-physical environmental	Land protected from degradation	Percent	0.201	0.234	0.213
	Vegetation cover	Percent	0.152	0.164	0.158
	Slope or topography of cultivated land	Percent	0.1	0.25	0.12
	Crop diversification	Percent	0.1	0.087	0.123
	Average		0.138	0.1837	0.1535
Social and institutional	Access to social member ship	Percent	0.2175	0.234	0.208
	Social interaction	Percent	0.245	0.267	0.243
	Local institutional support	Percent	0.066	0.089	0.072
	Access to indigenous knowledge	Percent	0.032	0.067	0.076
	Communities own knowledge to predict weather	Percent	0.075	0.084	0.1
	Average		0.1271	0.1482	0.1398
Finance and incomes	Access to credit	Percent	0.026	0.05	0.038
	Access to	Percent	0.009	0.014	0.011

remittances				
Access to saving		0.15	0.23	0.27
Access to money for emergency(willing group)	Percent	0.006	0.02	0.01
Subsidy from government	Frequency	0.007	0.009	0.01
Farm income	Birr	0.175	0.166	0.142
Average		0.062	0.0815	0.081

Source:-house hold survey, 2023

4.4.1 Vulnerability Components of each kebeles: Compare and Contrast

As presented in Table 8 above, the major components of the LVI for each kebeles are analyzed. The result revealed that the gendo kebele has also the highest score in skill and knowledge (0.3069), socio economic (0.0645) and biophysical components (0.1837), social and institutional components (0.1482) and finance and income components which is (0.0815) indicating relatively better access to social membership, social interaction local institutional support, access to indigenous knowledge and trust and communities own knowledge to predict weather which contributes for its higher adaptive capacity. On the other hand Gudumu Kebele registered the highest value in frequency of natural disaster (0.1528) and the least score of skill and knowledge (0.2654) and land and water (0.103), which significantly reduces the capacity to adapt to climate change. Whereas, yamala showed the highest value (0.1288) interims of land and water component, which includes land productivity, access to grazing land ,access to animal forage ,access to water, effect of post-harvest loss.

Table 9: Major components of LVI

Major components	yamala kebele	Gendo kebele	Gudumu kebele
Natural disaster	0.1377	0.1528	0.1536
Land and Water	0.1288	0.108	0.103
Nutrition and Health	0.4125	0.445	0.4675

Skill and Knowledge	0.2717	0.3069	0.2654
Socio-economic	0.056	0.0645	0.0638
Biophysical	0.138	0.1837	0.1535
Social and Institutional	0.1271	0.1482	0.1398
Finance and Incomes	0.062	0.0815	0.081

Source:-house hold survey, 2023

Access to money for emergency, subsidy from the government and access to savings and availability of financial resources and stable income support the development of adaptive Capacity (YoheandTol, 2002; Armitage, 2005; Engle and Lemos, 2007). The majority of climate change adaptation strategies entail some kind of financial sacrifice, and getting loans or cash enhance farmers' ability to adopt coping strategies to deal with the hazards of climate change.

Figure 3- illustrates how LVI sub components relate to major components that determine scores for LVI-IPCC contributing factors which make up the overall LVI-IPCC vulnerability for the study area.

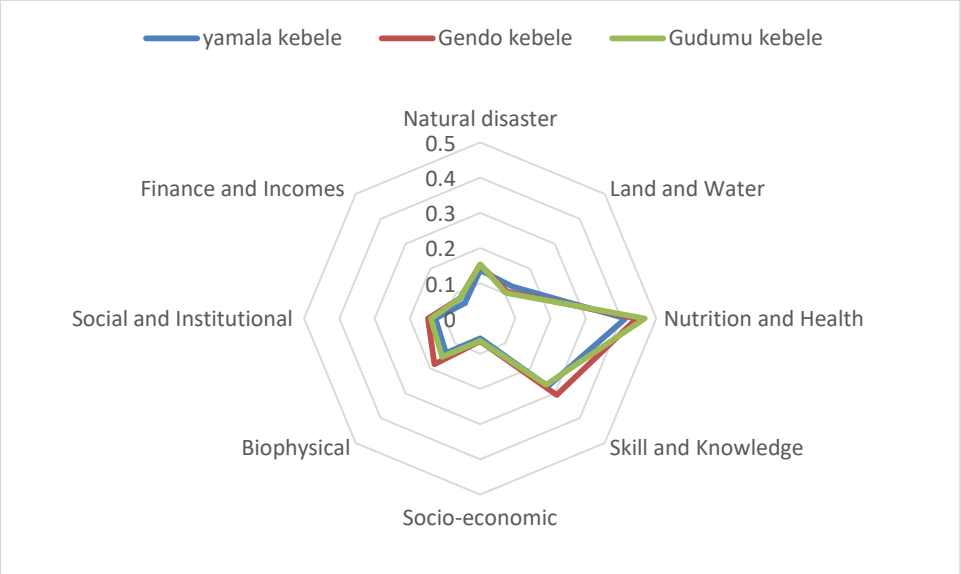

Figure 3: Major component values for the LVI diagram

Source:-house hold survey, 2023

4.4.2 IPCC's Vulnerability Index (LVI-IPCC): Compare and Contrast

The LVI-IPCC was calculated by classifying the nine major components into three groups: exposure (consisting of one sub- components), sensitivity (one sub-component), and adaptive capacity (six sub-components) (Table9). Index values used for internal comparisons within the research Sample. The LVI-IPCC uses a scale of -1 (least vulnerable) to 1 for its ratings (most vulnerable) according to equation 4. The overall LVI-IPCC result shows that gudumu kebele households was the highest vulnerable to climate change, whereas, gendo kebele was the medium vulnerable and yamala kebele was the least vulnerable to climate change.

Table 10: IPCC vulnerability factors

IPCC contributing Factors to vulnerability	Yamala kebele	Gendo kebele	Gudumu kebele
Exposure	0.069	0.0765	0.0768
Sensitivity	0.1288	0.108	0.103
Adaptive capacity	0.178	0.205	0.195
Community's vulnerability index for each kebele	-0.014	-0.0138	-0.012

Source:-house hold survey, 2023

Moreover, in the study area out of all farmer's households, about 22% were more vulnerable to climate change and variability means that they are more vulnerable to health stress ,extreme heat, floods and other climate related events, 48% were medium vulnerable and 29.9% were least vulnerable to climate change and variability. Generally, in the study area, all farmers' livelihood was more or less vulnerable to climate variability and change. However, these results are in line with the finding of (Amare and Simane 2017), (Tessema and Simane 2019), and Mekonnen *et al*., (2019) presented as different agro-ecologies have a different score of exposure, sensitivity, and adaptive capacity which results in differences in vulnerability level among the agro ecology..

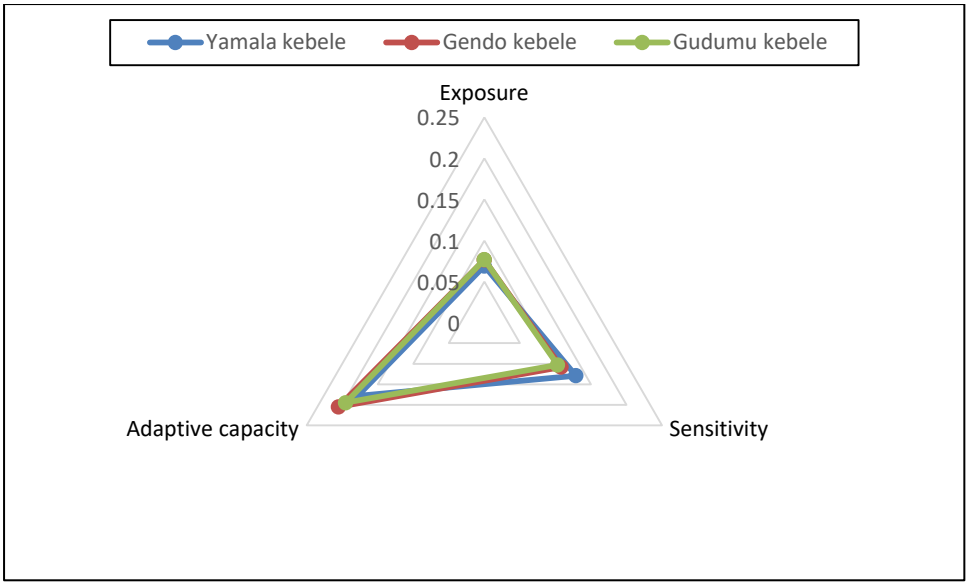

Figure 4: vulnerability triangle

Source:-house hold survey, 2023

4.5 Climate change adaptation strategies employed by households

With the recent trend of climate change, the need for adaptation strategies is becoming a pressing issue. Long-term adjustments to the range of activities necessary for subsistence are called adaptations, and they are made to lessen the livelihood vulnerability of households. Being the first step in the adaptation process, timely and accurate perceptions are important determinants for farmer's intentions and the choice of adaptation methods (Deressa *et.al*., 2011). However, the development of these perceptions may depend on various socio-economic factors, access to institutional resources and agro ecological settings. No perceptions may lead to mal- adaptation and may increase farmers 'exposure to climate change impacts while accurate perceptions may positively influence the adaptation process at farm level (LeDang *et.al*. 2014; cited in Abid *et.al*. 2016). With respect to their adaptation strategies, 14.3% of respondents in Gendo kebele use planting high-yielding varieties such as hybridized avocado and hybridized vegetable types as an important adaptation strategy to climate change. In Gudumu kebele, (26.9%) of the respondents widely use soil conservation

or terracing, also (28.5%) in yamala kebele farmers widely use soil conservation or terracing (Table 11).

Ethiopian farmers' suggested adaptation strategies are consistent with earlier findings in the literature on climate change adaptation (Bradshaw *et al*., 2004; Maddison, 2006; Hassan and Nhemachena, 2007; Hassan and Nhemachena, 2008). Moreover, this result is in line with the finding of Abate (2009) in the West Arsi zone, who indicated that farmers are accustomed to practicing planting drought resistance crops and saving money by selling animals in response to climate-related hazards in the West Arsi zone. Also, other studies (Gbetibouo, 2009; Nhemachena *et al*. 2007) stated that crop diversification, intercropping, changing planting dates, soil and water conservation, and irrigation are widely practiced in response to climate change impacts in Africa. This finding also confirmed with FGD and expert/leaders participants revealed that crop diversification, growing drought-resistant crop varieties, soil and water conservation, intercropping, and changing the planting date are the main adaptation strategies for climate variability in the study area. The findings were supported by different researchers in different study areas (Bryan *et al*., 2009, Temesgen, 2007).The FGDs in the study area experienced that the strategies are good and they use them because there is various options to use. They also added that those strategies improve our livelihoods and productions and insure food availability.

Table 11: Adaptation strategies of farmers to climate change

adaptation strategies of farmers to climate change	distribution of adaptation strategies of farmers to climate change (1st priority)					
	Gendo kebele		Gudumu kebele		Yamala kebele	
Adaptation strategies	Frequency	%	Frequency	%	Frequency	%
Planting early maturing varieties	7	12.5	-	-	4	11.4
Change in cropping pattern	4	7	4	15.4	-	-
using planting in line	4	7	3	11.5	6	17.14
Planting high-yielding varieties	8	14.2	4	15.4	3	8.5

		8				
Soil conservation or terracing	7	12.5	7	26.9	10	28.57
Diversification into non-farm activities	6	10.7	2	7.6	4	11.4
Emphasis on live stock keeping	5	8.9	1	3.8		-
Growing drought-tolerant crops	4	7	3	11.5		-
Diversification into off farm	5	8.9	1	3.8	3	8.5
Reducing livestock number	3	5.3	1	3.8	5	14.3
Manure or compost use	3	5.3	-		-	
Total	56	100	26	100	35	100

Source:-house hold survey, 2023

4.5.1. Barriers to climate change Adaptation

The information obtained from respondents, in relation to major limiting factors for farmers' climate change adaptation strategies were, a low level of economic status(61.5%)and poor infrastructural development(road, farmers training center, and veterinary center)(8.5%),poor farming system accounts(9.4%) lack of access to credit (11.1%),lack of labor force (6.%) and low educational level of farmers (3.4%). The outcome, which is also consistent with the IPCC, offers a systematic typology of constraints, which include knowledge, awareness, and technology as well as the physical environment, biological tolerances, financial factors, human resources, social and cultural factors, governance and institutional processes (Klein *et al.*, 2014).

Table 12: Barriers to adaptation measures

Variables	Frequencies	%
Economic status of livelihood	72	61.5
Poor infrastructural development	10	8.5
Poor farming system	11	9.4
Lack of access to credit	13	11.1
Lack of labor force	7	6
Low educational level of farmers	4	3.4

Source:-house hold survey, 2023

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The results of the study showed that more than 80% of farmers interviewed perceived an increasing trend of temperature and about 79.5% farmer's perceived decreasing trend of precipitation indicating how they are well aware of climate change. Farmers 'perceptions of an increasing trend of temperature and a decreasing trend of precipitation match well with the observed trends temperature and rainfall .There is an indication of greater climate variability characterized by extreme weather events such as drought, and shifts in the onset and cessation time of seasonal rainfall. Results of the vulnerability assessment confirmed that Gudumu kebele was the most vulnerable to climate change whereas; Gendo kebele was the medium vulnerable and yamala kebele was the least vulnerable to climate change. Assessment of vulnerability is useful to identify and prioritize vulnerable areas and contributing factors for adaptation planning. In order to reduce vulnerability to climate change of smallholder farmers at the local level, policymakers can benefit from the knowledge gained through this study.

Adaptation to climate change involves long-term changes to the mix of activities required for subsistence, in order to reduce the vulnerability of households' livelihood. Being the first step in the adaptation process, timely and accurate perceptions are important determinants for farmer's intentions and the choice of adaptation methods. Farmers practice different adaptation measures such as early and late planting, crop diversification, adjusting seasonal calendar and others. But there are some barriers to adapt climate change and variability. These include economic status, poor infrastructural development, lack of access to credit, lack of labor force and low educational level of farmers.

5.2 RECOMENDATION

The following recommendations are made in light of the findings:

- The national meteorology agency should install a meteorological station in Wereda to monitor climate relationship in the area to achieve better adaptation and to alleviate climate change and variability.
- Planned action for climate change adaptation is needed that goes beyond agriculture to ensure productivity and connectivity at grass root micro-scale level. In this regard, development programs should systematically integrate climate change adaptation and support complementary livelihood and adaptation goals as well as promote environmental protection measures. Enhancing the provision of agricultural technologies, improved seed types, fertilizer supplies, and irrigation development is advised to ensure sustainable agricultural production and reduce the small holder farmers' livelihood vulnerability to climatic variability and change.
- Provide farmers with better and improved agricultural inputs to get good success.
- Government policies should enhance access to affordable credit by adjusting interest rate of credit.
- Government should train and teach farmers on the issue of climate change ,upscale the local adaptation strategies and support to overcome vulnerability to climate change and the constraints in which they face in using adaptation strategies to climate change and so that ensure sustainable livelihoods

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7. APPENDICES

QUESTIONNAIRES FOR SURVEY INTERVIEW

Hawassa University

My name is Girma Mita Abdeta, MSC student at Hawassa University, Wondo Genet College of Forestry and Natural Resource. I am conducting the research concerned about the livelihood vulnerability and adaptation strategies of small holder farmers' to climate change and variability in Mareka district. Hence, your opinion and perception will support in this regard. Dear respondents: this type of local level study is crucial for society as well as decision makers. Therefore, the information that you will provide is believed to help the concerned bodies to in understanding thematic areas.

Taking into account the above objectives, you are kindly requested to response the appropriate answer for the following questions.

APPENDIX I. QUESTIONNAIRES FOR HOUSEHOLD SURVEY

The for mentioned questions are only for thesis data collection proposes in three kebeles: Yamala, Gendo and Gudumu kebeles

General Directions:

Choose and mark in space provided for closed-ended questions and write your response on space provided for open- ended questions.

PART ONE: Basic Information's

Name of the Interviewer_____Date_____

Region_____ Zone_____ Wereda _____ Kebele _____

Start of Interview (hrs/min)_____End of Interview (hrs/min)_____

Name of kebele_____& respondents _____.

Agro-ecological zones: Kola _____w/dega_____ Dega_____.

Part II-Questions for house hold head demographic characteristics

1. Gender of households' head 1. Male _____ Female_____
2. Age of house hold head 20-30_____ 31-40_____41-50 _____51-60_____61-70_____

3. Marital status A/ Married___ B/ single _____C/Divorced_____ D/ Widowed_____
4. Level of education for house hold A) None (including reading &writing)____B)primary (1-8)_____ C) Secondary (9-12)_____ D) diploma &above_____

PART III- Questions on Perception of House Hold Head Climate Change & Variability

1. Are there any climate change and variability in your area? A/ Yes____ B/ No_____

2. Is climate change variability declined your livelihoods? A/Yes ____ B/No_____

3. If the above question is yes, by what extent of climate change variability influenced your livelihood activity? A/high_____ B/ low_____ C/medium_____

4. When comparing the 1993s, with the recent past 30 years i.e. 2013s, 2014s & 2015s, have you observed any changes in climate? A/ Yes_____ B/ No_____

5. When comparing the past 1993s, with the recent past 30 years i.e. 2014s or 2015s, have you determined any changes in the rainfall patterns? A/Yes_____ B/No ____.

6. Question no.4, if you say yes; please specify the pattern of the change in rainfall you have noticed. A/ Increasing _____ B/ Decreasing_____

7. When comparing the 1993s, with the recent years i.e. 2013s, 2014s or 2015s, have you noticed any change in the temperature? A/ Yes_____ B/No_____

8. Question no.6, if yes; please answer the pattern of the change in temperature you have noticed. A/ Increasing_____ B/ Decreasing_____

9. Do you have coping /adaptation mechanisms in your area? A/ Yes_____ B/No_____

10. Question no.8; if yes, please put the coping or adaptation mechanism in your area. A/ High B/ Low C/ None

11. What is the coping/adaptation mechanisms used in your area? Describe some of them_____

_____.

12. Did you get any access to early warning before the last drought or flood? A/ Yes_____ B/No_____

13. If no, please mention the reasons, why? _____.

14. How did you take the measurement in coping with drought or flood in your area? Describe some of the methods

_____
_____.

15. Do you understand the hazards that related with climate variability and change in your area? A/ Yes_____ _____ B/ No_____

16. For the above question 12; if yes, what are the natural hazards that related with climate variability in your area? Please specify some of them _____

_____.

17. In response to the impacts of climate change, have you taken any adaptation measures in your area? A/ Yes _____ B/ No_____

18. If your answer to question no.17 is no, what is the reason for not taking adaptation measures to reduce impacts of climate change in your area at the past decades? Please put your answer in the table yes or no.

Numbers	Reasons for not taking adaptation	Yes	No	Remark
1	Lack of knowledge			
2	Lack of information about climate change			
3	Lack of capital			
4	Shortage in farm land			
5	Not considering climate related problems			
6	Giving low attention to climate change problems			
7	No early warning methods i.e. communications			
8	Distance of Institutions			
9	Problems of topography			

19. Do you know about livelihood vulnerability of climate change in your area in the last decade? A/ Yes_____ B/ No_____

20. If yes question no.19, have you observed the following climate change related impacts on livelihood in last decade? Answer in the table below, yes or no.

No.	Climate change related impacts on livelihoods of farmers	Yes	No
1	Decrease in crop yields		
2	Increase in crop yields		

3	Decline in livestock		
4	Increase in livestock productions		
5	Death of livestock due to shortage in fodder and water		
6	Food insecurity		
7	Increased weed and pest		
8	Transmission of disease		
9	Decrease of water quality and quantity		
10	Risks of crop damage due to drought		
others			

21. Do you have any access to climate information in your local area? A/ Yes __ B/ No__

22. If question no. 21, your answer is no, please specify the reason, why? _____

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23. Dear respondent, fill the following tables below if you are experienced with climate events?

No.	Have you experienced with the following types of climate change & variability indicators?	Yes	No	How often?(in the past decade)
1	Drought shocking			
2	Flood shocking			
3	Above average rainfall			
4	Below average rainfall			
5	Erratic rainfall patterns			
6	Landslides/degradation			
7	High temperature			
8	Strong wind			
9	Hailstorm			
Others				

PART VI-Questions on house hold head socio-economic characteristics

24. What type of farming practice would you experience? 1. Crop rotation 2.Live stock production 3. Mixed farming _____ 4. Others (specify _____.

25. How much income can you get from your farming activities in the last production? Specify in Birr.

1. Crop Production_____ 2.Livestock Production_____ 3. Fruits & vegetables_____

26. How much is your total expenditure in the last production year? Please specify in Birr._____

27. Based on land ownership/farm size

A/ Do you have your own agricultural land? 1. Yes_____ 2. No_____

B/ If yes question no. 27, how many hectares of land do you have? _____.

28. What are the physical characteristics of your farm, in terms of its exposure to erosion?

1. Susceptible to erosion 2. Moderately susceptible to erosion 3. Not susceptible at all.

29. Is there the fertility of the soil in your farm in general? 1. Very fertile_____ 2. Moderate _____ 3. Poor/infertile_____

30. What status of your crop production as compared to previous years? 1. Increasing 2. Decreasing

31. Do you have any communication devices like TV, radio, mobile phone, so on? 1. Yes_____2.No_____.

32. If your answer for question 31 is yes, what types of communication devices you have? 1. TV 2.mobile phone 3. Radio 4. Others_____

Part V. Questions on household head Institutional characteristics

33. Is there market distance in your area? 1. Yes_____ 2.No_____

34. If yes for the above question no.34, how far the market you buy your agricultural inputs? Distance in KM_____time it takes (hr) _____

35. How far is the market where you sell your agricultural outputs? Distance in KM_____ time_____

36. In undertaking your usual farming activities have ever faced shortage of finance? Example: to purchase agricultural inputs like fertilizer, oxen and others. 1. Yes_____ 2. No_____

37. Do you have access to any formal credits in time face shortage of money? 1. Yes____2.No_____

38. Do you have access to any informal credits (from neighbours, friends, relatives etc)? 1. Yes_____2.No_____

39. If yes, where you look for credit to fill your financial constraints? 1. Micro finance institutes 2. Non-formal money lenders 3. Relative friends

40. Do you have access to agricultural extension services in your kebele? 1. Yes _____2. No_____

41. Do you receive any support from agricultural extension which could help to improve your farming activities? 1. Yes _____2. No_____

42. If the answer on question 42 above is yes, please specify any kind of services you get from
them_____.

43. Have you ever got any kind of formal training w/c helps to improve your farm productivity? This might be how to (protect soil erosion, conserve rain water, use modern agricultural inputs, reduce post harvest loss, etc) 1. Yes _____ 2. No_____

44. If yes to the above question no.44, how do you find it in terms of its contribution to improve your farming income? 1. Very important 2. Important 3. Has no effect

APPENDIX II CHECK LISTS FOR FOCUS GROUP DISCUSSION

1. Do you have information on climate change and variability? A/ yes_____ B/ No_____

2. Have you observed the trends of climate change in the past decades? A/Yes____ B/No_____

3. Is there climate change and variability in your area? If yes what do you think the local indicators of climate change?
_____.

4. Do you know about coping mechanism to alleviate your livelihood from climate change? What are these coping mechanisms in your local area?
_____

5. Have you taken the coping or adaptation measures in order to reduce the impacts of climate change and variability? 1. Yes____ 2. No____

6. If your answer for question no.5 is yes, what are coping or adaptation measures you have used to climate change? Mention some of them_____

_____.

7. Have you examined the magnitude/extent of vulnerability due to climate change in your area?

8. Have you observed climate change related impacts on crop yield, livestock yield, shortages of fodder and water, food shortage, increased weed and pest pressures, transmissive diseases,

decrease of water quality and quantity, higher risk of crop damage from drought in last decade?_____

9. What a factors affecting the implementations of coping or adaptation mechanisms in your kebele? Please list some of them_____.

10. Do you have any suggestions or recommendations on climate change adaptation measurements or coping mechanisms?

APPENDIX III- CHECK LIST FOR KEY INFORMANT INTERVIEW

1.Name:_____2.Educational status_____

3. Position_____4. How long have you stayed in this position_____

5. How do you perceive about the following in your wereda in general and the study area in particular? _____

5.1 What does livelihood vulnerability mean? Do you have any idea on it? A/yes _B/No___

5.2 Have you understood the trends of climate change in the past decades mainly temperature and rainfall in your area? A/ yes_____ B/ No_____

5.3 How do you indicate climate change impacts on livelihoods of farmers in your locality?

5.4 In what magnitudes or extent of the livelihood vulnerability in your area? High vulnerability, medium vulnerability or low vulnerability?_____

5.5 Do you feel that is there climate change in Mareka wereda? A/ Yes _____B/no_____

5.6 Do you know which kebele/area more vulnerable to the impacts climate change?

5.7 How do you explain the coping mechanisms that have taken to reduce climate change impacts in your locality?

5.8 Do you have any suggestions or recommendations on climate change adaptation or coping mechanism in your vulnerable area? Please explain it_____.

Appendix IV

Monthly Rain Fall, Monthly Average Minimum and Monthly Average Max Temperature

Element:-Monthly Average Rain Fall

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1992	26.37	79.1	58.01	163.48	200.39	189.84	116.02	105.47	68.55	179.3	52.73	26.37
1993	73.83	47.46	79.1	184.57	263.67	189.84	105.47	189.84	73.83	184.57	26.37	5.27
1994	0	10.55	105.47	253.12	184.57	179.3	137.11	163.48	89.65	137.11	105.47	31.64
1995	5.27	63.28	94.92	221.48	147.66	163.48	142.38	89.65	189.84	126.56	26.37	47.46
1996	68.55	31.64	195.12	242.58	242.58	274.22	232.03	205.66	210.94	79.1	36.91	0
1997	15.82	0	68.55	358.59	168.75	152.93	147.66	116.02	58.01	316.41	290.04	84.38
1998	105.47	79.1	36.91	105.47	205.66	179.3	174.02	121.29	110.74	221.48	89.65	0
1999	26.37	0	121.29	131.84	142.38	73.83	131.84	63.28	58.01	216.21	26.37	31.64
2000	5.27	0	0	126.56	116.02	21.09	21.09	73.83	58.01	137.11	42.19	21.09
2001	31.64	5.27	121.29	216.21	152.93	94.92	15.82	68.55	63.28	131.84	89.65	5.27
2002	36.91	0	168.75	126.56	184.57	63.28	15.82	58.01	79.1	116.02	36.91	121.29
2003	0	15.82	105.47	152.93	94.92	73.83	26.37	105.47	26.37	26.37	94.92	84.38
2004	36.91	26.37	21.09	210.94	89.65	10.55	58.01	68.55	63.28	52.73	126.56	63.28
2005	26.37	15.82	89.65	168.75	284.77	21.09	36.91	36.91	58.01	79.1	26.37	0
2006	5.27	52.73	179.3	205.66	237.3	116.02	163.48	189.84	147.66	179.3	158.2	126.56
2007	47.46	58.01	89.65	179.3	221.48	147.66	158.2	189.84	174.02	105.47	63.28	15.82
2008	42.19	5.27	68.55	210.94	63.28	94.92	100.2	116.02	116.02	189.84	126.56	0
2009	47.46	5.27	52.73	242.58	116.02	31.64	89.65	73.83	179.3	184.57	36.91	110.74
2010	21.09	36.91	158.2	174.02	247.85	189.84	126.56	105.47	126.56	100.2	36.91	15.82
2011	0	0	52.73	158.2	200.39	100.2	68.55	68.55	68.55	84.38	221.48	10.55
2012	0	0	36.91	284.77	189.84	68.55	142.38	300.59	216.21	142.38	79.1	58.01
2013	21.09	0	121.29	290.04	258.4	158.2	168.75	126.56	131.84	174.02	163.48	0
2014	0	15.82	116.02	205.66	326.95	142.38	137.11	142.38	158.2	242.58	100.2	31.64
2015	0	5.27	42.19	158.2	205.66	142.38	116.02	52.73	36.91	316.41	184.57	89.65
2016	15.82	5.27	73.83	348.05	205.66	63.28	63.28	189.84	137.11	131.84	68.55	21.09
2017	0	31.64	79.1	121.29	300.59	79.1	121.29	94.92	168.75	195.12	68.55	0
2018	0	79.1	84.38	358.59	189.84	100.2	10.55	79.1	52.73	116.02	105.47	47.46
2019	0	21.09	89.65	258.4	179.3	110.74	116.02	126.56	158.2	300.59	184.57	79.1
2020	58.01	89.65	131.84	437.7	321.68	131.84	116.02	152.93	221.48	105.47	110.74	237.3
2021	94.92	15.82	15.82	177.95	310.97	41.17	149.11	167.96	141.54	132.94	72.48	46.76
2022	21.09	36.91	158.2	174.02	247.85	189.84	126.56	105.47	126.56	100.2	36.91	15.82

Monthly Average Maximum Temperature

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1992	33.12	31.75	34.03	33.22	26.95	25.4	24.37	24.76	26.7	25.4	27.16	30.73
1993	30.76	32.11	34.01	32.3	26.42	24.13	24.23	25.52	26.41	26.13	28.6	31.94
1994	33.8	33.84	34.9	30.87	26.39	24.46	24.26	24.54	26.4	26.44	26.25	30.82
1995	32.31	33.74	33.14	33.19	26.95	25.97	23.94	25.08	25.9	25.63	27.4	30.48
1996	30.35	33.35	33.83	27.73	26.79	24.12	24.48	24.29	25	25.23	26.08	30.67
1997	32.52	35	36.19	27.97	25.9	25.49	25.72	25.78	27.82	27.02	25.79	25.9
1998	28.29	28.5	33.94	34.44	28.71	25.96	23.8	24.96	26.55	25.32	26.33	30.68
1999	33.29	35.48	32.44	31.64	26.04	27.19	26.37	27.34	31.44	26.43	29.26	31.72
2000	34.03	35.39	36.26	34.9	27.76	29.02	28.8	31	30.21	29.12	29.96	32.05
2001	32.99	35.54	35.23	29.3	26.78	25.06	27.8	28.52	29.87	29.23	29.15	32.47
2002	32.44	35.91	32.35	30.26	26.19	26.58	29.48	30.24	33.37	29.27	31.15	31
2003	32.26	36.36	35.8	33.5	29.62	28.13	28.54	28.88	30.8	33.9	33.19	30.92
2004	33.3	34.55	36.16	29.3	26.84	29.03	29.55	29.23	29.01	31.91	30.8	30.23
2005	33.72	36.28	33.99	34.63	26.23	25.45	27.48	29.99	31.15	30.77	31.4	33.58
2006	35.08	35.08	31.92	27.94	26.39	25.19	24.22	24.8	25.71	25.52	25.88	25.98
2007	28.83	31.55	35.35	32.73	27.15	25.26	24.63	24.38	25.26	25.63	27.71	31.33
2008	32.87	34.37	35.43	31.26	26.44	27.43	28.33	27.09	27.74	27.3	25.86	30.4
2009	32.65	35.15	34.88	30.12	28.55	29	28.97	29.33	28.73	26.13	29.88	30.15
2010	32.52	32.98	33.16	28.63	26.31	25.33	25.33	25.13	25.82	27.13	29.48	31.66
2011	33.88	35.58	35.73	33.65	27.09	25.55	26.32	27.65	28.58	29.83	27.56	30.57
2012	33.62	35.53	35.55	30.46	26.06	24.87	24.26	24.58	25.01	26.36	25.83	27.67
2013	31.64	36.03	34.73	29.11	25.89	24.32	23.8	24.12	26.4	25.55	25.53	27.95
2014	33.83	33.26	35.49	27.54	26.72	26	24.98	25.01	25.81	25.51	25.78	26.77
2015	33.24	34.9	36.18	32.48	27.67	26.08	25.82	28.77	31.88	29.33	26.08	26.87
2016	29.99	35.73	35.67	29.65	26.23	25.79	25.2	25.47	27.17	26.15	29.94	32.12
2017	33.85	34.46	36.24	34.22	26.73	25.83	24.71	26.1	26.87	26.22	26.94	32.21
2018	34.27	35.11	31.9	29.37	27.01	24.83	24.55	26.62	31.43	28.55	29.4	31.38
2019	35.19	35.99	36.51	31.62	28.22	25.83	26.21	25.44	27.28	26.18	26.09	26.44
2020	29.68	32.4	33.19	31.53	26.11	25.62	24.84	25.11	25.83	25.98	26.35	30.37
2021	30.05	33.73	35.72	34.55	26.55	25.55	25.21	26.19	25.83	26.74	30.7	31.78
2022	32.99	35.54	35.23	29.3	26.78	25.06	27.8	28.52	29.87	29.23	29.15	32.47

Monthly Average Minimum Temperature

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1992	13.59	15.66	14.1	15.17	15.3	14.87	13.48	13.6	14.58	13.22	9.59	15.23
1993	13.52	14.15	10.15	16.8	15.83	14.86	13.78	12.97	13.76	14.48	13.9	10.11
1994	10.46	13.67	16.17	14.73	15.88	14.34	14.09	14.02	15.24	13.42	13.74	12.98
1995	12.55	15.15	15.9	16.23	15.45	14.94	13.83	14.23	14.9	12.13	13.96	13.99
1996	15.11	14.73	15.76	15.44	15.37	14.68	14.05	13.86	14.98	14.7	10.78	12.65
1997	14.85	11.76	17.34	15.99	15.96	15.23	13.9	14.45	15.98	14.72	14.95	15.04
1998	15.28	15.76	16.99	17.48	15.41	15.01	14.15	14.55	14.16	14.22	11.32	11.06
1999	12.03	11.26	16.62	16.36	14.74	14.55	14.16	14.76	15.74	14.49	11.6	11.12
2000	12.69	14.94	17.33	16.23	15.65	15.4	14.7	14.44	13.83	14.18	12.37	12.98
2001	14.87	15.61	16.24	16.55	14.86	14.23	15.17	13.98	16.3	14.91	13.43	15.71

2002	14.04	14.88	17.04	15.37	15.39	15.08	15.76	15.42	15.53	14.68	13.98	14.22
2003	11.3	14.58	16.48	14.3	15.37	15.5	14.78	14.94	15.83	16.95	15.79	10.2
2004	14.94	14.17	14.51	16.73	16.03	14.97	15.19	15.36	15.19	12.99	11.84	12.19
2005	10.81	14.44	17.04	15.25	15.64	15.06	14.54	14.33	15.81	15.04	11.44	11.26
2006	14.37	14.47	15.15	15.08	15.68	14.77	14.15	13.48	13.53	15.04	11.9	13.27
2007	11.99	14.88	15.3	15.62	16.12	14.73	14.53	14.11	14.01	12.91	10.92	9.16
2008	12.76	12.74	15.52	15.14	15.86	15.11	14.42	14.43	14.79	13.62	9.76	10.69
2009	12.48	15.68	16.45	16.39	16.07	15.66	15.13	15.16	15.54	14.32	10.97	14.7
2010	13.62	16.51	14.69	15.91	16.69	15.45	14.94	14.86	14.87	14.91	11.94	10.65
2011	14.23	14.29	15.41	16.37	16.21	14.69	14.48	14.83	15.15	13.48	14.19	9.66
2012	10.99	13.14	15.81	15.88	16.17	14.61	14.41	14.77	15	13.52	13.46	12.49
2013	11.95	16.41	16.53	16	15.95	15.23	14.3	13.99	15.08	13.22	12.48	10.71
2014	13.84	14.08	15.51	16.05	15.66	15.01	14.15	14.24	14.62	14.59	13.9	11.68
2015	10.5	14.58	16.08	15.76	15.98	14.52	15.05	14.94	16.01	15.37	12.69	13.24
2016	15.6	15.59	16.19	16.63	16.76	14.99	14.5	14.12	14.84	14.69	10.44	9.98
2017	8.58	15.91	16.34	16.47	16.44	15.81	15.13	14.95	14.99	15.56	11.89	10.45
2018	12.32	12.87	14.95	16.67	16.17	14.82	14.26	14.22	15.92	15.1	12.05	13.82
2019	11.15	16.19	18.05	17.07	15.91	15.92	14.75	14.18	13.89	14.84	13.99	12.71
2020	12.58	15.53	15.69	16.48	16.9	15.03	14.02	14	14.83	13.78	12.14	11.21
2021	11.74	12.72	15.84	14.6	14.69	15.37	14.09	14.41	15.55	12.85	13.37	10.8
2022	13.62	16.51	14.69	15.91	16.69	15.45	14.94	14.86	14.87	14.91	11.94	10.65