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WOLLEGA UNIVERSITY

College of Natural and Computational Sciences

School of Graduate Studies

**ASSESSING THE PERCEPTION AND ADAPTATION
STRATEGIES OF CLIMATE VARIABILITY ON LIVELIHOODS
Of LOCAL COMMUNITY IN WAYU TUKA WOREDA, EAST
WOLLEGA ZONE, OROMIA , ETHIOPIA.**

BY

Meseret Bayisa Diba

May, 2025

Nekemte, Ethiopia



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CLIMATE VARIABILITY ON LIVELIHOODS OF LOCAL
COMMUNITY IN WAYU TUKA WOREDA, EAST WOLLEGA ZONE,
OROMIA , ETHIOPIA.**

**A THESIS SUBMITTED TO DEPARTMENT OF BIOLOGY, COLLEGE OF
NATURAL AND COMPUTATION SCIENCES IN PARTIAL FULFILLMENTS OF
THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN
ECOLOGY AND CONSERVATION.**

BY:

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APPROVAL SHEET FOR SUBMITTING FINAL RESEARCH REPORT

As members of the Board of Examination of the Final MSc thesis open defense, we certify that we have read and evaluated the thesis prepared by Meseret Bayisa Diba under the title “Assessing The Perception And Adaptation Strategies Of Climate Variability On Livelihoods Of Local Community In Wayu Tuka Woreda, East Wollega Zone, Oromia , Ethiopia” and recommend that the thesis be accepted as fulfilling the thesis requirement for the Degree of Master of Ecology and Conservation Biology

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I hereby certify that all the corrections and recommendations suggested by the Board of Examiners are incorporated into the final thesis entitled “Assessing The Perception And

Adaptation Strategies Of Climate Variability On Livelihoods Of Local Community In Wayu Tuka Woreda, East Wollega Zone, Oromia , Ethiopia” by Meseret Bayisa Diba.

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Date

STATEMENT OF THE AUTHOR

I declare that this thesis entitled “Assessing The Perception And Adaptation Strategies Of Climate Variability On Livelihoods Of Local Community In Wayu Tuka Woreda, East Wollega Zone, Oromia , Ethiopia” is my work and that all sources of materials used for this thesis have been appropriately acknowledged. This thesis is submitted in partial fulfillment of the requirements for MSc Degree in Ecology And Conservation Biology at Wollega University. I seriously declare that this thesis is not submitted to any other institution anywhere for the award of any degree or diploma. The thesis will deposited at the University Library to make available to borrowers under the rules of the Wollega University Library.

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This is to certify that the thesis entitled by “Assessing The Perception And Adaptation Strategies Of Climate Variability On Livelihoods Of Local Community In Wayu Tuka Woreda, East Wollega Zone, Oromia , Ethiopia”, is designed for the partial fulfillment of the requirements for the award of the degree of master of Ecology And Conservation Biology by the school of graduate studies Wollega University through the college of natural and computational science done by Meseret Bayisa Diba is a genuine work carried out by her under my guidance. The matter embodied in this Proposal work has not been submitted earlier for the award of any degree or diploma.

The assistance and help received during the course of this investigation have been properly acknowledged. Therefore, I recommend that it can be accepted as fulfilling the research thesis requirements.

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BIOGRAPHIC SKETCH

The author was born on September 12, 1979 E.C, in Oromia National Regional State, East Wollega Zone, Diga Woreda, Demeksa Kebele. She attended elementary school at Some primary and secondary school at Diga secondary school. She has entered Wollega University in 2000 and graduated in 2006 with BSC degree in Biology. Then, She has served at Mote secondary school for 8 years in teaching. Also, she have been a teacher in Wayu Tuka Wereda Secondary school for 11 years until she joined Wollega University for her second degree in 2021 G.C.

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ACRONYMS AND ABBREVIATIONS

ACCA	American Chamber of Commerce Research Association
CBA	Community Based Adaptation
CRGE	Climate Resilient Green Economy
CSA	Central Statistics Agency
DFID	Department for International Development
EEA	Ethiopia Economic Association
EMA	Emergency Management Agency
EPA	Environmental Protection Authority
EPE	Environmental Policy of Ethiopia
FAO	Food and Agricultural Organization
FDREEP	Federal Democratic Republic of Ethiopia Environmental Protection
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GNI	Gross National Income
GoE	Government of Ethiopia
HH	Households
HHH	Households Heads
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy and Research Institute

IIED	International Institute for Environmental and Development
IPCC	Intergovernmental Panel on Climate Change
ISSET	Institution for Social and Environmental Transition
MOFED	Ministry of Finance and Economic Development
NAPA	National Adaptation Program Action
NMSA	National Meteorological Survey Agency
NMA	National Meteorology Agencies
NOAA	National Oceanic and Atmospheric Administration
OECD	Organization for Economic Co-operation Development
SSA	Sub Sahara Africa
SS	Sahara Africa
UKCIP	UK Climate Impact Programme
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Conventions on Climate Change

TABLE OF CONTENTS

Contents	Pages
APPROVAL SHEET	I

<u>STATEMENT OF THE AUTHOR</u>	III
<u>DECLARATION</u>	IV
<u>BIOGRAPHIC SKETCH</u>	V
<u>ACKNOWLEDGEMENTS</u>	VI
<u>ACRONYMS AND ABBREVIATIONS</u>	VII
<u>TABLE OF CONTENTS</u>	VII
<u>LIST OF TABLES</u>	IX
<u>LIST OF FIGURES</u>	XIV
<u>ABSTRACT</u>	XIII
<u>1. INTRODUCTION</u>	
<u>1.1. Background</u>	1
<u>1.2. Statement of the Problem</u>	4
<u>1.3. Objectives of the Study</u>	5
<u>1.3.1. General Objective</u>	5
<u>1.3.2. Specific Objectives</u>	5
1.4. Research Questions.....	5
<u>1.5. Significance of the Study</u>	6
<u>1.6. Scope and Limitation of the Study</u>	6
<u>1.7. Organization of the study</u>	7
<u>2. REVIEW OF RELATED LITERATURE</u>	8
<u>2.1. Definitions and Concepts</u>	8
<u>2.2. Climate Change and Farming Livelihood</u>	10
<u>2.3. Causes and Manifestations of Climate Change</u>	11
<u>2.4. Climate Change in Ethiopia</u>	13

Table of contents (Continued.....)

<u>2.4.1. The Impacts of Climate Change in Ethiopia</u>	15
<u>2.4.2. Impacts of Climate Change on Agriculture</u>	16
2.4.3. Impacts of Climate Change on Livestock Productions.....	16
<u>2.4.4. Impacts of Climate Change on Water Resources</u>	17
<u>2.5. Conceptual Framework</u>	17
<u>3. Materials and Methods</u>	19

<u>3.1. Description of the Study Area</u>	19
<u>3.1.1. Topography and soil</u>	20
<u>3.1.2. Climate</u>	20
<u>3.1.3. Population</u>	20
<u>3.1.4. Land Uses And Agricultural Activities</u>	20
<u>3.2. Research Design</u>	21
<u>3.3. Types and Sources of Data</u>	21
<u>3.4. Sampling Technique and Sample Size</u>	23
<u>3.5. Data Collection Techniques</u>	23
<u>3.5.1. Household survey</u>	23
<u>3.5.2. Key informant interview</u>	3
<u>3.5.3. Focus group discussion</u>	4
<u>3.6. Methods of Data Analysis</u>	24
<u>4. RESULTS AND DISCUSSION</u>	27
<u>4.1. Socioeconomic and Demographic Characteristics of the respondents</u>	27
<u>4.2. Livelihood Bases of the Sample Household</u>	29
<u>4.3. Land Holding Size of the Respondents</u>	30
<u>4.4. Livestock Ownership of the Sample Respondents</u>	31
<u>4.5. Meteorological Recorded Data of Climate in the Study Area</u>	33
<u>4.5.1. Rainfall Amount, Trends and Seasonal Concentration</u>	33
<u>4.5.2. Temperature Pattern</u>	43
<u>4.5.3. Perception of Precipitation and Temperature Pattern</u>	54
<u>4.6. Households Understanding and Perception of Climate Change</u>	56
<u>4.6.1. Households' Knowledge and Perceptions About Climate Change</u>	56
Table of contents (Continued.....)	
<u>4.6.2. Local Indicator of Climate Change</u>	58
<u>4.6.3. Trend of Animal Feeds</u>	59
<u>4.6.4. Source of Water for the Household</u>	60
<u>4.7. Vulnerability of Local Livelihood to the Impact of Climate Change</u>	61
<u>4.7.1. The Main Cause for Climate Change Related Problem</u>	61
<u>4.8. Climate Change Adaptation Strategies</u>	64
<u>4.8.1. Community Based Measures to Over Come the Climate Change Impact</u>	64
<u>4.8.2. Local Livestock Adaptation Strategies</u>	66
<u>4.8.3. Crop Production Adaptation Strategies</u>	67
<u>4.8.4. Adaptation Strategies of HH Related to Shortage of Water</u>	69

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS	71
5.1. Summary.....	71
5.2. Conclusion	72
5.3. Recommendations	73
References	75
Appendices	83
Appendix, I:	83
Appendix, II	85
Appendix, III	86
Appendix, IV.....	87
Appendix V.....	88
Appendix VI.....	89

LIST OF TABLES

Table 1: Distribution of sample household	22
Table 2: Socioeconomic and Demographic Characteristics of Respondents (n=128).....	27
Table 3: Surveyed means of HHs livelihoods	29
Table 4: Land holding size category	30
Table 5: Livestock ownership of the sample respondent between 2011 –	31
Table 6: Trends of rainfall in the study district for the period of 1990-2019.....	34
Table 7: Descriptive statistics of rainfall in the study district for the period of 1990-2019...	35
Table 8: Trend analysis of maximum and minimum temperature by using Mann-Kendall and Sen's slope test in Wayu Tuka district (1990-2019)	44
Table 9: Descriptive statistics of maximum temperature in the study district (1990-2019)...	46
Table 10: Descriptive statistics of minimum temperature in the study district (1990-2019)...	47
Table 11: Sample respondents perception of precipitation and temperature in the study area	55
Table 12: Views of respondents on notation of climate change	57

<u>Table 13: Respondents’view on local indicator of climate change</u>	58
<u>Table 14: Views of respondents on the trend of animal feeds</u>	59
<u>Table 15: Views of respondent on source of water household</u>	60
<u>Table 16: Views of respondents on the main cause for climate change</u>	61
<u>Table 17: Views of respondents on the challenges of climate change</u>	63
<u>Table 18: Respondents’views on community based measures of adaptation strategies</u>	64
<u>Table 19: Views on livestock related household adaptation strategies</u>	66
<u>Table 20: Respondents’views on crop production adaptation system to overcome climate change impact</u>	67
<u>Table 21: Views on adaptation strategies of farmers related to shortage of water</u>	69

LIST OF FIGURES

<u>Figure.1.The global average amount of carbon dioxide trend</u>	12
<u>Figure 2: Conceptual Framework of the study</u>	18
<u>Figure 3: Map of the study area</u>	19
<u>Figure 4: Trends of monthly Rainfall (1990-2019)</u>	36
<u>Figure 5: Trends of autumn (belg) rainfall patterns (1990-2019)</u>	37
<u>Figure 6: Trends of winter (bega) rainfall pattern (1990-2019)</u>	38
<u>Figure 7: Trends of spring/ tsidy rainfall pattern (1990-2019)</u>	39
<u>Figure 8: Trends of summer (kiremt) rainfall patterns (1990-2019)</u>	40
<u>Figure 9: Trends of annual rainfall patterns (1990-2019)</u>	41
<u>Figure 10: Trends of average rainfall patterns (1990-2019)</u>	42
<u>Figure 11: Trends of monthly maximum and minimum temperature (1990-2019)</u>	48
<u>Figure 12: Trends of autumn maximum, minimum and average temperature (1990-2019)</u> ...	49
<u>Figure 13: Trends of winter maximum, minimum and average temperature (1990-2019)</u>	51
<u>Figure 14: Trends of spring maximum, minimum and average temperature (1990-2019)</u>	52
<u>Figure 15: Trends of winter maximum, minimum and average temperature (1990-2019)</u>	53
<u>Figure 16: Trends of average annual maximum and minimum temperature (1990-2019)</u>	54

Abstract

This study sought to analyze climate Variability over the past three decades and identify the most vulnerable groups to the impact of climate change and assess the existing climate Variability adaptation strategies in Wayu Tuka Woreda of East Wollega Zone. Multistage stratified random sampling method was used to select three sample kebeles by considering agro-ecological zone. To this end, 128 household heads were selected using simple random sampling from the three sample kebeles. Additionally, three focus`` group discussions each of them composed of 6 individuals from different socio-economic status and age groups were selected and used as primary sources of information. Key informant interview was conducted with development agents and knowledgeable and experienced experts from Wayu Tuka Agricultural Organization office and secondary data were collected from published and unpublished sources. The collected data were entered into SPSS version 20, and analyzed using descriptive statistics such as percentage, frequency, mean, standard deviation and coefficient of variation. Mann-Kendall Sen's Slope test and linear regression were also used to evaluate rainfall and temperature trends in the study area. Results from this study indicate that, the rainfall amount is decreasing trend at a rate of 10.772mm annually along with 36.8% of the variability. The maximum and minimum temperature analysis showed an increasing trend at a rate of 0.037⁰C and 0.013⁰C annually respectively. The Mann-Kendall trend analysis result shows that months of January (-2.34mm), April (-2mm) and winter season (-1.98mm) rainfall were statistically significant decreasing trends whereas the maximum temperatures trends in March (2.89 ⁰c), July (2.13⁰c and September (2.04⁰c) were statistically significant increasing trend. Besides, the minimum temperatures in July (2.52⁰c), September (2.79⁰c), summer (2.05⁰c) and autumn (2.42⁰c) seasons were statistically significant increasing trends. Descriptive statistics on the perception level of households sample indicated that 59.4% of them perceive that rainfall has been decreasing followed by 34.4% were late-onset and early offset rainfall whereas 82.8% of them perceive that temperature has been increasing, leading to reduction of agricultural productivity. Results show that 81.6% of

households'livelihoods depend on agricultural production and the rest 18.4% depends on working as daily laborer, petty trade and renting out land. The main adaptation practice being exercised by the households in response to climate Variability were planting trees by 43.8%, soil and water conservation by 25.8% of the respondents. The community in the study area agreed that while rainfall amount has decreased, temperature has been increased which was supported by meteorological data of the study area. To adapt to the changing the climate of the area, rural livelihoods are already practicing long-aged coping mechanisms and adaptation strategies along with some government interventions in the response to climate Variability. Therefore, increasing household awareness on how to use agricultural technologies in puts, re-establishing the degraded environment, facilitating access to credit services and promoting community-based adaptation strategies as the main poverty reduction approach were some recommendation strategies forwarded based on the finding.

Key words: Adaptation Strategies, Agriculture Production, Perception, Climate Variability , Mann-Kendall trend Rural Livelihoods, Sen's Slope, Weather conditions.

1. INTRODUCTION

This section presents about the background of the study, Statement of the problem, Objectives of the study, research questions, significance of the study, scope of the study and organization of the study.

1.1. Background

There is a remarkable scientific consensus that global climate has changed. Many including the scientists working with the Intergovernmental Panel on Climate Change (IPCC) have concluded that these changes are already under way (ISET, 2013). The fourth assessment report of the IPCC dispelled many uncertainties about climate Variability (IPCC, 2007).

The warming of the climate system is now unequivocal. It is now clear that global warming is due to manmade emissions of greenhouse gas (GHG), mostly carbon dioxide (CO₂). Over the last century atmospheric concentrations of CO₂ increased from a per-industrial value of 287 parts per million to 379 parts per million in 2005 and the average global temperature rise by 0.74⁰C United Nations Framework Conventions on Climate Change (UNFCCC, 2007). The international consensus of scientific opinion, led by the IPCC, agreed that global temperature is increasing because of the accumulation of Co₂ and other greenhouse gases in the atmosphere as a result of human activity (Carr *et al.*, 2005). If emissions remain at current rates, by 2050 the concentrations of GHGs in the atmosphere will reach 550 parts per million and continue to increase there after (World Bank, 2010).

The negative effects of climate Variability are threatening to reverse development gains in many parts of the world, especially in Sub- Sahara Africa. It is now an accepted scientific phenomenon that the global climate is changing. In Sub- Saharan countries rainfall patterns have become less predictable, precipitation has decreased on average and temperatures are rising (Holmgren and Oberg, 2006). Evidence shows that the upward trend of the already high temperatures and the reduction of precipitation levels will increasingly result in reduced agricultural production in Sub- Sahara Africa (Mano and Nhemachena, 2008).

Global climate change will have an impact on food and water security in significant and highly uncertain ways, and here are strong inductions that developing countries will bear the brunt of the adverse consequences, particularly from climate change. This is large because poverty levels are high, and developing-country capacity to adapt to global change is weak. Furthermore, the rural populations of a developing countries for whom agricultural production is the primary source of direct and indirect employment and income will be most affected due to agriculture's vulnerability to global change processes (Ringler *et al.*, 2011).

Africa has been identified as one of the continent's most vulnerable to the impacts of climate change (Jones and Rahman, 2007). The reasons are the exposure of its population to climate variations and extremes, people's dependency on natural resources and the under development of much of the region. Africa is already affected by climatic extremes such as floods and droughts, which will be exacerbated by climate change. Such events are having a negative impact on livelihoods, especially those of the poor. Given the degraded environments, food insecurity, and poverty already affecting large parts of Africa, climate change poses a monumental problem for the region (Jones and Rahman, 2007).

In Ethiopia climate variability and change in the country are mainly manifested through the variability and a decreasing trend in rainfall and increasing trend in temperature (NMA, 2001). For the IPCC mid-range emission scenario, the mean annual temperature will increase in the range of 0.9-1.1 °C by 2030, in the range of 1.7-2.1 °C by 2050 and in the range of 2.7-3.4 °C by 2080 over Ethiopia compared the 1961-1990 normal (McSweeney *et al.*, 2008). Historical climate analysis for Ethiopia indicates that mean annual temperature has increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade. The increase in temperature in Ethiopia has been most rapid in June, August, and September at a rate of 0.32°C per decade (McSweeney *et al.*, 2008). Rainfall is historically highly variable and there is no clear trend in the amount of rainfall over time (McSweeney *et al.*, 2008; NAPA, 2007). Studies of localized meteorological data alongside community perceptions indicate that

seasonal change may already be occurring as there are declining and increasing trends in certain months of the year (ACCRA, 2011).

Besides, the mean annual temperature is projected to increase by 1.1-3.1°C in the 2060s and 1.5- 5.1°C in the 2090s (McSweeney *et al*, 2008). Under a single emissions scenario, the projected changes from different models span a range of up to 2.1°C (McSweeney *et al*, 2008).

Therefore, adaptation to climate Variability is critical to many proposed strategies, for reducing the negative impacts of climate change. Adaptive capacity building is increasingly embraced by government and other institutions as a means to improve economic and ecological resilience, sustainable development and will require action across multiple sectors at all levels (Bishaw *et al.*, 2013). There are three main reasons for this increase in interest. First, the impact of climate change are already being observed and, because of lags in the natural system, more impacts are inevitable (Burton *et al*, 2002). Second, mitigation responses have been shown and inadequate, making adaptation all the more necessary (Reid and Boko *et al.*, 2007). Third, knowing the greatest physical impacts from climate change, governments in developing countries are increasingly demanding greater attention to adaptation on the international stage (Prowse & Scott, 2008).

Climate Variability should therefore, systematically mainstreamed into socio-economic development policy and planning at national, regional and continental levels. At a local level, adaptation programmers should involve and give ownership to communities at the grassroots level, moving steadily towards a community-based adaptation approach. It is imperative that local government incorporates indigenous knowledge into adaptation policies and analyses and takes account of models of best practice and adaptation approaches at a grassroots level (Chevalier, 2010).

Therefore, household's perception and adaptation strategies on the impact of climate change are considered to be essential to ensure food security through rising agricultural production, and proper utilization in the right diversity and stability. There were insufficient empirical studies based on the impact of climate change on rural livelihoods and adaptation strategies in the study area so far to identify the impact of climate change on rural livelihoods and adaptation strategies.

Hence, in order to contribute to fill the research gap this study is planning to assess the impact of climate change on rural livelihoods and adaptation strategies in Wayu Tuka Woreda, East Wollega Zone, Oromia, Ethiopia.

1.2. Statement of the Problem

Ethiopia currently faces several critical development and ecosystem management challenges that impact the lives and livelihoods of their citizens. Current climate change, especially the cycles of drought and intense rainfall events in the highlands, exacerbates socioeconomic and environmental issues. Without urgent action, this could make it impossible for poor people to attain a wide range of development and social justice goals (ISET, 2013).

Climate Variability, decrease in grazing land and increasing food and energy demand as a result of ever-increasing population pressure are considered as some of the development challenges in Ethiopia. Climate change worsened the situation by increasing moisture stress in the growing seasons of most cereal crops. If agricultural production in the low-income developing countries of SSA like Ethiopia is diversely affected by climate change, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increase (Abebe, 2013; Kindu *et al.*, 2013).

As a result of this, crop and livestock production has decreased and the Woreda has become significantly vulnerable to the impacts of climate Variability. In addition to this, due to the change in the pattern and timing of rainfall, there is a change in the cropping pattern of the study area. Despite of the long-age local farmers endeavor to adapt to the changing climate, their effort to achieve resilient is constrained by various factors. This may be partly because, their adaptation strategies are not well organized, may not be pre community priorities and needs. Furthermore, it will be assumed that their attempt to adapt to climate change and attain a more resilient livelihood lacks, collective action and social capital and does emphasize local decision- making action.

Coming to the study areas, there is a research gap to farmers ‘perception and adaptation strategies to climate change, initiated the researcher to raise the issue under consideration. Therefore, this study was identifying the gaps, like the different perception of farmers to climate Variability, limited adaptation strategies and inadequate relevant information, knowledge and skills. Hence, to enhance farmers ‘perception and adaptation strategies to climate change by providing awareness creation and opportunities to farmers ensure household food security. Therefore, to contribute in filling this gap and meet the local

research need the study was aims to assess the impact of climate Variability on rural livelihoods and adaptation strategies, perception of farmers towards climate Variability, identify adaptation responses mechanisms.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of the study is to assess the perception and adaptation strategies of climate Variability On Livelihoods Of local community in Wayu Tuka Woreda, East Wollega Zone, Oromia , Ethiopia.

1.3.2. Specific Objectives

The specific objectives of this study were:

- To assess the perception of the local people towards climate Variability impact on rural livelihoods in the study area.
- To assess the adaptation strategies of livelihoods being practiced to climate Variability in the study area.

1.4. Research Questions

- I. How household farmer heads perceive towards climate Variability impact on rural livelihoods?
- II. How do local communities being practiced climate Variability adaptation strategies?

1.5. Significance of the Study

Climate Variability has become a serious challenging factor for the implementation of the country's development strategies. Even though climate change is affecting the whole world, the extent differs from region to region and from locality to locality. Similarly, the coping mechanism differs from community to community. These together indicate the fact that local studies are necessary to understand the extent of climate change at different levels and different coping mechanisms that may be replicated and used as remedial measures in other similar occasions.

It is obvious that outputs of an every well done research finding have its own contribution in the social, economic, political and environmental situations of a given area. Likewise, is expected this study a significant contribution in Wayu Tuka Woreda farmers in particular and

in the regional and national levels in general for those highly depend on rain-fed agriculture. The agricultural sector, in Ethiopia and Oromia region is the major anti-poverty strategy. It is significantly important to alleviate rural poverty, improve the well-being of the poor and move them into better economic sectors through the promotion of agricultural productivity through proper and a well-managed policies and strategies. Thus, the importance of the study can be outlined as follows:

So far no detailed study has been carried on the impacts of climate Variability and adaptation strategies in Wayu Tuka Woreda in particular, therefore, study can a springboard for various researches related to the topic. It helps to understand the perception and awareness of subsistence farmers towards the impact of climate change on their agricultural productivity and livelihoods as well as the way they are responding to overcome this challenge. The result of the study is also significant to use basic information on problems of climate Variability impact on subsistence farming for policy makers, government institutions, NGOs and other stakeholders which are interested on the issues. Besides, it helps to alert local authorities in finding solutions for such challenges and would contribute little about how to cope and adapt to the effects of climate change. Finally, this research is significant to depict the issues that need special attention and further research on this area.

1.6. Scope and Limitation of the Study

This study would have been delimited in two ways. Firstly, it is geographically delimited to the three selected sample kebeles. Such as highlands, mid-altitude and low land ,from highlands-DaloKomto, From Mid-altitude:- Gute Badiya and from Low land:- Bonaya Molo were selected from three agro-ecological zones of the Woreda. Secondly, conceptually the focus of the study is to assess the impact of climate Variability on rural livelihoods and adaptation strategies.

The result of this study was based on limited-number of sample households due to absence of the HHs at their home during the survey. The other challenge encountered during the survey was the shortage of secondary data and the unwillingness of some officials to be interviewed.

1.7. Organization of the Study

This thesis is organized into five chapters. The first chapter deals with the introduction part which includes the background of the study, statement of the problem, research questions, objectives, significance of the study, scope and limitation, and organization of the study. The

second chapter deals with review of related literature. The third chapter describes the methodology and description of the study area. Chapter four presents the discussion and finding of the study. And finally, the fifth chapter deals with the summary, conclusion and recommendations.

2. REVIEW OF RELATED LITERATURE

2.1. Definitions and Concepts

Climate Variability in IPCC usage refers to a change in the state of the climate that can be identified (E.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Variability (UNFCCC, 2007), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable periods (IPCC, 2007).

Vulnerability

Temesgen; *et al.* (2009) argued that, the term “vulnerability” has no universally accepted definition, largely because different disciplines use the term differently to explain their area of concern. Studies on natural hazards and epidemiology define vulnerability as the degree to which an exposed unit is susceptible to being harmed by exposure to a perturbation or stress, in conjunction with its ability to cope, recover or fundamentally adapt or become a new

system or go extinct (Temesgen *et al.*, 2009). Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001).

The vulnerability of countries and societies to the effects of climate change depends not only on the magnitude of climatic stress; but also on the sensitivity and capacity of affected societies to adapt to or cope with such stress, sensitivity to climatic stress is higher for activities entailing climate-dependent natural resources; such as agriculture resources-often critical for the livelihoods of the poor. The capacity to adapt and cope depends upon many factors, including wealth, technology, education, institutions, information, skills and access to resources, which are generally scarce in poor countries and communities (OECD, 2009).

Adaptation to Climate Variability

Adjustment in natural or human systems is response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptations can be distinguished such as anticipatory, autonomous and planned adaptation (IPCC, 2007).

According to UNFCCC, adaptation is defined as practical steps to protect countries and communities from the likely disruption and damage that will result from the effects of climate change. For example, flood walls should be built and in numerous cases, it is probably advisable to move human settlements out of flood plains and other low-lying areas. UNDP, (2010) also defines adaptation a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented. Adaptation is the process or outcome of a process that leads to a reduction in harm or risk of harm, or realization of benefits associated with climate variability and climate change, (UK Climate Impact Programmed (UKCIP, 2003)).

Community Based Adaptation

Community-based adaptation describes the process of reducing negative impacts of climate Variability on vulnerable populations-communities, households and individuals- from the bottom up (CARE, 2012). Community-based adaptation is targeted at those most vulnerable to climate change and represents a relatively new approach consisting of community-based development activities, practices, research and policies (Reid, *et al.*, 2010). Community-

based adaptation (CBA) is increasingly popular as an approach to support vulnerable communities to adapt to climate change. Impacts are already being felt by the pastoralist and farming communities (ALIN and ALP, 2012).

Community and households face climate-related stresses such as increased surface temperature, changes in the timing and amount of rainfall, hail storms, floods, droughts, wind instability etc. (IPCC, 2007). Thus, the lives and livelihood assets of the rural community are under such threats and their associated consequences.

2.2. Climate Change and Farming Livelihood

Climate Variability is a change of climate which is attributed directly or indirectly to human activity. It alters the composition of the global and/or regional atmosphere and natural climate variability observed over comparable periods. Climatic variability is the types of changes (temperature, rainfall, occurrence of extremes); magnitude and rate of the climate change that causes the impacts on the area of public health, agriculture, food security, forest hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services. Changes in the physical and socio-economic systems have been identified in many regions (UNFCCC, 2007). According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), the global average surface temperature is likely to rise by 1.8 to 4.0 degrees Celsius by 2100. The sea level may rise by 30 to 60 centimeters. Climate variability will increase almost everywhere. Northern latitudes will experience more rainfall; many subtropical regions will see less (IPCC, 2001)

Detecting these changes and associating them with climate Variability poses huge problems since these systems are usually subject to many stress factors other than climate change too. Vulnerability is the degree to which a system (such as a social-ecological system) is likely to be wounded or experience harm or stress in the natural or social environment. Vulnerability results from a combination of processes that shape the degrees of exposure to hazards, sensitivity to its stress and impacts, and resilience in the face of those effects. It is also considered a characteristic of all people, ecosystems, and regions conforming to environmental or socio-economic stress and, although the level of vulnerability varies widely, it is generally higher among poorer people (Kasperson *et al.*, 2001).

Livelihood- is broadly defined as “comprising people, their capabilities and means of living, including food, income and assets” (Chambers and Conway, 1992). A livelihood comprises the capabilities, assets (including both material and social resources), and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from

stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Chambers and Conway, 1992). The livelihood system could be categorized into broad five types: Pastoralist, agro-pastoralist, farming, hunting and gathering and urban livelihoods (Chambers and Conway, 1992).

Although poor people have limited income, they have assets and capabilities that can be strengthened to reduce their vulnerability to climate change. These assets or “capital” can be grouped into social capital, natural capital, physical capital, human capital, and financial capital. Adaptation policies should focus on providing stable conditions and support for making the livelihood assets of the poor more resilient to climate change through resource accessibility and the reforming of policies, institutions, and processes. It is important to ensure that sectoral and other policies do not undermine, but rather reinforce, the opportunities of the poor to access resources, build assets, and diversify their economic activities to increase their adaptive capacity to climate change.

The livelihood assets determine how livelihoods work and in particular are the basis for understanding how people will respond to climate-induced vulnerabilities. They are the basis for the development of adaptation strategies. Natural resources are among the most significant means of livelihood for the poorest and most vulnerable of the world, especially for the rural community. The rural communities depend directly on natural resources, through cultivation, livelihood breeding, collecting, or hunting for their livelihoods (DFID, 2002). As it has been reported (IPCC, 2007) changes in temperature and rainfall patterns (both to averages and the variability of rainfall) are widely predicted, many semi-arid parts of the developing world likely to become even hotter and dryer with even less predictable rainfall.

2.3. Causes and Manifestations of Climate Variability

The Earth’s climate has changed many times during the planet’s history, with events ranging from ice ages to long periods of warmth. During the last centuries, natural factors such as volcanic eruptions or the amount of energy released from the sun have affected the Earth’s climate a smaller scale and by the 1950s and early 1960s, it was becoming clear that human activities were releasing carbon dioxide fast enough to significantly increase its atmospheric abundance (Dessler and Parson, 2006).

Beginning in the 19th century, due to human activities associated with emissions of carbon dioxide and other greenhouse gases the composition of the atmosphere has changed. The Fourth Assessment Report of the IPCC published in 2007 stated that:- most of the observed

increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic (human-caused) greenhouse gas concentrations (Pender, 2001). The scientific community has reached a consensus that these changes cause a warming of the atmosphere and therefore, influence the Earth's climate. Continuations of greenhouse gas emissions can result in additional warming over the 21st century up to 4.5°C by 2100; (Mosbrugger *et al.*, 2008).

Land-use and land-cover change influences carbon fluxes and GHG emissions (Houghton, 1995; Braswell *et al.*, 1997), which directly alter atmospheric composition and radiative forcing properties. They also change land-surface characteristics and indirectly, climatic processes. Established evidence links land degradation to the loss of biodiversity and climate change, both as cause and effect. CO₂ induced climate change and land degradation remain inextricably linked because of feedback between land degradation and precipitation. Climate change might exacerbate land degradation through an alternation of spatial and temporal patterns in temperature, rainfall, solar radiation, and winds (Sivakumar, 2011).

CO₂ in the atmosphere and annual emissions (1750-2019)

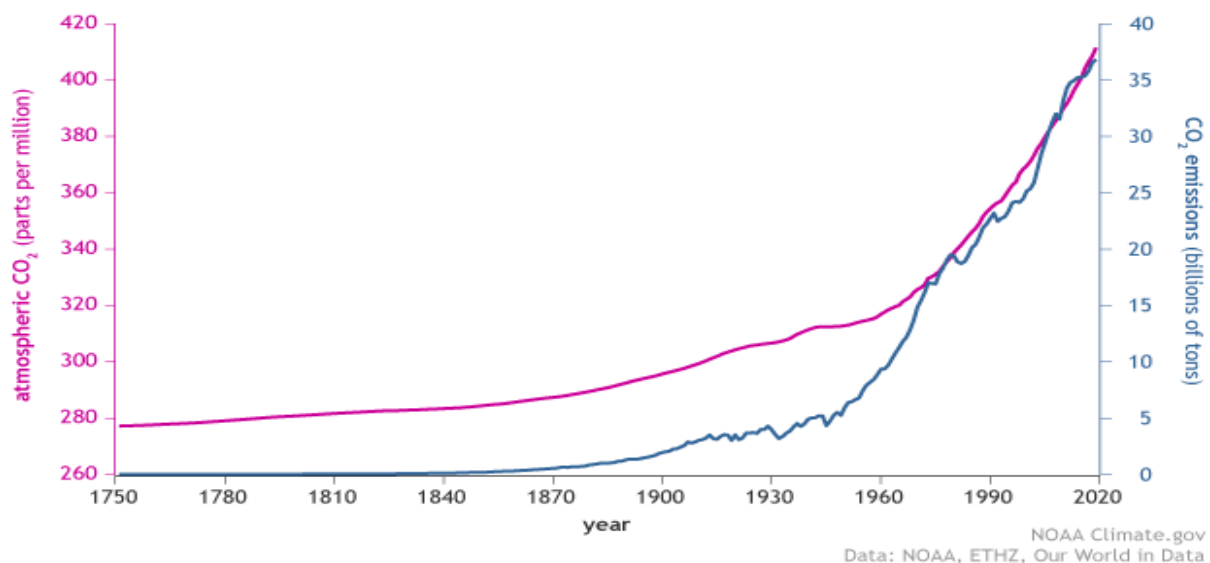


Figure: 1. The global average amount of carbon dioxide trend since the start of the industrial revolution

Source: NOAA, 2008)

As indicated in figure 1, the comparison of atmospheric samples contained in the cores and more recent direct measurements; provides evidence that atmospheric CO₂ has increased since the Industrial Revolution.

Rising fossil fuel burning and land-use changes have emitted, and are continuing to emit, increasing quantities of GHGs into the Earth's atmosphere (UNFCCC, 2007). These GHGs include carbon dioxide (CO₂), Methane (CH₄) and nitrogen dioxide (N₂O), and rise in these gases has caused a rise in the amount of heat from the sun which is held in the Earth's atmosphere, heat that would normally be back into space, (UNFCCC, 2007). GHGs and aerosols affect climate by altering incoming solar radiation and out-going infrared (thermal) radiation that are part of Earth's energy balance. Changing the atmospheric abundance or properties of these gases and particles can lead to a warming or cooling of the climate system. Since the start of the industrial era (about 1750), the overall effect of human activities on climate has been a warming influence. The human impact on climate during this era greatly exceeds due to known changes in natural processes, such as solar changes and volcanic eruptions (IPCC, 2007).

The knowledge of climate change manifestations is of paramount importance to understand its impact on different sectors. The increase in the average temperature of the planet and change in the hydrological cycle are major manifestations of climate change (Lovejoy and Hannah, 2005).

2.4. Climate Variability in Ethiopia

Like much of Africa, Ethiopia has become warmer from time to time and human-induced climate change will bring further warming at unprecedented rates, (EPA, 2011). The country has been subjected to drought, floods, new insect pests, new vector borne-diseases, and other problems made worse by climate change (Dawit and Habtamu, 2011). The mean annual temperature in Ethiopia has increased by 1.3°C between 1960 and 2006, at an average rate of 0.28°C per decade (Oxford, 2008) as cited in Dawit and Habtamu (2011). The temperature increase has been most rapid from July to September (0.32°C per decade). It is reported that the average number of hot days per year has increased by 73 (an additional 20% of days) and the number of hot nights has increased by 137 (an additional 35% of nights) between 1960 and 2006 (Dawit and Habtamu, 2011). Ethiopia's diverse agro-ecological zones are characterized by a dazzling variety of micro climates and corresponding weather patterns. Its people have developed agricultural systems adapted to Ethiopia's diverse environment. However, the rapid pace of climate change, along with increasing socio-economic pressures, threatens to overwhelm their ability to cope (Bishaw *et al.*, 2013). Over the past three decades, Ethiopia has experienced countless local drought events and even major droughts, five of which resulted in famines (World Bank Group, 2010).

The country faces considerable hurdles in coping with the adverse impacts of long-term climate change. Low economic development, inadequate infrastructure, and lack of institutional capacity all contribute to the country's vulnerability to the adverse impacts of climate change (IFPRI, 2011). As explained in NMA (2007), baseline climate that was developed using historical data of temperature and precipitation from 1971-2000 for selected stations in Ethiopia, showed a very high year-to-year variation in rainfall for the period 1951 to 2005 over the country expressed in terms of normalized rainfall over those periods (1951-2000), some of the years have been dry resulting in droughts and famine while others were characterized by wet conditions (NMA, 2007).

During extreme drought conditions, it is common that many farmers in the country either die due to hunger or depend on foreign food aid to sustain their lives (Temesgen. *et al.*, 2010). The observed trend in annual rainfall, however, remained more or less constant when averaged over the whole country (NMA, 2007). Studies also indicate that there has been a very high temperature variation and change in its trend over time. Annual minimum temperatures for the period 1951 to 2005 expressed in terms of temperature differences from the mean and averaged over 40 stations showed a very high variability (NMA, 2007).

According to the forecast NMA (2007), the country will experience an increased level of temperature and precipitation in the coming decades. Using the software AGICC/SCNGEN coupled model for three periods centered around the years 2030, 2050 and 2080, NMA (2007) generated that the mean annual temperature will increase in the range of 0.9-1.1°C by 2030, in the range of 1.7-2.1°C by 2050 and in the range of 2.7- 3.4°C by 2080 over Ethiopia for the IPCC mid-range emission scenario compared to 1961-1990 normal.

According to the National Meteorological Agency, long-term climate change in Ethiopia is associated with changes in precipitation patterns, rainfall variability, and temperature, which could increase the country's frequency of both droughts and floods. Although both developed and developing countries are affected by climate change, developing countries face greater challenges in overcoming its adverse consequences. Ethiopia is one of the least developed countries in the world; with a per capital income of less than US\$130 in 2006. Low economic development, inadequate infrastructure, and lack of institutional capacity all contribute to the country's vulnerability to the adverse impacts of climate change (IFPRI, 2010).

2.4.1. The Impacts of Climate Variability in Ethiopia

Ethiopia's climate is characterized by a history of climate extremes, such as: droughts and floods; and an increase and decrease in temperature and precipitation, respectively. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia. The most drought-prone and affected areas of the country are in the northern, eastern and southern parts (Dawit and Habtamu, 2011). Total failure or shortage of rainfall is often cited as the major cause of the recurring droughts and harvest failures. Such a shortage of rainfall problem or situation is further exacerbated by social, economic and ecological situations (Dawit and Habtamu, 2011).

Climate Variability is expected to bring greater variability, and extreme weather events (e.g. droughts) which will further drive degradation of the country's ecosystems. The impact of climate change in Ethiopia is already apparent in the increasing temperature and declining rainfall, particularly in northern parts which are exceptionally vulnerable to drought (Cesar and Ekbom, 2013). Ethiopia is also vulnerable to the health impacts of climate change and to climate-induced damage to transportation infrastructure.

The implications of future climate Variability will be felt throughout vulnerable a whole communities, although secondary impacts will be felt more widely, for example in education and gender equity. A recent study by the World Bank projects that, unless steps to build resilience are effective, climate change will reduce Ethiopia's GDP growth by between 0.5 and 2.5% each year Ethiopia is also vulnerable to the health impacts of climate change and to climate-induced damage to transportation infrastructure. There are strong links between environment and health concerns in Ethiopia, particularly related to malnutrition, indoor air pollution and water-related diseases (Cesar and Ekbom, 2013). Ethiopia is especially vulnerable to climate variability and change because large segments of the population are poor and depend on agricultural income, which is highly sensitive to rainfall variability. Most have low access to education, information, technology, and basic social and support services, and as a result, have low adaptive capacity to deal with the consequences of climate variability and change (Bishaw *et al.*, 2013).

2.4.2. Impacts of Climate Variability on Agriculture

Climate Variability can affect agricultural production in a variety of ways. Temperature and precipitation patterns, extreme climate conditions, surface water runoff, soil moisture and CO₂ concentration are some of the variables which can considerably affect agricultural development (IPCC, 2007; Zhai and Zhuang, 2009).

Ethiopia's agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 1% of the country's total cultivated land. Thus, the amount and temporal distribution of rainfall and other climatic factors during the growing season are critical to crop yields and can induce food shortages and famine (CSA, 2008).

During drought and delay in the onset of rain land becomes dry and difficult to plow, forage deficit leads to weakness and oxen mortality (the engine of subsistent cultivation), and lack of precipitation hinders seed cultivation and germination of cultivated seeds. Even weeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households'livelihood (Senbeta, 2009).

2.4.3. Impacts of Climate Variability on Livestock Production

Similar to crop production, the impact of climate change and variability in livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility (Nigus, 2011). Drought and delay in the onset of rain led to poor grass regeneration/ forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long-distance travel for water and pastures (Senbeta, 2009).

Climate Variability will have far-reaching consequences for dairy and meat production, especially in vulnerable parts of the world where it is vital for nutrition and livelihoods. The impact of climate change can heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as drought (Engida, 2013). The most vulnerable communities to the impacts of climate change inhabit the dry lands areas. Pastoralists inhabiting dry lands have been able to survive the harsh environments practicing various sustainable livelihood approaches including seasonal movements, keeping livestock, among others (UNDP, 2010).

2.4.4. Impacts of Climate Variability on Water Resources

Climate Variability will alter patterns of water availability by intensifying the water cycle. Drought and floods will become more severe in many areas. There will be more rain at high latitudes, and less rain in dry subtropics (Pender, 2001).Observed warming has been linked to changes in the large-scale hydrological cycle such as: increasing atmospheric water vapor content; changing precipitation patterns, intensity and extremes; reduced snow cover and

widespread melting of ice; and changes in soil moisture and runoff. Precipitation changes show substantial spatial and inter- decadal variability (Bates *et al.*, 2008).

Climate change is also likely to intensify the current challenges of water scarcity and water competition within and between communities and nations, linked by hydrological flows across watersheds and basins. By the middle of the 21st century, annual average river runoff and water availability are projected to increase as a result of climate change at high latitudes and in some wet tropical areas, and decrease over some dry regions at mid-latitudes and in the dry tropics (FAO, 2011).

2.5. Conceptual Framework

This study is aimed at assessing the effects of climate change and variability on rural livelihoods and the responses of rural people to the effects of climate change and variability. Communities and households face climate stresses such as increased surface temperature, changes in the timing and amount of rainfall, hail storms, floods, drought, wind stability (IPCC, 2007). Thus, the lives and livelihood assets of the rural community are under such threats and their associated consequences. The institutions and processes operating from the household to national level determine an individuals' household's or communities' access to assets, livelihood options, and thereby affect the vulnerability to climate change impacts. As reported by different researchers, Deresa *et al.* (2008), Yusuf *et al.* (2008), there are many climate change adaptation strategies for livelihood, including changes in crop variety and planting dates, crop diversification, irrigation development, water harvesting, tree planting, herd splitting, herd mobility, cattle breeding, migration, etc. Therefore, understanding the diverse and dynamic rural livelihoods strategies helps to identify appropriate intervention (adaptation measures) improve the wellbeing of livelihood outcomes.

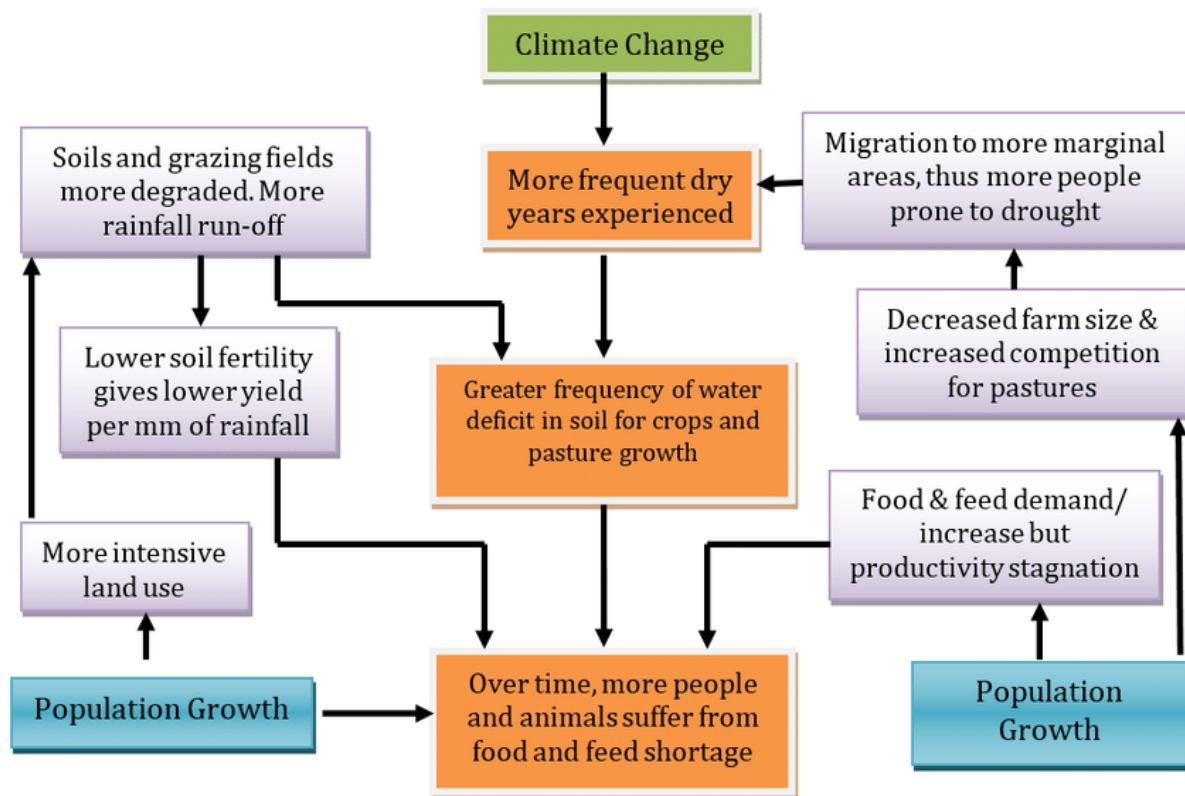


Figure 2: Conceptual framework of the study (Source: Author's Construct, 2025)

3. Materials and Methods

3.1. Description of the Study Area

This study were conducted in Wayu Tuka Woreda that is located at 8⁰56'N- 9⁰7'N and 36⁰32'E - 36⁰48'E. It is located at about 322 km west of Addis Ababa, in the East Wollega Zone of the Oromia National Regional State. Gute is the capital town of the Woreda, which is located at a distance of about 12 kilometers from the Zonal capital City or Nekemte. Wayu Tuka Woreda is bordered with Sibru Sire in the north and east, Leka Dulacha in the south, and Guto Gida in the west. The Woreda possesses a total area of 28,952.795 ha and comprises 12 Kebeles, 10 rural and 2 urban kebeles (Wayu Tuka Woreda Agricultural Organization and Rural Development Office).

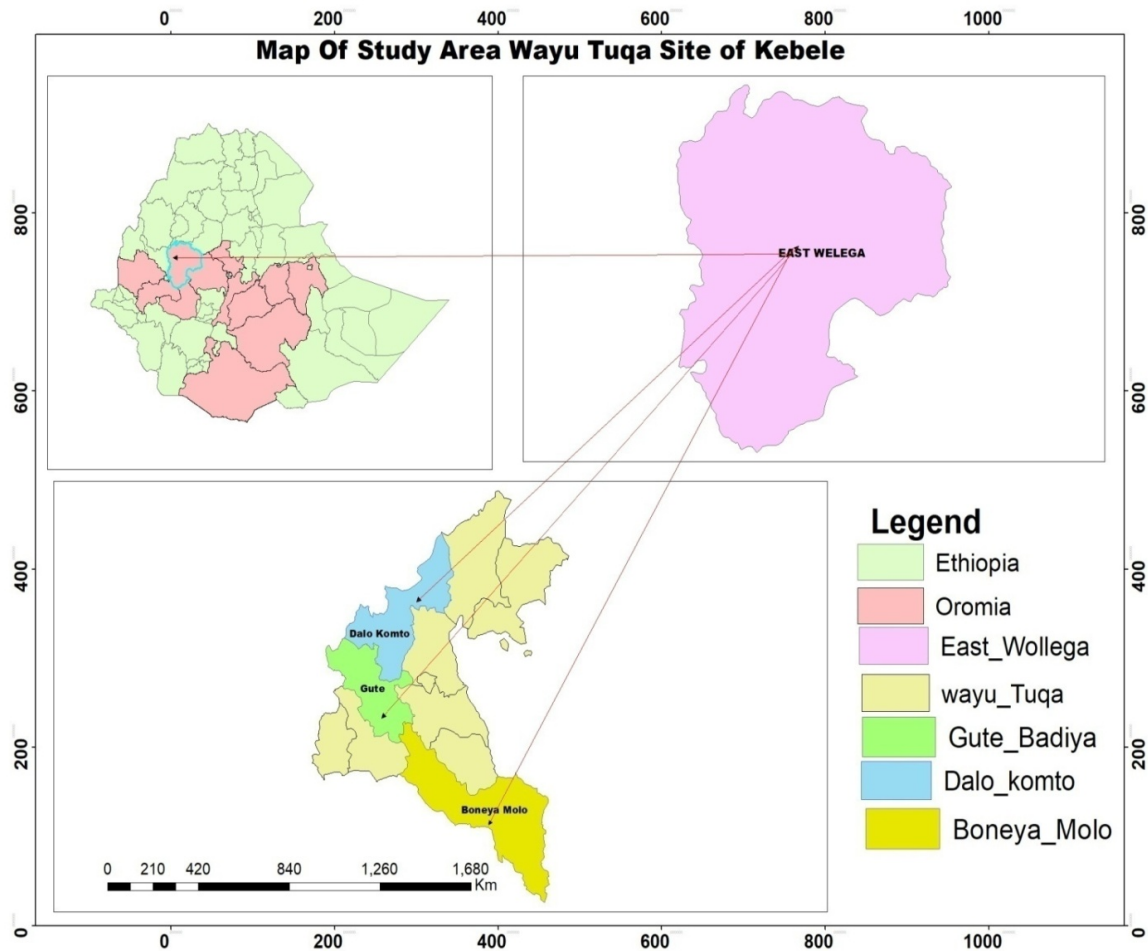


Figure 3: Map of the study area

3.1.1. Topography and Soil

The altitude of the study area is ranging from 1300-3140 and the Woreda has various topographic features, which means 62% (17,950.8445ha) of the land area is plain, 17% (4,922.00575ha) hilly areas, and mountain and lifts account for 13% (3,763.88675 ha) and 8% (2,316.238ha) respectively (Wayu Tuka Woreda Agricultural Organization and Rural Development Office, 2021). Regarding soil type, the major soil types clay loom, its spatial coverage of the district is 17371.68ha (60%). On the other hand, sandy covers an area of 10,133.49 (35%) and clay 1447.625ha (5%) the latter two soil types are suitable for agriculture such as cereal crops, maize, sorghum and teff production in the Woreda.

3.1.2. Climate

The climate of the area is classified traditionally into three main agro-climatic zones that mean, Dega, Woyina Dega, and Kolla (Wayu Tuka Woreda Agricultural Organization and Rural Development Office, 2021). Of the total land mass of the Woreda, about 49.23%

(14,249 hectares) fall under Woyina Dega while 37.665% (10,704.73 hectares) are categorized under Dega and 13.81% (3,999.065 hectares) fall under Kolla.

3.1.3. Population

The 2007 population and housing census result is the base of population projection all over the district. Based on this census result, the population of Wayu Tuka Woreda was projected to be 66394. From the total population in the Woreda, 63325 (95.4) was the rural population, which directly sustains his life and the neighboring urban dwellers by the agricultural activities. Whereas the rest number occupied by a population who dwell in urban areas (Gaba Jimata and Gute).

3.1.4. Land Uses and Agricultural Activities

Agriculture is the dominant livelihood in the study area. Out of the total land of the Woreda 28952.795ha, 25,592.83ha were suitable for plough. Of this, 25,348.78 were ploughed. Major crops produced in this Woreda are cereals under private farmer's holdings in the 'meher' season of the agricultural calendar. Area covered by cereal crops; especially maize, wheat, sorghum, teff and others.

3.2. Research Design

The major purpose of this study was to Assessing The Perception And Adaptation Strategies Of Climate Variability On Livelihoods Of Local Community In Wayu Tuka Woreda, East Wollega Zone, Oromia , Ethiopia. To accomplish the objectives of this study, mixed research design were employed. In this study, mixed approach (qualitative and quantitative methods) was followed to triangulate the interpretation of data and results to enhance the reliability and validity of findings. In qualitative approach in-depth key informant interview guide, and open ended questions were tools for data collection.

In the quantitative approach household survey on the basis of structured questionnaire interview was conducted by researcher. Therefore, collecting quantitative data was help to get baseline information about the district farmer's perception and adaptation strategies to climate change; and qualitative information were help to have detailed information about knowledge and practices as well as the factors that affect the household livelihood either negatively or positively.

3.3. Types and Sources of Data

To generate the necessary data for the research work, both primary and secondary sources of data were used. Primary data were collected from household surveys using structured questionnaires, FGDs (focus group discussions), and key informant interview such as closed and open ended questions was prepared and distributed to the selected households to get information about impact of climate change perception and adaptations strategies of rural livelihoods. Focus group discussions were held to get more information on relevant or similar ideas raised and concentrated points got at the end.

In addition, secondary sources such as published journals, papers, reports, practical hand book which directly related to the study topic, NMA and unpublished literatures have been collected from different government offices. Necessary data were collected from Wayu Tuka Woreda Agriculture and Rural Development Office. The past precipitation and temperature values (data) of the selected Woreda were collected from NMA of Ethiopia and monthly, annually, and decades of total precipitation and temperature to estimate the trends.

3.4. Sampling Technique and Sample Size

Multistage stratified random samplings were employed. In the first stage, based on the agro ecologies, the study area was divided into three category namely highlands which contains three kebeles namely (Haro, Kichi and Dalo Komtoo), mid-altitude which contains six kebeles namely Gute Badiya, GidaAbalo, GidaBeseka, Wara Babo Migna, Gute Town, and Gaba Jimata Town and low-land also contains three kebeles namely BonayaMolo, Migna Kura, and Gara Huda. A total household of Wayu Tuka Woreda 13,464 are (male 12,162 and female 1,302).

The samples were selected by using stratified random sampling method as it enables the researcher to obtain required information by dividing a heterogeneous populations into homogeneous populations based on agro-ecologic conditions which categorize the whole population into three strata. The main reason for stratifying the Woreda would have been by assessing the perception and adaptation strategies of climate Variability under the different agro climatic conditions as in all of the agro climatic condition of Wayu Tuka Woreda.

Concerning selected sample size of the three kebeles, Rule of Thumb, (1984) provides a simplified formula to calculate a sample size. Where 2569 is the total population out of which 128 sample size were selected from the three kebeles. According to Rule of Thumb, (1984), based on the population size 5% of sampling percent were taken, because the population size where found between 1,001-5,000 population.

Then from the three kebeles, 128 of HHs were selected using simple random sampling as it enables the researcher to give an equal chance to be included in the study and to use unbiased estimate parameter. The sampling technique considered different parameters such as wealth status, male and females headed. Therefore, the distribution of sample households in the sample kebeles proportion on their cluster as follows in the below table:

Table 1: Distribution of sample household (Wayu Tuka Woreda Agricultural Office, 2021).						
No	Name of Kebeles	Agro ecology	Total HHs	Sample size from each HHs		
				Male	Female	Total
1	Dalo Komto	Highlands	838	32	10	42
2	Gute Badiya	Mid-altitude	900	34	11	45
3	Bonaya Molo	Low-land	831	35	6	41
4	Total		2569	101	27	128

3.5. Data Collection Methods

The study involved a range of data collection methods. Data were collected from an interview which was made with different officials and experts of Agricultural and Rural Development Office of Wayu Tuka Woreda and the selected households, focus group discussion and questionnaires were conducted by respondents from the three selected kebeles. A structured survey questionnaire has been administered to get detailed information with regards to the three key methodologies such as impact assessment, vulnerability assessment and coping and adaptation methods assessments.

3.5.1. Household survey

Questionnaires were used as a data collection instrument and these were administered by the researcher and trained enumerators. The researcher used both open ended and closed questionnaires based on the objectives of the study. The questionnaires were translated into Afan Oromo Language (Appendix I). The enumerators were selected on the basis of fluency

in speaking Afan Oromo as well. Before the implementation of the survey, enumerators were trained. The questionnaires covered a wide range of information which includes household characteristics, household livelihood, perception of farmers on the severity of climate variability impact, food insecurity, asset endowment, coping mechanisms, institutional and stakeholder's adaptation strategies issues.

3.5.2. Key informant interview

The interview method is particularly suitable for intensive investigation issues. Primary information about the local indicators of climate change, possible impacts on the livelihoods of the small-holder farmers, and the adaptation methods were obtained through different data collection methods. Then, a key informant interview as one of the data collection methods was carried out with knowledgeable and experience experts from the Wayu Tuka Woreda's agricultural and Rural Development Office. Accordingly, three experts from the Agricultural organization and Rural Development Office of Wayu Tuka Woreda and DAs were interviewed once and semi-structured checklist was employed to conduct an interview with experts from the Agricultural organization and Rural Development Office.

3.5.3. Focus group discussion

Focus group discussion (FGD) was conducted in the three kebeles of the study area, and in each kebele one focus group discussion was conducted. Each focus group discussion was composed of 6 individuals who were selected based on the following parameters such as, age groups, sex, and socio-economic status. During the FGD, the perception of farmers about climate change in the area, indicators of climate change and adaptation strategies, particularly rainfall variability, pattern and reliability and the change in temperature and occurrence of extreme events were given an emphasis. Participants of focus group discussions have also discussed coping mechanisms and adaptation strategies (which encompassed communal properties and community-based adaptation) -being undertaken by households to the existing climate variability and change including the main challenges of the society to cope up and adapt well to the changing climate of their locality.

3.6. Methods of Data Analysis

Descriptive data analysis for the quantitative information, descriptive statistics such as percentages, frequency tables, means, and standard deviations were used to summarize and present demographic, socio-economic, and institutional factors depending on the nature of the

data. Accordingly, the statistical analysis was carried out by using SPSS (Statistical package for Social Science) version 20, for each variable the statistical test was conducted at 0.05 α level. The measure of central tendencies (mean) and measures of dispersion (standard deviation) were the major descriptive techniques that were used to summarize and compare the data. The data collected qualitatively was transcribed and analyzed using thematic analysis methodology. Thematic analysis is a good research approach to find out some things about people's views, opinions, knowledge, experiences, or values from a set of qualitative data. Qualitative data obtained through key informant interviews, and focus group discussions. The data organized, summarized, analyzed, and interpreted concerning the survey results. Both quantitative and qualitative data were used to assess the perception of farmers towards climate change and farmers' adaptation strategies responses because of its implication to household livelihoods in the area.

Analysis of rainfall and temperature variability

Rainfall and temperature variability over 30 years was analyzed by calculating the coefficients of variability (CV) of the rainfall and temperature values at different time scale. The CV of annual, seasonal and monthly rainfall and temperature calculated by using the following formula as (Agrawal, 2010):

$$CV = \frac{\sqrt{\sum f(x_i - \bar{x})^2}}{n\bar{x}} = \frac{\delta}{\bar{x}} \quad (1)$$

Where, $\bar{x}$ mean annual rainfall in mm, n-number of years for which the rainfall data are available, x_i - annual rainfall (mm) of the year (i) of a given station, and δ - standard deviation. According to NMSA (1996) the annual rainfall variability of an area with a coefficient of variation, where, $CV < 20\%$ is less variable, CV is between 20% and 30% moderately variable, and $CV > 30\%$ is highly variable. The analysis of rainfall and temperature involved characterizing long-term mean values, calculations of indices of variability and trend at annual and seasonal time steps.

Analysis of rainfall and temperature Trends

Mann Kendall test and Sen's slop test of non-parametric slope test was determined a trend of rainfall and temperature and calculated by excel and presented in graph and charts (Mann, 1945, Kendall. 1975 and Sen. 1968). An equation to calculate the statistical data of rainfall and temperature by a formula of Mann Kendall test and Sen's slop tests were given as below:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^n \text{sgn}(x_j - x_k) \quad (2)$$

$$\text{sgn}(x_j - x_k) = \begin{cases} +1, & \text{if } (x_j - x_k) > 0 \\ 0, & \text{if } (x_j - x_k) = 0 \\ -1, & \text{if } (x_j - x_k) < 0 \end{cases} \quad (3)$$

Where n is the length of the sample, x_k and x_j are from $k = 1, 2, \dots, n-1$ and $j = k+1, \dots, n$. If n is bigger than 8, statistic S approximates to normal distribution. The mean of S is 0 and the variance of S can be acquired as follows:

$$\text{var}(S) = \frac{n(n-1)(2n+5)}{18} \quad (4)$$

Then the best statistic Z is denoted by

$$Z = \begin{cases} \frac{s-1}{\sqrt{\text{var}(S)}}, & \text{if } s > 0 \\ 0, & \text{if } s = 0 \\ \frac{s+1}{\sqrt{\text{var}(S)}}, & \text{if } s < 0 \end{cases} \quad (5)$$

Z score follows a normal distribution. At a choice of $\alpha = 0.05$ (95% level of significance) and two-sided alternative, the critical values of Z are equal to -1.96 to 1.96 (Z) 0.025 = 1.96. The trend is said to be decreasing if Z is negative and the computed Z-statistics is greater than the Z-value corresponding to the 5% level of significance. The trend is said to be increasing if the Z is positive and the computed Z-statistics is greater than the Z-value corresponding to the 5% level of significance. If the computed Z-statistics is less than the Z-value corresponding to the 5% level of significance, there is no trend (Khambhammettu, 2005). The non-parametric procedure developed by Sen's slope test is calculated by:

$$\beta = \text{median} \left(\frac{x_j - x_i}{j - i} \right), j > i \quad (6)$$

Where

β is Sen's slope estimate. $\beta > 0$ indicates an upward trend in a time series. Otherwise the data series presents down-ward trend during the period. Hence the Sen's Slope estimator, which is a non-parametric method, was used to develop the linear models in this study. Sen's Slope estimator is a non-parametric method for slope estimator generally used to estimate the true slope of an existing linear trend (as change over time). If linear trend is present in times

series, then the true slope (change per unit time) can be estimated by using a non-parametric procedure developed by Sen's (1986).

4. RESULTS AND DISCUSSION

4.1. Socioeconomic and Demographic Characteristics of the respondents

As shown in Table 2, the Participant' demographic characteristics the total households sampled in the survey is 128 (78.90%) were males and 27 (21.10%) females. According to Tekeste (2019), male headed households were in a better position to pull more labor force than the female-headed ones and they also made decisions on farming activities.

Table 2: Socioeconomic and Demographic Characteristics of Respondents (n=128)

Variable		Frequency	Percent
Sex	Male	101	.9
	Female	27	.1
Age category	20-30		.2
	31-40		
	41-65		
	>65		.8
Marital Level	Single		.5
	Married		

	Divorced		.7
	Widowed		.8
Household Size	-3		.5
	4-6		.9
	7-9		.7
Educational Status	Illiterate		.7
	Read and write	20	.6
	Primary School		.3
	Secondary School		.1
	Above grade 12		.3

Source: Field survey, 2025

This finding aligns with the fact that male are traditionally heads of HHs, particularly in rural areas of the country. Like elsewhere in the country, the authority of leadership and administrations of HHs usually vests on males provided that they are capable of supporting and sustaining one or more individual within the HH. However, in the event when the male dies, becomes incapacitated or divorces, women can assume the role although they tend to face tough challenges under such circumstances. This is female-headed HHs are more vulnerable to different kinds of problems than the male-headed ones (IFAD 2012).

The HHHs of the study area had a total population of 2569 out of which (98.3%) were males and (1.7%) were females. Relatively female-headed households are more vulnerable to climate variability risks than male headed-households because they have a lot of burden to

solely carry out livelihood engaging issues and to involve off-farm activity than male-headed households.

As we see on survey result above, table 2, among all the respondents 7 (5.5%) were single, 96 (75%) were married, 10 (7.8%) were widowed and 15(11.7%) were divorced. This indicates that majority of household heads in the three kebeles are married. In order to assess whether there is association between age and adaptation strategies. This implies that the differentiation of social status and family size affects their livelihood bases adaptation to climate change. The table also depicts that, among all the respondents, 39(30.5%) of them had very small family size of less than or equal to 3(1-3), and 60(46.9%) had almost medium size (4-6), whereas, 29 (22.7%) had large family size (7-9). This figure showed that the family size of the study area was large. Based on this finding, it is possible to predict that the practices of family planning are not well developed in the study district.

Thus, it is possible to conclude that there was high illiteracy rate among local people of the Woreda especially the adult aged people which has its own influence on the introduction of modern technology to the modernization of local knowledge and innovation systems.

Scholars believes that education is important to determine readiness to adapt new ideas, enables people to realize the diversification of livelihood activities and technology, within the frame work of adaptation strategies on the impact of climate variability. Thus in turn it would improve the quality of life of the household at large and it enables to produce human resource such as skilled man power and also helps to generate aid for transforming society's economy. Indeed, education on level of households was assumed to increase participation of household heads were increased their ability to find information, better understanding and application of new technologies as well as better ability to cope with climatic risks. Furthermore, education is likely to enhance farmer's ability to receive, interpret and comprehend information relevant to making innovative decisions in their farms (Ndamdiri et al., 2013).

4.2. Livelihood Bases of the Sample Household

The principal livelihood components were grouped using clustering techniques where the majority (81.6%) of HHs were dependent on agricultural production and (9.4%), (5.5%), (3.1%) of the respondents were involving in activities such as working as daily laborer, petty trade and renting out land, respectively (Table, 3).

Table 3: Surveyed means of HHs livelihoods

No	Means of HHs livelihoods	The selected kebeles of respondents			
		Dalo Komto	Gute Badiya	Bonaya Molo	Total
1	Agriculture(crop production)				
2	Livestock rearing				
3	Renting out land				
4	Working as daily laborer				
5	Petty trade				
	Total respondents				

Source: Field survey, 2025

The survey result enables us to conclude that a rural livelihood in Wayu Tuka Woreda mostly depends on farming activities that largely depending on rainfall patterns. Any negative changes in the rainfall patterns are likely to negatively impact on rural livelihoods. The reduction of precipitation resulted in insufficient soil moisture for crops leading to wilting. This was farther exacerbated by high temperatures which enhanced evapotranspiration from moisture stressed.

The information obtained from the interviewees conducted indicted that, almost all HHs are involved in crop production as their main source of livelihood. This suggests that when such activates is impacted by climate change; it may have serious consequences on household food security and general livelihoods.

4.3. Land Holding Size of the Respondent

The majority 67 (52.3 %) of the HH respondents had 0-1ha land size and 34(26.6 %) of the respondent had1.25-1.75ha land size. Whereas, 22(17.2 %) of the HH respondents were in a range of 1.76-3.35ha in their land holding category and 5(3.9%) of the HH respondents were land less.

Table 4: Land holding size category

No	Selected kebeles	Land holding size category
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		landless	<1ha	.25-1.75ha	.76-3.35ha
1	Dalo Komto	(4.8%)	(57.1)%	(26.2)%	(11.9%)
2	Gute Badiya	(6.7%)	(55.6%)	(24.4%)	(13.3%)
3	Bonaya Molo	-	(43.9%)	12(29.3%)	(26.8%)
Total respondents		(3.9%)	(52.3%)	(26'%)	(17.2%)

Source: Field survey, 2025

According to the information obtained from the survey data, the size of land holdings by the sample HH respondents is very fragmented and it differs among individual's household respondents. However, relative to household size, it can be considered that there is land shortage in the Wayu Tuka Woreda as well. The ratio of household land holding to the number of people in the household is generally low even by Ethiopian standard (Descheemaeker *et al*, 2007). Like in many rural areas of the country, whenever a member of the household leaves his/her family due to marriage or other reasons, he/she were given a plot of land to establish himself/herself. In most parts of rural Ethiopia, parents are responsible to oversee direct transfers of resources, such as land, cattle and other material goods to their children and grandchildren (Gibson, 2009). There are a number of effects of lower land holding size, mainly on household economy and food security. For example, according to Nega *et al.* (2003), landholding is a major factor constraining household farm income and household food security.

4.4. Livestock Ownership of the Sample Respondents.

As shown in the table 5 above, the house hold respondents who had no livestock before ten years(before 2011) were 3(7.1%), 8(15.6%) and 4(9.8%) in Dalo Komto, Gute Badiya and Bonaya Molo kebeles respectively . But, after 10 years (in 2020), the number of the livestock in these kebeles became 4(9.5%), 5(13.3%) and 5(12.2%) respectively (Table, 10). Whereas, the data showed that the householders who had 1-2 livestock before ten years(in 2011) in Dalo Komto, Gute Badiya and Bonaya Molo kebele were 8(19%) , 8(11.1%) and 9(22%) which became 26(61.9%), 31(68.8%) and 27(65.9%) after ten years(2020) in these kebeles respectively.

Table 5: Livestock ownership of the sample respondent between 2015 –4

No of Livestock	Year	The Selected kebeles						Total	
		Dalo Komto		Gute Badiya		Bonaya Molo			
		Freq	%	Freq	%	Freq	%	Freq	%
0	2015	3	7.1		.6		.8		.7
	2024	4	.5		.3		.2		.9
1-2	2015	8			.1				.5
	2024	26	.9		.9		.9		.8
3-5	2015	24	57.1		.1		.8		.6
	2024	7	.7		.9		.2		.3
6-10	2015	4	9.5		.1				.5
	2024	3	.1		.7		.6		.8
>10	2015	3	7.1		.4		.3		.6
	2024	2	.8		.2	-	-		.3

The data also indicated that the households who had 3-5 livestock in 2015 in Dalo Komto, Gute Badiya and Bonaya Molo kebeles were 24 (57.1%), 22(51.1%) and 20(48.8%) which

became 7(16.7%), 5(8.9%) and 5(12.2%) after ten years(2024) in these kebeles respectively. Others sample respondents 4 (9.5%) in Dalo Komto, 5(11.1%) in Gute Badiya and 7(17%) in Bonaya Molo had 6-10 livestock in 2015 which became 3(7.1%), 3(6.7%) and 4(9.6%) respectively after ten years (2024). Furthermore, the respondents replied that the household community members who had >10 livestock in 2015 in Dalo Komto, Gute Badiya and Bonaya Molo were 3 (7.1%), 2 (4.4%), 1 (2.3%) respectively and after ten years (in 2024) the number of the household became 2 (4.8%), 1 (2.2%), 0(0%) in these kebeles respectively.

This finding, also suggested that livestock production is one of the product systems that are potentially vulnerable to the impact of climate variability. Information obtained from respondents in this study indicated that due to decreased rainfall and increased temperature conditions, the production of livestock in the study area also decreased. Moreover, when the time of rainfall seasons have been increasingly unpredictable, the warmer temperature leads to vegetation drying faster and drinking water become scarce much after the end of the rainy seasons that leads to insufficient livestock's feeding. This result indicates that the more animal feeds become decreased, the less livestock production is locally obtained.

The information obtained from the interviewee revealed that, the trends of livestock's lives are reducing from year to years as a result of climate Variability. This is because, when the climate Variability happened the amount of rainfall decreased and sometimes inversely the hotness and coldness of temperature increased. These phenomenon leads to shortage of grass and water that are sensitive to livestock's lives. Thus, this tells us that livestock's are the most vulnerable to the impacts of climate Variability. Also the interviewee stated that the community has been not only affected by climate Variability but also by population pressure. In the area, the land under cultivation has expanded, and most of the land previously used as communal grazing has been taken up by crops production and settlements of the population and mountain has been given to youngster who have been organized as IMX for different purposes. Therefore, these all lead to decreasing the number of livestock in the areas from time to time.

As information collected from FGD showed, people gained benefits from keeping their livestock as livelihood asset such as livestock product like (milk, meat, and others), to buy consumption goods including food crops by selling the livestock products, use livestock such as donkey, and horses for transportation and social status as well. The information shows, the future sustainability and viability of livestock rearing is indeed under question in the area due to the climate change and reducing of grazing land.

This finding was supported by literature that indicated climate Variability has adverse impact on the livestock composition and compromise the return for livestock as the availability and quality of pasture and water are highly affected by climate Variability. Moreover, recurrent drought and heat spells would create favorable conditions for the spread of infectious diseases that would eventually loss of livestock (Senbeta, 2009).

4.5. Trends of Rainfall, Temperature and Its Impacts on Agriculture in the Study Area

4.5.1. Rainfall Amount, Trends and Seasonal Concentration

One of the intended objectives of this study is to analyze the trends of rainfall and temperature over the past 30 years in the study area. Thus, to asses these variable four items questions were prepared and distributed to respondents and the rainfall and temperature data over the last 30 years also obtained from NMA. Thus, the following different figures indicate that the overall meteorological data and the four tables indicate the summaries of participants' views.

The rainfall distribution of the Woreda is unmodial. The rainy season is locally called `summer` that extends from June to August with the highest peak in June, July and August. The highest average monthly rainfall was recorded in July (332.1mm) and the lowest in December (15.8mm) (Table 13). Table 13 also shows that the maximum rainfall occurrence in 1996 with a total rainfall of 2630.03mm and minimum rainfall recorded in the year 2018 with a total rainfall of 40.96mm, whereas the highest seasonal mean, maximum and average rainfall were 939.7mm, 1531.8mm and 929.6mm respectively. The lowest mean, minimum and average rainfall was 49.2mm, 92.0mm and 49.1mm respectively. The mean annual rainfall of the Woreda were (1674.2 mm).

Table 6: Trends of rainfall in the study district for the period 1990-2019

Months/Seasons	Mann-Kendall					
		VAR(S)	Z	Trends	Sen's slope	Trends

	S					
January	-132		-2.34	Negative	-0.581	Negative
February	-93	.67	-1.64	Negative	-0.429	Negative
March	-84	.67	-1.48	Negative	-0.6	Negative
April	-113	.67	-2	Negative	-2.043	Negative
May	-22		-0.39	Negative	-2.112	Positive
June	-32		-0.58	Negative	-5.414	Negative
July	-32		-0.58	Negative	-3.091	Negative
August	-52	2842	-0.96	Negative	-7.06	Negative
September		.67	0.18	Positive	.471	Positive
October	-38		-0.69	Negative	-0.393	Negative
November		.67	0.29	Positive	.15	Positive
December	-34	.67	-0.59	Negative	-0.088	Negative
Summer	-34		-0.62	Negative	-13.274	Negative
Autumn	-20		-0.36	Negative	-.494	Positive
Spring	-28		-0.51	Negative	-0.724	Negative
Winter	-112	.67	-1.98	Negative	-1.078	Negative
Annual	-24		-0.43	Negative	-10.772	Negative

Source: NMA data, 2025

The Mann-Kendall analysis trend and other statistics value given in table 6 shows that, the trend analysis has been done for all months of the year, autumn, winter, spring, summer seasons and the whole year. The results of MK test for monthly precipitation data revealed that a statistically significant decreasing trend for the month of January, April and winter season. The remaining months, seasons and annual trends of rainfall have shows that, a non significant decreasing trend except September and November where a non significant increasing trends was observed. The rainfall amount is in decreasing trend at a rate of 10.772mm annually along with 36.8% of variability and the annual rainfall amount in decreasing trend at a rate of 107.72mm per decades. In addition, summer and winter rainfall shows that decreasing trend at a rate of 132.74mm and 10.78mm per decades respectively whereas the rainfall amount of autumn and spring were in increasing trend at a rate of 4.94mm and 7.24mm per decades respectively (Table 6). The overall result is in agreement with the national rainfall trend (NMA, 2007). This was in full agreement with FGD and

farmer's perception results obtained from the survey data. This result is also in line with the findings of (Daba, 2018) that elaborated average annual rainfall has been decreasing in western Oromia. Historical climate analysis for Ethiopia indicates that mean annual temperature has increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade. Rainfall is historically highly variable and there is no clear trend in the amount of rainfall over time (NAPA, 2007: McSweeney *et al*, 2008). Studies of localized meteorological data alongside community perceptions indicate that seasonal change may already be occurring as there are declining rainfall and increasing temperature trends in certain months of the year (ACCRA, 2011).

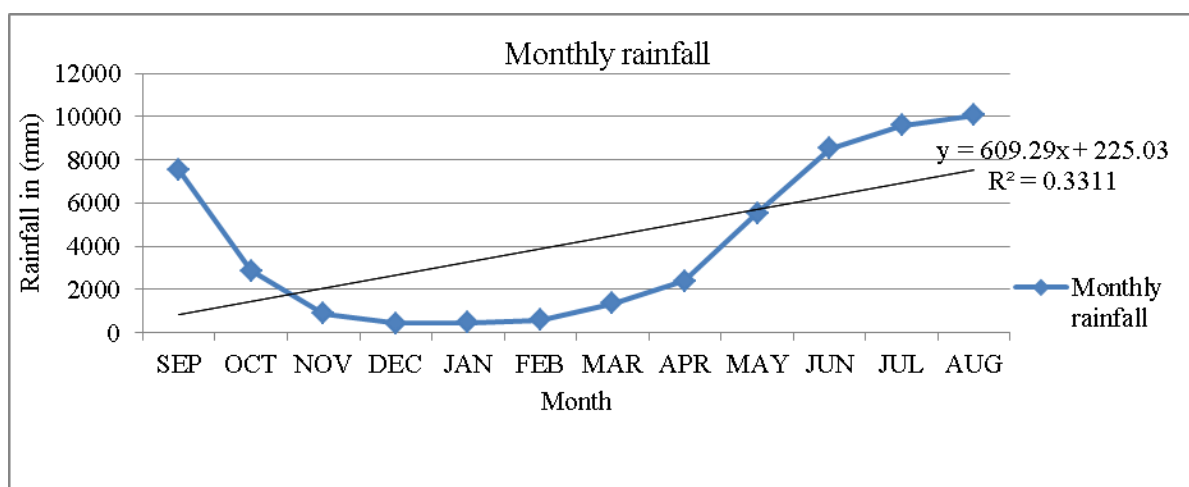
The mean annual rainfall of the area during the study period was 1674.2 mm with of standard deviation 616.2 mm and coefficient variation of 36.8% which indicating that the rainfall was highly variable. The minimum, maximum and average recorded rainfall was 41.00 mm (in 2018), 2630.0 mm (in 1996) and 1653.0 mm per year respectively. This longer term rainfall variation analysis in the study area indicated that, there is annual rainfall variability and the distribution patterns of 36.8% CV indicating that the rainfall was highly variable.

Table 7: Descriptive statistics of rainfall in the study district for the period 1990-2019

Months/ Seasons	Obs.	Mean	SD	CV	Variance	Min	Max	Av
January	30	15.3	14.2	93	450.1	0	60.3	16.2
February	30	19.2	17	88.9	466.8	0.2	61.9	19.9
March	30	45.5	25.4	55.8	761.1	0.4	114	46.3
April	30	80	45.1	56.4	2251.6	1.1	180.6	80.7
May	30	184.4	98.8	53.6	11259.4	2.6	401	185.5
June	30	284.1	130.2	45.9	21099.4	7.4	570.2	284.4
July	30	320.3	133.4	41.7	22862.4	7.6	583.4	318.8
August	30	335.3	132.2	39.4	22670.5	8.1	557.4	332.1
September	30	250.3	98.3	39.3	12538.7	4.8	425	248.1
October	30	95.8	81.3	84.8	6874.6	2.6	279.5	98.6
November	30	29.2	24.5	83.8	747.9	2	92.9	30.3
December	30	14.8	15.8	106.6	558.8	0	60.6	15.8
Summer	30	939.7	358.3	38.1	173162	23.7	1531.8	929.6
Autumn	30	375.3	154.5	41.2	31748.1	9.4	721	374.7
Spring	30	309.9	133.1	42.9	22542.1	6.4	583.7	309
Winter	30	49.2	25.3	51.4	683.4	1	92	49.1
Annual	30	1674.2	616.2	36.8	523867.5	41	2630	1653

Source: NMA data, 2025

Variability of seasonal rainfall ranges between 51.4% and 38.1% (Table 7). The highest rainfall variability was found during the winter season (51.4%) and the lowest rainfall variability was determined during the summer season (38.1%). In addition, variability of monthly rainfall ranges between 106.6% and 39.3%. The highest rainfall variability was found during the December (106.6%) month and the lowest rainfall variability was found during the September month (39.3%).



period but as indicated from the figure above, the rain season (June, July and August) it continued to rain until September and rainfall reduced from (November, December, January, February, March and April).

This trend brings, extreme weather events and climate-related shocks like unpredictable and uneven rainfall disrupt the stability of food production and access as well as people's livelihoods and increase the vulnerability of households and leave them less able to cope or adapt.

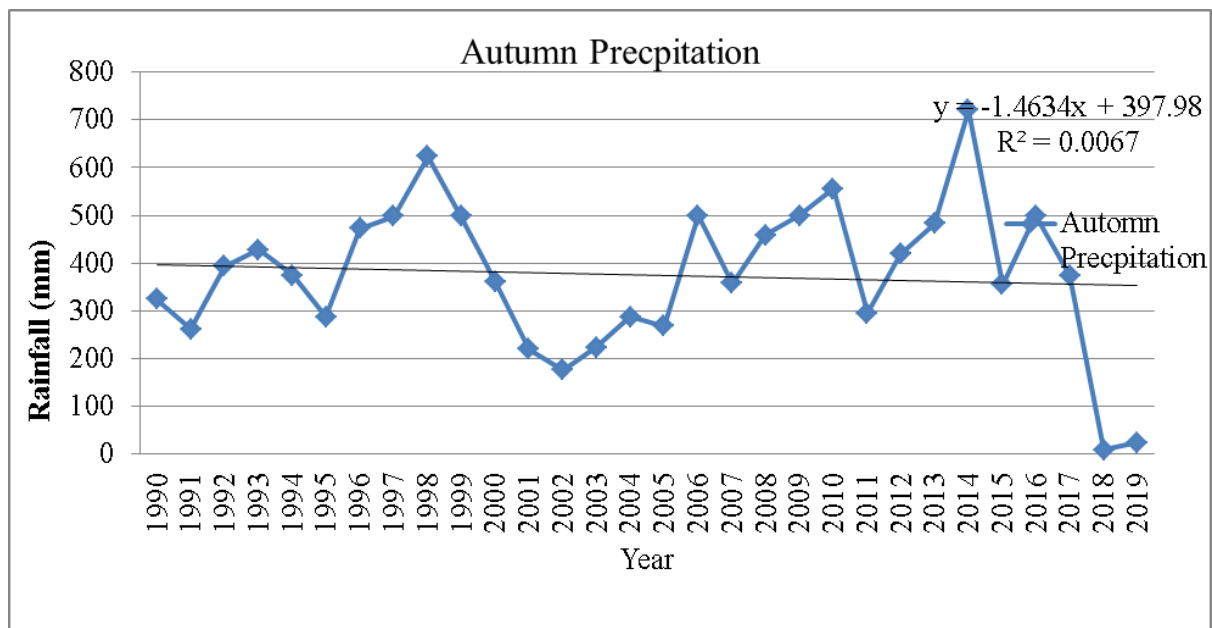


Figure 5: Trends of autumn rainfall patterns (1990-2019).

Source: NMA data, 2025

The amount of rainfall has shown fluctuating trends of rainfall. The maximum rainfall recorded in 1996 and 2014 and the minimum rainfall recorded in 2001, 2002, 2003, 2018 and 2019 (Figure 5). However, the interviewee and FGD stated that, autumn rainfall plays significant role in agricultural production. If the autumn rainfall becomes heavy, it may devastate the crops which are already to be harvested. On the other hand, if the amount of rainfall is scarce in this period particularly in the dry Mid-altitude agro-ecological zone the cropland will be invaded by locusts, highly devastate the crops while in moist Mid-altitude agro-ecological zone crops affected by frost then they wilt. The views of local communities are in tandem with meteorological evidence. As a conclusion, inter-annual and intra-seasonal climate variability is by far the predominate risk factor for rain-fed agriculture production systems. The majority of crop failures are associated with either a lack of or excess rainfall. Climate variability is also greatly associated with marketing risks. Unanticipated forces, such as inclement weather, drought conditions, crop failure

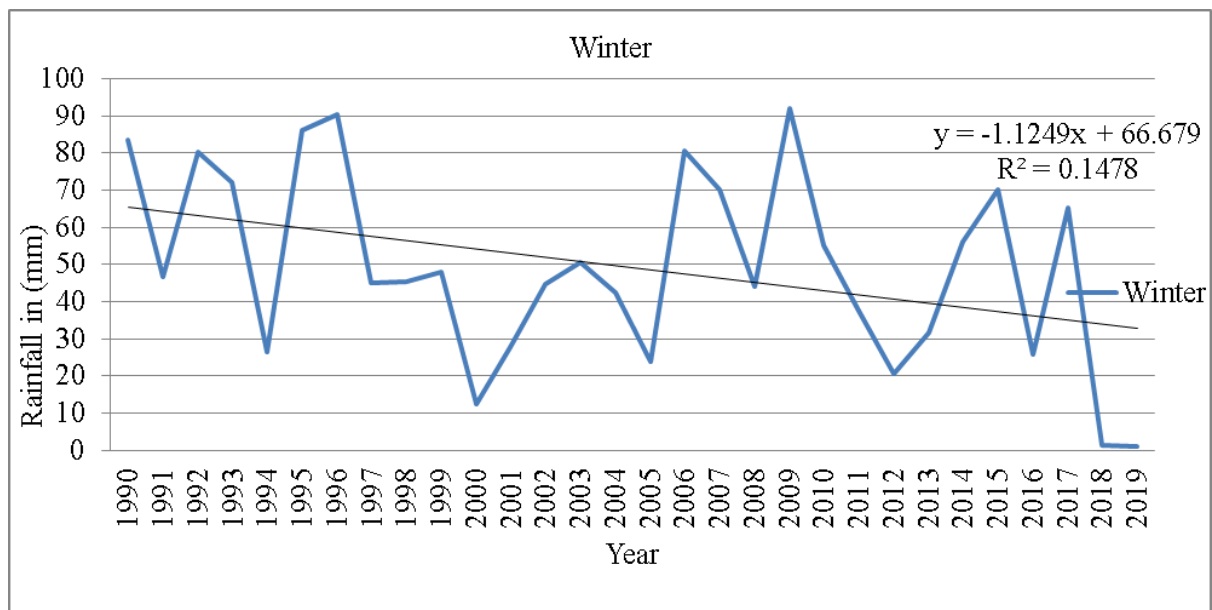


Figure 6: Trends of winter rainfall pattern (1990-2019).

Source: NMA data, 2025

The rainfall patterns show a fluctuating pattern with tendency to decreasing trends, was in 1999, 2000, 2004, 2008 and 2012, 2018 and 2019) and the highest rainfall patterns in the years of (1993, 1996, 2009 and 2017) (Figure 6).

This finding can result; droughts are characterized by precipitation deficit, loss of crop and fodder, high livestock mortality and subsequently nutritional deficit in the human population and high child mortality. Long term effects of famine on human health include stunted physical and mental growth.

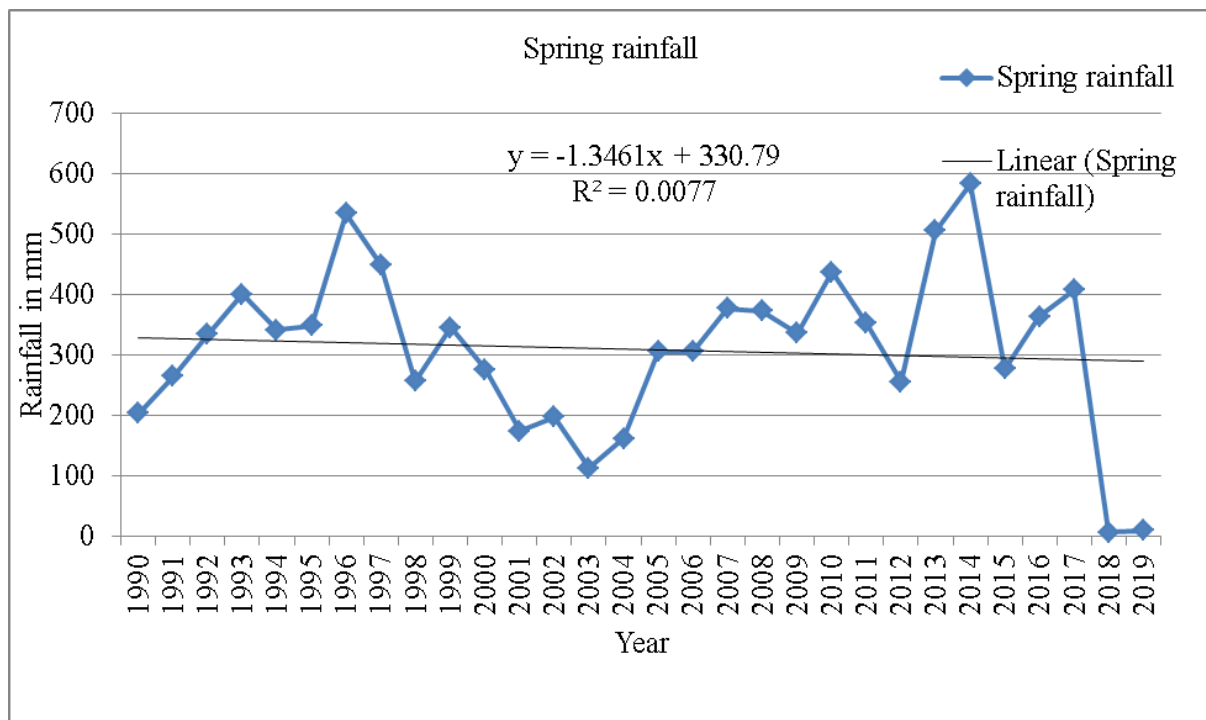


Figure 7: Trends of spring rainfall pattern (1990-2019).

Source: NMA data, 2025

The highest amount of rainfall was registered in the years in 1996(114.01mm) March month, 2013(401.01), 2010(346.69mm) and 2014(329.55mm) May month and the lowest amount of rainfall was registered in the years of 2003 (18.82mm) April month, 2018 (0.44mm) March month and 2019 (1.86mm) March month (Figure 7).

This finding indicated that, climate variability were reduce agricultural production, through environmental degradation, changing agro-ecological conditions and shifting growing seasons. Changes in rainfall and higher temperatures is also affect crop productivity, reducing food availability. This directly or indirectly affects the live and livelihoods of the communities.

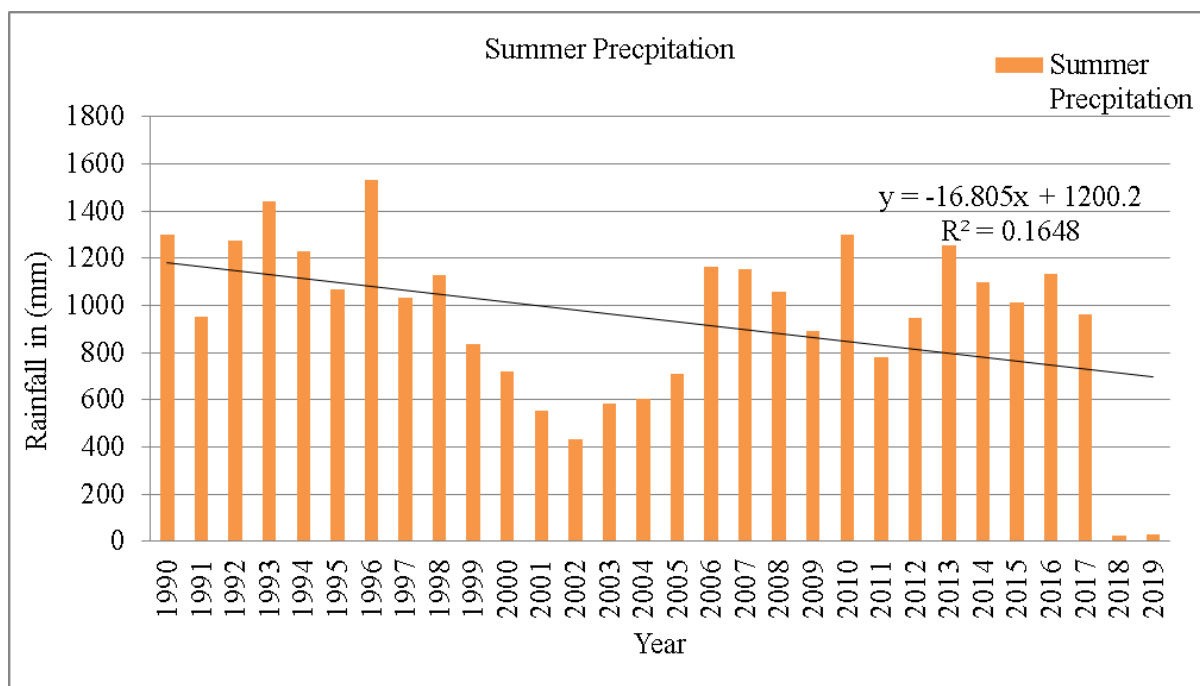


Figure 8: Trends of summer rainfall patterns (1990-2019).

Source: NMA, 2025

The highest rainfall amount of summer was registered in the years between in 1990, 1992, 1993 and 1996 (1173.63mm) and 1995-1996 (and lowest amount of rainfall was registered in the years between 1999, 2000, 2001, 2002, 2003, 2004, 2005 especially, in 2017 and 2018 (Figure 8). On the other hand, rainfall characteristics of linear regression analysis of Wayu Tuka Woreda in summer season rainfall patterns shows that, -16.80mm with $R^2=0.164$. Generally, the rainfalls patterns of the study area indicate that from time to time the summer rainfall has been decreasing. This was extremely affected the farmers economic activities. Hence, it was highly depend on rain fed agriculture.

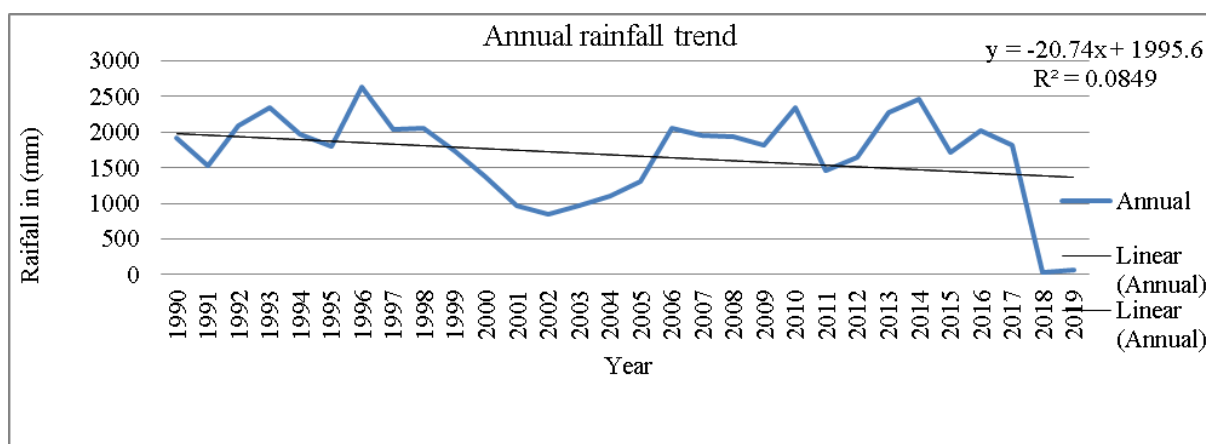


Figure 9: Trends of annual rainfall patterns (1990-2019).

Source: NMA data, 2025

The annual rainfall from (1990-2019) period in the study area its ranges from 3.43 mm to 2630.04 and annual maximum average rainfall was 207.63 mm recorded in 1991 and annual minimum average rainfall was 4 mm observed in 2019 over the last 30 years (Figure 9). In addition, as shows in figure 10 above, the assessed rainfall trend value indicates that, decreasing trends between 2018 and 2019 accounting for 5.32 and 3.43 mm respectively and increased in years 1992, 1996, 2010, 2013 and as well as 2014. In addition, rainfall characteristics of linear regression analysis of annual rainfall has the highest decreasing trends of -20.74mm with $R^2=0.084$, followed by summer -16.80mm with $R^2 =0.164$, autumn of -1.463mm with $R^2 =0.006$, Spring of -3.327mm with $R^2 =-1.346$ and winter of -1.124mm with $R^2 =0.147$. In general, there is a decreasing trend of annual rainfall patterns over the last three decades (1990-2019) in the study area with a rate of 10.772 (indicated as -10.772) mm per year.

In summary, the declining events of rainfall indicated that, prolonged drought and delay in onset of the rains. The fluctuations of rainfall season causes climatic change shock, particularly drought and late onset of rainfall. Drought and delay in the onset of rain leads to shortage of grass regeneration, water shortage, decreased agricultural productivities, and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration might have been occurring because due to long distance travel for searching water and pastures. Additionally, as the FGD asserted that, 2018 and 2019 was one of the devastative years for the agricultural society. This is somewhat harmed their livelihoods in general and exposed them to be sustained by the charity organization and by the government. Particularly, the untimed rainfall (onset and termination) of the Autumn and spring rainfall continue fluctuate. Its consequence was harming the rural population.

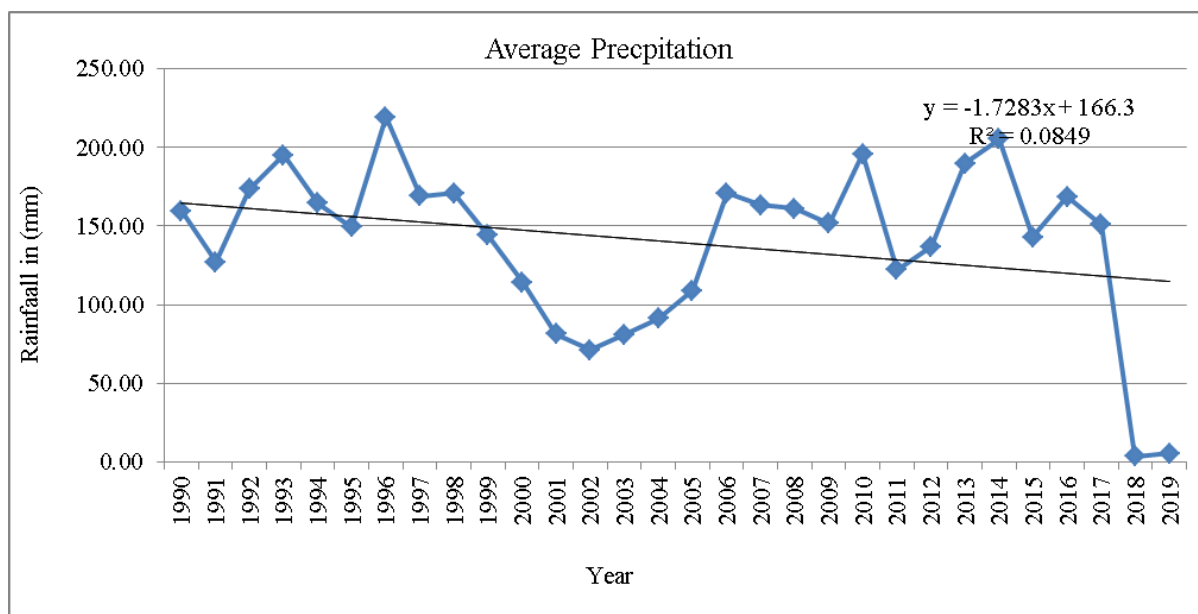


Figure 10: Trends of average rainfall patterns (1990-2019).

Source: NMA data, 2025

The average rainfall trends of the Woreda indicate that, rainfall displays a fluctuating patterns with tendency to decreasing and the highest average rainfall was 207mm recorded in 1990 and the minimum rainfall was 3.43 mm recorded in 2019 year. The results of the linear trend lines for the period of study (1990-2019) figure 10 above clearly shows that average rainfall has decreasing trends -1.728 with $R^2 = 0.048$.

In summary, the analysis of meteorological data of rainfall and HHs perceptions indicates that, the trends of rainfall has been decreasing and also the rainfall seasons are getting shorter (onset is late and early cease) and shows decreasing from time to time.

4.5.2. Temperature Pattern

Climate models suggest that Ethiopia will see further warming in all seasons of between 0.7⁰c and 2.3 ⁰c by the 2020's and of between 1.4⁰c and 2.9⁰c by the 2050s. The trend is defend as the general movement of a series over an extended of time or it is the long- term change in the dependent variable over a long period of time (Webber and Hawkins, 1980).

Accordingly, as indicated from the table below, the average yearly maximum temperature of the Woreda was 28.2⁰c (Table 9) while the average minimum temperature of the Woreda was 10.8⁰c (Table 10).

The highest Maximum temperature was recorded in March (32.2⁰c) in 2004, April (33⁰c) in 2

003 and May (35°C) in 2003. In addition the coldest months by which the lowest minimum temperature was recorded in December 9.2°C in 2002 and the mean annual maximum temperature was 25.8°C and the mean annual minimum temperature was 13.7°C and annual range of temperature recorded was 28.2°C- 13.7°C. In general, the mean annual temperature of the Woreda is (12.9°C). Therefore, trend shows that the maximum temperature of the Woreda is increasing and were continue in its increasing trend in the future.

Table 8: Trend analysis of maximum and minimum temperature by using Mann-Kendall and Sen's slop test in Wayu Tuka district (1990-2019)

Months/ Seasons		T-max							T-min					
	mean	S	VARs (S)	Z	Trend s	Sen's slope	Trend s	mean	S	VARs (S)	Z	Trend s	Sen's slope	Trend s
January	27.2	34	2842	0.62	Positive	0.5	Positive	9.4	-57	3130.3	-1	Negative	-0.021	Negative
February	29.3	50	2842	0.92	Positive	0.095	Positive	12.5	12	3129.3	0.2	Positive	0.004	Positive
March	30.5	168	3135.6	2.89	Positive	0.077	Positive	14.7	22	3127.3	0.38	Positive	0.006	Positive
April	30	97	3133	1.72	Positive	0.063	Positive	15.6	79	3110.3	1.4	Positive	0.013	Positive
May	27.7	19	2841	0.34	Positive	-0.011	Negative	15.3	74	3118	1.31	Positive	0.017	Positive
June	23.7	76	3132	1.34	Positive	0.029	Positive	14.9	86	3106.6	1.53	Positive	0.012	Positive
July	21.6	120	3118.6	2.13	Positive	0.025	Positive	13.9	141	3084.3	2.52	Positive	0.017	Positive
August	21.7	85	3110.3	1.51	Positive	0.017	Positive	14.3	54	3086.6	0.96	Positive	0	Positive

September	22.9	115	3126.33	2.04	Positive	0.03	Positive	14.3	155	3088.33	2.79	Positive	0.011	Positive
October	24.4	75	2841	1.39	Positive	0.023	Positive	11.5	42	3116	0.73	Positive	0.014	Positive
November	24.8	37	2841	0.68	Positive	0.01	Positive	9.7	102	3134.67	1.8	Positive	0.046	Positive
December	25.6	13	2841	0.23	Positive	-0.004	Negative	9.2	-1	3135.67	0	Positive	0	Positive
Summer	22.3	89	3113	1.59	Positive	0.021	Positive	14.3	115	3089.67	2.05	Positive	0.012	Positive
Autumn	24	29	2838.33	0.53	Positive	0.02	Positive	12.2	136	3110	2.42	Positive	0.025	Positive
Spring	29.4	24	2842	0.43	Positive	0.036	Positive	15.4	65	3110.33	1.15	Positive	0.01	Positive
Winter	28.6	37	2841	0.68	Positive	0.067	Positive	11.6	-48	3114	-0.84	Negative	-0.007	Negative
Annual	25.8	22	2842	0.39	Positive	0.037	Positive	13.7	10	2840	0.17	Positive	0.013	Positive

Source: NMA data, 2025

As indicated in table 8 above, MK trend test results revealed that, the trends for monthly maximum temperature showed a non-significant increasing trend (except for month of March, July and September) were statistically significant trend. The sen's Slope Estimates were 0.5 in January, 0.095 in February, 0.077 in March, 0.063 in April, 0.029 in June, 0.025 in July, 0.017 in August, 0.03 in September, 0.023 in October and 0.01 in November whereas December and May shows that a non-significant decreasing trend with sen's Slope Estimates of -0.004 and -0.011 respectively. In case of minimum temperature July and September were a statistically significant increasing trend where all the rest of months shows positive trends and a non-significant increasing trend but December haven't show any trends, with a slope of 0.004 in February, 0.006 in March, 0.013 in April, 0.012 in June, 0.00 in August (no trend), 0.011 in September, 0.014 in October, 0.046 in November, 0.00 in December (no trend) and 0.017 in May but January indicates that a negative trends and a non-significant decreasing trend with a slope of -0.021.

As the above table indicated that, both annual maximum and minimum temperature trends were positive trends and a non-significant increasing trend with a slope of 0.037 and 0.013 respectively. In addition, maximum temperatures trends in summer, autumn, spring and winter seasons were increasing and a non-significant increasing trend with a slope of 0.021, 0.02, 0.036 and 0.067 respectively.

As the same time, minimum temperatures in summer and autumn seasons were a statistically significant increasing trend whereas spring seasons were positive and a non-significant increasing trend with a slope of 0.012, 0.025 and 0.01 respectively, whereas the winter seasons only shows that a negative trend and a non-significant decreasing trend with a slope

of -0.007. The overall annual temperature observed in the study district is attributed to an increase in the minimum and maximum temperature the whole years.

Generally, results from this study indicate that, the annual maximum and minimum temperature were increasing trends at a rate of 0.037°C and 0.013°C per year respectively whereas the annual decades maximum and minimum temperature were increasing trends at a rate of 0.37°C, 0.13°C per year respectively, as the same time the seasonal decades of maximum temperature were in increasing trends at a rate of summer (0.21°C) , autumn (0.2°C), spring (0.36°C) and winter (0.67°C) and minimum temperatures were increasing trends at a rate of summer (0.12°C), autumn (0.25°C), spring (0.1°C) whereas winter season were in decreasing trends at a rate of (0.07°C) (Table 8). These results have been found to be higher than the national rate of increase of 0.028°C in the annual mean during 1960 to 2006 (Mc Sweeney *et al*, 2010), despite all the trends still indicate the existence of a warming trend in the country. Historical climate analysis for Ethiopia indicates that mean annual temperature has increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade. The increase in temperature in Ethiopia has been most rapid in June, August, and September at a rate of 0.32°C per decade (McSweeney *et al*, 2008).

Table 9: Descriptive statistics of maximum temperature in the study district (1990-2019)

Months/ Seasons	Obs.	Mean	SD	Variance	Min	Max	AV
January	30	27.2	1.6	34.1	9.4	30.9	24.7
February	30	29.3	1.8	39.8	12.5	33.2	26.8
March	30	30.5	1.3	45.7	14.7	32.2	28.1
April	30	30	1.6	43	15.6	33	27.6
May	30	27.7	2.3	34.4	15.3	34.5	25.2
June	30	23.7	0.9	26.9	14.9	25.5	21.2
July	30	21.6	0.8	21.9	13.9	24.5	19.3
August	30	21.7	0.5	23.8	14.3	22.9	19.4
September	30	22.9	0.7	25.9	14.3	24.1	20.5
October	30	24.4	1	27.7	11.5	27.9	21.9
November	30	24.8	1.1	28.4	9.7	29.4	22.4
December	30	25.6	1.4	30	9.2	29.6	23.1
Summer	30	22.3	0.6	24.4	14.3	24.3	20
Autumn	30	24	0.8	27.6	12.2	27.2	21.6
Spring	30	29.4	1.3	41.8	15.4	33	27
Winter	30	28.6	1.4	38.9	11.6	32.1	26.2
Annual	30	25.8	0.9	32.3	13.7	28.2	23.3

Source: NMA data, 2025

As it can be seen from the above table 9, the analysis of annual, seasonal and monthly temperature data was undertaken to detect the variability and trend of temperature change in the study area for the periods of 1990-2019. The mean annual minimum and maximum temperature in the study district ranges from 13.7⁰C to 25.8⁰C, respectively. The annual minimum and maximum temperature in the study area ranges from 9.2⁰C (minimum) to 34.5⁰C (maximum) with annual average temperature of 23.3⁰C and the standard deviations of annual and seasonal maximum temperature were (annual, summer, autumn, spring and winter) indicated 0.9, 0.6, 0.8, 1.3 and 1.4 respectively.

Table 10: Descriptive statistics of minimum temperature for the period of (1990-2019)

Months/ Seasons	Obs.	Mean	SD	Variance	Min	Av
January	30	9.4	1.2	5.6	9.4	11.6
February	30	12.5	1.1	7.4	12.5	12.9
March	30	14.7	0.8	10.7	14.7	14.1
April	30	15.6	0.6	12.4	15.6	14.6
May	30	15.3	0.7	11.9	15.3	14.5
June	30	14.9	0.4	11.6	14.9	13.5
July	30	13.9	0.4	10.2	13.9	12.8
August	30	14.3	0.2	11.2	14.3	12.8
September	30	14.3	0.2	11.3	14.3	12.9
October	30	11.5	0.9	6.1	11.5	11.7
November	30	9.7	1.2	4.9	9.7	10.8
December	30	9.2	1.6	6.4	9.2	11
Summer	30	14.3	0.3	11.2	14.3	13
Autumn	30	12.2	0.6	7.3	12.2	11.7
Spring	30	15.4	0.5	12.4	15.4	14.4
Winter	30	11.6	0.8	6.2	11.6	11.6
Annual	30	13.7	0.4	9.7	13.7	12.6

Source: NMA data, 2025

As it can be seen from the above table 10, the analysis of annual, seasonal and monthly temperature data was undertaken to detect the variability and trend of temperature change in the study area for the periods of 1990-2019. The mean annual minimum temperature ranges from 9.4°C to 15.6°C in the study district respectively. The annual minimum temperature was 9.2°C with annual average temperature of 10.8°C and standard deviations (SD) of annual minimum temperature of 0.4 with seasonal SD of summer (0.3), autumn (0.6), spring (0.5) and winter (0.8) respectively.

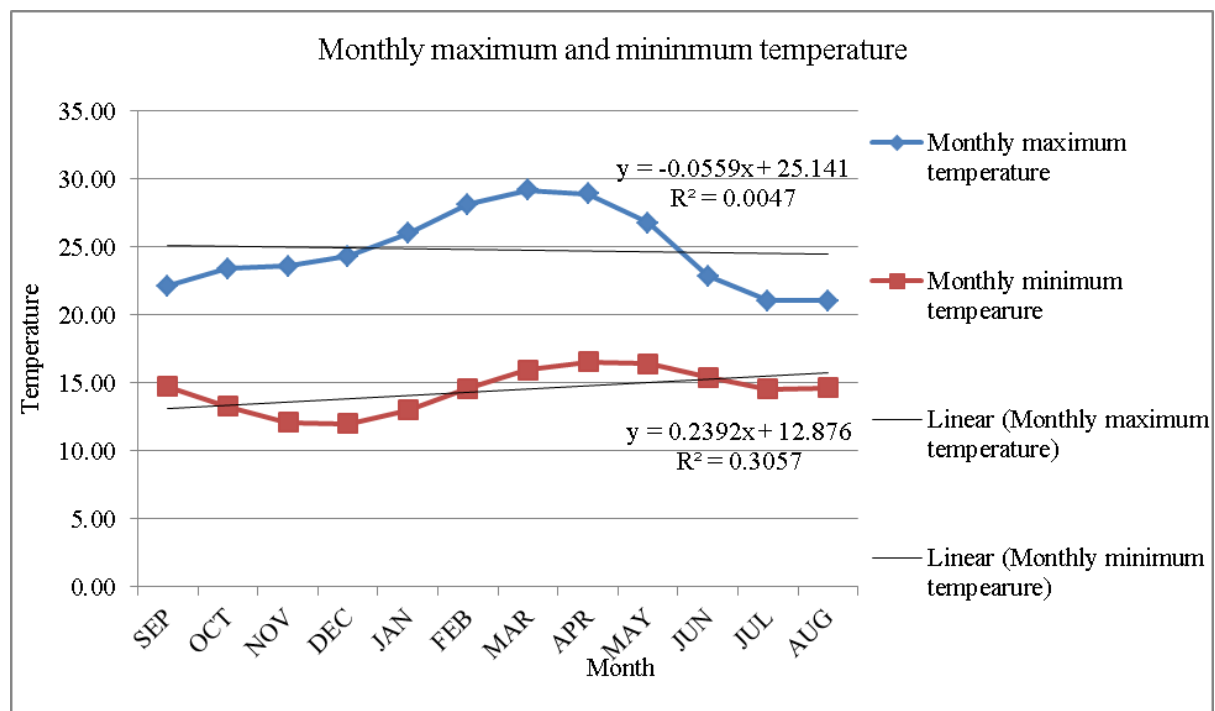


Figure 11: Trends of monthly maximum and minimum temperature (1990-2019).

Source: NMA data, 2025

The monthly maximum and minimum temperature has showed a decrease of -0.06°C with $R^2 = 0.004$ and an increase of 0.24°C with $R^2 = 0.31$ respectively (Figure 11).

This trend indicates that, average monthly temperatures have increased which have a detrimental impact upon agriculture and livestock, exacerbating food insecurity. Analysis of maximum and minimum monthly temperatures for Wayu Tuka woreda also reveals an increase over the 30-year period. It is the extremes of weather variability that will have the most detrimental impacts upon lives and livelihoods of communities in the study area .

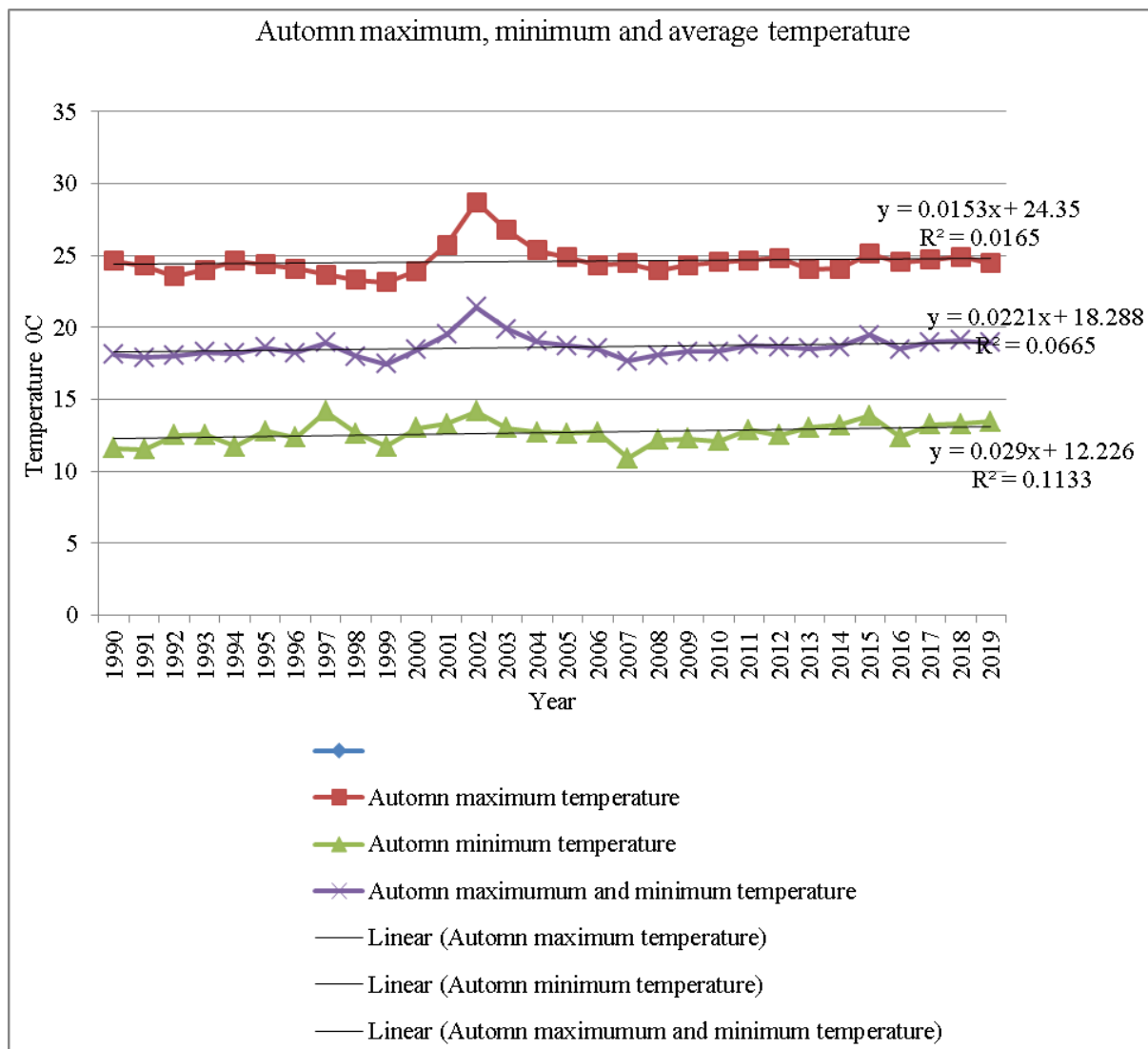


Figure 12: Trends of autumn maximum, minimum and average temperature (1990-2019).

Source: NMA data, 2025

As indicated on figure 12, autumn season, the trends of maximum and minimum temperature were somewhat slightly increasing but relatively indicate the normal distribution. Specifically, the highest maximum temperature recorded was 29.41⁰c in 1990 year in November month and the lowest temperature was recorded as 9.73⁰c in November month in 2000 observed while the highest average maximum temperature 20.30⁰c in 1991 and the lowest average minimum temperature was 17.51⁰c in 2007 observed in past years.

During the spring season according to the above figure shows that, the trends of temperature were increasing and its maximum temperature were 34.5. ⁰c occurred in May month of 2002 and the minimum temperature 25.08⁰c during the month of May in the year of 2012 and

finally, during summer season the distributions of maximum temperature somewhat at normal condition. In addition, the analysis of regression and variability for the maximum temperature in the study area showed that, the highest variability for spring season with $R^2 = 0.013$, followed by autumn with $R^2 = 0.016$, summer with $R^2 = 0.076$ and winter with $R^2 = 0.134$ respectively. The mean maximum temperature of the study Woreda had showed an increment of 0.015°C (Figure13), 0.02°C (Figure14), 0.030°C (Figure15), and 0.068°C (Figure16), per year for autumn, spring, summer and winter seasons respectively.

In the same manner, the analysis of regression and variability for the minimum temperature in the study area showed the highest variability for winter season with $R^2 = 0.022$, followed by spring with $R^2 = 0.071$, autumn with $R^2 = 0.113$ and summer with $R^2 = 0.164$ respectively. The mean minimum temperature of the study Woreda has showed an increment of 0.011°C (Figure 16), 0.015°C (Figure 15) and 0.0290°C (Figure 13) per year for summer, spring, and autumn respectively. On the other hand minimum temperature has showed a decrease of -0.014°C per year for winter season (Figure 14).

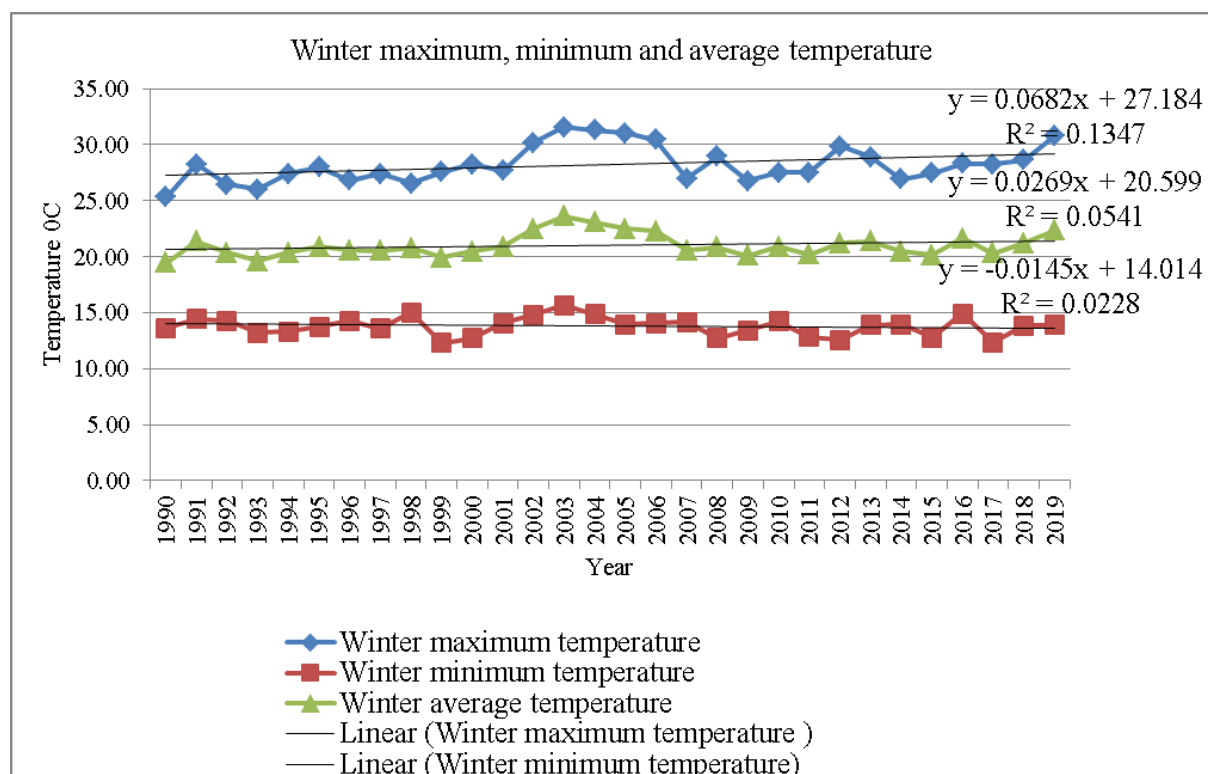


Figure 13: Trends of winter maximum, minimum and average temperature (1990-2019).

Source: NMA data, 2025

The trends of temperature in winter season indicate that, the temperature was increasing. Here the maximum temperature was 33.16⁰c happened in February in the year of 2003 and the minimum temperature was 24.2⁰c happened in the year of 2014 in the month of December while the highest average temperature 22.4⁰c in 1991 and the lowest average minimum temperature was 18.26⁰c in 2018 observed within 30 years (Figure 13).

As some of FGD member informed in winter season rainfall is scanty. The quality of animals was decreasing. This is due to the lack of forage and the scarcity of water and the prevalence of animal diseases resulted from high temperature change. Thus, the quality and the quantity of animal product also deteriorated.

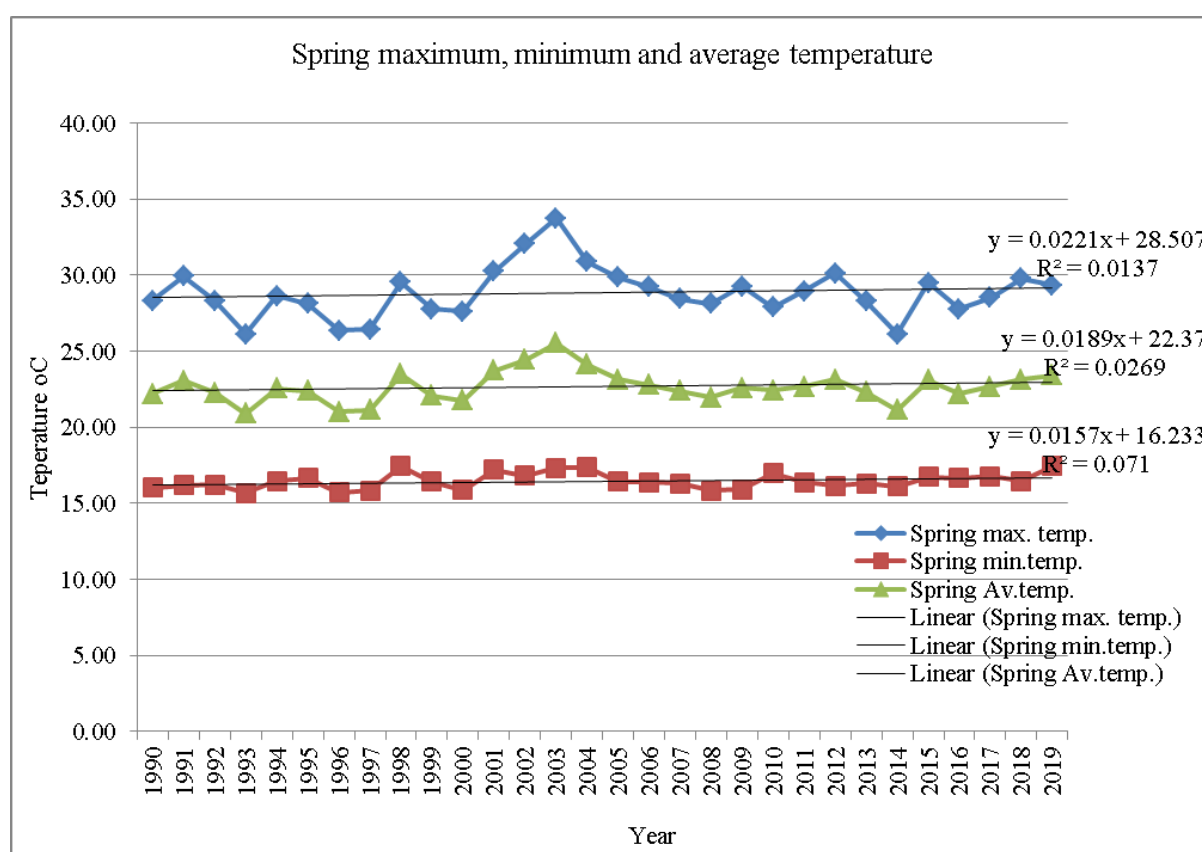


Figure 14: Trends of spring maximum, minimum and average temperature (1990-2019)

Source: NMA data, 2025

The general trend of temperature was indicates increasing trends. Specifically, the highest temperature recorded was 34.5⁰c in 1991 in the May month and the lowest temperature was recorded as 25.2⁰c in May 2017. In addition, the highest average temperature was observed as

25.1⁰c in 2002 and the lowest average minimum temperature was 22.5⁰c in 2011 observed within 30 years (Figure 14).

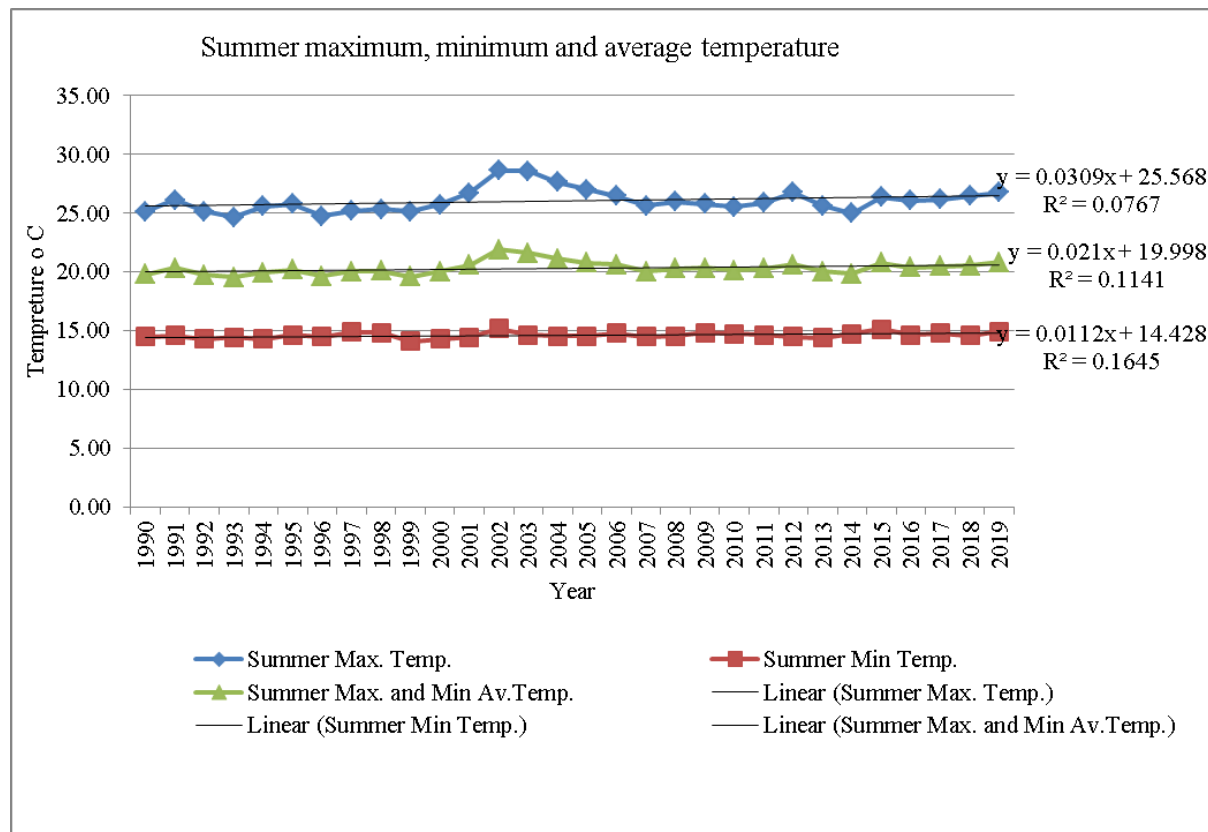


Figure 15: Trends of summer maximum, minimum and average temperature (1990-2019)

Source: NMA data, 2025

The trends of maximum and minimum temperature were during summer season indicate that, the trends looks like at normal condition but slightly shows that decreasing trends but the average maximum and minimum temperature shows an increasing trends. As indicated in figure 15, the highest temperature recorded during summer season in last 30 years was 25.48⁰c in 1991 in the June and the lowest temperature was recorded to be 13.88⁰c in July 1991.

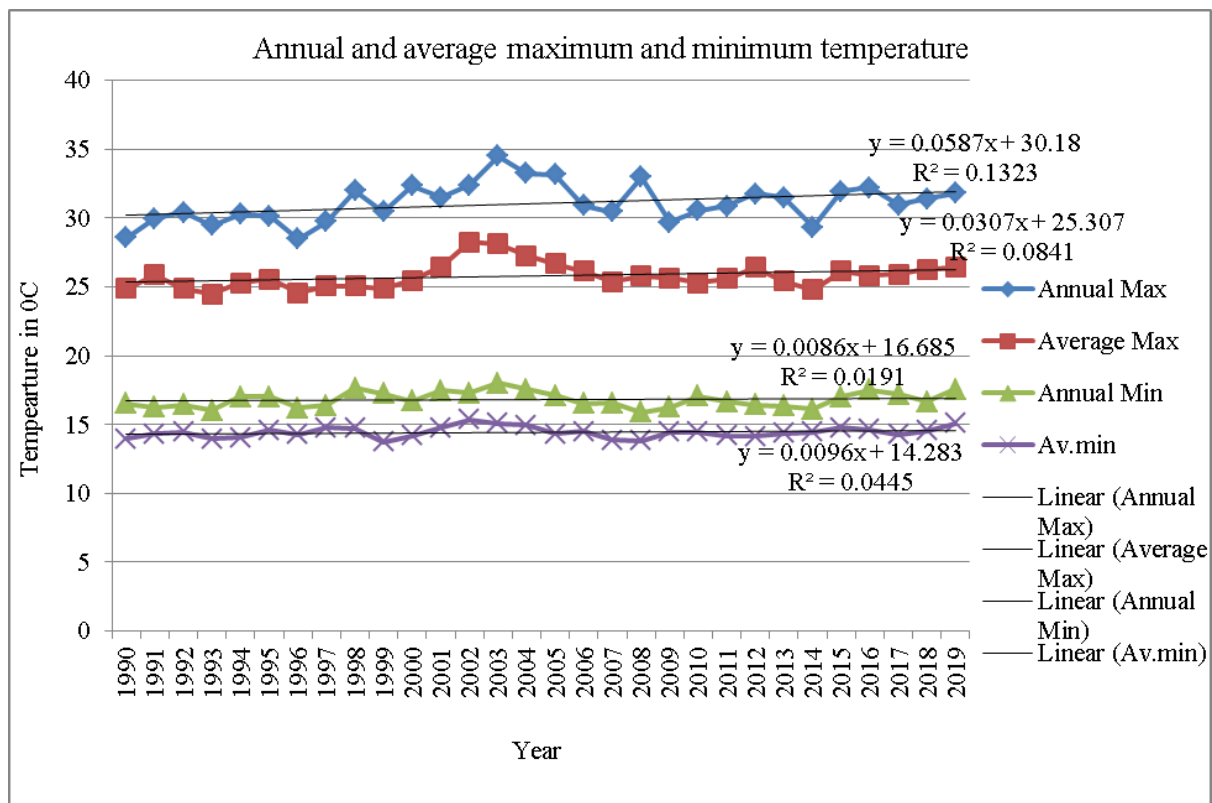


Figure 16: Trends of annual and average maximum and minimum temperature (1990-2019)

Source: NMA data, 2025

As indicated from the above figure there is increasing in trends of annual and average maximum and minimum temperature over three decades from (1990-2019) in the study district with a rate of increase of 0.06°C , 0.03°C , 0.008 and 0.009 per year respectively. This finding is not similar to global warming rate which is estimated 0.9°C and generally, annual temperature has been shows an alarming rate of increase in a district specially (2000, 2001, 2002, 2003, 2014, 2015, 2016, 2017, 2018 and 2019). As conclusions, analysis of both trends of line techniques and HHs responses on the survey are in line with the analysis of metrological data on temperature. In addition, HHs has been perceived that temperature is decreasing in all the three selected kebeles and analysis of temperature data also shows that, increasing trends. Finally, together with temperature change and shortening rainfall seasons and amount, these changes pose major challenges on the rural populations' livelihood especially on agriculture and livestock rearing.

4.5.3 Perception of Precipitation and Temperature Pattern

The rainfall pattern of the study area has changed about 76 (59.4%) of the respondents perceived that the amount of the rain fall has been decreasing, while 44 (34.4%) of the respondents replied that the rainfall of time onset become late and time of cessation become earlier but, 8 (6.3%) the respondents replied that the rainfall amount has been increasing.

Table 11: Sample respondents perception of precipitation and temperature in the study area

Variables	Frequency	Percent
Rainfall amount decreased	76	59.4
Rainfall amount increased		.3
Become late and go earlier	44	.4
Total		
Temperature increasing	106	.8
Temperature decreasing	14	.9
Temperature no observable change	8	.3
Total respondents		

Source: Filed survey (2025)

As indicated in table 11, 106 (82.8%) of the respondent replied that temperature has increased, while 14 (10.9%) of them have noticed that the temperature has been decreasing. whereas, 8 (6.3%) of the respondents suggested that there was no observable temperature change. Generally, this result indicated that a majority of HH respondents said that temperature has been rising over the years.

The information obtained from conducted FGDs showed that the respondents agreed that they have been observing the changes in rainfall and temperature pattern in Wayu Tuka Woreda. They expressed different changes in the rainfall and temperature pattern. Firstly, the local communities explained that they have been observing that the amount of the rainfall has been decreasing and temperature has been decreasing over time. Secondly, they expressed that the precipitation patterns had become unpredictable and the seasons have been changed consistently.

Also the FGD participant reported that, the rains are normally now starting late in March or April and ending early before the crops could mature. They noted that in the past, rains would normally begin sometime in February. However, the seasons appeared to have shifted as the

rains could now start as late as March. They expressed that they have a general feeling of uncertainty about when the best time to plant would be. Therefore, they explained that they need an efficient weather forecasting system if they were to remain effective in farming.

Generally, all of the participants in the FGD in all kebeles agreed that change in timing of precipitation is adversely affecting the whole process of cultivation.

Both participants in the FGDs and the respondents unanimously agreed that there was a climate change and ecological changes had been happened in the Woreda. Thus, it was generally acknowledged by the respondents in the whole study area that temperatures have increased over the past 30 years.

Participants noted that these changes hinged around increasing temperatures and reducing precipitation levels. And also FGD participants suggested that temperature levels had dramatically increased in recent years.

Some of the participants in FGDs said that, it seems that the sun has moved its position near to the earth, which lead to increasing hotness. Additionally, participants from the three FGDs reported that the sun had become nearer to the earth that leads to higher temperature.

As it is stated in chapter two, increases in seasonal mean temperature have be observed across Ethiopia over the past 50 years, the majority of the temperature rise was observed during the second half of the 1990s (EEA, 2008).

4.6. Households Understanding and Perception of Climate Variability

4.6.1. Households' Knowledge and Perceptions about Climate Variability

Farmers' perceptions and understanding of climate Variability are significant when it comes to household adjustments and adaptations strategies to climate change (Kebede and Adane, 2011). Community perception, views and opinions regarding climate change both in designing mitigation policies as well as formulating adaptation strategies. Besides, the degree to which an environment is affected by climate change depends on one hand on the level of perception by individuals and the other on mitigation and adaptive capacity to the change phenomenon (Gbetibouo, 2009).

At district and selected kebele levels, climate Variability is perceived through irregularity and disturbance in rainfall patterns, increase in temperature, and increase in frequency of some weather extreme events such as flood, drought, storms and heavy rain. A number of questions relating to climate Variability were asked in the questionnaire in order to understand the

selected kebeles' (district) views about the notion of climate change. The first question asked concerned whether or not respondents had ever heard about climate change. Respondents were asked the question 'Have you ever heard about climate variability?' respondents were required to answer 'yes' or 'no' to the question. The table below shows the distribution of responses to the question:

Table 12: Views of respondents regarding notion of climate change

Variables	Frequency	Percent
Yes	114	89.1
No	14	10.9
Total respondents	128	100

Source: Field survey, (2025)

The majority of respondents, 114(89.1%) agreed that they had heard about climate change and 14(10.9%) had never heard about the climate change. This shows that rural communities in Wayu Tuka Woreda are well informed about climate variability. This is an important finding for climate change adaptation strategies because responses cannot be effective without getting small holder farmers to understand the notion of climate change. Another question asked was about, 'What is your perception about climate Variability of your kebele?' Respondents were required to select a response from a set of responses arranged in progressive order of levels of agreement. The following table shows the distribution of responses to the question.

4.6.2. Local Indicator of Climate Variability

Table 13: Respondents' view on local indicator of climate change

Local indicator of climate Variability	Kebeles of respondents			Total
	Dalo Komto	Gute Badiya	Bonaya Molo	

Increase in hot temperature and cold temperature	23.8	.2	.3	
Unpredictable rainfall	38.1	.8	.5	.1
Decrease in river volume	31	.1	.4	.9
Flooding and Drought	7.1	.9	.8	
Total respondents				

Source: Field survey, (2025)

Similarly, way, the information obtained from FGD conducted revealed that trend of temperature has been increasing because of rainfall late coming and early cessation. Thus, the study area is characterized by decline in the amount of rainfall and frost with increasing in temperature. Increase in uncertainty of climate especially temperature and the uneven rainfall distribution have resulted in decline of crop production, livestock and their products.

The interviewees claimed that, seasonal variation, occurrence of decline rainy and dry season, unpredictable rainfall, happening of abnormal cold and hot temperature, occurrence of some diseases, reduction of forest resources, land degradation, deforestation, during prolonged dry seasons decline of surface and underground water resources, increased soil acidity, decreased soil fertility, reduction of crops productivities, decreased animal feed and decreased number of livestock are some of the major indicators of climate Variability.

Therefore, most of the respondents responded that the most indicators of climate Variability are unpredictable rainfall, next decreasing in river volume and the respondents perceived increase in hot temperature and cold temperature.

4.6.3. Trend of Animal Feeds

Table 14: Views of respondents on the trend of animal feeds

Trend of Animal Feeds	Kebeles of respondents			Total
		Gute Badiya	Bonaya Molo	
	Dalo Komto			
Declining				
	83.3	.2	.5	
The same (no change)				
	9.5	.3	.2	.7
Increasing				
	2.4	.2	-	.6
I do not know				
	4.8	.2	.3	.7
Total respondents				

Source: Field survey, 2025

Generally, even if the impact of climate Variability poses a major challenge to animal rising and its forages, the farmers are using their own land in wise and safe way. Therefore, as the respondents suggest that the feeding trend of animals has limited to crop residue and individual grazing field currently.

The finding was consistent with what literatures indicate states that drought and delay in the onset of rainfall led to poor grass regeneration (forage) deficit, water scarcity and heat stress on livestock, and consequently increased the death of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures(Senbeta, 2009).

4.6.4. Sources of Water for the Households

Table 15: Views of respondent on source of water

Source of Water	Kebeles of respondents			Total
	Dalo Komto	Gute Badiya	Bonaya Molo	
Rivers water	52.4	.1	.4	.5
Protected springs	11.9	.3	.8	.7
Unprotected springs	23.8	.8		.5
Ponds	4.8	.7	.4	.7
Pipe lines	7.1	.1	.3	.6
Total respondents				

Source: Field survey, 2025)

Water sources are a critical component of the equation in ensuring sustainable rural livelihoods especially in conditions where there is declining rainfall. The study also sought to understand the state of water sources in the relation to climate Variability taking place. According to the information obtained from Wayu Tuka Woreda water resource development office, the Woreda is endowed with all types of water resources, such as rivers, springs, ponds and pipe lines water.

Respondents to the household questionnaire were asked to select a comment on whether the state of water sources yields had regarding the question, ‘from where the household get

sufficient water in throughout a year?’As shown in table 15, about 71(55.5%) of the respondents replied that the source of water is river and 25(19.5%) of them replied that the source water is from unprotected spring. Others, 15(11.7%), 11(8.6%) and 6(4.7%) of the respondents replied that the source of water is protected spring, pipe lines and ponds, respectively.

Thus, when rainfall decreased, temperature become increased, climate Variability results in increased water scarcity, reduced river flows and water storage which seriously affect crop production on which rural livelihoods directly or indirectly depends.

In addition to this, members of FGD from three kebeles also said that, their source of drinking water is springs and pipe lines developed by the Woreda in very few kebeles. But most of the springs are unprotected and they are already drying up due to drought.

4.7. Vulnerability of Local livelihood to the Impact of Climate Variability

Vulnerability is depends on pre-existing condition of physical and social space. Pre-existing conditions include; the geographical location, nature of dwelling, access to physical infrastructure, information and communication systems, patterns of social capital, and the ability of different groups or individuals to secure alternative livelihoods and ensure the flow of resources such as financial, social and political to maintain livelihood security. Climate change vulnerability on agriculture includes decreased pasture availability and water, decreased capacity of livestock to resist disease and productivity in terms of milk and meat also death of livestock. Generally, drought causes crop failure, leading to food insecurity, increased conflict over scarce resources, migration of people for search of labor work and increased school dropout (Twig, 2001).

4.7.1. The Main Cause for Climate Variability

Table 16: Views of respondents on the main cause for climate Variability

Causes of climate Variability	Kebeles of respondents			Total
	Dalo Komto	Gute Badiya	Bonaya Molo	
Deforestation	20	21	18	59
	47.6	.7	.9	.1

Change in land use and land cover				
	19	.3		.4
Low fertility of land	10			
	23.8	.4	.3	.8
Absence of sustainable farming system	4			
	9.5	.6	.8	.7
Total respondents				

Source: Field survey, 2025

According to the information obtained from FGD participants, there are many problems that can cause climate Variability. Such as deforestation, soil erosion, soil degradation, drought, decrements of soil fertility and pasture lands are directly and indirectly the first and predominant climate change related to farmers problem. Additionally, governmental, local administration such as road construction and economic challenges are followed by the challenges of climate change and they increase vulnerability to the impacts of climate change. Also interviewee suggested that the climate change is becoming much more unpredictable since recent past. They reported that this may probably due to deforestation, land degradation and over cultivation to the ever increasing demand of agricultural land.

The above table 16 finding supported, scientific literature classifies the causes of climate Variability as natural and human-induced. Natural climatic variations emerge from processes internal to the earth or driven by external forces whereas human-induced climate change or global warming is largely caused by GHGs emissions. The determined that human activities have grown since pre-industrial times. For example, there has been 70% increase in GHG emissions between 1970 and 2004. GHGs are generated from the burning of fossil fuels, land use changes and deforestation. And CO₂ contained in these processes is one of the main GHGs that contribute to global warming (IPCC, 2007).

Table 17: Views of respondents on the challenges of climate Variability posed on livelihoods

Major challenges of climate Variability posed on livelihoods	Kebeles of respondents			Total
	Dalo Komto	Gute Badiya	Bonaya Molo	
Shortage of pasture land				
	19	.4	.1	.3
Crop yield reduction				
	33.3	.9	.1	
Loss of livestock				
	16.7	.7	.1	.3
Flooding and Drought				
	4.8	.3	.9	.8
Scarcity of water				
	26.2	.7	.8	.5

Total of respondents				
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Source: Field survey, 2025

The sample respondents stated that many factors that interrupt the rural livelihoods to adapt to climate change. As shown in table 17, majority of the sample respondents (households), 41(32%) suggested the main challenge that climate variability posted on livelihood was crop yield reduction and shortage of pasture land , 26 (20.3%) of sample households replied that loss of livestock while, 10 (7.8%) of them replied that flooding and drought. Others, 25 (19.5%) of them replied that posted on livelihood is scarcity of water. Generally, this shows that local coping strategies and adaptation practice to climate variability induce a crisis have seriously been challenged in the area. The information collected from FGD conducted indicates that local communities were highly marginalized in many aspects such as social, Economical, culturally and geographically and the local strategies and adaptation practice have remained challenging for them to overcome the impact of the climate change in their respective district. Additionally, they added that in the district the other challenges to adapt the impact of climate Variability includes lack of knowledge, lack of information, lack of enough agricultural input and shortage of land size.

4.8. Climate Variability Adaptation Strategies

One of the intended objectives of this study was to assess the adaptation strategies of livelihoods being practiced to climate Variability in the study area. Thus, to asses this variable two items question were prepared and distributed to respondents and the following four tables indicates the summaries of participants views.

4.8.1. Community Based Measures to Over Come Climate Variability Impact

Table 18: Respondents'views on community based measures of adaptation strategies

Climate change Measures taken	Kebeles of respondents			Total
		Gute Badiya	Bonaya Molo	
	Dalo Komto			
A forestation (Planting	20	.9	.7	.8

trees)	38.1			
Protecting water reservoirs	2	3	1	
	11.9	24.4	9.7	.7
Building flood protection features (ditches)	8			
	19		.4	.1
Constructing roads	3			
	9.5	.2	.9	.7
Soil conservation	9			
	21.4	.4	.3	.8
Total respondents	42			

Source: Field survey, 2025

As it can be seen from the above table 18, majority of the respondents, 56(43.8%) responded that societies in the study area used afforestation (planting trees) strategies in order to overcome the impact of climatic change while, 33(25.8%) of them replied that the HH communities used soil conservation strategies and 27 (21.1%), of the respondents stated that the local community used building flood protection features (ditches) and protecting water reservoirs to overcome the impact of climate change. Finally, 6 (4.7%) of the respondents replied that the local community has used the strategies of Constructing roads in order to overcome the impact of climatic changes.

According to the information obtained from officials of Wayu Tuka Agricultural officers and DAs, a number of Kebeles initiated adaptation strategies are being undertaken as part of the

federal and regional government's efforts to increase community's resilience to climate change and variability. Some of the activities that are already taking place currently include, soil and water conservation activities, a forestation and spring development and road construction are some of the major ones. Introduction of early maturing crop varieties is another government strategy under usage currently.

The interviewees expressed that communities have always adapted to climate variations by making preparations based on their resources and knowledge accumulated through experience of past weather pattern. Community based adaptation to climate change and variability emerged out of the growing recognition in the developing community that those most vulnerable to climate change are the poorest people in the world's poorest regions. Many of them are marginalized, and live in remote kebeles out of reach of government services. CBA may foster the resilience of rural communities, but also the resilience of the ecosystems on which these communities rely for a living.

The above finding matched with what literatures states which indicated that the following environmental problems such as climate change, land degradation, over grazing and deforestation, indoor air pollution and water pollution, loss of biodiversity and ecosystem services, spread of invasive species etc are identified as serious obstacles to achieve the county's green economy plan, (Cesar and Ekbom, 2013).

Participants of FGD conducted in Bonaya Molo kebeles particularly expressed that planting tree and soil and water conservation have been used as adaption strategies for many years in this study area, but did not bring a necessary change. They rose the ever decreasing of grassing land, decreasing of water availability, decreasing of rainfall and increasing of temperature as the reason for such occurrences. This implies that the overall management system was very poor. Therefore, to adapt properly the impact of climate change, the management system of different adaptation strategies must be implemented by the governments and the communities and a continuous awareness is needed for all communities. Households use different adaptation strategies to make balance to the impact of climate change. Regardless of the strategies that can be applied by any farmer, it predicted that taking adaptive measures reduces the negative effects of climate change on farm production, household income and farmers'livelihood (Uddin, *et al.* 2014).

4.8.2. Local Livestock Adaptation Strategies

As presented in the below table 20, about 63 (49.2%) of the respondents responded that decreasing the number of livestock is the adaption strategy that the local community have been using and 30 (23.4%) of the respondents replied that cattle fattening is the adaption strategies that has been used there while, 20 (15.6%), 11 (8.6%), 4 (3.1%), of the respondents replied that increasing the number of livestock, sale of weak and old animals before the dry season, seasonal migration with cattle in search of pasture water are the mostly used strategies for climatic variability adaption respectively.

Table 19: Views on livestock related household adaptation strategies

Livestock related household adaptation strategies	Kebeles of respondents			Total
	Dalo Komto	Gute Badiya	Bonaya Molo	
Increasing the number of livestock	7.1	.8	.9	.7
Decreasing the number of livestock	52.4	.1	.9	.2
Seasonal migration with cattle in search of pasture water	2.4		.3	.1
Cattle fattening	23.8	.4	.9	.4
Sale of weak and old animals before the dry season		.7	.9	.6

Total respondents				

Source: Field survey, 2025

While conducting an observation during data collection, it has been observed that over the entire area of the three kebeles namely Dalo Komto, Gute Badiya and Bonaya Molo the local communities have had predominantly cattle, got, sheep, horse and donkey. Livestock production has not been the most indispensable and not the basic economic for local community but they use as adaptive mechanisms next to crop production since whose life style has entirely been based on crop production mostly.

The information collected from the interviewees indicated that the trends of livestock's are reduced from year to years by the effects of climate change. This is because, when the climate change happened, the amount of rainfall decreased, due to the hotness and coldness of temperature increased. These causes shortage of grass and water that are sensitive to livestock's and the livestock's are the most vulnerable to the impacts of climate Variability.

4.8.3. Crop Production Adaptation Strategies

Table 20: Respondents'views on crop production adaptation system to overcome climate Variability impact.

Crop production related to adaptation to climate change	Kebeles of respondents			Total
	Dalo Komto	Gute Badiya	Bonaya Molo	
Using new varieties of crops				
	33.3	.7	.9	.4
Inter cropping system				
	14.3	.8	.2	.8
Wise storage of crops (Saving)				

		.4	.9	.5
	7.1			
Intensive irrigation				
	14.3	.5	.2	.1
Crop rotation				
	31	.5	.8	
Total respondents	42			

Source: Field survey, 2025

As the researcher observed during field observation, over the entire area of the selected kebeles, the predominant crops in the area are maize, teff, barley, wheat, bean and sometimes sorghum especially at Highlands agro-ecology. Crop production has been the most and basic economic activity for the local community and the respondent's use different local adaptation systems.

As presented in table 20, 44(34.4%) of the respondents responded that using new varieties of crops is the adaption strategy that the local community have been using while, 40 (31.3%) of the respondents responded that the community used crop rotation as adaption strategy and 19 (14.8%), 18 (14.1%), 7 (5.5%), of the respondents stated that inter cropping system, intensive irrigation and wise storage of crops (saving) are used as adaption strategy respectively. The finding showed that changing crop varieties and using crop rotation adaptation measures are the most widely used strategies as they need low costs and much access to be used easily.

The information collected from the elders while conducting FGD indicates that different local adaptation strategies are undertaken by farmers in response to changing climatic variation in the study area. According to them, the types of adaptation strategies of crop production such as using new varieties of crops, inter cropping system, wise storage crops (saving) and intensive irrigation are the major and common adaptation strategies of the community.

To implement the adaptation strategies of climate Variability, key informants from Wayu Tuka Woreda agricultural and developmental office expressed that government is supplying

inorganic fertilizer; new varieties of different crop and farmers use new agricultural technologies.

4.8.4. Adaptation Strategies of HH Related to Shortage of Water

Majority of the sample respondents 77 (55.5%) of the respondents replied that the HH use recharging ground water as adaptation strategy regarding water issues while, 36 (28.1%) them replied they use of reservoirs and ponds as adaption strategy and 15 (11.7%) of the replied that they use expanding irrigable farm as adaptation strategy. On the other hand, 6 (4.7%) of them replied that they use rain water harvesting in response to climate change regarding water irregularity.

Table 21: Views on adaptation strategies of farmers related to shortage of water

HHs adaptation strategies related to water	Kebeles of respondents			Total
		Gute Badiya	Bonaya Molo	
	Dalo Komto			
Rain water harvesting				
	4.8	.7	.4	.7
Expanding irrigable farm				
	11.9	.3	.8	.7
Use of recharging ground water	22			
	52.4	.1	.4	.5
Use of reservoirs and ponds				
	31	.9	.4	.1
Total respondents				

Source: Field survey, 2025

Accordingly, in an effort to address the problems of recurring climate variability conditions and food insecurity, the Woreda office of agriculture engaged in variety of water harvesting programs to supplement the rain fed agriculture and there by address drought and food shortages.

According to the information from experts of the Woreda agricultural office, the office has been trying to introduce and accomplish various adaptation strategies in response to water shortage due to climate change. Some of these are, localized pumping, either from a surface water source (river, stream, lake or dam or groundwater, using manual or motorized pumps and various on-farm water application methods). The information from key informant interviewees (experts from the Wayu Tuka Woreda's) noted that farmers are not aware of the benefit they could earn if they used various agricultural technologies, inputs and varieties of crop seeds to enhance yield per a plot of land.

FGD participants in a unanimous manner agreed that water accessibility is generally decreasing due to a reduced rainfall and decreasing temperature. They noted that many water points that used to provide water for animals and people had dried away. A specific mention was made of springs and pools in local rivers.

Ethiopia has essentially rain fed agriculture system, where more than 83% of the population depends on subsistence agriculture. While rainfall plays a major role as vital water source for securing nearly the entire food production of the country. The temporal and spatial distribution over the country varies above 2000 mm over some pocket areas in the south west to less than 250 mm over the vast areas of Afar and Ogaden low-lands (NMA, 2001).

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

This study indicates that, climate Variability and its impacts on livelihoods of local community perception and adaptation strategies in Wayu Tuka Woreda, the frequency of climatic variability is increasing, both in terms of extreme weather frequency and gradual changes.

The respondents' perception shows that the trend of agro-ecology is becoming toward hotter and less humid environment. However, the annual meteorological data shows decreasing precipitation and increasing temperature trend for Wayu Tuka Woreda.

According to the surveyed household headed 81.6% were depending on agricultural production. Consequently, the majority of the respondents, 52.3 % had 0-1ha land size. Whereas, 3.9% of the HH respondents were land less.

The result revealed that, annual rainfall patterns over the last three decades (1990-2019) decreasing trends by rate of 10.772 (indicated as -10.772) mm per year, with variability of 36.8% value which is considered as highly variable.

The results of MK test for monthly precipitation data revealed that, month of January, April, and winter season where a statistically significant decreasing trend. The remaining September and November months where a non significant increasing trends was observed. The MK trends test results of monthly maximum temperature revealed that, March, July and September) were statistically significant trend. In case of minimum temperature July and September were a statistically significant increasing trend whereas all the rest of months show positive trends and a non-significant increasing trend.

Both annual maximum and minimum temperature trends were positive trends and a non-significant increasing trend with a slope of 0.037 and 0.013 respectively. As the same time, minimum temperatures trends in summer, autumn and spring seasons were positive and a non-significant increasing trend with a slope of 0.012, 0.025 and 0.01 respectively, whereas the winter seasons only shows that a negative trend and a non-significant decreasing trend with a slope of -0.007.

The mean annual minimum and maximum temperature in the study district ranges from 13.7°C to 25.8°C respectively. The annual minimum and maximum temperature in the study area ranges from 9.2°C (minimum) to 34.5°C (maximum) with annual average temperature of 23.3°C.

According to meteorological data, the finding indicated that, the trends of rainfall and temperature, decline in amount of precipitation and increase monthly, seasonally, annually and average annual maximum temperature. Together with temperature change and shortening rainfall seasons and amount, these changes pose major challenges on the rural populations'livelihood especially on agriculture and livestock rearing.

Major indicators of climate change in the study area were increased in hot temperature and cold temperature, unpredictable rainfall, decreasing in river volume and cause of drought and flooding. In addition, shortage of pasture land, crop yield reduction, loss of livestock and scarcity of water, were the major challenges that climate change posed on livelihoods.

According to the finding of the study indicated that, adaptation strategies under taken by communities and government institution level. Such as, afforestation (planting trees), soil and water conservation, building flood protection features (ditches), and constructing roads in order to overcome the impact of climatic changes and use recharging ground water, use of reservoirs and ponds, use expanding irrigable farm, use rain water harvesting in response to climate change regarding water irregularity.

The finding showed that, planting trees, changing crop varieties and using crop rotations are adaptation measures that are the most widely used strategies as they need low costs and much access to be used easily.

5.2. Conclusion

The finding indicates that, the impact of climate change is promoting the vulnerability of different socio-economic activities of the community. The gradual changing of climate variability can causes to the environments: increasing temperature, decreasing rainfall, unpredictable rainfall, decreasing the level of water ground, occurrence of drought and flooding, unseasonal variation, occurrences of deforestation, increasing in hot and cold temperature, decreasing river volume, sources of animal feeds, crop productivities and the number of livestock's where some of the indicators of climate variability in the study Woreda.

Survey indicates that, almost all of the HHs has been understood about the changing of climate variability but some of the HHs has not been understood of the concepts of climate variability and its impacts but also their adaptation strategies have not been well developed in the study districts. The Analysis indicated that, perceptions of HHs about the changing of climate are in line with the finding of meteorological data in the study area.

The study has also indicated that, within the study area almost all farmers are vulnerable to the impact of climate change, but the most vulnerable groups are children, elderly, poor and landless HHs that are affected by the event of climate shocks.

As such, adaptation strategies have been practiced by government and CBA in the study area. Some of the activities that are taking place currently include, soil and

water conservation activities, a forestation, spring water development, early maturing crop varieties, crop rotation, mixed farming, using improved seed, use of fertilizer, pest control and improvement of livestock breed is government and CBA strategies under usage currently.

Furthermore, this finding indicated that, different types of governmental services such as access to information on climate change impact and improved agricultural technologies for both crop production and animals rearing for the accelerating of farmer's adaptation strategies.

5.3. Recommendations

Based on the finding of this study, the following main points were recommended for further study:

- ⇒ The study identified gaps that have policy implications. In terms of perceptions of climate variability and adaptation strategies, a need exists to narrow the gap between scientific knowledge on climate change and farmers' understanding of the causes and effect of climate variability.
- ⇒ As the same as increasing an awareness and information to the rural HHs to the impacts of climate change and diminish their vulnerability to the unfavorable impact of climate variability.
- ⇒ Government and any relating body should emphasis to address the effects of climate variability on agriculture productivities, source of livestock's feeds and their products, land degradation, water scarcity, and on live and livelihoods of the communities.
- ⇒ Besides this, as much as possible the communities have to support indigenous practices such as deep rooted practices in good land conserve on agronomic and physical soil conservation strategies and protection of water bodies from pollution, encouraging local farmers to protect soil erosion using various technologies must be applied.
- ⇒ The government must organize and establish responsible body institutionally to coordinate and follow up the climate change strategies in a continuous manner and reduction of GHGs emission in the atmosphere that have warming effect though fuel switching in the energy sector, and the direct reduction of their concentrations which could be through sequestration the sink capacity of biological and other systems.

- ⇒ To overcome the effects of climate changes, a continuous climate change adaptation measures and strategies must be taken by communities, stakeholders, governments (especially on extension program), different research institutions and the NGOs. This needs a collaboration of the integration of horizontal and vertical levels among public, government and private organizations.
- ⇒ Finally, further researches needed to work on rural livelihoods which undertake the impacts of climate change and adaptation strategies and the different challenges in different agro ecological conditions should take place, so that to supply more options to policy formulation and increases sustainability of livelihood of rural community.

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Appendices

Appendix I:

General information of respondents

1.1. Name of the kebele -----

1.2. Date of interview-----

1.3. Enumerator's name ----- signature-----

Checked by -----signature -----

2. Socio-Economic and Demographic Profile Characteristics

2.1 Sex of household: A. Male B. Female

1.2. Age A= 20-30, B =>31-40, C= >41- 65, D > 65

2.3. Marital status: A. Single, B. Married, C. Divorced, D. Widowed

2.4. Family size: Would you describe the age structure of your family, using the below table?

No	Years	Sex (In number)		
			Female	Total

		Male		
1	<14 year			
2	-65 years			
3	>65 year			

2.5. What is your educational level?

A. Illiterate B. Grade 1-4, C. Grade 1-8, D. Grade 9-12, E. Above grade 12

. What is your means of livelihood? (Multiple responses is possible)

A. Livestock rearing B. Agriculture (Crop production) C. Renting out land

D. Working as daily laborer, E. petty trade F. Other (specify).

. How much is the total size of your land? Hectare-----

. Do you have livestock (domestic animals)? A, Yes ----- B, No -----if yes, how many livestock do you have?

	Oxen	Cows	Sheep	Goats	Horses	Donkeys	Mule	Poultry	Others (specify)
Number of Animals Before 10yrs ago									
Nowadays (2025)									

6. What is the trend of livestock population in the area?

A. Decreasing B. The same B. Increasing C. I do not know

. What happened to pattern of rainfall on set and cessation in your area in the last 30 years?

A. Rain fall amount decreased B. Rain fall amount increased C. Time of onset became late and Time of cessation became earlier

. How do you perceive the temperature pattern of your locality or Village?

A. Increased B. decreased C. No observable change. D, Other specify

. Have you heard about the issue of climate change? A. Yes, B, No

. What is your perception about climate change of your kebele?

A. There is some climate change C. The climate has not changed B. The climate has totally changed D. I have no idea

. If your answer to Q No 2 is A, 'the climate has changed, what are the local indicators of the observed climate change? A, unpredictable rain fall (Fluctuation of rainfall) B. Drought and Flooding C. Increase in hot temperature and Cold temperature D. Decrease in river volume. E. Others

. What is the source of animal feed (rank the source of animal feed according to their importance)?

A. Communal grazing land B. Private grazing land C. Crop residue D. Hay F. Other sources, specify __

. How do you describe the trend of animal feed? A. Declining B. The same C. Increasing D. I do not know

. From where the households get water ?

A. Rivers (Stream) B. Protected springs C. pounds D. Unprotected springs E. pipe lines F. Dams

15. What is the Main Cause for Climate Change Related problem?

A. Deforestation B. Change in land use and land cover

C. Low fertility of land D. Absence of sustainable farming system

16. What are the major challenges that climate change posed on your livelihood?

A. Shortage of pasture land B. crop yield reduction C. Loss of livestock D. flooding

E. Drought E. Others (specify).

17. Which group of the society is most impacted to climate change?

A. Female headed households B. Male headed households C. Land less and the poor

D. elderly and children

. What is that measure (adaptation strategies) you have taken to overcome climate change problem?

A. planting trees (afforestation) C. protecting water reservoirs

B. Building flood protection features (ditches) D. constructing roads E. Others

. What are major local adaptation strategies you used to overcome climate change impacts on livestock production?

A. Increase the number of livestock B. Seasonal migration with your cattle in search of pasture & water

C. Sale of weak and old animals before the dry season.

D. Decreasing the number of livestock

E. cattle fattening F, Others (specify).

. Adaptation strategies, you used to overcome climate change impacts related with crop production?

A, using new varieties of crops B. Inter- cropping system

C. wise storage of crops (saving) E. Crop rotation

. Adaptation strategies related with shortage of water?

A. Rain water harvesting C. Use of recharging ground water

B. Expanding irrigable farm D. Use of reservoirs and ponds

Appendix, II

Interview Questions for Focus Group Discussions (FGD)

1. Name of Kebele: _____

2 .Date _____

. What is your occupation? _____

. How many households are there in kebele? _____

. What is the main climatic zone of this kebele? _____

. Which rainfall are you dependent on? Put in priority importance?

. How was the vegetation cover in the past? How is today?

. Is there change in temperature and rain fall pattern? What do you think the reason?

. What are the local indicators of Climate change in your kebele?

. Do you think climate change posed negative effects on your livelihood? If A. Yes, B. No, Please explain it.

. Which are the more vulnerable livelihood communities in your Kebele?

. Is there any change on water, grazing land, over the past years in your kebeles?

. What do you think is the major causes for the changes on the resources mentioned above?

. Is there any change on livestock number, composition and feeding of your kebeles?

Appendix, III

Interviews Questions for Key Informant with Experts from Wayu Tuka Agriculture Organization Office and DAS

1. Position/profession-----

- . In your view, are there climate changes in Woreda? Yes__No_If yes, please explain it-----
- . Is the amount of rainfall and temperature increased or decreased over 30 years in Wayu Tuka Woreda?
- . What do you think the reason for this? _____
- . What do you think is the impacts of climate change on the livelihoods of households?
- . Who are more vulnerable to the impacts of climate change and vulnerability?
- . Do local communities take part in making decisions with regard to adaptation mechanisms and how to implement CBA in Woreda level? If, yes, how / please explain it. If not why please explain it.
- . What are the main challenges to undertake CBA to climate change in your Woreda? And how do you think it can be improved? -----
- . What is an action undertaken (adaptation strategies) by government to reduce vulnerability to climate change? -----
- . What is the implication of agricultural productions at Wayu Tuka Woreda? Increased or Decreased?
11. Is there scarcity of water in this area? Why?

Appendix IV. Rainfall Data from NMA (1990-2019)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	24.4	54.07	43.92	71.5	87.81	313.8	441	545	275.6	35.7	13.7	5.18
1991	10.5	11.66	80.57	76.1	107.8	246.6	354	349	233	24.1	5.05	24.46
1992	15.7	50.76	38.97	130	165.4	388.3	340	543	183	174	36.73	13.59
1993	32.3	38.06	56.59	159	184.7	570.2	404	464	303.7	118	6.44	1.74
1994	0.25	18.64	55.66	105	180.7	352	452	425	352.3	8.51	13.18	7.52
1995	0.26	25.27	53.9	94.5	200.4	363.5	334	371	243.9	31.7	11.86	60.59
1996	60.3	16.88	114	117	303.9	453.5	583	495	370	69.9	33.63	13.12
1997	32.3	1.81	58.34	138	253.8	432.4	247	355	208.4	217	72.94	10.95
1998	28.1	16.57	37.13	38.4	181.6	243.2	454	428	307.2	279	37.3	0.65
1999	33.3	6.04	3.62	69.5	272.2	255	278	305	230	266	3.34	8.77
2000	1.74	0.66	13.02	109	154.2	182.2	277	259	220.8	109	32.46	10.03
2001	9.12	16.9	50.96	27.5	95.79	153.5	178	220	134	56.1	30.49	1.71
2002	26.4	5.75	72.67	71.8	52.65	141.7	116	175	146.5	25	5.44	12.72
2003	5.24	22.74	54.25	18.8	39.24	159.1	159	266	191.3	13.6	18.78	22.53
2004	4.19	8.37	8.32	71.9	81.14	169.9	216	218	198.1	59.6	30	29.86
2005	18.3	5.53	71.91	82.2	151.8	215.6	268	225	192.8	62.9	13.27	0.04
2006	8.06	35.01	57.96	45.7	202.1	340.6	440	384	293.5	169	37	37.36

2007	20.9	48.36	48.33	94.3	234.2	279.4	454	420	283.6	56.3	18.11	0.88
2008	27.2	4.82	12.9	88.5	271.4	276.2	427	353	239.7	127	92.86	12.21
2009	33.4	32.73	58.03	166	112.7	252.7	299	339	309.2	181	9.08	25.91
2010	8.26	28.04	28.2	62.5	346.7	522	406	373	406.4	93.3	56.5	18.72
2011	23.1	8.21	31.73	56.1	265	389.9	198	190	210.5	26.3	58.58	6.19
2012	2.13	0.15	36.93	70.9	148.4	221.1	323	402	345.8	33.4	40.51	18.39
2013	14.5	15.62	50.89	53.8	401	433.1	463	360	265.4	143	74.43	1.47
2014	10.1	10.32	73.58	181	329.5	370	372	358	419.8	274	27.71	35.8
2015	3.84	9.56	43.56	19.6	213.5	330.2	324	357	223.1	60.2	71.71	56.75
2016	4	18.89	41.53	63.9	258.7	196.3	379	557	425	63.4	10.68	2.99
2017	0.03	61.87	65.77	114	227.8	254.2	406	303	272.6	92.5	9.03	3.35
2018	0.03	1.3	0.44	1.14	4.77	7.42	8.12	8.11	4.83	2.63	1.96	0.21
2019	0.01	0.67	1.86	5.14	2.61	8.52	7.61	11.9	18.36	3.37	3.41	0.33

Appendix V: Maximum Temperature from NMA (1990-2019)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	25.3	25.39	27.5	28.1	28.56	23.31	21.4	21.6	22.23	24.4	24.81	25.95
1991	27.9	28.69	29.22	29.9	29.92	24.68	21.6	21.8	22.86	24.2	24.43	25.03
1992	26.5	26.37	30.41	29.6	27.12	23.23	21.1	20.5	21.99	23.3	23.77	24.69
1993	25.5	26.51	29.48	26.4	25.87	22.02	20.8	21.5	22.14	23.3	24.65	25.23
1994	26.9	27.92	29.5	30.3	26.99	22.42	20.9	20.8	22.09	24.6	24.67	26.25
1995	27.8	28.23	30.12	29.2	27.02	24.76	21.3	21.7	22.97	24.6	24.16	24.71
1996	25.3	28.32	28.47	27.5	25.22	22.67	20.9	21.5	22.25	24.1	24.07	24.2
1997	25.7	29.14	29.72	27.4	25.47	23.47	21.7	22	23.72	23.4	23.95	24.94
1998	25.9	27.2	29.38	32	27.15	23.37	21.1	21.2	21.93	22.4	24.15	24.72
1999	25.8	29.39	30.43	30.4	25.14	22.79	20.3	21.4	22.02	22.1	24.23	24.58
2000	27	29.44	32.35	28.3	26.96	23.06	21.3	22	22.27	23.5	24.27	24.88
2001	26.1	29.31	29.7	31.5	29.01	23.72	22.1	22.2	23.9	25.2	26.23	28.69
2002	28.4	31.97	30.59	31.7	32.36	25.48	24.5	22.9	24.14	27.9	29.41	29.57
2003	30.9	32.24	31.64	33	34.49	25.39	22.2	22.1	23.07	26.1	27.47	28.75
2004	30.7	31.85	33.23	30.4	31.44	23.64	22.3	22.4	23.31	24.7	26.01	27.24
2005	28.9	33.16	31	31.5	28.23	24.04	21.5	22	22.92	24.7	24.99	27.25
2006	30	30.91	30.78	30.8	27.63	23.91	21.9	21.5	22.7	24.3	24.35	24.72
2007	26.1	27.85	30.47	29.3	27.6	23.21	21.1	21.5	22.61	24.2	24.67	25.75

2008	27.9	30.06	32.95	29.9	26.38	22.79	21.5	21.9	23.36	24.1	23.78	24.63
2009	25.7	27.84	29.41	28.9	29.67	24.67	21.8	22.4	24.05	24	24.68	24.44
2010	26.7	28.43	30.56	30.3	25.45	23.52	21.3	21.2	22.57	24.7	24.38	24.23
2011	25.7	29.4	29.62	30.9	27.04	23.27	22.2	21.7	22.5	25	24.28	25.54
2012	28	31.71	31.75	31.3	28.96	23.99	21.8	21.6	22.49	24.9	24.77	25.48
2013	27.4	30.33	30.89	31.5	25.09	22.56	20.7	21	22.92	23.6	24.45	24.42
2014	25.9	28.05	29.34	27.2	25.09	23.96	21.5	21.5	22.38	23.8	24.38	24.15
2015	26	28.91	31.16	31.9	27.1	24.46	22.8	22.5	23.65	25.4	24.85	25.09
2016	26.9	29.75	32.2	30.5	25.08	24.16	21.6	21.8	23.05	24.5	24.6	25.6
2017	28.1	28.34	30.23	31	26.12	24.88	21.8	22.3	23.33	24.7	24.62	25.53
2018	27.4	29.82	31.4	31.3	28.29	22.66	21.6	21.9	24.02	24.7	25.17	27.02
2019	30.3	31.32	31.78	29.2	29.53	23.78	22.2	22	22.63	24.6	24.27	25.13

Appendix VI: Minimum Temperature from NMA (1990-2019)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	12.6	14.68	15.53	15.6	16.53	15.16	14.3	14.7	14.65	12	11.19	10.45
1991	13.7	15.19	15.82	16.1	16.26	15.91	14.6	14.6	14.39	12	11.08	12.13
1992	13.4	15.23	16.44	16.1	16.36	15.21	14.2	14.4	14.29	13.7	11.32	12.64
1993	12.9	13.52	14.97	16	15.31	15.09	14.1	14.8	14.59	13.6	11.46	10.96
1994	12.1	14.52	16.03	17	15.92	14.98	14.3	14.3	14.64	11.5	11.98	11.27
1995	12.6	14.91	15.4	17	16.33	15.77	14.5	14.7	14.56	13	12.54	13.47
1996	14.1	14.54	16.05	16.2	15.26	14.92	14.5	14.5	14.71	12.7	11.94	12.14
1997	13.9	13.26	16.39	15.8	15.9	15.06	14.8	15	14.81	14.1	14.19	14.06
1998	14.6	15.44	16.9	17.6	17.26	15.56	14.7	15	14.86	14.5	10.75	9.41
1999	12	12.61	15.4	17.2	15.62	14.86	13.9	14.3	14.52	13.7	9.73	11.05
2000	11.8	13.68	16.69	15.7	16.12	14.99	14.1	14.4	14.46	14	12.05	12.37
2001	13.3	14.8	15.09	17.5	16.95	15.03	14.3	14.6	14.54	14.5	12.11	14.42
2002	14	15.71	16.64	16.3	17.29	15.9	15.5	14.8	14.78	13.8	14.5	14.91
2003	14.5	16.86	17.03	16.6	18.02	16.13	14.6	14.7	14.89	12.9	13.04	11.94
2004	14.5	15.22	16.99	17.2	17.56	15.43	14.6	14.5	14.71	12.7	12.78	13.47
2005	12.6	15.31	16.32	17.1	15.77	15.76	14.5	14.6	14.83	13.6	11.73	9.73
2006	13.3	14.91	15.57	16.3	16.53	15.34	14.9	14.7	14.61	13.5	11.93	12.58
2007	13.2	15.14	15.26	16.1	16.56	15.33	14.5	14.4	14.74	11.5	10.3	9.23
2008	12.3	13.19	14.65	15.8	15.89	14.98	14.3	14.8	14.68	13.3	11.01	11.25
2009	12.4	14.44	16.25	16	15.82	15.7	14.7	15	14.62	13.2	11.34	13.73
2010	13.3	15.13	15.33	17.1	16.91	15.72	14.7	14.8	14.82	13	11.21	11.74

2011	13.2	12.57	15.01	16.6	16.11	15.45	14.9	14.4	14.49	12.6	13.19	11.58
2012	12.7	12.45	15.64	15.9	16.42	15.27	14.3	14.6	14.74	12.1	12.87	12.41
2013	13.6	14.17	16.17	16.3	16.35	15.06	14.2	14.6	14.87	13.6	12.47	10.83
2014	13.7	14.18	15.61	16.1	16.11	15.34	14.9	14.6	14.83	14	12.42	11.6
2015	11.6	13.98	15.66	17	16.47	15.77	15.1	15.1	15.18	14.1	13.64	13.75
2016	14.1	15.77	17.49	17.1	16.2	15.59	14.7	14.6	14.82	13.6	11.13	10.31
2017	9.39	15.34	16.12	17.2	16.4	15.88	14.7	14.9	14.87	14.2	12.3	10.01
2018	12.8	14.9	15.44	16.3	16.66	15.24	14.6	14.6	14.56	13.6	12.91	13.2
2019	11.9	15.9	17.48	17.3	17.54	16	15.1	14.7	15.22	13.2	13.68	13.03