DETERMINANT OF FARMERS' CLIMATE CHANGE ADAPTATION STRATEGIES: THE CASE OF CHIRO WOREDA, WEST HARARGHE ZONE, OROMIA REGION, ETHIOPIA

MA THESIS

NEGA MEKONIIN ANDARGHE

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Nega Mekonnin Andarghe

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APPROVAL SHEET

HARAMAYA UNIVERSITY
Post Graduate Program Directorate

We hereby certify that we have read and evaluated this Thesis entitled: Determinant of Farmers' Climate Change Adaptation Strategies: A Case of Chiro Woreda, West Hararghe Zone, Oromia region, Ethiopia prepared under our guidance by Nega Mekonnin . I recommend that it be submitted as fulfilling the thesis requirement for the degree of Master Science in Climate Change and Disaster Risk Management.

1. Kassaye Hussein (Ph.D.)	___________________	_______________
Major Advisor	Signature	Date
2. Admasu Bogale (Ph. D)	___________________	_______________
Co-Advisor	Signature	Date

As a member of the Board of Examiners of the MA Thesis Open Defense Examination, I certify that I have read and evaluated the Thesis prepared by Nega Mekonnin and examined the candidate. We recommend that the thesis be accepted as fulfilling the Thesis requirements for the degree of Master of Arts in Climate Change and Disaster Risk Management.

_____________________	___________________	________________
Chairperson	Signature	Date
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DEDICATION

For their perseverance, spiritual support, and encouragement during my field research at Haramaya University and at home, I am sincerely dedicating this thesis to my Father.

STATEMENT OF THE AUTHOR

I certify, by my signature below, that this thesis is my own work. I prepared, gathered, analyzed, and finished this thesis in accordance with all scholarly ethical guidelines. Every academic reference in the thesis is acknowledged with a citation. This thesis was presented in partial completion of Haramaya University's M.A. degree requirements. The thesis is placed in the Haramaya University Library and is accessible to users in accordance with the library's policies. I hereby certify that this thesis is submitted for consideration for any academic degree, diploma, or certificate to any other university or organization.

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Name: Nega Mekonnin
Signature: ____________________
Date: _______________
School: Geography and Environmental Studies

BIOGRAPHICAL SKETCH

In the West Hararghe Zone of the Oromia Region, on April 23, 1984, the author was born in the town of Ciro. In 2002 EC, he entered Chiro Comprehensive Senior Secondary School for his secondary education after completing his primary education at Chiro primary School. He enrolled at Jimma University after passing the Ethiopian School Leaving Certificate exam. In April 2006, he received his Bachelor of Science in NRM. He began working for the Ministry of Agriculture shortly after graduating in 2006, and he held a variety of professional positions at the West Hararghe Zone Office of Agriculture for six years.

In addition, he has four years of experience working for several public agencies. Since January 2013, he has served as the senior environmental team leader at the Environmental Protection Office. In June 2019, the author enrolled in Haramaya University's Postgraduate Program Directorate in order to pursue a Master's degree in Climate Change and Disaster Risk Management in the School of Geography and Environmental Studies.

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ACRONYMS AND ABBREVIATIONS

ACCRA	Africa Climate Change Resilience Alliance
ALE	Adult Labour Equivalent
CBO	Community-Based Organization
CCA	Climate Change Adaptation
CSA	Central Statistics Agency
CDAO	Chiro District Agriculture Office
CWLUAO	Chiro Woreda Land Use and Administration Office
CDBGO	Chiro District Busa Gonofa Office
CRGE	Climate Resilient Green Economy
DA	Development Agent
DFID	UK Department for International Development
DRM	Disaster Risk Management
EWS	Early Warning System
FTCs	Farmers’ Training Centers
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focused Group Discussion
GDP	Gross Domestic Product
HH	HouseHold
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
MNLR	Multinomial Logit Regression
MoARD	Ministry of Agriculture and Rural Development
NGO	Non-Governmental Organization
NMI	National Meteorological Institute
ORUSCSCO	Oromia Rural Saving and Credit Share Company
OSCSCO	Oromia Saving and Credit Share Company
PPS	Probability Proportional to Size

ACRONYMS AND ABBREVIATIONS (Continued)

PSNP	Productive Safety Net Program (Ethiopia)
SPSS	Statistical Package for Social Science
SC-UK	Save the Children – United Kingdom
SDC	Swiss Agency for Development and Cooperation
SSIS	Semi-structured Interview Schedule
TLU	Tropical Livestock Unit
UN	United Nations
UN/ISDR	United Nations International Strategy for Disaster Reduction
UNESCO	United Nations Education, Science and Cultural Organization
WFP	World Food Program
WHZAO	West Harerghe Zone Agriculture Office
WHZLRDHO	West Harerghe Zone Livestock Resources Development and Health

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Determinant of Farmers' Climate Change Adaptation Strategies: A Case of Chiro Woreda, West Hararghe Zone, Oromia region, Ethiopia

ABSTRACT

Adaptation to climate related hazards influenced by the experience in prolonged effects of changing climate and the determinants to choose adaptation measures by farm households. This is because the impacts of climate extremes could affect different areas and people within the same area differently. This study aims to determine how climate change is affecting subsistence farmers' decision to utilize adaptation strategies and how climate change is affecting them. A household survey conducted involving a sample of 145 randomly selected households. Field observation, KIIs, and FGDs utilized in order to collect qualitative data. Explanatory sequential mixed-method research approaches employed in order to meet the study's objectives. Furthermore, multinomial logit model (MNL) is utilized to identify the variables influencing the adaptation strategies sample household select, and farm households in the research area assessed institutional, socioeconomic, and demographic data using descriptive and inferential statistics. The findings showed that adaptation strategies used by farm households in the study area include improved crop varieties, crop diversification, soil and water conservation, and livelihoods diversification. The MNL model showed that Age, Family size, Income source, Membership/participation in informal institutions, Access to credit, and Extension contact, Access to water resource were found the determinants of choice of adaptation strategies to the effects of climate change by sample farm households. These factors have both positive and negative effects on smallholder farmers' decisions on adaptation strategies in the study area. The main effects of climate change on the health of Crop and livestock was the occurrence of crop disease, impact of pests, and degradation of land, this decreased crop yields and livestock products, and loss of household assets because of recurring droughts. The required interventions developed by public and community development organizations operating in the research area and at the regional level to enhance smallholder households' capacity to adapt to the negative effect of climate change.

Key words: Climate Change Adaptation Strategies, Smallholder Farmers', Explanatory Sequential Mixed-Method Research , Determinant and MNL

1. INTRODUCTION

1.1. Background of the Study

The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) provides strong evidence for the increasing trend of global mean temperature in the 21st century. The rising trend in temperatures due to greenhouse gas emissions has contributed to global warming. Global warming increased by + 1.07 °C (0.8 -- 1.3 °C; likely range) for 2010–2019 compared to the reference period 1850–1900 (IPCC, 2021).

For thousands of years, the global climate has been constantly shifting, impacting both natural ecosystems and human societies (Birara et al., 2018). However, in recent decades, these changes have accelerated at an unprecedented rate. This is evident in rising temperatures, increasing sea levels, higher greenhouse gas emissions, and a growing frequency of extreme weather events such as floods and droughts. Additionally, shifts in rainfall patterns, including changes in distribution and intensity, further highlight this trend (Asare-Nuamah, 2019). While climate change is a global issue, Africa is considered the most vulnerable continent due to its limited capacity to adapt and its heavy dependence on climate-sensitive sectors like rain-fed agriculture (Gebrechorkos et al., 2019).

Many believe that the two most significant effects of climate change are rising temperatures and changes in rainfall patterns (Abdelfatah and Kadous, 2022). In Africa, especially in sub-Saharan countries, these factors have devastating consequences for agricultural production and sustainable economic growth (Asfaw et al., 2018; Gebrechorkos et al., 2019).

Ethiopia is among the sub-Saharan African nations most vulnerable to climate variability and change (Birara et al., 2018). The country frequently experiences severe droughts and unpredictable rainfall, both in terms of amount and distribution throughout the seasons and years (Zeleke et al., 2017; Weldearegay and Tedla, 2018). These climate-related challenges significantly affect the productivity of rain-fed agriculture, which in turn impacts Ethiopia’s economic and social development.

Ethiopia's agriculture is largely dependent on rain-fed farming systems. However, traditional subsistence farming is particularly vulnerable to the effects of climate change—especially droughts—caused by rising temperatures and reduced rainfall in certain years, leading to severe hardships for communities. Climate change has made rainfall patterns more unpredictable, increased soil erosion due to heavy rains, and disrupted planting and harvesting schedules, including delayed rainfall onset and early cessation. It has also led to shifts in agricultural systems and a rise in pest and disease outbreaks. These challenges negatively impact crop yields, affecting staple crops like wheat and maize, as well as cash crops such as coffee, leading to poor harvests and worsening pest and disease pressures (Zinabu and Woldemichael, 2023). Moreover, climate change is expected to intensify environmental degradation, food insecurity, water shortages, disease outbreaks, and poverty in Ethiopia (Mekonnen and Hoag, 2023).

Ethiopia is particularly vulnerable to climate change due to a combination of geographic, economic, and social factors. The country's heavy dependence on climate-sensitive agriculture, along with a rapidly growing population, widespread environmental degradation, and fragile ecosystems, makes it highly susceptible to the effects of climate variability. Additionally, challenges such as limited scientific research, weak institutional capacity, financial and technological constraints, and inadequate infrastructure further hinder its ability to adapt (Lewis, 2017).

As a result, Ethiopia's agricultural sector and food security face significant risks. Ongoing droughts, unpredictable rainfall patterns, and rising temperatures threaten the country's ability to produce enough food to sustain its population. Agriculture is the backbone of Ethiopia's economy, playing a critical role in national development. The sector provides 70% of raw materials for local industries, employs 62.79% of the workforce, contributes 36.7% to the nation's GDP, and remains essential for ensuring food security (World Bank, 2022).

However, because agriculture in Ethiopia relies so heavily on rainfall, any disruption in weather patterns can have severe consequences. Both decreased rainfall and extreme fluctuations in precipitation pose serious threats to agricultural productivity, jeopardizing long-term economic growth and sustainability (Eshetie, 2021).

Historical data reveals a trend of rising temperatures and frequent droughts, resulting in devastating crop and livestock losses. These climate shocks have led to severe food insecurity and, in some cases, even famine (Desalegn et al., 2021). A striking example is the 2015 El Niño event, which had a catastrophic impact on Ethiopia, further highlighting the country's vulnerability to extreme weather conditions (Mergia, 2024). Throughout the growing season, rainfall and other climate-related factors play a crucial role in determining agricultural output. When these factors are disrupted, the risk of widespread drought and famine rises significantly, endangering the lives of millions of Ethiopians (Mustonen et al., 2018).

Rising temperatures could have a significant impact on agricultural production. Sub-Saharan Africa is home to millions of small-scale subsistence farmers who cultivate crops and produce food under extremely challenging conditions. The region's agricultural landscape is characterized by a combination of low land productivity and harsh weather conditions, resulting in poor crop yields and widespread food insecurity. Additionally, the region's economic development is closely tied to climate, a lack of economic diversification, and heavy dependence on rain-fed agriculture (FAO, 2022).

Projections on the impact of climate change on cereal crop yields in various regions indicate substantial losses, with yield reductions of up to 35% for rice, 20% for wheat, 50% for sorghum, 13% for barley, and 60% for maize, depending on location (Hailu et al., 2023).

Adaptation is both critical and necessary in developing countries, particularly in Ethiopia, where vulnerability to climate change is high. Farmers with better knowledge and information on climate change and agronomic practices are more equipped to adopt adaptation strategies that help them cope with climate challenges and improve their livelihoods (Tadele & Kassa, 2023). Adaptation measures such as diversifying crop rotations, integrating livestock with crop production systems, improving soil quality, and implementing other sustainable agricultural practices can strengthen the resilience of the agricultural sector, helping to mitigate the adverse effects of climate change on productivity (World Food Programme, 2023).

Ethiopian farmers have long relied on indigenous Climate Smart Agriculture (CSA) practices, carefully adapted to their unique landscapes and cultural traditions. In the Konso region, for example, the Konso Cultural Landscape showcases traditional soil and water conservation techniques that have supported agriculture for generations. Similarly, farmers in the Hararghe

Highlands use time-honored methods to preserve soil and manage water resources, ensuring their fields remain fertile despite challenging environmental conditions.

In areas such as Gedeo Zone, East Shewa Zone, East Wollega Zone, and West Gojjam Zone, traditional agroforestry practices are widely used. These systems integrate diverse plant species, improving both biodiversity and productivity. The Gedeo Cultural Landscape, in particular, is recognized for its sustainable indigenous agroforestry, which holds both environmental and cultural significance. Meanwhile, in the Amhara Region's Ankober woreda, farmers traditionally enrich their fields with animal manure, significantly increasing both crop biomass and yields (Abdulaziz and Yirga, 2023; Dawit and Tesfaye, 2022). These indigenous practices not only boost agricultural productivity but also strengthen resilience to climate variability, reflecting a deep and enduring connection between Ethiopian communities and their environment.

To ensure food security, it is crucial to enhance agricultural productivity through strategies such as risk management, diversification, and sustainable intensification. Risk management helps stabilize crop yields by reducing uncertainty, while intensification focuses on increasing average yields. Diversification influences both yield stability and overall productivity, offering a balanced approach to agricultural sustainability. Importantly, improved productivity and effective adaptation measures can also contribute to climate change mitigation (Abate et al., 2021).

Implementing strategies for crop, livestock, and rangeland management is essential, and strong institutional support plays a vital role in their success. For example, selecting livestock breeds that are well-adapted to local conditions can enhance productivity while reducing greenhouse gas emissions by decreasing the number of non-productive animals in herds. Additionally, agroforestry, which integrates trees and shrubs into farming systems, serves as an effective diversification strategy. This practice not only improves livestock fodder—often from nitrogen-fixing trees or shrubs—but also helps sequester carbon, making it a key tool in mitigating climate change (Abate et al., 2021).

Incorporating these approaches can lead to more resilient agricultural systems, ensuring food security while addressing environmental sustainability.

In Ethiopia, farming communities are increasingly recognizing the need to diversify their income sources beyond traditional agriculture to build resilience against challenges such as climate change and population growth. Exploring non-agricultural livelihood opportunities is especially important for low-income and food-insecure individuals striving for sustainable livelihoods (Tadesse et al., 2020).

However, several barriers hinder effective adaptation to climate change. One of the biggest challenges is the lack of access to information about climate change and available adaptation strategies. This knowledge gap is often due to limited institutional support and the failure to integrate climate change issues into public extension services. Additionally, farmers struggle with restricted access to essential farm inputs such as quality seeds, chemical fertilizers, and oxen, making it harder for them to adapt effectively (Teshome and Melaku, 2022).

To overcome these challenges, farmers can adopt on-farm diversification strategies, such as growing a wider variety of crops, integrating crop and livestock systems, or engaging in value-added processing. At the same time, pursuing off-farm opportunities, including non-agricultural employment, can further strengthen their ability to adapt to changing conditions (Yohannes and Melaku, 2022).

The Ethiopian government has taken a proactive approach to disaster risk management (DRM) to address recurring droughts and food insecurity. In recent years, the government has established the Disaster Management and Food Security Agency**,** developed **a** National Policy and Strategy on Disaster Management, and introduced a DRM Strategic Program and Investment Framework to guide both government and donor interventions. In 2011, Ethiopia launched its groundbreaking Climate-Resilient Green Economy (CRGE) strategy**,** which aligns with the country**'s** Growth and Transformation Plan (GTP**)**—an ambitious initiative aimed at achieving middle-income status by 2025 (Umer Abdela, 2022).

The CRGE initiative follows a sector-by-sector approach to building a green economy while addressing development challenges. This strategy helps Ethiopia meet its GTP targets and reduce greenhouse gas (GHG) emissions in an economically viable way. One of the key pillars of the CRGE strategy is the adoption of land-use and agricultural efficiency methods, which remain central to Ethiopia's economic foundation. Agriculture continues to be the backbone of the economy, employing the vast majority of the population, sustaining high sectoral growth rates, and playing a vital role in raising household incomes. Improving crop and livestock production methods not only enhances food security for Ethiopia's growing population but also helps reduce emissions and boosts agricultural exports. Additionally, the strategy supports the expansion of light manufacturing industries, many of which rely on agricultural inputs, further strengthening economic growth (Melkie, M. E., 2022).

Mitigation and adaptation have become essential strategies in responding to climate change. However, their effectiveness is highly dependent on local contexts, as institutions and socioeconomic conditions play a crucial role in shaping how external interventions are implemented and adapted to meet local needs (Gebreyes, 2018).

Smallholder farmers respond to the effects of climate change in different ways, with some adopting more scientific approaches to adaptation. This study aims to identify adaptation strategies and the key factors influencing them in the study area. Additionally, the findings will serve as a foundation for designing and implementing development interventions that can help communities better cope with the impacts of climate change in their respective districts.

1.2. Statement of the Problem

Food security and agricultural productivity are being significantly affected by climate change (Brenton et al., 2022). Since rain-fed agriculture is highly sensitive to climate variability, the impact of climate change extends across all sectors. Among the most vulnerable regions, Sub-Saharan Africa stands out due to its high poverty levels and limited capacity to adapt. These challenges make it especially difficult for communities to maintain their livelihoods in the face of a changing climate (Asfew et al., 2023).

Over the past few decades, Ethiopia has experienced extreme weather events such as droughts and floods (Mohammed and Yimam, 2021). Even small deviations from average rainfall and temperature can have profound effects on agricultural production. As a result, climate change is not only disrupting Ethiopia's agricultural sector but also impacting its overall economy. The decline in crop and livestock productivity has led to increasing food insecurity, affecting the dietary habits and nutritional well-being of rural populations. Rising temperatures, unpredictable rainfall, and an increase in extreme weather events (IPCC, 2019) have further worsened the situation.

In the Chiro district, smallholder farmers, like many others across Ethiopia, face growing challenges due to climate change, which has become a frequent natural disaster in the country. Several key issues are contributing to this crisis: Erratic and unreliable rainfall during the rainy seasons, coupled with untimely rainfall and hailstorms, has led to declining crop yields., Rising temperatures are affecting crop physiology, altering the microclimate, and disrupting soil conditions necessary for farming, Droughts and floods have repeatedly devastated both crop and livestock production, Annual river runoff and water availability have decreased dramatically, further straining agricultural productivity.

Food insecurity remains a major challenge in the region, and these climate-related shocks continue to worsen the livelihoods of smallholder farmers, who have limited capacity to adapt to these changes (Woreda Busa Gonofa Office, 2023).

The district's farmers depend mostly on agriculture for their livelihood, although droughts frequently have a detrimental effect on their output and socioeconomic standing because of climate change. The district's population is expanding at an accelerated rate, which raises demands for food, resources, land, and other necessities of life. This is particularly problematic during droughts, when the community particularly affected, with women and children more likely than others are to suffer from severe malnutrition (Woreda Agricultural office, 2023). Therefore, initiatives for adapting to climate change intended to increase agricultural productivity and strengthen farmers' resilience (Tamru *et al.*, 2022). It acknowledged that in order to recommend the most effective adaptation solutions, policymakers need access to climate information (Gebrechorkos *et al*., 2020; Carbonell, 2024). The knowledge that farmers have about the effects of climate change is necessary to develop adaptation plans (Chepkoech *et al*., 2020). Strategies for mitigating the negative impact of climate-related hazards on agricultural operations were adaptations to climate change (Abayechaw, 2022).

Farmers' choices of adaptation practices depend on demographic characteristics, socioeconomic factors, and agro-ecological settings. It is also dependent on access to institutional services, infrastructural development, and policies among others (Mitiku *et al.*, 2022).

Various studies conducted in various countries, including Ethiopia, to identify farmers' adaptation strategies to climate change and its determinants. The majority of studies factors like education, age, gender, farming experience, access to credit, markets, farm income, and farm size influence farmers' ability to adapt to climate change, and focused on the farmers of the Nile Basin or regional level as a case study (Ademe *et al., 2019*;Tamiru Urgessa and Busa Gonfa, 2020; Molla *et al.,* 2023*).* Besides adaptation, strategies vary contextually and spatially within communities and even within individuals (Ogugeet al., 2021; Farsangi, 2021). As site-specific issues require site-specific knowledge, it is therefore very important to understand what is happening at the community level. Local-level trend analysis is vital for situational planning and execution of climate change and coping strategies (Arragaw and Woldeamlak, 2017).

Unless persuading and educating the local communities to take adaptive action would be difficult, furthermore, the previous researcher's knowledge was lacking in studies on the socioeconomic factors influencing farmers' decision-making regarding adaptation strategies and their defenses against the effects of climate change. To bridge this knowledge gap, this research conducted with an emphasis on examining the Farmers Adaptation Strategies against Climate Change Impact at ChiroWoredaWest Hararghe zone.

1.3 .Objective of the Study

1.3.1.General Objective

To identify Farmers' Climate Change Adaptation Strategies and its determinant factor in the District, West Hararghe Zone, Ethiopia

1.3.2. Specific Objective

1. To identify status of climate change on farmers in the study area
2. To identify the existing adaptation strategies used by farmers in response to climate change in the study area
3. To identify factors that influence farmer's choice of adaptation strategies in response to climate change in the study area.

1.4. Research Questions

The study attempt to address the following questions:

1. What are the effects climate changes on farmers in the study area?
2. What kinds of adaptation strategies used by farmers in the study area in response to climate change?
3. What are the determinant factors that influence farmer's choice of adaptation strategies in response to climate change?

1.5. Significance of the Study

The impact of climate change affects the whole world, but adaptation options differ from region to region, from community to community, even from house to house. Different local studies needed to assess how the problem is going. The findings of this study would serve as a stepping-stone for local governmental and non-governmental organizations that are involved in the process of reducing the adverse effects of climate change on smallholder farmers and maintaining household food security. To bring more insights on adaptation strategies that are crucial to cope with climate change, this study also investigates key factors that govern farmers' decisions to adapt to climate change. Policymakers would be better informed of the effects of climate change as they were felt on the ground, the challenges and opportunities that people face in adjusting their livelihoods, and what further assistance should be provided. The outcome of the study is expected to be relevant to many areas of Chiro district and other parts of the country with similar agro-ecology and socio-economic characteristics.

Therefore, the study would have a significant contribution for the community living in the district and other parts of the country, in an effort to minimize the effects of climate change at local level or national level through providing the necessary scientific knowledge.

1.6. Scope of the Study

The study concentrates on identifying determinants of farmers' choice of adaptation strategies to climate change in Chiro district. The research is confined to only Chiro District, which can somehow represent other districts with similar agro-ecological conditions in the region and the nation. Three kebeles selected for the study, namely *Hara*, *Galma Cafe*, and *Saro*, limited area coverage in terms of time and budget constraints and use of cross-sectional data to identify adaptation strategies and its determinants factor in the study area.

1.7. Limitation of the Study

This study focused exclusively on the Chiro district and was confined to specific kebeles. Although there was potential interest in including more kebeles, financial and time limitations restricted the research to three selected kebeles, one from each agro-ecological zone. The availability of secondary data also posed a challenge for the study. Despite these limitations in geographical coverage and secondary data access, the findings can serve as a foundation for more comprehensive and localized studies in the future.

1.8. Organization of the Thesis

There are five chapters in this thesis. The introduction, study background, problem statement, objectives, research questions, significance of the study, study scope and limitations, definition of important terminology, and thesis organization are all covered in the first chapter. The conceptual and theoretical underpinnings of the study, as well as the results of empirical studies, thoroughly examined in the second chapter's reviews of related literature. The conceptual and analytical framework of the study is also provided in this chapter, illustrating the linkages and processes of interaction between the variables under consideration and the study's findings.

The research design, sampling techniques and sample size, data collecting and analysis techniques, and methodology overviews covered in brief in Chapter 3. The results of the analysis and the study's conclusions are briefly covered in Chapter 4. A summary of the study's main conclusions, recommendations for implementing changes that could enhance the lives of smallholder farm households in the study region that are vulnerable to the effects of climate change, and other major findings were present in Chapter 5.

2. LITERATURE REVIEW

2.1. Concepts and Definitions of Climate Change

Climate change is explained as a slight variation in climate over time, whether because of natural change or anthropological activity. Variations in climate denote changes in the means and variability for instance, temperature, precipitation, and wind over the course of months to millions of years. More broadly, climate refers to changes in the atmosphere, hydrosphere, cry sphere (snow, ice, and permafrost on and beneath the surface of the earth and ocean), land surface, and biosphere ecosystems and organisms living in the atmosphere, land, and oceans (Alizadeh, 2023).

Climate change is currently affecting almost all regions around the world, making it one of the most critical challenges facing humanity today. According to the Intergovernmental Panel on Climate Change (IPCC, 2021), extreme weather events like droughts, floods, storms, and cold and heat waves will become more frequent and severe in the next few years.

Climate change is a global challenge affecting human beings and their socioeconomic activities, health, livelihood, and food security (Muluneh, 2021)

Vulnerability: is the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes. 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 (Bitana *et al*., 2023)

Resilience: is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (Bowen *et al*., 2020).

Adaptation: defined as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Stavi and Ivetić, 2023).

Mitigation: is human intervention to reduce the sources or enhance the sinks of greenhouse gases. Technological change and substitution that reduce resource inputs and emissions per unit of output with respect to climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks (Voigt and Heley, 2021).

Adaptation strategies: are measures and options adopted by a household or community in order to adapt to impacts of climate related hazards, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Fekad and Bekalu, 2020).

Crop diversification: is Crop diversification can be consider when households grow more than two crops per season. It expected that if households grow more crops and might reduce the problems of yield losses caused by climate change (Hoque*et al*., 2023).

Drought-resistant crops: This type of crop can be termed as drought-tolerant crops, which require less water and can tolerate water shortages and stress. Water deficits during crop-growing periods have a significant negative impact on crop yields (Arvas*et al*., 2022).

Improved livestock varieties: Genetic variation in livestock population is necessary for both adaptations to climate and economic improvement (Alemayehu and Molla, 2019).

Adaptive capacity: is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages to take advantage of opportunities, or to cope with the consequences. One of the most important factors shaping the adaptive capacity of individuals, households and communities is their access to and control over natural, human, social, physical, and financial resources (Mesfin *et al*., 2020).

Hazards: The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (Chowhan, 2021).

Adaptation to climate change: refers to the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Haro-Monteagudo *etal*., 2022).Adaptation can be implemented by smallholder farmers themselves (autonomous adaptation) or by government policies aimed at promoting appropriate and effective adaptation measures (planned adaptation). However, in order to implement appropriate interventions, there is a need to understand location-specific opportunities, challenges, and the key drivers behind adaptation. Adaptation effected at different scales: individual or farm-level, national level, or international level. Although there is some autonomous adaptation at the farm level, it is usually inadequate and requires the intervention of different institutions. Moreover, adaptation at the national or international level entails an understanding of the process of location-specific autonomous adaptation at the farm level (Atanga, 2023).

2.2. History of Climate Change

Over the past 65 years, two of the most significant global events have been global warming and the climate changes observed and projected for the 21st century. Climate change presents a complex and multifaceted challenge for governments worldwide, as it impacts various aspects of ecological, environmental, socio-political, and socio-economic systems (Nivedha, P., 2022).

One of the most evident effects of climate change is the rise in global temperatures, which is occurring through multiple interconnected processes (Hereher, 2020). The urgency of this issue intensified with the onset of the industrial revolution, accelerating the Earth’s climate crisis (Dobson BS, 2018). While the exact sectoral consequences of climate change remain difficult to predict, research suggests that early intervention and proactive measures can significantly reduce its most severe effects (Liu et al., 2020).

Climate change is characterized by long-term shifts in temperature and precipitation patterns, along with other environmental factors such as atmospheric pressure and humidity levels. These variables help define the broader changes taking place in the Earth's climate. Some of the most well-known local and global consequences of climate change include unpredictable weather patterns**,** the melting of ice sheets**,** and the resulting rise in sea levels (Golledge, 2020).

Before the industrial revolution, natural events such as earthquakes, volcanic eruptions, and wildfires were considered the primary sources of greenhouse gases (GHGs**)**—including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and water vapor (H_2O**)**—released into the atmosphere (Noman et al., 2023).

2.3 .Causes of Climate Change

The primary greenhouse gases (GHGs) linked to climate change include methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), and chlorofluorocarbons (CFCs). Among these, carbon dioxide is the most significant contributor due to its high concentration in the atmosphere. While methane, nitrous oxide, and CFCs are far more effective at trapping heat per molecule**,** carbon dioxide remains the leading greenhouse gas produced by human activities (Jones et al., 2023).

Concerns about climate change continue to grow as its impact on both the natural world and human societies becomes more evident. It is widely recognized as one of the greatest challenges of our time**—**aglobal crisis that threatens economies, societies, and ecosystems worldwide (Mar, 2021; Demamu, 2018).

The rise in greenhouse gas emissions, largely driven by human activities, has significantly accelerated climate change**.** While natural factors still play a role, research confirms that human influence has become the dominant driver of climate change in recent years (Murshed et al., 2022). The industrial revolution marked a turning point, but other human activities—such as deforestation, burning fossil fuels, agricultural residue burning, intensive farming with fuel-powered machinery, and emissions from transportation sectors**—**continue to exacerbate the problem (Watson, 2020).

As a result, human activities are driving climate-related disasters that negatively impact human health, infrastructure, and overall productivity—both locally and globally. In many developing nations, fossil fuels remain the primary source of energy, leading to increased greenhouse gas emissions and rising global temperatures (Abbass et al., 2021a; Furuya, 2022).

While Ethiopia's contribution to global greenhouse gas emissions is relatively small, emissions from the energy and agricultural sectors have been rising since 1994. These two industries are the country's largest emitters, accounting for 15% and 85% of total emissions, respectively. This highlights the strong connection between high methane emissions and livestock farming, as Ethiopia's economy relies heavily on the agricultural sector. Among these emissions, methane is the dominant contributor, responsible for 80% of the projected warming effects (Mulusew and Hong, 2024).

2.4. Impacts of Climate Change

In addition to rising sea levels and surface temperatures**,** climate change is altering global rainfall patterns, shifting major air currents and ocean streams, and increasing the frequency and intensity of extreme weather events**.** Around the world, its effects are already causing loss of life, property damage, and disruptions to livelihoods**,** and these consequences are expected to worsen over time. While climate change affects all nations**,** low-income countries are hit the hardest**.** In Ethiopia, the signs of climate change are evident**—**recurrent droughts, famines, flooding, desertification, loss of wetlands and biodiversity, declining agricultural productivity, water scarcity, and a rise in pests and diseases such as malaria (Haileab, 2018).

Ethiopia is one of the most climate-vulnerable low-income nations and ranks among the top twelve most at-risk countries worldwide**.** The nation is already experiencing severe weather events and increasing climate vulnerability**,** leading to widespread agricultural losses, hardship for millions, and worsening food insecurity and water shortages (Demamu, 2018; Abayineh, 2018; Gebre, K., 2022). Over the past decade, climate change has had a profound impact on Ethiopia's crop production**,** making it increasingly difficult for farmers to sustain their livelihoods.

Prolonged dry seasons and declining rainfall have led to water and pasture shortages, the spread of diseases affecting both people and livestock, and even a rise in violent crime**.** These factors have significantly harmed livestock production**.** Historical data shows that years with favorable climate conditions (e.g., 1982/83, 1990/91) were linked to higher economic contributions from agriculture, while drought and famine years (e.g., 1984/85, 1994/95, 2000/2001) saw significantly lower contributions**.** This demonstrates how climate change has a direct negative impact on Ethiopia's GDP growth, particularly in the agricultural sector**.**

Across various regions**,** unpredictable rainfall and recurring droughts have created a critical food crisis for millions of households (World Bank, 2022). Beyond food security, climate change is straining Ethiopia's natural resources, increasing the risk of natural disasters, and threatening sustainable development and poverty reduction efforts**.** The frequent floods and droughts across vast areas of the country have resulted in devastating losses of both lives and property (Zelalem, 2020).

2.5. Perception of Farmers on Climate Change

Understanding how farmers perceive climate change is essential to assessing their responses and adaptation strategies. Farmers detect climate variations by observing key indicators such as shifting rainfall patterns, rising temperatures, strong winds, hailstorms, and droughts**.** These observations shape their decisions on how best to adapt to the increasing risks posed by climate change**.** As a result, it is crucial for farmers to develop effective coping mechanisms and adaptation strategies while staying aware of the ongoing climate changes in their regions. In semi-arid areas, various adaptation strategies are already being employed to reduce vulnerability and enhance resilience (Asfaw, A.,and Beshir, A., 2024).

Although research across different locations and time periods highlights various climate change indicators—such as irregular rainfall, dry spells, droughts, floods, and temperature fluctuations—farmers' understanding of these changes can vary. Some may clearly recognize the causes and effects of climate change, while others may not fully grasp its long-term implications (Moges, A., and Bork, H., 2024).

By leveraging their knowledge of climate patterns and risks, farmers can adopt practical adaptation strategies and diversify their income sources to better withstand climate-related threats. Therefore, exploring farmers' perspectives on climate change—its causes, signs, and impacts—is crucial for designing effective, community-based policies and adaptation initiatives (Kassie, M., et al., 2023). In semi-arid regions, where climate change poses a significant challenge, implementing a variety of adaptation strategies can help smallholder farmers reduce their vulnerability and apply targeted, practical solutions to sustain their livelihoods (Mastrorillo, M., et al., 2022)

If adaptation actions are not taken, agrarian families practicing agroecology may face significant risks from climate change. However, these farming communities have historically developed coping mechanisms and adaptations to address the impacts of climate change (Vandermeer, J., and Perfecto, I. 2023). To enhance rural farmers' understanding of and engagement with climate change adaptation strategies, it is important to emphasize socioeconomic factors (such as farming experience, education, training, access to weather information, household size, wealth, and land ownership), promote effective communication, encourage active community participation, and consider socio-cultural factors including religious practices and rituals (Adger, W. N., et al. 2023).

It is crucial to grasp farmers' perspectives on climate change, potential adaptation methods, and the factors influencing adaptation in order to improve policy initiatives aimed at addressing the challenges posed by this phenomenon. An essential aspect is how farmers perceive climate change. Local knowledge reinforces their understanding of climate change and its effects on agricultural land-use systems, underlining the need for farmers to develop adaptation strategies as they recognize the threats posed by climate change (Adger, W. N., et al. 2020). The IPCC report provides comprehensive evidence of how climate change is altering precipitation patterns, leading to more frequent and severe droughts and floods across various regions (IPCC, 2021).

Farmers’ perceptions shape their adaptation strategies, ultimately generating additional data relevant to policies and interventions designed to tackle sustainable development challenges in dynamic and uncertain environments (Ochieng, J., et al. 2024). Smallholder farmers are particularly attentive to the impacts of climate change and are implementing adaptation strategies, including crop rotation, intercropping, fertilization, additional irrigation, mixed cropping, and crop diversification (Williams et al. 2018).

2.6. Impact of Climate Change on Livestock

By 2050, future projections indicate that pasture quantity and quality in Asia will suffer due to climate change (Mastrorillo, M., et al., 2022). According to Downing et al. (2017), the primary cause of climate change is the cattle production industry, which accounts for 14.5% of global greenhouse gas emissions. Extreme weather conditions like heat waves can lead to an increase in disease infestation, a decrease in milk production, and a decrease in the rate of animal reproduction (Das, 2018; Kumar et al., 2018).

Heat stress will reduce the amount and quality of feed available to cattle. Several studies have demonstrated that heat stress lowers the protein and starch content of maize grains, a significant crop used as fodder (Yang *et al*., 2018; Bheemanahalli *et al*., 2022).

In a similar vein, heat stress lowers the levels of protein and soluble sugar in heat-sensitive alfalfa cultivars, another important feed crop (Wassie et al., 2019). In these conditions, heat stress results in feed that is of lower quality. Future climatic scenarios, according to Downing et al. (2017), would result in fewer livestock heads but more livestock products demanded. The cattle industry is particularly vulnerable to variations in temperature and precipitation in arid to semi-arid regions (Downing et al., 2017; Balamurugan et al., 2018).

Domestic cattle can tolerate temperatures between 10 and 30 degrees Celsius, but with each degree of increase in temperature, their feed intake drops by 3 to 5 percent. Likewise, in case of a drop in temperature, 59% more feed would be required. In addition, under climate change scenarios, heat stress and drought would have a major detrimental impact on cattle productivity (Habeeb et al., 2018). Numerous diseases related to animals may originate and spread because of climate change. For example, epidemics of tick-borne diseases (TBDs) in sheep, goats, cattle, buffalo, and camels are being caused by rising temperatures and Rift Valley Fever (RVF) caused by increased precipitation (Bett *et al.*, 2019).

Breeds of animals react differently to rising temperatures and dwindling water supplies. Poor growth and high rates of poultry mortality are caused by thermal stress's adverse impacts on animal reproduction features in India (Balamurugan et al., 2018; Chen et al., 2021; van Wettere et al., 2021). Significant rainfall variability combined with drought stress in Asia's dry regions would result in acute feed scarcity (Arunrat et al., 2018). Research indicates that elevated CO_2 lowers fodder's protein, iron, zinc, and vitamins B1, B2, B5, and B9. As a result, the nutritional value of the fodder is diminished (Ebi and Loladze, 2019).

Future climate scenarios would significantly affect pastures, grasslands, biodiversity, and the amount and quality of feedstock. Future climate scenarios that affect livestock productivity may have an impact on rangelands' capacity to maintain and buffer ecosystems, manage grazing, change the type of feed offered to animals, and release greenhouse gases (Nguyen et al., 2019). Due to the drought and delayed onset of the rainy season, livestock experienced poor grass regeneration, a shortage of fodder, water scarcity, and heat stress. Long distances traveled for pastures and water resulted in a rise in livestock mortality, illness susceptibility, and physical deterioration (Kiplagat, J. K., et al., 2021).

According to Thornton *et al.,* (2021), climate change-related variations in temperature and rainfall patterns have an impact on feed availability, grazing ranges, feed quality, and the frequency of weeds, pests, and illnesses.Crops and animals are affected by the adverse effects of climate change, according to Balamurugan *et al*. (2017). Temperature extremes and fluctuations in the quantity and quality of herbage throughout the year will have an influence on the health of cattle, lowering productivity and decreasing the effectiveness of reproduction (Obeidat B and others, 2020).

There is a strong correlation between climate change and livestock output (Thornton, P. K., *et al*. 2021). Feed intake and performance during lactation negatively impacted by climate change (Mason, D.R., and McCarthy, B 2022). Dairy cows in the middle of lactation are especially susceptible to the negative effects of heat stress, which can reduce milk production and negatively affect overall health. Because lactation has increased metabolic demands and mid-lactating dairy cows have physiological challenges in managing body temperature in hot weather, research has shown that these cows are more vulnerable to heat stress. Heat stress can disrupt the regular metabolic functions, nutritional uptake, and hormonal regulation of mid-lactating dairy cows, which can ultimately result in a reduction in milk production.

High-yielding cows experience noticeable yield losses at 24˚C. High temperatures have a major impact on milk yield (Zhao, Y., *et al.,* 2023). According to Rhoads et al. (2019), heat stress alters the body's water balance and cell osmolarity and increases fluid loss through perspiration and panting. Various factors affecting milk yield in dairy cows, including health issues, environmental stressors, and management practices that can lead to significant production losses Pérez-Cabal, M. A., et al. (2023). Furthermore, Shambel (2017) found that milk output may drop by 0.2 kg for every unit rise in the temperature humidity index (THI) above 72.

However, it is a well-known fact that the rainfall variability typical of arid and semi-arid locations has a significant impact on the quantity and quality of fodder and forage available for cattle consumption (Abdu *et al.,* 2020). By lessening the effects of drought on rangeland productivity, rainfall has an impact on the number of cattle. Oba *et al*. (2020) claim that these relationships are due to nutritional restrictions resulting from a drop in rangeland productivity during droughts.

Animals must use their body fat reserves to make up for the nutritional deficit in their feed as the dry season progresses. Climate change affects the productivity of beef cattle due to decreased grain output, increased water scarcity, and changes in feed resources related to rangelands' carrying capacity. The increased rivalry in the production of food, feed, and fuel has additional repercussions because of the lack of feed (Rojas-Downing, M. M., et al., 2023). It affects the system by changing the amount and caliber of animal feed that is available. It also affects the digestibility and nutritional quality of the fodder, changes the species composition of grasslands, and decreases the amount of water available, all of which have an adverse effect on livestock productivity (Bai et al. 2019). Beef has the highest nutritional density and is pack with essential vitamins and minerals among other animal protein sources. Vulnerabilities of specific cattle types, particularly -heavier and darker-coated breeds, to heat stress leading to significant impacts on their growth metrics, including body condition and fat thickness Renaudeau, D., et al. (2023).

According to Gaughan et al. (2021), heat stress is a major factor in the dairy and cattle industries' decreased output, which has a significant financial cost. Particularly at risk are Ethiopia's poor farmers and pastoralists, whose livelihoods and direct reliance on natural resources are susceptible to climate change. S. Tiruneh et al. (2018) state that increased temperatures have physiological effects on livestock production and productivity in addition to reducing livestock numbers because of disease outbreaks, floods, and droughts.

Forage crop quality and quantity may change, diseases may spread, livestock performance and maturity reduced, rainfall and water accessibility may decrease, animals' health, growth, and reproduction may be impacted, the number of cattle herds may decline, and income and prices may fluctuate throughout a large portion of Ethiopia (M. Habte et al., 2022).

Rangelands in eastern Ethiopia no longer managed using traditional techniques that enable the efficient distribution of resources because of changes in rainfall patterns and population that impair the ability of grazing resources to regenerate (Lemma, A., et al., 2021). Livestock provides numerous benefits to pastoralist households, such as milk, meat, skins, excrement, and socio-cultural capital (Catley, A., et al. 2021).

2.7. Impact of Climate Change on Crop Productivity

The increasing competition for crop usage presents significant policy challenges, further complicated by limited understanding of how crops are allocated across different purposes. To address this, researchers have developed high-resolution global maps illustrating where crops are harvested for seven primary use categories: food, feed, processing, export, industrial purposes, seed, and losses. Notably, yields for food crops tend to be lower compared to other crop-use categories. Given current trends, it is unlikely that the minimum calorie requirements needed to eliminate food undernourishment by 2030 will be met (Ray, D. K., et al., 2022).

As a result, any disruptions to these essential crops could severely impact food security**.** Climate change is already negatively affecting both the quantity and quality of staple crops such as wheat and rice (Din et al., 2022; Wasaya et al., 2022). For instance, rising temperatures have led to declines in wheat's protein content and grain yield (Asseng et al., 2019).

Additionally, shortened growing seasons due to rising temperatures have reduced evapotranspiration, further decreasing wheat production (Azad et al., 2018). In China, higher average temperatures during the growing season have negatively impacted winter wheat yields, highlighting the vulnerability of this essential crop to climate variability (Geng et al., 2019). Climate change is also altering wheat grain quality, affecting protein levels, as well as the proportions of sugar and starch**.**

Interestingly, while high-temperature and high-carbon dioxide environments can accelerate wheat grain growth, they also lead to a reduction in protein content (Asseng et al., 2019). Similarly, drought stress decreases the levels of protein and soluble sugars in whea**t**, while also reducing starch content (Rakszegi et al., 2019; Hussein et al., 2022; Noori & Taliman, 2022). In the same way, heat stress lowers the soluble sugar, protein, and starch content of wheat grain**s**, further diminishing their nutritional value (Zahra et al., 2021; Iqbal et al., 2022; Zhao et al., 2022).

Climate change also negatively affects the quality of wheat products since rising temperatures induce a reduction in the amount of protein, sugar, and starch in them. A 1-4 degree increase in temperature is predicted to cause a 17.6% decrease in wheat yield in Egypt's North Nile Delta (Kheir *et al.,* 2019). Crop phenology in China has been impacted by both crop management techniques and climate variability (Liu *et al.*, 2018). Wheat phenology adversely affected in China and India by both human management practices and climate change scenarios (Ren *et al.,* 2019).

Despite the fact that the green revolution has increased agricultural output, maintaining production and improving food security for impoverished rural populations in Asia under climate change scenarios remains a significant problem (Ahmad *et al.,* 2019). Significant drops in crop yield linked in many Asian regions to irregular and severe rainfall patterns during the past few decades, as well as decreased timely availability of water and rainfall (Hussain *et al*., 2018; Aryal *et al.*, 2019).

Because agricultural industries struggle with changing climatic conditions, climate change poses a serious threat to food security and economic stability in the least developed countries. This has an impact on national output. In 2020, Heady, D. and Fan, S. Different crops (such as rice and wheat) saw production losses in different places due to variations in climate trends (Yu et al., 2018). Even though CO2 fertilization will not be able to stop global warming entirely, it can lessen its negative effects on C3 plants and boost crop yields (Obermeier et al., 2017).Rising temperatures and unpredictable rainfall (Rezaei et al., 2018; Asseng *et al*., 2019) negatively impact (2018) Arunrat et al. Crop development and growth

In Asia, rice and wheat are essential for preserving food security. To fulfill the steadily rising demand for food, it would be extremely difficult to boost wheat production by 60% by 2050 (Rezaei et al., 2018). In dry to semi-arid environments, rising temperatures at lower latitudes are linked to decreasing crop productivity. Drought and flooding have caused China's yields of rice, wheat, and maize to decline; it is anticipated that these problems will have a greater impact on agricultural output going forward (Chen et al., 2018).

Naseem, S.,and Faizan,M. (2022). In line with the findings about the detrimental effects of rising temperatures and irregular rainfall on crops, draw the conclusion that higher temperatures have a substantial impact on wheat quality and yield. A different assessment highlights the negative impacts of rising temperatures on wheat harvests, pointing out reductions in starch, sugars, protein content, and total grain yield because of heat and unpredictable rainfall patterns Raza, A., et al. (2023).

The significant decrease in wheat yield caused by climate variability in the Egyptian North Nile Delta (up to 17.6%), India, and China can be attributed to a rise in temperature, irregular rainfall, and an increase in insect pest infestation (Arunrat et al., 2018; Shah et al., 2018; Aryal et al., 2019; Kheir *et al.,* 2019). State that rice yields in rain-fed areas could decline by approximately 14% by 2080 under the RCP 4.5 scenario and by about 10% under the more extreme RCP 8.5 scenario Islam, A., and Faramarzi, M. (2020). Due to their detrimental effects on the booting and a thesis stage, high temperatures and drought have reduced rice yields throughout Asia, particularly in Pakistan and China (Zafar *et al.,* 2018; Ahmad *et al.,* 2019).

Crop yields and climatic fluctuation and change in Ethiopia correlated over the long term (M. Asfew *et al*., 2022). For example, pests, illnesses, and recurring droughts posed challenges to sorghum productivity (S.A.Derese *et al*., 2018). Heat stress poses a serious risk to crops since it reduces the number of productive tillers, causes grains to shrink, and eventually lowers rice grain yield (Wang et al., 2019b). In Asia, rain-fed lowland rice (>13 million hectares) and highland rice (10 mil ha) would be impacted by climate change.

Climate change indicators, such as repeated droughts, flooding, and varying rainfall, have an impact on the yields of crops in Northern Ethiopia, including sorghum and teff (Eragrostis teff) (F.Destaw *et al.*, 2022).

Due to crop damage brought on by climate change, farmers in the agro-ecological zones of Woina-Dega and Kolla lost 22,728 and 30,772 dollars, respectively, to purchase crops for their households' consumption. An estimated 3230 and 5181 quintal of crops in the Kolla and Woina Dega agro-ecological zones in Konso district, SNNP regional state, Ethiopia, were harmed by climate change (K.Araro et al., 2019). However, the spread of pests and the locust upsurge reduce the production of cereal crops by 1,228,352, 1,026,132, and 843,241 quintals, respectively, in the Ethiopian regions of Oromia, Somali, and Tigray. Desert locust has caused damage to a wide range of crops, although in some regions of Ethiopia, the worst affected cereal crops were sorghum (112,476), maize (41,041), and wheat (24,419) quintals (FAO *et al.,* 2020).

Climate change has a major impact on rural Ethiopians' food security (R. Solomon *et al.,* 2021). One of the primary drawbacks of climatic unpredictability and change is food insecurity. Droughts, floods, the development of diseases like malaria, water-borne infections associated with floods, respiratory ailments associated with droughts, and soil degradation because of the country's abundant rainfall are the causes of it (M. Gezie et al., 2019). Due to the limited food and income sources caused by the drought, vulnerable rural households run the danger of widespread hunger and malnutrition (Macheka, M. T., and Kayira, G. W. (2021).

A government-led multi-agency meher assessment in late 2023 found that million people were food insecure, and- million of those people required assistance with agricultural inputs to resume food production (FAO *et al*., 2023). About 2.5 million people were at risk of food insecurity because of crop output damaged by desert locust (FAO *et al*., 2021). Additionally, it projected that 976,381 farmers were affected by desert locusts and required food assistance from humanitarian organizations. The Somali and Oromia areas, which experienced greater crop losses, have a greater need for humanitarian food aid (FAO *et al*., 2020).

2.8. Impact of Climate Change on Health of Crop and Livestock

Specifically, the Fusarium species that causes Fusarium head blight on wheat crops is more likely to attack in hot, humid climates (Shah *et al*., 2018). A related study (Iannella et al., 2021; Tan *et al*., 2021; Tonnang *et al*., 2022) showed a direct correlation between insect pests and diseases and higher temperatures and carbon dioxide levels in rice production.

Climate change can lead to the emergence and spread of numerous animal-related diseases. For instance, rising temperatures and Rift Valley Fever (RVF) brought on by increased precipitation are causing epidemics of tick-borne diseases (TBDs) in sheep, goats, cattle, buffalo, and camels (Bett *et al*., 2019). Higher temperatures and higher humidity generally accelerate the development of parasites and illnesses that spend a portion of their life cycle outside the host. The way that illnesses spread is affected by changes in wind direction (Aristodemou *et al*., 2023).

Flooding that occurs after a severe weather event provides the perfect habitat for a range of water-borne illnesses. Desiccation and drought have a negative impact on the majority of illnesses (Rezza, 2024). Climate change may cause significant changes in the distribution of diseases, and outbreaks of severe disease may occur in animal populations that were previously immune-compromised (perhaps because of the collapse of endemic stability) (R, 2019).

Numerous diseases that afflict animals can arise and spread more frequently as a result of climate change. For example, sheep, goats, cattle, buffalo, and camels are experiencing epidemics of tick-borne illnesses (TBDs) owing to rising temperatures and Rift Valley Fever (RVF) caused by increased precipitation (Bett *et al*., 2019). One of the main issues raised by the community is the spread of new illnesses. They think that the local animal population is wiped off by unknown virus regions. This has to do with the fact that diseases that are made worse by malnutrition are more common in animals (Clifton, 2021). Indirect effects of climate change on agriculture include increased soil erosion, decreased irrigation and water availability, an increase in the frequency and dispersion of unfavorable weather events, modifications to the emergence and spread of livestock diseases and agricultural pests, and more (Nosirovich, 2022).

The way that various livestock breeds react to rising temperatures and water constraints varies. Thermal stress affects animal reproduction features negatively in India, which leads to poor growth and high rates of poultry mortality (Balamurugan et al., 2018; Chen et al., 2021; van Wettere et al., 2021). Severe feed scarcity would result from excessive rainfall variability combined with drought stress in arid regions of Asia (Arunrat et al., 2018).

According to Ebi and Loladze (2019), there is a decline in protein, iron, zinc, and vitamins B1, B2, B5, and B9 when there is an elevated CO2 concentration in the feed. Future climatic scenarios would significantly affect all the quality and quantity of feedstuffs, pastures, grasslands, and biodiversity. Future climatic scenarios affecting livestock productivity could have an impact on rangelands' ability to support and buffer ecosystems, control grazing, change the type of feed that is fed to animals, and emit greenhouse gases (Nguyen et al., 2019).

2.9 . Response to Climate Change

2.9.1. Mitigation Strategies of Climate Change

Adaptation and mitigation of climate change have emerged as key response strategies (Kabir *et al.,* 2021).Technology substitution and change that lowers the inputs of energy resources and emissions per unit of output are referred to as mitigation. Mitigating climate change involves putting policies in place to lower greenhouse gas emissions and improve sinks.

Afforestation or reforestation, management of forests, decreased deforestation, management of collected wood products, utilization of forestry products for bioenergy to substitute the usage of fossil fuels, enhancement of tree species to boost biomass productivity and sequester carbon, improved remote sensing technologies for analysis of vegetation/soil carbon sequestration potential and mapping land-use change landfill management and monitoring.

Mitigating climate change entails lessening its effects on our globe. Reducing the amount of greenhouse gases in the atmosphere requires human activity. Achieving net-zero and limiting the rise in global temperature to 1.5°C require taking this crucial step (Morris *et al.,* 2023).

2.9.2. Adaptation Strategies of Climate Change

Strategies for adapting to climate change aim to improve agricultural productivity, reduce its impact on livelihoods, and make agriculture more resilient to shocks (Begeke and colleagues, 2019). It is well acknowledged that in order to recommend the most effective adaptation solutions, policymakers need access to climate information (Gebrechorkos *et al.,* 2020). According to Chepkoech *et al.* (2020), farmers' comprehension of the effects of climate change is a prerequisite for developing adaptation methods. In this situation, a wide range of individual and collective adaptation strategies have been employed. Community-based adaptation can reduce locals' susceptibility to climate variability and change and boost their resilience (Vasseur, 2021).

Climate change adaptation is site-specific, and the institutions and socioeconomic context of a given area play a mediating and translating role in the effects of external interventions aimed at facilitating adaptation to climate change (Bekele *et al*., 2020). Various farm-level adaptations exist, particularly for developing country smallholder farmers (Assefa *et al.*, 2021).

Local community members also adopt cooperative and participatory natural resources management strategies in order to reestablish the foundation of communal livelihoods based on soil and water resources. methods such as terracing, planting trees, preserving soil and water, building community ponds and deeper wells, and involving the public in the development of rules that, when approved, guard against the felling of trees and the destruction of forests. These bylaws are the outcome of conversations and awareness-raising initiatives by pertinent public and community organizations (CDANRO, 2020).

An empirical study from Kenya claims that households that are pastoralist or agro-pastoralist responded to the drought crisis by devising their own coping mechanisms and approaches. These included animal migration, herd management strategies such as keeping female-dominated herds, varying the kinds of livestock, keeping herd sizes big, and adding commercial feedstuffs and, when available, shrubs, tree materials, and agricultural residues to livestock diets (Mwenda, 2019).

According to Khan *et al*., (2021), Farming communities ought to implement autonomous adaptation to mitigate the possible consequences of climatic variability and change.
Crop diversification (Asfaw *et al*., 2018), drought-resistant crop varieties (Marie et al., 2020), mixed farming (Ubisi et al., 2017), improved livestock breeds (Faisal et al., 2021), crop type adjustment, planting date changes, crop variety changes, tree planting, soil and water conservation, and fertilizer application (Wondimagegn and Lemma, 2016). Several Adaptation Strategies discussed in earlier research.

The majority of Ethiopia's strategies for adapting to climate change include conserving soil and water, planting trees, diversifying crops and planting them early, small-scale irrigation, storing grain and minimizing postharvest loss, gathering wild foods (edible fruits, vegetables, and fish), harvesting water, managing rangelands, controlling wildfires, using indigenous forecasting and early warning systems, and cultivating fruit trees (Getachew *et al.*, 2021).

In this study, the adaptation measures were categorized into four: crop diversification; improved crop varieties; Soil and water conservation; Livelihoods diversification. Adaptation policy designed by considering the knowledge of smallholder farmers can bring fruitful and sustainable adaptation responses to the effects of climate change (Babiso, 2020).

2.10. Determinants to Choice Adaptation Strategies

The factors that drive adaptation choices play a crucial role in shaping the type and effectiveness of climate adaptation strategies (Ojo and Baiyegunhi, 2020). Climate adaptation takes place within a dynamic social, economic, technological, biophysical, and political landscape, all of which change over time, across locations, and within different sectors. These evolving factors create both opportunities and risks in the process of adapting to climate change.
Given this complex web of influences, the success of adaptation strategies depends on understanding the key drivers behind farmers' choices. When designing effective intervention strategies, it is essential to recognize and address the factors that shape adaptation decisions—helping farmers strengthen their ability to cope with climate challenges (Mabe et al., 2018).
Several key factors determine a community's capacity to adapt to climate change:Infrastructure and institutional support, Economic stability and access to financial

resources, Technological advancements and innovations, Knowledge, skills, and education levels

In the agricultural sector, farmers' adaptation decisions are influenced by agro-ecological conditions, socio-economic challenges, and demographic factors (Getachew et al., 2021). While many farmers recognize the impacts of climate change and adopt adaptation strategies accordingly, they also face barriers. Household demographics, institutional limitations, and economic constraints often prevent them from fully implementing climate adaptation measures (Amogne et al., 2018).

2.10.1. Socio-Economic

Implementing climate adaptation strategies is often challenging due to various socioeconomic factors**.** Several studies have identified key influences on the adoption of climate change adaptation measures, including household age, education level, farming experience, market access, agricultural extension services, and farm size (Bedeke et al., 2019; Masud). Additionally, weak institutional support and limited access to financial services pose significant barriers to adaptation efforts (Simotwo et al., 2018).

Education plays a crucial role in enhancing adaptation capacity. Research suggests that households with higher education levels are better equipped to process agricultural inputs, allocate resources efficiently, assess the costs and benefits of new strategies, and ultimately make informed decisions about adopting climate adaptation measures (Grabowski et al., 2019).

Access to climate information also significantly impacts households' ability to adapt (Eshetu et al., 2020; Mukherjee and Siddique, 2019). However, several obstacles hinder the adoption of effective adaptation strategies, including limited financial resources, insecure land tenure, labor shortages, water scarcity, and a lack of knowledge and information (Alemayehu and Bewket, 2017; Fahad and Wang, 2018).

Economic stability plays a major role in building resilience to climate change. Farmers who can diversify their income sources are often better equipped to plan for adaptation, respond to challenges, and mitigate the impacts of climate change (Zanmasu et al., 2020). Studies have shown that households with multiple income streams are more adaptable, whereas those with fewer economic opportunities tend to be more vulnerable. In particular, smallholder and subsistence farmers who rely primarily on production may face significant challenges in adapting to climate change (Choden et al., 2020).

2.10.2 .Technological Factors

Having a strong understanding of technology and the ability to use it effectively can significantly enhance a community's capacity to adapt to climate change. Technological literacy plays a crucial role in enabling individuals and communities to adopt climate-smart practices (Waaswa et al., 2021).

The level of adaptive capacity often depends on the availability and accessibility of technology at different scales, from local to national levels and across various sectors. Many of the strategies identified for managing climate change—such as early warning systems, protective structures, crop breeding, irrigation, flood control, and even settlement relocation or redesign—rely on technology in some form. This makes a community's technological capabilities and its ability to develop new technologies key factors in determining how well it can adapt to climate challenges.

There is strong evidence that access to technology provides a significant advantage in enhancing adaptive capacity**.** It not only facilitates the adoption of climate adaptation strategies but also empowers communities to innovate and implement solutions tailored to their specific environmental conditions (Mugi-Ngengat et al., 2021).

2.10.3. Information and Skills to Adapt

Favorable predictions for temperatures and precipitation lead to an increased likelihood of adopting adaptation strategies such as crop rotation and adjusting planting schedules, emphasizing the importance of reliable seasonal weather information Mastrorillo,M., *et al*. (2020). The study discusses how reliable access to seasonal and daily weather information enhances farmers' ability to plant shade trees, boost irrigation, and diversify crop production, aligning with favorable weather predictions Niles, M.T., *et al*., (2022).

Educational programs help communities become more adaptable by giving them the information and abilities needed to put effective adaptation techniques into practice Kohl and colleagues (2019). According to the research, formal education greatly improves farmers' perceptions of the effects of climate change and makes it possible for them to implement resilience-building techniques in their agricultural systems M.A. Davis and colleagues (2020). Improved agricultural resilience techniques and a greater awareness of environmental challenges correlated with higher educational attainment among family members S. Kumar and colleagues (2021).

Additionally, education, a crucial component for achieving innovation processes in Research, suggests that education plays a crucial role and links to a number of processes that can lead to better adaptation to the effects of climate change (Monterroso*et al.*, 2018). For instance, the establishment of markets, the definition of the agricultural calendar, crop rotation and diversification, the promotion of efficiently run communities or producer groups, the systematization of agricultural practices, and the attainment of profitability in the production units (Zanmassou*et al.*, 2020).

2.10.4. Infrastructural Factors

Adaptation initiatives are supported by sufficient infrastructure, including utilities, roads, and communication networks. An infrastructure that is well designed makes it easier to react quickly to changing circumstances. Farmers that have superior infrastructure are typically less exposed to the effects of climate change and experience less hardship. Road accessibility is a crucial component of the agricultural sector's infrastructure for the growth of profitable and productive operations, and some research indicates that it also influences the development of adaptive capacity (Mugi-Ngenga *et al*., 2021).

2.10.5. Institutional Factors

Institutional factors play a crucial role in shaping farmers' ability to adapt to climate change. These factors include access to agricultural training services, weather forecasts, and information on agricultural input prices (Singh and Kumar, 2023). Exposure to mass media and agricultural extension services helps farmers stay informed about climate change, influencing their awareness and decision-making. This information—delivered through radio, television, or extension agents—supports farmers in selecting the right crops and varieties for changing environmental conditions (Grabowski et al., 2019).

Access to local market information on the prices of pesticides and improved crop varieties also plays a key role in farmers’ decisions to diversify their income sources (Mokua and Ogutu, 2021). Similarly, agricultural training programs enhance farmers' skills, equipping them with better strategies to cope with climate change (Kassie et al., 2021). Additionally, microcredit services can help ease financial constraints, allowing farmers to invest in chemical fertilizers, high-yield crop varieties, or irrigation systems to enhance productivity (Kumar and Singh, 2022).

Institutions serve as the backbone of agricultural development, encompassing services such as financing, insurance, and information sharing (Babiso, 2020). They also provide the resources and infrastructure that improve farmers' access to profitable input and product markets.

For effective climate adaptation, strong governance, well-designed policies, and robust institutions are essential. Access to resources, transparent decision-making, and supportive legal frameworks all contribute to enhancing adaptive capacity. Both formal and informal institutions within a community play a significant role in shaping individual and collective responses to climate challenges. The effectiveness of these adaptation strategies depends on how institutions interact and share power (Cid et al., 2020).

Institutional efforts must prioritize the most vulnerable communities, ensuring that those most at risk of climate-related losses receive the support they need to sustain their agricultural production and livelihoods.

2.11 . Empirical Studies on Determinants of Choice to Adaptation Strategies

Adaptation to climate change and its associated risks takes place within a constantly evolving context, shaped by social, economic, technological, biophysical, and political factors. These influences vary across time, location, and sector, making adaptation a complex and dynamic process. The effectiveness of adaptation strategies depends on how these factors interact, highlighting the importance of understanding the key drivers behind farmers’ decision-making. Identifying these drivers is essential for designing interventions that enhance farmers' ability to adapt and build resilience (Mabe et al., 2018; Zhou et al., 2023).

Research on adaptability typically explores the people involved, the resources at stake, the strategies implemented, and the responses observed (Oladipo et al., 2021). Additionally, Adger et al. (2020) emphasized that both farmers and government entities continuously adjust their behaviors based on long-term experiences in farming and environmental changes.

Numerous studies have shown that education plays a crucial role in climate adaptation. Households led by individuals with higher levels of education are more likely to adopt improved technologies and implement effective adaptation strategies (Adeleke et al., 2022). This suggests that access to education and knowledge-sharing platforms can significantly enhance communities' ability to cope with climate-related challenges and increase resilience over time**.**

The impact of household size on the adoption of climate adaptation strategies can be understood from two different perspectives. One viewpoint suggests that larger families may need to allocate some of their labor force to off-farm activities to generate additional income, helping to ease the financial burden associated with a big household (Moges et al., 2022). On the other hand, another perspective argues that larger households benefit from a greater labor supply, enabling them to manage various agricultural tasks more effectively.

For instance, Kassie et al. (2021) highlight that households with more available labor are more likely to adopt and intensively use agricultural technologies, as they face fewer labor shortages during peak farming seasons. Additionally, farm income, non-farm income, and livestock ownership are considered key indicators of wealth. Farmers with higher incomes tend to have lower risk aversion, better access to information, a reduced discount rate, and a more long-term planning approach (Boko Tchamda, 2020).

Livestock plays a particularly crucial role, acting as a form of savings while also providing essential resources such as oxen for plowing and manure for soil fertility. Studies from various developing countries, including Ethiopia, have found a strong positive correlation between access to information and farmers' adoption behaviors (Mekonnen and Ayele, 2023). This underscores the vital role of agricultural extension services in increasing the likelihood of farmers adopting climate adaptation strategies (Beyene and Abate, 2022).

These perspectives illustrate how household size, labor availability, and financial stability shape a farmer's ability to adopt new technologies and strategies for climate resilience. While financial security is often seen as a prerequisite for adopting agricultural technologies (Kassie and Zikhali, 2021), higher-income farmers also tend to be better informed, more forward-thinking, and less risk-averse in their approach to adaptation (Zhou and Liu, 2023).

Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research on adoption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit Moges, A., Sahu, P. (2021).

The Role of Social Capital and Access to Information in Climate Adaptation Social capital—measured by the number of relatives living nearby and farmer-to-farmer extension efforts—plays a crucial role in the adoption of agricultural technologies (Bork and Shiferaw, 2020). Informal institutions and personal social networks serve three key functions in this process. First, they facilitate financial support, helping farmers overcome credit constraints. Second, they provide valuable information about new technologies, enabling informed decision-making. Lastly, social networks encourage collaboration to tackle collective challenges, particularly when technology adoption has wider community benefits.

Research by Mastrorillo and Henson (2020) highlights how ethnically based and participatory social connections function as key forms of social capital, influencing decisions such as fertilizer adoption. Studies on the adoption of agricultural technologies suggest that farm size can have both positive and negative effects, leading to mixed results on its overall impact (Alemayehu and Abate, 2021). However, since larger farms are often associated with greater wealth, they are generally believed to enhance climate change adaptation.

Another key factor in adaptation is proximity to markets, which facilitates information exchange among farmers and provides better access to inputs and services (Tambo and Abdoulaye, 2023). A study conducted in Ethiopia found that frequent contact with extension services and training sessions significantly shaped farmers' perceptions and adaptation strategies to climate change.

Similarly, a study by Rahman and Hossain (2022) in Bangladesh revealed that access to weather information positively influenced farmers' understanding and response to climate variability. This underscores the importance of strengthening extension services to enhance farmers’ knowledge and preparedness.

Additionally, research by Alemayehu and Kassa (2021) identified gender as a key factor in shaping farmers' perceptions of climate change. This finding is particularly relevant in Swaziland, where women play a more significant role in farming than men. Furthermore, higher levels of education are linked to better access to information about improved technologies and increased productivity (Moges and Bork, 2023).

In Ethiopia, studies have shown a positive correlation between extensive agricultural experience and the adoption of improved agricultural technologies (Tadesse Belayneh, 2021). Conversely, research by Hailu and Melaku (2022) revealed a negative relationship between age and the adoption of enhanced soil conservation practices.

2.12. Conceptual Frame Work

Without a question, one of the biggest issues facing African nations is climate change, partly because of their geographic location, increasing reliance on weather-sensitive agriculture, and lack of ability to adapt to it. Plans for household income and taking into account the needs of vulnerable populations in nations like Ethiopia that are directly impacted by climate change and other climate-related extremes. Farmers' choices on which adaptations to invest in and how much to spend on them are greatly influenced by the effects of climate change Tadesse, Tand Biruk, A. (2022).

The model illustrates how extreme weather events, such as droughts, floods, decreased crop production, food shortages, land degradation, water shortages, pest and disease prevalence, and a detrimental effect on household livelihoods, caused by climate change from a systems viewpointHence, in order to reduce the detrimental consequences of climate change on their means of subsistence, farmers would implement various adaptive techniques. However, the assets of the household's means of subsistence may have an impact on these adaptive strategies.

Reducing the impact of climate change requires an understanding of the factors that influence farmers' decisions on adaptation methods.This conceptual frameworks aim to investigate farmers' decision-making factors and how assets are affected by climate change, and targeted adaptation strategies to build resilience.

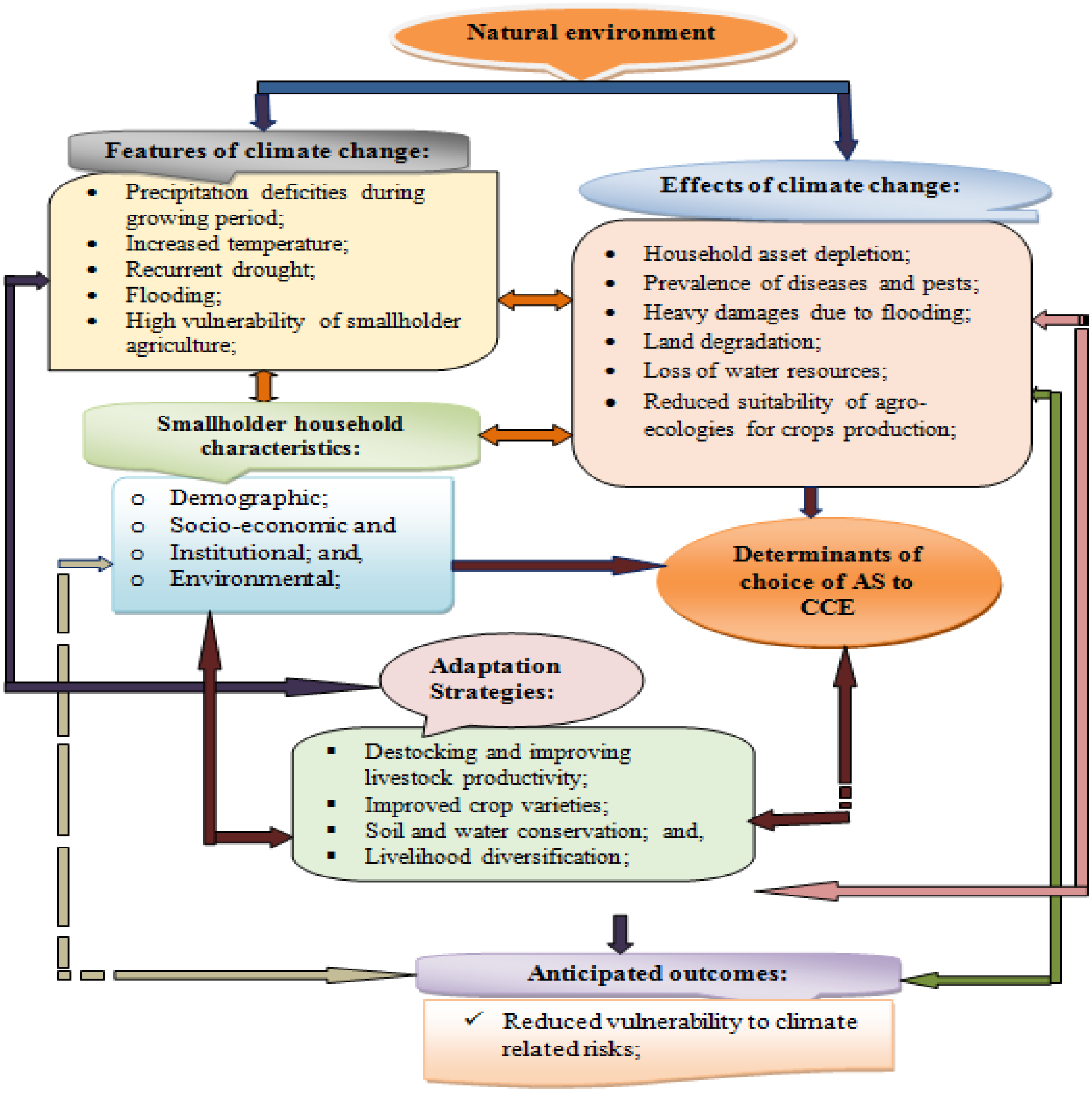

Figure 1. Conceptual framework of the study

Source: Adapted from own synthesis based on literature reviews

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location and Size

This study would be conducted in Chiro District of Western Hararghe Zone; Oromia Regional State, Ethiopia. The district is located at about 324 km east of the national capital Addis Ababa. Geographically, it is located between 10°24′N and 10°66′N and between 38°43′E and 38°81′E(CWLUAO, 2018). The study area covers about 362 km^2 and bordered with Miesso in the North, Gemechis in the South, Guba-koricha in the West and Tulo in the East(CWLUAO, 2018).

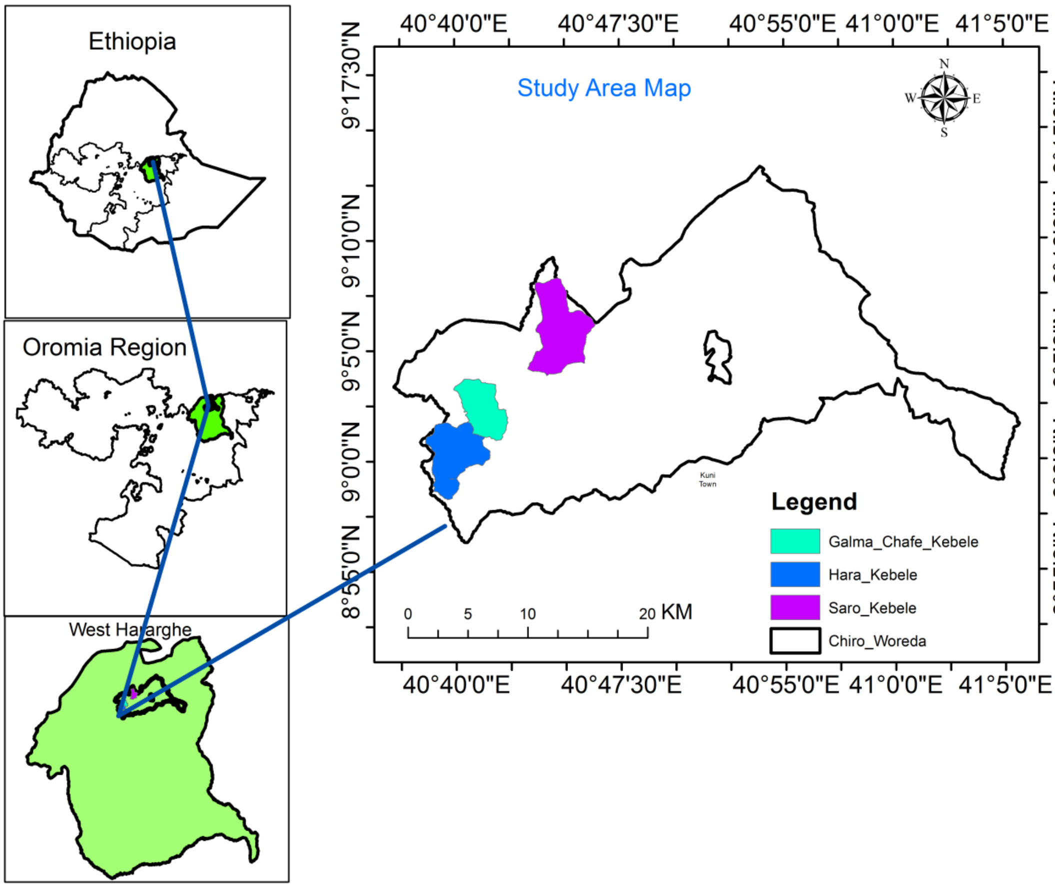

Figure 2. Map of the study area

Source: Arch GIS, 2023)

3.1.2 .Topography and Soil type

The research area's topography is primarily sloppy, rough, and mountainous, making it extremely sensitive to deforestation, low yields, low incomes, and shortages of grazing land, overexploitation, and soil infertility. In order to get support from PSNP, the district was classified as a food insecure area (CWAO, 2023). Data from the Woreda Land Use and Administration Office (CWLUAO, 2018) indicates that of the district's total land area, 25% is plain and 75% has steep slopes. The region is situated between 1500 and 2800 meters above sea level. Mount Jelo (1872 meters) is the highest peak, and there are rivers.

Loamy soil, sandy soil, and clay soil make up the majority of the district's soil types, covering 42.5%, 25.5%, and 32% of the total, according to data from the Chiro Woreda Land Use and Administration Office (2018). The geography affects the types of soil; in the highlands and midlands, black soils predominate, while in the lowlands, sand, clay, and red soil are found. Additionally, the average land holding size per HH is 0.25 hectares(CWAO, 2023).

3.1.3. Climate of the Study Area

The study area was characterized by three agro-climatic zones, which vary from *Kolla, Woyna Dega* and *Dega*. According to the National Metrological Institute rainfall is bimodal and erratic in nature occurring in February - April (small rains) locally known as '*Belg*' and June – September (main rainy season) locally known as '*Kiremt'*. It has a mean annual rainfall of 700 mm - 1800mm and a mean monthly temperature that ranges from 12°C to 23.5°C has mean annual temperature of 18.44°C(CWAO, 2023). Figure 3 and 4 below depict temperature and rainfall distributions over the last three decades (1992– 2021).

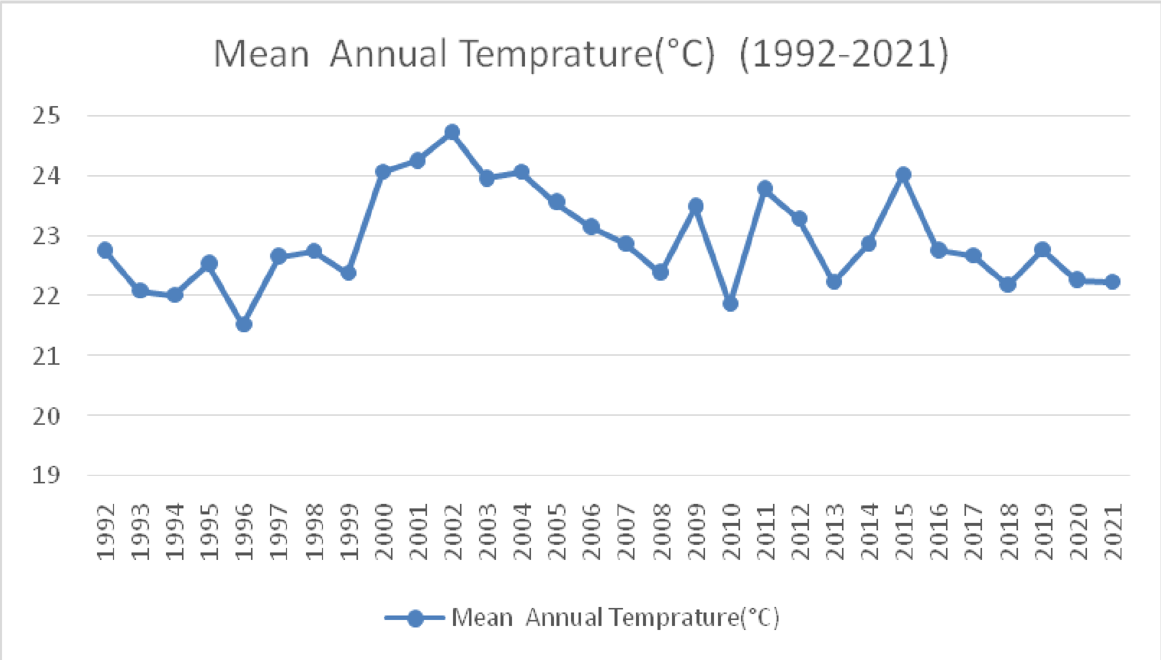

Figure 3. Mean annual temperature distributions (1992 – 2021)

Source: NMI, 2024

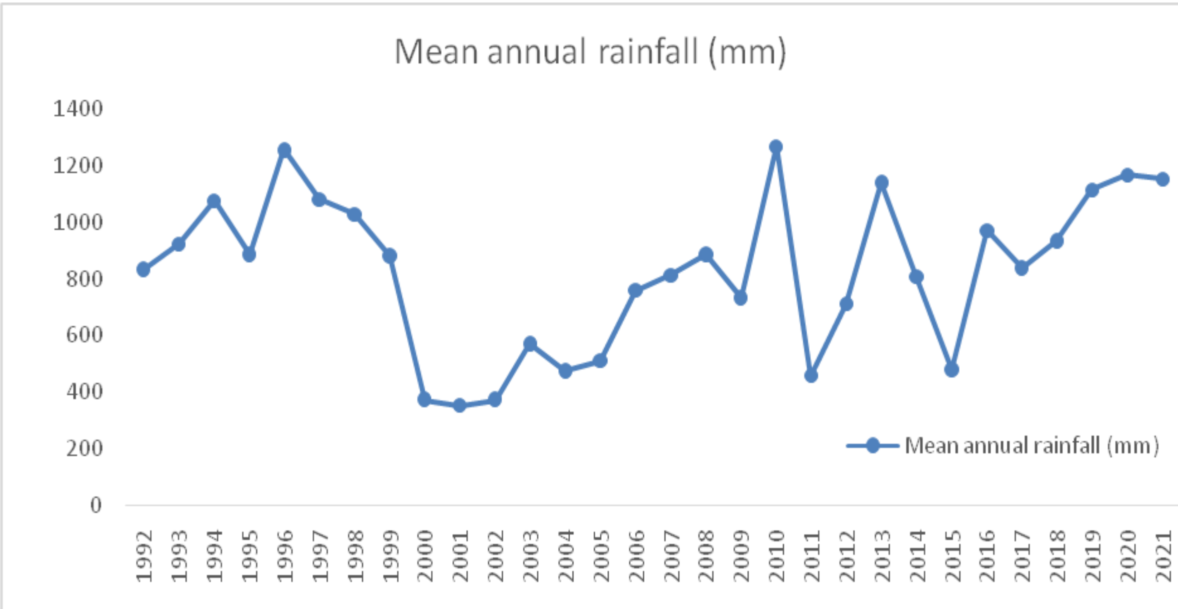

Figure 4. Mean annual rainfall distributions (1992 – 2021).

Source: NMI, 2024

3.1.4. Demographic Characteristics

The district has a total population of 207,553 of which 106,277 are males and 101,276 are females of which 192, 194 are rural dwellers and 15,359 are urban dwellers (CSA, 2013). The Woreda known to have a heavy population density per square kilometer and the average family size of a house hold in the district is 5 with fertility rate per women is 5.9 of which 3.3 is for urban and 6.4 for rural and growth rate is estimated to be 2.9%(CSA, 2007).According to data obtained from Woreda. The estimated crude population density of the Woreda is 273.9 persons per square kilometers. The age distribution of the Woreda was characterized by higher proportion of young (0-14) and low proportion of old age (above 65), reflecting higher fertility rate. The young population of ages less than 15 accounts 49.7%, adult and old ages account for 47.1% and 3.2% of the total population of the Woreda respectively. Hence, the dependency ratio of young and old age (0-14 age group + 65 and above age group) of the Woreda is 112.1% (105.4% for the young and 6.7% for the old), which illustrates that for each 100 persons in the economically active age groups there are about 112.1% young and old dependents to be supported in the Woreda (CWCRGEIP, 2015).

3.1.5. Land Use Type of The Study Area

The land use and land pattern in the Chiro district are varied. A significant amount is covered by forest and agricultural terrain. Both pasture and croplands are prone to erosion, but croplands are particularly vulnerable due to constant cultivation and lack of vegetation cover. The Chiro district currently occupies 715 square kilometers of land, of which 54.9% is arable land, 10.4% is forestland, 0.006% is grazing land, 0.7% is barren land, 0.01% is social service, and 0.09% is irrigation (CWLUAO, 2018). The land usage and land cover summarized and sized in the graph below.

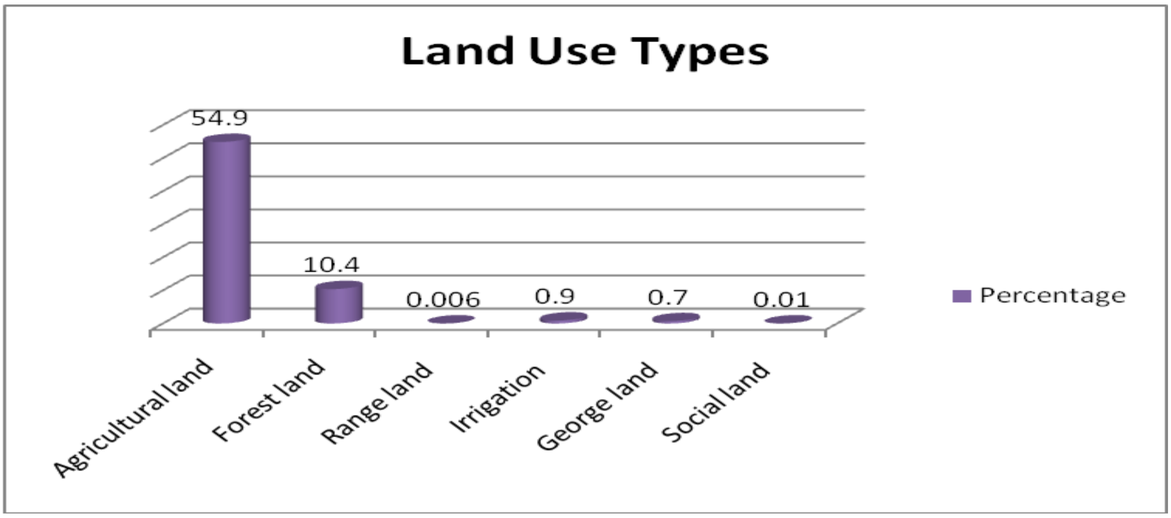

Figure 5 .The land use types
Source: Chiro Woreda Land Use and Administration Office (2023)

3.1.6. Socio-Economic Characteristic of the Study Area

The study area's primary economic activity and source of income is agriculture. The most valuable resource for households in terms of growing crops and raising livestock is land. About 98% of the livestock rearing in the mixed agricultural system is for subsistence, with the remaining 2% being pure pastoralists (Chiro woreda Agriculture Office, 2023).

The area's principal food crops include cereals such sorghum, maize, haricot beans, and chickpeas; cash crops predominate. Goats, sheep, and cattle are examples of small and big ruminants that are considered livestock and are a significant source of food and revenue for households. The average land holding size of Woreda farmers, according to the 2013 household survey, was 19% owned 0.26 ha or less, 45.4% owned 0.25 to 0.5 ha, 28.5% owned 0.51 to 1 ha, and only 5.8% owned 1 to 1.5 ha (Gosa, 2016).

The area is further characterized by high erosion problems, low yields, and low incomes, shortages of grazing land, overexploitation, soil infertility and deforestation. Thus, the district grouped under food insecure areas so that the Productive Safety Net Program (PSNP) has supported the district (Gosa, 2016).

3.1.7. Infrastructural Services

There are (seven) 7 health Centers and 38 health posts currently functioning in Chiro Woreda and the primary health service coverage of the Woreda is 88% (Chiro Woreda Health Office ,2023). Total veterinary clinics for livestock were 12 (CWAO, 2023). The coverage of grid electricity power is 14.5% and that of Solar panels is 2.17%, whereas the remaining population is dependent on firewood, cow dung and kerosene. The sources of water are pipe water, spring and hand dug wells. The number of kebeles having access to tap water, well water and spring water are 10, 24 and 36 respectively from the total 38 kebeles of the district and the water service coverage of the Woreda is 40.5%. There are 35 km asphalt roads, 64 KMs all weather and 183 KMs only dry season roads available in the Woreda. The percentage of households having mobile phones, television and radio is 42.8%, 14.14% and 60.7% respectively. The average adult literacy rate of the Woreda is 19.5%. The GPI in education is 0.78, 0.61 and 0.48 in the 1st cycle, 2nd cycle and in high schools respectively (Chiro Woreda CRGE investments proposal, 2015).

3.2. Research Design

Study would employ a mixed-methods approach, collecting qualitative and quantitative data in two stages. The design of this study, therefore, based on an explanatory sequential mixed-methods design that aims to collect qualitative data in the first stage to identify patterns, relationships, or trends in the data and assist in building the second stage quantitative data collection instrument. In the first stage, there would be interviews and focus groups to prepare the data collection instrument. In the second stage, a questionnaire survey would be conducted to collect and analyze quantitative data.

3.3 .Type and Sources of Data

Both qualitative and quantitative primary data collected from key informants would smallholder farmers, site workers and experts of districts and secondary data sources from official documents such as articles, books, web sites/internet, official reports from CSA, NMI, agricultural offices, Busa Gonofa Office, published and unpublished documents and other reports. Information determinants of farmers' choice of adaptation strategies to the changing climate change among smallholder farmers in the study area.

Prior to the study, a pretesting of the questionnaire was performed to avoid missing any important information.

3.4. Sample Size and Sampling Techniques

The district would be purposefully chosen due to the fact that the district is affected by climate change and variability like recurrent drought and irregularity of rainfall or taking into consideration the agro ecological setting, location within the district, and food security condition. Kebeles selected by stratified random sampling technique; the 38 kebeles stratified into three agro climatic zones, dega, waynadega, and kola, encompassing three kebeles (one from each agro-ecology).

Saro from the low land (Kola agro ecology), *Hara* from the highland (dega agro-ecology) and *Galma Café* from midland (woina dega) were selected for determining the adaptation strategies to climate change and different factors that influence farmers in the districts. The number of households in sample Kebeles identified and sample size would be determined in random sampling procedure. As a result, *Hara* 986, *G/Cafe* 675, *Saro*550, from these three Kebeles, 145 households were taken based on systematic random sampling. The sample size is determined by using the formula provided by (Yamane, 1967 as cited in Israel, 1992) to determine the required sample size at 92% confidence level, and level of precision (8%).

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

Where'' n'' is the sample size, ''N'' is the population size (total household heads size), and ''e'' is the level of precision. The respective numbers of household selected based on the size of household in each kebele.

Based on Byjus, the sample household heads would choose at random intervals. The term "N Choose K Formula" refers to the fact that there were (n/k) ways to select k elements from a set of n elements, regardless of the order they appear in. K was the sampling frame, N was the total number of households in the three kebeles, and n was the sample size. This means that the formula is K=N/n. Hence, K became 15, which would be interpreted as 15, and N= 2211, n= 145, and sample interval. Thus, the sample interval K would be 15 and every 16 household heads from the source list of each Kebele selected systematically.

Table1. Sample kebeles, target population and household sample size

S. no	Sample Kebeles	Agro-ecology	Target Population	HH Sample size	Sampling technique
1	Hara	Dega	986	65	systematic random sampling
2	G/Café	Waynadega	675	44	Systematic random sampling
3	Saro	Kola	550	36	systematic random sampling
	Total		**2211**	145	

Source: (CW*BG*O, 2023)

3.5 .Method of Data Collection

At the village level, focus group discussions are used to gather data, important information which can offer background knowledge on the topic and the historical context of climate change. Eight to ten people from various social segments, including experts, development agents, health extension, wealthy or impoverished farmers, village leaders, elders, youth, and women of the society with access to information on weather forecasts, the effects of climate change, and obstacles to adapting to it, would participate in the focus groups discussions (FGDs).

The FGDs would be facilitated by using checklist information on climate change impact and adaptation strategies. Finally, household surveys were employed through a questionnaire that would be developed based on information the research obtained from the FGDs. Relevant secondary data would also be collected from different organizations including Agriculture office, LU office, NMI, NGOs, Woreda EP office and related official documents.

3.5.1. Data Collection Instruments

The primary data collected from smallholder farmers and experts using Key informants, focus group discussions (FGD), Observation**,** Questionnaires**,** and Interview.Secondary data instruments such as books, reports, and home pages of different national and international organizations would used for the study.

3.5.1.1 . Questionnaires

A questionnaire employed as a tool to gather primary data from respondents in a chosen sample. Because survey questionnaires are more objective and allow for faster, more consistent data collection, the researcher chooses them as their data collection tool. The survey created in English and translated into Afan Oromo, the local tongue. This was a result of certain respondents' limited English reading and writing skills. During the pilot survey, 12 household heads—four from each of the three kebeles—interviewed to pretest the questionnaire.

After that, some duplicate and ambiguous items were removed from the final questionnaire. For the household survey, the investigator utilized both open-ended and closed-ended question types. It is made up of many kinds of questions about how climate change is affecting smallholder farmers and what factors influence their decision about which adaptation measures to use. Before administration, respondents were brief on the goal and significance of the study. A pilot research carried out in chosen kebeles to ensure the questionnaires' acceptance and validity. Pilot testing carried out in May 2024.

3.5.1.2 . Key informant interview (KII)

In order to gather qualitative information regarding the topic under investigation, the researcher also employed key informant interviews (KII).In order to obtain comprehensive information about the subject the investigator wishes to pursue, it was conduct with more knowledgeable heads of households. The prepared interview questions focused on how smallholder farmers choose their adaptation techniques and how the effects of climate change would affect them. Key informants were choosing by the researcher from among office experts, smallholder farming households, local leaders, elders, and NGOs' representatives. As a result, 30 key informants were involved, including nine (9) Development Agents (DAs), three (3) local leaders, six (6) model smallholder farmers, three (3) elders, one(1) NGo official, and eight (8) experts.

3.5.1.3 . Focused Groups Discussion (FGD)

The main objectives of FGD were to increase public knowledge of the effects of climate change, identify current adaptation strategies, and determine the factors influencing the selection of adaptation strategies. Thus, the researcher purposefully selected women, youth representatives, elders, model smallholder farmers, and young people to participate in focus group discussions (FGDs) based on predetermined criteria.There were eight to ten participants in each of the three Focus Group Discussions (FGDs) that conducted with chosen people from the sample kebele. Thirty, (30) people in total were involved. The main topics of discussion were smallholder farmers' awareness of the effects of climate change, the adaptation strategies they apply, and the factors that affect their choice to utilize an adaptation.

The focused group discussion holds at *kebele* Centered of each group member can arrive easily. Focus groups discussions (FGDs) were employ to collect information from group of individuals on a particular topic from selected *kebeles*. Focus group discussions helped generate conversations that uncover individual opinions regarding the climate trend and to explore effects of climate change on agricultural production, health, environment**,** etc.

3.5.1.4. Field Observation

Data related to the topic of the study collected through field observations for communities and setting at a research site. Observational protocol designed before data collection that is used for taking field notes during an observation. This helped to observe what would currently happen on the ground related to agricultural production, weather conditions and environment. This helped provide insight into the interaction between respondents and their physical environment and as well as realities on the ground.

3.5.2 . Data Collection Procedure

Primary data collected from sample smallholder households of the study area using semi-structured questionnaires that were prepared in English language but eventually translated to local language (*Afan Oromo*). Household survey employed through questionnaire that was developed based on information the researcher obtained from the FGDs. Moreover, data on demographic, scocio-economic, institutional characteristics, physical features and metrological data on temperature and rainfall distributions for thirty years collected by time and place.

3.6. Method of Data Analysis

The data obtained from different sources analyzed by using qualitative and quantitative data analysis methods. Both descriptive and inferential statistics with econometrics models were used to analyze the data.

3.6.1. Descriptive Statistics

In this study, descriptive statistics were used to reduce quantitative data collected and summarize them. Descriptive statistics such as, mean, standard deviation, range, percentages, frequency of occurrences, pie-chart, figures, graphs and tables were used. For this analysis, Microsoft Excel 2010 and SPSS Software Version 20 used to analyze quantitative data generated through questionnaires.

3.6.2. Inferential Statistics

In this study, inferential statistics used werediscussed in the following sub-sections.

3.6.2.1. Chi-square test

The Chi-square test of independence, also called the Pearson Chi-square test, is one of the most useful statistical methods for examining group differences when the dependent variable examined at a nominal level. According to Mekonnen, D., and Zewdie, A. (2023), the Chi-square test also has the advantage of being flexible in processing data from two-group and multiple-group research, resilient in terms of data distribution, simple to compute, and providing comprehensive information.

Studies could make advantage of it as parametric assumptions are not met. The chi-square test used in this study to explain why there is a significant difference in the opinions that the majority advised among sample responder groups with identical responses, which may indicate the need for suggested actions taken into consideration.

3.6.2.2. Weighted Average Index (WAI)

The weighted average index (WAI) used to analyze the level of effects of climate change on smallholder farmers (Williams et al., 2019 and Simotwo et al., 2018). The Likert scale was also used to rank farmers' opinions on climate change constraints using variables
It computed by:

$$WAI = \frac{\sum FiWi}{\sum F}$$

Where, WAI=weighted average index
Where F was frequency of adaptation response, W was the weight of each score and i was the score (1 = not effects; 2= less effects, 3= moderately effects and 4 = highly effects).

3.6.3.Econometric Model

3.6.3.1. Multinomial logit model

The factors affecting farmers' decisions about adaptation strategies in the study area were examined using a MNL model. It is significant to note that previous papers addressing the determinants of farmer's adaptation measures used a variety of methodologies, including multiple regression analysis (Khanaland Wilson, 2019), binary logit (Amare et al., 2018; Funk et al., 2020), multinomial logit (Asfawet al., 2019; Kom et al., 2020), and binary probit (Maina et al., 2020). The method used to look into the factors affecting farmers' decisions about crop-based adaptation strategies and livestock.

The benefit of the multinomial logit is that it allows decisions analyzed across more than two categories and relatively simple to understand and interpret, especially compared to the multinomial probit model, which can be more computationally intensive and widely available in statistical software packages, making it relatively easy to implement. which makes it possible to determine choice probabilities for various categories of Ethiopia in the central part of Rift Valley, both livestock and crop production farmers already adversely affected by climate change (Moges, A., and Mulugeta, W. 2023). Another study also stated that in analyzing the choices made by farmers regarding adaptation strategies, showing how these decisions vary between livestock and crop production systems in climate-affected areas Getu, A., and Berhanu, K. (2021).

The multinomial logit regression model used to analyze determinants of farmers' choice of adaptation strategies in the study area. This method used to analyze the choices farm households make in terms of adaptation practices in crop and livestock production and what factors determine those choices. The advantage of the multinomial logit is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories.

3.6.3.2. Model specification

In this study, specification of model and definition of dependent and independent variables as well as working hypothesis are present here.The choice of multinomial logit model, whenever the options are three or more are widely used (Abrham *et al*., 2017; Amogne *et al.*, 2018). However, the model requires that households associated with only their most preferred option from a given set of adaptation strategies .Unbiased and consistent parameter estimates using this model need to assume independence of irrelevant alternatives that requires the probability of using a certain adaptation method by a given household is independent from the probability of choosing another adaptation method. Method used to analyze crop (Smith.J *et al.*, 2021) and livestock (Lee, S et ***al*.,** 2021).Choices as methods to adapt to the negative impacts of climate change. The approach allows a high level of specification of the relations between adaptation strategies and underlying socioeconomic variables.

To describe the MNL model, let *y* denote a random variable taking on the values {1, 2...*J*} for *J* , a positive integer, and let ***x*** denote a set of conditioning variables. In this case, *y* denotes adaptation options or categories and ***x*** contains household attributes like age, education, income levels, and so forth. The question is how cetirus paribus changes in the elements of ***x*** affect the response probabilities *P*(*y* = *j* / *x*), *j* =1, 2 ...J. Since the probabilities must sum to unity, *P*(*y* = *j* / *x*) is determined once we know the probabilities for *j* = 2...*J*

Let ***x*** be a 1× *K* vector with first element unity. The MNL model has response probabilities:

$$p(y = j/x) = \exp(xBj)/\left[1 + \sum_{h=1}^{J} exp(\mathrm{xBh}), \mathrm{j} = 1, \ldots \ldots \mathrm{J}\right] \quad \ldots \ldots .1$$

The decision on whether or not to adopt a new technology an adaptation method in this case) is considered under the general framework of utility or profit maximization (Gebrehiwot, T.G *et al*., 2021; Smith,J *et al*.,2020). It assumed that economic agents, including smallholder subsistence farmers, use adaptation methods only when the perceived utility or net benefit from using such a method is significantly greater than is the case without it. Although utility not directly observed, the actions of economic agents observed through the choices they make. Suppose that *Yj* and *YK* represent a household's utility for two choices, which denoted by *Uj* and *UK* respectively. The linear random utility model could then specified as

$$U_j = BX_1 + \varepsilon_j + U_k \ = \ B_k X_j + \varepsilon_k \quad \ldots \ldots ..2$$

Where *j U* and *k U* are perceived utilities of adaptation methods *j* and *k*, respectively, *Xi* is the vector of explanatory variables that influence the perceived desirability of the method, *Bj* and

Bk are parameters to be estimated, and *εj* and *εk* are error terms assumed to be independently and identically distributed (Green ,2000). In the case of adaptation methods, if a household decides to use option *j*, it follows that the perceived utility or benefit from option *j* is greater than the utility from other options (say *k*) depicted as:

$$U_u\left(B_jX_i+\varepsilon_j\right)>(U_{jk}\left(B_kX_i+\varepsilon_k\right),k \quad \neq \mathrm{j} \quad \ldots\ldots.3$$

3.6.4. Model Specification Tests

3.6.4.1. Independence of irrelevant alternatives (IIA)

The odds ratios of multinomial logit are independent of the other alternatives. The property of the multinomial logit model where by P_j/P_k is independent of the remaining properties is called the Independence of Irrelevant Alternatives. Unbiased and consistent parameters of the multinomial logit model in equation seven requires the assumption of IIA to hold. Specifically, the IIA assumption requires that the likelihood of a household using a certain livelihood strategy needs to be independent of other alternative livelihood strategies used by the same household. Assesses the IIA assumption's relevance to decisions made by households about their livelihood and uses the Housman test to confirm or refute its validity Yao, Q., *et al.*, (2023).

3.6.4.2. Multi co linearity for continuous variables and dummy variables

The multicollinearity of continuous and dummy variables evaluated using the variance inflation factor and contingency coefficients, respectively, before the model run. The VIF values of all continuous variables were less than 10, and the values of all contingency coefficients were less than 0.75, indicating that multicollinearity was not a serious problem for this model.

VIF computed as follows: $\mathrm{VIF}\ =\dfrac{1}{(1-R^2)}$

Where: X_i indicates the variables regressed on another explanatory variable;

The coefficient of multiple determinations (R2i) obtained by regressing Xi over the explanatory variables. The VIF approaches infinity as the modified R2i gets closer to one. That is, the estimator's variance rises with the degree of collinearity and may eventually reach infinity. In the event that repressors are not collinear, VIF will have a value of 1. Furthermore, 1 - R2 is called the Tolerance. A tolerance number near 1 indicates low multicollinearity, while a value near 0 indicates multicollinearity can be dangerous. The Variance Inflation Factor is the reciprocal of the tolerance. The coefficient estimate's variance exaggerated by multicollinearity, as indicated by the VIF.

To determine the level of correlation between the dummy variables, the contingency coefficient is calculated. A chi-square-based measure of association contingency called a contingency coefficient, and it calculated as follows.

.

$$C = \sqrt{\frac{\chi^2}{N + \chi^2}}$$

Where C= Contingency Coefficient, χ^2 = Chi-square test and N= Total sample size.

One of the easiest and best ways to enhance model performance is to remove collinear variables V. Kumar and colleagues (2019). The contingency coefficient has values ranging from zero(0) to one(1), where a value close to 1 indicates a great degree of linkage and a value of zero indicates no correlation at all Stronger associations are usually indicated by a value of 0.75 or higher.

3.6.5 . Hypothesis and Explanation of Variables

3.6.5.1. Dependent variables

From the set of adaptation possibilities in the multinomial logitmode, the choice of adaptation strategy considered the dependent variable in this study. To lessen the negative consequences of climate change on their means of subsistence, the researcher conducted focus groups with selected sample household heads to hear about their preferred adaption options. In response, they stated that the options included raising livestock productivity, diversifying livelihoods, conserving water and soil, growing crops resistant to drought, and selecting adaptive measures.

These methods were a few of the ways that rain-fed agriculture in several African nations could adapt to climate change (Asrat and Simane, 2018; Kosoe and Ahmed, 2022). The adaption measures that chosen among the most widely used ones in the research area.

3.6.5.2. Independent variables

Sixten explanatory variables expected to dictate households' choice for adaptation strategies to the impacts of climate change. The independent variables of this study identified below based on theoretical background, related empirical reviews and suggestions from key informants.

Age of household head (AGE): A continuous variable measures the number of years of the household head that indicates the experience in farming. Various literatures provide a mixed influence of age on the decision of choosing adaptation strategies to climate change. Some studies show age has no influence (E. Molla et al., 2023) and positive influences (Maeregu A, BaranaB, 2020; Melesse, 2018; Destawand, M.M. Fenta, 2021) on the adaptation strategies to climate change. The negative relationship suggests that younger farmers are more likely to adopt compared to their older counterparts, possibly for being innovative and keen to try new technology and methods to improve agriculture. suggesting that older adults are less likely to engage in diverse livelihood strategies, which may limit their economic resilience Alhassan, A. and Wang, L. (2021). Therefore, this study hypothesized the relationship between age and the choice of adaptation strategies to climate change and either positively or negatively.

Head of household's sex (SEXH): This is a dummy variable that takes 1 for a male head of household and 2 for a female head of household. Knowing who owns what land becomes especially important when trying to get loans, technologies, and inputs. Specifically, women's ownership of lands and other assets may lessen their susceptibility to various economic shocks and increase their negotiating power and sense of empowerment in both homes and communities (Gilligan *et al*., 2020). Over and above that, marital status is considered an essential factor in a farmer's adaptation strategy. Two studies in Nigeria and Ghana proved that marital status has a negative impact on farmer adaptation (Ogunpaimo and Dipeolu, 2019; Denkyirah*et al*., 2017). In Ethiopia, marital status positively affected early and late planting adaptation measures and had a negative effect on all other adaptation measures (Marie *et al*., 2020). Crop diversification is a choice for adaptation that female-headed households are more likely to adopt. Women are vital to agricultural output because of their experience and knowledge base, which enables them to successfully adjust to shocks and changes in the climate B. Agarwal. (2020).Crop diversification is a choice for adaptation that female-headed households are more likely to adopt. As a result, this variable is dependent upon the adaption type.

Education level of household head (EDU): Education level is a continuous variable that can be measured in years of schooling. A positive and significant effect of education on adapting methods to the changing climate observed in Ethiopia. Education increases farmer's choices and use of adaptation practices. , finding that literate farmers are more proactive in adopting adaptation practices due to their enhanced understanding and access to resources Beyene, A. D., et al. (2023). The importance of education in enabling farmers to adopt adaptation practices in response to climate change, highlighting the advantages that literate farmers have in terms of knowledge acquisition, planning, and accessing opportunities.

A one-year increment in the level of education increases the chance of employing soil and water conservation, adjusting planting dates, and providing supplementary feeding for livestock. The reason might be that literate farmers anticipated adopting new technologies based on their awareness of the potential benefit of adaptation measures (Molla *et al*., 2023). In this study, it would be expected that educated farmers make better decisions to use different sources that help with climate change adaptation than non-educated farmers.

Family size of household (FSIZE): It a discrete variable that denotes the number of family members residing in a households with larger family sizes are more likely to invest in improved crop varieties and sustainable practices due to increased labor (Moges, A., and Tadele, G. 2022). However, a large family may be forced to shift a portion of its labor force into nonfarm activities in order to generate more income and adopt a number of coping strategies. Some research indicating that households with larger family sizes tend to focus on fewer crops, possibly due to limited resources and increased labor demands Koffi, A. and Ndung'u, J(2022).Therefore, it hypothesized that smallholders with more family size will expected better to take on various adaptations strategies that will enhance their response to change in climatic conditions.

Farming Experience (FARM EXP): Farming experience is a continuous variable that measures the number of years the household head has engaged in farming. Farming experience increased the probability of taking adaptation options since experienced farmers are more likely to implement adaptive measures due to their accumulated knowledge about climatic changes and farming practices.(Kumar, P., and Singh, R. 2022), while a study by Shiferaw and (E. Molla et al., 2023) indicates a negative relationship between age and adoption of improved soil conservation practices. Studies by F. Destaw, M.M. Fenta, (2021) .who noted that households who have long experience in farming can predict the trends of crop production better than young households. Hence, this study hypothesized that long years' engagement in farming makes households use adaptation strategies.

Farm income (FARMI): is a continuous variable with a Birr unit of measurement adopting improved crop varieties leads to increased productivity and, consequently, higher household farm income Kassie, M., et al. (2020). It also positively and significantly affects planting date adjustments (Marie *et al*., 2020; Molla *et al*., 2023). Farmers typically invest in productivity-boosting strategies like improved seed types, soil and water conservation, and crop diversification as their primary source of revenue rises. In this study, it anticipated that farm income would have a beneficial impact on the likelihood of adopting improved crop varieties, crop diversity, and soil and water conservation techniques as primary options for agricultural production to adapt to climate change. Therefore, this study hypothesized that the relationship between income and adaptation strategy to climate change may be positive/negative.

Off-farm income (OFFARM): is a continuous variable that is measured in Birr. Participating in off-farm revenue activities allows farmers to overcome their financial constraints, income from off-farm activities provides financial resources that enable farmers to invest in soil conservation techniques, improved crop varieties, and agricultural inputs Kassie, M., et al. (2019). Which discovered a link between the adaptation of pesticide management strategies and off-farm revenue? The possibility of adapting superior crop varieties, altering planting dates, and conserving water and soil is higher when off-farm revenue is included (Kumasi *et al*., 2017). However, off-farm income are less likely to diversify their crops or invest in soil and water conservation practices, as they rely more on their off-farm earnings (Moges, A., and

Tadele, G. 2021). Therefore, this study will hypothesize that the relationship between household off-farm income and adaptation strategy to climate change may be positive.

Livestock ownership (TLU): The quantity of livestock owned by a family measured in Tropical Livestock Units (TLUs), and livestock ownership (TLU) is a continuous variable. (Belay *et al.*, 2017 ; Molla *et al.*, 2023) reported that owning livestock has a favorable and significant impact on the likelihood of utilizing adaptation strategies such as modifying the planting season, combining crops with livestock rearing, and conserving water and soil. Therefore hypothesized farmers with large numbers of livestock are expected to use improved crop varieties, adjusting planting date and soil and water conservation practices as adaptation strategy because it serves as a proxy for wealth status.

Access to farm inputs (FARMIN): When a household uses agricultural inputs, this dummy variable takes on the value of one, and when it does not, it takes on the value of two. A number of researches (Mekonnen, D., and Zewdie, A. (2023) demonstrated the importance of farm inputs in raising agricultural productivity and output. The utilization of farm inputs and adaptation strategies found positively correlated in this study as well.

Frequency of Extension Contact (FREXT): a discrete variable measured by the number of contacts in the year that the respondent makes with the development agent. The role of extension services is very critical to the perception of and adaptation to climate change. Households with access to formal agricultural extension are better adapted to climate change. Access to extension services has a positive impact on the probability of adopting adaptation strategies to climate change, and an increase in extension contact raises the chance of employing soil and water conservation, tree planting, crop diversification, and adjusting planting dates (Asrat, B., and Simane, 2018). Therefore, it is expected that increasing the number of visits by the development agent or expert will have a positive correlation with adaptation strategies. Therefore, it is expected that increasing the number of visits by the development agent or expertise will have a positive correlation with adaptation strategies.

Access Credit utilized (CREDIT): is a dummy variable that can have a value of 1 if credit is received and 2 if not it is. Credit availability relieves household cash flow problems and makes it possible for them to invest in inputs like fertilizer, improved crop varieties, and irrigation systems that will make them more robust to the effects of climate change. Credit received has a favorable and significant effect on farmers' ability to meet the transaction costs associated with different adaptation options, which enables them to buy the inputs and irrigation systems they need, as well as their likelihood of using improved crop variety and crop diversification. It also has a positive and significant effect on the likelihood of using crop selection, soil and water conservation, and irrigation as adaptation strategies to climate change in agricultural production (Maeregu A., Barana B., 2020). It hypothesized that those HH who are the actual credit users are more resilient and may better adapt to climate change.

Membership (MEMBER): A dummy variable called "membership" has a value of 1 if the household belongs to a formal or informal social organization and 2 otherwise. Effective adaptation choices adopted at a higher rate and farmer-to-farmer information sharing improved through membership and participation in official social organizations such as village committees and co-ops (Gemechis and Engdasew, 2024). Thus, a positive correlation between adaptation strategies and social organization membership was postulated by this study.

Distance to market (DSTM): It is a continuous variable and measured in kilometers from the home of the households to the nearest market. Markets are communication centers for producers, consumers and traders. As the majority of climate change adaptation strategy is market oriented, it believes that smallholders who have up-to-date market information are more responsive to use different adaptation options than those who have no access to market information. The distance to the main market was found to positively and significantly affect the rural households‟ decision to invest in soil and water conservation practices. This is explained by the fact that households in the remote area have less opportunity cost to adapt labor-intensive adaptation practices, for example soil and water conservation practices. This may be explained by the fact that households in the remote area have less opportunity cost to adapt labor-intensive adaptation practices (e.g., SWC) (Gemechis and Engdasew, 2024).
Hence being a far market center decreases the probability of using soil and water conservation. Because better access to markets enables farmers to buy new soil and water conservation practices and other important inputs may have been needed to cope with predicted changes in future climate, so that needs for improving household farmers‟ relatively poor access to markets. It has a negative and significant impact on improved crop variety, soil, and water conservation techniques. Better access to market enables farmers to buy new crop

varieties, new soil and water conservation technologies and other important inputs Alemayehu, A., and Haji, J. (2021).Therefore, it hypothesized if the greater distance from market will negatively correlate with adaptation strategy.

Information on climate (CLIMINFO) This variable is dummy, meaning that it takes a value of 1 otherwise and a value of 2 if current information about weather forecasts and climate change is available. Complementing contemporary climate data with traditional weather expertise might increase farmers' access to and use of weather forecasts M. Balehegn and colleagues (2019).The region's growing access to accurate climate change projections and weather forecasts, which can aid in farmers' decision-making, Biagini, B., and Kuhlmejbybib, J. (2022). It has been demonstrated that information access explains how new farming methods are adapted.

Access to Water Source (AWSA): The amount of water points (excavated ponds and dams, ground water from springs or wells, and masonry tanks) that the household may reach is measured by this variable. It predicted that HHs with greater access to water sources would exercise adaptation higher frequently than HHs with less access to water sources similar to the study of (Thompson, G., and Moyo, S. 2021). Consequently, there is a positive correlation between the respondents' access to water sources and their strategy for adapting to climate change.

Table 2. Determinant of farmers' choice of adaptation strategies to climate change

Variable Code	Variable Type	Description and measurement	Exp .sign
EDULEVEL	Continuous	Education of the HH, 1 if the HH attend formal education, 0,otherwise	+
AGE	Continuous	Age of the HH in years	-
FAMSZE	Continuous	Number of people in the household,	+/-
FARMI	Continuous	Amount of Farm income HH gain in (1 if accessed 2 otherwise) birr	+
OFFARM	Continuous	Amount of off farm income HH gain in (1 if accessed 2 otherwise) birr	+
LIVSHOLD	Continuous	Number of tropical livestock holding in TLU	+
EXTSRVCE	Dummy	Access to extension service yes=1,No=2	+
ACRD	Dummy	Amount of credit received annually in(1 if accessed 2 if not access) Birr	+
MARKDIST	Continuous	Market distance from their home in km	-
CLIMINFO	Dummy	1 if the HHH have access to climate information, 2, otherwise	+
AGROECO	Dummy	1 if the HHH farming in dega and 2 otherwise	+
(SEXH)	Dummy	1, if the household head is male; 2, otherwise	+
AWSA	Dummy	1 if the HHH have access to water, 2, otherwise	+
Membership (MEMBER):	Dummy	1 if the household is engage a member of formal and informal social organization and 2 otherwise	+
Farming Experience (FARMEXP)	Continuous	the number of years the household head has engaged in farming	+
Access to farm inputs(FARMIN)	Dummy	1 if HH Access to farm inputs and 2 if not access	+

Source: Own survey, 2024

4. RESULTS AND DISCUSSION

This chapter looks at the study's findings regarding how smallholder households' means of subsistence are impacted by climate change, the strategies farm households are currently employing to cope with the effects of climate change, and the variables influencing their choices of adaptation measures in the study area. Thus, the first section of this chapter addresses the biophysical and socioeconomic features of the sample homes as well as their availability of institutional support services. The second section highlights the key ways in which small farmers' livelihoods are affected by climate change.

The third section presents the findings about the effects of climate change on livestock and agricultural output. Section four of the chapter contains the examination and conclusions on current approaches of adapting to the consequences of climate change. Section 5 provides a summary of the research findings on the key factors influencing farm households' choice of adaptation approaches. Up to now, empirical data is used at each level of the analysis to support, illustrate, or highlight areas of agreement or disagreement with the conclusions.

4.1. Profile of Sample Respondents

4.1.1. Biophysical features

The biophysical characteristics of a sample household investigated in this study comprise the demographic and infrastructural characteristics of sample households in the study area. The primary household factors that looked at were the sample farm households' Age, Gender, Marital status, Family size, and Farming experience.

4.1.1.1 . Age of the household head (in years)

The average age of household heads was 46 years old, with a maximum age of 69 years old and a minimum experience level of 27 years old, according to survey data. The results of the study demonstrated that age has a significant impact on a farmer's adoption of adaptation techniques. The majority of sample families are adult, with age groups including young (≤ 35 years), adults (36–64 years), and elderly (≥65 years) according to the FAO's age disaggregation in agriculture (2023).

This study align with the FAO's age categories to analyze how adults participation in farming influences agricultural output and decision-making processes, the age group revealed that 19.31% of sample families found to be less than 36 years old, 72.41% to be between 36 and 64 years old, and 8.27% to be above 65 years old. These studies collectively highlight the importance of adult household members in agricultural research and productivity, using the FAO's classification for age disaggregation as a key reference in the analyses.

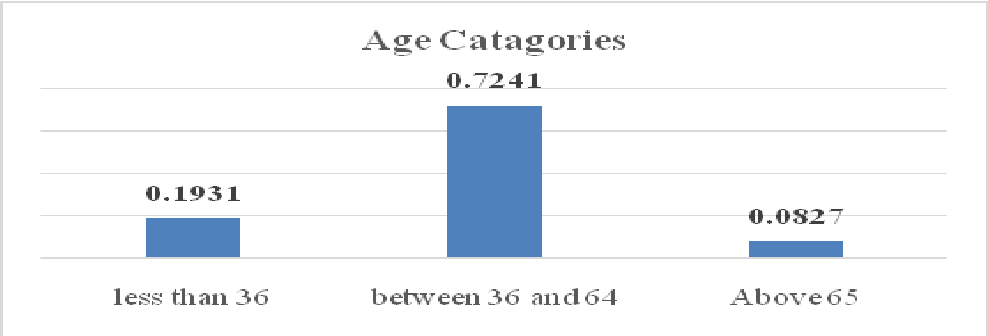

Figure 6. Age category
(Source: Own survey, 2024)

4.1.1.2. Gender of the household head

Of all sample households, there were 24.8% female households and 75.2% male households. The survey's findings showed that households headed by both men and women were implementing adaptation strategies to lessen the effects of climate change. These findings, taken together, emphasize the significance of gender in understanding household responses to climate change and the active role that both genders play in putting these strategies into practice. The adaptation strategies utilized by families discussed by Khan, M. A., and Ahmad, M. (2023). Based on gender, it is evident that both male and female heads of households take considerable steps to reduce the impacts of climate change . FGDs and KIIs also reinforced these opinions in the discussion.

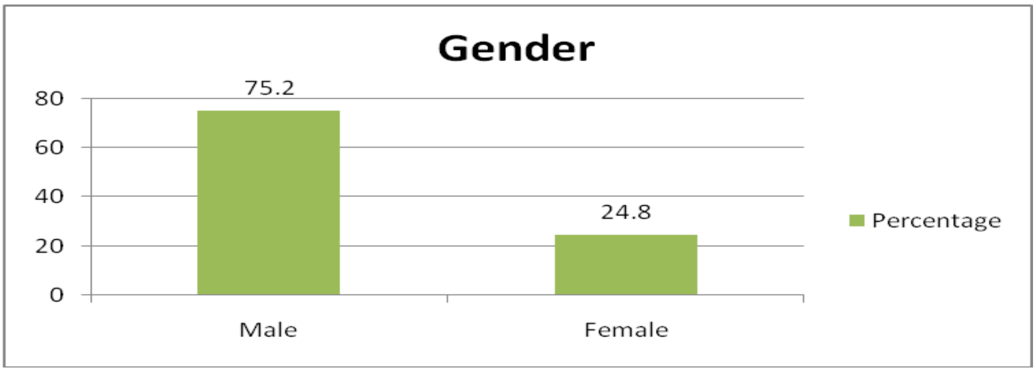

Figure 7. Gender of the household heads
(Source: Own survey, 2024)

4.1.1.3. Marital status

The result of analysis on the marital status of sample household heads showed 86.2 % married , 2% single households , 6.89% household Divorced, 4.82% household Widowed and examines how the marital status of household heads influences their economic resilience and adaptation strategies in the face of challenges. A different study highlights the distinctions between married, single, and divorced families as it investigates the connection between the marital status of household heads and the general well-being of the home. Zhao, Y. and Chen, Land (2024).

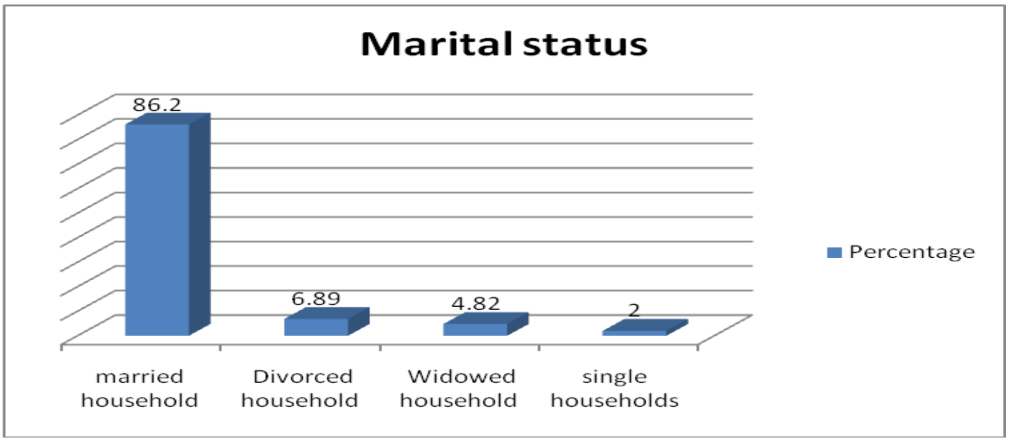

Figure 8. Marital status of sample household heads
Source: Own survey, 2024

4.1.1.4 . Family size

The distribution of family sizes classified as follows: the mean family size per household was 5.45 members, while the minimum family size was one (1) member. The maximum family size was ten (10) members. Regarding the distribution of family sizes and adult labor equivalent, these studies shed light on the dynamics of family size, labor participation, and the consequences for economic activity within the home. Similar studies examine the distribution of family sizes and how they affect the availability of labor, emphasizing the relationship between the mean family size and active labor participation H. T. Nguyen and P. Tran (2022).

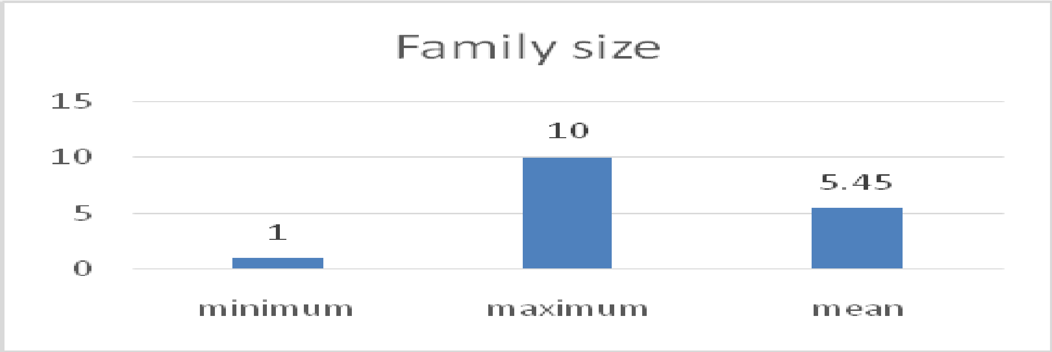

Figure 9. Family size
(Source: Own survey, 2024)

4.1.1.5. Farm experience of household head

The study examines the relationship between farmers' age and years of experience in terms of how likely they are to apply adaptation measures to climate change. More seasoned farmers are better able to identify and respond to climate hazards, according to other comparable studies that examine the relationship between farming experience and the adoption of climate adaptation techniques (Bennett, M., and DeVries, W. 2021; Khan, Z., and Qureshi, K. M. (2022). Households who have long experience in farming can predict the trends of adaptation strategies better than young households (F. Destaw, M.M.,2021). The results of the investigation show that the average number of years that a sample home has been farming is 22.32. This implies that farmers with more experience in the field are more likely to have developed adaptation techniques and to be aware of the consequences of climate change.

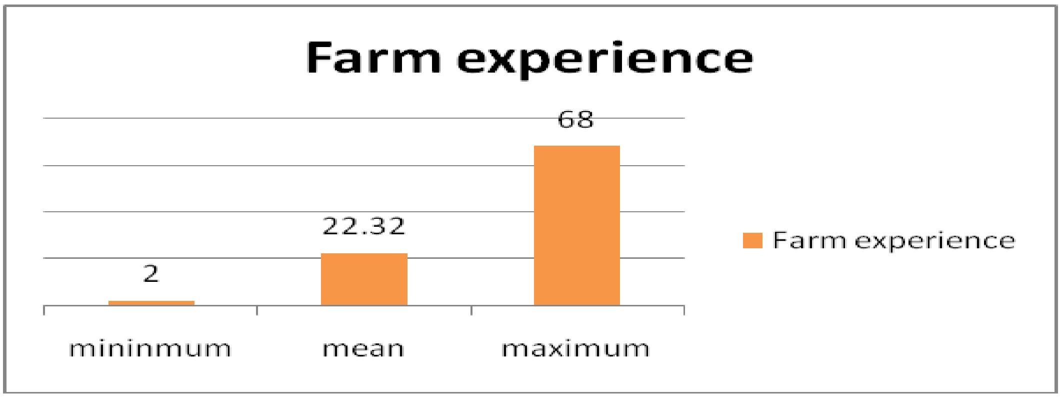

Figure 10. Farm expereince
(Source: Own survey, 2024)

4.1.1.6 .Market distance

Additionally, the results of the infrastructure features of the sample houses concentrated on how far a household was from the closest market center inside the neighborhood kebele. The average distance a sample home must travel to get to the closest market centers, according to the results, is 33.02 km, with minimum and maximum lengths of 8 and 58 km, respectively. Together, these studies shed light on the relationship between market proximity and livelihood options, as well as how income diversification, resource accessibility, and overall household resilience are affected by distance to market centers. More research examines the relationship between household distance and market centers and agricultural diversity and income stability, concluding that longer distances result in less possibilities for subsistence Sawyer, E., and Minot, N. (2021).Proximity to market has a significant influence on efforts to diversify income options, inputs and products marketing. Tadesse, A., Abate, G. (2022). justified low pattern of livelihood diversification in remote areas during hazards is due to costly physical access to market.

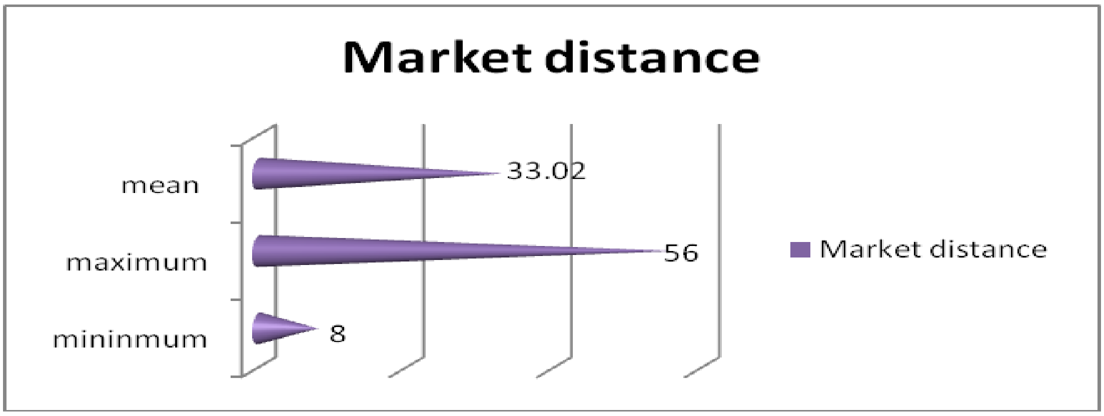

Figure 11. Market distance
(Source: Own survey, 2024)

Moreover, as most public institutions are located in urban centers the rural community adjacent to the urban area may look for additional job in urban centers in times of drought. The main market centres of the study area were *Chiro, Mi'esso, Asabot*, and *Baka, Rabsu as* sample respondents and participants of FGDs and KII corroborated.

4.1.2. Socio-Economy

The social service were education level, membership and standing within formal and informal organizations and networks, size of land holdings, size of livestock herds, average yearly income, and sources of income are among the socioeconomic attributes of sample households evaluated in this study.

4.1.2.1. Education

This study looks at the relationship between household heads' educational attainment and agricultural productivity, the adoption of strategies for adapting to climate change, and the difficulties faced by households with low literacy rates. It also finds that farmers with higher levels of education are better able to respond to the risks associated with climate change. Additional studies look into the educational backgrounds of household heads and how they affect rural families' decision-making processes, highlighting the link between low literacy and little socio economic prospects A Yimer and A. Ayalew (2023).

The sample household heads of study area who participated in the survey 57.9% of were illiterate, 20% were in grades 1-4, 11.7% were in grades 5-8, 6.2% had a religious education, 1.4% were in years 9–10, 2.1% were in grades 11–12, and 0.68% were above grade 12 (university/college). It analyzed that the majority of the sample farm households lacked literacy. The study area's adult literacy rate was lower than Ethiopia's overall average. As (World Bank, 2017) study, approximately 52% of Ethiopians were literate.

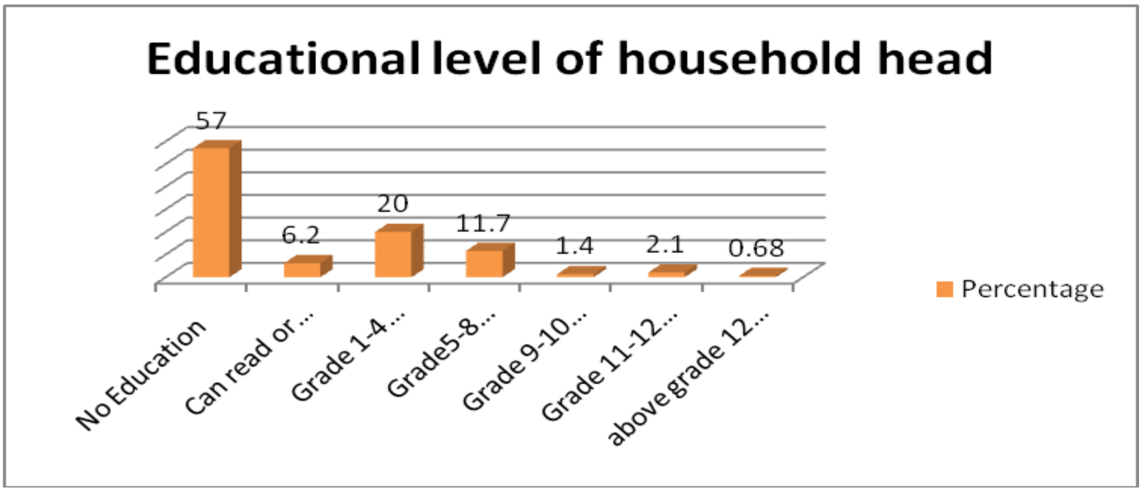

Figure 12. Educational levels of household head
(Source: Own survey, 2024)

4.1.2.2. Membership in social organizations

Together, these studies highlight the value of social networks and community involvement in facilitating information sharing among farm households and strengthening their ability to adjust to the problems posed by climate change. Additional comparable research emphasizes how social networks help farmers exchange information and raise awareness of climate threats, which enhances their ability to adapt (Tulu, L., and Teferi, M. 2022). Farm households are better able to exchange knowledge and implement efficient adaptation measures when they are involved in community-level groups (Mekonnen, A., and Usman, A. 2021).

In this study, 53.8% of sample houses in community-level organizations overall and 46.2% of households with solely community members reported participating in formal and informal social groups in their neighborhood. The degree to which a farm household participates in and is a member of social networks or unofficial groups facilitates information sharing among farmers at recurring get-togethers. The result of analysis presented in figure below.

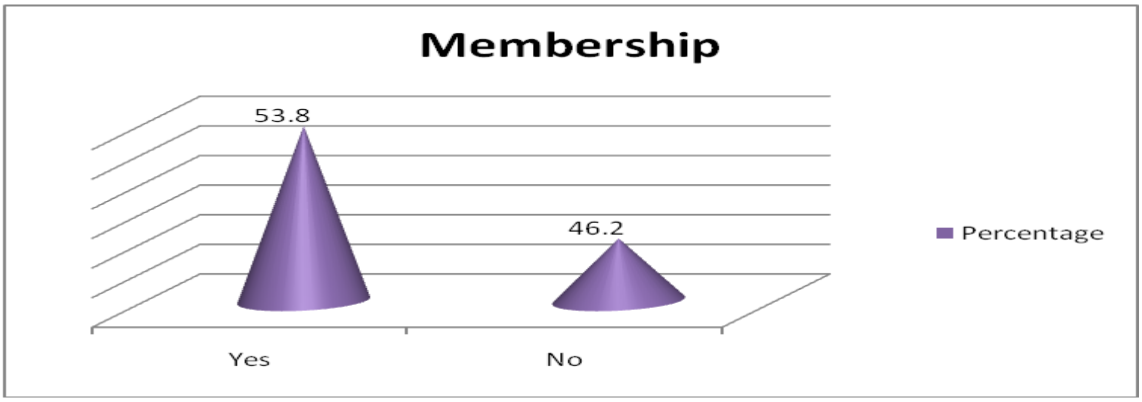

Figure 13. Households Membership in social organizations

(Source: Own survey, 2024)

4.1.2.3. Land holding size

The studies as a whole emphasize the value of land as a basic resource for rural households in the research area, offering information on the sizes of land holdings and how they affect subsistence farming and lives. Additional research examines the effects of varying land holding sizes on agricultural productivity and food security by analyzing land holding sizes among sample farm households, providing average holdings A. Teshome, M. Kassa, and others (2022). The average amount of land owned by rural households, taking into account size variations and the importance of land in terms of housing, social identity, and subsistence Zewdie, A., and G. Kebede (2024). The analysis of the land holding sizes of the sample farm households revealed that the average household's land holding size was 0.418 hectares, falling between the maximum of 1.50 hectares and the minimum of 0.125 hectares figure below present's summary of the findings.

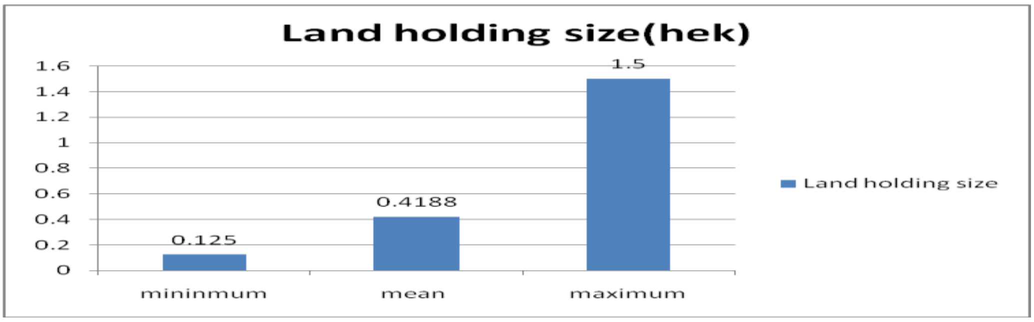

Figure 14. Land holding size
(Source: Own survey, 2024)

As can be seen from the table, the largest land size possessed by a sample household is 1.50ha, while 0.125ha is the smallest value. As can be seen the total landholding size each farm household includes land cultivated for staple and vegetable crops production, grazing land and private forestland owned by individual sample household.

4.1.2.4. Livestock herd size

These studies collectively provide insights into livestock herd sizes in study area, emphasizing their significance for the livelihoods and economic stability of farming households. This study investigates the herd sizes of livestock among rural households, findings and discussing how livestock holdings affect food security and livelihoods Kassahun, A., and Abebe, M. (2024).

The results of analysis on livestock herd size by sample households showed mean score 6.81. The largest livestock holding size in the in the sample kebele is 22, whereas, zero is the minimum value.

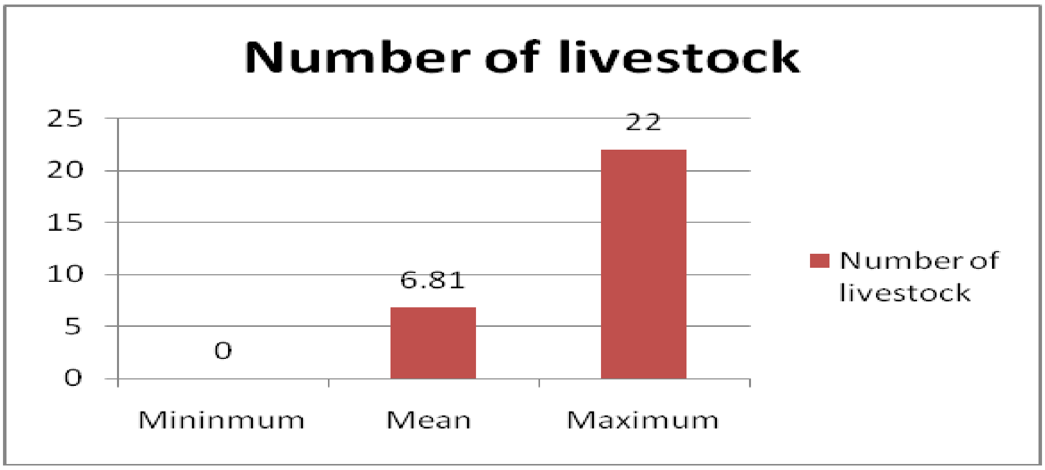

Figure 15. Livestock herd size
(Source: Own survey, 2024)

4.1.2.5. Household income sources

The investigation and conclusions showed that the mean annual household income was an average income of ETB 15,693.59 and a standard deviation of ETB 6,857.37, and discusses the relationship between these income levels and the adoption of climate adaptation strategies. Another study examines the connection between household income and adaptation strategies, finding that higher income levels facilitate greater investment in climate-resilient technologies and practices Mekonnen, D. and Zewdie, A. (2024). These studies collectively emphasize the critical role of household economic status and income levels in enhancing the capacity to adapt to climate change, illustrating the importance of financial resources in implementing effective adaptation strategies.

This result contrasted with that of FAO (2018), which calculated the average annual household income for the national mixed crop-livestock production system to be ETB 14, 512.00 based on the national socio-economic survey conducted in 2015–06. The discrepancy may be related to the Hararghe region, which includes the Chiro district and is well known for cash crops such as haricot beans and chat that fetch high prices on the market. Additionally, this study has determined the primary sources of income for a sample home.

This included sale of crops (sorghum, maize, haricot bean,teff), livestock (cattle, goats and sheep), livestock products (milk and milk products), cash crop (*chat*), nonfarm employment (casual labour, trading, pity trading,*chat* and livestock trade)and others as wage income from employment (salaries) and transfers (including public and private, international and domestic transfers). Graph below summarizes the result of analysis on sources of income earned in 2023.

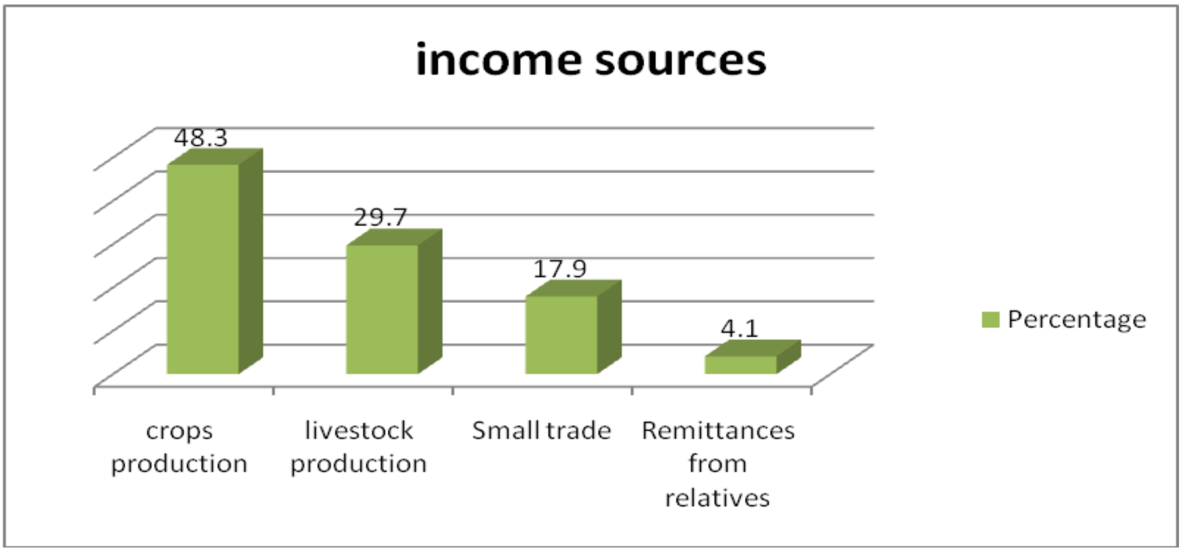

Figure 16. Household income sources
(Source: Own survey, 2024)

As can be seen from the graph, majority of sample households 48.3% earned annual income from crops production followed by livestock production 29.7 % and from off farm income from Small trade 17.9 % income and Remittances from relatives 4.1 %. This result can be compared with FAO’s (2018) report that the share of annual household income for mixed crop-livestock production system at Ethiopian national level has been estimated 51% from crops production, 34% from livestock production, 11% from non-farm employment and 4% for others (transfers and wage), based on the 2015/06 national level socio-economic survey.

4.1.3. Institutional Services

In this study, aspects of institutional support services emphasized include inputs supply, credit, product marketing, agricultural extension and climate information.

4.1.3.1. Inputs supply

Agricultural inputs for enhancing productivity and resilience among farmers in study area, as well as identifying key sources of these inputs. Various farm inputs, including improved seeds and fertilizers, in boosting agricultural production and productivity among Ethiopian farmers Tadesse, T., and Abate, A. (2021). identifies the primary inputs used by farmers, such as chemical fertilizers and artificial insemination, and explores the sources of these inputs, including government programs, cooperative unions, and NGOs Mekonnen, A., and Teshome, A. (2023).

Among the primary inputs that farmers in the study area commonly use are improved agricultural seeds, chemical fertilizers, concentrated feed, improved fodder crops, artificial insemination (AI), vaccines, and pesticides. It was propose that the main sources of inputs in the research area were the government, cooperative unions, and NGOs.

Non-governmental organizations (NGOs) as World Vision, Care Ethiopia, FAO, and the Harerghen Catholic Secretariat (HCS) supply supplies in times of emergency (seeds), in addition to the government. When asked if they had used agricultural inputs in the preceding 12 months, the sample households in this study likewise provided a response (2023). The results of the investigation demonstrated that the sorts of inputs that supplied and used included chemical fertilizers, improved maize, sorghum, and haricaot bean seeds, as well as insecticides and vaccinations.

This graph provides a summary of the inputs used by sample households in 2023. Out of all sample families, the data shows that 21.7% have used inorganic fertilizer, 31.0% have used improved agricultural seeds, 5.5% have used pesticides, 7.6% have had immunizations, and 6.9% have used artificial insemination (AI). The remaining 28.3% not have to chance, with the inputs providing 72.7% of the total. Despite the fact that participants in focus group discussions and key informant interviews revealed that a vaccination campaign has been conducted on a large number of livestock in the district to reduce the prevalence of fatal animal diseases during drought years.

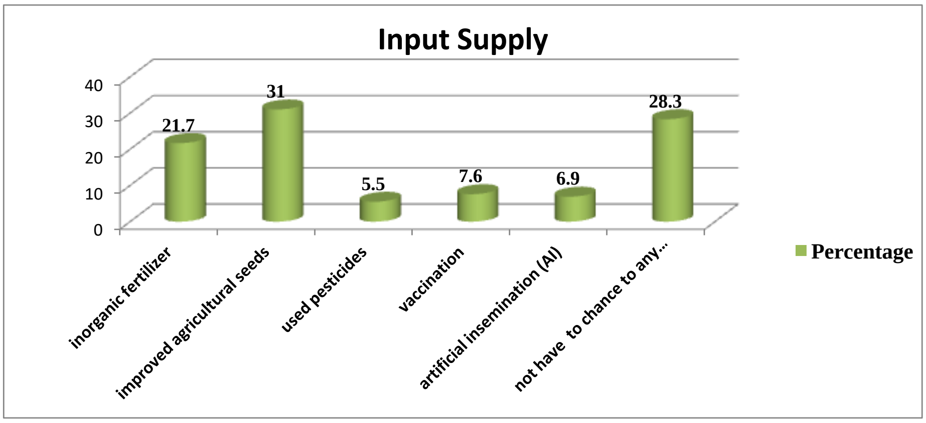

Figure 17 .Input supply
Source: Own survey, 2024

4.1.3.2. Credit service

Credit is a crucial institutional function that helps financially struggling farmers who are unable to buy input with their own funds, particularly in the beginning stages of adoption. Credit availability reduces financial restraints and enables farmers to buy inputs like improved crop types, fertilizer, and irrigation systems. Increased loan availability made it easier for farming households to deal with the effects of the drought because they were able to sell their valuable assets. Increasing access to financial services and other savings options could assist to reduce the risk of drought since many rural Ethiopian households choose to invest their savings in livestock, which destroyed during droughts (Vogt et al., 2018). Sample homes asked to react to the credit service in 2023 as part of this study.

Credit service was providing to farming households during last year. From RIP project to purchace goat and from union to purchase agricultural input it tried to cross-validate the data obtained from household survey during FGDs and KIIs.

In response, it verified that credit services offered over the last five years. The government sector cooperatives promotion agency was once in charge of overseeing the district's official credit system. Currently, though, the district has terminated the service and is selling inputs straight to people who can afford to pay cash. During the conversation with heads and specialists at the district's agriculture office, it also noted that the government has already set up credit services so that farmers may obtain inputs.

Rather, Chiro area farmer households much habituated to the so-called informal source of credit. The informal credit system, which includes family members, neighbors, private dealers, and neighborhood lenders who can offer credit services in cash and in kind (non-cash credit), is crucial in the study district. 42.8% of the sample homes in community level organizations in this study assessed in official and informal credits in their local community, whereas 57.2% do not have access to such information.

Credit loans have terms of eight to twelve months for cash loans and one to sixteen months for non-cash loans. In this sector, households in need of seed or cash had given a particular amount of grain in kind, contingent on their settlement within a year. Additionally, this study discovered that farm households mostly rely on the informal credit system throughout both happy and sad occasions. In general, FGD members at all levels emphasized that the district's main obstacles to credit distribution were cooperative underperformance and a shortage of credit services.

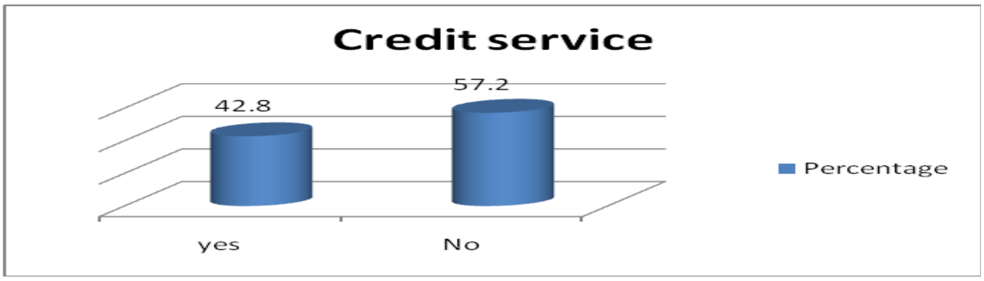

Figure 18. Credit service
(Source: Own survey, 2024)

4.1.3.3. Product marketing

This study examines the barriers that rural households face in accessing product markets, highlighting the risks and costs associated with market participation for impoverished communities. The importance of institutional and organizational reforms in addressing the capacity constraints faced by smallholder farmers, emphasizing that with the right support, these challenges can be mitigated Yirga, C., and Haji, J. (2023). Research discusses the lack of organizational and technological capabilities among smallholder farmers, which limits their ability to engage effectively in value chains and suggests potential reforms to enhance their market participation Biruk, A., and Teferi, M. (2022).

An assessment conducted in this study to determine the primary livestock and crop products that sold. It appears that farm households sell some of their produce at adjacent towns or local markets immediately after harvest in order to pay for necessary family expenses, social obligations and farm input costs. The study's conclusions showed that haricoat beans, maize, and sorghum are the primary market agricultural goods.FGDs conducted in each sample kebele confirmed this. Accordingly, it discovered that the primary livestock market items in the research area were cattle, goats, and sheep.

4.1.3.4. Agricultural extension service

Agricultural extension services in enhancing farmers' access to information and resources, improving their ability to make informed decisions regarding climate change adaptation. The role of development agents (DAs) in providing technical expertise, facilitating access to credit, and disseminating climate information, highlighting their crucial role in helping farmers adapt to environmental changes Kassahun, A., and Berhe, K. (2024) . Examines how farmers' access to better markets, technology, and climatic information is made easier by agricultural extension services, improving farmers' ability to adapt to climate change Tadesse, T., and Biruk, A. (2022). Farmers' understanding of and ability to make better decisions about the hazards associated with climate change can be enhanced by increased interactions with agricultural extension services and climate data A. Alemayehu and J. Haji (2021).

During trips to the district and field levels, as well as conversations with important informants such as heads, experts, and DAs, it noted that out of the 38 kebeles in the district, 36 DAs' houses built. Three DAs, one for each of the fields of plant science, animal science, and natural resource management, as well as a supervisor for each of the 3 kebele, work in each DA home. In particular, the centers act as hubs for farmers to obtain information, education, guidance, and demonstration at the local level.

In this study, sample respondents were ask to suggest on the current agricultural extension system functioning in their respective *kebeles* or in the district. Accordingly, the findings revealed that, 56.6% of sample households had accessed extension service during 2023, based on the DAs operational guideline declared by MoARD (2009). The operational manual dictates that every farm household has the right to receive extension service, technical support and advice at least once in two months and six times a year, and at most once a month through assigned extension agents. Thus, farm households who have made purposeful contact with DAs at least six times a year named "extension accessed."

In the district, Chiro district office of agriculture is extension organization responsible for agricultural extension service representing Zonal office of Agriculture, regional level BoA and the Federal ministry of agriculture (MDPADO, 2023). Assessment done on the quality of extension service as one of the important focuses of this study indicated that, 56.6% of sample households had accessed extension service. However, it must be born in mind that it only attempted to observe the level of farm household is reaction towards the quality of extension service currently functioning in the study area.

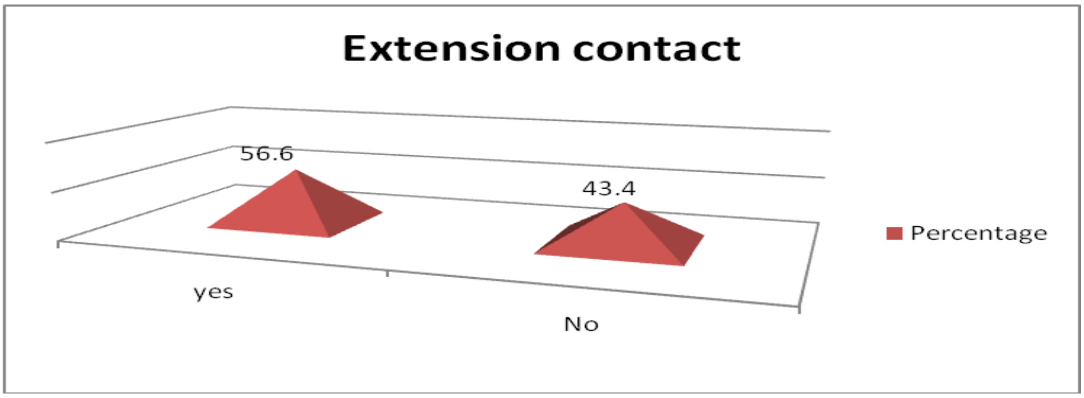

Figure 19.Frequency of extension contact
(Source: Own survey, 2024)

4.1.3.5. Climate information

The study's conclusions verified that the district now has two different kinds of early warning systems in place. These are the early warning systems (EWS), both official and informal. Based on the hierarchy from the regional Busa Gonofa agency to district offices, the formal early warning system in the study area is active at the zonal and district levels and managed by Busa Gonofa offices at those levels. The district administrator is in charge of the formal EWS in the study area, and the head of the district Busa Gonofa office serves as secretary.

The formal EWS tasked with gathering, organizing, analyzing, interpreting, and communicating information to the district level EW taskforce. The following important areas are the focus of these areas.

- ***Rainfall performance***: on set, off sets, distribution, amount, pattern, predictability, continuity, cessation as compared to the previously known normal year(s);
- ***Crops and cropping activities***: land preparation, seed sowing, damage (if any), inputs use and monitoring of crops stages, and targets and achievements;
- ***Water and pasture*****:** availability/scarcity;
- ***Livestock movement*****:** in search of pasture and water; if disputes happen to occur due to scarcity;
- ***Market price*****:** livestock and grain markets, cash crops (demand and supply), fuel, transportation;
- ***Human and livestock health status*****:** health services, disease outbreaks and actions taken; quality of water for humans and livestock; damaged water points (if any);
- ***Cattle body condition*****:** normal or less than normal**,** and any impact on plowing of farm lands;
- ***Major food crops yield estimates***: deviation from targets or results of previous years;
- ***School enrollment*****:** or drop out, etc.
- ***Nutrition status****:* for pregnant and lactating mothers, and malnourished children and aged people;
- ***Beneficiaries***: of productive safetyent programme and relief distributions for transitory status (availability/scarcity of food resources);
- ***Hazards:*** drought, flood, land slide, conflict and displacement, fire hazard (magnitude and frequency), damage level and measures taken;

Overall, the analysis's findings demonstrated that, out of the 145 sample families who took part in the study, only 44.1% had access to knowledge about climate change in 2023. This outcome linked to a household's closeness to Busa Gonofa, district offices of agriculture, and DAs. Additionally, during the study period (2023), farm households with greater education and access to radio and television programming also obtained climatic information. Conversely, participants in focus groups and knowledge interviews revealed that the Busa Gonofa district office connected to an EW committee at the kebele level, which led by a local administrator, or kebele chairperson.

The committee consists of eight to ten people, including the lead DA for the kebele, the school director, the health extension agent, elders, traditional forecasters, the women's and youth affairs representatives, the manager, and any NGOs operating in the kebele. The kebele EW committee gathers information from every village in the kebele every day and reports it by phone to the district Busa Gonofa office every three days. This is the method of information communication and distribution at the kebele level.

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Similarly, on a weekly basis, the zonal Busa Gonofa office receives a written report from the district Busa Gonofa office, which has compiled the data obtained. Written reports sent on a weekly and monthly basis by the zonal office of Busa Gonofa to the regional and federal Busa Gonofa agencies. On the other hand, in order to respond to any emergency scenario that occurs, prompt contact in two ways by phone and online must be established on a daily or weekly basis.

Although, the district office of Busa Gonofa had the responsiblity to regularly notify and communicate EW information to the local community members, there exist bigger gaps due to the absence of any established link between the office and community because of lack of skilled work force, logistics and finanacial limitations. Instead, farm households often times use traditional forecasters to predict for rainfall condition in the upcoming rainy season.

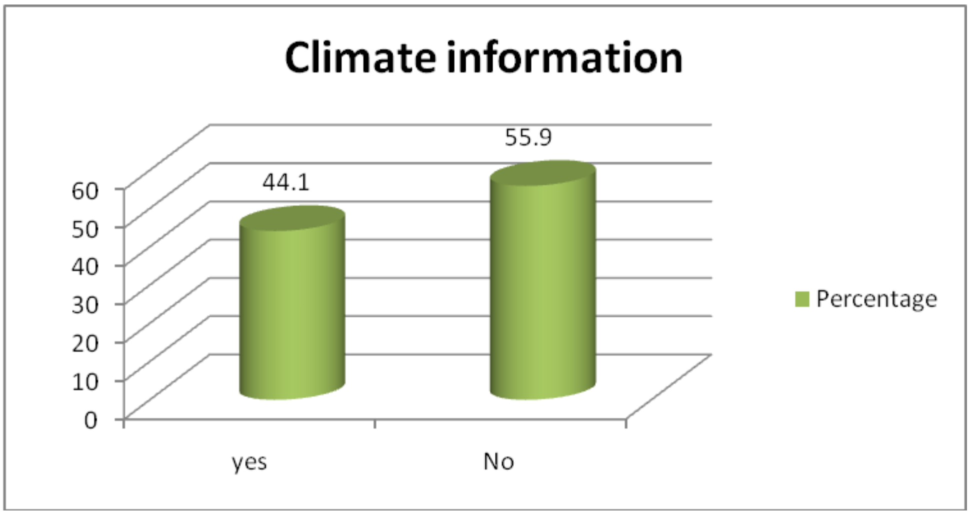

Figure 20. Access to climate information
(Source: Own survey, 2024)

4.2. Effects of Climate Change

In this study, sample respondent households were asked to opine the main effects of climate change on smallholder farmers' livelihoods on four-points scale to elicit the degree of effects as 4= High effect 3=Moderate effect 2= Low effect 1 = No effect from list of items carefully constructed based on suggestions of farmers' and relevant literature. Assess the perceived effects of climate change on farmers' livelihoods, using a weighted average index to rank the impact of various climate-related factors Alemayehu, A., and Haji, J. (2021) used to calculate index values and rank each response variable for adaptation strategy.

4.2.1. Effects of Climate Change on Agriculture

According to Thornton *et al.* (2021), climate change-related variations in temperature and rainfall patterns have an impact on feed availability, grazing ranges, feed quality, and the frequency of weeds, pests, and illnesses. Climate change-driven increases in pests, diseases, and heat stress are adversely affecting both crop and livestock production in many regions of the world according to Arias,P. et al. (2023). Temperature extremes and fluctuations in the quantity and quality of herbage throughout the year will have an influence on the health of cattle, lowering productivity and decreasing the effectiveness of reproduction (Obeidat B and others, 2020).

Important meteorological variables like temperature and rainfall are impacted by climate change, which has a direct impact on agricultural output and productivity (Biruk, A., and Tadesse, T. 2022; Alemayehu, A., and Haji, J. 2021).

The main goal of this study was to find out how smallholder-farming households perceived the possibility of a connection between agriculture and climate change. The vast majority of participants in the focus group discussions acknowledged that there is a connection between agriculture, encompassing the production of crops and livestock, and climate change. For example, they link higher rainfall to higher crop yields and livestock goods like milk and meat as animals breed during the rainy seasons. Conversely, during the dry season, there is a decrease in crop and livestock production because of the drought, and livestock may perish from severe torrents.

Table 3. Effects of climate change on agriculture

No	Description of effects	Level of effects					
		High	Modrate	Low	No effect	WAI	Rank
1.	Severe shortage of soil moisture during growing seasons	114	27	4		2.50	1
2.	Reduced crop yields	114	26	5		2.49	2
3.	Damages to crop fields due to flooding	87	41	13	4	2.23	6
4.	Increased reduction in water and feed availability for livestock	78	61	4	2	2.25	5
5.	Land degradation and fertility deterioration;	93	48	2	2	2.36	3
6.	Reduction in milk production	85	54	1	5	2.27	4
7.	Reduction in meat production	69	60	11	5	2.11	7
8	Reduction in the productive performance of cattle resource	68	62	9	6	2.09	8

Source: Own survey, 2024

The investigation found that a significant loss of soil moisture during growing seasons—which had an index value of 2.50—was the biggest effect of climate change on agriculture. One of the detrimental effects of climate change on crop production, according to sample houses, was decreased agricultural output. Studies show that the effects of climate change on agriculture are significant, with lower rainfall and higher temperatures being major contributors to lower agricultural yields Roberts, M. J., and Schlenker, W. (2020). Crop yields are greatly impacted by climate variations, such as temperature extremes and erratic rainfall patterns, highlighting how susceptible agricultural systems are to abrupt climate shifts S. Kumar and colleagues (2023). With an index score of 2.49, crop yield reductions coin me in second among the main effects of climate change. With an index value of 2.36, declining fertility and land degradation rank third among the primary effects of climate change in the study area.

A severe shortage of soil moisture, declining crop yields, and ongoing land degradation are interconnected challenges that place immense pressure on smallholder farmers, trapping them in a cycle of poverty and food insecurity (Tadesse and Abate, 2023). One of the most immediate consequences is reduced crop yields due to insufficient moisture, which shrinks the food supply and drives up prices, making it even harder for communities to access proper nutrition.

For smallholder farmers, these lower yields translate into economic hardship, as declining incomes make it difficult to invest in their farms, purchase essential inputs, or support their families. At the same time, continuous farming without effective soil management accelerates land degradation, further reducing long-term productivity. Additionally, intensive agricultural practices can lead to biodiversity loss, which weakens ecosystem resilience and further threatens food security. To break this cycle, sustainable agricultural practices and strong policy support are essential. Without these interventions, the situation will likely worsen, deepening poverty, increasing food insecurity, and leading to broader societal challenges (Zhou et al., 2022). Investing in resilient farming techniques and providing smallholder farmers with the resources they need is critical to ensuring a more secure and sustainable future.

For example, higher rainfall boosts the production of livestock goods like meat and milk, and animals procreate during the wet seasons, according to the sample respondents. Conversely, because of the drought and the risk of cattle death from strong floods, livestock productivity decreases during the dry season. Temperature variations affect dairy cow performance, with Krysiak, K., *et al.* (2024) reporting that higher temperatures, especially above 24°C, result in lower milk yields in high-producing cows. This is the fourth-ranked main effect of climate change With an index value of 2.27 in the study area.

According to Rhoads *et al*. (2019), heat stress alters the body's water balance and cell osmolarity and increases fluid loss through perspiration and panting.Shambel (2017) found that milk output could drop by 0.2 kg for every unit increase when the temperature humidity index (THI) exceeded 72. But it's a well-known fact that the fluctuation of rainfall typical of arid and semi-arid locations has a significant impact on the quantity and quality of fodder and forage available for cattle consumption (Abdu *et al*. 2020).

The study area's fifth-ranked effect of climate change is a greater shortage of water, with feed availability for livestock index scoring 2.25. The productivity of livestock is greatly impacted by increases in feed reduction and water availability.

The consequences of climate change on grazing systems, pointing out that the availability of pasture and water, which are increasingly threatened by climate change, are crucial for livestock production J. Schröder and colleagues (2023). A report was also available regarding the increase in flood hazards over the past few decades. Flood threats that occurred in different parts of Ethiopia in 1988, 1993, 1994, 1995, 1996, and 2006 as well as in 2009, 2015, 2019 and 2020 are examples of such indicators (NMI, 2020). These flood dangers have not only claimed lives but also required the annihilation of livestock and crops. Additionally, the study area's sixth-place ranking for the effects of climate change on smallholder farmers' livelihoods achieved by crop field damages caused by floods, with an index value of 2.23.

Taffesse, A. S., and Dorosh, P. A. (2020), who offers evidence to support these findings, demonstrate the relationship between climate change and agricultural productivity in Ethiopia. They show that small-scale subsistence farmers in Ethiopia are primarily influenced by climate variations, which increases food insecurity and stress. The effects of climate change on Ethiopia's rural livelihoods, with a focus on the difficulties small-scale farmers confront because of climate unpredictability and the necessity of effective adaptation strategies Kebede, A. H., *et al.*, (2024).

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Furthermore, declines in meat output and livestock's ability to reproduce rank seventh and eighth, respectively, among the study area's effects of climate change, according to the analysis's findings, with index values of 2.11 and 2.09. While adequate nutrition and energy reserves are necessary for fertility, poor nutrition has a direct impact on cattle fertility (Mason, J. W., *et al*. 2023; Duncan, A. J., *et al.*, 2021), inadequate nutrition can lead to infertility and reproductive anomalies, including issues related to starvation and obesity. Abnormalities in the reproductive system and infertility associated with obesity, wasting, and malnutrition.

Participant households in FGDs and KIIs also reinforced the opinions and viewpoints of sample households in diverse approaches to the discussion topic. With significant fluctuations related to changes in rainfall, rising temperatures are predicted to extend the growing season for forages but reduce their quality. Furthermore, the effects of rainfall variability on food security in Ethiopia, documenting how fluctuations in rainfall patterns significantly affect agricultural productivity and, consequently, the economy Mastrorillo, M., *et al*. (2021).

4.2.2. Effects of Climate Change on Health Crop and Livestock

The elevated temperature has increased the infestation of the aphid population on crops and ultimately reduced yield (Tian et al., 2019).

In general, parasites and diseases that spend a part of their life cycle outside the host develop more quickly in warmer and more humid environments. The WHO (2024) report highlights the health concerns connected with flooding and emphasizes the rise in waterborne infections that follow extreme weather events. It also discusses how drought conditions can restrict the development of certain diseases. Wind shifts affect the movement of germs. the effects of both flooding and drought on the patterns of infectious diseases, coming to the conclusion that while drought can slow the spread of other infectious diseases, flooding greatly raises the danger of waterborne illnesses A. Lopez *et al.* (2023). Various environmental stressors, such as heat and a shortage of food and water, can have a detrimental effect on host immunity and increase susceptibility to illnesses, according to Mastrorillo, M., *et al.*, (2021). Extended dry seasons raise the risk of heat stress and poor feed availability in cattle, which raises the disease rate in animals Mason and colleagues (2021).

Climate variability causes variations in temperature and rainfall, which have an impact on the life cycles and dispersal of vectors and raise the risk of vector-borne illnesses A. H. Khan and associates (2022). This study investigated the main effects of climate change on agricultural and livestock health. The weighted average index (WAI) is used to calculate and rank each response variable for Effects of climate change on health, agriculture, and animals based on the opinions of sample houses. The analysis's conclusions are shown in the table below.

Table 4 **.** Effects of climate change on health Crop and livestock (N = 145)

No.	Description of effects	Level of effect					
		High	Modrate	Low	No effect	WAI	Rank
1.	Occurance of crop disease,insect and pest	79	48	10	8	2.37	1
2.	Prevalence of new contangious disease	78	47	12	8	2.34	2
3.	Increase death of livestock	66	56	19	4	2.27	3
4.	Occurance of livestock disease	69	50	21	5	2.26	4

Source: Own survey, 2024

The occurrence of crop diseases, insect infestations, and pest outbreaks significantly hinders agricultural sustainability and food security in the study area, particularly in the context of changing climate conditions. Climate change has altered rainfall patterns and increased temperatures, creating favorable environments for pests and diseases Hailu, G., Alemayehu, K. (2020). While warmer temperatures can extend growing seasons, they also accelerate pest reproduction, leading to higher infestations and substantial yield losses from diseases like wheat rust. Farmers, especially smallholders, face financial strain when investing in pest control measures. Crop losses disrupt supply chains, raise food prices, and reduce dietary diversity, leading to nutritional deficiencies Mekonnen, D., Hailu, G. (2022). Additionally, decreased yields of fodder crops negatively impact livestock health, as poor-quality feed can weaken their immune systems and increase vulnerability to infections. Climate change exacerbates both crop diseases and livestock diseases by creating favorable conditions for pathogens and pests in the study area.The interconnectedness of crop and livestock health underscores the need for comprehensive management strategies to ensure overall agricultural resilience in the face of climate change Hailu, G., Tadesse, A. (2023).

In the study area the primary health effects of climate change were occurrence of crop disease, insect and pest index value 2.37 and similar studies have demonstrated a direct correlation between insect pests and diseases and higher temperatures and carbon dioxide levels in production (Iannella *et al.,* 2021; Tan *et al*., 2021; Tonnang *et al*., 2022). Farmers in the study area mentioned that delays in rainfall increased the occurrence of pests and diseases, harming plant health considerably and lowering yield levels of the staple crop. The main problem of crops in the study area were Occurrence of disease and pest attack crop mainly at the beginning of germination ,vegetative stage ,at flowering stage and grain filling stage this result agree with (Gosa ,2016).

Major disease of maize were honey dew, Major disease of sorghum were smut, Major disease of onion and potato were rust and Major crop pest stalk borer for sorghum, termite for maize and sorghum and Control method for this crop pest that used by farmer of study area were at vegetative stage spraying DDT and Malatheyne.

In addition, Prevalence of new contangious disease diseases and livestock deaths, with index values of 2.34 and 2.27, respectively, rank second and third in terms of their impact on health, while the occurrence of livestock diseases ranks fourth, with an index value of 2.26. FAO (2021) reports that there is a considerable worldwide burden of animal diseases and those environmental changes, such as climate change, have an impact on animal health, exacerbating pre-existing conditions and promoting the creation of new ones.

Climate variability causes variations in temperature and rainfall, which have an impact on the life cycles and dispersal of vectors and raise the risk of vector-borne illnesses A. H. Khan and associates (2022). The frequency of FMD in pastoralist environments in East Africa, emphasizing the disease's substantial effects on cattle health and the financial difficulties pastoralist communities suffer as a result of it M. A. Khan *et al*., (2021).

The wider effects of climate change on diseases carried by vectors, highlighting the possibility that rising temperatures can cause different arthropod vectors to feed more frequently, thereby intensifying their role in the spread of disease. J. A. Patz and colleagues (2023), The NAPA (National Adaptation Programme of Action) (2021) report highlights the major threat to the human health sector and describes the risks posed by climate change, particularly the movement of malaria vectors into higher altitudes. It also highlights the substantial impact of malaria on child mortality, noting that up to 20% of deaths in children under the age of five can be attributing to malaria.

The distribution and prevalence of agricultural pests and illnesses are also impact by climate change, with increasing temperatures and extreme weather events having the potential to cause changes in insect populations and disease outbreaks in crops and livestock A. H. Khan *et al*., (2021). This study investigates how changes in vegetation cover brought on by climate change can exacerbate the risk of agricultural dryness by increasing soil erosion and decreasing soil moisture Beyene, A. D. *et al*., (2023).

These factors also raise the possibility of crop losses due to flooding and have an impact on the dynamics of livestock illnesses and their vectors. WHO (2020) report discusses the influence of climatic factors, particularly rainfall, on the distribution and abundance of mosquito populations, highlighting its implications for public health and disease prevention.

Furthermore, this study tried to assess the prevalence of livestock diseases outbreak seen in the study area since the last few years. Figure 21 below illustrates the types of diseases encountered as recent as 2023/2024 drought and famine year in *Chiro* and surrounding areas. These include Anthrax (*Awwaara*) 43.42% %, Pasteurellosis (*Goroorsaa*) 19.31 %, Bovine 9.06 %, Blackleg (*Qaankaa*) 27.77 %, Mastatis .0.074% and Rabis (*Dhukkuba saree maraatte*) 0.35 % that were highly prevalent diseases.

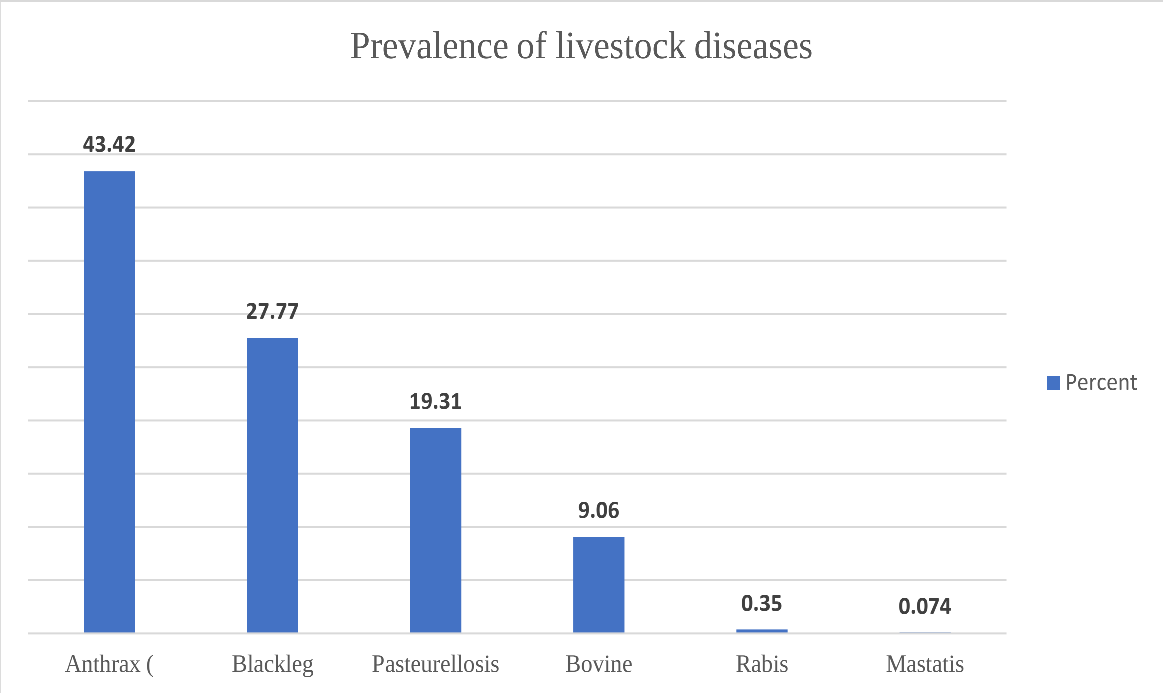

Figure 21. Prevalence of livestock diseases

Source: Own survey, 2024

The relationship between crop diseases and livestock health in Ethiopia illustrates a complex web of interactions that can exacerbate the prevalence of contagious diseases Hailu, G., Tadesse, A. (2023). Addressing these challenges requires an integrated approach that considers the health of both crops and livestock, promotes sustainable farming practices, and enhances the resilience of farming communities against climate change and disease outbreaks. Strategies such as improved veterinary care, diversification of crops and livestock, and sustainable agricultural practices are essential for breaking this cycle and promoting overall agricultural sustainability and food security Mekonnen, H., Tesfaye, K. (2022) . Overall, this study also tried to corroborate the result of analysis of data obtained through household survey, secondary data review, FGDs and KIIs carried out in the process.

4.3. Adaptation Strategies

Smallholder farmers’ are vulnerable to climatic and non-climatic induced stress that caused high income and consumption fluctuations (GAO and Mills, 2018). Climate change adaptation is site-specific, and the institutions and socioeconomic context of a given area play a mediating and translating role in the effects of external interventions aimed at facilitating adaptation to climate change (Bekele *et al*., 2020). Various farm-level adaptations exist, particularly for developing country smallholder farmers (Assefa *et al.,* 2021). In this study, to rank the importance of adaptation strategies in the study area, 16 adaptation strategies with a 4-point Likert scale were prepared, and then the households were interviewto rank the degree of importance as [not important (1), slightly important (2), moderately important (3), and highly important (4)]. Weighted Average Index (WAI) as reported earlier (Williams *et al.*, 2019; Simotwo *et al.,* 2018), calculated the relative importance of climate change adaptation.

Table 5. Adaptation strategies

No	Description of adaptation strategy	Degree of importance					
		Very important	Moderate Import-ant	slightly important	Not important	WAI	Rank
1.	Soil and water Conservation	108	14	8	15	2.48	1
2.	Crop diversification	74	38	26	7	2.24	2
3.	Improved crops	77	33	25	10	2.22	3
4.	Livelihood diversification	64	59	12	10	2.22	4
5.	Drought resistance crop	78	22	29	16	2.12	5
6.	Change crop variety	63	35	27	20	1.97	6
7.	Planting early maturing crop	50	48	35	12	1.94	7
8.	Improving livestock varieties	55	27	38	25	1.77	8
9.	Use of Durable Crops (short term varieties)	44	32	44	25	1.66	9
10.	Reduce number of livestock	24	39	67	15	1.50	10
11.	Use of rain water harvesting technology	22	42	60	18	1.48	11
12.	Livestock vaccinations and treatment	26	44	47	28	1.47	12
13.	Temporary migration	22	40	54	29	1.38	13
14.	Use of wild foods	19	35	73	18	1.38	14
15	Irrigation	19	36	59	31	1.29	15
16	Planting trees	6	23	55	61	0.82	16

Source: Own survey, 2024

Soil and water conservation practices are vital for strengthening the resilience of farming systems.They enhance soil health, boost water availability, control erosion, foster biodiversity, empower communities, and ensure economic stability, leading to a more sustainable agricultural environment. Integrating these practices into agricultural planning is essential for developing resilient systems that can withstand climate change and other challenges due to this soil and water conservation was the first ranked key adaptation strategy currently practiced by smallholder farm households (index value 2.48).

In agricultural fields, building soil and stone bunds is a common technique to enable and improve soil moisture during periods when cultivated crops experienced a lack of rainfall. The study evaluates the effectiveness of soil and stone bunds in enhancing soil moisture retention and improving crop yields during periods of low rainfall in eastern Ethiopia, highlighting their role in drought management Tadesse, T., *et al.,* (2021). Using crop diversification ranks as the second most popular adaptation strategy (index value: 2.24). This finding is consistent with the findings of Mastrorillo, M., *et al.,* (2021) and Khan, A. H., *et al.,* (2022). That farm households in Ethiopia's lowlands adopt practices such as choosing and planting new varieties of crops; various studies on crop diversification, concluding that diversifying crop systems significantly improves resilience against climate-related shocks while maintaining productivity (A. Smith, L. M. Jones, *et al*., 2022)

Adaptations of short cycle drought resistant crop varieties, such as maize, sorghum, haricoat bean, wheat, and the like, is the main emphasis of improved crop varieties and techniques. In addition, there is cultivation, weeding, count our plowing, and crop protection. The study area's third-ranked adaptation method to the negative consequences of climate change is improved crops, with an index score of 2.22. Furthermore, with an index value of 2.22, livelihood diversification is the study area's fourth-ranked critical adaptation strategy to the effect of climate change.

The importance of income diversification as an adaptation strategy for vulnerable households, noting that activities such as wage employment, fuel wood collection, and livestock trading are commonly pursued to reduce reliance on agriculture Khan, A. H., *et al.* (2022). FAO (2020) report discusses various adaptation strategies, highlighting the need for income diversification for lower-class households, particularly through activities such as wage employment, fuel wood collection, and livestock trading to mitigate the effects of climate change.

According to Hailay (2019), there is a high degree of fluctuation in the commencement and cessation timings of rainfall, which could lead to an unpredictable duration of growing season. Local indigenous adaptation techniques with national strategies, finding that local approaches are more effective in addressing specific community needs and environmental conditions Mastrorillo, M., *et al.,* (2022). In the research area, smallholder farm households adopt drought resistance crops (index value 2.12) as their fifth-ranked key adaptation technique to mitigate the adverse consequences of climate change. Changing crop variety (index value of 1.97), planting early maturing crops (index value of 1.94), improving livestock varieties (index value of 1.77), and using short-term varieties (index value of 1.66), which are ranked sixth to ninth in the study area.

Additionally, Studies collectively illustrate the diverse strategies employed by pastoralists in the Somali region, including livestock immunization and various feeding practices, to enhance animal productivity and resilience in the face of environmental challenges. The vaccination practices of pastoralists in the Somali region, highlighting the importance of livestock immunization in improving animal health and productivity. Abdi, A. M., *et al.,* (2021). The primary adaptation strategies ranked tenth to sixteen include reducing the number of livestock (index value of 1.50), using rainwater harvesting technology (index value of 1.48), vaccinating and treating livestock (index value of 1.47), temporary migration (index value of 1.38), using wild foods (index value of 1.38), irrigation (index value of 1.29), and planting trees (index value of 0.82).

Rainwater storage for supplemental irrigation of agriculture fields during late start and early cessations of rainfall provided by wells, family ponds, roof catchment harvesting at homesteads, and community ponds. In addition, water harvesting as one of the most popular adaptation approaches among farmers, emphasizing its effectiveness in enhancing water availability and improving agricultural resilience Mastrorillo, M., *et al.,* (2021). Additionally, by increasing household income, intercropping high-value crops like haricoat beans with maize or sorghum as the primary crop is a better adaptation strategy to lower the risk of rainfall unpredictability and volatility.

Reducing the number of grazing cattle and sheep while maintaining mixed herds of camels and goats can enhance resilience against climate change impacts, including drought and disease outbreaks Hassan, A., *et al.,* (2021) One crucial tactic for preparing for drought hazards is to change the composition of herds to include more drought-tolerant goats and camels.

Certain adaptation strategies among farmers in study areas can be influenced by a variety of factors, including local knowledge, economic barriers, and resource accessibility. Resistance to change often stems from adherence to traditional practices, limited awareness of new strategies, and economic constraints that hinder investments in new technologies. Additionally, a lack of access to quality agricultural inputs and extension services impedes the effective adoption of these strategies. To improve acceptance and implementation of adaptation strategies, it is essential to engage farmers in the development process, respect local knowledge, provide financial and technical support, enhance infrastructure, and create supportive policies tailored to community needs Moges, A., Hailu, Y. (2022). FGDs and KIIs also reinforced these opinions in the discussion.

4.4. Determinants of Choice for Adaptation Strategies

Farmers perceive the effects of climate change and employ adaptation strategies in a sustainable manner; however, they also believe that household demographic, institutional, and socioeconomic factors influence their decision not to adopt adaptation strategies Amogne *et al., (*2018).

Infrastructure and institutions, together with economic success, technology, knowledge, and skills, are the main attributes of towns or communities that seem to affect their capacity for adaptation. Agro-ecological conditions, socio economic problems, and demographics were some of the factors that influenced farmers' decisions about adaptation strategies (Getachew *et al.*, 2021). In this study, the adaptation measures were categorized into four independent choice sets: Soil and water conservation, Crop diversification, improved crop varieties and livelihood diversification.

As can be showed in the figure below the four categories of adaptation options were adopted that is Soil and water conservation 42.8%, Crop diversification 37.2%, Improved crops varieties 11.7% and Livelihoods diversification 8.3% of sample households in that order. Thus, 15 explanatory variables were select for multinomial logistic regression adaptation model. These include, sex, age, education, family size, farm experience, land size, Livestock herd size, sourceof household income, membership in social organizations and networks, credit service accessed, farm inputs used, proximity to market (s), extension contact accessed and access to climate information by smallholder sample households.

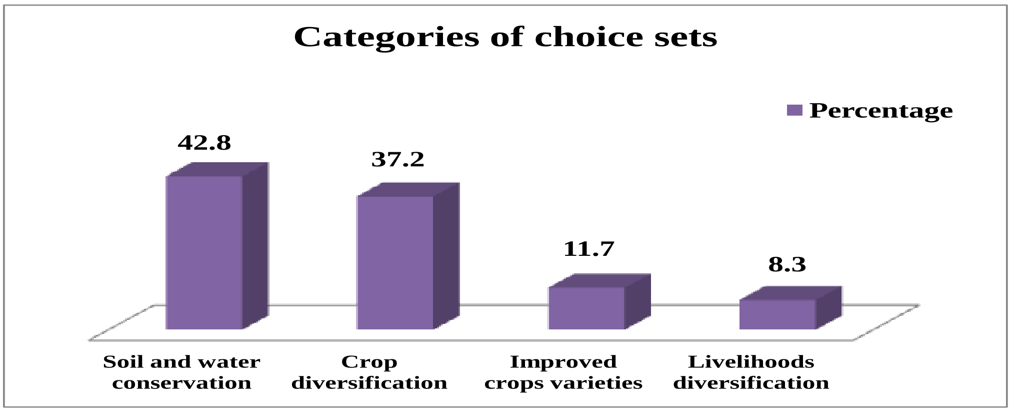

Figure 22. Categories of choice sets
(Source: Own survey, 2024)

The multinomial logit model of sample household is adaptation strategies estimated, inwhich households choose from a number of mutually exclusive adaptation strategies pursued in their contextual settings. The results of maximum likelihood estimation of parameters of multinomial logit of climate change adaptation model presented in table 6 below. Regression coefficients and their significance levels from the MNL model demonstrated in the table.

The predictors incorporated into the model at the following iteration. Since the objective is to minimize the log probability, the log likelihood drops iteration. The model considered to have "converged" when the difference between subsequent iterations is relatively tiny; this is the fitted model's log likelihood (Scott, 2005). It utilized in tests of nested models and the Likelihood Ratio (LR) Chi-Square test to determine if all predictors' regression coefficients in the model are concurrently zero.

Therefore, at least one of the predictor's regression coefficients is not equal to zero, according to the LR Chi-Square test for the four equations (Livelihoods diversification relative to soil and water conservation, Improved Crop Varieties relative to soil and water conservation, and Crop diversification relative to soil and water conservation). A predetermined alpha threshold, set at 0.05 or 0.01 is compared to the p-value from the LR test, which is <0.00001.

Seven (7) of the total fifteen explanatory variables were found to be statistically significant in influencing the likelihood that farm households will choose improved crop varieties, soil and water conservation, crop diversification, and livelihood diversification as their methods of adapting to climate change. Consequently, it is possible to draw the conclusion that the multinomial logit model's results show that a variety of institutional, infrastructure, demographic, and socioeconomic factors influence the likelihood of choosing adaptation solutions to climate change effects that are mutually exclusive.

As will be covered below, these include factors like age, family size, income source, membership, credit obtained, access to water, and extension contact, which are important at the 1% and 5% likelihood levels. Conversely, farm experience, gender, and sample household head's educational attainment, total cash income, accessibility to climate information and market proximity, size of livestock herd, and farm input do not statistically significantly explain farm households' decision to climate change adaptation either positively or negatively.

Table 6. Parameter estimates of the multinomial logit adaptation model

Explanatory variables	Livelihoods diversification		Improved crop varities		Crop diversification	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Age House Hold	.415***	.003	0.228	0.137	.063	.271
SEXH=1	1.833	.366	-1.363	.384	1.110	.164
FSIZE	-.971	.086	-.880	.114	-.787***	.003
Education level	20.352	.998	5.246	.999	21.289	.998
Farm experience	-.142	.867	-.005	.964	-.031	.461
Landholding size	-6.741	.094	-2.538	.470	.859	.548
Livestock herd size	-.031	.834	-.135	.447	.114	.131
Income Source	-1.958	.141	-6.390**	.048	18.586	.997
Membership	4.061**	.030	6.984***	.001	.292	.692
Access to credit	-4.025**	.033	-2.858	.060	.111	.878
Farm inputs use	-3.621	.119	.384	.843	-1.874	.084
DSTM	-.019	.659	.075	.120	.009	.683
Extension contact	5.089**	.024	4.606**	.023	1.335	.076
Marsial status	-16.703	.261	15.584	.998	.121	.940
AWSA	-.097	.939	2.320**	.049	.178	.772
Constant	-29.126t	.997	-30.360	.997	40.315	.997
Diagnostics:						
Base category: Soil and water Conservation						
Number of Observns:	145					
LR Chi-Square)	135.899					
Prob>Chi^2:	.000					
Log likelihood:	199.937					
Pseudo R-Square:	0.675					

***, **, * = significant at 1%, 5%, and 10%, respectively.

Source: Survey output, 2024

Age: The result indicated that age had positive and significance levels at 1%, correlation with Livelihoods diversification. Interpretation of the odds-ratio implies that if other factors are held constant, the odds-ratio in favors of the probability of the household to choose on-farm and non-farm income-generating livelihood strategies of the household increases by a factor of 1.515 times higher than Soil and water Conservation as the age of the household increases by 1 year. Hence, increasing rural households' remittance income plays a vital role for enhancing and smoothing household consumption problems, strengthening social capital, increasing savings and investment, helping households gain access to diversified opportunities like trading, and then being able to improve their livelihood. The result of this study is consistent (Njeri, M.and Mwangi, J., 2023) and contradicts with (Alhassan, A. and Wang, L.2021).) The probability of participating in non-farm activities in rural areas decreases with increasing the age of the household head

This showed that, for age, the probability that use Livelihoods diversification compared to base categories Soil and water Conservation 60.2% and the remaining used Soil and water Conservation were 39.8%.

Family size: Family size negatively influenced the choice for Crop diversification, at 1% significance levels. Interpretation of the odds-ratio implies that if other factors are held constant, the odds-ratio in favors of the probability of the household increase in 1 (one) adult lab out of a family size, the chance to choose of Crop diversification 2.2 time lower than the chance Soil and water Conservation. This result similar with the finding of (Mensah, J. and Osei, R.2023; Kassa, Y. *et al*.,2022) who agree that farmers having a larger family size might divert part of its labor into non-farm economic activities to generate additional income and larger family sizes are associated with less crop diversification, potentially due to resource constraints and labor allocation issues. Contradicts with households with larger family sizes are more likely to invest in improved crop varieties and sustainable practices due to increased labor (Moges, A., and Tadele, G. 2022). Stated Households who have a larger family size have an opportunity to practice various adaptation options in the face of climate change. Thus, its positive and significant sign clearly shows that the larger the family size, the higher the probability for responding to reduce the effects of climate change and variability.

This showed that, for Family size, the probability of using Crop diversification compared to base categories Soil and water Conservation 31 % and the remaining used Soil and water Conservation were 69 %.

Income Source: It increased the chance of implementing income from Sale of livestock negatively influenced Improved crop varieties significant at 5%. A unit increase in Sale of livestock income decrease the chance of implementing improved crop by 50 time lower than the chance Soil and water Conservation. The reason could be farmers with high Sale of crop produce income might have higher possibility to invest more time in crop produce and other off-farm activity to reduce the influence of climate change risks. Similarly that as the farmers' income from off-farm activities increased they devote less time to livestock hence it could negatively affect the households' adaptation to climate change. Households with higher income from livestock are less likely to implement improved crop varieties, possibly due to the perceived stability of livestock income (Alhassan, A. and Dufour, D. 2022). Contradict with the result of the study of (Mwangi, J.and Karanja, and F. 2023) who investigates how income from livestock sales influences the adoption of improved crop varieties among farmers in Kenya. The findings indicate a significant positive relationship at the 5% level, suggesting that farmers with higher income from livestock are more likely to invest in improved crop varieties, viewing it as a means to enhance overall farm productivity.

This showed that, for Income Source from Sale of livestock, the probability that use improved crop varieties compared to Soil and water Conservation 2 % and the remaining used Soil and water Conservation were 98 %.

Membership/participation in informal institutions*:* the MNL estimates showed that membership and participation in social organizations and networks positively influenced the choice for livelihood diversification and improved crop varieties, respectively, significant at 5% and 1%, . The multinomial log-odds for being a member in informal local institutions is expected to be 58 and 1.08 times higher than soil and water conservation based adaptation to climate change effects. (Alhassan, A. and Dufour, D.2021). The findings reveal that membership and participation in these networks positively influence livelihood diversification choices at the 5% level and the adoption of improved crop varieties at the 1% level because of the importance of social networks in enhancing agricultural resilience. The study investigates livelihood diversification among rural households in Ghana Suggesting that reliance on established social networks may limit exposure to innovative practices and alternative livelihoods(Osei, R. and Mensah, J.2023).

Involvement in cooperatives is positive and significantly related to adoption of adaptation strategies, implying that the probability of adaptive strategy adoption is higher for those farmers who have connections with different cooperatives enterprises compared to farmers not participating in such coordinated actions and groups. We interpret this observation as an indication that membership and engagement in a cooperative encourages farmers to engage in a united strategies orientation; farmers involved in cooperatives share knowledge and innovation ideas, discuss problems and challenges with others, and engage in collaborative decision-making.

Contradicts with (Adeagbo *et al*. (2023), who found a negative relationship between membership and the level of adoption of adaptation strategies among smallholder maize farmers in southwest Nigeria.

This showed that, for Membership, the probability of use for livelihood diversification and improved crop varieties compared to soil and water conservation 98 % and 52 % the remaining used soil and water conservation were 2 % and 48 %.

Credit accessed the MNL estimates for access to credit negative and significant at 5%, influenced farm household's choice decision for Livelihoods diversification. The multinomial log-odds for households who accessed credit compared their Livelihoods diversification 5.6 units lower than soil and water conservation based adaptation options. The result was similar to who revealed that credit access adversely affects farmers' adaptation strategies (E. Molla *et al*., 2023, (Mensah, J. and Kpogo, A. 2024). indicating that access to credit may constrain households to traditional agricultural practices, limiting their willingness to diversify. In addition, the result contradicts (Karanja, F. and Njeri, and M.2021). The findings show a significant positive correlation at the 5% level, suggesting that access to credit allows households to explore various income-generating options, thereby enhancing their resilience. A livelihood diversification strategy increases by a factor of 5.519 as access to credit increases by one. In fact, formal savings and credit institutions are available in the study area and farm households observed having high interest for credit for the purpose of reducing the problem of working capital, purchase of farm inputs and farm oxen; and to cover social obligatory expenditures. However, High interest rates, a lack of collateral, and the fear of not being able to repay debt were the main obstacles preventing the majority of smallholder farmers from using credit Woldeyes, F.B. and Adugna, T.A. (2021).

This showed that, for Credit accessed, the probability that use livelihood diversification compared to soil and water conservation 15 % and the remaining 85% use soil and water conservation.

Extension contact: the results of the MNL estimates showed that The frequency of extension visits had positive and significant impacts at 5%, influencing the choice for Livelihoods diversification and Improved crop varieties. This implies that for households with access to extension service compared to those without is higher than 16.2 units and 10 units for use of Livelihoods diversification and improved crop varieties, relative to soil and water conservation. The results agree with the findings of (Ojo and Baiyegunhi 2018; Tesfaye, W. *et al*., 2021) who revealed that extension access is positively related with farmers' adaptation of improved crop varieties. This is because farmers with more extensive access and technical assistance on agricultural activities create more awareness to adopt adaptation strategies and farmers who received climate-related information and close contact with the agricultural advisory services were willing to do whatever it takes to address climate change and pursue different adaptation strategies. These findings were consistent with previous studies that indicate the contribution of access to climate related information and agricultural extension services to choosing climate change adaptation strategies (Getahun et al., 2021; Hilemelekot et al., 2021; Kifle et al., 2022). In contrast, less accessibility to climate information and agricultural services makes them reluctant to adopt various adaptation strategies and exposes them to food insecurity.

Farmers who frequently met and discussed issues with extension services were more likely to be aware of climatic conditions. This implies that farmers with better access to information about the changing climate have a higher chance of adopting adaptation measures. This result was in line with many other similar research results that showed the relation those farmers who obtained information through extension workers were likely more informed about the climatic situation and the responses that followed. contradict with (Amare and Simane, 2017; Baffour-Ata *et al.,* 2023; Demem, 2023) , the results also show that access to extension services is negatively and significantly associated with the uptake of climate change adaptation strategies. This implies that access to extension services from the government or other service providers reduces the probability of households using adaptation strategies. This finding was unexpected as extension services expected to create awareness and provide knowledge and information regarding different adaptation strategies, as reported in previous studies.

This showed that, Extension contact, the probability that use Livelihoods diversification and improved crop varieties compared to soil and water conservation 94 % and 91% the remaining used soil and water conservation 6 % and 9 %.

Access to Water Source (AWSA): The results of the MNL estimates showed that access to water positively and significantly at 5%, influenced the choice for Improved crop varieties at significant level. This implies that for households with access to Water Source compared to those without is higher by 1.078time than soil and water conservation. Amount of water point (excavated pond and dam, ground water from spring or wells and masonry tank) accessed by the household. It assumed that those Households access to plenty of water sources are more likely to practice adaptation options than those who have less access to water source.similar research the majority of focus group discussion argued that irrigation has a positive effect in terms of increasing water for crop and livestock production. Irrigation indeed increases access to water for growing diverse crops, thereby maximizing crop production (B.K. Kurgat et al, 2020). Similar research in Sub-Saharan Africa It finds that households with greater access to water points, such as dams and wells, demonstrate higher frequencies of adaptation strategies in response to climate variability, supporting the hypothesis of a positive correlation (Nkosi, T., and Ochieng, C 2023). Communities that possess strong adaptive capacity are more capable of effectively managing water resources in the face of climate variability. They achieve this by investing in infrastructure, implementing sustainable farming practices, and improving water conservation efforts. Several factors that impact a community's adaptability include financial resources, access to technology, governance structures, education levels, and social networks. In contrast, farmers with limited adaptive capacity are more susceptible to fluctuations in water availability. Conversations with participants revealed that those without adequate infrastructure or financial means struggle more significantly to deal with droughts or floods. Consequently, sound water resource management and cohesive climate adaptation strategies are crucial for promoting sustainable development Mekonnen, Z., Kassa, H. (2022).

This showed that, access to Water Source, the probability of using improved crop varieties compared to soil and water conservation 51% and 49% the remaining used soil and water conservation.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

The necessity of putting adaptation strategies into practice differed depending on the community and farmer. Farm households' selection of adaptation methods is influenced by factors such as their experience with the long-term effects of climate change, as well as their awareness of and ability to adjust to climate-related threats. This is because the effects of climate change may affect different regions and individuals within the same area differently. However, many empirical researches are not in the field of study that addresses this issue. Even published research frequently bases its analysis on an inadequately demonstrated causal relationship between climate change and the decision to adopt adaptation strategies depending on the specific characteristics of each farm household.

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This study aims to identify determinants of choice of adaptation strategies used by subsistence farmers to the impact of climate change. One hundred forty five (145) sample households randomly selected for household survey. FGDs, KII and field observation were used for qualitative data collection. Descriptive and explanatory research designs employed to fulfill the objectives of the study. Descriptive and inferential statistics also used to assess household, socio-economic and institutional characteristics, while the multinomial logit model (MNL) used to identify the factors influencing the choice decision for adaptation strategies to climate change effects.

The findings revealed that of total sample households, 75.2% were males and 24.8% females with mean age of 46 years. While the age category showed the proportion of sample, households found between < 36 years comprised 19.31%, 36–64 years 72.41 % and the remaining 8.27% was with ages of above 65 years.

The family size found a mean of 5.4 members, The mean distance a sample household needs to travel to reach the nearest market center was found 33.02km., while mean distance a sample household needs to travel to reach an DA office in his/her local *kebele* was found 8 km. The results of analysis on educational level indicated 57.9% were unable to read and write, this showed the majority of sample farm households lack literacy and numeracy.

Of the total households interviewed, 53.8% have participation in formal and informal social organizations in their local community. The mean land holding size of a sample household was .42 ha. The results of analysis on livestock herd size by sample households showed mean score 6.81TLU. The findings revealed that the mean annual household income is ETB 15693.59 with standard deviation value of 6857.37. The principal income sources include sale of crops, sale of livestock and livestock products, cash crop and nonfarm employment. Namely, (48.3%) from crops, production followed by livestock production (29.7%) and non-farm employment 22%. Institutional support services provided include inputs supply, credit, product marketing and agricultural extension. The findings also showed that only 44.1% of sample respondent households accessed climate related information in 2023.

The findings of the study are the main effects of climate change on crops and livestock production that affect smallholder farm livelihoods. The occurrence of climate related hazards in the study area showed (8) eight indicator variables. Increased frequency of precipitation deficit during growing seasons, untimely and intensive rainfall, household assets depletion, increased reduction of water and feed availability, severe food insecurity, land degradation and fertility deterioration, poverty (weak adaptive capacity to impacts of recurrent drought) ,Reduction in meat production and Reduction in the productive performance of cattle resource were found the main climate change effects.

This study has identified the main adaptation strategies used by smallholder households to adapt to effects of climate change under the local environment. Accordingly, a total of 16 (sixten) adaptation measures were screened. Overall, the results of analysis indicated that 85% of sample households had taken practical adaptation measures to endure livelihoods in the face of changing climate. The choice of adaptation strategies showed 42.8%, for Soil and water conservation, 11.7 % for improved crops varieties and practices, 8.3% for livelihood diversification and 37.2 for Crop diversification. Finally, 16 (sixten) explanatory variables selected for econometrics analysis of multinomial logistic regression model.

These include sex, age,marital status , education, family size, farm experience, land size, livestock holding, total household income, membership in social organizations and networks, access to credit service, access to farm inputs,access to water resource proximity to market centers, extension contact and access to climate information by a sample farm household. The dependent variable is "choices of adaptation strategies to the effects of climate change" with four dependent categories of choice sets. The multinomial logit model of sample households "adaptation strategies" estimated, in which households choose from a number of mutually exclusive adaptation strategies pursued in their contextual settings.

Regression coefficients and their significance levels from the MNL model indicated that different socio economic, and institutional factors affect the probability of selecting mutually exclusive adaptation strategies to the effects of climate change. From the total 16 explanatory variables 7 (seven) were found statistically significant to influence negatively and positively the probability of farm households' choice for climate change adaptation strategies from four mutually exclusive category sets. These include age, family size, Access to Water Source, income source, membership, credit accessed, and access to extension contact at 1% and 5% statistically significant level. On the contrary, farm experience , farm inputs used ,land size,marital status , gender, education level of household head, livestock herd size, proximity to market center , and access to climate information are not statistically significant to explain farm households' choice decision either positively or negatively.

5.2. Conclusions

The study's conclusions indicated that smallholder households in the study area are extremely vulnerable to the effects of climate change. This means that their systems for producing crops and livestock are affected by frequent flooding and droughts, which has a negative impact on crop failure, water resource loss, and livestock feed and water consumption. Deforestation and overgrazing have also contributed to land degradation, fertility degradation, and loss of water sources, as well as food insecurity and the loss of household assets. Reduced crop yields, decreased livestock production and products, underfeeding of calves, and lactating and pregnant cows are some of the effects of climate change.

Farm households respond by implementing adaptation strategies to reduce the adverse effects of climate change. From 16 (sixty) adaptation strategies, it prioritizes and selects The four adaptation strategies that most implement by the farmer : crop diversification, improved crop varieties, soil and water conservation, and livelihood diversification. Socioeconomic and institutional factors pertaining to smallholder farm households in the research area influence the decision-making process when it comes to selecting adaptation techniques to mitigate the consequences of climate change. At the 1% and 5%, statistically significant levels include age, family size, income source, membership, credit Access, access to water resource and access to extension contact. Nevertheless, there is no statistically significant relationship between farm experience, farm inputs used, land size, marital status, gender, education level of the household head, animal herd size, location to the market center, and access to climate information and the reasons behind farm households'. The government must develop a comprehensive plan to address the challenges of adaptation in farming communities. By equipping vulnerable populations with technical skills and contemporary scientific knowledge, their ability to adapt to climate change can be strengthened. It is vital for international, national, and local institutions to work together to improve irrigation, provide affordable farming inputs, secure sufficient funding and subsidies, develop better crop and livestock varieties, manage agricultural pests and diseases, and offer timely information to farmers. Policymakers should prioritize enhancing access to adult education, livestock ownership, both farm and off-farm income, affordable credit, and market opportunities in their adaptation strategies. Development Agents need to engage more actively with farmers to disseminate information about climate change and support adaptation efforts. Furthermore, offering support and affordable credit for investments in both farm and off-farm activities is essential for boosting farmers' resilience to climate-related issues.

5.3. Recommendations

Different communities and farmers had different needs when it came to implementing adaptation measures. This illustrates the need for sustainable development must also assist in reducing the effects of climate change and enable concurrent adaptation in order for them to be successful.

The study's conclusions have led to the recommendations listed below.

It is necessary to develop adaptation strategies, such as using improved crop varieties to respond to the drought environment, in order to strengthen smallholder households' capacity to adapt to changing climate conditions.

In order to increase capacity for resistance to climatic extremes, it is critical to invest in irrigation infrastructure and the creation of water stations to improve access to water resources for people and cattle.

To minimize the negative effects of climate change and increase water and feed availability for livestock the government should collaborate with non-governmental organizations?

The primary obstacle to applying adaptation strategies determined to be land scarcity, farmers should concentrate on adaptation strategies that can be performed on restricted land, such as Through fruit production, intercropping high-value crops like haricot beans, and the diversification of multipurpose trees (fodder crops), agroforestry techniques can boost the output of both crops and livestock in crop-animal production systems.

When creating adaptation strategies, policymakers in the agriculture sector should fully consider the interventions that enhance farmers' ability to obtain affordable financing, market access, farm revenue, off-farm income, and adult education. Development agents should get in touch with farmers more frequently in order to give them up-to-date information about climate change and to encourage their attempts at adaptation. Support and reasonably priced loans also made available to farmers in order to let them make adaptation investments in improved seed varieties, feed availability for livestock, and livelihood diversification. This would be crucial to improving farmers' ability to adapt to climate-related extremes.

Community mobilization for watershed management may make it simpler to mitigate and resist the harmful effects of climate change.

Generally, evaluation of the primary effects of climate change on smallholder livelihoods, identification of factors influencing adaptation strategy selection, and assessment of the main effects of climate change on smallholder livelihoods help to suggest suitable recommendations to carry out context-specific study based on specific farm household demographic, socio-economic, and institutional characteristics. Therefore, assessing socio-cultural factors like religious belief and local knowledge to improve strategies for adapting to climate change, as well as identifying potential obstacles to successful adaptation that may result from cultural differences within communities, are some of the crucial areas that require additional research.

6. REFERENCES

Abbas, M., Ribeiro, P. F and Santos, J. L.2023.Farming system change under different climate scenarios and its impact on food security: an analytical framework to inform adaptation policy in developing countries.Mitigation and Adaptation Strategies for Global Change, 28(8), 43.

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H and Younis, I. 2022. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental Science and Pollution Research, 29(28), 42539-42559.

Abdelfatah, M., and Kadous, E. 2022.An Econometrics Study of the Impact of Climate Change on the Productivity of the Most Important Field Crops in the Governorates of Egypt. Alexandria Science Exchange Journal, 43(1), 415–449. https://doi.org/10.21608/asejaiqjsae.2022.225445

Abdi, A. M., et al. 2021.Livestock immunization and management practices among pastoralists in the Somali region of Ethiopia: Tropical Animal Health and Production.

Abdulaziz, M., Yirga, G. 2023. "Cultural landscapes and climate-smart practices: The Konso experience." *Journal of Environmental Management*, 321, 115-125.

Abdul-Razak, M and Kruse, S. 2017. the adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana. Climate Risk Management, 17, 104-122.

Abera K. Crespo O. SeidJ. Mequanent F. (2018),Simulating the impact of climate change on maize production in Ethiopia, East Africa.

Adeagbo,O.A.,Bamire,A.S., Akinola,A .A., Adeagbo,A.D., OluwoleT.S.,Ojedokun,O.A ., et al 2023. The level of adaption of multiple climate change adaptation strategies: evidence from small –holder maize farmer in south west Nigeria

Adger, W. N., *et al.* 2020. "Perceptions of Climate Change and Adaptation Strategies among Rural Farmers: A Comparative Study." *Climate Policy*, 20(5), 575-590.

Adger, W. N., *et al.* 2023 ."Socio-Cultural Dimensions of Climate Change Adaptation: Implications for Rural Communities." *Global Environmental Change*, 78, 102121

Agarwal, B. 2020. "Gender Advancements and Agricultural Resilience: The Role of Women in Adaptation Strategies." World Development.

Alemayehu, A and Bewket,W.2017.Determinants of smallholder farmers' choice of coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia. Environmental Development, 24, 77-85.

Alemayehu, A., and Haji, J.2021. "The Impact of Climate Change on Agricultural Productivity: Evidence from Ethiopia." *Journal of Agricultural Science and Technology*, 23(4), 459-475.

Alemayehu, K and Molla, E. 2018. The role of economically important traits for genetic improvement and climate change adaptation in livestock production: A review. Ethiopian Journal of Science and Technology, 11(2), 145-163.

Alhassan, A. andDufour, D.2022.Research Study: "Income Diversification and Its Effect on Crop Improvement Adoption in Rural Communities".*Journal of Agricultural Economics.*

Alhassan, A.,and Wang, L.2021.The influence of age on livelihood diversification in developing countries.**Journal of Development Studies**.

Alizadeh, O. 2023. Changes in the mean and variability of temperature and precipitation over global land areas. *Environmental Research: Climate*, 2(3), 035006.

Amare, A and Simane, B. 2017.Determinants of smallholder farmers' decision to adopt adaptation options to climate change and variability in the Muger Sub basin of the Upper Blue Nile basin of Ethiopia. *Agriculture and food security*,6, 1-20.

Arias, P.*et al*.,2023. "The Impact of Climate Change on Livestock Production: Challenges and Opportunities." *Animal Frontiers*, 13(2).

Arunrat, N., Pumijumnong, N.,and Hatano, R. 2018. Predicting local-scale impact of climate change on rice yield and soil organic carbon sequestration: a case study in Roi Et Province, Northeast Thailand. Agric. Sys.164, 58–70. doi: 10.1016/j.agsy.2018.04.001

Arvas, Y. E., Yolci, M. S and Marakli, S. 2023.Investigation the effect of drought stress on tolerant and resistant rice (Oryza sativa L.) varieties in terms of morphologic and genetic characters. Genetic Resources and Crop Evolution, 70(2), 427-436.

Asfaw, A., Simane, B, Bantider, A and Hassen, A.2019. Determinants in the adoption of climate change adaptation strategies: evidence from rainfed-dependent smallholder farmers in north-central Ethiopia (Woleka sub-basin). Environment, Development and Sustainability, 21, 2535-2565.

Asfaw, A.,and Beshir, A. 2024. "Adaptation Strategies to Climate Change in Semi-Arid Agriculture: Insights from Ethiopian Farmers." Environmental Science and Policy, 132, 45-58.

Asrat, P and Simane, B.2018.Farmers'perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. Ecological processes, 7(1), 1-13.

Asrat,M and Babiso, B. 2020.Smallholder Farmers' Adaptation to Climate Change and Determinants of their Adaptation Choices in Hobicha, Southern Ethiopia. soil and water, 1(2), 3.

Assefa, B. T.,Reidsma, P., Chamberlin, J and van Ittersum, M. K. 2021.Farm-and community-level factors underlying the profitability of fertiliser usage for Ethiopian smallholder farmers. Agrekon, 60(4), 460-479.

Atanga.2023.Planned experiments or autonomous adaptation.Anassessment of initiatives for climate change adaptation at the local level in Ghana. *Cogent Social Sciences*, 9(2). https://doi.org/10.1080/23311886.2023.2282719

Ayuba, H. K., Oruonye, E. D and Oruonye, E. D.2020.Original Paper Potentials of Nature-Based Solutions to Climate Change Mitigation in Nigeria.

B.K. Kurgat, C. Lamanna, A. Kimaro, N. Namoi, L. Manda, T.S. Rosenstock.2020 .Adoption of climate-smart agriculture technologies in Tanzania, Front. Sustain. Food Syst. 4 (May) 1–9, https://doi.org/10.3389/fsufs.2020.00055.

Balehegn, M.,*et al*. 2019. "Integrating Indigenous Weather and Climate Knowledge into Seasonal Climate Forecasts for Climate Change Adaptation in Ethiopia." Climate and Development.

Bekele, F., Tolossa, D and Woldeamanuel, T.2020. Local institutions and climate change adaptation: Appraising dysfunctional and functional roles of local institutions from the bilate basin agro pastoral livelihood zone of sidama, southern ethiopia. Climate, 8(12), 149.

Belay, A., Recha, J. W., Woldeamanuel, T and Morton, J. F. 2017.Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agriculture and Food Security, 6, 1-13.

Bennett, M., and DeVries, W.2021. "Agricultural Experience and Climate Change Adaptation: Evidence from Farm Households." **Agricultural Systems*, 189, 103021.

Bernabucci, U. 2019. Climate change: impact on livestock and how can we adapt. Animal Frontiers, 9(1), 3-5.

Bett, B., Lindahl, J., and Delia,G. 2019.Climate change and infectious livestock diseases: the case of Rift Valley fever and tick-borne diseases.*Climate Smart Agri*. Pap. 3, 29–37. doi: 10.1007/978-3-319-92798-5_3

Betts, A. K.2023.Accelerating Climate Change and the Living Earth. Mother Nature's View of Climate Change, 13(2), 1-11.

Beyene, A. D., *et al* ., 2023."Vegetation cover changes and their effects on soil erosion and moisture dynamics."Journal of Environmental Management.

Beyene, A. D., *et al.*, 2023. "Linking education and adaptive capacity: A study of farmers' responses to climate variability" Journal of Rural Studies

Biagini, B., and Kuhlmejbybib, J. 2022. "Increasing the Availability and Reliability of Weather and Climate Data for Agricultural Adaptation in Southeast Asia." Climate Services.

Birara *et el* ,.2018 . Trend and variability analysis of rainfall and temperature in the Tana basin region, Ethiopia.

Biruk, A.,and Tadesse, T. 2022. "Climate Change and Its Effects on Agricultural Output: A Review of Evidence from Developing Countries." *International Journal of Climate Change Strategies and Management*, 15(5), 675-690.

Bitana, E. B., Lachore, S. T and Utallo, A. U. 2023. Vulnerability and Responses of Rural Households to Climate Variability: Agro-Climatic-Based Evidence from Southern Ethiopia. Sustainability and Climate Change, 16(4), 286-301.

Bowen, T.,Del Ninno, C., Andrews, C., Coll-Black, S., Johnson, K., Kawasoe, Y and Williams, A. 2020.Adaptive social protection: building resilience to shocks.World Bank Publications.

Brown, S. J. 2020. Future changes in heat wave severity, duration and frequency due to climate change for the most populous cities.*Weather and Climate Extremes*, 30, 100278.

Carbonell. 2024.Adaption solutions for improved climate change resilience. Open Access Government, 41(1), 348–349.

Chen, L.,and Zhao, Y. 2024. Marital Status and Household Well-being: A Comparative Analysis." *Journal of Family Issues, 45(3), 450-470.

Chen, S., Yong, Y., and Ju, X.2021.Effect of heat stress on growth and production performance of livestock and poultry: mechanism to prevention. J.Thermal Biol. 99, 103019. doi: 10.1016/j.jtherbio.2021.103019

Chiro Woreda Agriculture Office,"Chiro Woreda Agriculture Office report "unpublished.2019.

Chiro Woreda BusaGonofa office,‟Chiro Woreda disaster risk reduction and early warning office report‟ unpublished, 2018.

Chiro Woreda Health Office, ‟Chiro Woreda Health Office report ‟ unpublished, 2020.

Chiro Woreda Land Use Office "ChiroWoreda Land Use Office report‟ unpublished, 2018.

Choden, K., Keenan, R. J and Nitschke, C. R.2020.An approach for assessing adaptive capacity to climate change in resource dependent communities in the Nikachu watershed, Bhutan. *Ecological Indicators*, 114, 106293.

Chowhan,2021.Potential Hazards of Air Pollution on Environment, Health and Agriculture.International Journalof Environmental Sciencesand Natural Resources, 28(2).

Cid, A., Cano, D.,Montalvo, V., Ruíz-Bedolla, K., Romero-Cazares, M., Monterroso-Rivas, A. I. and García-Meneses, P. M. 2020. Insights for building institutional capacities for climate change adaptation: evidence from Mexico. Handbook of climate change management: Research, leadership,transformation, 1-21.

CSA (Central Statistics Agency), "Agricultural Sample Survey Report on Farm Management, Practices (Private peasant Holding Summer Season). 2014_2015".Addis Ababa

Davis, M.A., et al. 2020. "Education and its effect on climate change perception and adaptation strategies among farmers in sub-Saharan Africa." Climate Policy.

Dawit, A., Tesfaye, T. 2022. "The role of indigenous knowledge in sustainable agriculture: A case study from Ankober Woreda." *Sustainability*, 14(4), 2201.

Dechassa, C.,Simane, B and Alamirew, B. 2020. Farm-level determinants of farmers' adaptation decisions to climate variability and change in didessa basin, Ethiopia.Asian J. Agric. Ext. Econ. Soc, 38, 42-55.

Degefie, D. T., Seid, J.,Gessesse, B and Bedada, T. B. 2019. Agricultural drought projection in Ethiopia from 1981 to 2050:Using coordinated regional climate downscaling experiment climate data for Africa.In Extreme hydrology and climate variability (pp. 311-323). Elsevier.

Demelash, T., Amou, M., Gyilbag, A., Tesfay, G., and Xu, Y. 2021. Adaptation potential of current wheat cultivars and planting dates under the changing climate in Ethiopia. Agronomy, 12(1), 37.

Demem ,M.S.2023. Impact and adaptation of climate variability and change on small –holder and agricultural in Ehiopia

Desalegn, a., Getachew, t., and Kassa, G. 2021. Analysis of long term trends of rainfall and temperature of Andittid watershed, central highland of Ethiopia. International Journal of Environmental, Sustainability, and Social Science, 2(3), 192–203. https://doi.org/10.38142/ijesss.v2i3.93

Destaw, F and Fenta, M. M.2021.Climate change adaptation strategies and their predictors amongst rural farmers in Ambassel district, Northern Ethiopia. Jàmbá: Journal of Disaster Risk Studies, 13(1), 1-11.

Dobson BS .2018. How Much do we Affect Climate Change ALook at the Water System and its Function.Journal of Earth Science and Climatic Change, 09(04).

Duncan, A. J., *et al.*, 2021.The impact of nutrition on reproductive performance in cattle."Animal Productin.

Ebi, K. L.,and Loladze, I. 2019. Elevated atmospheric CO2 concentrations and climate change will affect our food's quality and quantity. Lancet Planetary Health 3, 283–284. doi: 10.1016/S2542-5196(19)30108-1

Erekalo, K. T and Yadda, T. A. 2023. Climate-smart agriculture in Ethiopia: adoption of multiple crop production practices as a sustainable adaptation and mitigation strategies.World Development Sustainability, 3, 100099.

Eshetie, G. G. 2021.Impact of rainfall variability on crop yields and its relationship with sea surface temperature in northern Ethiopian Highlands.Arabian Journal of Geosciences, 14(22). https://doi.org/10.1007/s12517-021-08316-4

FAO .2022. "The State of Food and Agriculture 2022: Climate Change and Agriculture." Food and Agriculture Organization of the United Nations

Farsangi, E. N. (Ed.). 2021. Natural Hazards: Impacts, Adjustments and Resilience. BoD–Books on Demand.

Fekad, M and Bekalu,Y. 2020. Climate change impacts on household food security and its adaptation options in rural Ethiopia: a systematic review. EPRA Int. J. Res. Develop, 2455-7838.

Fekadu, G and Belay, D.2024.Determinant of Farmers' Choice of Adaptation Strategies to Climate Change in Rural Areas of Ambo District, Ethiopia. Journal of Asian and African Studies, 00219096231225950.

Food and Agriculture Organization (FAO).2021."The State of the World's Animal Genetic Resources for Food and Agriculture."

Food and Agriculture Organization(FAO). 2023. "The Role of Youth in Sustainable Agriculture: Insights from the FAO"

Gebre, K. 2022. The Effect of Climate Variability on Farmers' Vulnerability on Different Agroecological Zones: The Case of Legambo District, South Wollo, and Northcentral Ethiopia (Doctoral dissertation).

Gebrechorkos, S. H.,Hülsmann, S and Bernhofer, C. 2020.Analysis of climate variability and droughts in East Africa using high-resolution climate data products. Global and Planetary Change, 186, 103130.

Gebrehiwot, T.G., van der Veen, A., and Mamo, T.2021."Farmers' decision-making on climate change adaptation strategies: A multinomial logit analysis in the Nile Basin of Ethiopia" Journal: Land Use Policy

Gebremedhin, B. et al. 2019. "Determinants of Access to Credit and Impact of Credit on Income of Smallholder Farmers in Ethiopia." *Journal of Agribusiness in Developing and Emerging Economies*, 9(4).

Gebreyes, M.2018. NJAS - Wageningen Journal of Life Sciences “Producing” Institutions of Climate Change Adaptation and Food Security in North Eastern Ethiopia. NJAS Wageningen Journal of Life Sciences 84: 123-132.

Gemeda, D. O., Korecha, D., andGaredew, W.2021. Evidences of climate change presences in the wettest parts of southwest Ethiopia. Heliyon, 7(9).

Getachew, F., Bayabil, H. K., Hoogenboom, G., Teshome, F. T and Zewdu, E.2021. Irrigation and shifting planting date as climate change adaptation strategies for sorghum. Agricultural Water Management, 255, 106988.

Getu, A., and Berhanu, K. 2021."Multinomial logit analysis of farmers’ preferences for climate adaptation strategies in Ethiopia." *Journal of Environmental Management*

Golledge. 2020. Long-term projections of sea-level rise from ice sheets. WIREs Climate Change, 11(2). https://doi.org/10.1002/wcc.634

Hailu, A., *et al.* (2023). "Assessing the vulnerability of Ethiopian agriculture to climate change: Impacts on cereal crops." *Agricultural and Forest Meteorology*, 324, 109139.

Haro-Monteagudo,D., Palazón, L.,Zoumides, C and Beguería, S.2023. Optimal implementation of climate change adaptation measures to ensure long-term sustainability on large irrigation systems. Water Resources Management, 37(8), 2909-2924.

Hassan, A., *et al*. 2021. The impact of livestock diversification on resilience to climate change in pastoral systems. *Journal of Arid Environments*

Heady, D., and Fan, S. 2020. "Reflections on the food crisis: How to achieve food security in developing countries." Global Food Security.

Hereher, M. E. 2020. Assessment of climate change impacts on sea surface temperatures and sea level rise—The Arabian Gulf. Climate, 8(4), 50.

Hoque, M. A., Gathala, M. K., Timsina, J., Ziauddin, M. A., Hossain, M and Krupnik, T. J. 2023. Reduced tillage and crop diversification can improve productivity and profitability of rice-based rotations of the Eastern Gangetic Plains. Field Crops Research, 291, 108791.

IPCC. 2021.Summary for Policymakers. In Climate Change 2021 The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Ishikawa-Ishiwata, Y and Furuya, J.2022. Economic evaluation and climate change adaptation measures for rice production in vietnam using a supply and demand model: special emphasis on the Mekong River Delta region in Vietnam.In Interlocal Adaptations to Climate Change in East and Southeast Asia: Sharing Lessons of Agriculture, Disaster Risk Reduction, and Resource Management (pp. 45-53). Cham: Springer International Publishing.

Islam, A., and Faramarzi, M.2020."Projected impacts of climate change on rice yield in rain-fed ecosystems of South Asia."Climate Change.

Jones, M. W., Peters, G. P., Gasser, T., Andrew, R. M., Schwingshackl, C., Gütschow, J. and Le Quéré, C. 2023. National contributions to climate change due to historical emissions of carbon dioxide, methane, and nitrous oxide since 1850. Scientific Data, 10(1), 155.

Kabir, A., Amin, M. N., Roy, K and Hossain, M. S. 2021. Determinants of climate change adaptation strategies in the coastal zone of Bangladesh: implications for adaptation to climate change in developing countries. Mitigation and Adaptation Strategies for Global Change, 26(7), 30.

Kassie, M *et al*. 2023. "Farmers’ Perceptions of Climate Change and Their Adaptation Strategies: A Case Study from Ethiopia." Environmental Science and Policy, 135, 55-65.

Kassie, M., *et al*. 2020. "The Role of Improved Crop Varieties in Enhancing Farm Income Among Smallholder Farmers in Eastern Africa." Field Crops Research.

Kassie, M., *et al*. 2021. "The Role of Agricultural Training in Enhancing Farmers' Adaptive Capacity to Climate Change: Evidence from East Africa." Climate Policy, 21(3), 354-368

Kassie, M.,*et al*., 2019. "Off-Farm Employment and Agricultural Investment: Evidence from Ethiopian Smallholder Farmers." World Development.

Kebede, A. H., *et al*. 2024. “Assessing the impacts of climate change on rural livelihoods in Ethiopia.”: International Journal of Climate Change Strategies and Management

Kebede, G.,and Zewdie, A. 2024. "Land Size and Socioeconomic Outcomes: A Study of Rural Households in Ethiopia." : African Journal of Agricultural Research*, 19(3), 215-230.

Khan, A. H *et al*.2022. "Climate variability and its impact on vector-borne diseases: The role of rainfall and temperature." International Journal of Environmental Research and Public Health.

Khan, M. A.,and Ahmad, M. 2023. "Gendered Perspectives on Climate Change Adaptation. A Comparative Study of Male and Female Households." *Climate Risk Management*, 37, 100-115.

Khan, Z., and Qureshi, K. M. 2022. "The Role of Experience in Adopting Climate Change Adaptation Strategies among Farmers: Insights from a Longitudinal Study." *Environmental Science and Policy*, 125, 142-148.

Kiros, S and Meshesha, G. B.2022. Factors affecting farmers' access to formal financial credit in BasonaWorana district, North Showa zone, Amhara regional state, Ethiopia. Cogent Economics and Finance, 10(1), 2035043.

Kohl, M., et al., 2019. "The role of education in enhancing adaptive capacity to climate change in rural areas." Climate Policy.

Koo, J., Thurlow, J., ElDidi, H., Ringler, C and De Pinto, A.2019. Building resilience to climate shocks in Ethiopia (No. 9780896293595). International Food Policy Research Institute (IFPRI).

Kosoe, E. A and Ahmed, A.2022.Climate change adaptation strategies of cocoa farmers in the Wassa East District: Implications for climate services in Ghana. Climate Services, 26, 100289.

Krysiak, K., *et al.* 2024. "Temperature effects on dairy cow performance: A systematic review." : Livestock Science.

Kumar, A., and Singh, S. 2022. "Financial Inclusion and Agricultural Resilience: The Role of Microcredit in Adaptation Strategies." *Journal of Development Studies*, 58(7), 1234-1250.

Kumar, L., and Singh,.R. 2023. "Institutional Factors Influencing Adaptation Strategies Among Farmers: A Systematic Review." Agricultural Systems, 207, 102-115

Kumar, S., *et al*.,2021. "Empowering rural farmers through education:The pathway to sustainable agriculture." Sustainability.

Kumar,V., *et al.*, 2019. "Addressing Multicollinearity in Multiple Linear Regression: A Comparison of Techniques." Applied Statistics in Business and Industry.

Leal Filho, W.2021.African handbook of climate change adaptation Springer Nature.

Leal Filho, W., Barbir, J., Gwenzi, J., Ayal, D., Simpson, N. P., Adeleke, L.,and Yaffa, S. 2022.The role of indigenous knowledge in climate change adaptation in Africa. *Environmental Science and Policy, 136*, 250-260.

Leal Filho, W., Taddese, H., Balehegn, M., Nzengya, D., Debela, N., Abayineh, A and Wolf, F. 2020.Introducing experiences from African pastoralist communities to cope with climate change risks, hazards and extremes: Fostering poverty reduction.*International Journal of Disaster Risk Reduction*, 50, 101738.

Lee,S.,Kim,Y.,andPark,J.2021.Adaptation strategies to climate change In livestockproduction: Multinomial logit Analysis Journal Agricultural Economics.

Lewis, K.2017.Understandingclimate asadriver of food insecurity in Ethiopia. *Climatic Change*, 144, 317-328.

Liu, Y., Li, N., Zhang, Z., Huang,C., Chen, X and Wang, F. 2020.Climate change effects on agricultural production:The regional and sectoral economic consequences in China.Earth's Future, 8(9), e2020EF001617.

López, A., *et al*. ,2023. "The dual impact of drought and flooding on infectious diseases: A systematic review." Global Environmental Change.

Maeregu A, Barana B. 2020.Smallholder Farmers' Adaptation to Climate Change and Determinants of their Adaptation Choices in Hobicha, Southern Ethiopia. Agri Res and Tech: Open Access J. 25 (1): 556291. DOI: 10.19080/ARTOAJ.2020.25.556291

Makanji, D. L., and V. O. Oeba.2019. "The role of the Kenyan private forestry sector in response to climate change mitigation and adaptation." International Forestry Review 21, no. 1 (2019): 102-111.

Mar, K. A. 2021.Putting the brakes on climate change–it's about more than just CO2.Climanosco Research Articles.

Marie, M., Yirga, F., Haile, M., and Tquabo, F.2020. Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon*,*6*(4).

Mason, D.R., and Mc Carthy, B.2022. The influence of climate change on feed Efficiency and Lactation performance in Dairy cattle “livestock Science “ ,261,104872.

Mason, J. W., *et al*. 2021."Impact of prolonged dry seasons on livestock health and disease prevalence.": Tropical Animal Health and Production.

Mason, J. W., *et al.*,2023. Nutritional management and its effects on fertility in beef cattle. Journal of Animal Science. on Science.

Mastrorillo, M., *et al*.,2021. "Rainfall variability and its impact on food security in Ethiopia: A systematic review." : Climate and Development.

Mastrorillo, M., et al.,2020. "Weather variability and the adoption of climate-smart agriculture: Evidence from Southeast Asia." Agricultural Systems.

Mastrorillo, M., *et al*.,2023. "Futre scenario of climate change impacts on agricultural production in asia: asystematic review “gobal change biology “, 29(4),1035-1050

Mastrorillo, M., *et al*.,2022."Smallholder Farmers’ Perceptions and Adaptation Strategies to Climate Change in Semi-Arid Areas." *Climate Risk Management*, 36, 100-110.

Mekonnen, A., and Usman, A.2021.The Role of Community Participation in Climate Change Adaptation: An Analysis of Social Networks in Rural Ethiopia. *Journal of Environmental Management*, 287,112300.

Mekonnen, D.,and Zewdie, A. 2023. "Analyzing Group Differences in Survey Data:The Role of the Chi-Square Test of Independence." Journal of Social Science Research, 14(3), 147-160.

Mekonnen, D.,and Zewdie, A. 2023.Assessing theImpact of Agricultural Inputs on Adaptation Strategies in the Face of Climate Change. African Journal of Agricultural Research*, 18(3), 210-225.

Mekonnen, K., Hoag, D. 2023. "Climate Change Adaptation Strategies and Poverty Alleviation in Ethiopia: A Systematic Review." *Sustainability*, 15(3), 1234.

Melesse, A., A.btew, W., and Senay, G. (Eds.).2019. Extreme hydrology and climate variability: monitoring, modelling, adaptation and mitigation. Elsevier.

Melkie, M. E. 2022. Green Industrialisation in Ethiopia

Mensah, J. and Kpogo, A.2024. "The Impact of Financial Services on Livelihood Diversification: An Analysis of Farm Households" Journal: International Journal of Agricultural Research

Mergia,G. 2024.Spatio temporal analysis of meteorological drought in El Niño years over Oromia region, Ethiopia. *Journal of Agrometeorology*, 26(1), 109–114. https://doi.org/10.54386/jam.v26i1.2329.

Mitiku,A., Zewdu, B., Yihenew, G. S and Getachew, A. 2022.Socioeconomic determinants of maize production among northwestern Ethiopia's small-scale farmers: Evidence from three agro-ecology zones. African Journal of Food, Agriculture, Nutrition and Development, 22(10), 21863-21889.

Moges, A., and Mulugeta, W. 2023. "Farmers' decision-making processes under climate change: Insights from the Central Rift Valley of Ethiopia." International Journal of *Climate Change Strategies and Management*

Moges, A., and Bork, H.2024. "Understanding Farmers' Awareness of Climate Change: Evidence from Ethiopia." *Journal of Environmental Management*, 310, 114-126.

Moges, A.,and Tadele, G. 2022. "Family Size and Agricultural Productivity: Evidence from Ethiopian Smallholder Farmers." *Agricultural Systems*, 195, 103-115.

Mohammed, Y and Yimam, A. 2021.Analysis of meteorological droughts in the Lake's Region of Ethiopian Rift Valley using reconnaissance drought index (RDI): Geoenvironmental Disasters, 8(1), 13.

Mokua, R., and Ogutu, M.2021. "Market Information Access and Livelihood Diversification Among Smallholder Farmers: Evidence from Kenya." Journal of Agricultural Economics, 72(2), 345-362

Molla, E., Melka, Y and Desta, G.2023. Determinants of farmers' adaptation strategies to climate change impacts in northwestern Ethiopia. Heliyon, 9(8).

Morris, J., Chen, Y. H. H., Gurgel, A.,Reilly, J and Sokolov, A. 2023. Net Zero Emissions Of Greenhouse Gases By 2050: Achievable And At What Cost?. Climate Change Economics (CCE), 14(04), 1-28.

Mugi-Ngenga, E. W., Kiboi, M. N., Mucheru-Muna, M. W., Mugwe, J. N., Mairura, F. S., Mugendi, D. N and Ngetich, F. K. 2021.Indigenous and conventional climate-knowledge for enhanced farmers' adaptation to climate variability in the semi-arid agro-ecologies of Kenya: Environmental Challenges, 5, 100355.

MuhammadFaisal; Azhar Abbas; Chunping Xia;Muhammad HaseebRaza., Shoaib Akhtar., 2021.Assessing small livestock herders' adaptation to climate variability and its impact on livestock losses and poverty .climate Risk manegmant .30, 100358.

Muluneh, M. G.2021.Impact of climate change on biodiversity and food security: a global perspectivea review article. Agriculture and Food Security, 10(1), 1-25.

Mulusew, A and Hong, M.2024.Adynamic linkage between greenhouse gas (GHG) emissions and agricultural productivity: evidence from Ethiopia. Humanities and Social Sciences Communications, 11(1), 1-17.

Murshed, M., Nurmakhanova, M., Al-Tal, R.,Mahmood, H., Elheddad, M and Ahmed, R. 2022. Can intra-regional trade, renewable energy use, foreign direct investments, and economic growth mitigate ecological footprints in South Asia.Energy Sources, Part B: Economics, Planning, and Policy, 17(1), 2038730.

Mustonen, E. A., Tuori, M., Kurki, P., Isolahti, M.,Taponen, J and Vanhatalo, A. 2018. Variety,time of harvest and conditions during growing season have impact on red clover isoflavone content.Agricultural and Food science, 27(2), 102-109.

Mwangi, J. and Karanja, F. 2023. "The Role of Livestock Income in Promoting Adoption of Improved Crop Varieties": Journal of Agricultural Economics.

NAPA(National Adaptation Programme of Action) 2021. "Climate Change and Health: Addressing the Malaria Threat in Highland Regions."

Naseem, S., and Faizan, M. 2022. "Climate change impacts on wheat productivity in South Asia: Consequences of temperature extremes." Climate and Development.

Nasir Abas Khan.,jiamei Qiao., MuhamedAbid .,QijieQao.,2021 . Understanding farm-level cognition of and autonomous adaptation to climate variability and associated factors: Evidence from the rice-growing zone of Pakistan. Land use policy 105, 105427.

Nguyen, H. T., and Tran, P.2022. "Household Size and Labor Dynamics: A Comparative Study of Family Structures." *Population Studies*, 76(2), 215-230.

Nguyen, H., Morrison, J., and Neven, D.2019.Changing food systems: implications for food security and nutrition. Sustain Food Agric. 21, 153–168. doi: 10.1016/B978-0-12-812134-4.00009-1

Niles, M.T., *et al.*,.2022. "Climate information and agricultural adaptation: The role of seasonal forecasts." Environmental Research Letters.

Nivedha, P. 2022.Socio-Economic Impact of Global Warming. Climate Change and Disaster Management Research, 1(1), 18-23.

Njeri, M. and Mwangi, J., 2023 Research Study: "Age and Livelihood Diversification: Insights from Rural Households in Kenya" Journal of Rural Studies.

Nkosi, T., and Ochieng, C .2023. "Water Access and Adaptive Capacity: Insights from Sub-Saharan Africa" Journal: Climate and Development

Noman, M., Iqbal, J and Amjad, S. 2022. Greenhouse Gas (CO2, CH4 and N2O) Emissions from Electricity Consumption in Private Sectors Universities of Karachi. Journal of Sustainable Environment, 1(2), 22-29.

Ochieng, J., et al.,2024. "The Role of Farmers' Perceptions in Adapting to Climate Change: Insights from East Africa.”: Sustainability, 16(1), 50.

of Agricultural Research, 7(2). https://doi.org/10.23880/oajar-16000286.

Ojo, T. and Baiyegunhi, L.2018. ‘Determinants of Adaptation Strategies to Climate Change among Rice Farmers in Southwestern Nigeria: A Multivariate Probit Approach’, 2018 Conference, July 28 – August 02, *International Association of Agricultural Economists*, Vancouver, British Columbia.

Ojo, T. O and Baiyegunhi, L. J. S.2020. Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. Land Use Policy, 95, 103946.

Osei, R. and Mensah, J.2023."The Role of Social Networks in Livelihood Diversification: A Critical Analysis”: Journal of Rural Studies.

Pascoe, S., Brincat, S and Croucher, A.2019. The discourses of climate change science: Scientific reporting, climate negotiations and the case of Papua New Guinea lobal environmental change, 54, 78-87.

Pérez-Cabal, M. A., *et al*., 2023. "Factors Affecting Milk Yield in Dairy Cows: A Review of Recent Findings.": Livestock Science, 263, 104897.

Pete, S., Johnson, N., Katherine, C., Donovan, C., Francesco, C.,Giacomo, G and Vizzarri, M. 2019. Interlinkages between desertification, land degradation, food security and greenhouse gas fluxes: synergies, trade-offs and integrated response options. In Climate Change and Land: IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems (pp. 551-672).*Cambridge University Press*.

Ray, D. K., et al.,2022. "Crop Yields and Food Security: The Role of Major Crops in Global Food Systems." Global Food Security, 31, 100586

Raza, A., et al.,2023. "Impact of climate change on wheat quality and yield: A review." Journal of *Agricultural Science and Technology*.

Renaudeau, D., *et al.*, 2023. "Adaptation strategies for beef cattle under climate change." Animals.

Rojas-Downing, M. M., *et al.*, 2023."The Effect of Climate Variability on Rangeland Productivity and Beef Cattle Performance." *Agricultural Systems* 197, 103353.

Sare-NuamahP.BotchwayE.(2019) Understanding climate variability and change: analysis of temperature and rainfall across agro ecological zones in Ghana.

Schlenker, W., and Roberts, M. J. 2020. "Estimating the impacts of climate change on crop yields: A review of the literature." : Annual Review of Resource Economics.

Schröder, J., et al.,2023. "Climate change impacts on grazing systems: A review of the evidence." Agricultural Systems.

Simotwo, H.K., Mikalitsa, S.M., Wambua, B.N.2018. Climate change adaptive capacity and smallholder farming in Trans-Mara East sub-Country, Kenya. Geoenviron. Disasters 5, 5.

Smith, L. M. Jones,*et al*., 2022. "The Role of Crop Diversification in Enhancing Resilience to Climate Change: A Meta-Analysis": *Agricultural Systems.*

Smith,J.,Brwn,A.,and Johnson ,C. 2021. Adaptation strategies to climate change in crop production: Multinomial logit Analysis Journal Agricultural Economics.

Stavi, I., and Ivetić, V. 2023.Thematic Workshop: Challenges, opportunities, and adaptation strategies to climatic changes in dry land forestry systems. Reforesta, 15, 1–3. https://doi.org/10.21750/refor.15.01.103

Sultan, B., Ahmed, A. I., Faye, B and Tramblay, Y. 2023. Less negative impacts of climate change on crop yields in West Africa in the new CMIP6 climate simulations ensemble. PLOSClimate, 2(12), e0000263.

Tadele, G., Kassa, H. 2023. "Empowering farmers through climate information services in Ethiopia: Impacts on adaptation and livelihoods." *Agricultural Systems*, 205, 102878.

Tadesse, T.,*et al.*,2021.Effectiveness of soil and stone bunds for soil moisture conservation in eastern Ethiopia. *Soil and Tillage Research*.

Taffesse, A. S., and Dorosh, P. A. 2020. "Climate change, agricultural productivity, and food security in Ethiopia." : Food Security.

TamiruUrgessa andBusaGonfa,. 2020. Review on Determinants of Farmers' Perception on Adaptation Strategies in Ethiopia.International Journal of Environmental Protection and Policy.

Tamruamru, S., Hansen, J, Zebiak, S, Tesfaye, A, Minten, B, Demissie, T and Solomon, D .2022. Climate Information Services Enhance Farmers' Resilience to Climate Change: Impacts on Agricultural Productivity.

Tesfaye, W. et al., 2021."The Impact of Agricultural Extension Services on Smallholder Farmers' Livelihood Diversification: Evidence from Ethiopia." World Development, 141.

Teshome, A and Zhang, J.2019. Increase of extreme drought over Ethiopia under climate warming. Advances in Meteorology, 2019, 1-18.

Teshome, A., and Kassa, M.2022. "The Role of Land in Rural Livelihoods: Evidence from Farm Households in Ethiopia." Journal of Rural Studies, 89, 45-58.

Thomas, K., Hardy, R. D., Lazrus, H., Mendez, M., Orlove, B., Rivera-Collazo, Winthrop, R. 2019. and I. Explaining differential vulnerability to climate change: A social science review. Wiley Interdisciplinary Reviews: Climate Change, 10(2), e565.

Thompson, G., and Moyo, S. 2021. Research Study: "Access to Water Sources and Climate Change Adaptation in Rural Communities" , Environmental Science and Policy.

Tulu, L.,Teferi, M. 2022. "Social Capital and Climate Change Resilience: The Case of Farm Households in Ethiopia." *Global Environmental Change*, 74, 102074.

Umer Abdela. 2022.Climate change adaptation and mitigation strategies in maddawalabu district, bale zone, southeast Ethiopia. International Journal of Ecology, 2022, 1-12.

Van Valkengoed, A. M., Perlaviciute, G and Steg,L. 2022. Relationships between climate change perceptions and climate adaptation actions: policy support, information seeking, and behaviour.*Climatic Change*, 171(1-2), 14.

Vandermeer, J., and Perfecto, I.2023. "The Resilience of Agroecological Systems in the Face of Climate Change: Adaptations and Innovations." *Agricultural Systems*, 196, 103249

Vasseur, L. 2021. How ecosystem-based adaptation to climate change can help coastal communities through a participatory approach. Sustainability, 13(4), 2344.

Voigt, K and Heley, K. 2021. Reduce Utility Greenhouse Gas Emissions to Mitigate Climate Change. Journal-American Water Works Association, 113(10), 74-76.

Waaswa, A., Nkurumwa, A. O., Kibe, A. M and Ng'eno, J. K. 2021. Understanding the socioeconomic determinants of adoption of climate-smart agricultural practices among smallholder potato farmers in Gilgil Sub-County, Kenya. Discover Sustainability, 2, 1-19.

Watson, A. 2020. “The Single Most Important Factor”: Fossil Fuel Energy, Groundwater, and Irrigation on the High Plains, 1955–1985. Agricultural History, 94(4), 629-663.

Weldearegay S. K.TedlaD. G.2018.Impact of climate variability on household food availability in Tigray, EthiopiaAgric. Food Secur.

Williams, P.A., Crespo, O., Abu, M.,.2019.Adapting to changing climate through improving adaptive capacity at the local level-The case of smallholder horticultural producers in Ghana. Clim. Risk Manag. 23, 124–135

Wordofa, M. G and Sassi, M.2020.Impact of agricultural interventions on food and nutrition security in Ethiopia: uncovering pathways linking agriculture to improved nutrition.*Cogent food and agriculture*, 6(1)1724386.

World Bank. 2022. "Ethiopia Economic Update: Climate Resilience and Sustainable Growth."

World Food Programme .2023. "Climate Adaptation in Agriculture: Integrating Sustainable Practices in Ethiopia." WFP Report.

World Health Organization.2024. "Health and flooding: Understanding the risks of waterborne diseases."

Yamane, Taro. 1967. Statistics: An Introductory Analysis, 2ndEd, New York: Harper and Row.

Yao, Q., *et al.,* 2023. "The Role of the Independence of Irrelevant Alternatives Assumption in Analyzing Rural Livelihood Choices: Evidence from China." Journal of Rural Studies.

Yesuph, D. S.,Bedeke, S. B and Didana, H. L. 2023.Assessing climate change-induced poverty of mixed crop-livestock smallholders in Wolaita zone.*Research in Globalization*, 7, 100158.

Yimer, A., and Ayalew, A.2023. Analyzing the Educational Attainment and Its Impact on Rural House hold Decision-Making in Ethiopia . *African Journal of Agricultural Research*, 18(6), 345-358.

Yohannes, A., Melaku, T. 2022. "The Impact of Diversification on Climate Change Adaptation Strategies among Rural Households in Ethiopia." *Environmental Science Policy*, 128, 143-152.

Zanmassou, Y. C.,Al-Hassan, R. M., Mensah-Bonsu, A., Osei-Asare, Y. B andIgue, C. B. 2020.Assessment of smallholder farmers' adaptive capacity to climate change: Use of a mixed weighting scheme.Journal of environmental management, 276, 111275. https://doi.org/10.1016/j.jenvman.2020.11127.

Zegeye,H.2018.Climate change in Ethiopia: impacts, mitigation and adaptation. International Journal of Research in Environmental Studies, 5(1), 18-35.

Zhao, Y., *et al.,* 2023. Heat stress and its impact on Feed Intake and Milk Production in lactating cow under climate change " journal of Animal Science ",101(4),1235-1246.

Zinabu, M. A., Woldemichael, B. 2023. "Adaptation Strategies for Smallholder Farmers in Ethiopia Facing Climate Change: Evidence from a Survey." *Agricultural Systems*, 193, 103258.

7. APPENDIX

Appendix I: Survey Questionnaire

My name is Nega Mekonnin. I am writing a thesis entitled Determinant of Farmers' Climate Change Adaptation Strategies: A Case of Chiro Woreda, West Hararghe Zone, Oromia region, Ethiopia" in partial fulfillment for MSc in climate change and disaster risk management. The objective of this study is to identify and assess determinants factor that influence adaptation to climate change impact. Confidently this research has a significant contribution in an effort to reduce the climate change relate problems of the farmers of this Woreda especially. Therefore, your valid contribution by giving accurate information is highly valuable in achieving the objective of this research. The information we will collect from you will serve only the academic purpose and it will kept confidential. Thus, please feel free to convey the required information honestly.

Thank you in advanced for your cooperation.

General Directions

Put (**x**) marks in space provided for closed-ended questions and write your response onspace provided for open-ended questions.

Part I. Supportive Information

a. Name of interviewer:

b. Date: .../......../............. Time spent for interview: From............to............

c. Name of respondent..

d. Name of Kebele: ....

e. Agro-ecological Zone; 1. Dega, 2. Woina-dega,3. Kola

Part II. Questions on Household Head Demographic Characteristics

1. Gender of the Household Head: 1.Male 2. Female
2. Age of the household head (in years) ....
3. Marital status: 1) Married: 2) Single; 3) divorced: 4) widowed
4. Educational level of household head: 1 = No Education 2 = Can read or write (informal/religious education only) 3 = Grade 1-4 (Primary School) 4 = Grade5-8 (Primary School) 5 = Grade 9-10 (secondary school) 6 = Grade 11-12 (Preparatory)\ 7= above grade 12 (University/College).

5. Did head of the household have some social position in the community1? Yes 2. No

6. Number of total family members: Male............ Female................. Total --------

Age group	Male	Female	Total
< 7			
8-10			
11-14			
15-48			
49-64			
>65			

7. Number of active household members aged between 15-64 years 1. Male--- 2. Female ------- Total ___________

8. Farm experience of household head----------------------

Part III. Questions on Household Head Socio-economic Characteristics

9.Farming system you follow currently

1. Crop production only

2. Livestock rearing only

3. Mixed farming

4.Others (please specify)..................

10. Sources of household income: Starting with the most important, select main sources of household income from the below listed 1= Sale of crop produce 2= Sale of livestock 3 = Small trade 4= Formal employment 5 = Casual labour 6= Remittances from relatives 7= Pensions

11. Do you any members of your family has any sources of non-farm income i.e. income fromremittance, petty trade, employment in government or private enterprise, etc?1. Yes 2. No

12. If yes to the above question, how much money you/your family make during last Production year 2023 from off-farm activity? Please specify in Birr: ....

13. How much is your total expenditure during last production year 2023? Please specify in Birr: ....

14. Total land owned by in hectare? _______

15. Do you have certificate for your land? 1.Yes 2. No

16. What are the physical characteristics of your farm, in terms of its exposure to erosion? 1.Susceptible to erosion, 2. Moderately susceptible to erosion,3. Not susceptible at all

17. How is the fertility of the soil of your farm in general? 1. Very fertile 2. Moderate 3. Poor/ infertileIf you have more than one plot, answer the following questions

18. How long does it take to reach your farm from your home? take its average distance and time. Distance (KM)...................... In terms of time it takes (in min) ....

19.How do you get/purchase the inputs? 1. On cash 2. On credit 3. Both 4. Other

20.during the last 12 months? What types of input used listed below

1.Fertilizer

2.Improved seed

3.Pesticides andher bicides

4.Artificial insemination

5.Vaccination 6 .not used any type

A. Crop production

22. Please, rank the following crops in order of importance that your household produced during the last production season as 1^{st}, 2^{nd}, 3^{rd}, 4^{th};

Types of crop	Rank	
Sorghum		
Maize		
Haricot bean		
Sesame		
Teff		
Khat/chat		
Other1		

23. How many quintals of yield have you harvested per hectare in 2023? In kun Sorghum_______Maize_______Haricotbean_____Sesame______Teff______chat) ____

24. Does your household have any access to water resource? 1. Yes 2. No

25. If yes Question no 24 from where 1.Excavated pond and dam, 2. Ground water from 3. Spring or wells and masonry tank

B. livestock production

26. Please, tick the most important livestock that household rear in the last production season and mention the number of your livestock holdings?

Types	Tick	Number	Remark
Oxe			
Cow			
Sheep			
Goat			
Camel			
Donkey			
Poultry			
Beehives			
Other			

27. What is the source of feed for livestock in the area? Source of feed

1. Grazing 2. Crop residue 3. Grazing and crop residue 4. other specify -----

C. Crop and livestock marketing

28. Why do you primarily grow crop? 1. Sell for cash 2. Feed own family 3. Both
    4. Other specify _
29. Why do you primarily rare livestock?1. Sell for cash 2. Feed own family 3. Both
    4. Other specify ________
30. Is the market easily accessible to sell the products that you produced? 1. Yes 2. No
31. If sell, to whom? 1.Any body on the open market 2.Cooperatives 3. Local traders

4. Intermediaries/brokers 5=1 and 2 6= 1 and 3

Part IV. Questions on Institutional Factors

32. How far the market where you buy your agricultural inputs is (e.g. hoes, seeds, fertilizers, etc.)? Distance in km________ In terms of time it takes (in hour) ________
33. How far is the market where you sell your agricultural outputs? Distance in km________In terms of time it takes (in hour) _________
34. Do you or any member of your household belong to any farmers'/community organization/association? 1. Yes 2. No
35. If yes, how helpfulness to you are the following organizations in the case you faced risks? Rate as 5(1-5)

No.	Associations	Rate	Remark
1	Cooperatives		
2	Microfinance institutions		
3	Women Groups		
4	Producer Group		
6	Self-help groups		
7	Iddir (Afosha)		
8	Ikub		
9	Guza/debo		

36. Is anybody of this household a member of a credit scheme or group? Purchase agricultural inputs like fertilizer, oxen, and others 1. Yes 2. No

37. Do you have access to any formal credits in time face shortage of money? 1. Yes 2. No

38. Does the household have borrowed money during the last 12 months? 1. Yes 2. No.

39. If yes to 37 and 38 where you look for credit to fill your financial constraints ? More thanone choice is possible. From: 1. Relatives, 2. Friends, 3. Non-formal moneylenders, 4. Microfinance Institutes.

40. Do you have access to agricultural extension services in your kebele? 1. Yes 2. No.

41. Do you receive any support from agricultural extension, which could help improve yourfarming activities? 1. Yes 2. No.

42. Specify any kind services you get from them

1. Awareness or advice on crop and livestock production.
2. Advice on the use of agricultural seeds, fertilizer, pesticides and other inputs
3. Advice on the use of techniques for the improvement of animal breeds (eg artificial insemination)
4. Awareness / advice on health, vaccination of livestock
5. Awareness / advice on the storage and preservation of agricultural products
6. Awareness / advice on the storage and preservation of livestock products
7. Awareness / advice on the marketing of agricultural products
8. Awareness / advice on the purchase of cattle feed
9. Awareness / training on drought risks, conservation of natural fodder and conservation of crop residues for animal feed;
10. Awareness / advice on adaptive strategies of drought risk reduction

43. Have you given early warning information on weather forecast on rainfall and temperature in the past two years? 1. Yes 2. No 3. Do not remember

44. How do you evaluate the importance of access to climate information and early warning on climate hazards? 1. Very important 2. Important 3. Less important 4. Do not know.

Part V. Questions on Perception of Climate Change

45. Comparing the 2014s with the recent past 10years i.e. 2024s, have you perceive anychanges in climate? 1. Yes 2. No

46. Comparing the 2014s with the recent past 10 years i.e 2024s, have you noticed anychanges in the rainfall patterns? 1. Yes 2. No

47. If yes, please specify the pattern of the change in rainfall you have noticed.1. Increasing 2. Decreasing

48. Comparing the2014s with the recent past 10 years i.e. 2024s, have you noticed anychanges in temperature? 1. Yes 2. No

49. If yes, please specify the pattern of the change in temperature you have noticed.

1. Increasing 2. Decreasing

50. What are the effect of climate change on crops and livestock production, and environment? Please, rate on the following list of items in the table in order of importance as 4= high effect 3=moderate effect 2= low effect? 1= no effect

No.	Main effects of climate change on crops and livestick production	Response
1	Severe shortage of soil moisture during growing seasons;	
2	Reduced crop yields;	
3	Damages to crop fields due to flooding;	
4	Loss of household assets due to recurrent drought occurrence;	
5	Increased reduction in water and feed availability for livestcok;	
6	Land degradation and fertility deterioration;	
7	Reduction in water availability for livestock;	
8	Reduction in milk production;	
9	Reduction in meat production;	
10	Reduction in the productive performance of cattle resource;	

51. What are the effect of climate change on health of crops and livestock production, and environment? Please, rate on the following list of items in the table in order of importance as 4= high 3=moderate 2= low? 1= no effect

No.	Main effects of climate change on health of crops and livestick	Response
1	Prevalence of new contangious disease	
2	Increase death of livestock	
3	Occurance of livestock disease	
4	Occurance of crop disease,insect and pest	

Part VI. Questions on adaptation strategies

52. The following climate change impact adaptation strategies in your farm in past decades. What strategies have you implemented to cope with the impacts of climate change on your farming activities? Please, respond 4=Very Important 3= Moderately Important 2=Slightly Important 1=Not Import.

No	Adaptive strategies to climate change impact	Response	Remark
1	Change crop variety		
2	Crop diversification		
3	Temporary migration		
4	Planting early maturing crop		
5	Soil and water Conservation		
6	Planting trees		
7	improving livestock productivity		
8	Improved crops		
9	Reduce number of livestock		
10	Drought resistance crop.		
11	Irrigation		
12	Livelihood diversification:		
13	Livestock vaccinations and treatment		
14	Use of wild foods		
15	Use of rain water harvesting technology		
16	Use of Durable Crops (short term varieties)		

53. In the past years do you received any agricultural technical support from the Government in implementing adaptation? 1. Yes 2. No

54. If yes, what kind of technical support do you received in your effort to reduce the impacts climate change and improve your farming system? Please list

i. ……………………………………………………..............................

ii...

55. If no, what kind of support would you want to receive? Please list
i ……………………………………………………......................................
ii ……....................................

56. Do you have access to climate information? 1. Yes 2. No

57. If question No. 56 no, please specify the

Reason…………………………………………………………………………………
……………………………………………………………………………………………

58. What do you suggest to bedone to reduce the impacts of climate change in yours Kebele?
....
....

59. Do you have any recommendations for policymakers or stakeholders to promote effective climate resilience in agriculture?

Thank you so much for your time

Appendix 2: Guide for focused Groups Discussions

Focus Group discussion guiding questions Principles: before you commence your discussion/ask question please acknowledge and thank the participant for their time and willingness to participate on the FGD.

General instruction: take name of the list of the participants/interviewees (disaggregated

by sex, age) from where they are and their responsibilities (if any); focus on major components of outcomes of the project: Community capacity, livelihoods, disaster, weather and climate change information, Climate change adaptation.

Strategy and modality of FGD: please organize FGDs (mixed groups including a mix of elders, men and women, youth boys and girls

1. How do you explain climate change in your area?
2. What are the main features of climate change often seen in your locality?
3. What are the main effects of climate change?
4. What are the main adaptations strategies farm households' practices in your area to adapt to changing climate? Please, list those adaptation strategies used for crops production, livestock production and environmental protection.
5.What are the factors affecting your choices of adaptation practices
1. Demographic factors (family sizes, age, sex, etc)
2. Socio-economic factors (education, income, etc)
3. Institutional factors (credit, extension services, climate information, market distance, etc.
6. Please, list some of the opportunities exist to reduce vulnerability in your locality.
7. Have government and Non Governmental organization supported vulnerable households during the occurrence of climate related hazards?
8 What do you think are the key areas that need to bedone to improve the resistance capacity of farm households and communities?

Thank you so much for your time

Appendix 3: Guide for Key Informant Interviews

Is there any form of climate change hazards in your kebele? 1. No 2. Yes

What is your observation on the climatic (temperature and rainfall) condition in your area? past 30 years?

2. Are the temperature and rainfall distribution and intensity changing? 1. No 2. Yes

3. If say yes Question no 2 how?

4. What are the main climatic shocks (hazards) affecting livelihood in your locality?

5. Explain years of extreme climate condition that affect your income in your locality (drought, flood, storm etc...).

6. Who is more vulnerable to the impacts? Why? By the type of hazard and impact

7. What are the most important adaptation strategies the farming communities practice in to adapt to climate change?

9. What do you think are the opportunities exist to reduce negative effects of climate change in Chiro district?

10. What do you recommend to done to reduce the adverse effects of climate change?

11. What are the factors affecting farmers' choices of adaptation practices (family sizes, age, sex, education, income, credit, extension services, climate information, market distance, etc.

12. Did you observe any support provided to vulnerable farm households during hazards of climate related impacts?

13. Please, mention the prevalence of livestock disease that happened in the in the past few years.

14. Please, mention the prevalence of crop disease that happened in the in the past few years.

Thank you so much for your time

Table 4: Reliability Main effect of climate on health of crop and Livestock

Cronbach's Alpha	N of Items
.837	4

Source: Own survey, 2024

Table 5: Realiability Test to adaptation strategies climate change

Scale: Adaptation strategies

Cronbach's Alpha	N of Items
.774	15

Source: Own survey, 2024

Table 6: Multicollinearity test for continuous explanatory variables

Variables	Collinearity
	VIF
Age (years)	4.572
Family size	2.367
Farm experience (years)	3.714
Total household income	1.017
Land size	1.712
Market proximity in km	1.234
Livestock herd size	1.289

Source: Own survey, 2024

Table 7: Corelation dummy variable

Variables	Gender	Marital status	Income source	Farm input	Membership	Accessed to credit resource	Access to ext
Gender	1						
Marital status	.621**	1					
Income source	-.030	.091	1				
Farm input	-.258**	.160	.143	1			
Membership	-.084	-.058	-.058	.111	1		
Accessed to credit	. -.052	-.073	-.031	.059	0.633**	1	
Access to extension	.366**	.363**	.021	.296***	0.360**	0.279**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Own survey, 2024

Table 8: Mean annual temperature (1992-2021)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean
1992	22.36	22.3	25.15	24.8	24.7	25.45	22.86	20.2	20.36	21.55	20.7	22.5	22.75
1993	22.47	22.6	25.62	23.4	22.8	23.15	21.32	20.2	20.83	21.17	20.4	21.02	22.08
1994	22.05	23.9	25.91	24.9	23	24.69	21.34	19.9	19.96	19.33	19.5	19.83	22.01
1995	20.93	23.4	23.47	23	24.4	25.51	22.84	21.2	21.05	22.04	21.3	21.34	22.53
1996	22.23	25	23.92	22.4	21.8	22.04	20.74	19.9	20.36	20.28	20.1	19.72	21.52
1997	23.48	23	25.19	22.4	24.2	24.17	22.09	21.7	23.69	21.47	20	20.51	22.65
1998	21.91	24.5	26.3	27.8	24.8	25.62	22.15	20.9	21.3	20.08	18.5	19.36	22.73
1999	22.51	25.4	22.8	24.2	26.1	25.64	21.19	20.8	21.08	20.02	18.8	20.23	22.37
2000	21.85	23.9	25.26	24.9	26.1	27.39	23.93	22.9	23.69	23.54	22.6	22.57	24.05
2001	21.66	24.8	25.05	26.2	26.8	27.58	24.4	22.8	22.65	23.84	21.9	23.47	24.24
2002	22.23	24.7	24.65	24.6	26.6	27.29	25.69	24.2	24.95	25.08	23.1	23.51	24.71
2003	23.27	25.3	26.51	25	25.5	26.19	24.47	22	22.44	23.72	23.5	19.65	23.95
2004	24.31	23.8	25.3	23.9	26.9	26.07	24.14	23.9	23.65	22.74	22.1	21.76	24.05
2005	21.51	25.2	24.76	24.8	22.1	24.29	23.25	24.5	25.31	24.44	22.1	20.72	23.55
2006	23.75	24.5	23.09	23.4	25	26.37	23.19	21.9	22.49	22.55	21	20.64	23.14
2007	22.69	23.7	25.12	23.7	25.2	25.27	22.78	22.1	21.73	21.22	20.6	20.31	22.86
2008	22.74	22.7	24.89	24	24.8	25.81	22.99	20.4	21.35	21.67	17.9	19.28	22.38
2009	21.63	24	26.19	24.4	26.9	26.45	22.38	22.2	23.26	21.01	21.2	22.32	23.48
2010	22.42	23.2	22.08	23.4	23.9	24.87	22.01	20.2	20.01	20.07	19.9	20.3	21.86
2011	22.72	24.2	24.01	25.3	24.8	25.04	23.48	24	24.36	23.88	22.6	21	23.77
2012	22.59	23.9	25.94	23.9	25.6	26.37	22.7	21	20.73	20.93	23	22.8	23.28
2013	23.01	25.1	25.41	23.1	24.1	25.28	21.23	20.3	20.95	20.19	19.5	18.8	22.22
2014	22.24	24.9	24.9	23.9	24.4	25.9	23.96	22	21.1	19.99	21	20.29	22.86
2015	20.76	25.2	25.96	25.7	24.1	24	25.14	23.3	24.9	24.97	22.4	21.96	24.01
2016	23.05	23.8	27.54	23.2	21.6	23.43	23.05	21	22.04	22.24	21.9	20.29	22.75
2017	20.66	23.8	25.48	24.5	23	25.2	23.63	22.6	21.65	21.37	21.1	19.31	22.67
2018	20.94	24	24.08	21.7	22.8	23.51	22.89	21.8	21.51	22.27	20.6	20.18	22.18
2019	21.87	26.1	26.84	24.2	25.3	24.42	24.26	21.7	20.89	18.5	20.1	19.09	22.76
2020	20.3	24.2	25.71	24	22.1	23.15	22.16	21.3	21.09	20.77	21.6	20.86	22.26
2021	20.43	23.6	25.98	24.6	22.8	24.62	21.47	21.3	20.88	20.15	20.6	20.51	22.23

Source: (NMI, 2024)

Table 9: Mean annual rainfall mm (1992-2021)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean
1992	10.55	73.8	31.6	73.8	47.5	36.9	137	274	111	15.8	16	5.27	833.2
1993	15.82	15.8	15.8	163	100	68.6	179	185	94.9	79.1	0	5.27	922.85
1994	0	0	42.2	121	116	36.9	253	253	179	15.8	58	0	1075.78
1995	0	52.7	105	142	42.2	15.8	158	195	100	15.8	11	47.5	885.94
1996	36.91	0	174	142	111	84.4	301	258	100	5.27	42	0	1255.08
1997	0	0	79.1	137	52.7	89.7	195	148	31.6	301	47	0	1081.05
1998	36.91	31.6	26.4	52.7	89.7	42.2	174	206	185	174	11	0	1028.32
1999	0	0	127	36.9	15.8	42.2	200	258	73.8	127	0	0	880.66
2000	0	0	10.6	52.7	42.2	15.8	31.6	137	36.9	42.2	5.3	0	374.41
2001	0	0	63.3	5.27	31.6	10.6	21.1	111	84.4	15.8	11	0	353.32
2002	15.82	0	84.4	52.7	47.5	5.27	63.3	79	15.8	10.6	0	0	374.41
2003	0	15.8	10.6	111	31.6	10.6	84.4	185	68.6	0	5.3	47.5	569.53
2004	0	0	63.3	63.3	10.6	31.6	89.7	63	84.4	15.8	37	15.8	474.61
2005	5.27	0	42.2	148	174	0	47.5	37	26.4	10.6	21	0	511.52
2006	5.27	36.9	94.9	94.9	52.7	15.8	163	127	68.6	52.7	0	47.5	759.38
2007	5.27	47.5	47.5	132	84.4	10.6	179	174	79.1	31.6	21	0	812.11
2008	10.55	0	0	94.9	52.7	26.4	258	253	47.5	58	84	0	885.94
2009	15.82	15.8	36.9	68.6	15.8	63.3	179	132	73.8	94.9	5.3	31.6	733.01
2010	0	73.8	111	121	89.7	63.3	221	301	264	5.27	16	0	1265.62
2011	0	0	47.5	79.1	89.7	21.1	89.7	79	21.1	10.6	21	0	458.79
2012	0	0	0	84.4	52.7	31.6	158	258	116	5.27	5.3	0	711.91
2013	15.82	0	73.8	158	36.9	21.1	322	237	94.9	73.8	105	0	1139.06
2014	0	5.27	52.7	84.4	73.8	10.6	142	148	190	94.9	5.3	0	806.84
2015	0	0	21.1	10.6	137	84.4	21.1	132	21.1	5.27	37	10.6	479.88
2016	15.82	21.1	31.6	237	195	10.6	158	179	63.3	15.8	26	15.8	970.31
2017	0	31.6	116	31.6	142	10.6	105	163	211	21.1	5.3	0	838.48
2018	0	26.4	26.4	243	47.5	52.7	94.9	216	89.7	47.5	90	0	933.4
2019	0	0	42.2	116	47.5	100	52.7	248	232	153	63	58	1112.7
2020	5.27	5.27	47.5	311	174	36.9	137	148	248	10.6	11	31.6	1165.43
2021	21.09	10.6	0	121	122	33.9	206	241	196	105	65	31	1152.52

Source: (NMI, 2024)