SMALLHOLDER FARMERS' PERCEPTIONS OF CLIMATE CHANGE AND VARIABILITY AFFECTING FOOD SECURITY IN KAZOMBA EXTENSION PLANNING AREA, MZIMBA DISTRICT, MALAWI

MSc THESIS IN TRANSFORMATIVE COMMUNITY DEVELOPMENT

RONALD WILSON LONGWE

MZUZU UNIVERSITY

DECEMBER, 2025

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RONALD WILSON LONGWE

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A THESIS SUBMITTED TO THE FACULTY OF ENVIRONMENTAL SCIENCES, DEPARTMENT OF AGRI-SCIENCES IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE (MSc) IN TRANSFORMATIVE COMMUNITY DEVELOPMENT

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DECLARATION

I hereby declare that this thesis titled, "Smallholder Farmers' Perceptions of Climate Change and Variability affecting food security in Kazomba Extension Planning Area, Mzimba District, Malawi" has been written by me and is a record of my research work. All citations, references, and borrowed ideas have been duly acknowledged. It is being submitted in fulfilment of the requirements for the award of the Master of Science in Transformative Community Development of the Mzuzu University. None of the present work has been submitted previously for any degree or examination in any other University.

Ronald Wilson Longwe	**10th December, 2025**
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Student's name	**Date**

CERTIFICATE OF APPROVAL

This thesis, 'Smallholder Farmers' Perceptions of Climate Change and Variability Affecting Food Security in Kazomba Extension Planning Area, Mzimba District, Malawi' by Ronald Wilson Longwe, is submitted with our approval as university supervisors for the MSc in Transformative Community Development.

Sign Date 10/12/2025

Frank Mnthambala (PhD)

Major Supervisor

Sign Date 10/12/2025

Mavuto Tembo (PhD)

Co-Supervisor

DEDICATION

To the memory of my late father and mum, Wilson Sokwani Longwe and Ivy Winiwa Banda respectively, who could not live to see me reach this far. May your departed souls continue resting in eternal peace dad and mum.

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First of all, I would like to thank God, for His grace and for giving strength to complete this thesis. There have been many ups and downs; however, with the love of God, I was able to survive.

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LIST OF ABBREVIATIONS AND ACRONYMS

EPA	Extension Planning Area
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
LULUC	Land Use and Land Use Change
MDC	M'mbelwa District Council
MZUNIREC	Mzuzu University Research Committee
NAP	National Adaptation Plan
UNFCCC	United Nations Framework Convention on Climate Change

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Climate change and variability pose significant threats to rural livelihoods in Malawi, particularly among smallholder farmers who depend on climate -sensitive agricultural activities. Climate change and variability have a direct effect on agricultural output, ultimately impacting the food security of smallholder farmers. This study assessed farmers' perceptions of climate change and variability affecting food security, focusing on its occurrence, causes, impacts, and adaptation strategies in Kazomba Extension Planning Area, Mzimba District, Malawi. A convergent mixed-methods approach was employed, combining household interviews with 320 smallholder farmers and historical meteorological data obtained from the Department of Climate Change and Meteorological Services. Data analysis was conducted using SPSS (version 25.0), applying descriptive statistics, Chi-square tests, and correlation analysis and Microsoft Excel 2016. The findings revealed that farmers' perceptions aligned with the observed climate trends, including a 2.4^{o}C rise in temperature and declining rainfall between 1982 and 2019. Farmers reported increased drought frequency (82%) and reduced flood events (83.1%), attributing climate changes primarily to human activities such as deforestation, poor farming practices, and vehicle emissions. Reported impacts included reduced crop yields, declining soil fertility, shorter rainy seasons, and increased pest and disease prevalence. Adaptation strategies adopted by farmers included crop diversification, intercropping, mulching, organic manure use, prayers, and dietary changes. Adoption of these strategies was significantly associated with demographic and socioeconomic factors such as marital status, age, gender, education level, income source, land ownership, access to extension services, climate change training, farm credit, and local group membership. The study recommends the development of tailored, household-specific interventions and the strengthening

of education and extension services at the village level to enhance resilience among smallholder farmers.

CHAPTER ONE: INTRODUCTION

1.1. Background

1.1.1. Climate Change and Variability

Climate change and variability have been observed as crucial issues for the international community to respond to as they pose major challenges to agricultural development efforts and human welfare. This concern about climate change and variability is due to its adverse impact on the living conditions of humankind (Asante and Amuakwa, 2014). When it comes to some developmental issues like poverty, discussions are skewed to developing countries like those in Sub-Saharan Africa, Latin America and Asia. However, issues of climate change have taken centre stage in developmental discussions globally. Climate change is a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (Intergovernmental Panel on Climate Change [IPCC], 2007). Climate variability means deviations in the mean state of climate and inconsistencies (e.g., in the occurrence of wind and precipitation extremes), on all temporal and spatial scales beyond those of individual weather events, including short-term fluctuations that happen from year to year (Ogalleh, *et. al.,* 2012). In this case, variability is an integral part of climate change, in which a change in mean climatic conditions is experienced through changes in the nature and frequency of particular yearly conditions, including extremes.

Climate is important because it determines our localities and in general our livelihoods and how we organize our societies. It is expected that our climate will change over time and this may occur both naturally, as integral parts of how the global and regional climate system functions, as well as in response to additional influences due to anthropogenic activities (IPCC, 2018). The changes that may occur over time may pose major challenges to humanity. The sixth assessment report of IPCC indicates that even with immediate implementation of climate change and variability mitigation policies, the global climate system will continue to shift and change for decades (IPCC, 2022). It is predicted that in the tropics, temperature will continue to increase, rainfall will decrease and floods and droughts will increase overtime.

Climate change and variability including increases in the frequencies and intensity of extremes has reduced food and water security globally, hindering efforts to meet sustainable development goals (Joshua *et. al.,* 2016; Mugambi, 2017). Although overall agricultural productivity has increased globally over the past 50 years, climate change and variability have significantly slowed this growth, particularly in low-and mid-latitude regions. According to the IPCC sixth Assessment Report (2021), climate change has reduced agricultural productivity growth by approximately 21% since 1961, with the most severe impacts observed in tropical and subtropical zones. Increasing weather and climate extreme events have exposed millions of people to acute food insecurity and reduced water security with the largest impacts observed in many locations and/or communities in Africa, Asia, Central and South America, Small Islands and the Arctic (IPCC, 2022). Jointly, sudden losses of food production and access to food exacerbated by climate-induced disruptions such as droughts, flood, and shifting seasons have significantly increased malnutrition in many communities. According to Owino *et. al.* (2022), climate change undermines the stability of global food systems by reducing crop yields, altering nutrient composition, and limiting food availability, which in turn decreases diet diversity and quality. Vulnerable populations including indigenous people, small-scale food producers, and low-income households are disproportionately affected due to limited adaptive capacity and reliance on subsistence agriculture (FAO, 2024).

World Vision (2024) reports that in 2023, nearly 282 million people globally experienced acute food insecurity, with Africa, the Middle East, and South Asia bearing the greatest burden. The report links climate-related disasters directly to all three underlying causes of malnutrition: insufficient household food security, inadequate maternal and child care, and poor health services. Children under five, pregnant women, and the elderly are particularly impacted, with climate change contributing to rising rate of stunting, wasting and micronutrient deficiencies.

1.1.2. Climate Change and Variability in Africa

Climate change and variability affect both developed and developing nations, impacting both wealthy and impoverished populations. However, underdeveloped countries and low-income communities are more susceptible to its effects (Ayanlade, 2017). Climate variability poses a significant threat to sustainable growth across the continent. If its negative impacts are not addressed, African nations may struggle to achieve some of the Millennium Development Goals (MDGs) such as MDGs 1, 4, 5 and 7 (IPCC, 2022; FAO, 2024). Smallholder farmers in Africa are particularly the most vulnerable due to the combined challenges of poverty, limited infrastructure, low technological advancement and heavy reliance on rain-fed agriculture (Lipper *et. al*., 2014; Ericksen *et. al*., 2011). Smallholder farmers are rural producers, predominantly in the developing countries, who farm using mainly family labour and for whom the farm provides the principal source of income (Uwusu *et. al.,* 2015). Although Africa contributes the least to global climate change (Food and Agriculture Organization [FAO], 2018), it remains the most vulnerable due to heavy reliance on rain-fed agriculture, widespread poverty and limited capacity. In fact, over 95% of agricultural production in Africa depends on rainfall (Zamasiya *et. al.,* 2021; Simelton *et. al.*, 2013), the sector is mostly dominated by smallholder farmers.

Climate projections indicate that Africa is expected to undergo substantial climatic shifts, with extreme warming and drying in most subtropical areas, while slight increases in precipitation may occur in tropical regions (Abegaz and Wims, 2015). Climate change models also predict that their effects will be more severe across Africa (Ayanlade, 2017). However, a major challenge with these models and scenarios is the uncertainty surrounding changes in precipitation patterns as the climate evolves. Most models project a drier Southern Africa, while some regions, particularly West Africa show inconsistencies in projections. Additionally, reports from the IPCC (2013, 2014) highlight those uncertainties regarding future rainfall patterns in sub-Saharan Africa.

A total of 96% of Sub-Saharan Africa's population are smallholder farmers, the sector which is challenged most by climate change and variability (Joshua *et. al.,* 2016). The region is at risk of losing about 11% of its total arable land area (265 million hectares) for crop production due to environmental constraints induced by climate variability (Kotir, 2011). The future projections also indicate an increase of 50% yield deficit from the sector by 2050 in the region (IPCC, 2019; Gedefaw *et. al*., 2018). Rainfall is the major determinant of agricultural production output in the region. Reports show that the mean annual rainfall has already declined by over 5% and is forecasted to further decrease by 10% in Southern African countries (Rurinda *et. al.,* 2013).

The long-term effects of climate change and variablity in Africa include shifting rainfall patterns that reduce agricultural productivity and threaten food security, declining water availability, decreasing fish stocks in major lakes due to rising temperatures and the spread of vector-borne diseases. A decline in agricultural output slows economic growth in many African nations, as agriculture forms a significant part of their national income. Furthermore, the sector employs a large proportion of the population, making climate change a critical challenge for livelihoods and economic stability (Asante and Amuakwa, 2014)

The IPCC's 2018 Special Report on Global Warming of 1.5ºC warns that if greenhouse gas emissions continue at current levels, global temperatures are likely to exceed 1.5ºC by mid-century. Such an increase would have devastating effects on resource-limited smallholder farmers in Southern Africa, particularly those with low adaptive capacity. In South Africa, climate change has already led to increase drought frequency and reduced water availability, significantly impacting maize and livestock production, which are central to rural livelihoods (Ogundeji, 2022). In Zambia, rising temperatures and erratic rainfall have disrupted planting seasons and reduced yields of stable crops like cassava and maize, contributing to food insecurity among small-scale farmers (Akram *et. al.,* 2025). Similarly, Zimbabwe has experienced prolonged dry spells and crop failures, with over 2.7 million people facing food insecurity in 2023 due to climate-related shocks (FAO, 2024).

In Africa, studies further show that yields of stable crops such as maize, sorghum, and millet have declined due to increased temperatures and erratic rainfall. Zhao *et. al.* (2017) found that for every 1ºC rise in global temperatures, wheat yields decline by 6%, rice by 3,2%, and maize by 7.4%, with the steepest losses occurring in low-latitude areas. These reductions threaten food security and economic stability, especially among smallholder farmers who lack access to irrigation, improved seed varieties and climate-smart technologies. These impacts are expected to worsen chronic malnutrition in developing countries, especially among vulnerable groups such as children, pregnant women, and the elderly. Southern Africa is projected to be one of the severely affected regions due to its high dependence on rain-fed agriculture and limited institutional capacity to support adaptation (Ndaki, 2014). Given these challenges, it is crucial for smallholder farmers-who are the primary food producers to adopt strategies that enhance their resilience to climate change and variability. These include climate-smart agriculture, improved access to climate information, and diversified livelihood strategies (Abid *et. al.,* 2015).

1.1.3. Climate Change and Variability in Malawi

The economic development of developing countries, especially Least Developed Countries (LDCs) like Malawi, is disproportionately affected by climate change and variability. Malawi's social and economic sectors are increasingly vulnerable, making its path to prosperity more complex, difficult and costly. Several underlying factors exacerbate a country's susceptibility to climate change and variability, including widespread poverty, rapid population growth leading to overexploitation of natural resources and heavy reliance on subsistence farming (Government of Malawi, [GoM], 2020).

Over the recent times, Malawi has experienced various climate-related hazards, including dry spells, seasonal drought, intense rainfall and both riverine and flash floods (Munthali *et. al.,* 2016; Singini *et. al*., 2015; World Bank, 2014). The frequency, intensity and magnitude of droughts and floods have increased in the past decades, negatively impacting food and water security, energy supply and the overall livelihoods of rural communities. For instance, in January 2015, Malawi received extreme precipitation of four times higher than average and caused severe flooding in 15 of the 28 districts, adversely affecting more than 1.3 million people (World Bank, 2018). Furthermore, in the last four years, four major cyclones (cyclones Idai in January 2019, Ana in January 2022, Gombe in March 2022 and Freddy in March 2023) hit Malawi with devastating impacts. Given the country's dependence on rain-fed agriculture, flooding associated with these cyclones significantly disrupted agricultural production in multiple districts across the country. On the other hand, prolonged droughts have led to poor crop yields and even total crop failure resulting in severe food shortages, hunger and malnutrition.

The most vulnerable groups to climate change and variability include smallholder farmers who lack the necessary resources to adapt to a changing climate (Uwusu *et. al.,* 2015; Kasulo *et. al.,* 2012; Buys *et. al.,* 2011). Smallholder farmers play a crucial role in Malawi's agriculture, cultivating approximately 78% of the land and contributing about 75% of the country's total agricultural output (Maganga and Malakini, 2015). Their communities often suffer from weak infrastructure, making them more susceptible to climate-related disasters like floods. Chronic food shortages are now a recurring issue in many parts of the country, a situation worsened by recurrent floods and drought (Gama *et. al.,* 2014). Erratic rainfall patterns and extreme weather events also contribute to water pollution and increase the prevalence of diseases such as malaria and cholera (Gedefaw *et. al.,* 2018), which affects the health of smallholder farmers too.

Malawi is already experiencing the brunt of climate change and variability, but projections are still not favourable to the country. For instance, Malawi is expected to experience temperature increases that exceed the global average under all greenhouse gas emission scenarios. According to Zulu (2017) future climate projections derived from General Circulation Models (GCMs) show significant variability and uncertainty, especially in rainfall patterns. However, most models indicate a likely increase in mean annual temperatures by 1 °C to 3 ºC by 2060, with more frequent occurrences of extremely hot days and nights. While rainfall projections are inconsistent, Gama *et. al.* (2014) found that a modest decline in precipitation averaging 1.1% by 2070, with shorter rainy seasons that could lead to frequent maize crop failures thereby exacerbating food insecurity in districts such as Mzimba. Thus, World Bank (2010) ranked Malawi among the most vulnerable countries to climate change and variability, highlighting the significant risks posed to smallholder farmers who have low adaptive capacity.

Despite spotting the urgency of climate action, smallholder farmers in Malawi face numerous barriers to implementing effective adaptation and mitigation strategies (Maganga and Malakini, 2015). A primary challenge is the country's limited financial capacity to fund adaptation initiatives. Other constraints include extreme poverty and illiteracy as a result many smallholder farmers live in poverty and have low literacy levels, making it difficult to introduce new technologies and implement long-term adaptation plans. Furthermore, poor infrastructure such as roads and bridges hinders access to rural areas, complicating the delivery of essential farm inputs such as seeds and fertilizers as well as market access for agricultural products. Limited access to credit makes smallholder farmers struggle to obtain financial support which restricts their ability to invest in climate-resilient farming practices. Unfortunately, local institutions often lack the expertise needed to assess climate threats and develop effective adaptation strategies.

The patterns and effects of climate change and variability vary across different locations, leading to diverse conditions in terms of both nature and intensity. As a result, populations exposed to the same climatic events may experience different impacts. Even within a specific region, sub-populations, groups and individual households may perceive and respond to climate shifts differently. For a household to effectively react to climate change, it must first recognize that changes are occurring (Madison, 2006). Local knowledge plays a crucial role in shaping how households adapt to climate change and variability (Ogalleh *et. al.,* 2012). This knowledge, developed through experience and practice, enables communities to make informed decisions about responding to environmental changes helping them mitigate losses or capitalize on emerging opportunities. The adaptive capacity of smallholder farmers can be strengthened by integrating the practices they already employ into national climate change and variability strategies. Numerous scholars have emphasized the significance of local knowledge in formulating effective responses to climate change (Gemeda *et. al.,* 2023; Kenea & Mebratu, 2020). However, many development agencies including national governments, NGOs and international donors often overlook local communities' perceptions when designing interventions (FAO, 2011). Therefore, this study aimed at assessing how smallholder farmers in Kazomba Extension Planning Area of Mzimba District perceive climate change and variability affecting food security.

This study seeks to contribute to the climate change discourse by cross-referencing local knowledge with quantitative climate data to assess its relevance in climate studies. The initial step involved assessing the extent and nature of climate change and variability already experienced in the study area, with a focus on how these changes have affected smallholder farmers' agricultural practices, livelihoods, and food security. The study then explored how smallholder farmers in the area perceive these changes, adopting an approach that emphasizes their firsthand, practical experiences rather than the broad climate risks and threats typically highlighted by scientists. Additionally, the study examined the characteristics of households that had recognized changes in climate and adaptation mechanisms.

1.2. Problem Statement

Climate change and variability pose significant threats to agricultural productivity and food security across sub-Saharan Africa, with Malawi being particularly vulnerable due to its heavy reliance on rain-fed agriculture. In Kazomba Extension Planning Area (EPA) of Mzimba District, smallholder farmers who form the backbone of local food systems are increasingly exposed to erratic rainfall, rising temperatures, and shifting growing seasons. These climatic changes have led to reduced crop yields, increased food insecurity, and heightened vulnerability among farming households.

Despite the growing body of evidence on climate change and variability impacts (Singini *et. al.,* 2015), there remains a critical gap in understanding how smallholder farmers perceive these changes and how their perceptions influence adaptive behaviour and food security outcomes. Perception is not merely a passive reflection of environmental change; it actively shapes decision-making technology adoption, and resilience strategies (Saruchera, 2019; Tshuma and Mathuthu, 2014; Okumu, 2013). In Kazomba EPA, where extension services and access to climate-smart technologies are limited (Zulu, 2017), farmers perceptions may be better shaped by indigenous knowledge and cultural beliefs rather than scientific understanding.

Recent studies underscore the importance of perception in climate adaptation. For instance, Shani *et. al.* (2024) found that in Zomba District, only 26% of smallholder adopted climate-smart agricultural practices, with compatibility and simplicity being the key determinants. Similarly, Munthali *et. al.* (2016) revealed that in Rumphi District, 76% of farmers perceived increased temperatures and 74% perceived decreased rainfall, though scientific data did not always support these perceptions. These findings suggest that while awareness of climate change is growing misconceptions and limited access to reliable information hinder effective adaptation. Moreover, Twinomugisha and Mushy (2022) highlighted that climate change in Salima District affects all four pillars of food security; availability, access, utilization, and stability and that adaptation is constrained by limited livelihood assets and weak extension systems. These insights are highly relevant to Kazomba EPA, where similar socio-economic and environmental conditions prevail.

Therefore, this study sought to assess the perceptions of smallholder farmers in Kazomba EPA regarding climate change and variability, and how these perceptions affect their food security strategies. By identifying the gaps between perception and scientific reality, and the barriers to adaptation, the study aimed at informing targeted interventions that enhance resilience and promote sustainable agricultural practices.

1.3. Main objective

The overall objective of the study was to assess smallholder farmers' perception of climate change and variability affecting food security in Kazomba Extension Planning Area, Mzimba District, Malawi.

1.3.1 Specific objectives

i. To investigate the perception of smallholder farmers on climate change and variability.

ii. To determine the rainfall and temperature trends/patterns between 1982 to 2019 in Kazomba Extension Planning Area.

iii. To assess the impacts of climate change on smallholder farmers' livelihoods and natural resources utilization.

iv. To evaluate the adaptation strategies to climate change and variability among smallholder farmers.

1.3.2 Research Questions

i. How do smallholder farmers perceive climate change and variability in the study area?

ii. What are the rainfall and temperature trends/patterns in Kazomba Extension Planning Area over time based on meteorological recorded data?

iii. How do changes in climatic variables affect the livelihoods of the smallholder farmers and natural resources in the study area?

iv. How are the smallholder farmers adapting to climate variability and change in the study area?

1.4. Justification of the study

Climate change and variability have emerged as critical challenges affecting agricultural productivity and rural livelihoods in Malawi. Smallholder farmers, who constitute the majority of the agricultural workforce, are particularly vulnerable due to their reliance on rain-fed farming systems and limited access to adaptive resources. Despite the growing body of scientific evidence on climate change impacts, there remains a significant gap in understanding how smallholder farmers perceive these changes and respond to them. This study is justified by the need to capture farmers lived experiences and perceptions, which are essential for designing effective and context-specific adaptation strategies.

By documenting farmers' observations of rising temperatures, declining rainfall, and increased frequency of droughts, the study provides empirical evidence that aligns with historical meteorological data. This convergence between perception and scientific trends reinforces the credibility of local knowledge and highlights its value in informing climate policy. Furthermore, the study explores the socio-economic factors influencing adaptation, such as education, income, land ownership, and access to extension services. These insights are crucial for identifying barriers to resilience and targeting interventions where they are most needed.

The study also sheds light on the diverse adaptation strategies employed by smallholder farmers, ranging from agronomic practices like crop diversification and intercropping to non-agricultural responses such as prayers and dietary adjustments. Recognizing and supporting these grassroots strategies can enhance the effectiveness of climate adaptation programs. Importantly, the findings challenge the notion of one-size-fits-all solutions and advocate for household-specific interventions that reflect the heterogeneity of rural communities.

In addition, the study underscores the importance of strengthening education and extension services at the village level. Improved access to climate information and training can empower farmers to make informed decisions and build long-term resilience. By integrating farmers' perceptions into policy frameworks, the study contributes to the development of inclusive and responsive climate strategies that are grounded in local realities. Therefore, this study was not only timely but also essential for bridging the gap between scientific knowledge and practical action in the face of climate change and variability.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 Climate change and variability

Climate change has become a global phenomenon with overwhelming evidence that warming of the climatic system commonly known as global warming is taking place (Leeuwen *et. al*., 2011). Kalungu *et. al*. (2014) defined global warming as the average increase in temperatures near the earth's surface and in the lowest layer of the atmosphere. An increasing rate of global warming has been observed since the 1950s, indicated by an increase in global mean surface temperature (IPCC, 2013). A number of observed changes, such as warming of the oceans and atmosphere, diminishing of snow and ice and sea level rise are extraordinary over decades to millennia (IPCC, 2013; 2014). Several scholars document how global warming will affect future climate change and variability across a range of spatial and temporal scales (IPCC, 2013).

According to IPCC (2013) climate change is a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties such as temperature, and precipitation, and that persists for a prolonged period of time, typically decades or longer (over 30 years). Climate change can be the result of natural internal processes or external forcing such as solar cycles, volcanic eruptions and anthropogenic activities that change the composition of the atmosphere. Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or variations in natural or anthropogenic external forcing or external variability (IPCC, 2013).

The United Nations Framework Convention on Climate Change (UNFCCC) makes a clear distinction between climate change attributable to anthropogenic activities and climate variability as a result of natural causes. The IPCC (2013) proclaims that it is extremely likely (95 – 100% certainty) that human influence has been the main cause of the observed warming since the mid-20th century. Anthropogenic activities are responsible for post-industrial age climate change by causing changes in Earth's atmosphere in the amounts of greenhouse gases, aerosols (small particles), and cloudiness (IPCC, 2014). Thus, the UNFCCC, in its Article 1, defines climate change as a change of climate which, in addition to natural climate variability observed over comparable periods, is attributed directly or indirectly to anthropogenic activities that alter the composition of the global atmosphere (IPCC, 2013). The largest known contribution comes from the burning of fossil fuels, deforestation, land use and land-use changes (LULUC), livestock production, fertilization, waste management, and industrial processes, which release carbon dioxide, methane, and nitrous oxide gases to the atmosphere (IPCC, 2018). Greenhouse gases and aerosols affect the climate by altering incoming solar radiation and outgoing infrared (thermal) radiation that are part of Earth's energy balance.

2.2 Conceptual Framework

Based on theoretical concepts and relevant studies, it is hypothesized that demographic, socioeconomic, and institutional characteristics of households are key factors influencing climate change adaptation. Demographic aspects like the gender, education level, farming experience, and climate change awareness of the household heads are expected to positively impact adaptation decisions. Similarly, socioeconomic factors such as farm income and livestock ownership are presumed to have a positive influence on farmers' decisions to adapt.

Institutional incentives like participation in local organizations, access to climate information, climate-related training, credit availability, and regular interaction with agricultural extension workers are expected to positively influence climate change adaptation. However, within socioeconomic factors, larger farm sizes and non-farm income are anticipated to negatively affect adaptation decisions. Additionally, demographic factors such as ages and sex of household heads and family sizes are believed to have both positive and negative impacts on climate change adaptation.

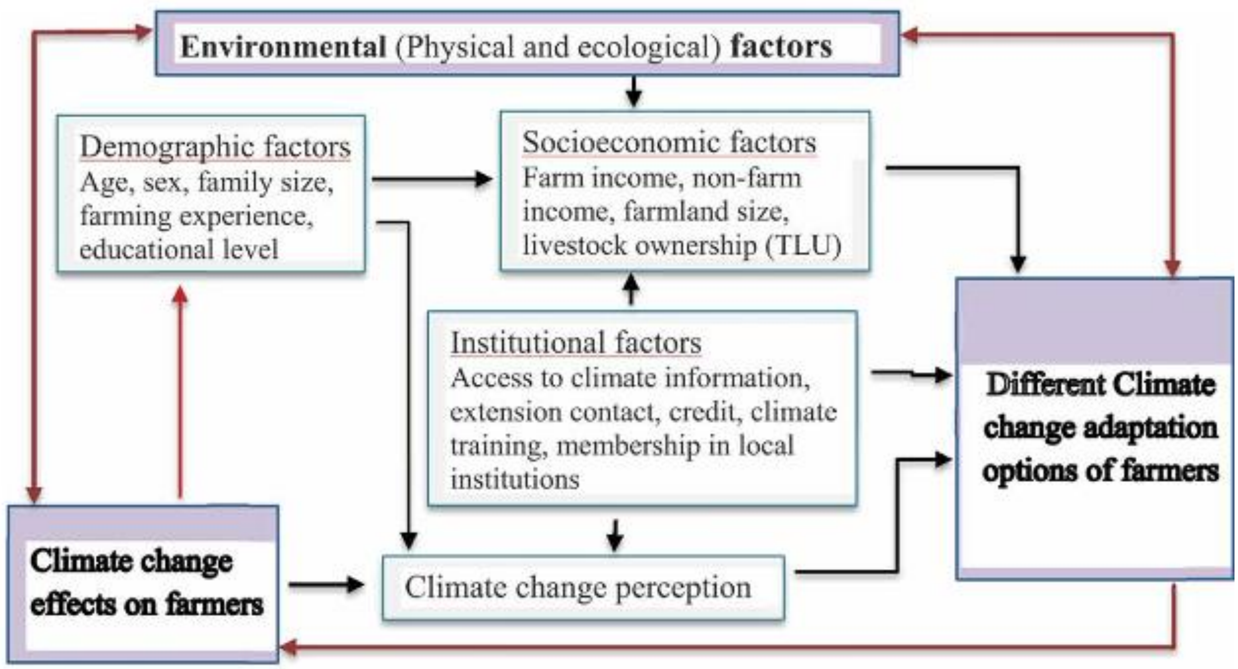

Figure 1: Conceptual framework (Adapted from Mihiretu *et. al.,* 2020).

2.3 Empirical Evidence

2.3.1 Smallholder farmers' perceptions of climate change and variability

Climate change and variability are primarily manifested through shifts in temperature and precipitation: two critical elements directly linked to agricultural productivity. Ogalleh *et. al.* (2012) emphasize that it is not only the range of these elements but also the frequency and intensity of extreme events that affect farming outcomes. In Sub-Saharan Africa, rising average temperatures exacerbate existing heat stress, shorten crop viability periods, increase soil evaporation, and heighten the risk of severe droughts (Kotir, 2011). Similarly, erratic rainfall patterns contribute to soil erosion and reduce soil moisture, both of which are detrimental to crop yields.

Empirical studies across Africa consistently show that smallholder farmers are aware of changing climate patterns. Ayanlade *et. al.* (2017) found that farmers in Nigeria observed shifts in rainfall timing, increased frequency of extreme weather events, and declining crop yields. Livestock farmers reported challenges in accessing water and pasture during prolonged dry spells. These perceptions were validated by meteorological data, reinforcing the credibility of farmers' experiential knowledge. Similar findings were reported by Okumu *et. al.* (2013) and Ogalleh *et. al.* (2012) in Kenya's Kitui and Laikipia districts respectively. Farmers noted decreasing rainfall, rising temperatures, increased frost events, and food shortages. In Malawi's Chikwawa district, Joshua *et. al.* (2016) documented declining yields from rain-fed agriculture due to persistent rainfall failure and rising temperatures. These studies collectively highlight the alignment between farmers' perceptions and scientific data, underscoring the widespread impact of climate change and variability on agricultural systems.

Munthali *et. al.* (2016) found that in Rumphi district, 76% of farmers perceived increased temperatures and 74% perceived reduced rainfall. While temperature perceptions aligned with meteorological data, rainfall perceptions did not, highlighting a gap between scientific evidence and local understanding. This underscores the need for targeted climate education and improved access to reliable data. Similarly, Shani *et. al.* (2024) observed that in Zomba District, only 26% of farmers adopted climate-smart agricultural practices, with simplicity and compatibility being key determinants of uptake.

Furthermore, Twinomugisha and Mushy (2022) highlighted that in Salima District, farmers often attributed climate variability to spiritual or traditional causes, which shaped their openness to scientific interventions. These findings suggest that perception is shaped by cultural beliefs, indigenous knowledge, and access to information, all of which influence adaptation behaviour. Jantke *et. al.* (2020) also revealed that German farmers were generally aware of climate change and express a commitment to reducing greenhouse gas (GHG) emissions. However, their understanding of specific agricultural emission sources was moderate, with many unable to identify or monitor on-farm emissions. The study relied solely on online questionnaires, with limited deeper insights into farmers' reasoning and practices. Incorporating qualitative methods such as focus group discussions could have enriched the data by probing farmers' perceptions and knowledge gaps more thoroughly.

The consequences are severe: unpredictable planting seasons, reduced yields, and heightened food insecurity. Many households survive on one meal per day, leading to malnutrition and related health issues. Okumu *et. al.* (2013) also observed increased livestock and human disease outbreaks, as well as migration in search of better conditions. These findings point to a growing crisis that demands precautionary action, as the cost of inaction could be catastrophic.

Yamba *et. al*. (2019) reported that coefficient agents of deforestation causing climate variability was statistically significant in the empirical model at 5 percent in Ghana. This implies that there was high perception of deforestation as anthropogenic cause of climate variability in study area. Consequently, climate change increasingly becomes variable as forests are cleared. Smallholder farmers therefore identified deforestation as a key contributor to climate change. This might be attributed to deforestation that affects climate in two major salient ways: disruption of rainfall regimes on local or national basis and through effects of the greenhouse which tend to impact agriculture directly (IPCC, 2014). Solutions that can help adapt to and mitigate climate change while contributing to combating deforestation are site-related and regionally specific (IPCC, 2019). These may include water harvesting, micro-irrigation, restoring degraded lands using drought-resilient ecologically appropriate crops, agroforestry, and other agro-ecological and ecosystem-based adaptation practices (Joshua *et. al.,* 2016). This would enhance soil fertility, increase carbon storage in soils and biomass, while benefitting agricultural productivity and food security.

In Australia, Buys *et. al*. (2011) came up with similar findings that communities believed in anthropogenic or human-induced factors that contributed to climate change, and this report described the changing climate as evidence of climate change, whereas those who were more skeptical believed that what was happening was due to weather variability. This suggest that there is a divide in various communities that, unless urgently addressed, will hinder local and national policy responses to this global issue. This is the case because community engagement and support are essential for ensuring adaptation to climate change and variability. After all, the first step in achieving engagement is documenting how the communities are currently perceiving and understanding climate change and variability issues, specifically the importance they place on this global problem and identifying any unique challenges for individual communities.

However, Kalinda *et. al*. (2011) found that most smallholder farmers in Zambia perceived supernatural forces as cause of climate change. Farmers referred to the Bible arguing that disobedience of humankind to God's principles and/or lack of respect to ancestral spirits and other customs caused climate change. Similarly, Owusu *et. al*. (2015) also observed that majority of smallholder farmers in Ghana associated climate change to the anger of ancestors. According to smallholder farmers, this is a vivid signal that their ancestors do not like their modern way of life. Despite some studies (Yamba *et. al*., 2019; Munthali *et. al*., 2016; Kyaw, 2018) reporting that farmers associate causes with environmental explanations that identified deforestation, pollution from industries and modernization as causes of climate change, these findings imply that there are still some quarters of smallholder farmers who do not understand the concept of climate change and variability. Thus, no surprise IPCC (2014) is worried that most smallholder farmers in various developing countries do not understand the concept of climate change and variability fully. This is an indication that perceptions are really context and location specific due to heterogeneity in factors that influence them such as culture, education, gender, age, resource endowments and institutional factors (Kalinda *et. al.,* 2011; Shisanya, 2015).

2.3.2 Impacts of climate change and variability on livelihoods and natural resources utilization

The impact of climate change and variability on farming communities, particularly those in ecologically fragile zones, is profound and multifaceted. These effects are more pronounced in developing countries like Malawi, where rain-fed agriculture is often a primary source of subsistence and livelihood. The study of Choudri *et. al.,* (2015) in Al-Suwayq Wilayat, Sultanate of Oman noted that these changes include but are not limited to changes in rainfall frequency and intensity, the shrinkage of glaciers, gradual shifts in the growing season, early flowering of trees, emergence of insects, and likely shifts in the distribution ranges of plants and animals, insects in response to changes in climatic conditions.

Climate change and variability lead to alterations in temperature patterns, precipitation levels, and atmospheric CO_2 concentrations (Choudri *et. al.,* 2013). These changes directly influence crop growth and productivity. For instance, higher temperatures can accelerate evaporation rates, leading to soil moisture depletion and drought stress on crops. Changes in precipitation patterns can result in periods of excessive rainfall or prolonged droughts, both of which can negatively impact crop yields IPCC, 2014). Additionally, IPCC, (2019) indicates that elevated CO_2 levels can affect crop physiology, altering photosynthesis rates and nutrient uptake, which may impact adversely overall crop productivity.

Climate change also affects soil quality and the distribution and frequency of pests, diseases, insects, and weeds. Choudri *et. al.,* (2013) and Tsokota (2015) in different studies observed that changes in temperature and precipitation influence soil moisture levels, nutrient availability, and microbial activity, all of which contribute to soil health and fertility. Alterations in these factors can impact crop growth and yield potential. Furthermore, shifts in temperature and precipitation patterns create favorable conditions for the proliferation of pests, diseases, and invasive species, leading to increased crop damage and yield losses (IPCC, 2022).

Annual agricultural productivity and food security are closely linked to the variability of precipitation. Changes in precipitation patterns, including shifts in timing, intensity, and distribution, significantly impact crop production and harvest yields (IPCC,2019; IPCC, 2022).

Variability in precipitation can lead to water stress, crop failures, and reduced agricultural output, threatening food security for Smallholder farmers (Tsokota, 2015). Moreover, extreme weather events such as floods, droughts, cyclones and storms, which are becoming more frequent and severe due to climate change, further exacerbate these challenges amongst smallholder farmers. Ricart *et. al.* (2023) reported that smallholder farmers primarily identify three factors affecting their farming operations, for instances escalating temperatures and extreme heat, shifting rainfall patterns characterized by unpredictability and irregularity, and a rise in drought occurrences and dry periods. The majority of research findings indicate a growing pattern in temperature and its variability (Asfaw *et. al.,* 2019).

2.3.3 Adaptation Strategies to Climate Change and Variability

Addressing the impacts of climate change on agriculture requires comprehensive strategies that encompass both adaptation and mitigation measures. These may include implementing sustainable farming practices, improving water management techniques, developing drought-resistant crop varieties, enhancing pest and disease management strategies, and promoting agroforestry and soil conservation practices. Additionally, international cooperation and support are crucial for assisting smallholder farming communities, particularly those in vulnerable regions, to adapt to climate change and build resilience in their agricultural systems.

A study by Cordova *et. al.* (2019) explored perceptions among Kayambi indigenous farmers in Ecuador and found that both agroforesters and conventional farmers recognized rising temperatures and declining precipitation. However, conventional farmers reported higher exposure to droughts (20%), solar radiation (43%) and pest outbreaks (40%) compared to those practicing agroforestry. This suggests that agroforestry systems offer greater resilience to climate stressors. Agroforestry and organic farming practices are increasingly recognized as effective adaptation and mitigation strategies. These systems rely on the rational use of natural resources, crop rotation, nitrogen-fixing intermediate crops, organic fertilizers, composting and biotic pest control. They also promote the use of disease-resistant crop varieties. Such practices enhance soil fertility, reduce sensitivity to climate extremes, and improve long-term agricultural sustainability.

Atoma *et. al.* (2019) advocated for the promotion of organic farming in Nigeria as a sustainable alternative to conventional agriculture. Organic farming avoids synthetic inputs and offers multifaceted benefits; economic, environmental, and social. It enhances food security, builds resilience to climate change, improves health outcomes and combats desertification (Perpar and Udovc, 2019). Despite these advantages, awareness and adoption of organic practices among smallholder farmers remain low (IPCC, 2007), necessitating intensified extension campaigns and sensitization efforts. Organic farming is portrayed as a deliberate, resource-efficient system that aligns with ecological principles.

Ogundeji (2022) reported that farmers in South Africa had adopted crop diversification, conservation agriculture, and agroforestry. Using endogenous treatment-effect ordered probit model, the study found that access to climate information, gender of household head, and livestock ownership significantly influenced the adoption of adaptation measures. These strategies were positively correlated with improved food security outcomes. In Limpopo Province, Maponya and Mpandeli (2013) found that farmers responded to climate change and variability by shifting planting dates, using drought-tolerant crops, and increasing reliance on irrigation. However, access to water and extension services remained major constraints. Similarly, Mubaya *et. al.* (2010) conducted studies in Mashonaland and Matabeleland provinces, revealing that farmers perceived increased temperatures and reduced rainfall. Adaptation strategies included mulching, planting early-maturing varieties, and engaging in off-farm income activities. The study emphasized the role of social networks and farmer-to-farmer knowledge exchange in promoting adaptation.

However, Lamichhane *et. al.* (2022) identified several barriers to adaptation, including economic constraints (e.g., lack of credit and high input costs), information gaps (e.g. limited access to forecasts and extension services), and environmental challenges (e.g., soil degradation and water scarcity). The study emphasized the need for agroecosystem-specific policies to overcome these barriers and promote resilience among smallholder farmers.

According to Kaira (2023), participatory vulnerability analysis (PVA) conducted in Nsanje and Salima districts revealed that farmers are experiencing shortened growing seasons, increased frequency of droughts and floods, and declining productivity. In response, farmers have adopted hybrid crop varieties, adjusted planting calendars, diversified income sources, and engaged in community-based disaster preparedness. However, frequent climate shocks often erode these gains, leaving farmers with limited capacity to recover and adapt effectively. Indigenous knowledge plays a critical role in guiding local adaptation. Smallholder farmers often rely on traditional indicators to predict rainfall and determine planting times. Community-based adaptation initiatives, such as shared irrigation schemes and village saving groups, have emerged as grassroots responses to climate change and variability. these approaches enhance collective resilience and foster local ownership of climate solutions (Kaira, 2023).

Effective adaptation requires enabling environments supported by policy and institutional frameworks. Strengthened extension services, gender-responsive policies, access to climate data, and early warning systems are critical for empowering smallholder farmers. Government and developing partners must invest in institutional support mechanisms that facilitate the adoption of climate-resilient practices, particularly among female-headed households and marginalized communities. Community engagement and participatory approaches are essential for designing locally appropriate adaptation strategies. Integrating indigenous knowledge with scientific insights can enhance the relevance and effectiveness on interventions.

While climate change affects the entire globe, adaptation and mitigation measures to these changes must be tailored to specific locations. Addressing site-specific issues requires detailed local knowledge. However, simply identifying adaptation measures does not guarantee their implementation. Various barriers such as financial constraints, social dynamics, cultural norms, psychological factors, and physical limitations hinder planned adaptation and mitigation efforts (Asfaw *et. al.,* 2019; IPCC, 2014; IPCC, 2022). Therefore, it is crucial to gain a clear understanding of the realities faced by communities, particularly smallholder farmers, as they are among the most vulnerable to climate impacts.

CHAPTER THREE: METHODOLOGY

3.1. Study Area

The research was conducted in Kazomba Extension Planning Area (EPA) in Mzimba District in the Northern Region of Malawi, which is geographically situated around the coordinates 11°30' South latitude and 33°30' East longitude. For easy operation, the area has been divided into 6 sections which include: Kajorwe, Kamwamphimbi, Kamwiro, Kasangazi, Katowo and Wozi. For this research, the study was conducted in four sections and these are Kamwamphimbi, Kamwiro, Kasangazi and Wozi. The area is worthy for this study because of smallholder farmers' vulnerability to climate change and variability (Zulu, 2017). The study area has been characterized by very unpredictable and short rainfall seasons and there have been more frequent droughts and flash floods [M'mbelwa District Council, (MDC, 2017)]. Frequent dry spells, droughts, flash flooding and loss of arable land due to climate change and variability are reducing agricultural yields and causing crop failure and loss of livestock which endangers smallholder farmers' livelihoods in the area. The impact of climate change on agriculture and other key economic sectors in the food production and supply chain such as forestry and energy threatens food security across the area (MDC, 2017). With the majority of the inhabitants being rain-fed agrarians, the area is more vulnerable to climate change and variability.

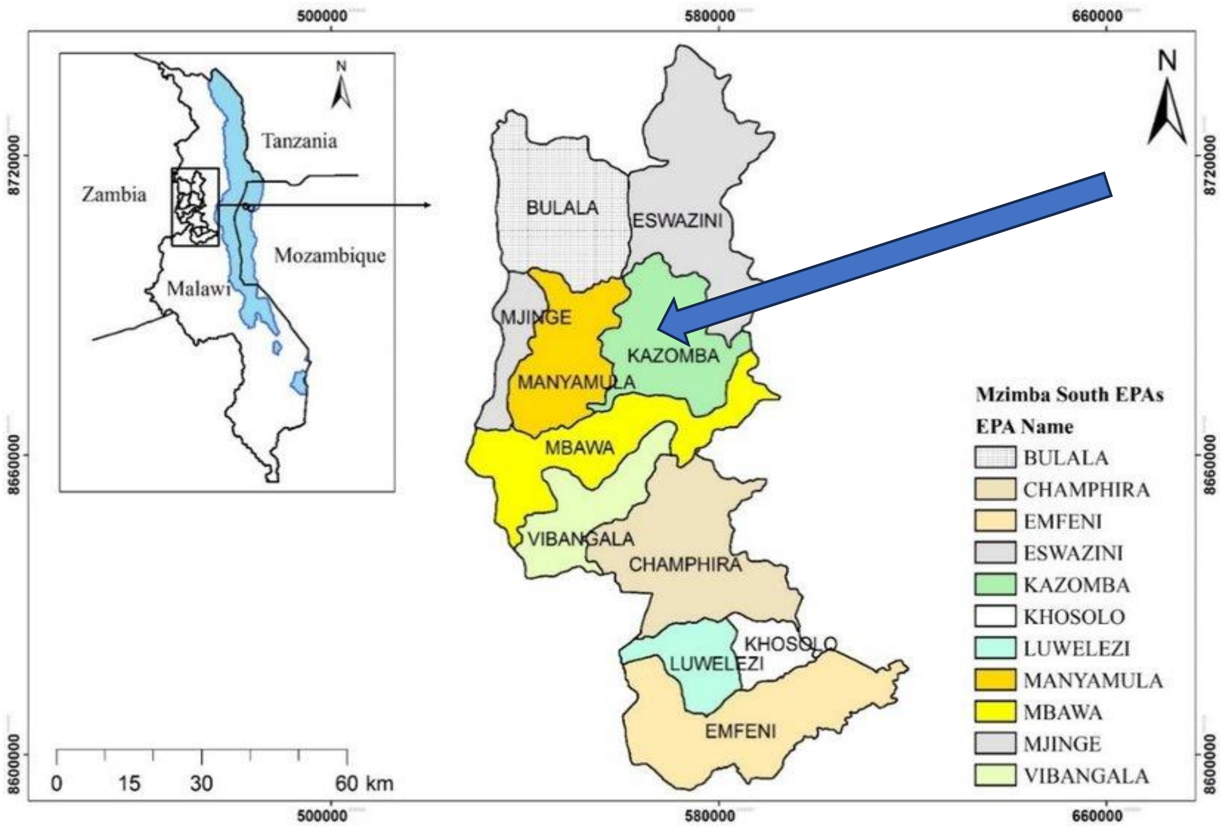

Figure 2: Map of South Mzimba showing Kazomba EPA (*Source: JOCA, 2012*)

3.2. Study Approach and Design

This study adopted a convergent mixed-methods to collect both quantitative and qualitative data, merge the data, and use the results to understand the research problem. According to Creswell (2012) one data collection form supplies strengths to offset the weaknesses of the other form, and that a more complete understanding of a research problem results from collecting both quantitative and qualitative data. Mixed-methods approaches allow for a wider range of research questions to be asked and enable the rich information generated to present a stronger body of evidence than is possible using a single method (Yin, 2018). The study involved the collection of secondary data on temperature and rainfall from the Department of Climate Change and Meteorological Services in Blantyre.

The quantitative descriptive design systematically measures and summarizes the characteristics of a defined population or phenomenon at a single point in time, providing precise estimates of attributes, frequencies, central tendencies, and distributions. It is oriented toward answering "what" and "how many" questions rather than explaining causal mechanisms or testing casual hypothesis. According to Creswell (2014), the primary aim of a descriptive design is to answer descriptive research questions by documenting the current status of variables of interest and presenting an accurate account of their distribution within the sample or population.

3.3. Study Population

A simple random sampling technique was used to select the households where questionnaire survey was carried out and a total of 320 smallholder farmers were randomly selected for the study. Sub-samples of 112, 40, 43, and 125 households respectively were randomly selected within the functional sections of the study area (Table 1). The study was carried out in four functional sections of the EPA, namely: Kamwamphimbi, Kamwiro, Kasangazi and Wozi in order to generate a better representation of the EPA. The four functional sections have a total of 3247 farming households.

Table 1: Distribution of households sampling framework

Section	No. of Villages	Male headed household	Female headed household	Total	Sub-Sample
Kamwamphimbi	8	793	339	1132	112
Kamwiro	7	257	149	406	40
Kasangazi	6	303	134	437	43
Wozi	11	483	789	1272	125
Totals	**32**	**1836**	**1411**	**3247**	**320**

To determine the sample size needed to measure a given proportion with a degree of accuracy at a given level of statistical significance, the Yamane (1967) formula were employed:

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

……………………………………… ***Equation 1***

Where "n" is the sample size, "N" is the sample frame and "e" is the margin of error at a 95% confidence level and the degree of accuracy expressed as a proportion (.05). The respective samples for each section were obtained through the proportional allocation method.

3.4. Sample Size and Sampling Technique

A combination of sampling strategies were employed to align with the methodological requirements of different data collection techniques within the study. Specifically, simple random sampling was utilized for the household survey component. This approach involved the lottery method without replacement, ensuring that each selected smallholder farmer had an equal and independent chance of being chosen, while also preventing any individual from being selected more than once. Such method enhances the representativeness and internal validity of the sample by minimizing selection bias and ensuring that the sample accurately reflects the broader population of smallholder farmers in the Kazomba Extension Planning Area.

According to Yin (2018), random sampling is defined as a procedure in which every unit in the population has a known and non-zero probability of selection. This probabilistic framework is fundamental to quantitative research designs, as it allows for the application of inferential statistics and generalization of finding to the target population. In this study, the use of simple random sampling was particularly appropriate given the need to capture diverse household-level experiences and perceptions related to climate change impacts and adaptation strategies. By employing the method, the study upheld key principles of objectivity, transparency, and statistical reliability, thereby contributing to a robust research design and the credibility of its findings.

3.5. Data Collection Methods

Data on demographic and socio-economic characteristics of smallholder farmers were collected using a semi-structured questionnaire administered through direct interviews with 320 respondents. The questionnaire captured a wide range of variables. These included age, marital status, family size, education level, farming experience, sources of income, land ownership, land size, land fertility, types of crops grown, livestock domestication, access to extension services, access to climate change information or training, access to farm credit, and membership in local institutions.

Data collection was essential for several reasons. First it provided a comprehensive profile of the smallholder farmers, enabling the identification of patterns and differences in climate change perception across various socio-economic groups. Second, demographic and institutional factors play a critical role in shaping farmers' vulnerability and adaptive capacity. For instance, education level and access to extension services can influence how farmers interpret climate information and adopt resilient agricultural practices. Furthermore, socio-economic variables such as income sources, land ownership, and access to credit directly affect the resources available for adaptation, while institutional membership often facilitates knowledge sharing and collective action. By integrating these variables into the analysis, the study was able to uncover the complex interplay between household characteristics and climate change perception, thereby informing targeted interventions and policy recommendations.

One of the specific objectives was to investigate the perception of smallholder farmers on climate change and variability. Under this specific objective, a household survey was conducted involving 320 randomly selected households to investigate smallholder farmers' perceptions about local climate change and variability over the past two decades or more. Farmers provided insights on the impact of these changes in relation to their livelihoods. Perceptions were assessed using a categorical nominal scale, with response options ranging from "increase," "decrease," "no change," and "don't know", specifically for the variables such as rainfall and temperature. This approach aimed at systematically capturing farmers' views on climate trends and their implications.

Understanding these perceptions was critical, as they influence farmers' awareness and decision-making regarding adaptive strategies, thereby affecting their overall adaptive capacity. For instance, recognizing changes in climate conditions enables smallholder farmers to make timely decisions, such as altering agricultural practices to align with the changing environment or adopting alternative adaptive measures. Therefore, identifying farmers' perceptions was fundamental preliminary a step before delving into further analyses.

The second specific objective sought to determine the rainfall and temperature trends/patterns between 1982 to 2019 in Kazomba Extension Planning Area. Meteorological data regarding rainfall and temperature was collected from the Department of Climate Change and Meteorological Services in Malawi for a period between 1982 - 2019. The meteorological data was collected to determine the trends or patterns of rainfall and temperature in the Kazomba Extension Planning Area and also compare with the perceptions of smallholder farmers on climate change variability in the area.

Under objective three, this study adopted a qualitative research approach to systematically assess the socio-economic implications of perceived local climate changes and their influence on smallholder farmers' agricultural practices. The design enabled the collection of standardized data from a large sample, allowing for statistical analysis and generalization of findings within the study area. The data was collected using a structured questionnaire, designed to elicit information observed regarding impacts on agricultural productivity and household income. Face-to-face interviews were conducted with the 320 selected farmers by trained enumerators fluent in the local language. This approach ensured accurate interpretation of questions and minimized non-response bias.

This data captured the farmers' perspectives on how perceived changes have affected them, both at the household and community levels. Farmers were asked to report their observations regarding various climate-related impacts. These included increased flooding, reduced crop yields or productivity, frequent droughts or dry spells, and early cessation of rainfall. Additional indicators included rising pest prevalence and invasions, increased incidences of crop and livestock diseases, worsening weed infestations, and noticeable shifts in suitable growing areas. Responses were recorded using a structured format: “yes”, “no”, or “don’t know”. This approach was used to systematically assess the perceived adverse effects of climate change and variability in the study area.

Furthermore, smallholder farmers were asked about their views on the causes of climate change and variability. The study addressed human-induced factors such as the burning of fossil fuels like oil, coal, and natural gas, vehicle emissions, deforestation, and unsustainable agricultural practices such as overgrazing and pesticide use. It also explored cultural and spiritual beliefs, including the roles of ancestral anger, divine wrath, the end of the world, and supernatural forces. Responses to the questions also followed the “yes,” no,” or “don’t know” format to identify farmers’ understanding of climate drivers.

The fourth specific objective of this study involved collecting data from 320 smallholder farmers to evaluate the adaptive strategies employed to enhance their resilience to climate change and variability. The study aimed at documenting specific measures farmers adopted to cope with the adverse impacts of climate variability within their local environments. Farmers identified a range of adaptation strategies to cope with climate change and variability. These included crop diversification, use of improved varieties, intercropping, cover cropping, crop residue management, minimum tillage, crop rotation, mulching, organic manure application, irrigation, and rainwater harvesting. Non-agricultural measures, such as mixed farming, dietary modifications, changes in land use, migration, reliance on remittances and even cultural practices like praying for rain, were also reported. Responses were recorded in a binary “yes” or “no” format to identify which strategies were actively employed.

In addition to documenting adaptive strategies, this section examined the barriers that prevent the adoption of certain measures. Farmers were asked to identify constraints from a list of categories, including financial limitations, insufficient information and technical knowledge, labour shortages, unsuitable environmental or infrastructural conditions and other socioeconomic challenges. By analyzing these responses, the study aimed to gain a comprehensive understanding of the factors that hinder effective adaptation among smallholder farmers.

Smallholder farmers were also surveyed to assess their levels of concern regarding potential future impacts of climate change and variability. The collection of data under this section focused on different issues critical to agricultural livelihoods and sustainability. Farmers were asked to express their concerns about recurrent droughts, recurrent floods, crop failures, outbreaks of crop pests and diseases, declining market prices for farm produce, declining soil fertility, rising costs of agricultural inputs, delayed onset of rainfall, shorter rainy seasons, temperature fluctuations (both increases and decreases) and changes in precipitation patterns (excessively high or low rainfall). The responses were measured using a four-point Likert scale to capture the intensity of their concerns, with the options being “never,” “rarely,” “sometimes,” and “often.” This structured approach aimed at quantifying the degree of worry among farmers regarding each issue, providing insight into their perceptions of potential climate-related risks.

Such data is vital for understanding the subjective experiences of smallholder farmers and their readiness to adapt to climate uncertainties. It helps identify priority areas where interventions, such as climate-resilient agricultural practices, financial support mechanisms, or educational programs, could alleviate concerns and strengthen adaptive capacity. By capturing both the frequency and intensity of these worries, the study aimed at informing targeted policy decisions and strategies to support farmers in mitigating and adapting the multifaceted impacts of climate and variability.

3.6. Data Analysis

The demographic, socio-economic, and institutional collected data was entered into Statistical Package of Social Scientists (SPSS) version 25.0 and analyzed using descriptive statistics (frequencies, percentages) and inferential statistics (e.g., chi-square tests) to identify relationships between climate perceptions and changes in agricultural practices. Results were presented in tables and graphs to enhance interpretability.

For specific objective one, Statistical Package of Social Scientists (SPSS) programme (Version 25.0) was utilized to analyze weather variables and smallholder farmer' perceptions of climate change. A series of statistical analyses were performed. Frequency analysis was conducted to summarize categorical data on farmers perceptions, providing counts and percentages to depict the distribution of responses. This facilitated the identification of patterns in perceptions related to climate change and variability within the study population. Cross-tabulation was employed to generate contingency tables that examined relationships among categorical variables. For example, the analysis assessed how perceptions varied across demographic attributes, such as educational attainment. The Chi-square test was applied to the cross-tabulated data to evaluate the statistical significance of associations between categorical variables, using a 0.05 significance threshold as the critical value.

Furthermore, on the second specific objective, the data on climate variables, specifically rainfall and temperature were examined to identify trends and variability using Microsoft Excel 2016 for analysis. For the rainfall, the analysis focused on a single variable: the trend of average annual rainfall. Monthly rainfall totals for the area were calculated and then summed to obtain the total annual rainfall for each year, which served as a data point. This process was repeated across all the years in the study period. A trend line using simple regression was plotted to identify the pattern of average annual rainfall (increasing, decreasing, or constant). Similarly, temperature trends for the study area were analyzed. Both minimum and maximum temperature trends were plotted using simple regression across the years to determine the overall trend of average annual temperature (whether increasing, decreasing, or constant) for the timeframe 1982–2019.

The data collected under specific objective three underwent a series of rigorous pre-processing steps, including editing to correct inconsistencies or errors and coding to enable efficient input and categorization within the statistical framework. These processes were aimed at ensuring the reliability and validity of the dataset. The analysis was conducted using SPSS software, version 25, which provided a robust platform for statistical computation. Frequency analysis served as the primary method to quantify and summarize the responses. This involved calculating the frequency and corresponding percentages of each response category for the assessed variables, offering valuable insights into the patterns and trends within the data. The results were systematically presented using frequency tables which provided a clear and structured overview of the distribution of responses. To further enhance the interpretability and communication of the findings graphical representations were generated. Specifically, bar charts were employed to visually depict the relative magnitudes and proportions of the variables of interest. This analysis not only quantified the prevalence of challenges and perceptions related to climate change but also provided a methodological foundation for understanding the underlying dynamics within the study population.

Under fourth specific objective, data obtained through structured questionnaire underwent thorough analysis using SPSS software, version 25. This statistical program facilitated the computation of descriptive statistics which provided a summary of the dataset by organizing and presenting key metrics such as frequencies and percentages. The results were systematically displayed in table format, ensuring clarity.

Additionally, correlation analysis was employed to rigorously examine the statistical relationships between various socio-demographic attributes of farmers, such as age, education level, source of income, land ownership and their adoption of climate change adaptation strategies within the study area. The correlation coefficients generated by this analysis allowed for the identification of both the direction (positive or negative) and strength of these relationships. For instance, a strong positive correlation might indicate that higher education levels are associated with a greater likelihood of implementing advanced adaptation strategies, while a negative correlation could suggest that certain age groups are less inclined to adopt the practices. This analytical approach not only provided insights into patterns and associations within the data but also offered a robust foundation for understanding the decision-making process and barriers faced by farmers in adapting to climate change.

3.7. Validation of the questionnaire

The questionnaire was validated through a pre-test conducted in Kazomba Extension Planning Area, the same location as the main study site. A small group of representatives from the target population participated in the pre-test, which followed a one-day training session for the enumerators. This process ensured that the enumerators were familiar with the survey tools and could administer them effectively. Feedback from the pre-test was used to refine question wording, structure, and sequencing, resulting in the final version of the questionnaire.

This research involved the collection of both primary and secondary data. Secondary data was sourced from the Department of Climate Change and Meteorological Services Headquarters in

Blantyre, Malawi. It included temperature and rainfall records of the study area spanning the last 37 years (1982–2019). This data was used to compare smallholder farmers' perceptions of climate variability with the actual trends reported by the Meteorological Services.

3.8. Ethical Consideration

Ethical issues related to the professional code of conduct were followed by the researcher in the process of conducting research. It involves following a set of guidelines (Creswell, 2009). To meet these guidelines, this study ensured that the purpose statements of the research were clearly highlighted to participants to avoid deception.

Therefore, as part of ethical consideration, this study also sought approval from Mzuzu University Research Committee (MZUNIREC) prior to data collection. Further, the consent was sought from all participating smallholder farmers and they were allowed to withdraw from the process if they felt uncomfortable.

In addition, during data analysis and interpretation, the anonymity of individuals was adhered to at all times. During the writing of this thesis, validity and reliability were fostered by ensuring the report was not falsified, suppressed or findings were not invented.

CHAPTER FOUR: RESULTS

4.1. Demographic and Socio-economic Characteristics of Farmers

The information presented in this section shows the details of the demographic and socio-economic characteristics data collected from smallholder farmers in the study area.

4.1.1 Smallholder farmers' demographic information

Table 2: Farmers households' information

Farmers' household information		Number of farmers	Percent (%)
Age			
	20-30 years	103	32.2
	31-40 years	81	25.3
	41-50 years	50	15.6
	51-60 years	38	11.9
	>60 years	37	11.6
	Don't know	11	3.4
Gender			
	Male	115	35.9
	Female	205	64.1
Marital status			
	Single	6	1.9
	Married	275	85.9
	Divorced/Separated	13	4.1
	Widow/Widower	26	8.1
Education			
	None	19	5.9
	Some primary education	126	39.4
	Completed primary education	108	33.8
	Secondary education	64	20
	College/University education	3	0.9
Household size			
	1-3 members	73	22.8
	4-6 members	184	57.5
	> 6 members	63	19.7
Farmers' experience			
	< 5 years	67	20.9
	5 -10 years	52	16.3
	11 - 20 years	67	20.9
	> 20 years	134	41.9

The smallholder farmers who participated in the study were predominantly adults aged above 20 years. As shown in Table 2, 32,2% of the smallholder farmers were aged between 20 and 30 years, 25.3% were between 31 and 40 years, 15.6% were between 41 and 50 years, 11.9% were between 51 and 60 years, and 11.6% were aged above 60 years. Additionally. 3.4% of the smallholder farmers were unable to specify their age. This distribution indicates that approximately 85% of the farmers were within the active age range, suggesting that they had likely experienced and observed climatic changes over a substantial period. Consequently, their responses provided credible and experience-based insights into the perception of climate change and variability in the study area.

The study revealed that the majority of smallholder farmers interviewed were female, accounting for 64.1% of the respondents, while males comprised 35.9%. This gender imbalance may be attributed to socio-economic dynamics in rural Malawi, where women predominantly remain at home to manage household responsibilities and agricultural activities, whereas many men engage in off-farm income-generating ventures, often away from their homesteads. This observation underscores the critical role women play in small-scale agriculture and suggests that they possess substantial experience and exposure to climate change and variability. Their active involvement in farming activities positions them as key informants in understanding the local impacts of climate change and the effectiveness of adaptation strategies.

In terms of marital status, the majority of the smallholder farmers (85.9%) were married, while 14.1% were single due to reasons such as divorce, widowhood, separation, or having never been married. Regarding educational attainment, 73.2% of the farmers had attended primary school, 20% had reached secondary education, only 0.9% had attained tertiary education, and 5.9% had no formal education. This distribution suggests that most smallholder farmers had basic literacy, which could influence their ability to access and interpret climate-related information.

Household size varied among smallholder farmers, with 57.5% reporting between four and six family members, 22,8% having between one and three members, and 19.7% having more than six members (Table 2). These figures reflect the typical family structure in rural Malawi and have implications for labour availability and household resilience to climate shocks.

Farming experience was also assessed, revealing that 41.9% of the farmers had more than 20 years of experience, 20.9 had between 11 and 20 years, 16.3% had between 5 and 10 years, while the remaining proportion had less than 5 years of farming experience. The predominance of experienced farmers in the sample suggests that most famers had long-term exposure to climatic patterns and were therefore well-positioned to provide informed perceptions of climate change and variability in the study area, as summarized in Table 2.

4.1.2 Smallholder farmers' entitlements information

Table 3: Farmers' entitlement information

Farmers' farm information		Number of farmers	Percent (%)
Source of income			
	Crop production	139	43.4
	Livestock production	4	1.3
	Business	26	8.1
	Employment	101	31.6
	Remittance	30	9.4
	Other	20	6.3
Land ownership			
	Private property with a title deed	1	0.3
	Communal land	1	0.3
	Ancestral land	318	99.4
Land size allocated to agriculture			
	< 1ha	144	45
	1 - 2 ha	135	42.2
	2 - 3 ha	34	10.6
	> 3 ha	7	2.2
Perception of land fertility			
	Very fertile	4	1.4
	Fertile	109	34.1
	Infertile	202	63.1
	Don't know	5	1.6
Main food crop grown			
	Maize	317	99.1
	Millet	0	0
	Beans	1	0.3
	Cassava	0	0
	Other	2	0.6
Livestock domestication			
	Yes	277	86.6
	No	43	13.4
Types of livestock (n=277)			
	Cattle	26	9.3
	Goat	111	40.0
	Sheep	1	0.3
	Pigs	55	19.8
	Others	85	30.6
Purpose for animal production (n=278)			
	Food	130	46.8
	Money	139	50.0
	Prestige	5	1.8
	Others	4	1.4

Table 3, shows information on smallholder farmers' entitlements. The study findings revealed that the primary sources of income for smallholder farmers in Kazomba EPA were crop production (43.4%), off-farm activities such as employment in nearby companies like Raiply (31.6%), and remittances (9.4%). Other income-generating activities including small-scale business, livestock production, and casual labour (locally known as piece work) were reported by a limited number of farmers. The alternative sources were not substantial enough to provide meaningful economic relief or diversification for most households.

The results further indicated that the majority of farmers practiced subsistence agriculture, with minimal engagement in cash crop production. This was confirmed by 99.1% of smallholder farmers who reported cultivating maize primarily for household consumption and, to a lesser extent, for sale. Such reliance on a single staple crop poses significant risks to food security, particularly in the face of climate-related shocks such as droughts and floods.

Table 3, the study revealed that the vast majority of smallholder farmers (99.4%) were cultivating ancestral land, with only 0.3% each practicing agriculture on private and customary land. This predominance of ancestral land use reflects traditional land tenure systems in rural Malawi, where land is typically inherited and communally managed. Given the long-term use of the same plots, it is unsurprising that 63.1% of farmers perceived their soils to be less fertile than in the past. In contrast, 34.1% believed their land remained fertile, while 1,6% and 1.4% of farmers reported being unsure of their land's fertility status or considered their land to be very fertile, respectively. Regarding land holding size, the majority of farmers (45.0%) reported owning one hectare or less for agricultural activities, as shown in Table 3. An additional 42.2% had land holdings ranging between one and two hectares. About 10.6% of farmers owned land exceeding two hectares but not more than three hectares, while only 2.2% had land holdings greater than three hectares. These findings suggest that most farmers operate on small plots, which may limit their capacity to diversify crops or implement certain climate adaptation strategies, thereby increasing their vulnerability to climate change and variability.

Given the significant role livestock production plays in rural livelihoods, the study found that a majority of smallholder farmers (86.6%) domesticated animals within their farmyards, while only 13.4% did not engage in livestock production. Disaggregated data revealed that 40.0% of households kept small ruminants such as goats, 30.6% raised local breeds of chickens, 19.8% were involved in pig production, 9.8% kept cattle, and only o.3% engaged in sheep rearing. These figures reflect a preference for livestock types that are well-suited to smallholder farming systems and local environmental conditions.

Livestock served multiple purposes in the study area. Half of the farmers (50%) indicated that they kept animals primarily for income generation through sales, while 46.8% reported using livestock for household food consumption. A small proportion of farmers (1.8%) kept animals for prestige, and 1.4% for cultural purposes such as Lobola during marriage ceremonies. Nearly all farm households raised local breeds, which were highly valued for their resilience to feed shortages and disease, making them more suitable for the resource-constrained conditions faced by smallholder farmers compared to improved breeds.

4.1.3 Farmers' institutional characteristics

Table 4: Farmers' institution characteristics

Farmers' institutional characteristics		Number of farmers	Percent (%)
Access to extension services			
	Yes	274	85.6
	No	46	14.4
Access to climate change information or training			
	Yes	33	10.3
	No	287	89.7
Access to farm credits			
	Yes	109	34.1
	No	211	65.9
Source of farm credits (n=109)			
	Commercial banks	2	1.8
	Sacco	1	0.9
	Village banks	88	80.7
	Others	18	16.5
Local membership / institution			
	Yes	190	59.4
	No	130	40.6
Groups / institutions (n=190)			
	Farmers club	87	45.8
	Mother care group	3	1.8
	Village banks	89	46.8
	Others	11	5.8

Institutional characteristics were assessed to understand the extent of smallholder farmers' engagement with agricultural support systems and community organizations, as summarized in Table 4. The majority of farmers (85.6%) reported having access to agricultural extension services, while14.4% indicated they did not receive such support. Despite this relatively high access to extension services, only 10.3% of farmers had ever received information or training specifically related to climate change, whereas 89.7% had not accessed any climate-related education or support. This gap highlights a critical need for targeted climate change awareness and training programs within the study area.

Regarding access to financial services, 65.9% of farmers reported having no access to loans or credit facilities for farming activities, while 34.1% had accessed such support. Among those who received financial assistance, the majority (80.7%) obtained loans or credit through local savings groups commonly referred to as Village Banks. A small proportion accessed credit from commercial banks (1,8%), Savings and Credit Cooperatives (SACCO) (0.9%), and other informal sources such as peers and relatives (16.5%).

Participation in community-based organizations was also examined. Most farmers (59.4%) indicated that they were members of various local groupings, while 40.6% did not belong to any formal group. Among those affiliated with organizations, 46.8% were members of Village Banks, 45.7% participated in farmer' clubs, 1.8% were involved in mother care groups, and 5.8% belonged to other groups such as church-based associations. These institutional affiliations play a vital role in facilitating access to resources, information, and collective action, which are essential for enhancing resilience to climate change and variability.

4.2 Perception of Smallholder Farmers on Climate Change and Variability

4.2.1. Farmers' Perceptions of Climate Parameters

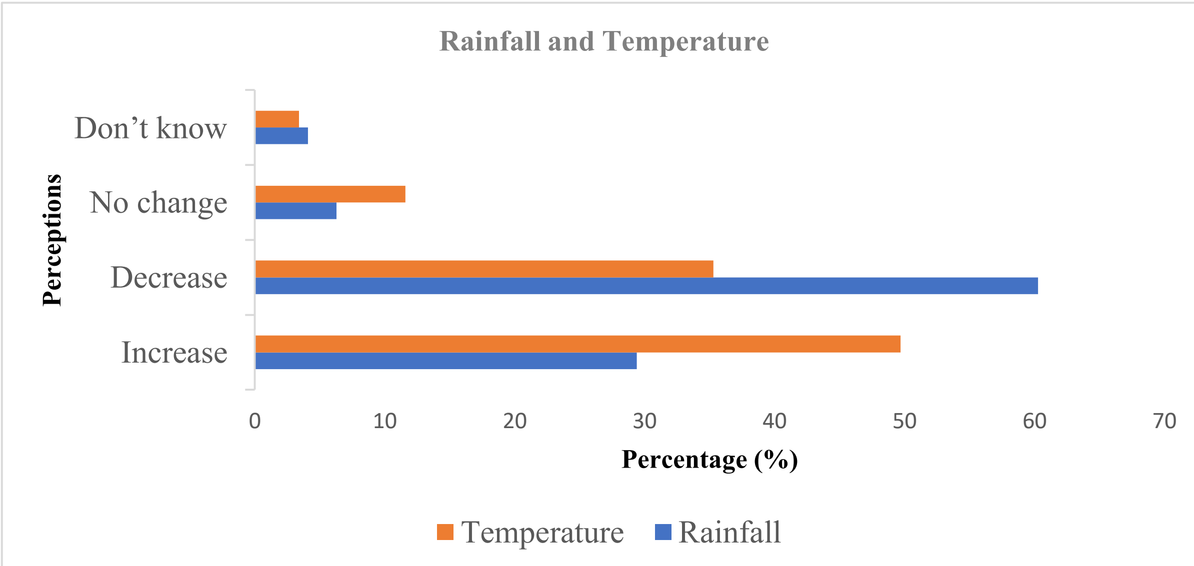

Figure 3: Farmers' perceptions on climate variables (temperature and rainfall)

The findings in this section address the first specific objective: to assess smallholder farmers' perceptions of climate change and variability within the study area. It was essential to gain a comprehensive understanding of how smallholder farmers describe and interpret the state of their local climate, based on their experiential knowledge and observations. Consequently, the initial research question aimed to investigate farmers' perceptions regarding the state of their local climate over the past two decades or more, focusing on how these perceptions relate to their livelihoods. Responses were categorized on a nominal scale: increased, decreased, no change, or don't know.

The study investigated farmers' perceptions of changes in key climate variables over the past two decades. As illustrated in Figure 3, nearly half of the farmers (49.7%) reported that temperatures had increased over the last 20 years or more. This perception aligns with broader climatic trends observed in the region. In contrast, perceptions regarding rainfall revealed a different pattern. A majority of farmers (60.3%) observed a decline in both the amount and reliability of rainfall during the same period. These findings suggest that smallholder farmers are acutely aware of shifts in climate conditions, particularly the warming trend and reduced precipitation, which have direct implications for agricultural productivity and food security in the study area.

4.2.1.1 Cross-tabulation between perception on temperature and education

Table 5: A cross tabulation on farmers' perception of temperature in relation to educational levels (%)

Perception on changes in temperature over the past 20 years	Highest level of education					Pearson Chi-Square test
	None	Some primary	Completed primary	Secondary	Tertiary	
Increased temperature	9 (5.7)	58 (36.5)	58 (36.5)	31 (19.5)	3 (1.9)	$X^2 = 8.551$
Decreased temperature	7 (6.2)	52 (46.0)	34 (30.1)	20 (17.7)	0 (0.0)	DF = 12
No change	2 (5.4)	13 (35.1)	13 (35.1)	9 (24.3)	0 (0.0)	p = 0.741
Don't know	1 (9.1)	3 (27.3)	3 (27.3)	4 (36.4)	0 (0.0)	

Table 5 presents a cross-tabulation and a Pearson chi-square test result, which reveals insignificant association $(x^2 = 8.551, df = 12, p > 0.05)$ between farmers' educational levels and their perception of temperature trends.

4.2.1.2 Cross-tabulation between perception on rainfall and education

Table 6: A cross tabulation on smallholder farmers' perception on rainfall and educational levels (%)

Perception on changes in rainfall over the past 20 years	Highest level of education					Pearson Chi-Square test
	None	Some primary	Completed primary	Secondary	Tertiary	
Increased rainfall	4 (4.3)	40 (42.6)	30 (31.9)	20 (21.3)	0 (0.0)	$X^2 = 11.559$ DF = 12 p = 0.482
Decreased rainfall	10 (5.2)	74 (38.3)	67 (34.7)	39 (20.2)	3 (1.6)	
No change	3 (15.0)	6 (30.0)	9 (45.0)	2 (10.0)	0 (0.0)	
Don't know	2 (15.4)	6 (46.2)	2 (15.4)	3 (23.1)	0 (0.0)	

Table 6 presents a Chi-square test which revealed insignificant association ($X^2 = 11.559$, df = 12, $p > 0.05$) between smallholder farmers' perceptions of rainfall patterns and their educational levels in the study area.

4.2.2. Extreme weather events indicators in the study area

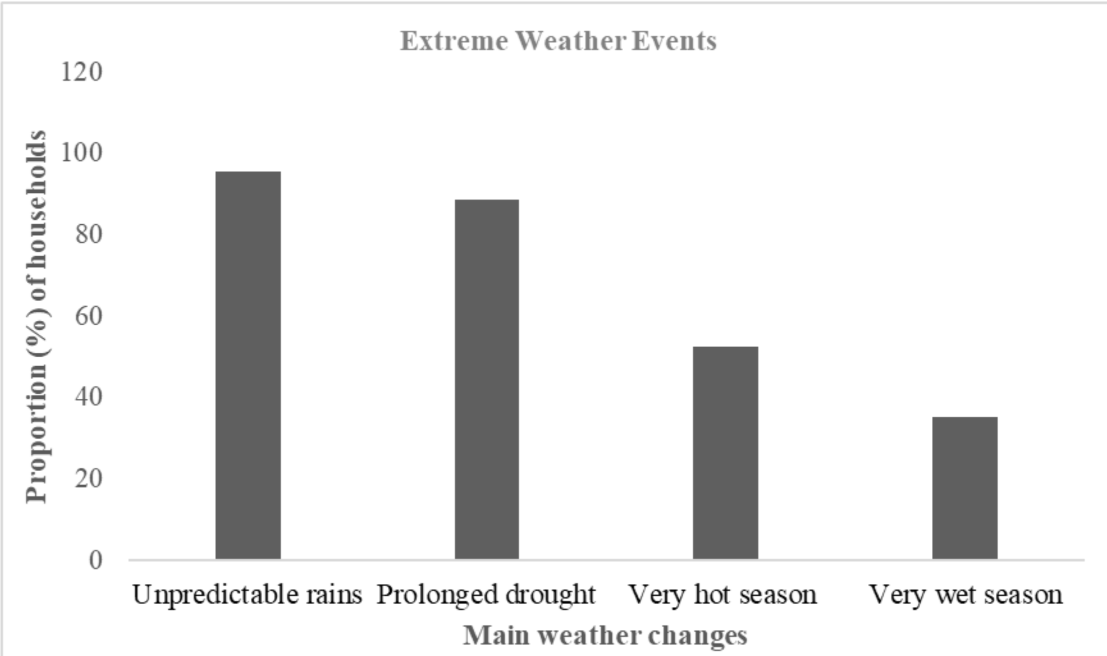

Figure 4: Distribution of farmers by main weather changes over the past 20 years

To complement the analysis of general climate perceptions, smallholder farmers were asked whether they had observed notable changes in specific weather phenomena over the past 20 years. These included unpredictable rainfall, prolonged droughts, extreme heat, and heavy wet seasons. Responses were recorded using a binary (yes/no) format to identify key indicators of climate change and variability in the study area. As illustrated in Figure 3, the most commonly reported changes were unpredictable rainfall ((95.3%), prolonged droughts (88.4%), and very hot seasons (52.5%). These findings suggest that farmers are highly aware of shifts in weather patterns that directly affect agricultural productivity and household food security.

4.2.2.1 Cross-tabulation between extreme weather events and farmers' experience

Table 7: Across tabulation between the main extreme weather event indicators and farmers' experience (%)

Perception on extreme weather changes	Farmers' experience in farming (Years)				Chi-Square Test		
	≤_5	6 - 10	11 - 20	> 20	X^2	DF	p - value
Unpredictable rains	62 (20.3)	49 (16.1)	62 (20.3)	132 (43.3)	5.508	3	0.138
Prolonged drought	57 (20.1)	46 (16.3)	60 (21.2)	120 (42.4)	0.985	3	0.805
Very hot seasons	29 (17.3)	19 (11.3)	41 (24.4)	79 (47.0)	11.865	3	0.008
Very wet seasons	28 (24.8)	13 (11.5)	23 (20.4)	49 (43.4)	3.773	3	0.287

Table 7, revealed a statistically significant association between the occurrence of extremely hot seasons and the farming experience of farmers ($\chi^2 = 11.865$, df = 3, $p < 0.05$). This suggests that farmers with more years of experience are more likely to perceive and report changes in climate conditions. Their long-term exposure to seasonal patterns may enhance their ability to detect subtle shifts in temperature and other climatic variables, reinforcing the value of experiential knowledge in climate monitoring and adaptation planning.

4.3 Temperature and Rainfall Trends in Kazomba EPA

4.3.1 Temperature

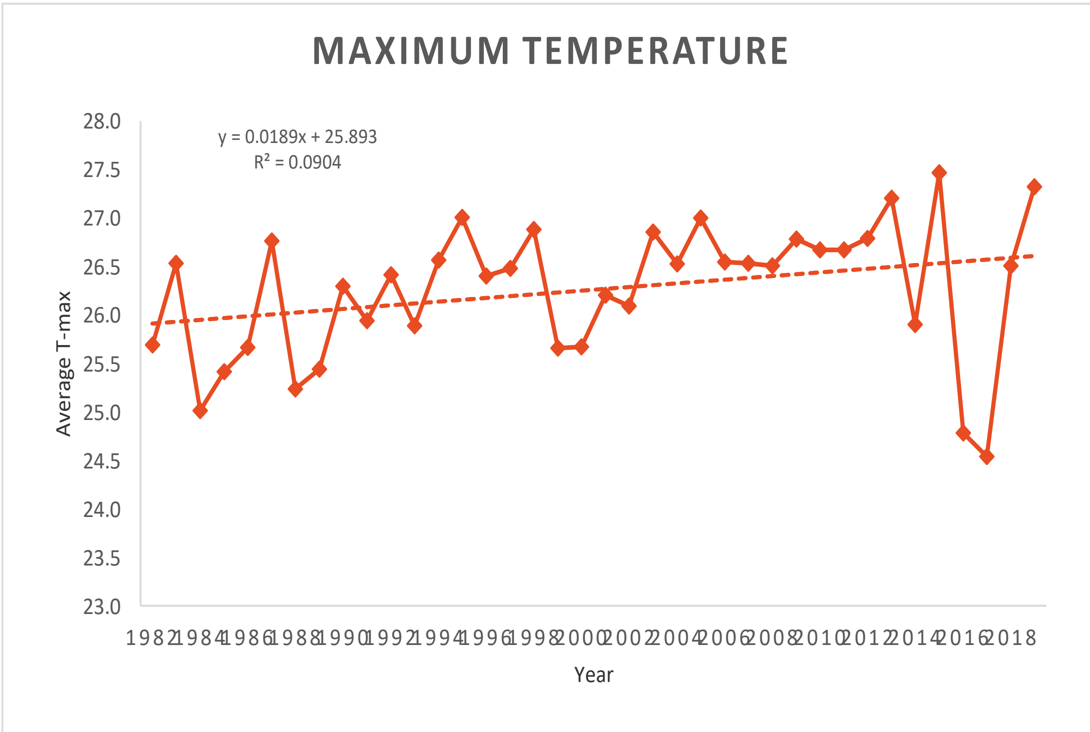

Figure 5: Annual average maximum temperature

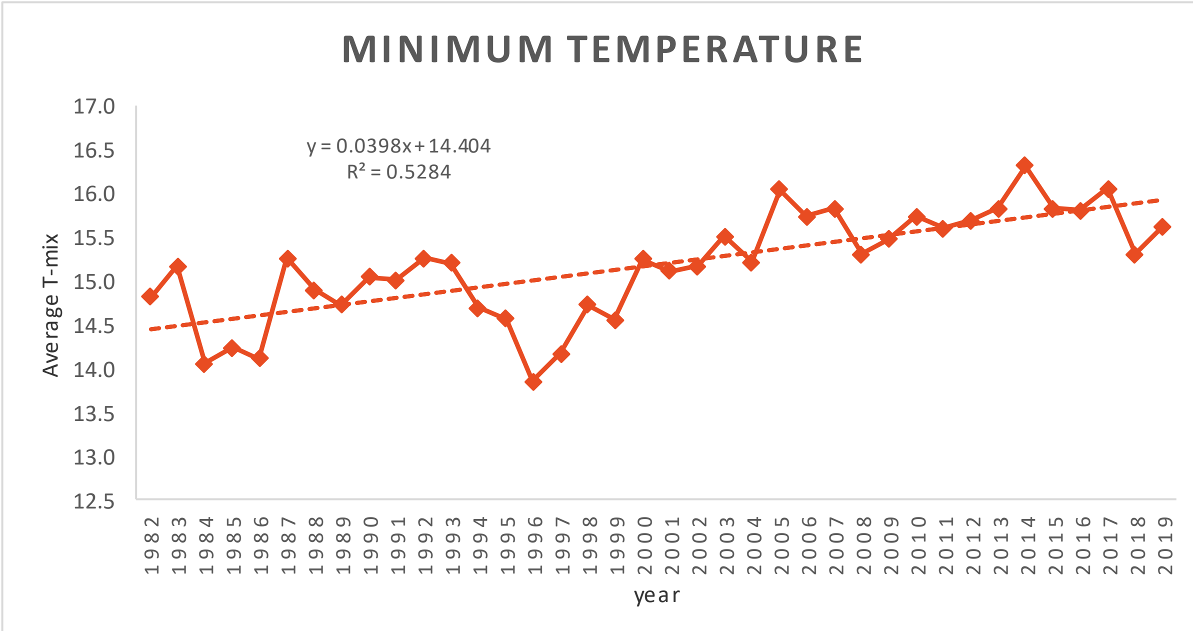

Figure 6: Annual average minimum temperature

Both the minimum and maximum temperature readings from the Climate Change and Meteorological Services Department for Kazomba extension planning area showed a positive trend, with equations $y = 0.0398x + 14.404 \; and \; y = 0.0189x + 25.893$, respectively. This data suggests a temperature increase over the past 37 years (Figures 5 & 6) and were in consistent with smallholder farmers' perceptions that temperature had increased in the study area. The yearly average maximum temperature data from 1982 to 2019 showed an upward trend, with an average of 26.3ºC. The R^2 value of 0.0904 indicated a moderate correlation, suggesting that maximum temperatures had generally increased over this period in the study area (Figure 5). Similarly, yearly minimum temperature data from 1982 to 2019 also showed a general upward trend, with temperatures ranging from a low as 13.9°C in 1996 to a high of 16.3°C in 2014 (Figure 6). The R^2 value of 0.5284 suggests a strong correlation, indicating that over this period in the study area, minimum temperatures had generally increased. Such trends align with broader patterns of global warming and climate change, demonstrating a consistent rise in maximum and minimum temperatures across the observed years. These fluctuations highlight the dynamic nature of the climate in the study area, emphasizing the importance of continuous monitoring and analysis to understand and predict future changes accurately.

4.3.2 Rainfall

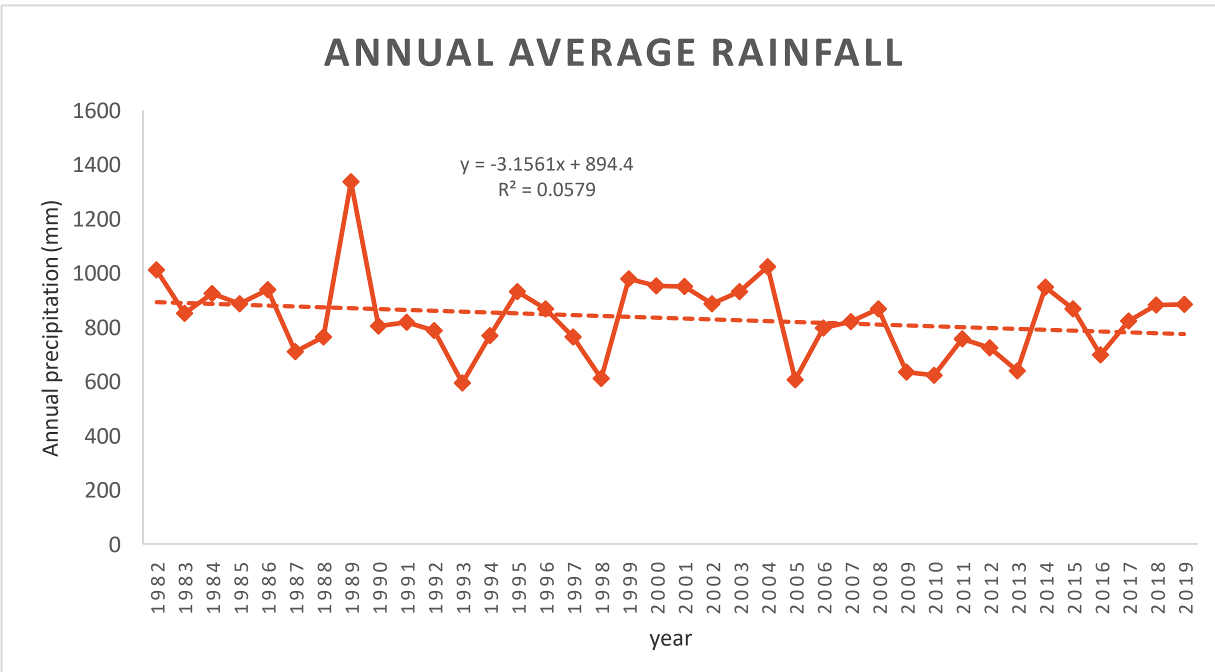

Figure 7: Annual average rainfall

Kazomba EPA experienced an average annual precipitation of approximately 832.9mm over the period from 1982 to 2019 (Figure 7). However, this period was marked by considerable interannual variability in rainfall. A linear regression analysis indicated a declining rainfall trend, represented by the equation $y = -3.1561x + 894.4$, although the trend was statistically weak, as reflected by a low coefficient of determination (R^2 = 0.0579). This observed decline was consistent with the perceptions of smallholder farmers, who reported decreasing rainfall over time. Notably, rainfall extremes were recorded during the study period, with a maximum of 1336.4 mm in 1989 and a minimum of 594.6 mm in 1993.

4.4. Impacts of Climate Change and Variability in Kazomba EPA

4.4.1 Causes of climate change and variability

Table 8: Causes of climate change

Causes of climate change	Yes	No	Don't know	No response
Burning of fossil fuels (oil, coal or natural gas)	43.4	11.6	40.6	4.4
Transportation (driving of vehicles) through vehicle emissions	46.6	20	30	3.4
Deforestation	91.2	2.2	6.6	0
Poor Agricultural practices	60	20.3	19.4	0.3
Anger of ancestors	5.3	79.7	14.4	0.6
End of the world	13.1	68.8	17.5	0.6
Anger of God	31.6	54.4	13.7	0.3
Supernatural forces	4.4	74.1	19.1	2.4

From Table 8, results indicated that majority of farmers knew that climate change was attributed to human activities (90%). As a result, 91.2% indicated that deforestation is the main agent contributing to climate change and variability. Most of farmers (60%) also indicated that poor agricultural practices contributed to climate change and variability. Smallholder farmers (43.4% and 46.6%) indicated that climate change and variability was caused by burning of fossil fuels (oil, coal or natural gas) and transportation (driving of vehicles) through vehicle emissions, respectively. In addition to the points highlighted above, 31.6% of farmers were still presumed that climate change and variability was caused by anger of God due to people's conduct.

4.4.2 Effects of climate change and variability

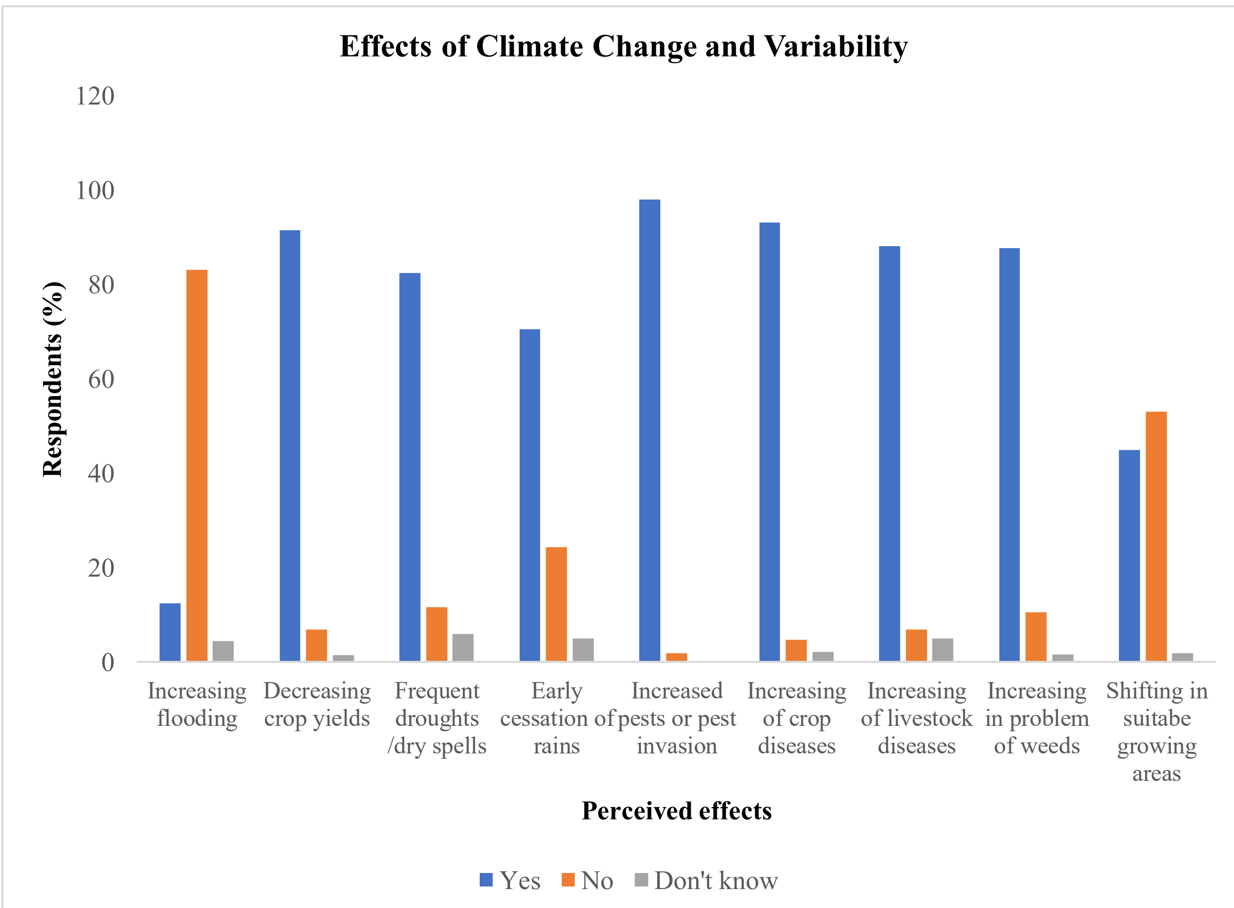

Figure 8: Effects of climate variability and change

The results presented in Figure 8 indicated that the majority of smallholder farmers in the study area had observed significant agricultural challenges attributed to climate change. Specifically, 98.1% of farmers reported an increase in pest invasions, while 93.1% noted a rise in crop diseases. These trends were perceived to be direct consequences of changing climatic conditions, particularly rising temperatures and erratic rainfall patterns. Interestingly, 83.1% of farmers indicated that there had been no substantial increase in flooding events in the area. However, concerns regarding water availability were prominent. Although some farmers expressed uncertainty about the relationship between climate change and water resources, over 82% reported frequent droughts of dry spells, which had negatively impacted water availability for agricultural activities.

Furthermore, 91.6% of farmers observed a decline in crop yields, and 88.1% reported an increase in livestock diseases, both of which are linked to climate variability. Additionally, 70.6% of farmers indicated that early cessation of rains has become more common, disrupting planting and harvesting schedules. Despite these challenges, only 45% of farmers reported experiencing shifts in suitable growing areas, suggesting that land suitability had remained relatively stable for most households.

4.5 Farmers' Responses to Perceived Climate Variability and Change

4.5.1 Farmers' anxiety on future climate change

Table 9: Percentages of responses to farmers anxiety on future climate change and possible impacts

Household concerned to:	Never	Rarely	Sometimes	Often
Recurrent droughts	0	2.5	5	92.5
Recurrent floods	0.3	12.2	16.2	71.3
Crop failure	0	0.6	2.2	97.2
Crop diseases	0	0.9	2.5	96.6
Livestock diseases	0	0.6	3.5	95.9
Price decline of farm produce	0	0	0	100
Price increase of farm inputs	0.3	0	0.3	99.4
Soil fertility decline	0.3	0	0.3	99.4
Late onset of rains	0.6	1.3	4.1	94
Shorter rainy seasons	0	1.3	4.6	94.1
Increase in temperature	3.8	10.9	30	55.3
Decrease in temperature	5.6	18.8	30.9	44.7
High in precipitation	9.7	48.4	26.6	15.3
Low in precipitation	0.3	0.6	6.6	92.5

Table 9, results show that the majority of farmers indicated that they were worried that they would face droughts (97.5%), floods (87.5%), and crop failure (99.4%). Interestingly, most farmers (75.6%) were very anxious that they could face a decline in temperature. In addition, most of the farmers were anxious about price decline of farm produce (100%), crop diseases (99.1%), livestock diseases (99.4), price increase of farm inputs (99.7%), soil fertility decline (99.7%), late onset of rains (98.1%), shorter rainy seasons (98.7%), increase in temperature (85.3%), high precipitation (41.9%) and low precipitation (99.1%).

4.5.2 Smallholder farmers' adaptation strategies

Table 10: Farmers adaptation to climate change and possible reasons for not using the strategy

Climate Change Adaptation Strategy	Yes	No	Reason for not using this method of adaptation			
			Lack of information	Shortage of labour	Bad	Others
Crop diversification	90	10	4.4	2.5	0	0.6
Growing different varieties	92.5	7.5	3.4	0.3	0	0
Intercropping	88.1	11.9	10.2	0.6	0	0.6
Cover cropping	70.6	29.4	25.7	2.5	0	0.6
Crop residual management	37.8	62.2	47.5	3.8	0.3	10.3
Minimum tillage	14.7	85.3	71.9	10.3	0.9	1.6
Annual crop rotation	29.1	70.9	46.3	6.9	0	17.4
Practicing crop mulching	70	30	18.1	11.3	0	0.6
Use of organic manure	92.5	7.5	1.6	1.6	0	1.5
Practicing agroforestry	3.8	96.3	67.5	1.6	0	24.4
Practicing irrigation	83.4	16.6	1.9	5.9	0	3.8
Rain water harvesting	1.9	98.1	89.1	2.7	0	5
Praying for rain	68.8	31.2	7.8	0	17.5	5.9
Mixed farming	84.4	15.6	7.5	4.1	0	0.6
Changing diet	70.3	29.7	0	0	0	0
Land use change	37.2	62.8	22.8	6.9	0	30.6
Migration	15	85	1.3	0	10.6	50
Depending on remittance	25.3	74.7	0.3	0.3	9.7	53.8

Analysis of response of smallholder farmers (Table 10) on adaptation mechanism practiced to withstand climatic variability showed that majority of farmers have implemented crop diversification ((90%), growing different varieties (92.5%), intercropping (88.1%), cover cropping

(70.6%), crop mulching (70%), organic manure (92.5%) use of traditional irrigation (83.4%), praying for rains in times of drought and delays (68.8), mixed farming (84.4%), and changing diet (70.3%). However, results also showed that most of smallholder farmers are not practicing some notable adaptation strategies despite having perceived climate change and variability in the study area. For instance, it was indicated that 62.2% of the farmers did not use crop residual management, 85.3% not used minimum tillage, 70.9% annual crop rotation, 96.3% agroforestry, 98.1%% rainwater harvesting, land use change (62.8%), migration (85%), and 74.7% did not depend on remittance. Among the notable reasons for not using adaptation strategies by the smallholder farmers were varied between two areas. Among the most farmers stated that reasons included lack of knowledge concerning appropriate adaptation strategy and shortages of labor for implementing adaptation strategy (Table 10).

4.5.3 Farmers' characteristics and adoption of some adaptation strategies

Table 11: Correlation analysis of farmer characteristics and adoption of some adaptation strategies

Adaptation Strategies	Level of education	Household size	Gender	Age	Farmers' experience	Marital status
Crop diversification	**-0.121***	0.000	-0.011	0.076	0.094	0.085
Growing different varieties	0.001	-0.097	0.015	-0.016	0.004	-0.015
Intercropping	**-0.127***	-0.072	0.013	0.073	0.028	**0.139***
Cover cropping	-0.083	-0.107	0.054	0.043	0.008	0.032
Crop residual management	-0.062	**-0.117***	0.061	-0.021	-0.051	**0.119***
Minimum tillage	0.049	**-0.168****	**0.149****	-0.078	-0.065	0.070
Annual crop rotation	0.007	-0.095	0.080	-0.019	-0.046	0.105
Mulching	**-0.133***	-0.010	**0.149****	0.064	0.070	0.042
Organic manure	-0.062	-0.023	**0.139***	-0.018	-0.090	**0.151****
Agroforestry	-0.083	**-0.135***	0.092	-0.096	**-0.138***	0.058
Irrigation	-0.067	-0.018	0.106	0.107	0.095	0.041
Rainwater harvesting	-0.107	-0.078	0.041	-0.059	-0.052	0.041
Praying for rain	**0.126***	-0.072	0.027	-0.080	-0.095	-0.025
Mixed farming	**-0.165****	**-0.165****	0.035	0.059	-0.004	**0.192****
Land use change	0.044	**-0.197****	0.057	-0.064	-0.072	-0.015
Migration	**-0.177***	0.007	-0.041	0.079	0.064	0.094
Changing diet	-0.100	-0.031	-0.084	**0.115***	0.106	**0.124***
Remittance	**0.133***	0.071	0.013	**-0.158****	**-0.130***	-0.021

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

*. Correlation is significant at the 0.05 level (2-tailed)

Table 11: Correlation of the farmers' characteristics and adoption of some adaptation strategies cont…..

Adaptation Strategies	Source of income	Land ownership	Land size	Access to extension services	Climate change trainings	Farm credits	Local membership
Crop diversification	0.104	0.026	-0.193**	0.101	0.079	-0.046	0.146**
Growing different varieties	0.098	-0.127	-0.199**	0.086	0.058	0.079	0.223**
Intercropping	0.040	-0.093	-0.096	0.070	-0.003	-0.042	0.090
Cover cropping	0.163**	0.051	-0.238**	0.146**	0.038	-0.130*	0.137*
Crop residual management	0.066	0.102	-0.153**	-0.030	0.244**	0.147**	0.173**
Minimum tillage	0.007	-0.033	-0.190**	-0.031	0.266**	0.167**	0.110*
Annual crop rotation	0.151**	-0.051	-0.361**	0.125*	0.077	-0.039	0.025
Mulching	0.050	0.052	-0.271**	0.121*	0.110*	-0.119*	0.056
Organic manure	0.015	0.023	-0.179**	0.052	0.097	0.029	0.079
Agroforestry	-0.022	-0.016	-0.252**	-0.060	0.041	0.101	0.029
Irrigation	0.062	0.035	-0.116*	0.225**	-0.015	-0.176**	0.111*
Rain water harvesting	0.024	0.280**	-0.177**	0.057	0.029	-0.051	0.067
Praying for rains	0.085	0.053	0.052	0.050	0.029	-0.070	0.101
Mixed farming	0.125*	0.034	-0.290**	0.167**	0.061	0.091	0.187**
Land use change	0.073	0.021	-0.280**	0.002	0.122*	0.170**	0.163**
Migration	-0.008	-0.033	-0.025	0.072	0.030	-0.062	-0.098
Changing diet	0.139*	0.052	0.208**	0.007	0.108	-0.009	0.103
Remittance	-0.059	0.045	-0.157**	0.054	0.063	-0.130*	-0.001

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed)

Correlation analysis (Table 11) results indicated several significant relationships. Marital status was significantly correlated with intercropping ($r = 0.139$, $p < 0.05$), crop residue management ($r = 0.119$, $p < 0.05$), organic manure use ($r = 0.151$, $p < 0.01$), mixed farming ($r = 0.192$, $p < 0.01$), and changes in diet ($r = 0.124$, $p < 0.05$). Age of the respondents showed a positive correlation with dietary changes ($r = 0.115$, $p < 0.05$). Gender was positively correlated with minimum tillage ($r = 0.149$, $p < 0.01$), mulching ($r = 0.149$, $p < 0.01$), and the use of organic manure ($r = 0.139$, $p < 0.05$). Education level was significantly correlated with praying for rain ($r = 0.126$, $p < 0.05$) and relying on remittances ($r = 0.133$, $p < 0.05$). Additionally, the source of income was significantly correlated with cover cropping ($r = 0.163$, $p < 0.01$), annual crop rotation ($r = 0.151$, $p < 0.01$), mixed cropping ($r = 0.125$, $p < 0.05$), and dietary changes ($r = 0.139$, $p < 0.05$).

The analysis further revealed positive correlations between several factors and climate adaptation strategies. Land ownership was significantly linked with rainwater harvesting ($r = 0.280$, $p < 0.01$) as a response to weather shocks. Additionally, larger land size was positively correlated with dietary changes ($r = 0.208$, $p < 0.01$) as an adaptation measure. Access to extension services showed positive correlations with multiple practices: cover cropping ($r = 0.146$, $p < 0.01$), annual crop rotation ($r = 0.125$, $p < 0.05$), mulching ($r = 0.121$, $p < 0.05$), irrigation ($r = 0.225$, $p < 0.01$), and mixed farming ($r = 0.167$, $p < 0.01$). Similarly, access to climate change training or information was positively correlated with crop residue management ($r = 0.244$, $p < 0.01$), minimum tillage ($r = 0.266$, $p < 0.01$), mulching ($r = 0.110$, $p < 0.05$), and land use changes ($r = 0.122$, $p < 0.05$).

Farm credit was also positively associated with several strategies, including crop residue management ($r = 0.147$, $p < 0.01$), minimum tillage ($r = 0.167$, $p < 0.01$), and land use changes ($r = 0.170$, $p < 0.01$). Finally, local group membership was significantly correlated with crop diversification ($r = 0.146$, $p < 0.01$), planting different crop varieties ($r = 0.223$, $p < 0.01$), cover cropping ($r = 0.137$, $p < 0.05$), crop residue management ($r = 0.173$, $p < 0.01$), minimum tillage ($r = 0.110$, $p < 0.05$), and irrigation ($r = 0.111$, $p < 0.05$).

Although most demographic and socio-economic characteristics of farmers exhibited positive correlations with various adaptation strategies, the study also identified several significant negative correlation coefficients. According to Table 11, education level was negatively associated with crop diversification, intercropping, mulching, migration ($p<0.05$), and mixed farming ($p<0.01$). Similarly, household size showed negative correlations with crop residue management, agroforestry, mixed farming, minimum tillage, and land use change ($p<0.01$).

The results further revealed that farmers' age was negatively correlated with the use of remittances as an adaptive strategy ($p<0.01$). In addition, farming experience was inversely associated with agroforestry practices and the use of remittances ($p<0.05$). Land size was found to be negatively correlated with a broad range of adaptation strategies, including crop diversification, cultivation of different varieties, cover cropping, crop residue management, minimum tillage, annual crop rotation, mulching, organic manure usage, agroforestry, rainwater harvesting, mixed farming, land use change, remittance reliance ($p<0.01$), and irrigation (0.05).

Finally, access to farm credit was negatively associated with the adoption of cover cropping, mulching, remittance reliance ($p<0.05$), and irrigation ($p<0.01$). These findings indicate that certain demographic and socio-economic factors may act as constraints, limiting the adoption of specific adaptation strategies, despite their potential to enhance resilience to climate change.

CHAPTER FIVE: DISCUSSION

5.0 Introduction

This section interprets the study's principal findings on smallholder farmers' perceptions of climate change and variability and their implications for household food security in Kazomba Extension Planning Area, Mzimba District. It situates the empirical results within the study's objectives and the broader literature on climate perceptions, adaptation behavior, and food-security outcomes, highlighting where the findings collaborate, extend, or contradict existing evidence. The section prioritizes causal explanation, the plausibility of reported adaptation strategies, and the pathways through which perceived climatic shifts translate into changes in agricultural practice and food security status. The section synthesizes the key patterns observed in farmers' experiential knowledge of rainfall, temperature, and extreme events and evaluates the consistency of those perceptions with documented climatic trends.

5.1 Demographic data

5.1.1 Age

The age distribution of smallholder farmers in the study area revealed a predominantly active farming population, with approximately 85% of farmers aged between 20 and 60 years. This demographic profile suggests that the majority of participants had likely experienced and observed climatic changes over a substantial period, thereby providing credible and experience-based insights into the perception of climate change and variability. Notably, 32.2% of the farmers were aged between 20 and 30 years, indicating a significant presence of youth in the agricultural sector. This finding aligns with the findings of Atube *et. al.* (2021) in Uganda. In this study, younger farmers demonstrated a higher propensity to adopt climate change adaptation strategies due to their openness to innovation and greater access to information and education. Similarly, Kabote *et. al.*

(2024) in Manyoni District, Tanzania, found that age was a significant determinant in the choice of adaptation strategies, with younger farmers more inclined towards technology-driven and market-oriented practices.

These results underscore the potential of youthful farmers to serve as catalysts for climate resilience, given their trainability, digital literacy, and physical capacity for labor-intensive adaptation measures. However, contrasting evidence was found by Som Castellano and Moroney (2018) from agricultural communities in the United States suggested that, despite being less receptive to innovation, older farmers often possess more resources, experience, and land tenure security, factors that also strongly influence adaptation capacity. This highlights the complexity of age as a variable in the climate change adaptation, suggesting that, while youthfulness offers certain advantages, it must be considered alongside other socio-economic and institutional factors. Overall, the demographic composition observed in this study presents a promising foundation for targeted interventions that leverage the strengths of both younger and older farmers to enhance adaptive capacity in the face of climate variability.

5.1.2 Gender

The findings show that 64.1% and 35.5% of smallholder farmers interviewed were females and males, respectively, underscoring the significant role women play in agricultural livelihoods within the study area. This gender distribution reflects broader patterns observed across sub-Saharan Africa, where women often constitute the majority of the agricultural labour force, particularly in subsistence farming. In Malawi, women are deeply involved in crop production, food processing, and marketing, often balancing these responsibilities with domestic care. Their predominance in smallholder farming suggests that any interventions aimed at improving agricultural productivity, climate resilience, or food security must be gender-sensitive and inclusive.

These results align with several studies that highlight the centrality of women in smallholder agriculture. For instance, Henriksson *et. al.* (2021) found that women in Malawi are more engaged in farming activities but often lack access to climate information and agricultural extension services, which limits their adaptive capacity. Similarly, Greehy *et. al.* (2024) reported that while women dominate agricultural labour, they face systemic barriers in agribusiness, including limited access to land, credit, and decision-making platforms. Mgalamadzi *et. al.* (2024) further emphasized that commercialization efforts tend to marginalize women, reinforcing gender inequalities in household decision-making and expenditure control. These studies collectively suggest that although women are numerically dominant in smallholder farming, they remain disadvantaged in terms of access to productive resources and institutional support.

However, contradictory evidence exists in contexts where men dominate farming activities, particularly in areas with high commercialization or cash crop production. In such settings, men often control land ownership and income, even when women significantly contribute to labour. Cultural norms may also restrict women's mobility, land rights, and participation in farmer organization, thereby limiting their visibility in agricultural statistics and decision-making processes. These variations highlight the importance of contextualizing gender roles in agriculture, as they are influenced by socio-cultural, economic, and policy environments. These findings imply that agricultural extension services must be tailored to meet the specific needs of female farmers, including flexible training schedules and inclusive communication strategies. Further, policies should promote equitable access to land, inputs, and credit for women to enhance their productivity and resilience. Fostering women's participation in farmer groups and local governance structures can strengthen their voice in decision-making and improve the effectiveness of agricultural interventions. These results also imply that recognizing and integrating women's indigenous knowledge into climate adaptation strategies can lead to more sustainable and locally appropriate solutions. The predominance of female smallholder farmers in the study area calls for gender-responsive approaches in agricultural development and climate adaptation.

5.1.3 Education

The study revealed that most smallholder farmers had basic schooling. This likely supports basic literacy and numeracy. Basic literacy improves the ability to read extension leaflets, weather advisories, and input labels. It also helps with phone-based information and radio messages. However, low secondary and tertiary attainment may limit uptake of complex climate-smart techniques and access to formal training and credit (Kaira, 2015). Several studies in Malawi report similar distributions and note that primary education is common among smallholder farmers, which aids simple information uptake but does not support advanced innovation adoption (One Acre Fund, 2023). Other studies emphasize that even with low formal education, farmers use experiential learning and local knowledge to adapt successfully, especially when extension is practical and participatory. These findings show that education helps in adopting new approaches to farming but it is not the sole determinant of adaptive capacity, training design and delivery matter.

5.1.4 Farming Experience

About 41.9% of smallholder farmers in the study area reported long farming careers, the highest being over 20 years. This implies prolonged exposure to local climatic patterns and rich experiential knowledge of rainfall shifts, droughts, pests, and planting windows. Similar findings were reported by Akram *et. al*. (2025) that experienced smallholder farmers provided valuable observational records that complement meteorological data. Other reviews link long tenure to strong risk management skills but note that experience does not always mean rapid adoption of new, capital-intensive climate-smart practices (Sithole *et. al.,* 2024).

Nevertheless, some empirical work in sub-Saharan Africa shows mixed relationships between experience and adaptation. Systematic reviews report that experience often correlates with better use of indigenous knowledge and conservative coping strategies, while younger or less experienced farmers can be more willing to test innovations when supported by inputs and trainings (Mnukwa *et. al.,* 2025). These studies suggest combining experienced smallholder farmers' historical insights with participatory training and inclusive sampling to capture generational differences in adaptation approaches.

5.1.5 Source of Income

The findings reveal that 43.4% of households rely primarily on crop production, 31.6% on off-farm employment, and 9.4% on remittances, indicating limited livelihood diversification among smallholder farmers in Kazomba EPA. Heavy dependence on crop income increased vulnerability to climate shocks because farm yields are directly tied to rainfall variability and extreme events. Off-farm wages provide an important buffer for many households, but such income is often seasonal, precarious, and linked to the local labour market. When off-farm opportunities shrink, households face simultaneous losses in both farm and non-farm incomes. The relatively small contributions from businesses, livestock, and casual labour suggest that these activities do not scale sufficiently to transform household risk profiles nor provide robust coping reserves in the study area. Empirical research from Malawi, Kenya and Ghana reports comparable findings where employment in nearby factories or plantations reduces but does not eliminate vulnerability to climatic shocks (Jayne, *et. al.,* 2010). Normally, where market access, credit, and training are available, smallholder farmers achieve more meaningful diversification into small enterprises and livestock, which improves resilience.

5.2 Perception of Farmers on Climate Change and Variability

5.2.1 Temperature and Rainfall

An analysis of temperature and rainfall data from 1982 to 2019 in the Kazomba Extension Planning Area revealed a consistent annual temperature increase of 2.4°C and general decline in rainfall, with levels dropping as low as 594.6 mm in 1993. These findings are consistent with projections by the Intergovernmental Panel on Climate Change (IPCC, 2019), which anticipate rising temperatures and reduced precipitation as key indicators of climate change and variability. Smallholder farmers in the study area demonstrated a strong understanding of these climate-related changes, with many actively sharing their observations and experiences. Their perceptions of rising temperatures and declining rainfall over the past two decades closely align with local meteorological records, reinforcing the credibility of their insights. Similar studies by Minwuye (2017) in Ethiopia and Shisanya (2015) in South Africa also found that smallholder farmers' perceptions of climate shifts were consistent with empirical climate data, suggesting a broader regional awareness of climate trends among farming communities.

However, not all studies report such alignment. For instance, research in Ghana by Juah M-Buu and Nhamo (2024) revealed discrepancies between farmers' perceptions and meteorological data, with some farmers reporting declining rainfall despite stable precipitation records. Additionally, a systematic review by Troncarelli *et. al.* (2023) noted that farmers perceptions are often shaped by immediate experiences, such as crop failure or extreme weather events rather than long-term climate trends. These findings suggest that, while perceptions can be reliable indicators of climate change, they may also be influenced by socio-economic conditions, memory biases, and localized impacts. Therefore, understanding farmers' perceptions in conjunction with meteorological data provides a more comprehensive view of climate change impacts and enhances the design of targeted adaptation strategies.

The findings indicate that smallholder farmers in the study area perceive the climate as becoming increasingly hot and dry, with a significant association between this perception and the farmers' level of experience. This perception aligns with the meteorological data previously presented in (Figure 5, 6 & 7) of an increase in both minimum and maximum temperature, and a decline in precipitation for the study area. The potential impacts include reduced stream flow and groundwater recharge, leading to insufficient water for both crop and livestock production, which could heighten food insecurity levels in the Kazomba Extension Planning Area. Access to irrigation water can serve as a safety net for households, lessening the impact of temperature and rainfall fluctuations. Additionally, experienced smallholder farmers were more inclined to detect climate shifts, possibly due to an increased sensitivity developed over time. This is consistent with the work of Arunrat *et. al.* (2017) and Epule and Bryant (2016), who found that experienced farmers often possess valuable indigenous knowledge, allowing them to recognize and respond to climate variability. Such factors commonly affect farmers' approaches in adapting to climate change and variability.

Rising temperatures could lead to increased pest and disease outbreaks, further jeopardizing already strained household food supplies. This outcome supports concerns raised by Ricart *et. al.,* (2023) that rural households, which heavily depend on climate-sensitive resources like local water sources, arable farming, livestock production, and other natural resources, will be profoundly affected by climate change. In Kazomba Extension Planning Area, decreasing rainfall is likely to directly reduce crop yields, necessitating greater investment in irrigation to enhance productivity.

Adapting to declining rainfall may require shifts in the farming system, such as cultivating drought-resistant crops and varieties. Additionally, rising temperatures are expected to increase crop pest and disease prevalence, leading to reduced yields. Animal pests and diseases may also thrive, leading to lower livestock productivity. Altogether, these climate-related changes will have significant impacts on household food security in the study area. When a smallholder farmer makes decisions to use adaptation strategies, households should recognize local changes in the long-term climate such as temperature and rainfall patterns (Bryan *et. al.,* 2013).

5.3 Impacts of Climate Change and Variability

5.3.1 Causes of climate change and variability in Kazomba EPA

The farmers who participated in this study appeared to understand the factors contributing to climate variability and change, given the severe impacts experienced by smallholder farmers in the study area. Ninety percent of farmers (Table 8) who believed that climate variability and change were largely driven by human activities identified causes such as deforestation, fossil fuel burning, vehicle emissions, unsustainable agricultural practices, and divine displeasure. These findings align with Munthali *et. al.* (2016), who reported that deforestation caused by tobacco farming was exacerbating the effects of climate change and variability in the Bolero community of Rumphi district. Similar results were equally reported by Buys *et. al*. (2011) in Australia that communities who believed that anthropogenic or human-induced factors contributed to climate change described the changing weather as evidence of climate change, whereas those who were more skeptical and believed that it was happening naturally were not that concerned with such changes and termed it as weather variability.

The findings echoed the views of most participants who attributed today's climate change and its impacts to both divine anger and human activities in the area. The belief among smallholder farmers that climate change is a result of divine anger may lead them to under-invest in resources like inputs, labour, and good agricultural practices, as they may anticipate failure. Therefore, there is a need to implement climate change awareness programmes in Kazomba Extension Planning Area to help shift societal views and increase understanding of climate change issues. Similar findings from different study areas have also been documented by several scholars like Yamba *et. al.* (2019), Atoma *et. al.* (2019), Maguza-Tembo *et. al.* (2017), Arbuckle *et. al.* (2013) and Oepen (2012).

5.3.2 Effects of climate change and variability in Kazomba EPA

In assessing indicators of climate variability and change, many smallholder farmers observed a steady decline in the yield of major food crops such as maize from their fields. They reported reduced crop yields, frequent droughts or dry spells, early end to the rainy season, increased pest infestations, rising incidence of crop and livestock diseases, greater weed problems, and shifts in suitable growing areas (Figure 8). Farmers attributed these negative impacts to climate variability and change. The study findings align with the observation of IPCC (2019; 2022) that changes in precipitation patterns, including shifts in timing, intensity, and distribution, significantly impact crop production and harvest yields. Similarly, the studies by Tsokota (2015) and Choudri *et.al.* (2013) noted that variability in precipitation could lead to water stress, crop failures, and reduced agricultural output, threatening food security for smallholder farmers.

Moreover, extreme weather events such as droughts, cyclones and storms, which are becoming more frequent and severe due to climate change, further exacerbate these challenges amongst smallholder farmers. These results were consistent with the study by Mihiretu *et. al.* (2020) in Ethiopia, which reported that nearly all farmers were experiencing climate change-related disasters, with varying impacts on their livelihoods. The effects noted included reduced crop yields, outbreaks of livestock and human diseases, decreased livestock productivity, recurring windstorms, food insecurity, and frequent conflicts with neighboring communities over grazing land.

Smallholder farmers confirmed that since the 1990s, temperatures have risen while rainfall has decreased, significantly affecting agricultural productivity. These findings concur with what Joshua *et. al*. (2016) observed in Chikwawa district, Malawi. The study established persistent declining yields from rain-fed production in the district because of perennial rainfall failure and rising temperatures. As a result, many smallholder farmers face frequent food insecurity due to reduced production. They also mentioned that higher temperatures have impacted cash crops like tobacco, making it difficult for them to afford their children's education. Kalungu *et. al.* (2013) suggested that smallholder farmers' perceptions of climate change and its indicators could help initiate shifts in farming practices, strengthening resilience, increasing productivity, and reducing greenhouse gas emissions. This indicates that climate change has a direct impact on their livelihoods.

Furthermore, the findings also emphasized that climate extremes, especially drought, had a significant impact on crops and livestock in the study area. It is clear that climate change heavily affects the rain-fed agricultural economy, resulting in food insecurity among smallholder farmers. The vulnerability of these farmers is largely linked to climate variability and changes, including altered rainfall and temperature patterns, as well as the occurrence of droughts and severe storms. Additionally, limited infrastructure, weak institutional support, and restricted access to natural, social, physical, financial, and human resources in the area have further heightened the vulnerability of smallholder farmers, a clear indication of the effects of climate variability and change. Climate variability and change have not only heightened the vulnerability of smallholder farmers in the study area but have also diminished their ability to predict the start of the rainy season based on natural signs. With traditional indicators becoming unreliable, planning agricultural activities has also become more challenging.

5.4. Experiences and Adaptation Strategies among Smallholder Farmers

5.4.1 Adaptation Strategies Adopted by Smallholder Farmers

The study found that severe climatic changes had significantly altered rainfall patterns and temperatures, negatively impacting food security and other livelihoods in Kazomba Extension Planning Area. Although climate change is affecting the agricultural activities of smallholder farmers in Kazomba EPA, it is important to highlight that smallholder farmers have not remained passive observers. In fact, the study observed that smallholder farmers have proved to be active participants by adapting to the changes through the use of crop diversification, cultivation of multiple varieties, intercropping, annual crop rotation, cover cropping and crop residue management, to mention a few. These strategies were identified based on their frequency of use among smallholder farmers in the study area (Table 10). Similar findings were also observed by Ndaki (2014) in Tanzania that farmers were engaged in various adaptation strategies in their agricultural activities. The strategies included shifting to higher yielding crop varieties, shifting to shorter cycle crop varieties which take short periods of time like three months from planting to harvesting, concentrating on crops that command good market prices, shifting to drought tolerant crops and varieties and concentrating and intensifying small-scale irrigation in the river valley instead of reliance on rain-fed agriculture alone. The results are equally consistent with the findings of the study by Tsokota (2015) and Fatuase *et. al.,* (2015) in Zimbabwe and Nigeria, respectively.

Coping and adaptation strategies, along with strengthened adaptive capacity, are essential for smallholder farmers to address climate variability and change. Perceived climatic changes influence the promotion and adoption of effective adaptation strategies. Adoption of these strategies enhances farmers' resilience to climate change, boosts productivity and helps reduce greenhouse gas emissions (Nyang'au *et. al*., 2021). Due to the ongoing decline in crop yields, as reported by surveyed households, smallholder farmers have adopted various strategies to build resilience. The choice of coping or adaptation strategy depends on the opportunities and limitations available to smallholder farmers. In this study, adaptations are defined as modifications or interventions designed to manage losses or leverage opportunities arising from a changing climate. Adaptation aims at improving society's capacity to manage climate fluctuations over both short-term and long-term periods. Thus, the objective of adaptation measures is to increase a system's capacity to endure external shocks or changes.

Based on their experience with a changing climate in the study area, smallholder farmers are genuinely afraid of its impacts and are committed to doing what they can to prepare for the trends. The findings confirm that climate change adaptation is indeed occurring at the household level, where these efforts are expected to significantly reduce the adverse effects of climate change and variability. For smallholder farmers to effectively implement adaptation strategies, they need to be well-prepared in terms of suitability and efficacy. Many farmers prefer to rely on traditional adaptive practices that are familiar and accessible to them. However, these responses may be limited in addressing the full scope of climate change and variability. Thus, it is essential to introduce smallholder farmers to new, proven methods that have been successful in other communities. Extension services should be integrated into community adaptation systems, emphasizing local context and strong community engagement, including consideration of location, demographic, social and economic factors. Access to information is crucial in helping smallholder farmers adapt effectively. This study revealed that farmers who are literate or have information are more likely to propose a wider range of strategies for coping with climate change.

The findings also reveal that most farmers in the study area (85% for migration and 74.4% for reliance on remittances) do not consider these to be effective adaptation strategies (Table 10). This is in sharp contrast with the studies by Owusu *et. al.* (2015), Fatuase *et. al.* (2015) and Ndaki (2014), in Ghana, Nigeria and Tanzania, respectively, which found that smallholder farmers often turn to migration or remittances during extreme weather events. According to these studies, migration provides temporary or permanent relief by allowing farmers to move to areas with better economic opportunities and stable conditions, while remittances offer financial support from migrated relatives, offsetting losses from climate-impacted agriculture. Together, these strategies can enhance resilience by diversifying income, boosting food security, and creating financial safety nets against environmental challenges among smallholder farmers.

5.4.2 Barriers to Effective Adaptation to Climate Change and Variability

Research indicates that a range of factors influence farmers' ability to adapt to climate change and variability. Key factors include socio-economic status of households, policy and institutional framework, and access to and the relevance of climate information. The study found that smallholder farmers struggle to adopt effective adaptation strategies like rainwater harvesting, minimum tillage and agroforestry largely due to insufficient information on suitable approaches to counter climate challenges. Smallholder farmers also cited shortage of labour as a major barrier to adopting various adaptation strategies in the area. These results align with findings by Tsokota (2015) in Zimbabwe, where farmers identified key obstacles such as limited land, lack of credit, insufficient irrigation water, inadequate information on climate change and viable adaptation strategies, restricted market access, insecure land tenure, lack of inputs, scarcity of livestock, and poor soil fertility. Additionally, these findings are also consistent with Kyaw (2018) observations in Myanmar, where smallholder farmers faced challenges in adopting adaptation strategies due to labour shortages, limited knowledge and inadequate irrigation systems.

Labour tends to be a major constraint to adaptation among smallholder farmers (Deresa *et. al.,* 2010). The family offers technical and manual skills that are crucial for executing agronomic practices on time. Therefore, smallholder farming households that have large pools of labour can spread labour resources across different adaptation practices. Such households can utilize labour intensive practices such as crop diversification and soil and water conservation (Zamasiya *et. al.,* 2018). As such, households with higher labour resources are more likely to have higher levels of adaptation than their counterparts. These findings collaborate with the results of Ali and Erenstein (2017).

According to the IPCC (2019), social inequalities, including disparities in land ownership and limited access to resources such as credit, education, and involvement in decision-making, significantly impact people's ability to adapt to climate change and variability. Similarly, research by Antwi-Agyei *et. al.* (2014) in Northeast Ghana identified financial, socio-cultural, institutional, and technological constraints, with a particular emphasis on the lack of information about climate conditions, as key challenges facing smallholder farmers. These findings underscore the need for developing early warning systems, improving climate information communication, and gaining a deep understanding of local contexts to support effective adaptation and improve smallholder farmers' livelihoods. Results also concur with what Gedefaw *et. al.* (2018) observed in Qwara district in Ethiopia. This evolving body of research highlights various factors and processes that hinder smallholder farmers from successfully adapting to climate change. These included limited access to timely climate information and early warning systems, low levels of education and awareness about adaptation options, and scarce financial resources including lack of credit.

5.4.3 Farmers' Characteristics and Adoption of Some Adaptation Strategies

This study highlighted the varied factors that affected the adoption of adaptation strategies, with correlation analysis revealing the significance of marital status, farmer's age, gender, education level, income source, land ownership, land size, access to extension services, climate change training or information, farm credits, and local membership. Household and farm characteristics, along with institutional factors, had differing impacts on the uptake of adaptation measures in the study area.

Marital status emerged as a significant predictor of adaptation, with married households more likely to adopt intercropping, crop residue management, dietary change, organic manure, and mixed farming. These significant correlations suggest that a married couple or a household with more than one adult might be associated with a greater likelihood of adopting these agricultural activities and lifestyle practices in order to be resilient to the impacts of climate variability and change. Married smallholder farmers or households with multiple adults may have more available labour making the agricultural activities more manageable and sustainable since they require more attention and coordination. Furthermore, households with married members may favour diverse farming systems to balance the family's food and income needs. For instance, mixed farming provides resilience against crop failures, supports diverse diets and creates income opportunities through both crops and livestock. Overall, marital status might correlate positively with these practices due to shared labour, greater resources and a strong focus on family nutrition and income resilience all of which align well with sustainable farming methods. This implies that married couples were more likely to adapt to climate change and variability. This point agrees with the findings of Kyaw (2018); Oluwatayo and Ayodeji (2016), who stated that marital status has an influence on positioning in terms of adaptive strategies and the same study encouraged taking up other livelihood activities to sustain the household's condition.

Regarding the age of the farmers, the results (Table 11) show a positive correlation coefficient with changing diet as an adaptation to climate variability and change. This suggests that older farmers may be more likely to adjust their diets in response to shifting climate conditions. Older farmers may have a deeper understanding of the local climate after observing how it has changed over time. Such experience can make them more adaptable, aware of the impacts of climate on food production and alter their diets to ensure food security than the young farmers. In addition, older people may be more mindful of health and nutrition, especially if they have noticed that climate shifts affect food availability and quality. This awareness drive seeks alternative food that provides necessary nutrients while being resilient to climate impacts. Similar results of positive correlation between age and adaptation strategies were found in the study by Habtemariam *et. al.* (2016); Belay *et. al.,* 2017). With age, while younger people may resist changes to dietary practices, older individuals may have greater willingness to experiment with new foods or dietary practices, enabling them to adapt more readily to the availability of climate resilient crops or different food sources. In essence, older individuals may recognize diet change as a practical, accessible way to adapt to the limitation that climate change imposes on traditional food options.

Gender of the household head is a proxy for access to information and resources and therefore influences a household's ability to adapt to climate change. Some scholars observed that male-headed households are more likely to adapt to such changes as they have access to information and control resources at the household level. Male-headed households are also better positioned to source labour for on-farm operations than female-headed households. However, the findings of the study found that there were more female respondents (64.1%) than their male counterparts (Table 2), and gender was significantly correlated with numerous adaptation strategies like minimum tillage, mulching and use of organic manure among smallholder farmers (Table 11). This result supports the sentiment that female-headed households are more likely to adapt to climate change compared to their male-headed households (Nhemachena and Hassan, 2007). It is argued that women are actually involved in the agricultural production processes while the males are away working in cities and towns. As a result, women have richer knowledge of different farming practices as compared to men. Similar findings were observed by the study of Zamasiya *et. al.* (2018). These findings collectively suggest that gender roles play a significant part in the adoption of certain climate resilient farming practices. Therefore, this may imply that gender has a differential impact on the likelihood of adapting to climate change.

Smallholder farmers who had attained a high level of education are likely to perceive and adapt to climate change and variability. This finding is consistent with the study by Zamasiya *et. al.* (2021) which found that higher levels of education influence access to information and knowledge, which in effect enhances adoption of agricultural technologies. Education is commonly considered an enabler of adaptation, as education facilitates access to information and the adoption of new technologies (Gil-Clavel *et. al.,* 2025). Correlation analysis results showed that the level of education was significantly correlated with praying for rains and reliance on remittances in the study area (Table 11). This result reveals some interesting dynamics as climate variability and changes adaptation is concerned. This suggests that even individuals with higher levels of education still engage in traditional or spiritual practices as part of their climate adaptation strategies in the study area. It may reflect a cultural dimension where, regardless of education, prayer is viewed as an essential response to climate stressors like unpredictable rainfall. Higher education may also increase awareness of the severity of climate impacts leading farmers to seek a broader array of adaptive measures to implement other strategies including traditional practices like prayers.

Furthermore, positive correlation with remittances implies that individuals with higher education levels might be more likely to have family members working away from the local area who send financial support. Education often correlates with broader social networks and opportunities for family members to secure jobs in urban areas or abroad, enabling remittances to serve as a financial buffer against climate-induced hardships. Therefore, these findings suggest that education can influence adaptation strategies by incorporating both traditional practices which include prayer and modern financial support mechanisms such as remittances, illustrating a blend of cultural continuity and adaptive resilience. The findings are consistent with the study of Zamasiya *et. al.* (2021) who found that remittances were very statistically significant and positively improve a smallholder farmer's level of adaptation to climate change and variability. Remittances improve the number of financial resources that are available to a household for the purposes of financing transaction costs associated with adaptation to climate. These costs could include the cost of improved seed, inorganic fertilizers and herbicides. This implies that smallholder farmers who have access to remittances are more likely to adapt to the new challenges than their counterparts.

The result shows a positive and statistically significant relationship between source of income and the likelihood of smallholder farmers choosing cover cropping, annual crop rotation, mixed farming and changing diet (Table 11). The correlation between income and these adaptive practices suggests that a stable or diverse income source enables farmers to invest in and experiment with adaptive strategies, making them better equipped to reduce the negative impacts of climate variability on their livelihoods. Smallholder farmers generating better income and having adequate assets are better placed to adopt new farming practices to enhance their resilience (Maguza-Tembo *et. al.,* 2017). Soil conservation practices and proper use of manure require capital investments. Because of their financial endowment, wealthier farmers are likely to adopt these practices than the less endowed in the community. This implies that a unit increase in income will increase the likelihood of a farmer adopting cover cropping, annual crop rotation, mixed farming and changing diet in the study area. This result collaborates with the reports of Fatuase *et. al*. (2015).

The result shows that the smallholder farmers who employed agricultural activities on their owned farmland has a positive correlation and are more likely to adopt rainwater harvesting as adaptation measure and the adaption practices are statistically significant ($p < 0.01$) (Table 11). Land owners are often more willing to make long term investments on their land, like rainwater harvesting systems because they have security over the land's future use. Unlike tenants, land owners can expect to benefit from improved water resources over time making rainwater harvesting a worthwhile investment. Owning land provides greater autonomy in implementing physical changes such as installing rainwater tanks, digging pits or constructing other rainwater capture systems. In contrast, renters may face restrictions on making these modifications limiting their ability to harvest rainwater. The landowners often seek to enhance the productivity and resilience of their land as a long-term asset especially under climate variability. Rainwater harvesting improves soil moisture availability and ensures more stable water resources during dry periods which directly supports productivity and resilience. The farmland owner has the right to make decisions how will be used including deciding what crops should be planted and to benefit financially from the sale of crops. This finding is consistent with some studies by Kyaw (2018) and Rahut *et. al.* (2017) which reported that the household farmer with more land holdings has a positive and significant impact on adopting more climate risk coping strategies. Land owned or larger farm farmers are more able to adopt new technologies to cope with climate risk.

Large farm size increases the likelihood of adopting different crop varieties. Owners of large sized farms are relatively wealthy and can try out new farming practices, thus why correlate positively with variety of adaptation strategies like changing of diets (Table 11). This suggests that households with larger landholdings are more likely to adapt their diets in response to climate variability and change. Larger land sizes allow smallholder farmers to diversify their crops, including growing climate-resilient or nutritionally diverse crops. This may enable households to vary their diet based on what is grown on their land, making it easier to adapt to seasonal or climate-driven changes in crop availability. In line with this, having more land farmers can maintain a buffer by growing a mix of staple and alternative crops which may be less impacted by climate stressors. This flexibility supports dietary adjustments as households with larger plots are likely to have more food choices available even when some crops are affected by climate shifts.

Additionally, larger landholdings can increase agricultural output, allowing households to generate additional income. This financial stability may help households afford diverse foods either by growing or purchasing them, facilitating diet changes as part of climate adaptation. In essence, the positive correlation suggests that larger land sizes offer farmers greater flexibility in crop production and food security, making it easier for farmers to adapt their diets to cope with climate variability. However, this result disagrees with the study by Oluwatayo and Ayodeji (2016) which reported that farm size decreases the likelihood of a farmer choosing other adaptation strategies like mixed cropping. This is so because as more land becomes available to the farmer, he/she will allocate more land to different crops.

The positive correlation between access to extension services and adoption of management practices like cover cropping, annual crop rotation, mulching, irrigation and mixed farming (Table 11) highlights the significant role that extension services play in promoting climate adaptation strategies among farmers. Improved smallholder farmers access to extension service increases the probability of perceiving and adapting to climate change and variability. Hence, extension services are likely providing training and information on the benefits of these adaptation strategies such as soil health, moisture retention, weed suppression, prevention of soil nutrients depletion, pests control, maintaining long-term soil fertility, reduces temperature fluctuations, and also encouraging smallholder farmers to diversify into both crops and livestock which spreads risk and enhances resilience. Similar findings were observed in the study by Ayanlade (2017) and Okumu (2013) in Nigeria and Kenya respectively, showed that smallholder farmers who have access to extension services are more likely to be aware of changing climatic conditions and have knowledge of the various management practices that they can use to adapt to changes in climatic conditions in their localities.

Promoting awareness to changes in climatic conditions would therefore have greater impact in enhancing adoption. This would be attained through appropriate communication pathway available to farmers such as extension services. Therefore, access to extension services facilitates the adoption of a variety of climate-resilient practices by providing farmers with knowledge, training and support. This access empowers farmers to implement diverse, adaptive strategies effectively, enhancing their resilience to climate variability. According to Zamasiya *et. al.* (2021; 2018) smallholder farmers who have access to agricultural extension services are more likely to know different adaptation practices. As such they are more likely to have higher levels of adaptation to climate change and variability than their counterparts.

Access to climate change trainings or information is considered as the driving impetus among smallholder farmers to adopt different adaptation strategies in rural communities. Therefore, it is not surprising to note that this study found that it was significantly correlated to adaptation strategies such as crop residual management, minimum tillage, mulching, and land use change (Table 11). Such correlations suggest that climate change trainings / information significantly encourages smallholder farmers to adopt adaptations to climate change and variability. Trainings provide insights into how retaining crop residues helps maintain soil moisture, improve fertility and prevent erosion which are key practices for climate adaptation. Climate information does not only highlight the benefits of minimizing soil disturbance to conserve soil carbon but also maintains soil structure under changing climate conditions.

These results also imply that information gathered from climate trainings makes smallholder farmers more open to changing traditional land use change patterns, possibly to more sustainable or diversified uses. The result collerates with the study by Nyang'ua *et. al.* (2021) in Kenya which reported that farmers' access to climate and weather information increases their awareness and knowledge of the variations in rainfall and temperature. This aids smallholder farmers to execute an informed decision on the relevant adaptation strategy to enhance their resilience. Smallholder farmers in rural areas receive information on climate change and variability from agricultural extension services officers, fellow farmers, print and electronic media (Nhemachena and Hassan, 2007). Therefore, such correlations indicate that climate change training or information helps farmers understand the value of specific adaptive practices, leading to more decisions that improve resilience. This highlights the importance of continuous education and information sharing to empower smallholder farmers with the skills needed for effective climate adaptation. It is therefore likely that smallholder farmers with access to climate information are likely to adapt to climate change and variability than their counterparts. Information constraints on seasonal and daily weather forecasting (temperature and rainfall) have a negative and insignificant effect on the probability of adaptation to climate change and variability alike.

The results further show that access to farm credits has a significant influence on smallholder farmers' adaptation strategies. The household using the strategy of the crop residual management, minimum tillage and land use change have a positive significant probability level ($p < 0.01$). This suggests that financial support through credit access plays a significant role in enabling smallholder farmers to adopt various climate resilient practices. Accessibility to credit facilities is an important factor in narrowing the financial gap of the farmers. This can help farmers purchase the required farm inputs and useful technologies in adaptation to climate change. For instance, access to credit correlates with crop residual management, as farmers with financial resources may find it easier to invest in necessary tools or labour to manage crop residues. Access to credit facilities also enables smallholder farmers to adopt practices that maintain soil fertility and moisture both of which are crucial for resilience under climate variability. The financial resources tend to empower farmers to modify or diversify land use, potentially shifting to more climate resilient crops or adopting agroforestry systems. Support from access to credit facilities provides flexibility and this in the long run ensures initial investment more attainable. This finding agrees with the study of Rahut *et. al.* (2017) who reported that access to financial services has a positive and significant influence and is more likely to use some adaptation measures. Smallholder farmers highlighted that lack of access to financial resources limits their ability to implement several adaptation practices.

Local membership groups influence the adoption of crop diversification, growing of different varieties, cover cropping, crop residual management, minimum tillage, irrigation, mixed farming and land use change Table 11). This suggests that being part of local groups or networks significantly influences farmers' adoption of climate change and variability adaptation strategies. Similar study in Kenya (Ochieng' *et. al.,* 2012) showed that social groups could pull resources together for their individuals benefits and access information from extension NGOs and government. As a result, they can help their members to access farm inputs on schedule, overcome credit constraints, lobby for good policies and bargain for better prices. Local group membership provides valuable support and shared knowledge, making it easier for farmers to adopt diverse climate adaptation practices. Local networks can foster collaboration, facilitate resource sharing and offer a platform for exchanging ideas, thereby empowering farmers to become more resilient in the face of climate variability.

To the contrary, the results of this study reveal several significant negative correlations between demographic and socio-economic characteristics of smallholder farmers and their adoption of various climate adaptation strategies. These findings do not only provide critical insights into the constraints faced by farmers in implementing adaptive measures but also align with existing literature on agricultural adaptation and climate resilience.

The negative correlation between education level and adaptation strategies such as crop diversification, intercropping, mulching, migration and mixed farming ($p<0.05$ and $p<0.01$) (Table 11), suggests that higher education levels may lead farmers to prioritize alternative strategies or non-agricultural livelihoods. This finding contrasts with studies that highlight the positive role of education in enhancing adaptive capacity by improving access to information and decision-making skills (Mango *et. al.,* 2018 and Paltasingh and Goyari 2018). However, it aligns with other research findings indicating that educated farmers may shift focus toward off-farm income opportunities of advanced technologies, hence reducing reliance on traditional practices (Paltasingh and Goyari, 2018).

Furthermore, the inverse relationship between household size and strategies like crop residue management, agroforestry, mixed farming, minimum tillage, and land use change ($p<0.01$) indicates that larger households may face labour or resource constraints that limit their ability to adopt labour-intensive practices (Atube *et. al.,* 2018, Naicker *et. al.,* 2025). This finding is consistent with study showing that household size can negatively impact the adoption of adaptation strategies due to competing demands for labour and financial resources (Naicker *et. al.,* 2025).

The negative correlation between farmers' age and the use of remittances ($p<0.01$) as an adaptive strategy suggests that older farmers may have limited access to or reliance on external financial support. Similarly, the inverse relationship between farming experience and strategies like agroforestry and remittance use ($p<0.05$) highlights potential resistance to adopting newer or less familiar practices (Meyer and Strohle, 2023, Szaboova, 2023). These findings align with literature emphasizing that younger and less experienced farmers are often more open to innovative adaptation measures (Meyer and Strohle, 2023). The results are also consistent with what Nyang'au *et. al.* (2021) found in Kenya where farming experience correlated negatively and statistically significantly with the adoption of climate smart agricultural practices. This upshot is contrary to the findings that report more experienced farmers are more informed about climate changes and are more likely to employ adaptation measures to enhance resilience (Mwungu *et. al.,* 2018).

The negative correlation between land size and a wide range of adaptation strategies, including crop diversification, cover cropping, minimum tillage, and irrigation ($p<0.01$) and $p<0.05$), suggests that larger landholdings may reduce the perceived need for intensive adaptation measures

(Atube *et. al.,* 2018; Ma and Rahut, 2024). This is consistent with studies indicating that farmers with smaller landholdings are more likely to adopt diverse and resource-efficient practices to maximize productivity (Ma and Rahut, 2024). Additionally, the negative association between access to farm credit and strategies like cover cropping, mulching, remittance reliance and irrigation ($p<0.05$ and $p<0.01$) highlights potential insufficiencies in the allocation or utilization of credit resources (Duhan, 2016; Ullah *et. al.,* 2024). While agricultural credit is generally expected to enhance adaptive capacity, these findings suggest that credit may not always be directed toward sustainable practices, as noted in the previous research findings (Duhan, 2016).

These results underscore the complex interplay between socio-economic factors and adaptation strategies. They highlight the need for targeted interventions that address specific barriers, such as financial constraints, labour shortages, and knowledge gaps. For example; extension services and training programs can help bridge knowledge gaps and promote the adoption of sustainable practices (Paltasingh and Goyari, 2018). Microfinance initiatives and community-based credit schemes can improve access to financial resources for smallholder farmers (Ullah *et. al.,* 2024). Further to this, Naicker *et. al.* (2025) pointed out that policies that support labour-sharing arrangements and resource pooling can mitigate the impact of household size on adaptation efforts. Ultimately, these results contribute to the growing body of literature on climate change adaptation by providing empirical evidence on the socio-economic determinants of adaptive capacity. The adaptation report emphasizes the importance of context-specific strategies to enhance resilience and sustainability in smallholder farming systems.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

This study explored the relationship between household perceptions of climate change and variability and quantitative meteorological data. Climate analysis for the Kazomba Extension Planning Area indicates a general warming trend, with a 2.4°C rise in annual temperature from 1982 to 2019. The area is experiencing drier conditions, as shown by a consistent decline in rainfall over the same period. Farmers' perceptions of climate change align with recorded climate data, as they have noted rising temperatures and decreased rainfall. Given the diverse climate factors across the study area incorporating local knowledge in development interventions will become increasingly important for agencies.

The current study found that temperatures have been rising and rainfall has been declining in the study area, significantly affecting crop production, management, and various aspects of food security for smallholder farmers. Several impacts of climate and variability change were noted, including crop yield failure, outbreak of livestock/human diseases, deterioration of livestock productivity, lower water quantity and quality, crop and animal pest outbreaks, invasive weed problems, frequent droughts, a shortened rainy season, and delayed onset of rainfall. Analysis of the data and farmers' observations revealed that the ongoing food insecurity in Kazomba is largely a result of shifting rainfall patterns, increased temperatures, and more frequent droughts, among other factors. Hence, this initiated various adaptation strategies to be implemented such as crop diversification, adjusting planting dates, better timing of agricultural activities, using more resilient crop varieties, modern irrigation methods, and soil conservation practices in the study area.

The study also found that farmers adjust their agricultural practices based on their perceptions of climate change. Smallholder farmers adopted strategies such as crop diversification, altering planting schedules, crop rotation/mixed cropping, application of manure, and selecting different crop varieties to strengthen their resilience to climate variability and change. However, key barriers to adaptation identified by farmers included a lack of training and extension services, insufficient climate information, financial constraints, limited access to credit facilities, and labour shortages. Correlation analysis showed that factors like marital status, education level, farm income, age, gender, land size and ownership, access to climate-related training, climate information, extension services, and local group membership significantly influenced farmers' decisions to adapt to climate change in the study area.

6.2. Recommendations

To enhance smallholder farmers' understanding of climate change and variability, it is recommended that local extension services develop regular, participatory workshops in partnership with community leaders and meteorological experts. These workshops should blend scientific forecasts with indigenous knowledge, allowing farmers to recognize long-term trends alongside local signs of weather shifts. Complementing face-to-face training, radio broadcasts in local languages can deliver timely seasonal outlooks and early warning messages. Establishing demonstration plots in the study area will provide hands-on opportunities for farmers to observe how altered rainfall and temperature patterns affect different crops. Over time, farmer-to-farmer exchange visits can reinforce these lessons and foster peer-led climate literacy networks.

To mitigate the impact of climate change on livelihoods and natural resources, programs should promote diversified income streams such as intercropping, beekeeping, and small-scale livestock rearing, reducing reliance on a single crop. Accessible microcredit facilities can buffer households against income shocks from extreme droughts or floods. Community-driven conservation plans focused on soil erosion control, reforestation of degraded lands, and the construction of water-harvesting structures will help sustain vital ecosystem services. Linking farmers to value-added markets for climate-resilient crops ensures stable prices even during climatic stress. Policy incentives, such as subsidies for drought-tolerant seeds or water-efficient irrigation technologies, should be aligned with these initiatives to foster sustainable resource management.

To strengthen and scale effective adaptation strategies, it is crucial to systematically document both indigenous practices like mulching and validated scientific techniques, integrating them into a unified extension curriculum. Input packages combining improved seed varieties, soil amendments, and simple drip-irrigation kits should be distributed alongside tailored, hands-on training and structured follow-up visits. Multi-stakeholder platforms that bring together farmers, researchers, extension officers, and NGOs can co-design site-specific resilience roadmaps and monitor progress. Finally, a farmer-friendly monitoring and evaluation framework with clear, locally relevant indicators will enable continuous learning, adaptation, and policy refinement.

Furthermore, future study could investigate the role of youth engagement in climate resilience, the potential of community-based carbon financing schemes, and cross-regional learning networks to accelerate the diffusion of effective adaptation solutions.

REFERENCES

Abegaz, D.M., & Wims, P. (2015). Extension Agents' Awareness of Climate Change in Ethiopia. *Journal of Agriculture Education Extension*. 21, 479-495.

Abid, M., Scheffran, J., Schneider, U.A., & Ashfaq, M., (2015). Farmers' Perception of and Adaptation Strategies to Climate Change and their Determinants: The Case of Punjab Province, Pakistan. *Earth System. Dynamics.* 6, 225.

Ado, A.M., Leshan J., Savadogo P., Koivogui S.K. & Pesha J. (2018). Households' Vulnerability to Climate Change: Insights from a Farming Community in Aguie District of Niger**.** *Journal of Environment and Earth Science*. Vol. 8, (3): pp. 127-137.

Afrifa-Yamoah, E. (2015). Application of ARIMA Models in Forecasting Monthly Average Surface Temperature of Brong Ahafo Region of Ghana. *International Journal of Statistics and Applications.* 5(5): pp. 237-246. DOI: 10.5923/j.statistics.20150505.08.

Afrifa-Yamoah, E., Saeed, B.I.I. & Karim, A. (2016). Sarima Modelling and Forecasting of Monthly Rainfall in the Brong Ahafo Region of Ghana. *World Environment*. Vol. 6(1): 1-9 DOI: 10.5923/j.env.20160601.01.

Agresti, A. (2007). *Building and Applying Logistic Regression Models: An Introduction to Categorical Data Analysis.* Hoboken, New Jersey. Wiley.

Ahmed, U.I., Ying, L., Bashir M.K., Abid M., Zulfiqar F. (2017). Status and determinants of small farming households' food security and role of market access in enhancing food security in rural Pakistan. *PLoS ONE* 12(10): e0185466. https://doi.org/10.1371/journal.pone.0185466.

Akram, A.A., Abidoye, B. & Kannan, S. (2025). The Impact of Climate Change on African Agriculture: A Ricardian Analysis of Smallholder Farmers in sub-Saharan Africa. *Climatic Change* 178, 52. https://doi.org/10.1007/s10584-025-03878-8

Ali, A. & Erenstein, O. (2017). Assessing Farmers Use of Climate change Adaptation Practices and Impacts on Food Security and Poverty in Pakistan. *Clim Risk Manag* 16:183-194

Aqib, S., Kazmi, S.M.A., Amjad, M., Soomro, A.A. & Khoso, G.F. (2023). Climate Change Perceptions, Impacts and Adaptation Strategies of Farm Households in Potohar Region of Punjab, Pakistan. *Journal of Energy and Power Engineering*. Vol. 17. Pp126-151. doi: 10.17265/1934-8975/2023.04.003.

Arbuckle, J.G., Prokopy L.S., Haigh T., Hobbs J., Knoot T., Knutson, C., Loy A., Mase, A.S., McGuire, J., Morton, L.W. & Tyndall, J. (2013). Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. *Climatic Change*: 117(4): pp.943-950

Arunrat, N., Wang C., Pumijumnong, N., Sereenonchai S. & Cai, W. (2017). Farmers' Intention and Decision to Adapt to Climate Change: A Case Study in the Yom amd Nan Basins, Phichit Province of Thailand. *J. Clean. Prod.* 143, 672-685.

Asante, F.A. & Amuakwa-Mensah, F., (2015). Climate Change and Variability in Ghana: Stocktaking. *Climate.* doi:10.3390/cli3010078.

Asare-Nuamah, P. (2021). Climate Variability, Subsistence Agriculture and Household Food Security in Rural Ghana. *Elsevier Ltd*. https://doi.org/10.1016/j.heliyon.2021.e06928.

Asfaw, A., Simane B., Bantider A., & 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). *Environ Dev Sustain 21:2535–2565*. https://doi. org/ 10. 1007/ s10668- 018- 0150-y

Asfaw, S., McCarthy, N., Lipper, L., Arslan, A., Cattaneo, A. & Kachulu, M. (2014). Climate variability, adaptation strategies and food security in Malawi. *ESA Working Paper* No. 14-08. Rome, FAO.

Atiqul-Haq, S.M.D., Vanwing T., & Hens L., (2010**).** Perception, Environmental Degradation and Family Size Preference: A Context of Developing Countries. *Journal of Sustainable Development.* Vol.3(4): pp. 102-108. www.ccsenet.org/jsd

Atoma, C.N., Adesope, O.M., & Familusi, L.C., (2019). Organic Farming Practices among Livestock and Fish Farmers in Southern Nigeria. In: Larramendy M. and Soloneski S. ed(s). Organic Fertilizers – History, Production and Applications. London. *IntechOpen*. http://dx.doi.org/10.5772/intechopen.85522

Atube, F., Malinga, G.M., Nyeko. M. (2021). Determinants of Smallholder Farmers' Adaptation Strategies to the Effects of Climate Change: Evidence from Northern Uganda. *Agric & Food Secur,* 10, 6. https//doi.org/10.1186/s40066-020-00279-1

Ayanlade, A., Radeny M., Morton J.F. (2017). Comparing Smallholder Farmers' Perception of Climate Change with Meteorological Data: A case study from Southwestern Nigeria. *Weather and Climate Extremes,* 15 pp. 24-33.

Berhane, A., (2018). Climate Change and Variability Impacts on Agricultural Productivity and Food Security. *Journal of Climatology & Weather Forecasting.* Vol. 6(3): pp. 1-6. DOI: 10.4172/2332-2594.1000240.

Buys, L., Miller E., & Megen K.V., (2012). Conceptualizing Climate Change in Rural Australia: Community Perceptions Attitudes and (In)actions. *Regional Environmental Change,* 12(1) pp. 237-248.

Chambers, R. (1992). Rapid Appraisal: Rapid, Relaxed and Participatory. IDS Discussion Paper. *311 Institute of Discussion Development Studies*, Sussex, UK.

Chinnasamy, B., Ganesa-Moorthy, S.K., Thirunavukkarasu, M., & Manogaran B.R., (2019). Forecasting of Milk Production in Tamil Nadu: An Application of ARIMA Model. *Indian Journal of Veterinary and Animal Sciences Research*: 48(6) 31-39.

Choudri, B. S., Al-Busaidi A., & Ahmed M., (2013). Climate change, vulnerability and adaptation experiences of farmers in Al-Suwayq Wilayat, Sultanate of Oman. *International Journal of Climate Change Strategies and Management.* Vol. 5 No. 4, 2013 pp. 445-454 Emerald Group Publishing Limited

Cordova, R., Hogarth, N.J., & Kanninen M., (2019). Mountain Farming Systems' Exposure and Sensitivity to Climate Change and Vulnerability: Agroforestry and Conventional Agriculture Systems Compared in Ecuador's Indigenous Territory of Kanyambi People. *Sustainability MDPI*. Vol. 11(2623): pp 1-30.

Creswell, J.W., (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research.* 4th Ed. Boston: Pearson Education, Inc.

Deressa, T., Hassan R., & Rinler C., (2011). Perception and Adaptation to Climate Change: The Case of Farmers in the Nile Basin of Ethiopia. *J Agric Sci* 149:23-31

Duhan, P.K. (2016). Agriculture Credit and Its Impact on Farm Income. *International Journal of Research in Economics and Social Sciences (IJRESS).* Vol.6(11), pp 448-455. https://euroasiapub.org

Epule, T.E., & Bryant C.R. (2016). Small-Scale Farmers' Indigenous Agricultural Adaptation Options in the Face of Declining or Stagnant Crop Yields in the Fako and Meme Divisions of Cameroon. *Agriculture 6 (2). 22*

Fatuase, A.I., Aborisade A.S. & Omisope E.T. (2015). Determinants of adaptation Measures to Climate Change by Arable Crop Farmers in Owo Local Government Area of Ondo State. Nigeria. *World Rural Observations*. Vol. 7. No.1, pp1-9.

Gama, A.C., Mapemba, L.D., Masikat, P., Tui, S.H., Gespo, O. & Bandason, E. (2014). Modeling Potential Impacts of Future Climate Change in Mzimba District, Malawi, 2040-2070: An Integrated Biophysical and Economic Modeling Approach. *International Food Policy Research Institute (IFPRI)*: Working Paper 08.

Gan, Y., Liang, C., Chai, Q., Lemke, R., Campbells, C.A., & Zentner, R.P. (2014). Improving farming practices reduces the carbon footprint of spring wheat production. *doi:10.1038/nmomms6012*.

Gedefaw, M., Girma, A., Denghua, Y., Hao W. and Agitew, G. (2018). Farmer's Perceptions and Adaptation Strategies to Climate Change, Its Determinants and Impacts in Ethiopia:

Evidence from Qwara District. *J Earth Scl Cli Change 9: 481*. Doi:10.4172/2157-7617.1000481

Gemeda, D.O., Korecha, D. & Garedew W. (2023). Climate Change Perception and Vulnerability Assessment of the Farming Communities in the Southwest Parts of Ethiopia. Climate **2023**, 11, 183. https://doi.org/10.3390/cli11090183

Gil-Clavel, S., Wagenblast, T., & Filatova, T. (2025). Incremental and Transformational Climate Change Adaptation Factors in Agriculture Worldwide: A Comparative Analysis Using Natural Language Processing. *PLoS ONE* 20(3): e0318784. https://doi.org/10.1371/journal.pone.0318784

Girip, M., Maracine D. & Dracea L. (2020). Environmental Impact of Conventional Agriculture *Economic Sciences Series*: Vol. XX, Issue 1 /2020: pp 372-381

GoM., (2020). *Malawi's National Adaptation Plan Framework*. Malawi, Lilongwe

GoM. (2016a). National Adaptation Plan Roadmap. *Ministry of Natural Resources, Energy and Mining:* Lilongwe Malawi.

GoM. (2017c). Sectoral Guidelines for Integration of Climate Change Adaptation in Development Planning. *Ministry of Natural Resources, Energy and Mining*. Malawi, Lilongwe.

Henriksson, R., Vincent, K., Archer, E. & Jewitt, G. (2025). Understanding Gender Differences in Availability, Accessibility and Use of Climate Information among smallholder Farmers in Malawi. *Climate Development*, 13:6, 503-514. Doi:10.1080/17565529.2020.1806777.

IPCC. (2007). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. *Cambridge University Press, Cambridge*, United Kingdom and New York, NY, USA, 1535 pp.

IPCC. (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects***.** *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, *Geneva,* Switzerland, 151 pp.

IPCC. (2018). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

IPCC. (2019). *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.

Jantke, K., Hartmann, M. J., Rasche, L., Blanz, B. & Schneider, U. A. (2020). Agricultural Greenhouse Gas Emissions: Knowledge and Positions of German Farmers. *Land:* 9 (130): pp. 1-13. doi:10.3390/land9050130.

Japan Overseas Cooperative Association [JOCA]. (2012). Malawi Project for Farmers' Self-Reliance Towards Community Empowerment in Mzimba 2005-2012. *JOCA*

Jiri, O., Mafongoya, P., & Chivenge, P. (2015). Smallholder Farmer Perceptions on Climate Change and Variability: A Predisposition for their Subsequent Adaptation Strategies. *J Earth Sci Clim Change*. doi:10.4172/2157-7617.1000277.

Joshua, M.K., Ngongondo, C., Chipungu, F., Monjerezi, M., Liwenga, E., & Majule, A.E., (2016). Climate change in Semi-arid Malawi: Perceptions, adaptation strategies and water governance. *Jàmbá: Journal of Disaster Risk Studies* 8(3): pp. 1-10. http://dx.doi.org/10.4102/jamba.v8i3.255.

Juan M-Buu, D. & Nhamo, G. (2024). A Comparison of Farmers' Perceptions and Meteorological Data on Climate Change in Northwestern Ghana. *Cogent Social Sciences*, 10:1, 2407028, https://doi:10.1080/23311886.2024.2407028

Kabote, S.J., Mbwambo, E.P., & Kazuzuru, B.B. (2024). Determinants of Farmers' Choice of Adaptation Strategies Against Climate Variability and Change: Lessons from Central Tanzania in Manyoni District. *Climate Services* 34 (2024) 100470. https://doi.org10.1016/j.cliser.2024.100470.

Kaira, C. (2015). Participatory Vulnerability Analysis in Salima and Nsanje. *IIED*

Kalinda, T.H., Nyanga, P.H., Johnson, F.H., & Aune, J.B., (2011). Smallholder Farmers' Perceptions of Climate Change and Conservation Agriculture: Evidence from Zambia. *Journal of Sustainable Development,* 4(4): pp. 73-85.

Kasulo, V., Chikagwa-Malunga, S., Chagunda, M., & Roberts, D. (2012). The perceived impact of climate change and variability on smallholder dairy production in northern Malawi. *African Journal of Agricultural Research.* Vol. 7(34): pp4830-4837. DOI: 10.5897/AJAR12.259.

Kenea, T. & Mebratu, S., (2020). Review on Perception and Adaptation Strategies of Smallholder Farmers to Climate Change in Ethiopia. *International Affairs and Global Strategy*. Vol.82. doi:10.7176/iags/82-03

Kotir, J.H. (2011). Climate change and variability in Sub-Saharan Africa: a review of current and future trends and impacts on agriculture and food security: *Environ Dev Sustain* 13: pp. 587–605. Doi: 10.1007/s10668-010-9278-0.

Kyaw, Z. W. (2018). Factors Influencing Farmers' Perception of Climate Change: A Case Study of Pakokku Township in Dry Zone. *Mahidol University*, Myanmar.

Lemma, W. (2016). Analysis of Smallholder Farmers' Perceptions of Climate Change and Adaptation Strategies to Climate Change: The Case of Western Amhara Region. PhD Thesis, *University of South Africa,* Pretoria.

M'mbelwa District Council [MDC]. (2017). *Socio Economic Profile*. Malawi: M'mbelwa District Council.

Ma, W., & Rahut, D. B. (2024). Climate-Smart Agriculture: Adoption, Impacts, and Implications for Sustainable Development. *Mitig adapt Strateg Glob Change.* 29, 44. https://doi.org/10.1007/s11027-024-10139-z

Maganga, A.M. & Malakini, M. (2015). Agrarian Impact of Climate Change in Malawi: A Quantile Ricardian Analysis. International Conference of Agricultural Economists. *Milan* 8-14 August, 2015: Milan. Agriculture in an Interconnected World.

Maguza-Tembo, F., Edriss, A.K., & Mangisoni, J. (2017). Determinants of Climate Smart Agriculture Technology Adoption in the Drought Prone Districts of Malawi Using a

Multivariate Probit Analysisi. *Asian Journal of Agricultural Extension, Economics & Socioogy;* 16(3): 1-12. Article no. AJAEES.32489.

Mihiretu, A., Okoyo, E.O. & Lemma, T. I. (2020). Small holder farmers' perception and response mechanisms to climate change: Lesson from Tekeze lowland goat and sorghum livelihood zone, Ethiopia. *Cogent Food & Agriculture,* 6:1, 1763647: https://doi.org/10.1080/23311932.2020.1763647

Mnukwa, M.L., Mdoda, L. & Mudhara, M. (2025). Assessing the Adoption and Impact of Climate-Smart agricultural Practices on Smallholder Maize Farmers' Livelihoods in sub-Suharan Africa: A Systematic Review. *Front. Sustain. Food Syst.* 9:1543805. Doi:10.3389/fsufs.2025.1543805

Munthali, C.K., Kasulo, V., & Matamula S. (2016). Smallholder farmers perception on climate change in Rumphi District, Malawi. *Journal of Agricultural Extension and Rural Development:* Vol.8(10): pp 203-210. Doi:10.5897/JAERD2016.0798.

Murray, U., Gebremedhin, Z., Brychkova, G. & Spillane, C. (2016). Smallholder Farmers and Climate Smart Agriculture: Technology and Labour-Productivity Constraints amongst Women Smallholders in Malawi. *Gender, Technology and Development*. 20:2, 117-148. Doi:10.1177/0971852416640639.

Musah-Surugu, J.I., Anunga, S.W. (2023). Remittances as a Game Changer for Climate Change Adaptation Financing for the Most Vulnerable: Empirical Evidence from Northern Ghana. In: Meyer, S., Strohle, C. (eds) Remittances as social Practices Agents of Change. *Palgrave Macmillan, Cham*. https://doi.org/10.3390/su17020488

Mutunga, E.J., Ndungu, C.K. & Muendo, P. (2017). Smallholder Farmers' Perceptions and Adaptations to Climate Change and Variability in Kitui County, Kenya. *J Earth Sci Clim Change 8: 389.* doi: 10.4172/2157-7617.1000389.

Muzari, W., Muvhunzi, S., Soropa, G., & Kupika O.L. (2012). Impacts of Climate Variability and Change and Farmers' Responsiveness in the Agricultural Sector in Zimbabwe. *International Journal of Science and Research (IJSR).* Vol.3(9): pp. 1726-1736.

Naicker, M., Naidoo, D., Hlatshwayo, S.I., and Ngidi, M.S. (2025). Factors Affecting the Choice and Level of Adaptation Strategies Among Smallholder Farmers in KwaZulu Natal Province. *Sustainability,* 17(2), 488. https://doi.org/10.3390/su17020488

National Statistical Office [NSO]. (2020). The Firth Integrated Household Survey. *Zomba,* Malawi http://www.nsomalawi.mw/mw/index.php?option=com_content&view=article&id=230&ltemid=111

Ndaki, P.M. (2014). Climate Change Adaptation for Smallholder Farmers in Rural Communities: the Case of Mkomazi Sub-Catchment, Tanzania. PhD Dissertation. Germany. *Oldenburg – Carl von Ossietzky University of Oldenburg.*

Nyang'au, J.O., Mohamed, J.H., Mango, N., Makate, C. & Wangeci, A. (2021). Smallholder Farmers' Perception of Climate Change and Adoption of Climate Smart Agriculture Practices in Masaba South Sub-County, Kisii, Kenya. *Elsevier Ltd*. https://doi.org/10.1016/j.heliyon.2021.e06789

Oepen, M. (2012). Knowledge attitude and practices surveying Lao PDR related to environmental protection, biodiversity, conservation and climate change adaptation: *KAP survey report. www.laos-proceed.com/la/.../surveys/kap-survey-report_v19_final-final_small.pd.*

Ogalleh, S.A., Vogl, C.R., Eiteinger, J., & Hauser, M. (2012). Local Perceptions and Responses to Climate Change and Variability: The case of Laikipia District, Kenya. *Sustainability MDPI* 4, pp. 3302-3325.

Ogundeji, A.A. (2022). Adaptation to Climate Change and Impact on Smallholder Farmers' Food Security in South Africa. *Agriculture* 2022, 12, 589. https://doi.org/10.3390/agriculture12050589.

Okumu, O.F. (2013). *Small-scale Farmers' Perceptions and Adaptation Measures to Climate Change in Kitui County, Kenya.* MA Thesis. Nairobi: University of Nairobi.

Olaleye, A. G., Peak, D., Shorunke, A. & Dhillon, G., Oyedele, D., Adebooye, O., & Akponikpe, I. P. B., (2020). Effect of Manure and Urea Fertilization on Yield, Carbon Speciation and Greenhouse Gas Emissions from Vegetable Production Systems of Nigeria and Republic of Benin: A Phytotron Study. *doi: 10.3390/agronomy10030400***.**

Oluwatayo, I. B. & Ojo, A. O. (2016) Awareness and Adaptation to Climate Change among Yam-Based Farmers in Rural Oyo State, Nigeria. *The Journal of Developing Areas*. Vol. 50, No. 2.

Owusu, K., Obour, P.B., & Baffour, S.A., (2015). Climate Variability and Climate Change Impacts on Smallholder Farmers in the Akuapen North District, Ghana. *Handbook of Climate Change Adaptation.*

Paltasingh, K.R. & Goyari, P. (2018) Impact of Farmer Education on Farm Productivity under Varying Technologies: Case of Paddy Growers in India. *Agricultural and Food Economics.* Vol. 6(7). https://doi.org/10.1186/s40100-018-0101--9.

Perpar, A., & Udovč, A. (2019). Organic Farming: A Good Production Decision for Slovenian Small Size Farms and Farms in the Areas with Restrictions/ Limitations or Natural Obstacles for Agriculture? *IntechOpen.* http://doi.org/10.5772/intechopen.89716.

Rahut, D. B. & Ali, A. (2017). Coping with Climate Change and Its Impact on Productivity, Income and Poverty: Evidence from the Himalayan Region of Pakistan. *International Journal of Disaster Risk Reduction.* Vol. 24 pp.515-525.

Ricart S., Gandolfi C., & Castelletti A. (2023). Climate change awareness, perceived impacts, and adaptation from farmers' experience and behavior: a triple-loop review. *Regional Environmental Change (2023)* 23:82. https://doi.org/10.1007/s10113-023-02078-3

Sani, S. & Chalchisa, T. (2016). Farmers' Perception, Impact and Adaptation Strategies to Climate Change among Smallholder Farmers in Sub-Saharan Africa: A Systematic Review. *Journal of Resources Development and Management.* Vol.26.

Saruchera, M.M. (2019). Smallholder Farmers' Understandings of and Reponses to Climate Change in Malawi: A Case Study of Mpunga Group Village, Salima District**.** PhD Thesis. *Stellenbosch University,* South Africa.

Serdeczny, O., Adams S., Baarsch F., Coumou D., Robinson A., Hare W., Scheffer M., Perrette M. & Reinhardt, J. (2016). Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. *Regional Environmental Change:* Vol.15(8). doi:10.1007/s10113-015-0910-2.

Shani, F.K., Joshua, M. & Ngongondo, C. (2024). Determinants of Smallholder Farmers' Adoption of Climate-Smart Agricultural Practices in Zomba, Eastern Malawi. *Sustainability* 16, 3782. https://doi.org/10.3390/su16093782.

Shisanya, S. & Mafongoya P. (2016). Adaptation to Climate Change and the impacts on Household Food Security Among Rural Farmers in uMzinyathi District of Kwazulu-Natal, South Africa. *Food Secur* 8:597-608

Shisanya, S. O. (2015). Rural Households' Perception of The Effect of Climate Change on Food Security in uMzinyathi District Municipality of Kwazulu-Natal, South Africa. PhD Thesis. *School of Agricultural, Earth and Environmental Sciences:* College of Agriculture, Engineering and science University of KwaZulu-Natal Pietermaritzburg.

Simelton, E., Quinn, C.H., Batisani, N., Dougill, A.J., Dyer, J.C., Fraser, E.D., Mkwambisi, D., Sallu, S. & Stringer, L.C. (2013). Is Rainfall Really Changing? Farmers' Perceptions, Meteorological Data and Policy Implications. *Climate Development.* 5, 123-138.

Singini, W. (2013). Bioeconomic Analysis of Chambo (Oreochromis Spp.) and Kambuzi (Small Haplochromine Spp.) Fish Stocks of Lake Malombe. *PhD Thesis.* Bunda College of Agriculture. University of Malawi.

Singini, W., Tembo M. & Banda C., (2015). Forecasting Climate Change Pattern for Bolero Agriculture Extension Planning Area in Malawi. *J Climatol Weather Forecasting* 3: 145. doi:10.4172/2332-2594.1000145.

Sithole, A. & Olorunfemi, O.D. (2024). Sustainable Agricultural Practices in sub-Saharan Africa: A Review of Adoption Trends, Impacts, and Challenges among Smallholder Farmers. *Sustainability.* 16, 9766. https://doi.org/10.3390/su16229766.

Som Castellano, R.L. & Moroney, J. (2018). Farming Adaptations in the Face of Climate Change. *Renewable Agriculture and Food Systems*. 33, 206-211. https://doi.org/10.1017/S174217051700076X.

Szzaboova, L. (2023). Climate Change, Migration and Rural Adaptation in the Near East and North Africa Region. Rome, FAO. *https://doi.org/10.4060/cc3801en.*

Tesfahunegn, G. B., Mekonen, K., & Tekle, A. (2016). Famers' perception on causes, indicators, and determinants of climate change in northern Ethiopia: Implication for developing adaptation strategies. *Applied Geography* 73:1-2.

Tongwane, M., Mdlambuzi T., Moeletsi M., Tsubo M., Mliswa V. & Grootboom L. (2016). Greenhouse Gas Emissions from Different Crop Production and Management Practices in South Africa. *Environmental Development*. 19(2016), pp. 23-35.

Troncarelli, L.T., De Ataide, M.T. & Morsello C. (2023). Existing Evidence of Conceptual Differences in Research on Climate Change Perceptions Among Smallholders? A Systematic Map. *Environmental Evidence*, 12:28. https://doi.org/10.1186/s13750-023-00321-2.

Tshuma, N. & Mathuthu, T. (2014). Climate Change in Zimbabwe: Perceptions of Smallholder Farmers in Mangwe District. *The International Journal of Humanities and Social Studies,* 2(5), pp. 318-325.

Tsokota, F.C. (2015). An Assessment of The Impacts of Climate Change, Vulnerability, and Adaptation Strategies to Household Food Security of Rural Communities in The District of Buhera; The Case of Dorowa. MSc Thesis, *the Women's University in Africa*, Harare.

Tubiello, F.N., Salvatore M., Rossi S., Ferrara A., Fitton N. & Smith P. (2013). The FAOSTAT Database of Greenhouse Gas Emissions from Agriculture. *Environmental Research Letters*: Doi:10.1088/1748-9326/8/1/015009.

Tuncok, K. (2021). Impacts of Climate Change in Central Asia. *Academia Letters*, Article 1219. https://doi.org/10.20935/AL1219.

Twinomugisha, B.B. & Mushy, R.B. (2020). Impacts of Climate Change on Food Security and Adaptation Options for Smallholder Farmers in Malawi. *Huria Journal*, Vol 27(2), 165-189.

Ullah, A., Verner, V., Madaki, M.Y., Adams, F., & Bavoroya, M. (2024). Factors Influencing Informal Credit Access and Utilization Among Smallholder Farmers: Insights from Mountainous Regions of Pakistan. Agriculture, 14(10), 1764. https//doi.org/10.3390/agriculture14101764

United Nations Framework Convention on Climate Change (UNFCCC), (2020). *United Nations Climate Change Annual Report 2019*. New York: UNFCCC.

World Bank. (2010). *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World.* Mearns R. and Norton A. (eds). Washington DC: World Bank.

World Bank. (2018). Climate Change management Portal for Development Practitioners and Policy Makers. *http://climateknowledgeportal.worldbank.org/country/malawi/extremes*

World Bank. (2022). Malawi Country Climate and Development Report. *Washington, DC:* World Bank Group. https://openknowledge.worldbank.org/server/api/core/bitstreams/bbcae1ac-127f-5219-a490-c80012bfea8f/ content.

Yamane, T. (1967). Statistics: An Introductory Analysis, 2nd Ed., *New York: Harper and Row*.

Yamba, S., Appiah D.O. & Siaw, L.P. (2019). Smallholder farmers' perceptions and adaptive response to climate variability and climate change in southern rural Ghana, *Cogent Social Sciences.* 5:1, 1646626. https://doi.org/10.1080/23311886.2019.1646626.

Yin, R.K. (2018). Case Study Research and Applications: Designs and Methods. 6th Ed. *Los Angeles.* USA: COSMOS Corporation.

Zamasiya, B., Nyikahadzoi, K. & Mukumuri B. (2018). Drivers of Adaptationto Climate Change by Smallholder Farmers Residing in Zimbabwe's Communal Areas: A Case Study of Hwedza Districtin Zimbabwe. *Zambbezia J Human* 45(ii):75-92

Zhao, C. (2017). Temperature Increase Reduces Global Yields O Major Crops in Four Independent Estimates. *PNAS*, 114(35), 9326-9331

Zulu, L. (2017). Existing Research and Knowledge on Impacts of Climate Variability and Change on Agriculture and Communities in Malawi**.** *Technical Report of the Malawian Innovation Activity, Improving Food Security and Resilience to Climate Change.*

APPENDICES

Appendix 1: Interviewer Administered Questionnaire for smallholder farmers

SMALLHOLDER FARMERS' PERCEPTIONS ON CLIMATE CHANGE AND VARIABILITY AFFECTING FOOD SECURITY IN KAZOMBA EXTENSION PLANNING AREA, MZIMBA DISTRICT, MALAWI.

IDENTIFICATION
EPA Section ……………………………………………………………………………   **Household Number………………………………………………………………...**   **Enumerator Name ……………………………………………………………………**

Nº	QUESTIONS		ANSWERS
	A. DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS		
1.	Record sex of the respondent		01 = Male 02 = Female
2.	How old are you? **Record age in years**		Record number of years ………………………… 01 = Don't Know
3.	What is your marital status?		01 = Single, 02 = Married 03 = Divorced/Separated 04 = Widow/Widower 05 = No answer, 06 = Don't know
4.	What is your highest level of education you have attained?		00 = None, 01 = Some primary education 02 = Completed primary, 03 = Secondary 04 = College, 05 = University 06 = Other (specify)…………….
5.	How many people including your children who eat from the same pot you are living with in your household?		00 = None 01 = 1 - 3 02 = 4 – 6 03 = 7 and above
6		< 5 years	
		5 – 17 years	

	How many are family members of age;	18 – 59 years	
		>59 years	
7.	How long have you lived in this community?		………………Years
8.	How long have you been a farmer?		01 = Less than five years 02 = 6 – 10 years 03 = 11 – 20 years 04 = Over 20 years
B. SOCIOECONOMIC CHARACTERISTIC OF THE RESPONDENTS			
1.	What is your main source of income? ***(Only one answer is possible. Record the principal income source.)***		01 = Crop production 02 = Livestock production 03 = Business, 04 = Employment 05 = Remittance, 06 = Other (Specify) …………..
2.	What is your main fuel for cooking in your household?		01 = Firewood 02 = Charcoal, 03 = Gas 04 = Crop residuals (specify)…………
3.	What is the type of land ownership?		01 = Private property with title deed 02 = Communal land, 03 = Ancestral land 04 = Leasehold 05 = Other (specify)…………………
4.	Who makes most of the decision over land management?		01 = Head of household 02 = The entire family 03 = Other (specify)………………….
5.	How much land is allocated to agricultural activities		01 = < 1ha, 02 = 1-2ha, 03 = 2-3ha 04 = > 3ha
6.	What is your perception on fertility of your land for crop production?		01 = Very fertile, 02 = Fertile 03 = Infertile, 99 = Don't know
7	What main food crops do you grow?		01 = Maize, 02 = Beans 03 = Millet, 04 = Cassava 05 = Others (Specify) ………………
8	Do you domesticate livestock?		01 = Yes, 02 = No
9	If yes in 8 above, what are these animals and how many do you have currently?		01 = Cattle ……, 02 = Goat.......... 03 = Sheep ……., 04 = Pigs ..……. 05 = Others (specify) ……………
10	Why do you domesticate the animals you have mentioned?		01 = Food, 02 = Cash, 03 = Prestige 04 = Others (specify)……………

C. INSTITUTIONAL FACTORS		
1.	Do you have access to extension services on climate variability and change?	01 = Yes 02 = No
2.	Do you receive climate change related information or trainings as a farmer?	01 = Yes 02 = No
3.	If yes to question 2 above, who conducts or facilitates the trainings?	01 = Non-governmental organizations 02 = Extension workers 03 = Lead farmers 04 = Traditional leaders 05 = Don't know
4.	Do you have access to formal credit to run your farming activities?	01 = Yes 02 = No
5.	If yes to question 4 above, where is the sources of credit? **(Name the sources)**	………………………………… …………………………………. ………………………………….
6.	Do you belong to any group or institution in your area as a farmer?	01 = Yes 02 = No
7.	If yes to question 6 above, which group(s) or institution(s) do you belong to? **(Name them)**	………………………………. ………………………………. ………………………………..
D. CLIMATE CHANGE AND VARIABILITY		
1.	Do you perceive climate variability and change?	01 = Yes 02 = No
2.	**Have you observed significant changes on the following weather conditions in your community over the last 20 years?**	(a) Unpredictable rains — Yes — No (b) Prolonged drought — Yes — No (c) Very hot seasons — Yes — No (d) Very wet season — Yes — No
3.	Have you noticed any long-term changes in the mean temperature over the last 20 years?	01 = Increased, 02 = Declined 03 = No change, 05 = Don't know
4.	Have you noticed any long-term changes in the mean rainfall over the last 20 years?	01 = Increased, 02 = Declined 03 = No change, 04 = Don't Know
5.	Have you experienced any long-term changes in rainfall patterns over the last 20 years?	01 = Start earlier, 02 = Starts late 03 = Erratic rainfall, 04 = No change 05 = Don't know
6.	Have you noticed any long-term changes in the frequency of floods over the last 20 years?	01 = Frequent, 02 = Rare 03 = No change, 04 = Don't know
7.	Have you noticed any long-term changes in the frequency of droughts or dry spells over the last 20 years?	01 = Frequent, 02 = Rare 03 = No change, 04 = Don't know

8.	Have you noticed any long-term changes in the water sources over the last 20 years?	01 = Numerous, 02 = No change 03 = Fewer, 04 = Bad 05 = Don't know
9.	Have you noticed any long-term changes in the frequency of forest fires over the last 20 years?	01 = Frequent, 02 = Fewer, 03 = No change, 04 = Don't know
10	Can you describe the intensity of forest fires in your area	01= Very severe, 02 = Moderate 03 = Less severe, 04 = Don't know

E. CAUSES AND EFFECTS

1.	**Do you think climate change and variability are caused by human activities?**	01 = Yes 02 = No

2.	**Do you think any of the following cause climate change and variability?**	**Yes**	**No**	**Don't know**	**No response**
	Burning of fossil fuels such as oil, coal, natural gas	01	02	03	99
	Transportation (driving of vehicles) through vehicle emissions	01	02	03	99
	Deforestation	01	02	03	99
	Poor agricultural practices (e.g. overgrazing, pesticides)	01	02	03	99
	Anger of ancestors	01	02	03	99
	End of the world	01	02	03	99
	Anger of God	01	02	03	99
	Supernatural forces	01	02	03	99

3.	**Do the following occur in your area?**	**Yes**	**No**	**Don't know**	**If yes, do you think they are caused by climate change**		
					Yes	**No**	**Don't know**
	Increased flooding	01	02	03	01	02	03
	Decreased crop yields or productivity	01	02	03	01	02	03
	Frequently occurring of droughts or dry spells	01	02	03	01	02	03
	Early cessation of rains	01	02	03	01	02	03
	Increased pests and pests' invasion	01	02	03	01	02	03

	Increased in crop diseases	01	02	03	01	02	03
	Increased in livestock diseases	01	02	03	01	02	03
	Increased in the problem of weeds	01	02	03	01	02	03
	Any shift in suitable growing areas	01	02	03	01	02	03

Perception of household on future changes due to climate change

4	Household worry to:	Never	Rarely	Sometimes	Often
	Recurrent droughts	01	02	03	04
	Recurrent floods	01	02	03	04
	Crop failure	01	02	03	04
	Crop diseases	01	02	03	04
	Livestock diseases	01	02	03	04
	Price decline of farm products	01	02	03	04
	Soil fertility decline	01	02	03	04
	Price increase of farm inputs	01	02	03	04
	Late onset of rains	01	02	03	04
	Shorter rainy seasons	01	02	03	04
	Temperature increase	01	02	03	04
	Decrease in temperature	01	02	03	04
	High precipitation	01	02	03	04
	Low precipitation	01	02	03	04

F. ADAPTATION STRATEGIES

5. If in your view, overall crop/livestock is decreasing, especially as a result of climate variability, how does your household seek to adapt to or cope this adverse situation?	Yes	No	Reason for not using this method of adaptation				
			Lack of money	Lack of informatio	Shortage of labour	Bad	Other (Specify)
Crop diversification	01	02	01	02	03	04	
Growing different varieties	01	02	01	02	03	04	

Intercropping	01	02	01	02	03	04	
Cover cropping	01	02	01	02	03	04	
Crop residual management	01	02	01	02	03	04	
Minimum tillage	01	02	01	02	03	04	
Annual crop rotation	01	02	01	02	03	04	
Practicing mulching	01	02	01	02	03	04	
Use of organic manure	01	02	01	02	03	04	
Practicing agroforestry	01	02	01	02	03	04	
Practicing irrigation	01	02	01	02	03	04	
Rain water harvesting	01	02	01	02	03	04	
Praying for rain	01	02	01	02	03	04	
Mixed farming	01	02	01	02	03	04	
Changing diet	01	02	01	02	03	04	
Land use change	01	02	01	02	03	04	
Migration	01	02	01	02	03	04	
Depending on remittance	01	02	01	02	03	04	

Appendix 2. Checklist / or Observation guide

The following are to be observed by the researcher where possible:

1. Observable evidence of climate change.
2. Observable signs of climate change impacts (floods, droughts)
3. Observable adaptation strategies mentioned by farmers.
4. Observable livelihood strategies.
5. Any other observable aspects that may be relevant to the study.

Appendix 3: Meteorological Data (Temperature and Rainfall)

Year	Average Tmax	Average Tmix	Annual rainfall
1982	25.7	14.8	1011.5
1983	26.5	15.2	850.1
1984	25.0	14.1	924.5
1985	25.4	14.2	885.2
1986	25.7	14.1	939.2
1987	26.8	15.3	708.6
1988	25.2	14.9	763.2
1989	25.4	14.7	1336.4
1990	26.3	15.0	804.7
1991	25.9	15.0	816.8
1992	26.4	15.3	786.3
1993	25.9	15.2	594.6
1994	26.6	14.7	768.7
1995	27.0	14.6	930.7
1996	26.4	13.9	866.9
1997	26.5	14.2	762.6
1998	26.9	14.7	610.5
1999	25.7	14.6	977.3
2000	25.7	15.3	952.9
2001	26.2	15.1	950.6
2002	26.1	15.2	887.3
2003	26.9	15.5	931.8
2004	26.5	15.2	1021.9
2005	27.0	16.0	606.3
2006	26.6	15.7	795.7
2007	26.5	15.8	821.1
2008	26.5	15.3	867.3
2009	26.8	15.5	633.9
2010	26.7	15.7	622.8
2011	26.7	15.6	756.5
2012	26.8	15.7	722.8
2013	27.2	15.8	639.1
2014	25.9	16.3	946.7
2015	27.5	15.8	867.8
2016	24.8	15.8	698.7
2017	24.5	16.1	822.2
2018	26.5	15.3	882.1
2019	27.3	15.6	883.1