FACULTY OF AGRONOMY AND FORESTRY ENGINEERING

CLIMATE VARIABILITY, GENDER-RESPONSIVE ANTICIPATORY ACTION, LIVELIHOOD SYSTEMS AND HOUSEHOLD FOOD SECURITY IN RURAL MOZAMBIQUE

BY

Adeke Martha Among

Reg. No: 20235539

Supervised by

Prof. Luís Artur

A dissertation submitted in the Department of Economics and Agrarian Development in partial fulfilment of the requirement for the award of the Master's degree in Climate Change in Agrarian Systems from the Faculty of Agronomy and Forestry Engineering at Eduardo Mondlane University

Maputo, July 2026

DECLARATION

I, Adeke Martha Among, declare that this dissertation, submitted for the award of the degree of Masters of Science in Climate Change in Agrarian Systems, is presented in the format of a Master's by Publication and is composed of a series of original research papers.

I confirm that the work presented in this dissertation is my own, except where explicitly stated. The included papers have been written by me as the lead author, in collaboration with co-authors where applicable. The contributions of all co-authors have been clearly acknowledged in each paper, and their roles are duly indicated.

I further declare that all sources of information have been properly acknowledged and referenced, and that this work has not been submitted, either in whole or in part, for any other degree or award at this or any other institution.

This dissertation has been prepared under the supervision of Prof. Luís Artur, and any assistance received during the course of the research has been appropriately acknowledged.

Signature: …….

Date: …….

APPROVAL

This is to certify that the dissertation titled "Climate Variability, Gender-Responsive Anticipatory Action, Livelihood Systems and Household Food Security in Rural Mozambique", submitted by Adeke Martha Among was prepared under my supervision. I hereby confirm that I have reviewed the work and approved it

1. Prof. Luís Artur

Department of Economics and Agrarian Development, Faculty of Agronomy and Forest Engineering

Signature …….

Date …….

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to all individuals and institutions that contributed to the successful completion of this research. I am deeply grateful to my family for their unconditional love, patience, and constant encouragement. Their belief in my abilities and their support during challenging moments made this academic journey possible.

First and foremost, I extend my deepest appreciation to my supervisor, Prof. Luís Artur, for the invaluable guidance, constructive feedback, and continuous support provided throughout the entire research process. His academic insight, encouragement, and patience greatly strengthened the quality of this work and contributed significantly to my development as a researcher.

I am also grateful to the academic staff and colleagues of the Department of Economics and Rural Development, at Eduardo Mondlane University for their intellectual support, discussions, and encouragement during my studies. Their contributions created an enriching academic environment that facilitated the completion of this dissertation.

Special appreciation goes to the communities and respondents in Guijá district, Mozambique, who generously shared their time, knowledge, and experiences during the fieldwork. Without their participation and openness, this research on climate variability, livelihoods, and household food security would not have been possible.

I would also like to acknowledge the institutions and organizations that supported this research either financially, technically, or logistically, particularly the Regional Centre of Excellence in Agri-Food Systems and Nutrition (CE-AFSN), whose support made the data collection and publication possible.

My sincere thanks also go to my colleagues and friends for their encouragement, helpful discussions, and moral support throughout the course of this research.

This work is dedicated to all those striving to improve food security and climate resilience among vulnerable rural communities.

DISSERTATION ABSTRACT

Climate-induced shocks, including recurrent droughts, cyclones, and rainfall variability continue to exacerbate food insecurity and undermine rural livelihoods in vulnerable regions of Mozambique specially among female headed households. However, empirical evidence integrating gender, anticipatory action, and livelihood systems in explaining household food security remains limited. This study synthesizes findings from two complementary cross-sectional studies. The first, carried out under the auspice of the World Food Program, comprised 1,644 households surveyed across drought-affected provinces of Tete, Sofala, and Gaza. The second, led by the author of this dissertation, surveyed 407 households in Guijá district of Gaza province. The main objective was to examine the food security status of the climate-stressed households by using a gender perspective. Food security was assessed using the Food Consumption Score (FCS), complemented by the Household Dietary Diversity Score (HDDS) and Household Hunger Scale (HHS). Descriptive statistics, binary logistic regression, Principal Component Analysis (PCA), Multiple Correspondence Analysis (MCA), and cluster analysis were employed to identify determinants of food security, dietary patterns, and household livelihood typologies. The results indicate high levels of food insecurity for both studies, affecting 54.1% of households across the 3 studied provinces for the first study and 67.6% for the second study in Guijá district, with significant spatial disparities. Female-headed households consistently exhibited higher levels of food insecurity, although gender was not consistently a significant determinant after controlling for socioeconomic and environmental factors. Participation in gender-responsive anticipatory action was associated with 41% lower odds of food insecurity and narrower gender disparities among beneficiary households. Across both study contexts, food security was strongly associated with income, livelihood diversification, market access, asset ownership (including livestock and transport assets), land-use practices, and shock recovery capacity, whereas irregular rainfall and limited productive resources were associated with poorer food security outcomes. MCA further identified distinct livelihood typologies and dietary patterns, with most households relying on staple-dependent diets rather than diversified, nutrient-rich diets. Overall, the findings demonstrate that household food security and resilience are shaped by the interaction of gender, livelihood assets, market access, and climate risk management. Integrating gender-responsive anticipatory action with livelihood diversification, market integration and assets promotion offers a promising pathway for strengthening adaptive capacity and promoting more equitable and sustainable food security outcomes in drought–prone regions in Mozambique.

Keywords: *Anticipatory Action, Climate Shocks, Food Security, Gender, Livelihood Diversification, Resilience, Mozambique*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AA- Anticipatory Action

CCS- Center for Climate and Security

CRF- Compendium Results Framework

DRM- Disaster Risk Management

FCS- Food Consumption Score

FEWS NET - Famine Early Warning Systems Network

FAO- Food and Agriculture Organization

GDP- Gross Domestic Product

HHS- Household Hunger Scale

HDDS- Household Dietary Diversity Score

IFRC- International Federation for the Red Cross Crescent

INGD- Instituto Nacional de Gestão e Redução do Risco de Desastres (National Institute for Disaster Management and Risk Reduction)

INAM- Instituto Nacional de Meteorologia (National Institute of Meteorology)

IPC- Integrated Food Security Phase Classification

INE- Instituto Nacional de Estatística (National Statistical Institute of Mozambique)

MASA- Ministério da Agricultura e Segurança Alimentar (Ministry of Agriculture and Food Security)

MZN- Mozambican Metical

MTA- Ministério da Terra e Ambiente (Ministry of Land and Environment)

MCA- Multiple Correspondence Analysis

OR- Odds Ratio

ODI- Overseas Development Institute

PCA- Principal Component Analysis

RCS- Red Cross Society

SDG- United Nations Sustainable Development Goal

SLF- Sustainable Livelihoods Framework

UNDRR- United Nations Office for Disaster Risk Reduction

WFP- World Food Program

STRUCTURE OF THE DISSERTATION

This dissertation follows a *dissertation-by-publication format* and is organized into seven chapters to ensure coherence between the overall research framework and the included papers.

Chapter 1 introduces the study, presenting the background, problem statement, significance, research objectives and hypothesis, situating the empirical studies within the broader context of climate variability, gender, livelihoods, and food security globally and in Mozambique in particular.

Chapter 2 provides an integrative literature review, covering key concepts, theoretical frameworks, and existing studies. It identifies knowledge gaps particularly on gender-responsive anticipatory action and localized climate-food security interactions and presents a conceptual framework linking climate variability, livelihoods, gender dynamics, anticipatory action, and household food security.

Chapter 3 describes the methodological framework, integrating the approaches used across both studies. It outlines the study context, population and sampling, data collection and analysis methods (including FCS, HDDS, and HHS), ethical considerations, and study limitations, ensuring a coherent justification of the research design.

Chapter 4 presents the first research paper titled *"Gender-Responsive Anticipatory Action for Addressing Climate-Induced Food Insecurity in Disaster-Prone Mozambique."* This paper examines the role of anticipatory action and gender dynamics in reducing food insecurity in disaster-prone communities.

Chapter 5 presents the second research paper titled **"***Climate Shocks, Livelihoods, and Household Food Security in Rural Mozambique: Evidence from Guijá District."* This paper analyzes how climate variability and livelihood systems influence household food security among smallholder farming households.

Chapter 6 provides a general discussion that synthesizes the findings from both papers and highlights their implications for climate adaptation, disaster risk management, and food security policy.

Chapter 7 concludes the dissertation by summarizing the key findings, outlining policy recommendations, and identifying directions for future research.

CHAPTER ONE: GENERAL INTRODUCTION

1.1 Background and Context

Food insecurity remains one of the most pressing global development challenges, particularly in regions where livelihoods depend heavily on climate-sensitive sectors such as agriculture. Food security is defined as a condition where all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO et al., 2025). Despite sustained global efforts to improve food systems, hunger and food insecurity remain widespread. In 2024, approximately 9% of the world's population (that is nearly 800 million) experienced hunger, with the burden disproportionately concentrated in Africa, where nearly one in five people was affected (FAO et al., 2025). Current projections suggest that although global hunger may decline slightly by 2030, Africa is expected to remain the region most affected by food insecurity (FAO et al., 2022).

Climate change has emerged as a critical driver of food insecurity by increasing temperatures, altering rainfall patterns and intensifying the frequency and severity of extreme weather events such as droughts, floods, and storms. These changes disrupt agricultural production, reduce crop yield and quality, damage infrastructure, and undermine food availability, access, and utilization, threatening progress toward Sustainable Development Goal 2 (SDG 2) of ending hunger by 2030 (FAO et al., 2022; Feulner, 2017; IPCC, 2023; Marie et al., 2020; Soares et al., 2019).

Sub-Saharan Africa is widely recognized as one of the most vulnerable region's to climate variability due to its heavy reliance on rain-fed agriculture, widespread poverty, and structural development constraints (Deressa, 2007; Harvey et al., 2014; Omotoso et al., 2023). Smallholder farming households, which form the backbone of agricultural production in the region, are particularly vulnerable and exposed to recurrent climatic shocks that result in crop failures, livestock losses, and declining household incomes. These shocks often force households to adopt negative coping strategies including selling productive assets, reducing food consumption and withdrawing children from school, thereby eroding resilience and increasing long-term vulnerability to food insecurity (Costella et al., 2021; Morton, 2007).

Mozambique exemplifies the intersection of climate vulnerability, agricultural dependence and persistent food insecurity. Agriculture supports the livelihoods of more than 80% of the population but remains predominantly rain-fed, making production highly sensitive to climate

variability (World Bank, 2020). The country's location along the south-western Indian Ocean and its extensive coastline make it highly exposed to recurrent hydro-meteorological hazards, including tropical cyclones, floods, and droughts which have repeatedly disrupted agricultural production, damaged infrastructure, and undermined rural livelihoods. Recent extreme events, including Cyclone Idai (2019), Cyclone Freddy (2023), and the 2023/2024 El Niño-induced drought, resulted in widespread crop losses, livestock mortality, displacement, and deteriorating food security, particularly across southern and central Mozambique. These recurrent shocks illustrate the country's high climate vulnerability and underscore the need for climate-resilient agricultural and proactive disaster risk management strategies to withstand food insecurity (Fekete, 2024; The World Bank Group, 2023, 2025; WFP, 2021; World Bank, 2020).

Within this context, Gaza, Tete and Sofala provinces stand out among the most impacted by climate shocks including drought, cyclones and flooding therefore requiring particular attention by the government and partners. In Gaza province, Guijá district is one of the areas most affected by recurrent climate shocks. Located in Mozambique's semi-arid zone, the district experiences frequent droughts and highly variable rainfall, while its economy is dominated by rain-fed smallholder agriculture and limited livelihood diversification. These conditions constrain agricultural productivity, household incomes, and adaptive capacity, leaving many households chronically vulnerable to food insecurity and recurrent climatic shocks (IPC, 2023; Maia et al., 2019). As a result, Guijá provides an important case for understanding how climate-related risks interact with livelihood systems to shape household food security and resilience.

Gender dynamics further compound these vulnerabilities. Women play a central role in agricultural production, food processing, and household nutrition, yet they frequently face structural barriers to accessing land, credit, extension services, agricultural inputs, and decision-making opportunities (African Development Bank Group, 2024; World Bank Group, 2023). These inequalities limit women's adaptive capacity constrain their ability to respond to climatic shocks and may increase their risk of food insecurity, underscoring the importance of integrating gender-responsive approaches into food security, climate adaptation, and disaster risk management interventions.

In response to increasing climate risks, anticipatory action has emerged as a proactive disaster risk management approach that uses climate forecasts and early warning information to trigger

interventions before hazards occur. Anticipatory action involves taking early measures based on climate forecasts and early warning systems before a disaster occurs in order to reduce potential impacts on livelihoods and food systems (FAO, 2021a; IFRC, 2022, 2025). Evidence suggests that anticipatory approaches can help protect livelihoods, safeguard productive assets, and support household food security in climate-vulnerable settings (Start Network, 2020; WFP, 2020, 2025a). Nevertheless, empirical evidence on how anticipatory action interacts with gender, livelihood systems, and household resilience remains limited, particularly in Mozambique. Understanding these interactions is essential for designing interventions that not only respond to climate shocks but also strengthen long-term resilience and promote equitable food security outcomes.

1.2 Problem Statement

Rural households in Mozambique remain highly vulnerable to recurrent droughts, floods, and tropical cyclones that disrupt agricultural production, erode livelihoods, and reduce household resilience (The World Bank Group, 2023, 2025; WFP, 2021; World Bank, 2020). Although national policies and development programmes have increasingly prioritized climate adaptation and disaster risk management, food insecurity remains widespread, particularly among smallholder farming communities that depend heavily on rain-fed agriculture (Ministry of Land and Environment, 2021; World Bank, 2025). This suggests that existing interventions have been insufficient to address the complex and interconnected drivers of household food insecurity.

This research attempts to fill up this gap by using multiple lens. First, across the global, there is a shift from post-disaster response to proactive risk reduction using anticipatory action. Anticipatory action has emerged as a promising approach for protecting livelihoods and reducing the impacts of climate-related hazards before they occur. Although being practised in Mozambique evidence on its effectiveness in improving household food security remains limited. In particular, little is known about how anticipatory action interacts with livelihood systems, household assets, and gender dynamics to influence food security outcomes, despite increasing recognition that vulnerability is shaped by both climatic and socioeconomic factors (ODI & CCS, 2024).

Second, existing research has largely examined climate change, livelihoods, gender, and food security as separate issues or at broad national and regional scales. Consequently, there is limited household-level evidence on how these factors interact within localized, climate-

vulnerable settings to shape food security and resilience. This knowledge gap constrains the design of context-specific interventions capable of addressing the multidimensional nature of vulnerability.

Addressing these gaps is critical for informing policies and programmes that move beyond reactive disaster response towards proactive, gender-responsive, and livelihood-sensitive strategies for strengthening household resilience and improving food security in climate-vulnerable communities in Mozambique.

1.3 Research Objectives

1.3.1 General Objective

To examine the influence of climate variability, gender dynamics, livelihood systems and gender-responsive anticipatory action on household food security and resilience in climate-vulnerable communities of Mozambique.

1.3.2 Specific Objectives

1. To examine the association between participation in gender-responsive anticipatory action and household food security in disaster-prone areas of Mozambique.
2. To assess the effects of climate variability on livelihood systems and household food security among smallholder farming households in Guijá district.
3. To identify the socioeconomic, livelihood, and gender-related determinants of household food security in climate-vulnerable communities.
4. To characterize household livelihood and dietary patterns associated with food security and resilience

1.4 Research Hypotheses

The study was guided by the following hypotheses:

H_{01}: Participation in gender-responsive anticipatory action is not significantly associated with household food security in disaster-prone areas of Mozambique.

H_{11}: Participation in gender-responsive anticipatory action is significantly associated with household food security in disaster-prone areas of Mozambique.

H_{02}: Climate variability is not significantly associated with livelihood systems and household food security among smallholder farming households in Guijá district.

H_{12}: Climate variability is significantly associated with livelihood systems and household food security among smallholder farming households in Guijá district.

H_{03}: Household livelihood strategies and sociodemographic characteristics are not significantly associated with household food security in climate-vulnerable communities.

H_{13}: Household livelihood strategies and sociodemographic characteristics are significantly associated with household food security in climate-vulnerable communities.

H_{04}: Household livelihood and dietary patterns are not significantly associated with food security and resilience.

H_{14}: Household livelihood and dietary patterns are significantly associated with food security and resilience.

1.5 Significance and Justification of the Study

This study contributes to the growing body of research on climate change, livelihoods, and food security in Sub-Saharan Africa by providing context-specific evidence from rural Mozambique. Understanding how climate variability interacts with livelihood systems and gender dynamics is essential for designing policies and interventions that effectively address food insecurity in climate-vulnerable regions.

The findings of this study are expected to contribute to policy and practice in several ways. First, they provide empirical evidence to support the development of anticipatory action strategies that proactively reduce the impacts of climate-related disasters on household food security. Second, by highlighting the importance of gender-responsive approaches, the study contributes to efforts aimed at promoting inclusive and equitable climate adaptation strategies. Third, the research offers insights into the socioeconomic and livelihood factors that shape household food security, thereby informing targeted interventions that strengthen rural resilience.

More broadly, the study contributes to global development efforts aimed at achieving the Sustainable Development Goals, particularly SDG 2 (Zero Hunger) and SDG 13 (Climate Action).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter provides a critical synthesis of scholarly literature on climate variability, rural livelihoods, gender dynamics, anticipatory action, and household food security. While the empirical papers included in this dissertation contain their own literature discussions, this chapter establishes the broader conceptual and theoretical foundations of the research. It situates the study within ongoing academic debates on climate vulnerability and rural resilience, emphasizing the complex interactions between environmental shocks, livelihood systems, and social inequalities. Particular attention is given to the role of anticipatory action in disaster risk management and the importance of gender-responsive approaches in strengthening household resilience. Through this synthesis, the chapter highlights key gaps in existing knowledge that inform the empirical investigations presented in later chapters.

2.2 Climate Variability, Agricultural Systems, and Rural Livelihoods

Agriculture remains a fundamental component of rural livelihoods across much of the developing world. In Sub-Saharan Africa, smallholder farming systems provide the primary source of food, income, and employment for the majority of rural households (Stephens et al., 2018). These systems are, however, highly dependent on climatic conditions, rendering them particularly vulnerable to fluctuations in rainfall patterns, temperature variations, and extreme weather events (Jalane et al., 2021; Morton, 2007).

Climate variability refers to variations in the mean state and other statistics 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 to variations in natural or anthropogenic external forcing (external variability). On the other hand, climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (FAO, 2021a; IPCC, 2007a, 2007c, 2007b). Scientific evidence demonstrates unequivocally that human activities have warmed the atmosphere, ocean, and land, making anthropogenic climate change one of the defining global challenges of the twenty-first century

(IPCC, 2021). This evidence underscores the urgent need for coordinated mitigation and adaptation efforts by governments and societies worldwide to reduce climate risks and enhance resilience (FAO, 2016a; IPCC, 2022; UNFCCC, 2016). Both processes are increasingly recognized as major threats to agricultural productivity and rural livelihoods. Studies have documented how rising temperatures, declining soil moisture, and increasingly erratic rainfall patterns reduce crop yields and increase production uncertainty (El Bilali et al., 2020; FAO, 2008; Karmakar et al., 2016; Mekonnen et al., 2021; Sultan & Gaetani, 2016).

Smallholder farmers are particularly susceptible to these climatic pressures because their production systems are largely rain-fed and resource constrained. Limited access to irrigation infrastructure, financial services, and climate information reduces their capacity to adapt to climatic variability (Morton, 2007; Ogundeji, 2022; Zeleke et al., 2021). As a result, climatic shocks often translate into reduced agricultural output, income losses, and increased livelihood insecurity.

The implications of climate variability therefore extend beyond agricultural production to affect the broader livelihood systems upon which rural households depend. Climatic shocks frequently disrupt local markets, damage infrastructure, and erode productive assets, forcing households to adopt coping strategies such as asset sales, migration, or reduced food consumption (Vermeulen et al., 2012). These responses may temporarily mitigate immediate shocks but often undermine long-term resilience.

While the literature provides substantial evidence regarding climate variability impacts on agricultural production, most of the research remains concentrated on macro-level analyses of crop yields and economic performance. Consequently, limited focus has been devoted to understanding how climate variability interacts with local livelihood systems and household socioeconomic conditions to shape food security outcomes. Addressing this gap requires moving beyond production-focused analyses toward a more integrated understanding of the relationship between climate variability and household food security.

2.3 Climate Variability and Household Food Security

Food security is defined as a condition where all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO et al., 2025). This definition, adopted as the working definition in this study, recognizes food security as a multidimensional concept

comprising four interrelated dimensions: *food availability*, *food access*, *food utilization* and *food stability* (FAO, 2016a). These dimensions acknowledge that adequate food production alone is insufficient to guarantee household food security, particularly in contexts characterized by poverty, inequality and environmental stress.

Climate variability can affect all four dimensions of food security (FAO, 2015, 2016b). **Food availability** refers to the physical presence of sufficient quantities of food from domestic production, imports, food stocks, or food assistance (FAO, 2016a; IPCC, 2022). Climate variability threatens food availability by reducing agricultural productivity through droughts, floods, erratic rainfall, rising temperatures and other extreme weather events that cause crop failure and lower yields (Freduah et al., 2019; IPCC, 2001; van Oort & Zwart, 2018; Yadav et al., 2019). These impacts are particularly severe in climate-vulnerable regions where households rely predominantly on rain-fed agriculture for their livelihoods.

Food access refers to households' ability to obtain sufficient food through production, purchases, exchanges, or transfers for a nutritious diet (FAO, 2016a; IPCC, 2022). Climate variability can reduce food access by lowering agricultural incomes, disrupting livelihood activities, increasing food prices, and weakening household purchasing power (Bandara & Cai, 2014; El Bilali et al., 2020; Tamako & Chitja, 2017). Extreme weather events may also damage transportation networks, markets, and rural infrastructure, thereby restricting the physical movement and distribution of food (Gregory et al., 2005; Hussain et al., 2016).

Food utilization concerns the appropriate biological use of food, which depends on adequate dietary intake, food quality and safety, health status, sanitation, and access to clean water (FAO, 2016a; IPCC, 2022). Climate variability can compromise food utilization by reducing dietary diversity and increasing the prevalence of climate-sensitive diseases such as malaria, dengue fever, diarrheal infections, and heat-related illnesses. These health conditions impair nutrient absorption and utilization, thereby negatively affecting nutritional outcomes and overall wellbeing (IPCC, 2007c; Schmidhuber & Tubiello, 2007).

Food stability refers to the ability of households to maintain adequate food availability, access, and utilization over time without significant disruptions (FAO, 2016a; IPCC, 2022). Recurrent climatic shocks, including prolonged droughts and repeated flooding, can erode household assets, reduce livelihood opportunities, and weaken coping capacities, making households increasingly vulnerable to food insecurity (Harvey et al., 2014). Consequently, even

households that are food secure during normal periods may experience food insecurity when exposed to repeated climate-related shocks.

These four dimensions are closely interconnected, and climate variability often affects them simultaneously. For example, declining agricultural production may reduce food availability while simultaneously lowering household incomes and limiting food access. Likewise, disruptions to water supply, sanitation and healthcare services may impair food utilization, whereas repeated climatic shocks undermine the stability of household food systems over time. Consequently, food insecurity is increasingly understood as the outcome of interacting environmental, socioeconomic and institutional factors rather than agricultural production shortfalls alone.

Recognizing this multidimensional nature of food security, recent studies have increasingly employed composite indicators such as the Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS) and Household Hunger Scale (HHS) to assess household food security. Evidence from Ethiopia, Nigeria and Indonesia demonstrates that food insecurity frequently results from the combined effects of climate variability, livelihood vulnerability and structural inequalities rather than environmental shocks alone (Gadiso et al., 2024; Raffo-Babici et al., 2025; Suparna, 2020). These findings highlight the importance of considering both environmental and socioeconomic drivers when assessing household food security.

Despite this growing body of evidence, much of the existing literature continues to examine climate variability primarily as an external environmental driver of agricultural production. Comparatively less attention has been paid to the institutional and policy interventions that can reduce household vulnerability before climatic shocks translate into food insecurity. This limitation has stimulated increasing interest in proactive disaster risk management approaches, particularly anticipatory action, which seeks to minimize climate-related losses through timely interventions implemented before hazards occur.

2.4 Anticipatory Action and Disaster Risk Management

Traditional disaster response approaches have historically focused on reactive humanitarian assistance delivered after disasters occur. In recent years, however, there has been an increasing recognition that reactive responses alone are often inadequate to cope with the increasing scale and frequency of climate-related hazards. This recognition has prompted the development of

anticipatory action approaches that emphasize proactive interventions implemented prior to the onset of predicted hazards.

Anticipatory action relies on early warning systems and climate forecasts to trigger predefined interventions aimed at protecting livelihoods and reducing potential losses (IFRC, 2022; Levine et al., 2020). These interventions may include early cash transfers, livestock protection measures, distribution of agricultural inputs, or temporary livelihood support. By enabling households to prepare for anticipated hazards, anticipatory action seeks to reduce humanitarian needs and strengthen resilience.

Empirical evidence suggests that anticipatory interventions can significantly reduce disaster-related losses. For example, forecast-based cash transfer programs implemented in Bangladesh enabled vulnerable households to safeguard assets and reduce flood-related damages (Pople et al., 2021). Similar interventions in Senegal and Madagascar have been associated with improved food access and reduced reliance on negative coping strategies (FAO, 2019; Start Network, 2020).

Despite these promising outcomes, the literature also highlights important limitations. The effectiveness of anticipatory action depends heavily on the reliability of early warning systems, the timeliness of intervention delivery, and the equitable targeting of vulnerable populations (Baker et al., 2020; Brauw, 2025; Popat et al., 2024; Pople et al., 2021). Moreover, much of the existing evidence focuses primarily on short-term humanitarian outcomes, with relatively limited attention given to how anticipatory interventions influence longer-term livelihood resilience and food security (UNDRR, 2023).

An additional limitation concerns the extent to which anticipatory action programs account for social inequalities that shape vulnerability to climate risks. In particular, gender dynamics are especially important in shaping resource access, adaptive capacity, and participation in disaster preparedness activities. As a result, understanding these dynamics is crucial for designing anticipatory interventions that effectively reach and support the most vulnerable populations.

2.5 Gender, Climate Vulnerability, and Food Security

Gender is a socially constructed concept that refers to the roles, responsibilities, behaviors, expectations, and power relations that societies assign to women, men, girls, and boys. Unlike biological sex, which is determined by physiological characteristics, gender is shaped by social, cultural, economic, and institutional contexts and determines individuals' access to resources,

opportunities, decision-making, and livelihood options (UN Women, 2022b). Importantly, gender goes beyond the numerical representation of women and men to include the unequal power relations and social norms that shape control over resources and participation in development processes.

These gendered structures significantly influence how individuals experience and respond to climate-related shocks. In many rural contexts, women play central roles in agricultural production, food processing, food preparation, and household resource management. However, structural inequalities often limit their access to land, credit, agricultural inputs, extension services, and climate information (FAO, 2015; Nyasimi & Huyer, 2017). In addition, climate stress often intensifies gender inequalities by increasing women's unpaid workload, particularly in water collection, fuelwood gathering, food preparation, and caregiving responsibilities, thereby limiting their ability to engage in productive and resilience-building activities (Jost et al., 2015).

The implications of these gender inequalities extend beyond individual wellbeing to household food security. Limited access to productive resources and decision-making power constrains women's contribution to agricultural productivity, income generation, and adoption of climate-smart practices, thereby affecting food availability, access, utilization, and stability at household level (FAO, 2011, 2017). Conversely, evidence shows that improving women's access to resources, services, and decision-making can enhance agricultural productivity and strengthen household food security outcomes.

In response to these challenges, increasing attention has been given to gender-responsive anticipatory action. This refers to the systematic integration of gender analysis into the design, implementation, and evaluation of anticipatory actions to ensure that early interventions address the distinct needs, capacities, and vulnerabilities of women, men, girls, and boys (UN Women, 2022b). It aims to remove barriers to equitable access to early warning information, anticipatory finance, and livelihood support while promoting the meaningful participation and leadership of women and other marginalized groups throughout the anticipatory action process (Jones et al., 2020; UN Women, 2022a).

Empirical evidence suggests that gender-responsive interventions can significantly improve food security and resilience outcomes. For example, when women are targeted in cash transfer and agricultural support programs, households often experience improvements in food

consumption and dietary diversity (Armand et al., 2021; Miller et al., 2011). However, interventions that overlook gender dynamics risk reinforcing existing inequalities and reducing the effectiveness of climate adaptation and resilience-building efforts.

Despite growing recognition of gender in climate adaptation and disaster risk management, gender considerations remain insufficiently integrated into many anticipatory action frameworks (UN Women, 2022a). Existing studies often focus on sex-disaggregated analysis rather than deeper gender relations and power structures that shape access to resources and decision-making. This gap highlights the need for further empirical research on how gender-responsive anticipatory action can enhance household food security in climate-vulnerable communities.

2.6 Theoretical Framework

This study is anchored in ***Vulnerability Theory*** and the ***Sustainable Livelihoods Framework (SLF)***, which provide complementary theoretical perspectives for understanding the relationships among climate variability, livelihood systems, gender-responsive anticipatory action, and household food security. Together, the two frameworks explain both the conditions that make households susceptible to climate-related shocks and the resources and strategies that enable them to cope with, adapt to, and recover from these shocks.

Vulnerability Theory explains why some individuals, households, or communities are more susceptible to the adverse effects of hazards than others. Vulnerability is defined as the conditions determined by physical, social, economic, environmental, and institutional factors that increase the likelihood of suffering harm when exposed to shocks (Bohle et al., 1994; Wisner et al., 2003). Thus, vulnerability is not determined solely by exposure to climatic hazards such as droughts or floods but also by the pre-existing conditions that limit households' capacity to anticipate, cope with, resist, and recover from these events. These conditions include poverty, unequal access to productive resources, weak institutions, and social inequalities. While vulnerability describes the existing conditions that make households susceptible to shocks or rather predisposition to be adversely affected by shocks, resilience refers to their capacity to absorb, adapt to, and recover from those shocks while maintaining essential functions, identity and structure livelihoods (IPCC, 2022) Consequently, households may experience similar levels of climate exposure but differ substantially in their vulnerability and resilience depending on the resources and opportunities available to them.

Complementing this perspective, the Sustainable Livelihoods Framework provides a people-centred approach for understanding how households construct and sustain their livelihoods in the face of environmental and socioeconomic change. The framework defines a livelihood as comprising the capabilities, assets, and activities required for a means of living, while a sustainable livelihood is one that can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, and preserve the natural resource base for future generations (Chambers & Conway, 1992; DFID, 1999; Scoones, 1998). Central to the framework are five categories of livelihood assets namely human, natural, financial, physical, and social capital which households mobilize to pursue different livelihood strategies and achieve desired livelihood outcomes. However, access to these assets is mediated by transforming structures and processes, including policies, institutions, governance systems, and social norms, which influence the opportunities available to households and shape their livelihood choices (DFID, 1999). Since access to livelihood assets is often unequally distributed across gender, socioeconomic status, and geographical location, the SLF provides a useful framework for examining differential vulnerability, adaptive capacity, and food security among rural households.

The integration of Vulnerability Theory and the Sustainable Livelihoods Framework provides a comprehensive analytical foundation for this study. Vulnerability Theory explains why some households are more susceptible to climate-related shocks than others by emphasizing the underlying conditions that create vulnerability. The Sustainable Livelihoods Framework complements this perspective by explaining how households mobilize livelihood assets and strategies within institutional and policy contexts to strengthen their adaptive capacity and resilience. Together, these frameworks facilitate an integrated analysis of how climate variability interacts with livelihood assets, sociodemographic characteristics, gender relations, and institutional support to influence household food security. They further provide an appropriate theoretical basis for examining how gender-responsive anticipatory action can reduce vulnerability, strengthen livelihood resilience, and improve household food security in climate-vulnerable communities.

Drawing on Vulnerability Theory and the Sustainable Livelihoods Framework, this study develops an integrated analytical framework (Figure 1) to illustrate the relationships among climate variability, household vulnerability, livelihood assets, and food security. Vulnerability Theory informs the analysis of how exposure to climate-related hazards, together with existing

socioeconomic and institutional conditions, influences household vulnerability, while the Sustainable Livelihoods Framework explains how access to livelihood assets shapes households' capacity to respond to these shocks. The framework therefore proposes that climate-related hazards do not automatically result in food insecurity. Rather, their effects are mediated by households' access to livelihood assets and institutional support, which determine their ability to adapt, diversify livelihoods, and build resilience. This integrated perspective guides the analysis of the pathways through which climate variability influences household food security and identifies potential entry points for strengthening resilience through gender-responsive anticipatory action

Figure 1 illustrates the analytical pathway adopted in this study. Climate variability exposes households to environmental shocks, but the resulting food security outcomes depend on their level of vulnerability and access to livelihood assets. Households with stronger human, natural, financial, physical and social capital are expected to be better able to diversify livelihoods, adapt to climatic shocks, and maintain household food security. The framework therefore provides the analytical basis for examining how livelihood assets, vulnerability, and gender-responsive anticipatory action interact to influence household food security.

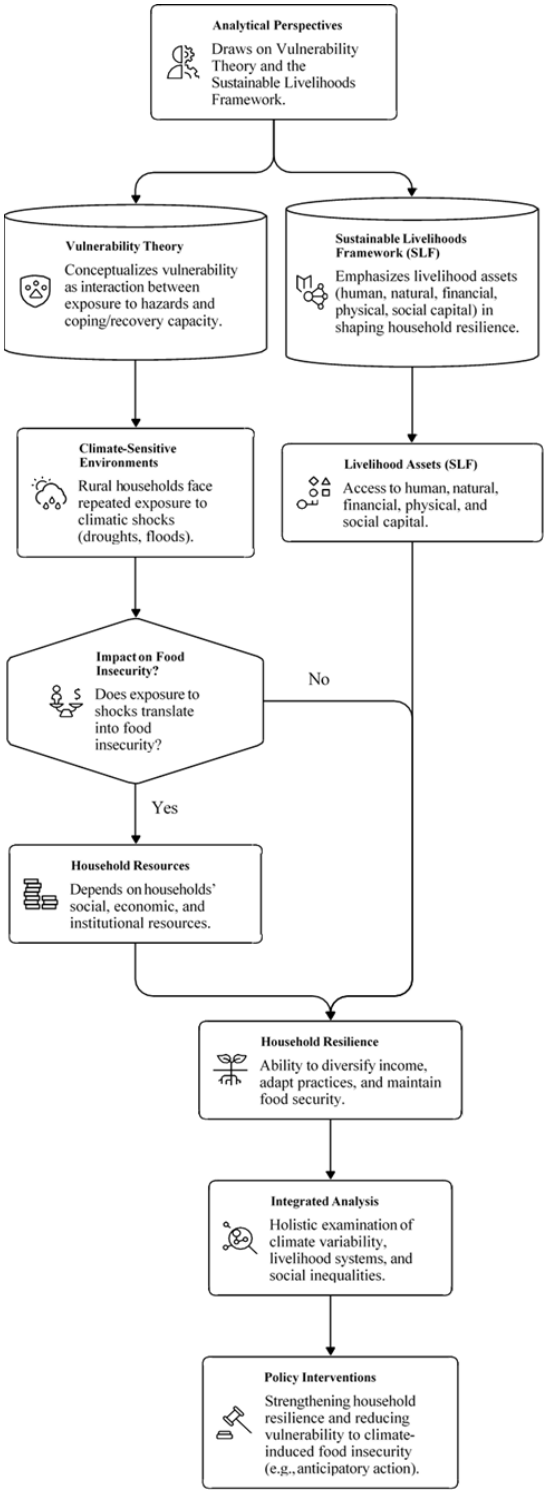


Figure 1: Showing analytical framework for climate-induced food insecurity

Source : Author, 2026

CHAPTER THREE: METHODOLOGICAL FRAMEWORK

3.1 Research Design

This study employed a quantitative research approach grounded in cross-sectional survey methods and supported by advanced econometric and multivariate analytical techniques to assess the relationships between climate variability, anticipatory action, gender dynamics, livelihood systems and household food security in Mozambique. The methodological framework integrates empirical evidence generated from two complementary studies that collectively explore how climatic shocks and policy responses influence household food security outcomes within vulnerable rural contexts.

The first study investigates the role of gender-responsive anticipatory action in mitigating climate-induced food insecurity in selected drought-affected provinces across the provinces of Sofala, Gaza and Tete. It adopts a comparative cross-sectional design that contrasts households that received anticipatory assistance with comparable households that did not receive support. This design allows for the assessment of short-term differences in food security outcomes following intervention implementation while controlling for shared exposure to similar climatic and market conditions. This study is based on secondary database provided by the World Food Program. The data were originally collected by the WFP through primary field surveys. A detailed description of the original data collection procedures is presented later in this chapter.

The second study investigates the relationships among climate variability, livelihood systems, gender dynamics, and household food security in Guijá district, Gaza Province. Using a cross-sectional analytical design, it examines how climate-related shocks interact with socioeconomic and livelihood conditions to influence household food security. Through a comparative analysis of male- and female-headed households within the same geographic setting, the study identifies structural inequalities that shape vulnerability, adaptive capacity, and resilience to climate-related stressors. This study is based on primary data collected by the author of this dissertation.

The cross-sectional design was chosen because it allows the systematic analysis of relationships among socioeconomic characteristics, climate shocks, and food security indicators at a specific point in time. This approach is specifically appropriate for examining short-term post-shock conditions and evaluating the immediate effects of policy interventions such as anticipatory action assistance. Furthermore, the design facilitates the use of multivariate

statistical techniques capable of identifying determinants of vulnerability and resilience within complex rural livelihood systems.

3.2 Study Setting and Context

The research was conducted in Mozambique, one of the most climate-vulnerable countries in sub-Saharan Africa. The country's vulnerability is driven by a combination of high dependence on rain-fed smallholder agriculture, limited irrigation infrastructure, widespread rural poverty, and recurrent exposure to droughts, floods, and tropical cyclones. These hazards frequently disrupt agricultural production, erode livelihoods, and undermine household food security (FEWS NET, 2025a, 2025b).

Study I was conducted across selected districts of **Gaza, Sofala, and Tete provinces** following the 2023/2024 El Niño-induced drought. Although districts served as the primary sampling units, the analysis was undertaken at the **provincial level** to examine geographic variation in household food security and the association between participation in gender-responsive anticipatory action and food security outcomes. Districts were purposively selected based on two objective criteria: (i) classification as **IPC Phase 3 (Crisis) or Phase 4 (Emergency)** following the 2023/2024 post-harvest IPC assessment, and (ii) classification within **severity levels 1 or 2** of the Composite Drought Index developed by the National Institute of Meteorology (INAM). The Composite Drought Index integrates multiple biophysical indicators, including rainfall anomalies derived from CHIRPS, potential evapotranspiration from the FAO WaPOR database, satellite-derived vegetation conditions, and root-zone soil moisture from ECMWF reanalysis products. These criteria ensured that sampled districts were simultaneously experiencing severe drought and acute food insecurity, making them suitable for evaluating anticipatory action interventions.

Study II was conducted in **Guijá district**, Gaza province, one of Mozambique's most drought-prone districts. Located within the semi-arid Limpopo River Basin, the district experiences recurrent droughts, highly variable rainfall, and frequent agricultural production failures. Livelihoods are predominantly based on rain-fed smallholder farming, with limited opportunities for income diversification, increasing household vulnerability to climate shocks. Guijá has consistently been classified under **IPC Crisis (Phase 3) or Emergency (Phase 4)** during major drought episodes, reflecting persistent acute food insecurity (FEWS NET, 2025a, 2025b; IPC, 2023). These characteristics make the district an appropriate setting for examining

the interactions among climate variability, livelihood systems, gender dynamics, and household food security.

3.3 Population and Sampling

The target population comprised rural smallholder farming households residing in climate-vulnerable areas of Mozambique. For **Study I**, the study population included households located in drought-affected districts of Gaza, Sofala, and Tete provinces where gender-responsive anticipatory action interventions were implemented during the 2023/2024 El Niño response. Although households were sampled from selected districts, analyses were conducted at the provincial level to examine geographic differences in household food security and the association between anticipatory action participation and food security outcomes. For **Study II**, the study population comprised all smallholder farming households in Guijá district, Gaza province, estimated at 17,538 households according to the 2017 Population and Housing Census (Instituto Nacional de Estatística (INE), 2017).

Sampling procedures were tailored to the objectives of each study. In **Study I**, a two-stage sampling design was employed. First, districts were purposively selected based on the dual criteria of IPC food insecurity classification (Phase 3 or above) and drought severity according to the INAM Composite Drought Index. Second, households were selected from communities targeted for anticipatory action interventions. Household eligibility followed the standardized vulnerability-targeting criteria developed by the National Institute for Disaster Management and Risk Reduction (INGD), which combine hazard exposure with socioeconomic vulnerability. Eligible households included those experiencing severe crop or livestock losses, dependence on rain-fed agriculture, limited productive assets and livelihood opportunities, and demographic characteristics associated with heightened vulnerability, including female-headed households, households headed by older persons, households with persons living with disabilities or chronic illness, and households with high dependency ratios. Beneficiary households were randomly selected from validated program beneficiary registers, while non-beneficiary households were randomly selected from the same communities to ensure comparable exposure to climatic, environmental, and market conditions.

For **Study II**, a multistage sampling design was adopted. All four administrative posts namely Nalazi, Mubangoene, Caniçado, and Chivongoene were included to capture spatial variation in livelihood systems and food security conditions across the district. Communities were

subsequently mapped with the assistance of local authorities and community leaders, after which households were selected using a systematic random sampling procedure. Enumerators began from a centrally identified landmark and selected every third household along a predetermined route until the required sample size was achieved. Eligible households were those engaged in smallholder farming and headed by either a male or female adult.

3.3.1 Sample size determination

Sample size determination followed established statistical procedures appropriate to each study design.

For **Study I**, the minimum sample size was determined using the Raosoft Sample Size Calculator in accordance with the WFP Compendium of Results Framework guidance for operational surveys. The sample was designed to achieve provincial-level representativeness at a 90% confidence level, a 5% margin of error and a design effect of 1.05 to account for clustering. Based on beneficiary caseloads of 2,000 households each in Tete and Sofala provinces and 7,799 households in Gaza Province, the minimum required beneficiary sample was 251 households in Tete, 251 in Sofala, and 275 in Gaza. An equivalent number of non-beneficiary households was selected for comparison, resulting in a minimum required sample of 1,554 households. However, the WFP surveyed 1,644 households (826 beneficiaries and 818 non-beneficiaries), exceeding the minimum required sample. The larger achieved sample increased the statistical precision of the estimates and reflected the final number of completed interviews available in the secondary dataset.

For **Study II**, sample size was determined using Cochran's formula for estimating population proportions. In the absence of district-level estimates of food insecurity prevalence, a conservative population proportion ($p = 0.5$) was assumed to maximize sample variability. At a 95% confidence level and a 5% margin of error, the initial sample size was estimated at 384 households. Application of the finite population correction for a sampling frame of 17,538 households reduced the required sample to 376 households. To account for potential non-response and incomplete interviews, the sample was increased by 8%, resulting in a final target sample of 407 households**.**

3.4 Data Collection Methods

For **Study I**, secondary household survey data were obtained from the WFP Mozambique country office following implementation of the 2023/2024 El Niño anticipatory action program. The survey was conducted between April and May 2024, approximately three months after implementation of anticipatory action interventions, to assess short-term post-intervention outcomes. Data were collected using a standardized structured household questionnaire administered through face-to-face interviews by trained enumerators. The questionnaire captured information on household demographic and socioeconomic characteristics, livelihood activities, agricultural production, access to productive resources and financial services, exposure to drought-related shocks, participation in anticipatory action interventions, coping capacity, and food security indicators. Data were collected electronically using the KoboCollect mobile platform, which incorporated built-in validation checks to improve data completeness and consistency. Prior to data collection, enumerators received standardized training on interview procedures, electronic data capture, ethical considerations, and quality assurance protocols. The dataset was anonymized before being made available for this research, and permission to use the data for academic purposes was obtained from the WFP.

For **Study II**, primary data were collected through structured face-to-face household interviews conducted by trained enumerators using a standardized questionnaire. The questionnaire captured information on household demographic characteristics, livelihood activities, agricultural production, income sources, access to productive resources, exposure to climate-related shocks, and household food security. Data were collected electronically using the KoboCollect mobile platform, which incorporated real-time validation checks to minimize missing values and logical inconsistencies. Prior to the main survey, the questionnaire was pre-tested in a community (Chokwe) with similar socioeconomic characteristics to assess clarity, cultural appropriateness, and logical sequencing, and minor revisions were made accordingly. Enumerators were fluent in both Portuguese and Xitsonga (Shangana), the predominant local language in the study area, facilitating accurate communication with respondents.

Household food security was assessed using internationally validated indicators. In both studies, the primary outcome measure was the Food Consumption Score (FCS), which captures dietary diversity and food consumption frequency over a seven-day recall period. In **Study II**, the assessment was complemented by the Household Dietary Diversity Score (HDDS) and the Household Hunger Scale (HHS) to capture additional dimensions of food access, dietary quality, and household experiences of food deprivation.

3.5 Data Analysis Techniques

Quantitative data were analyzed using Stata version 17. The analytical approach combined descriptive statistics, econometric modelling, and multivariate statistical techniques to examine household food security, identify its determinants, and explore underlying patterns of vulnerability and livelihood characteristics.

Descriptive statistics were first generated to summarize demographic, socioeconomic, and livelihood characteristics of households. Frequencies, percentages, means, and standard deviations were used to describe the study population. Household food security was assessed primarily using the FCS, with households classified as food secure or food insecure according to the WFP's standard thresholds. **In Study II,** the HDDS and HHS were also analyzed to provide complementary measures of food access and dietary quality. Chi-square tests of independence were subsequently conducted to examine associations between categorical variables, including household food security status and selected demographic, socioeconomic, livelihood, and gender-related characteristics. These bivariate analyses provided an initial assessment of statistically significant associations and informed the subsequent multivariate analysis.

Binary logistic regression models were then estimated to identify factors independently associated with household food security. Logistic regression was considered appropriate because the dependent variable was binary (food secure = 0; food insecure = 1). The models estimated the probability of household food insecurity as a function of socioeconomic characteristics, livelihood assets, climate-related shocks, gender, access to productive resources, and participation in anticipatory action interventions. Results are presented as odds ratios with corresponding 95% confidence intervals. Given the cross-sectional nature of the data, the regression estimates represent statistical associations rather than causal effects.

To examine multidimensional patterns of household vulnerability, **Principal Component Analysis (PCA)** and **Multiple Correspondence Analysis (MCA)** were employed. PCA is a multivariate dimension-reduction technique used to transform a set of correlated continuous variables into a smaller number of uncorrelated principal components that capture the maximum amount of variation in the data (Jolliffe & Cadima, 2016; Jolliffe, 2002). It is particularly appropriate when variables exhibit substantial correlation and the objective is to identify underlying latent structures or construct composite indices while minimizing

information loss. Prior to PCA, the suitability of the data was assessed using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity, which determine whether the variables are sufficiently intercorrelated to justify dimension reduction (Hair et al., 2019).

In **Study I**, PCA was applied to FCS food groups to identify dominant dietary consumption patterns, while in **Study II** it was applied to continuous livelihood and asset variables to derive composite indicators of household resources. Because several livelihood and dietary variables were expected to be correlated, PCA provided an appropriate method for summarizing these variables into a smaller number of interpretable components that represent underlying dimensions of household livelihoods and food consumption.

Since several variables of interest were categorical, MCA was employed to complement PCA. MCA is an extension of correspondence analysis designed for the exploration of relationships among multiple categorical variables by projecting categories and observations into a lower-dimensional space based on their associations (Greenacre, 2017). It is particularly useful for identifying latent structures, clustering similar response categories, and visualizing complex relationships among categorical variables without imposing distributional assumptions. In **Study I**, MCA was used to examine relationships among dietary patterns, household food security status, gender, exposure to climatic shocks and other categorical household characteristics. In **Study II**, MCA was applied to explore latent relationships among livelihood strategies, agricultural production systems, market access, and household vulnerability. Because MCA tends to overestimate the explained variance (inertia), Benzécri's correction was applied to obtain more reliable estimates of the retained dimensions and improve the interpretation of the results (Greenacre, 2017).

The combined use of PCA and MCA enabled the study to examine both continuous and categorical dimensions of household vulnerability, thereby providing a comprehensive understanding of the complex relationships among livelihood assets, climate variability, gender, and household food security.

To further characterize livelihood systems in **Study II**, factor scores derived from the MCA were subsequently used as inputs into a **k-means cluster analysis**. This unsupervised classification technique grouped households into relatively homogeneous livelihood typologies by minimizing within-cluster variation while maximizing differences between clusters. The

resulting clusters were interpreted based on their livelihood portfolios, production characteristics, market orientation, and food security outcomes.

Gender differences in food security were examined throughout the analysis. In **Study I**, descriptive and regression analyses compared food security outcomes between male- and female-headed households and assessed whether participation in anticipatory action was associated with reduced gender disparities. In **Study II**, interaction terms between gender and selected climate-related variables were incorporated into the logistic regression models to evaluate whether the association between climate variability and household food security differed by sex of household head. Marginal effects were subsequently estimated to facilitate interpretation of statistically significant interaction terms.

3.6 Ethical Considerations

All research procedures adhered to established ethical standards for social science research. Participation in the study was voluntary, and informed consent was obtained from all respondents prior to the commencement of interviews. Participants were informed about the objectives of the study, the voluntary nature of their participation, and their right to withdraw from the survey at any time without consequence.

Confidentiality of respondents' information was strictly upheld throughout the research process. Personal identifiers were excluded from the dataset to ensure anonymity, and all collected data were used exclusively for academic research purposes. Engagement with community leaders during the initial stages of fieldwork facilitated community entry while preserving the independence and integrity of the household selection process.

3.7 Study Limitations

Despite careful methodological design, several limitations should be acknowledged. First, the cross-sectional nature of the data limits the ability to establish causal relationships between climate shocks, interventions, and food security outcomes. The analysis therefore focuses on identifying associations rather than definitive causal effects.

Second, Study I was based on a secondary dataset provided by the WFP. Although the dataset was collected using rigorous sampling procedures and standardized survey instruments, the researcher had limited control over the original study design, variable selection and data

collection process. Consequently, the analysis was restricted to the available variables in the dataset and some potentially relevant information could not be incorporated.

Third, the food security indicators used in the study, particularly the seven-day Food Consumption Score (FCS), rely on short recall periods and may not fully capture seasonal variations in food availability and consumption patterns. As a result, the findings primarily reflect household food security conditions during the period immediately following the climatic shock rather than longer-term food security dynamics.

Fourth, although sampling procedures ensured representativeness within selected districts, the findings cannot be generalized to entire provinces or to Mozambique as a whole. Therefore, the results reflect the socioeconomic and climatic conditions of the sampled communities and should be interpreted within that geographic context.

Finally, while the study generated robust quantitative evidence on the relationships among climate variability, gender dynamics, livelihoods, and household food security, it incorporated limited qualitative data to explain the underlying social and institutional processes shaping these relationships. Additional qualitative evidence could have provided deeper insights into household experiences, gender relations, and decision-making processes that influence vulnerability, resilience, and the effectiveness of anticipatory action interventions.

Finally, some survey variables relied on self-reported information, which may have been subject to recall bias or reporting errors. However, the use of standardized food security indicators, structured questionnaires, trained enumerators, and established data quality assurance procedures helped to minimize potential measurement errors.

Overall, despite these limitations, the combination of rigorous sampling procedures, standardized measurement tools, and appropriate statistical techniques provides a robust methodological basis for examining the relationships among climate variability, gender dynamics, livelihoods, and household food security in drought-prone regions of Mozambique.

CHAPTER FOUR / PAPER ONE (FOSE-D-25-00588)

Anticipatory Action, Household Resilience, and Food Security: Evidence from Climate-Vulnerable Regions of Mozambique

Martha Among Adeke[12*], Luís Artur[12], Sandre José Macia[12]

[1]Department of Economics and Rural Development, Faculty of Agronomy and Forest Engineering, Eduardo Mondlane University, Maputo, Mozambique

[2]Centre of Excellence in Agri-Food Systems and Nutrition (CE-AFSN), Eduardo Mondlane University, Maputo, Mozambique

**** Corresponding Author:*** amomartha23@gmail.com

Abstract

Climate induced shocks, particularly recurrent droughts and cyclones are exacerbating food insecurity in disaster-prone countries like Mozambique, disproportionately affecting women due to persistent structural inequalities in access and control over resources. Although anticipatory action which involves pre-emptive interventions implemented before predicted shocks occur has proven effective in mitigating losses, evidence demonstrating the impact of comprehensive gender-responsive anticipatory action on household resilience and food security outcomes remains limited. This study examined the role of gender-responsive anticipatory action in strengthening food security and climate risk resilience in Mozambique. A cross-sectional survey of 1,644 households was conducted across vulnerable provinces of Tete, Sofala and Gaza. Data were analyzed using descriptive statistics, binary logistic regression, Principal Component Analysis (PCA) and Multiple Correspondence Analysis (MCA) to identify determinants of food security and explore underlying vulnerability and dietary dimensions. Findings revealed that 54.1% of households were food insecure, with pronounced regional differences (62.9% in Gaza) and higher prevalence among female-headed households and gender disparities (58.7%). Participation in anticipatory action significantly reduced the likelihood of food insecurity by 41%, while gender disparities in food security outcomes were nearly eliminated among beneficiaries. Livestock ownership, livelihood diversification, and strong shock recovery capacity emerged as key resilience factors. MCA identified two dominant dietary patterns: staple-dependent and diversified nutrient-rich with most households relying on the former. Overall, the findings demonstrate that gender-responsive anticipatory action strengthens household resilience, protects livelihoods and asset,

and promotes gender equity, underscoring the importance for inclusive and sustainable climate adaptation and food security strategies in Mozambique.

Keywords: anticipatory action, food security, drought, gender, resilience Mozambique

1.0 Introduction

Food insecurity remains a persistent and defining challenge in disaster-prone agrarian systems, particularly in sub-Saharan Africa, where livelihoods are highly dependent on climate-sensitive agricultural production (Sweileh, 2020). Recent estimates indicate that approximately 9% of the global population experienced hunger in 2024, with the burden disproportionately concentrated in Africa, where prevalence rates approach 20% and are projected to remain significantly above the global average by 2030 (FAO et al., 2022, 2025). These trends threaten progress toward Sustainable Development Goal 2 and underscore the urgency of addressing the structural and environmental drivers of food insecurity (FAO et al., 2022, 2025).

In this context, climate variability and extreme weather events including droughts, floods, and tropical cyclones have emerged as critical stressors disrupting food systems. In rain-fed agricultural economies, such shocks undermine crop production, reduce household incomes, and destabilize local markets, thereby exacerbating both acute food crises and chronic vulnerability (IPCC, 2022; Toromade et al., 2024). Importantly, climate risks do not operate in isolation; rather, they interact with pre-existing socioeconomic inequalities, amplifying disparities in access to resources and adaptive capacity (Hallegatte et al., 2016; IPCC, 2022; Risk-informed Early Action Partnership (REAP), 2021).

Mozambique exemplifies the convergence of climatic and structural vulnerabilities. The country's heavy reliance on rain-fed smallholder agriculture, combined with recurrent exposure to extreme weather events such as the 2001 floods, Cyclone Idai (2019), and Cyclone Freddy (2023), has resulted in repeated disruptions to livelihoods and persistent food insecurity (Fekete, 2024; FEWS NET, 2025a; Risk-informed Early Action Partnership (REAP), 2021). Recent estimates suggest that millions of Mozambicans continue to face acute food insecurity, particularly in regions affected by drought and climatic instability. These challenges are further compounded by low agricultural productivity, limited infrastructure, and widespread poverty (IPC, 2025a, 2025b, 2026).

Conventional disaster response systems in such settings have largely relied on reactive, ex post humanitarian interventions and are no longer sufficient (IFRC, 2025). While these responses provide essential relief, they are often implemented after households have already engaged in negative coping strategies, such as selling productive assets or reducing food consumption, thereby reinforcing long-term vulnerability (Levine et al., 2020). In response to these limitations, anticipatory action has gained increasing attention as a proactive approach to

disaster risk management. By using climate forecasts to trigger early interventions such as cash transfers, input support, and livelihood protection measures, anticipatory action aims to prevent asset depletion, stabilize consumption, and reduce the severity of food insecurity outcomes (IFRC, 2022, 2025; IFRC et al., 2022; Levine et al., 2020; Start Network, 2020).

Despite the growing adoption of anticipatory action, important gaps remain in understanding how it interacts with social and structural factors, particularly gender (FAO, 2021a; WFP, 2024, 2025d; World Bank, 2024). Women play a central role in shaping food security outcomes, yet persistent inequalities in land ownership, access to credit, extension services, and decision-making power constrain their ability to adapt to climate shocks (Nyasimi & Huyer, 2017; World Bank Group, 2023). Consequently, female-headed households often experience higher levels of food insecurity and reduced resilience.

These inequalities are further exacerbated by limitations in early warning systems. Although forecasting technologies have improved, early warning information often fails to reach last-mile communities in accessible, timely, and actionable forms. Warnings may be delivered too late, communicated in inaccessible languages or formats, or lack clear guidance on expected impacts and appropriate responses (IFRC, 2022; Levine et al., 2020; Popat et al., 2024). Women are particularly disadvantaged because they frequently have less access to information channels and lower mobility, reducing their ability to act on early warnings.

While emerging evidence suggests that anticipatory action can improve food security and reduce vulnerability, limited research has examined its gendered impacts or its contribution to broader household resilience. In Mozambique, despite relatively strong climate adaptation and disaster risk management frameworks, evidence on the effectiveness and inclusiveness of gender-responsive anticipatory action remains scarce (ODI & CCS, 2024).

This study addresses this gap by examining the association between anticipatory action participation and household food security in disaster-prone regions of Mozambique. Specifically, it assesses the role of anticipatory action in reducing food insecurity, examines how gender dynamics shape food security outcomes, and identifies key socioeconomic and structural determinants of household resilience. By integrating gender analysis with econometric and multivariate approaches, the study contributes evidence to inform more inclusive, effective, and resilience-oriented climate adaptation and disaster risk management strategies.

2.0 Materials and Methods

2.1 Study Area

The study was conducted in selected drought-affected districts of Gaza, Tete, and Sofala provinces in Mozambique. These provinces were purposively selected because they were severely affected by the 2023/2024 El Niño–induced drought and were targeted by anticipatory action interventions implemented by the Government of Mozambique in collaboration with humanitarian partners, including the World Food Programme (WFP).

Mozambique is highly vulnerable to climate-related shocks due to its dependence on rain-fed smallholder agriculture, limited irrigation infrastructure, and widespread reliance on climate-sensitive livelihoods. During the 2023/2024 agricultural season (November 2023–March 2024), El Niño conditions resulted in delayed rainfall onset, prolonged dry spells, above-average temperatures, and substantial rainfall deficits. These conditions contributed to significant crop losses, early depletion of household food stocks, and rising staple food prices, particularly in the semi-arid regions of southern and central Mozambique.

2.2 Study Design and Anticipatory Action Intervention

A cross-sectional comparative study design was employed to assess differences in food security outcomes between households that received anticipatory action support (beneficiaries) and those that did not (non-beneficiaries). Data were collected after the implementation of the intervention, enabling evaluation of short-term post-intervention outcomes.

The anticipatory action intervention was implemented between December 2023 and February 2024, based on seasonal forecasts and IPC projections indicating deteriorating food security conditions. The intervention formed part of Mozambique's nationally coordinated drought preparedness and response efforts and included early warning dissemination, social protection assistance, agricultural support, and water access interventions delivered before the peak impacts of drought.

Delivery modalities varied by context. In Tete and Sofala provinces, households with access to mobile networks received cash transfers through mobile money, while households in remote areas received commodity vouchers. In Gaza province, all beneficiaries received vouchers. Transfer values were standardized at 2,450 Mozambican Metical (approximately USD 38) per household per month for three months. Voucher recipients received a standardized food basket comprising cereals, pulses, cooking oil, and salt. While minor variations in implementation sequencing occurred, all interventions were delivered within the same agricultural season.

Given the non-randomized nature of program participation and the absence of baseline data, the study identifies associations rather than causal effects.

2.3 Sampling Strategy

A two-stage sampling strategy was employed. In the first stage, districts were purposively selected based on two criteria: (i) classification as IPC Phase 3 (Crisis) or Phase 4 (Emergency) in the post-shock analysis conducted between April and May 2024, and (ii) drought severity levels 1 (severe drought) or 2 (intense drought) according to the Composite Drought Index developed by the National Institute of Meteorology (Instituto Nacional de Meteorologia [INAM]).

The Composite Drought Index integrates multiple biophysical indicators, including rainfall anomalies derived from Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data, potential evapotranspiration from the FAO WaPOR database, vegetation conditions from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite products, and root-zone soil moisture from European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis products. This approach ensured that selected districts were characterized by both severe drought conditions and acute food insecurity.

In the second stage, households were selected from communities targeted by anticipatory action interventions. Household eligibility followed vulnerability-targeting criteria developed by the National Institute for Disaster Management and Risk Reduction (Instituto Nacional de Gestão e Redução do Risco de Desastres [INGD]), which combine hazard exposure with socioeconomic vulnerability. Indicators included residence in high-risk areas, dependence on rain-fed agriculture, loss of crops, livestock, or productive assets, limited livelihood and income opportunities, and demographic characteristics associated with heightened vulnerability, such as female-headed households, elderly-headed households, households with persons living with disabilities or chronic illnesses, and households with high dependency ratios.

Beneficiary households were randomly selected from validated beneficiary lists compiled by implementing partners in collaboration with INGD, local authorities, and community leaders. Non-beneficiary households were randomly selected from the same communities but had not received anticipatory action support. Selecting both groups from the same geographic areas

ensured comparable exposure to climatic, environmental, and market conditions; however, residual differences resulting from vulnerability-based targeting may persist.

2.4 Sample Size Determination

Sample size was determined using the total number of targeted beneficiary households as the sampling frame. Following WFP Compendium of Results Framework guidance for resource-constrained surveys, the sample was designed to achieve representativeness at a 90% confidence level with a 5% margin of error. A design effect of 1.05 was applied to account for clustering.

Sample size calculations were conducted using the Raosoft calculator, yielding a minimum sample of 777 beneficiary households across the three provinces. To facilitate comparisons, an equivalent sample of non-beneficiary households was selected. The final sample comprised 1,644 households (826 beneficiaries and 818 non-beneficiaries).

Households were allocated proportionally across districts according to program caseload. Consequently, the sample is representative of the selected drought-affected districts rather than the entire provinces.

2.5 Data Collection and Measures

Data were collected through structured face-to-face interviews with household heads or primary food providers between April and May 2024, approximately three months after intervention delivery. Enumerators received standardized training, and field supervision procedures were implemented to ensure data quality and consistency.

The primary outcome variable was the Food Consumption Score (FCS), a composite indicator that measures dietary diversity and the frequency of food group consumption over a seven-day recall period. Households were classified as food secure or food insecure using standard WFP thresholds. Although FCS is a robust indicator of short-term food consumption, it does not fully capture seasonal or long-term food security dynamics.

Secondary indicators included livelihood disruptions, coping strategies, and household resilience characteristics to provide a broader understanding of food security outcomes.

2.6 Data Analysis

The data were analyzed using Stata in three stages:

1. Descriptive analysis was used to characterize household attributes and food security status.
2. Inferential analysis employed a binary logistic regression model to identify socio-economic and demographic factors associated with food insecurity.
3. Multivariate analysis using Principal Component Analysis (PCA) and Multiple Correspondence Analysis (MCA) was applied to explore latent dimensions of vulnerability, resilience, and dietary patterns.

The multivariate techniques complement regression analysis by identifying underlying structural relationships among variables rather than estimating causal effects.

2.7 Econometric Model

To identify determinants of household food security, a binary logistic regression model was applied, given that the dependent variable (household food security status) is dichotomous. The logit model was chosen because it is a best suited technique to model the dependent variable's variation given a set of independent variables. Furthermore, the model is flexible, easy to use and interpret (Fernandes et al., 2020). The model estimates the probability of the household being food insecure conditional on its socio-economic and other demographic characteristics.

The general form is:

(1) $logit_{\pi} = \beta_0 + \sum_{i=1}^{9} \beta_i X_i + \varepsilon_i$

Where:

πi = probability of a household being food insecure, β0 = intercept, β1… βp = regression coefficients, X1i…., Xpi = predictor variables. εi = error term, X_1- Household head Sex; X_2 – Household access to credit; X_3– Household experienced crop destruction; X_4 - Household land proportion irrigated; X_5 - Household anticipatory action state; X_6 - Number of livelihood sources; X_7- Storm impact on household; X_8- Household received training on crop loss management; X_9- Households ability to recover from shocks

2.7.1 Multivariate approach

The core of the methodology utilizes two interconnected multivariate statistical techniques: Principal Component Analysis (PCA) and Multiple Correspondence Analysis (MCA). The process begins with PCA, which is used to consolidate key quantitative indicators (like land

size, household assets, and savings) into robust, non-redundant synthetic indices. The multivariate approach is a set of statistical techniques for the simultaneous analysis of multiple variables, examining the relationships between them and the underlying structures. This approach is essential for identification of latent dimensions of family vulnerability and resilience, integrating complex interactions between qualitative factors (such as gender, resources access) and quantitative factors (such as food production, income) within a unified framework.

Principal Component Analysis (PCA) is a dimensionality reduction technique for quantitative variables. It transforms a set of variables into a new set of uncorrelated variables, called Principal Components (PCs). PCA simplifies a large set of quantitative data and allows for the creation of synthetic indices that can be used as variables in subsequent models. The Principal Components are linear combinations of the original variables. In terms of interpretation, the eigenvalue of each PC represents the explained variance. Variables that cluster within a PC and have high weights (in absolute value) are correlated and define an underlying dimension (Hair et al., 2019; Jollife & Cadima, 2016). These Principal Components (CP_j) are linear combinations of the original variables (x_k), defined by the formula:

(2) $CP_j = \sum_{k=1}^{p} a_{jk} x_k$

Where a_{jk} are the weights (eigenvectors) of the variables x_k. After calculation, these indices are then discretized (categorized) to prepare them for the next stage.

Multiple Correspondence Analysis (MCA) is a dimensionality reduction and visualization technique specifically for categorical (qualitative) variables, extending PCA to nominal or ordinal data. Its primary goal is to integrate ALL variables (qualitative factors like gender and climate impacts, and the categorized quantitative indices from PCA), along with the dependent variable (Food Insecurity), into a single matrix. This allows for the identification of the principal latent dimensions of family vulnerability. The MCA mathematically decomposes the indicator matrix into orthogonal factors. The core similarity measure for this decomposition is based on the χ^2 distance.

Categories that are close on the resulting perceptual map are strongly associated, and the axes (dimensions) represent the main gradients of the vulnerability-resilience system. It is important to note that the eigenvalues (λ) obtained from the MCA are subject to correction formulas (such

as Benzécri's) to provide a better estimate of the inertia (variance) extracted, due to the artificial inflation from the indicator matrix coding:

$$(3) \quad \check{\lambda} = \frac{D.N_{var}}{D-1}\left(\lambda - \frac{1}{k}\right)^2$$

Here, $\check{\lambda}$ is the corrected eigenvalue, D is the total number of individuals, N_{var} is the number of variables, and k is the total number of categories.

3.0 Results

3.1 Characteristics of Respondents

Demographic characteristics. The sample was relatively evenly distributed across the three study provinces, with 35.9% of households from Tete, 32.3% from Gaza, and 31.8% from Sofala, enabling meaningful spatial comparisons. Household headship was also balanced by sex, with female-headed households accounting for 49.5% of the sample and male-headed households for 50.5%.

Agricultural resource access. Although access to agricultural land was nearly universal (96.5%), agricultural production remained overwhelmingly dependent on rainfall, as 91.8% of households reported no access to irrigation. Livestock ownership was also limited, with only 40.0% of households owning livestock. These findings highlight the reliance of rural households on climate-sensitive agricultural systems and their susceptibility to drought-related shocks.

Economic capacity and livelihood diversification. Households exhibited low levels of financial inclusion and human capital development. Only 14.1% of households had access to credit, while 14.8% had received agricultural training. Livelihood diversification was modest; although most households (58.3%) reported two income sources, one-third (33.2%) depended on a single livelihood activity, largely agriculture, indicating limited adaptive capacity.

Climate vulnerability and resilience. Exposure to climate-related shocks was substantial, with 38.2% of households reporting crop losses due to drought. However, only 6.8% of households reported an ability to recover from shocks, suggesting weak resilience and limited absorptive capacity. Participation in anticipatory action interventions was evenly distributed between

beneficiaries (50.2%) and non-beneficiaries (49.8%), providing a balanced basis for comparative analysis.

Overall, the descriptive statistics portray a structurally vulnerable rural population characterized by high dependence on rain-fed agriculture, limited access to productive and financial resources, low adaptive capacity, and weak shock recovery mechanisms. These underlying conditions are likely to contribute to the high prevalence of food insecurity observed across the study areas.

Table 1 presents the descriptive characteristics of the 1,644 surveyed households. Overall, 54.1% of households were classified as food insecure, indicating a high level of vulnerability across the study population.

Demographic characteristics. The sample was relatively evenly distributed across the three study provinces, with 35.9% of households from Tete, 32.3% from Gaza, and 31.8% from Sofala, enabling meaningful spatial comparisons. Household headship was also balanced by sex, with female-headed households accounting for 49.5% of the sample and male-headed households for 50.5%.

Agricultural resource access. Although access to agricultural land was nearly universal (96.5%), agricultural production remained overwhelmingly dependent on rainfall, as 91.8% of households reported no access to irrigation. Livestock ownership was also limited, with only 40.0% of households owning livestock. These findings highlight the reliance of rural households on climate-sensitive agricultural systems and their susceptibility to drought-related shocks.

Economic capacity and livelihood diversification. Households exhibited low levels of financial inclusion and human capital development. Only 14.1% of households had access to credit, while 14.8% had received agricultural training. Livelihood diversification was modest; although most households (58.3%) reported two income sources, one-third (33.2%) depended on a single livelihood activity, largely agriculture, indicating limited adaptive capacity.

Climate vulnerability and resilience. Exposure to climate-related shocks was substantial, with 38.2% of households reporting crop losses due to drought. However, only 6.8% of households reported an ability to recover from shocks, suggesting weak resilience and limited absorptive

capacity. Participation in anticipatory action interventions was evenly distributed between beneficiaries (50.2%) and non-beneficiaries (49.8%), providing a balanced basis for comparative analysis.

Overall, the descriptive statistics portray a structurally vulnerable rural population characterized by high dependence on rain-fed agriculture, limited access to productive and financial resources, low adaptive capacity, and weak shock recovery mechanisms. These underlying conditions are likely to contribute to the high prevalence of food insecurity observed across the study areas.

Table 1: Descriptive Statistics of Household Characteristics, Livelihood Strategies, and Food Security Outcomes.

Observation=1644				
Variable	Mean	Std. dev.	Min	Max
Food Insecurity	0.541	0.498	0	1
province				
Tete	0.359	0.480	0	1
Sofala	0.318	0.466	0	1
Gaza	0.323	0.468	0	1
Sex				
Female	0.495	0.500	0	1
Male	0.505	0.500	0	1
Credit access	0.141	0.348	0	1
Household own livestock	0.400	0.490	0	1
Crop destruction	0.382	0.486	0	1
Land	0.965	0.185	0	1
Land irrigated				
0	0.918	0.275	0	1
0.1	0.027	0.162	0	1
0.2	0.022	0.148	0	1
0.3	0.015	0.121	0	1
0.5	0.008	0.091	0	1
0.9	0.001	0.025	0	1
1	0.009	0.094	0	1
Anticipatory action status				
Non-beneficiary	0.498	0.500	0	1
Beneficiary	0.502	0.500	0	1
Livelihood sources				
0	0.014	0.117	0	1
1	0.332	0.471	0	1
2	0.583	0.493	0	1
3	0.069	0.253	0	1
4	0.002	0.049	0	1
Receive trainings	0.148	0.355	0	1
Shock Recovery ability	0.068	0.251	0	1

3.2 Household Food Security Status

Food insecurity was widespread, affecting 54.08% of households (Table 2). This confirms persistent challenges in achieving stable and adequate food access in drought-affected areas.

3.2.1 Anticipatory Action and Food Security

Clear differences emerged between program beneficiaries and non-beneficiaries. Among beneficiaries, 54.6% were food secure compared to only 37.2% of non-beneficiaries. Conversely, food insecurity affected 62.8% of non-beneficiaries versus 45.4% of beneficiaries (Table 2).

These differences suggest a strong association between anticipatory action participation and improved food security outcomes. However, given the cross-sectional design, these findings should be interpreted as correlational rather than causal, as pre-existing differences between groups may also influence outcomes.

3.2.2 Spatial Disparities

Substantial provincial variation was observed. Tete recorded the highest proportion of food-secure households (57.2%), followed by Sofala (42.2%), while Gaza had the lowest (37.1%) (Table 2). These differences likely reflect heterogeneity in agroecological conditions, drought severity, market access, and intervention coverage.

3.2.3 Gender Disparities

Gender-based differences in food security were evident. Male-headed households exhibited higher food security (50.4%) compared to female-headed households (41.3%). Food insecurity affected 58.7% of female-headed households versus 49.6% of male-headed households, highlighting persistent structural inequalities in access to productive resources and economic opportunities (Table 2).

Notably, among anticipatory action beneficiaries, this gender gap was no longer observed, with similar food security levels for female-headed (55.0%) and male-headed households (54.2%). This suggests that anticipatory interventions may contribute to reducing gender disparities, although further causal analysis would be required to confirm this effect (Table 2).

Table 2: Household Food Security Status by Anticipatory Action Status, Province, and Sex of Household Head

Category	Sub-category	Food Secure (%)	Food Insecure (%)	Total (N)	P-value
Overall	Total Sample	45.92	54.08	1644	—
Anticipatory Action Status	Non-beneficiary	37.16	62.84	818	—
	Beneficiary	54.60	45.40	826	—
Province	Tete	57.19	42.81	591	—
	Sofala	42.15	57.85	522	—
	Gaza	37.10	62.90	531	—
Sex of Household Head (Overall)	Male	50.42	49.58	831	—
	Female	41.33	58.67	813	—
Anticipatory Action × Sex	Non-beneficiary (Male)	47.40	52.60	—	**0.000**
	Non-beneficiary (Female)	24.20	75.80	—	
	Non-beneficiary (Total)	37.20	62.80	818	
	Beneficiary (Male)	54.20	45.80	—	**0.816**
	Beneficiary (Female)	55.00	45.00	—	
	Beneficiary (Total)	54.60	45.40	826	

3.3 Factors Associated with Household Food Security

A binary logistic regression model was estimated to identify determinants of household food insecurity (Table 3). The model was statistically significant (LR $\chi^2 = 271.18$, $p < 0.001$), indicating that the included predictors jointly explain variation in food insecurity status. The pseudo R^2 (0.213) suggests moderate explanatory power, which is typical for cross-sectional household data.

3.3.1 Model Performance and Limitations

The model correctly classified 85.1% of cases; however, performance diagnostics revealed important limitations. Sensitivity was very high (98.2%), indicating strong ability to identify food-insecure households. In contrast, specificity was low (10.6%), reflecting limited capacity to correctly identify food-secure households.

This imbalance suggests that the model is biased toward predicting food insecurity, which may inflate predictive accuracy and should be considered when interpreting results. Despite this imbalance, the Positive Predictive Value (PPV) was high (86.21%), suggesting that households

predicted to be food insecure were, in most cases, correctly classified. These diagnostics indicate that while the model was highly effective at detecting vulnerability.

3.3.2 Key Determinants

(i) Geographic Location

Location emerged as a major determinant. Households in Sofala had substantially higher odds of food insecurity (OR = 25.37, $p < 0.001$), while those in Gaza also faced elevated risk (OR = 1.63, $p = 0.028$), relative to Tete. The magnitude of the Sofala effect is unusually large, which may indicate unobserved heterogeneity or model specification issues, warranting cautious interpretation.

(ii) Anticipatory Action Participation

Participation significantly reduced the likelihood of food insecurity (OR = 0.59, $p = 0.002$), corresponding to a 40.9% reduction in odds. This reinforces descriptive findings and supports the potential effectiveness of anticipatory interventions.

(iii) Assets and Resilience Capacity

Livestock ownership reduced the odds of food insecurity by 54.0% (OR = 0.46, $p < 0.001$), highlighting the importance of productive assets. Shock recovery capacity had the strongest protective effect (OR = 0.27, $p < 0.001$), indicating that resilience mechanisms are critical determinants of food security.

Livelihood diversification also significantly reduced risk (OR = 0.65, $p = 0.003$), emphasizing the role of income diversification in buffering shocks.

(iv) Gender

Male-headed households had lower odds of food insecurity (OR = 0.66, $p = 0.014$), confirming persistent gender inequalities in access to resources and adaptive capacity.

In summary, food insecurity is shaped by a combination of geographic, socio-economic, and resilience-related factors, with anticipatory action participation emerging as a significant protective factor.

Table 3: Determinants of household food security status

Logistic regression						
Food Insecurity	Odds ratio	Std. err.	z	P>z	[95% conf.	interval]
Sex						
Male	0.662	0.111	-2.460	0.014	0.477	0.920
Province						
Sofala	25.372	12.160	6.750	0.000	9.918	64.910
Gaza	1.629	0.362	2.200	0.028	1.054	2.517
Credit access	0.844	0.183	-0.780	0.434	0.553	1.290
Households' own livestock	0.460	0.079	-4.510	0.000	0.328	0.644
Crop destruction	1.340	0.301	1.300	0.192	0.863	2.080
Land	1.103	0.682	0.160	0.874	0.328	3.707
Land irrigation	1.041	0.076	0.550	0.583	0.902	1.202
Anticipatory action status						
Beneficiary	0.591	0.100	-3.110	0.002	0.424	0.823
Livelihood sources	0.648	0.094	-3.000	0.003	0.488	0.860
Received trainings	1.047	0.225	0.210	0.832	0.687	1.595
Shock Recovery	0.268	0.066	-5.320	0.000	0.165	0.436
_cons	15.475	10.746	3.940	0.000	3.967	60.359

3.4 Dietary Patterns of Households

Principal Component Analysis (PCA) was conducted to identify underlying dietary consumption patterns among households using the eight Food Consumption Score (FCS) food groups. Three components were retained based on the Kaiser criterion (eigenvalues > 1), collectively explaining 58.6% of the total variance in household dietary consumption. The first component explained 25.6% of the variance, the second component 20.5%, and the third component 12.5% (Annex 1).

Interpretation was based on the rotated component matrix, which improved the separation and interpretability of dietary patterns.

Component 1 (Diversified nutrient-rich diet) was characterized by high positive loadings for fruits (0.511), sugar (0.515), dairy products (0.482), fats (0.359), and animal proteins (0.315). This pattern reflects households consuming a broader range of nutrient-dense and energy-rich foods, indicative of better dietary quality and greater food access.

Component 2 (Legume-vegetable dietary pattern) was positively associated with pulse consumption (0.538) and protein intake (0.362) but negatively associated with vegetable

consumption (-0.678). The contrasting loadings suggest variation in dietary preferences or access to complementary food groups, potentially reflecting households that rely on legumes and protein sources while consuming fewer vegetables.

Component 3 (Staple-dependent dietary pattern) was overwhelmingly dominated by cereal consumption (0.921), indicating a strong dependence on staple foods with limited dietary diversity. This pattern is typical of vulnerable rural households that primarily rely on cereals to meet their caloric needs.

Overall, the PCA reveals substantial heterogeneity in household diets, ranging from cereal-dominated consumption patterns to more diversified nutrient-rich diets. The prominence of the staple-dependent dietary pattern suggests that many households remain vulnerable to nutritional inadequacies despite meeting minimum caloric requirements. In contrast, households exhibiting diversified dietary patterns are likely to have better food security and resilience outcomes.

These findings support the broader evidence that food insecurity in drought-prone regions is not solely a matter of food availability but also of dietary quality and access to diverse food sources.

3.4.1 Multiple Correspondence Analysis (MCA)

Multiple Correspondence Analysis (MCA) was conducted to explore the relationships among household food security, gender, dietary patterns, asset ownership, exposure to climatic shocks, and participation in anticipatory action interventions. The first two dimensions explained 68.2% of the total inertia, with Dimension 1 accounting for 46.8% and Dimension 2 accounting for 21.4%, indicating a strong representation of the underlying relationships among household characteristics (Annex 2).

Dimension 1 (Vulnerability–Resilience Gradient) primarily differentiated households along a continuum of vulnerability and resilience. Food-insecure households, lower asset ownership, less diversified diets, and female-headed households clustered on the vulnerable end of the spectrum. In contrast, food-secure households, higher asset ownership, diversified and nutrient-rich diets, and anticipatory action beneficiaries clustered on the more resilient end. This pattern

suggests that household resilience is closely linked to access to productive resources, dietary diversity, and participation in anticipatory action interventions.

Dimension 2 (Intermediate Differentiation) captured variation among households with moderate levels of resources and dietary diversity and was partly influenced by exposure to climatic shocks. Unlike the first dimension, this axis did not represent a clear vulnerability gradient but rather reflected heterogeneity in household livelihood and consumption profiles.

Overall, the MCA revealed that household food security is embedded within a multidimensional vulnerability–resilience system, where gender, livelihood assets, dietary quality, and participation in anticipatory action are interconnected. Notably, anticipatory action beneficiaries clustered closer to food-secure and higher-asset categories, suggesting that program participation is associated with more favorable resilience outcomes. Similarly, male-headed households tended to cluster with more resilient profiles, reflecting persistent gender disparities in access to productive resources and adaptive capacity.

These findings reinforce the argument that food insecurity is not solely driven by climatic shocks but also by underlying structural inequalities that shape households' ability to anticipate, absorb, and recover from shocks. The results further highlight the potential of gender-responsive anticipatory action to strengthen resilience, improve dietary diversity, and reduce food insecurity among vulnerable households in drought-prone areas of Mozambique. However, these associations should be interpreted with caution, as MCA identifies patterns within the data and does not establish causal relationships.

4.0 Discussion

4.1 Prevalence and Spatial Structuring of Food Insecurity

This study found that over half (54.1%) of households in the surveyed drought-affected districts were food insecure, underscoring the severity of livelihood vulnerability in El Niño–exposed contexts. Although this prevalence exceeds national estimates reported by the World Food Programme (20% in 2023 and 33% in 2024), the difference is expected because the study focused on districts classified as IPC Phase 3 (Crisis) and Phase 4 (Emergency), where acute food insecurity is concentrated (IPC, 2023, 2025a, 2026; WFP, 2024, 2025d). These findings reinforce evidence that climate shocks disproportionately affect already vulnerable

populations, particularly those dependent on rain-fed agriculture and climate-sensitive livelihoods (FAO et al., 2024; IPCC, 2023).

Beyond overall prevalence, the results further demonstrate that food insecurity is spatially differentiated rather than uniformly distributed. Even after controlling for household socioeconomic characteristics, provincial differences remained significant, suggesting that geography is a structural determinant of food security. Households in Tete exhibited relatively better food security outcomes than those in Gaza, likely reflecting more favourable agroecological conditions, greater agricultural potential, stronger market integration, and more diversified livelihood opportunities. This is consistent with previous studies showing that the central and northern Mozambique benefits from relatively higher and more reliable rainfall, while the southern semi-arid regions experience recurrent droughts, lower agricultural productivity, and greater climate vulnerability (World Bank, 2017).

By contrast, the higher prevalence of food insecurity observed in Gaza Province reflects the cumulative effects of recurrent drought, limited livelihood opportunities, weak market access, and high food prices, all of which constrain household purchasing power and dietary diversity (FEWS NET, 2025a; IPC, 2023; World Bank, 2020). These findings support the broader literature which argue that vulnerability is determined not only by exposure to climatic hazards but also by differential access to assets, infrastructure, markets, and institutions that enable households to anticipate, absorb, and adapt to shocks (Béné et al., 2016; FAO, 2021b; FEWS NET, 2025a; World Bank, 2024).

Overall, the findings suggest that climate-related food insecurity in Mozambique is shaped by the interaction of environmental exposure and structural inequalities. Consequently, strengthening household resilience requires geographically targeted interventions that address both immediate climate risks and the underlying socioeconomic constraints that perpetuate vulnerability. This further highlights the importance of tailoring gender-responsive anticipatory action to local livelihood systems and agro-ecological conditions rather than adopting uniform national approaches.

4.2 Anticipatory Action and Food Security Outcomes

A key contribution of this study is the empirical evidence linking anticipatory action participation to improved food security outcomes. Beneficiary households were significantly more likely to be food secure, and regression results indicate a substantial reduction in the likelihood of food insecurity among participants.

These findings are consistent with emerging evidence that anticipatory action through early transfers, input support, and asset protection can mitigate the welfare impacts of climate shocks (Costella et al., 2021; Start Network, 2020; WFP, 2025b). By intervening before shocks fully materialize, such approaches help stabilize consumption and prevent negative coping strategies, thereby interrupting the downward spiral of asset depletion commonly associated with reactive humanitarian responses (Levine et al., 2020; WFP, 2025c).

However, the interpretation of these effects should remain cautious. Given the cross-sectional design, the observed relationships reflect associations rather than causal impacts, and unobserved factors such as targeting mechanisms, social capital, or institutional access may partially influence outcomes. This limitation is consistent with broader challenges in evaluating anticipatory interventions in real-world settings (WFP, 2025c)

Importantly, the effectiveness of anticipatory action appears to be context-dependent. In provinces with higher baseline vulnerability and weaker market integration, such as Gaza, the magnitude of impact may be constrained. This supports operational evidence that anticipatory action outcomes depend not only on timing but also on enabling conditions such as infrastructure, market functionality, and institutional capacity (Baker et al., 2020; Popat et al., 2024) Overall, the findings support anticipatory action as a promising but context-sensitive resilience strategy, rather than a standalone solution.

4.3 Gendered Dimensions of Vulnerability

The analysis identifies gender as a critical axis of food security inequality. Among non-beneficiaries, female-headed households were significantly more food insecure than male-headed households, reflecting well-documented structural constraints in access to land, credit, inputs, and decision-making power with constrained resource access despite making a large proportion (70%) of the labour force (World Bank, 2024; World Bank Group, 2023).

Notably, this disparity nearly diminished among anticipatory action beneficiaries, suggesting that such interventions may partially mitigate gender-based vulnerabilities. While the magnitude of convergence is modest, the pattern indicates that improving access to resources and stabilizing consumption can reduce gender gaps in food security outcomes.

This finding aligns with literature linking women's economic empowerment to improved household welfare, dietary diversity, and resilience (Costella et al., 2021; FAO et al., 2022, 2025; World Bank, 2024; World Bank Group, 2023). It also reflects evidence that women's

expenditure patterns tend to prioritize food and household wellbeing, thereby amplifying the impact of income or transfer-based interventions (Egah et al., 2023; Soh Wenda et al., 2024).

However, these results should not be interpreted as evidence that anticipatory action eliminates structural gender inequality. Rather, they suggest that gender-responsive design including inclusive targeting, access to assets, and participation in decision-making is essential for ensuring equitable resilience outcomes.

4.4 Structural Determinants and Systemic Constraints

The findings indicate that food security outcomes are shaped not only by participation in anticipatory action interventions but also by broader structural and livelihood factors. Households with diversified livelihood portfolios and productive assets, particularly livestock, were less likely to experience food insecurity, highlighting the importance of asset-based resilience in drought-prone environments. These results align with resilience theory, which emphasizes livelihood diversification as a key strategy for managing risk, reducing exposure to shocks, and enhancing adaptive capacity (Rothwell & Chang-Keun, 2010; Sun et al., 2023; Tadesse et al., 2025). Livestock ownership may be particularly important in rural Mozambique, where animals serve as productive assets, income sources, and buffers during periods of climatic stress.

Access to financial resources was also positively associated with food security outcomes. Households with access to credit were better positioned to smooth consumption, invest in productive activities, and cope with temporary income shortfalls, supporting previous evidence linking financial inclusion to enhanced resilience and adaptive capacity (Tadesse et al., 2025; World Bank, 2024). These findings suggest that the effectiveness of anticipatory action may depend, in part, on households' existing asset bases and access to complementary resources that enable them to act on early support and warnings.

Conversely, the limited effects observed for irrigation and agricultural training highlight the importance of contextual and systemic constraints. While both interventions are widely promoted as mechanisms for strengthening agricultural resilience, their benefits may be constrained by inadequate infrastructure, limited water availability, high operational costs, weak extension systems, and barriers to technology adoption. Similar challenges have been documented across drought-prone regions of sub-Saharan Africa, where the effectiveness of technical interventions often depends on the presence of enabling institutional and market conditions (World Bank, 2024).

This underscores a key insight that technical interventions alone are insufficient without supportive systems, including functioning markets, infrastructure, and governance. Food security outcomes are therefore shaped by systemic conditions rather than isolated interventions.

4.5 Multidimensional Nature of Vulnerability: Insights from PCA and MCA

The PCA and MCA results underscore the multidimensional nature of food insecurity and vulnerability in drought-prone regions of Mozambique. PCA identified distinct dietary patterns ranging from staple-dependent diets to more diversified and nutrient-rich diets. This finding highlights that food security extends beyond caloric sufficiency to include dietary quality and diversity, which are increasingly recognized as critical dimensions of food and nutrition security (FAO et al., 2024). The predominance of cereal-based diets among many households suggests persistent nutritional vulnerability despite meeting basic energy needs, reflecting constraints in access to diverse foods and resilient livelihoods.

The MCA further revealed that food security outcomes are embedded within broader livelihood and resilience systems. The first dimension represented a clear vulnerability–resilience gradient, with food-secure households clustering alongside diversified diets, stronger asset ownership, and participation in anticipatory action interventions, while food-insecure households were associated with less diversified diets and greater structural vulnerability. These patterns are consistent with resilience frameworks that emphasize the role of assets, livelihood capacities, and adaptive resources in shaping households' ability to withstand and recover from shocks (Béné et al., 2016; FAO, 2021b).

Although gender contributed less strongly to the MCA structure than dietary and asset-related factors, female-headed, households tended to be positioned closer to vulnerable profiles, a finding that mirrors the descriptive results showing a higher prevalence of food insecurity among female-headed households. This pattern is consistent with extensive evidence indicating that women in rural agrarian systems often face constraints in access to land, productive assets, credit, agricultural services, and decision-making opportunities, all of which can undermine adaptive capacity and resilience to climate-related shocks (C. R. Doss, 2017; UN Women, 2024; World Bank Group, 2024). The results therefore suggest that gender disparities in food security are mediated through broader structural inequalities rather than gender alone.

Taken together, the PCA and MCA findings provide a more comprehensive understanding of vulnerability than single-indicator measures of food security. They demonstrate that food insecurity is embedded within broader livelihood and resilience systems, where dietary diversity, asset ownership, livelihood opportunities, and social inequalities interact to shape household outcomes. These findings support growing calls for multidimensional approaches to food security analysis that move beyond food availability and consumption measures to incorporate resilience capacities and structural determinants (Béné et al., 2016; FAO et al., 2024).

From a policy perspective, the results suggest that gender-responsive anticipatory action should be integrated with longer-term resilience-building strategies that strengthen productive assets, livelihood diversification, and equitable access to resources. While anticipatory action may help households prepare for and manage impending shocks, its effectiveness is likely to be enhanced when combined with interventions that address the structural drivers of vulnerability. Such an approach is particularly important in drought-prone regions of Mozambique, where recurrent climatic shocks interact with persistent socioeconomic inequalities to shape food security outcomes.

4.6 Policy Implications

The findings suggest three key policy priorities. First, anticipatory action should be institutionalized within national disaster risk management and social protection systems, given its demonstrated potential to reduce food insecurity. Second, structural investments in irrigation, market access, and financial inclusion are essential to sustain and amplify these gains. Third, gender-responsive approaches must be embedded within all interventions to address persistent inequalities in resource access and adaptive capacity.

Crucially, these interventions must be context-specific, reflecting spatial differences in vulnerability and institutional capacity.

4.7 Limitations and Future Research

Several limitations should be acknowledged. The cross-sectional design limits causal inference, and the reliance on self-reported food consumption data introduces potential recall bias. Additionally, the timing of data collection may not fully capture seasonal variation in food security.

Future research should prioritize longitudinal or quasi-experimental designs to better assess causal impacts and long-term effects of anticipatory action. Integrating qualitative approaches would also provide deeper insights into household decision-making and gender dynamics.

4.8 Overall Contribution

This study contributes to the literature in three key ways. First, it provides empirical evidence on the association between anticipatory action and improved food security in a high-risk climate context. Second, it demonstrates that vulnerability is shaped by spatial and gender inequalities, which mediate both risk exposure and intervention effectiveness. Third, it highlights the value of multidimensional analytical approaches in capturing the complex and layered nature of food security.

Overall, the findings suggest that while anticipatory action can effectively mitigate short-term shocks, its long-term impact depends on integration with broader structural and institutional interventions that address the root causes of vulnerability.

5.0 Ethical Statement

5.1 Conflict of Interest

The authors declare that they have no known conflict of interests or personal relationships that could have appeared to influence the work reported in this paper.

5.2 Author Contributions

Martha Among Adeke: Methodology, data curation, visualization, formal analysis, writing the original draft and funding acquisition.

Luís Artur: Investigation, designing methodology, conceptualization, supervision, reviewing & editing, validation and project administration.

Sandre José Macia: Methodology, formal analysis, writing- review and editing, visualization.

5.3 Funding

This publication will be funded by the regional Center of Excellence in Agrifood Systems and Nutrition (CE-AFSN).

5.4 Acknowledgements

The authors would like to express their sincere gratitude to the National Institute for Disaster Management and Risk Reduction (known in Portuguese as Instituto Nacional de Gestão e Redução do Risco de Desastres or INGD), Food and Agriculture Organization of the United Nations (FAO), World Food Program (WFP) and the National Institute for Social Action (known in Portuguese as Instituto Nacional de Acção Social or INAS) for their support and for providing access to the data used in this research. we are also deeply thankful to the local communities in the provinces of Sofala, Tete, and Gaza, and to the respondents who generously shared their time and insights, contributions that were invaluable to this study. Furthermore, we extend our appreciation to Co-creating knowledge for local adaptation to climate change in least developed countries (COLOCAL) initiative for their technical and scientific support and the Regional Center of Excellence in Agrifood Systems and Nutrition (CE-AFSN) for funding this publication.

5.5 Data Availability Statement

Data will be made available on request.

6.0 References

Adger, W. N. (2000). *Social and ecological resilience : are they related ? 3*, 347–364. https://sci-hub.africa/10.1191/030913200701540465

Adger, W. N. (2003). *Social Capital , Collective Action , and Adaptation to Climate Change*. *79*(4), 387–404. https://doi.org/10.1111/j.1944-8287.2003.tb00220.x

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Adjognon, S. G., Liverpool-tasie, L. S. O., & Reardon, T. A. (2016). Agricultural input credit in Sub-Saharan Africa : Telling myth from facts. *Food Policy*. https://doi.org/10.1016/j.foodpol.2016.09.014

African Development Bank Group. (2024). *CLIMATE RESILIENT FOOD & NUTRITION SECURITY FOR WOMEN, YOUTH & SMALLHOLDERS (CREFONS) P_MZ-AA0-045* (Issue October). https://www.afdb.org/sites/default/files/documents/projects-and-operations/mozambique_-_climate_resilient_food_nutrition_security_for_women_youth_smallholders_project_crefons.pdf?utm_source=chatgpt.com

Armand, A., Attanasio, O., Carneiro, P., & Lechene, V. (2021). The effect of gender-targeted conditional cash transfers on household expenditures: Evidence from a randomized experiment. *Economic Journal*, *130*(631), 1875–1897. https://doi.org/10.1093/EJ/UEAA056

Aryal, J. P., Rahut, D. B., Maharjan, S., & Erenstein, O. (2018). Factors affecting the adoption of multiple climate-smart agricultural practices in the Indo-Gangetic Plains of India. *Natural Resources Forum*, *42*(3), 141–158. https://doi.org/10.1111/1477-8947.12152

Babbie, E. (2013). *The Practice of Social Research* (Thirteenth).

Baker, J., Nicholas, T., Afonfoso, F., & Artur, L. (2020). *Inter-Agency Humanitarian Evalution of the Response to Cyclone Idai in Mozambique*. *August*. https://link.springer.com/article/10.1186/s41018-024-00162-9

Bandara, J. S., & Cai, Y. (2014). The impact of climate change on food crop productivity, food prices and food security in South Asia. *Economic Analysis and Policy*, *44*(4), 451–465. https://doi.org/10.1016/j.eap.2014.09.005

Barrett, C. B., Reardon, T., & Webb, P. (2001). *Nonfarm income diversification and household livelihood strategies in rural Africa : concepts , dynamics , and policy implications*. *26*, 315–331.

Below, T., Astrid, A., Rosemarie, S., & Sieber, S. (2010). *Micro-level Practices to Adapt to Climate Change for African Small-scale Farmers*. *February*. https://cgspace.cgiar.org/server/api/core/bitstreams/4f498680-b006-429f-85b6-ad4e7e7bb5a4/content

Béné, C., Headey, D., Haddad, L., & Grebmer, K. Von. (2016). *Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations*. *8*(1), 123–138. https://doi.org/10.1007/s12571-015-0526-x

Bernstein, H. (2010). *CLASS DYNAMICS OF AGRARIAN CHANGE*.

Bohle, H. G., Downing, T. E., & Watts, M. J. (1994). Climate change and social vulnerability. *Global Environmental Change*, *4*(1), 37–48. https://doi.org/10.1016/0959-3780(94)90020-5

Brauw, A. De. (2025). *Cost- Effectiveness of Anticipatory Action*. *February*, 0–16.

Cameron, A. Colin & Trivedi, P. K. T. (2005). *Microeconomics; Methods and Applications*.

Carletto, C., Corral, P., & Guelfi, A. (2017). Agricultural commercialization and nutrition revisited : Empirical evidence from three African countries. *Food Policy*, *67*, 106–118. https://doi.org/10.1016/j.foodpol.2016.09.020

Carter, M. R., & Barrett, C. B. (2006). *The Journal of Development The economics of poverty traps and persistent poverty : An asset-based approach*. https://doi.org/10.1080/00220380500405261

Chambers, R., & Conway, G. R. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century*. https://www.researchgate.net/publication/248535825_Sustainable_rural_livelihoods_practical_concepts_for_the_21st_century

Cochran, W. G. (1977). Sampling Techniques, Third Edition, Page 75 read with 51. In *John Wiley and Sons, Inc.*

Concern Worldwide & Welt Hunger Hilfe. (2024). *Global Hunger Index 2024 : Mozambique*.

October, 2024.

Costella, C., McCord, A., Aalst, M. van, Holmes, R., Ammoun, J., & Barca, V. (2021). Social protection and climate change: Scaling up ambition. *Social Protection Approaches to COVID-19 Expert Advice Service (SPACE), October*. https://doi.org/10.13140/RG.2.2.15187.91680

Cristhina, M., Pinto, L., Mirzabaev, A., & Qaim, M. (2025). Effects of recurrent rainfall shocks on poverty and income distribution in rural Ecuador. *World Development*, *195*(June), 107107. https://doi.org/10.1016/j.worlddev.2025.107107

D'Errico, M., & Giuseppe, S. Di. (2018a). Resilience mobility in Uganda : A dynamic analysis. *World Development*, *104*, 78–96. https://doi.org/10.1016/j.worlddev.2017.11.020

D'Errico, M., & Giuseppe, S. Di. (2018b). Resilience mobility in Uganda : A dynamic analysis. *World Development*, *104*, 78–96. https://doi.org/10.1016/j.worlddev.2017.11.020

Daba, B., Regasa, T., & Mammo, S. (2025). *Impacts of climate change and variability on rural livelihoods and adaptation strategies in Ethiopia : a review paper*. *April*, 1–8. https://doi.org/10.3389/fclim.2025.1563176

de Estatística (INE), I. N., & Program., T. D. H. S. (2024). Mozambique DHS, 2022-23 - Final Report (Portuguese). *Rockville, Maryland, USA: INS, INE, and ICF*. https://www.dhsprogram.com/pubs/pdf/FR389/FR389.pdf%0AMozambique%0ADHS, %0A2022-23%0A-%0AFinal%0AReport%0A(Portuguese)

Deressa, T. (2007). Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian Approach. *Social Science Research Network*, *4342*(July), 32-pp. https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-4342

Deressa, T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). *Determinants of farmers ' choice of adaptation methods to climate change in the Nile Basin of Ethiopia*. *19*, 248–255. https://doi.org/10.1016/j.gloenvcha.2009.01.002

Dessie, Z. G., Zewotir, T., & North, D. (2022). The spatial modification effect of predictors on household level food insecurity in Ethiopia. In *Scientific Reports* (Issue 0123456789). Nature Publishing Group UK. https://doi.org/10.1038/s41598-022-23918-y

DFID. (1999). Sustainable Livelihoods Guidance Sheets. *Sustainable Livelihoods Guidance Sheets*, 10.

https://www.staff.ncl.ac.uk/david.harvey/AEF873/Development/DfIDSustLiv.pdf

Dorward, A., Anderson, S., Nava, Y., Pattison, J., Paz, R., Rushton, J., & Sanchez, V. E. (2009). *Hanging In, Stepping up and Stepping Out : Livelihood Aspirations and Strategies of the Poor*. https://d1wqtxts1xzle7.cloudfront.net/46030696/HangingInDIP-libre.pdf?1464485519=&response-content-disposition=inline%3B+filename%3DHanging_in_stepping_up_and_stepping_out.pdf&Expires=1774378588&Signature=fu74ASduLBLLjROM1who8iGvvjV-e-dCCa-zT8KvlVM8GfVA1d

Doss, C., Chiara, K., Peterman, A., Quisumbing, A., & van den Bold, M. (2015). *Gender inequalities in ownership and control of land in Africa : myth and reality* (Vol. 46). https://doi.org/10.1111/agec.12171

Doss, C. R. (2017). *Women and agricultural productivity : Reframing the Issues*. *February*, 35–50. https://doi.org/10.1111/dpr.12243

Egah, J., Zakari, S., Idrissou, L., Kotobiodjo, N., El Ghazi, I., Baco, M. N., & Kestemont, M. P. (2023). Eliciting the gender income influences on household's food security in west africa. *Heliyon*, *9*(6). https://doi.org/10.1016/j.heliyon.2023.e17408

Egerson, D., Kpegba-Fiaboe, E. E., & Christian, A. K. (2025). Understanding food (In) security through land and livelihoods: Evidence from longitudinal household data. *Journal of Rural Studies*, *119*, 103750. https://doi.org/10.1016/j.jrurstud.2025.103750

El Bilali, H., Bassole, I. H. N., Dambo, L., & Berjan, S. (2020). Climate change and food security. *Agriculture and Forestry*, *66*(3), 197–210. https://doi.org/10.17707/AgricultForest.66.3.16

Ellis, F. (2000). *RURAL LIVELIHOOD DIVERSITY IN DEVELOPING COUNTRIES : EVIDENCE AND POLICY IMPLICATIONS*. *40*, 1–10.

Ellis, F., & Freeman, H. A. (2004). *Journal of Development Rural Livelihoods and Poverty Reduction Strategies in Four African Countries*. http://dx.doi.org/10.1080/00220380410001673175 PLEASE

Etana, D., Snelder, D. J. R. M., & Wesenbeeck, C. F. A. Van. (2021). *The Impact of Adaptation to Climate Change and Variability on the Livelihood of Smallholder Farmers in Central Ethiopia*.

FAO. (2008). Climate change and food security. *Agriculture and Forestry*, *66*(3), 197–210. https://doi.org/10.17707/AgricultForest.66.3.16

FAO. (2011). *FAO at work 2010–2011: Women -Key to Food Security*. 24. www.fao.org

FAO. (2015). *Climate change and food security: risks and responses*.

FAO. (2016a). *Climate change and food security: risks and responses. Rome, Italy: FAO* (Issue September). https://www.fao.org/3/i5188e/i5188e.pdf

FAO. (2016b). The state of food and agriculture: Climate change, agriculture and food security. In *Scottish Geographical Magazine* (Vol. 71, Issue 2). https://doi.org/10.1080/00369225508735601

FAO. (2017). The Future of Food and Agriculture: Trends and Challenges. In *The future of food and agriculture: trends and challenges* (Vol. 4, Issue 4). www.fao.org/publications%0Ahttp://www.fao.org/3/a-i6583e.pdf%0Ahttp://siteresources.worldbank.org/INTARD/825826-1111044795683/20424536/Ag_ed_Africa.pdf%0Awww.fao.org/cfs%0Ahttp://www.jstor.org/stable/4356839%0Ahttps://ediss.uni-goettingen.de/bitstream/han

FAO. (2018). *Mongolia. Impact of Early Warning Early Action. Protecting the livelihoods of herders from a dzud winter*. 32. http://www.fao.org/emergencies/fao-in-action/ewea/en/

FAO. (2019). *Colombia. Impact of Early Warning Early Action. Boosting food security and social cohesion on the frontline of the migration crisis Food*. 32. http://www.fao.org/emergencies/fao-in-action/ewea/en/

FAO. (2020). *Applying an inclusive and equitable approach to anticipatory action*.

FAO. (2021a). *The Impact of Disasters and Crises on Agriculture and Food Security*. https://doi.org/10.4060/cb3673en

FAO. (2021b). *The State of Food and Agriculture: Making Agrifood Systems More Resillient to Shocks and Stesses*. https://doi.org/10.4060/cb4476en

FAO. (2023a). The impact of disasters on agriculture and food security. Avoiding and Reducing Losses through Investment in Resilience. In *The impact of disasters on agriculture and food security 2023*. https://doi.org/10.4060/cc7900en

FAO. (2023b). The status of women in agrifood systems. In *The status of women in agrifood*

systems. https://doi.org/10.4060/cc5343en

FAO, IFAD, UNICEF, WFP, & WHO. (2024). *The State of Food Security and Nutrition in the World: Financing to End Hunger, Food Insecurity and Malnutrition in All its Forms*.

FAO, IFAD, UNICEF, WFP, & WHO. (2022). *The State of Food Security and Nutrition in the World. Repurposing food and agricultural policies to make healthy diets more affordable*. https://doi.org/10.4060/cc0639en%0A

FAO, IFAD, UNICEF, WFP, & WHO. (2025). *The state of Food security and Nutrition in the World 2025 – Addressing high food price inflation for food security and nutrition. Rome. https://doi.org/10.4060/cd6008en*. https://doi.org/10.1016/S2213-8587(22)00220-0

Fekete, A. (2024). Natural Hazards and Climate Change Impacts on Food Security and Rural–Urban Livelihoods in Mozambique—A Bibliometric Analysis and Framework. *Earth (Switzerland), 5*(4), 761–783. https://doi.org/10.3390/earth5040040

Fernandes, A. A. T., Filho, D. B. F., da Rocha, E. C., & da Silva Nascimento, W. (2020). Read this paper if you want to learn logistic regression. *Revista de Sociologia e Politica*, *28*(74), 1/1-19/19. https://doi.org/10.1590/1678-987320287406EN

Feulner, G. (2017). Global Challenges: Climate Change. *Global Challenges*, *1*(1), 5–6. https://doi.org/10.1002/gch2.1003

Few, R. (2003). Flooding, vulnerability and coping strategies: Local responses to a global threat. *Progress in Development Studies*, *3*(1), 43–58. https://doi.org/10.1191/1464993403ps049ra

FEWS NET. (2025a). *Crisis (IPC Phase 3) outcomes expected in south , center , and north*. *October 2024*. https://fews.net/southern-africa/mozambique/food-security-outlook/october-2024/print

FEWS NET. (2025b). *Seasonal improvements likely short-lived following below-average 2025 harvest Key Messages*. *July*, 2024–2026. https://fews.net/southern-africa/mozambique/key-message-update/july-2025/print

Folke, C. (2016). *Resilience (Republished)*. *21*(4). https://www.researchgate.net/profile/Carl-Folke/publication/311621233_Resilience_Republished/links/5878c3ce08aebf17d3be2463/Resilience-Republished.pdf?origin=publication_detail&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZS

I6InNpZ251cCIsInBhZ2UiOiJwdWJsaWNhdGlvbkRvd2

Foster, E., Jolliffe, D. M., Ibarra, G. L., Lakner, C., & Tettah-Baah, S. (2025). Global Poverty Revisited Using 2021 PPPs and New Data on Consumption. *Global Poverty Revisited Using 2021 PPPs and New Data on Consumption*, *June*. https://doi.org/10.1596/1813-9450-11137

Fottrell, E., & Byass, P. (2008). *Population survey sampling methods in a rural African setting : measuring mortality*. *11*. https://doi.org/10.1186/1478-7954-6-2

Freduah, B. S., MacCarthy, D. S., Adam, M., Ly, M., Ruane, A. C., Timpong-Jones, E. C., Traore, P. S., Boote, K. J., Porter, C., Adiku, S. G. K., Gbangou, T., Ludwig, F., van Slobbe, E., Greuell, W., Kranjac-Berisavljevic, G., Spear, D., Selato, J. C., Mosime, B., Nyamwanza, A. M., … Ertsen, M. W. (2019). Contextualising seasonal climate forecasts by integrating local knowledge on drought in Malawi. *Climate Services*, *141*(May), 31–36. https://doi.org/10.1016/j.cliser.2021.100268%0Ahttps://doi.org/10.1016/j.cliser.2019.05.001

Gadiso, W. J., Alemu, B. A., & Shete, M. (2024). Unpacking regional variations of multidimensional food security in rural Ethiopia: insights for policy. *International Journal of Social Economics*, *51*(5), 585–603. https://doi.org/10.1108/IJSE-02-2023-0139

Greenacre, M. (2017). *Correspondence Analysis in Practice* (Third edit). https://www.perlego.com/book/1575804/correspondence-analysis-in-practice-pdf

Greenacre, M., & Blasius, J. (2006). *Multiple Correspondence Analysis and Related Methods*.

Gregory, P. J., Ingram, J. S. I., & Brklacich, M. (2005). Climate change and food security. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *360*(1463), 2139–2148. https://doi.org/10.1098/rstb.2005.1745

Haggblade, S., Hazell, P., & Reardon, T. (2010). The Rural Non-farm Economy : Prospects for Growth and Poverty Reduction. *World Development*, *38*(10), 1429–1441. https://doi.org/10.1016/j.worlddev.2009.06.008

Hair, J. F. J., Black, W. C., Babin, B. J., Anderson, R. E., Black, W. C., & Anderson, R. E. (2019). *Multivariate Data Analysis, Eighth Edition*.

https://doi.org/10.1002/9781119409137.ch4

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., & Vogt-Schilb, A. (2016). *Shock waves. Managing the impacts of Climate Change on Poverty*. https://www.researchgate.net/publication/283642157_Shock_Waves_Managing_the_Impacts_of_Climate_Change_on_Poverty/link/56531bef08aeafc2aabaee4f/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19

Harris, D., & Orr, A. (2014). Is rainfed agriculture really a pathway from poverty ? *Agricultural Systems*, *123*, 84–96. https://doi.org/10.1016/j.agsy.2013.09.005

Hartigan, A., & Wong, M. A. (1979). *A K-Means Clustering Algorithm*. https://doi.org/10.2307/2346830

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., Rajaofara, H., & MacKinnon, J. L. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1639). https://doi.org/10.1098/rstb.2013.0089

Headey, D. D., & Martin, W. J. (2016). *The Impact of Food Prices on Poverty and Food Security*. https://doi.org/10.1146/annurev-resource-100815-095303

Hertel, T. W., & Rosch, S. D. (2010). Climate change, agriculture, and poverty. *Applied Economic Perspectives and Policy*, *32*(3), 355–385. https://doi.org/10.1093/aepp/ppq016

Hirvonen, K., Taffesse, A. S., & Hassen, I. W. (2017). *Seasonality and household diets in Ethiopia*. *19*(13), 1723–1730. https://doi.org/10.1017/S1368980015003237

Hisali, E., Birungi, P., & Buyinza, F. (2011). Adaptation to climate change in Uganda : Evidence from micro level data. *Global Environmental Change*, *21*(4), 1245–1261. https://doi.org/10.1016/j.gloenvcha.2011.07.005

Hübler, M., Ogenrwoth, B., Walusimbi, R., Ssali, P., Bonabana, J., & Kyamanywa, S. (2025). The impact of weather shocks on food security in Uganda : a panel regression analysis. *Food Security*, 957–978. https://doi.org/10.1007/s12571-025-01542-8

Hussain, A., Rasul, G., Mahapatra, B., & Tuladhar, S. (2016). Household food security in the face of climate change in the Hindu-Kush Himalayan region. *Food Security*, *8*(5), 921–

937. https://doi.org/10.1007/s12571-016-0607-5

IFPRI. (2005). The Future of Small Farms: Proccedings of a Research Workshop. *The Future of Small Farms: Proceedings of a Research Workshop. 2005. Wye, UK, June 26-29, 2005*, 362. http://pdf.usaid.gov/pdf_docs/Pnado609.pdf#page=362

IFRC. (2022). *Early Warning and Anticipatory Action*. 5–8.

IFRC. (2025). *Strengthening National Disaster Risk Management Systems through the integration of Anticipatory Action*. https://www.ifrc.org/sites/default/files/2025-09/Strengthening_National_Disaster_Risk_Management_Systems_through_integration_of_anticipatory_action.pdf

IFRC, FAO, WFP, OCHA, & Network, S. (2022). Enabling Anticipatory Action to Scale to Address the Challenge of the Climate Crisis. *Disasters*, *46*(1), 95–118. https://doi.org/10.1111/disa.12467

Instituto Nacional de Estatística (INE). (2017). *Gaza quadro 6. Chefes de agregado familiar por estado civil, segundo área de residência, distrito e sexo. Província de Gaza, 2017*.

IPC. (2023). *Mozambique Current Acute Food Insecurity*. *March*.

IPC. (2025a). *MOZAMBIQUE : IPC Acute Food Insecurity Snapshot | October 2024 - March 2025*. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/COMBINED_IPC_Mozambique_Acute_Food_Insecurity_Oct2024_Mar2025_Snapshot_English.pdf

IPC. (2025b). *MOZAMBIQUE: IPC Acute Food Insecurity Snapshot |. October 2024*, 2025. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Mozambique_Acute_Food_Insecurity_Aug2024_Mar2025_Snapshot_English.pdf

IPC. (2026). *MOZAMBIQUE: IPC Acute Food Insecurity Snapshot |. MARCH*, 2026. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/COMBINED_IPC_Mozambique_Acute_Food_Insecurity_Oct2025_Mar2026_Snapshot.pdf

IPCC. (2007a). *Climate Change: Impacts, Adapataions and Vulnerability*. https://doi.org/10.1016/B978-008044910-4.00250-9

IPCC. (2021). *Climate Change 2021 The Physical Science Basis Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate*

Change. https://doi.org/10.1017/9781009157896.

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://doi.org/10.1017/9781009325844.Front

IPCC. (2023). *Climate Change: 2023 Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf

IPCC, I. P. on C. C. (2001). Climate Change: Impacts, Adaptation & Vulnerability. *Ipcc Working Group*, 10032. http://www.ipcc.ch/ipccreports/tar/wg2/index.htm

IPCC, I. P. on C. C. (2007b). Climate change 2007. The Physical Science Basis. In *Weather* (Issue 8). https://doi.org/10.1256/wea.58.04

IPCC, I. P. on C. C. (2007c). *The Intergovernmental Panel on Climate Change*. https://doi.org/10.1201/b11064-39

Jalane, O. I., da Silva, E. V., & Sopchaki, C. H. (2021). Subsistence Agriculture and Climate Change: Cases of the Districts of Magude and Moamba (South of Mozambique). *Revista de Geociencias Do Nordeste*, *7*(2), 123–130. https://doi.org/10.21680/2447-3359.2021v7n2ID21231

Jemaneh, S. A., & Shibeshi, E. M. (2023). Women empowerment in agriculture and its effect on household food security : evidence from Gamo Zone of Southern Ethiopia. *Agriculture & Food Security*, 1–26. https://doi.org/10.1186/s40066-023-00437-1

Jiri, O., Mafongoya, P. L., & Chivenge, P. (2017). *Building climate change resilience through adaptation in smallholder farming systems in semi-arid Zimbabwe*. https://doi.org/10.1108/IJCCSM-07-2016-0092

Jollife, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *374*(2065). https://doi.org/10.1098/rsta.2015.0202

Jolliffe, I. . ., & Cadima, J. (2016). *Principal Component Analysis : A Review and Recent Developments*. https://doi.org/doi.org/10.1098/rsta.2015.0202

Jolliffe, I. . T. (2002). *Principal Component Analysis, Second Edition* (Second Edi).

http://cda.psych.uiuc.edu/statistical_learning_course/Jolliffe I. Principal Component Analysis (2ed., Springer, 2002)(518s)_MVsa_.pdf

Jones, C., Guerten, N., Hillesland, M., & Koechlein, E. (2020). *Applying an inclusive and equitable approach to anticipatory action*. https://wrd.unwomen.org/sites/default/files/2021-11/CB1072EN.pdf

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bistrom, M. L., Nelson, S., & Kristjanson, P. (2015). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development*, *8*(2), 133–144. https://doi.org/10.1080/17565529.2015.1050978

Karmakar, R., Das, I., Dutta, D., & Rakshit, A. (2016). Potential Effects of Climate Change on Soil Properties: A Review. *Science International*, *4*(2), 51–73. https://doi.org/10.17311/sciintl.2016.51.73

Kassie, M., Ndiritu, S. W., & Stage, J. (2014). *What Determines Gender Inequality in Household Food Security in Kenya ? Application of Exogenous Switching Treatment Regression*.

Lamichaney, A., Tewari, K., Basu, P. S., Katiyar, P. K., & Singh, N. P. (2021). Effect of elevated carbon-dioxide on plant growth, physiology, yield and seed quality of chickpea (Cicer arietinum L.) in Indo-Gangetic plains. *Physiology and Molecular Biology of Plants*, *27*(2), 251–263. https://doi.org/10.1007/s12298-021-00928-0

Larson, J. B., Castellanos, P., & Jensen, L. (2019). Gender , household food security , and dietary diversity in western Honduras. *Global Food Security*, *20*(March 2018), 170–179. https://doi.org/10.1016/j.gfs.2019.01.005

Le Masson, V. (2016). Gender and resilience: from theory to practice. *BRACED Knowledge Manager*, 60. https://odi.cdn.ngo/media/documents/10224.pdf

Levine, S., Wilkinson, E., Weingärtner, L., & Mall, P. (2020). Anticipatory action for livelihood protection: A collective endeavour. *ODI Working Paper 580*, 1–36.

Loison, S. A. (2015). Rural Livelihood Diversification in Sub-Saharan Africa : A Literature Review Rural Livelihood Diversification in Sub-Saharan Africa : A Literature Review. *The Journal of Development Studies*, *51*(9), 1125–1138.

https://doi.org/10.1080/00220388.2015.1046445

Lowder, S. K., Skoet, J., & Raney, T. (2016). The Number , Size , and Distribution of Farms , Smallholder Farms , and Family Farms Worldwide. *World Development*, *87*, 16–29. https://doi.org/10.1016/j.worlddev.2015.10.041

MacQueen, J. (1967). *SOME METHODS FOR CLASSIFICATION AND ANALYSIS OF MULTIVARIATE OBSERVATIONS*. *233*(233), 281–297.

Maia, R. da, Nhambiu, B., Cuna, J., Amid, U., Vilanculos, A., & Machele, J. (2019). *Forecasts for Anticipatory Humanitarian Action (FATHUM). Mozambique Country-Specific Risk and Vulnerability Profile Report*. *July*. https://www.anticipation-hub.org/Documents/Reports/Mozambique_Risk_Profile_Report_Final_July_2019.pdf

Marie, M., Yirga, F., Haile, M., & Tquabo, F. (2020). Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon*, *6*(4). https://doi.org/10.1016/j.heliyon.2020.e03867

Matchaya, G. C., Tadesse, G., & Kuteya, A. N. (2022). Rainfall shocks and crop productivity in Zambia: Implication for agricultural water risk management. *Agricultural Water Management*, *269*, 107648. https://doi.org/10.1016/j.agwat.2022.107648

Maxwell, D., Coates, J., & Vaitla, B. (2013). *How Do Different Indicators of Household Food Security Compare ? Empirical Evidence from Tigray*. *August*.

McCordic, C., Riley, L., & Raimundo, I. (2021). Household food security in Maputo: the role of Gendered Access to education and employment. *Development Southern Africa*, *38*(5), 816–827. https://doi.org/10.1080/0376835X.2021.1932423

McDowell, J. Z., & Hess, J. J. (2012). Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Global Environmental Change*, *22*(2), 342–352. https://doi.org/10.1016/j.gloenvcha.2011.11.002

Meinzen-Dick, R., Quisumbing, A., Doss, C., & Theis, S. (2019). Women's land rights as a pathway to poverty reduction: Framework and review of available evidence. *Agricultural Systems*, *172*(November 2017), 72–82. https://doi.org/10.1016/j.agsy.2017.10.009

Mekonnen, A., Tessema, A., Ganewo, Z., & Haile, A. (2021). Climate change impacts on household food security and farmers adaptation strategies. *Journal of Agriculture and Food Research*, *6*, 100197. https://doi.org/10.1016/j.jafr.2021.100197

Miller, C. M., Tsoka, M., & Reichert, K. (2011). The impact of the Social Cash Transfer Scheme on food security in Malawi. *Food Policy*, *36*(2), 230–238. https://doi.org/10.1016/j.foodpol.2010.11.020

Ministério da Agricultura e Desenvolvimento Rural. (2023). *INQUÉRITO AGRÁRIO INTEGRADO 2023*. *1383*, 1–11. https://www.agricultura.gov.mz/wp-content/uploads/2024/09/Inquerito-Agrario-Integrado-IAI-2023.pdf

Ministry of Land and Environment. (2021). *Update of the First Nationally Determined Contribution to the United Nations Framework Convention on Climate Change, Mozambique*. 2020–2025.

Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(50), 19680–19685. https://doi.org/10.1073/pnas.0701855104

Murendo, C., Kairezi, G., & Mazvimavi, K. (2020). Resilience capacities and household nutrition in the presence of shocks . Evidence from Malawi. *World Development Perspectives*, *20*(June 2019), 100241. https://doi.org/10.1016/j.wdp.2020.100241

Muthayya, S., Rah, J. H., Sugimoto, J. D., Roos, F. F., & Black, R. E. (2013). *The Global Hidden Hunger Indices and Maps : An Advocacy Tool for Action*. *8*(6), 1–12. https://doi.org/10.1371/journal.pone.0067860

Mwangi, V., Owuor, S., Kiteme, B., Giger, M., Jacobi, J., & Kirui, O. (2020). *Linking Household Food Security and Food Value Chains in North West Mt . Kenya*. 1–15.

Niang, I., Ruppel, O. C., Abdrobo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. *Postcolonialism*, 217–235. https://doi.org/10.1002/9781119316817.ch17

Niazi, R., Liu, A., Han, J., Hassan, S., Elham, H., & Osewe, M. (2025). *Household Income Diversification and Food Insecurity : A Case Study of Afghanistan*. 1–24.

Njuki, J., Eissler, S., Malapit, H., Meinzen-dick, R., Bryan, E., & Quisumbing, A. (2022). A review of evidence on gender equality , women ' s empowerment , and food systems. *Global Food Security*, *33*(February), 100622. https://doi.org/10.1016/j.gfs.2022.100622

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. https://doi.org/10.1017/CBO9780511808678.003

Nyasimi, Mary & Huyer, S. (2017). Closing the Gender Gap in Agriculture. *Gender, Technology and Development*, *20*(2), 105–116. https://doi.org/10.1177/0971852416643872

Nyasimi, M., & Huyer, S. (2017). Background: the gender gap in agriculture under a changing climate. *Agriculture for Development*, *30*, 2015–2018. https://cgspace.cgiar.org/rest/bitstreams/114804/retrieve

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L., & West, J. (2004). Mapping vulnerability to multiple stressors: Climate change and globalization in India. *Global Environmental Change*, *14*(4), 303–313. https://doi.org/10.1016/j.gloenvcha.2004.01.001

ODI & CCS. (2024). *Climate change and human security implications for humanitarian, development, disaster and climate risk management in Mozambique*. www.odi.org/en/publications/meeting-report-climate-change-human-

OECD. (2024). *Breaking the Vicious Circles of Informal Employment and Low-Paying Work*.

Ogundeji, A. A. (2022). Adaptation to Climate Change and Impact on Smallholder Farmers' Food Security in South Africa. *Agriculture (Switzerland)*, *12*(5). https://doi.org/10.3390/agriculture12050589

Omokpariola, D. O., Agbanu-kumordzi, C., Samuel, T., Kiswii, L., Moses, G. S., & Adelegan, A. M. (2025). *Climate change , crop yield , and food security in Sub-Saharan Africa*.

Omotoso, A. B., Letsoalo, S., Olagunju, K. O., Tshwene, C. S., & Omotayo, A. O. (2023). Climate change and variability in sub-Saharan Africa: A systematic review of trends and impacts on agriculture. *Journal of Cleaner Production*, *414*, 137487. https://doi.org/10.1016/j.jclepro.2023.137487

Opoku, S., Jacobs, B., & Cunningham, R. (2026). The role of institutions in enhancing climate change adaptation by smallholder farmers in the Talensi district of Ghana. *Environmental Development*, *57*(September 2025), 101341. https://doi.org/10.1016/j.envdev.2025.101341

Ostrom, E. (1990). *Governing the Commons. The Evolution of Institutions for Collective Action*.

Pereira, R. A., & Hodge, A. (2015). *Editorial Food insecurity : a critical public health nutrition*

concern. *18*(16), 2893–2894. https://doi.org/10.1017/S136898001500292X

Popat, M., Rathod, K., Artur, L., Perez, E. C. De, Sharma, A., Beca, N., & Sant, C. Van. (2024). Anticipatory actions : lessons from the storm Ana in Mocuba district , Mozambique. *Journal of International Humanitarian Action*, *9*. https://doi.org/10.1186/s41018-024-00162-9

Pople, A., Hill, R., Dercon, S., & Brunckhorst, B. (2021). Anticipatory Cash Transfers in Climate Disaster Response. *CSAE Working Paper*, *07*(April 2021). https://static1.squarespace.com/static/61542ee0a87a394f7bc17b3a/t/616ad24fdbfca62188f8e614/1634390614711/FINAL%2BAnticipatory_Cash_Transfers_in_Climate_Disaster_Response%2B%28for%2BWP%29%2BF3.pdf

Porter, J. R., Xie, L., Challinor, A. J., Cochrane, K., Howden, S. M., Iqbal, M. M., Lobell, D. B., Travasso, M. I., Aggarwal, P., Hakala, K., & Jordan, J. (2014). *Food security and food production systems. In Climate Change 2014: Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects*. 485–534. https://doi.org/10.1017/CBO9781107415379.012

Pörtner, H.-O. . R. H. . A. I. . A. C. A. R. A. P. A. E. A. R. A. B. B. B.-F. R. B. K. R. B. J. B. K. B. M. A. C. (2023). Climate Change2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of theIntergovernmental Panel on Climate Change. In *Climate Change 2022 – Impacts, Adaptation and Vulnerability*. https://doi.org/10.1017/9781009325844.Front

Quisumbing, A. R., Meinzen-Dick, R., Raney, T. L., Croppenstedt, A., Behrman, J. A., & Peterman, A. (2014). Gender in agriculture: Closing the knowledge gap. *Gender in Agriculture: Closing the Knowledge Gap*, 1–444. https://doi.org/10.1007/978-94-017-8616-4

Raffo-Babici, V., Calderon-Cisneros, J., Peralta-Gamboa, D., & Coloma-Casanova, A. (2025). Multidimensional analysis of access to resources and its relationship with food security in vulnerable populations. *Clinical Nutrition Open Science*, *61*, 317–328. https://doi.org/10.1016/j.nutos.2025.05.001

Rajasooriar, D., & Soma, T. (2022). Food access , mobility , and transportation : a survey and key informant interviews of users of non-profit food hubs in the City of Vancouver before and during the COVID-19 crisis. *BMC Public Health*, 1–18.

https://doi.org/10.1186/s12889-021-12434-9

Risk-informed Early Action Partnership (REAP). (2021). *Country case studies Mozambique*. 1–13. https://www.anticipation-hub.org/Documents/Case_Studies/REAP_-_Mozambique.pdf

Rothwell, D. W., & Chang-Keun, H. (2010). *Exploring the Relationship Between Assets and Family Stress Among Low-Income Families*. *59*(October), 396–407. https://doi.org/10.1111/j.1741-3729.2010.00611.x

Salite, D. (2019). Explaining the uncertainty : understanding small-scale farmers ' cultural beliefs and reasoning of drought causes in Gaza Province , Southern Mozambique Intergovernmental Panel on Climate Change Statistical Package for Social Sciences. *Agriculture and Human Values*, *36*(3), 427–441. https://doi.org/10.1007/s10460-019-09928-z

Sanchez, P. A., & Swaminathan, M. S. (2005). Cutting world hunger in half. *Science*, *307*(5708), 357–359. https://doi.org/10.1126/science.1109057

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(50), 19703–19708. https://doi.org/10.1073/pnas.0701976104

Scoones, I. (1998). *SUSTAINABLE RURAL LIVELIHOODS A FRAMEWORK FOR ANALYSIS IDS WORKING PAPER 72*. https://opendocs.ids.ac.uk/articles/report/Sustainable_Rural_Livelihoods_A_Framework_for_Analysis/26473384?file=48230770

Scoones, I. (2009). Livelihoods perspectives and rural development. *Journal of Peasant Studies*, *36*(1), 171–196. https://doi.org/10.1080/03066150902820503

Shifat, Z. F., Alam, M. J., *, Ismat Ara Begum, M. A. I., Sarma, P. K., And, & McKenzie, A. M. (2025). *The association between household ' s asset ownership and food security : panel data evidence from Bangladesh*. *January*, 1–13. https://doi.org/10.3389/fsufs.2024.1479410

Soares, J. C., Santos, C. S., Carvalho, S. M. P., Pintado, M. M., & Vasconcelos, M. W. (2019). Preserving the nutritional quality of crop plants under a changing climate: importance and strategies. *Plant and Soil*, *443*(1–2), 1–26. https://doi.org/10.1007/s11104-019-04229-0

Soh Wenda, B. D., Fon, D. E., Molua, E. L., & Longang, S. G. (2024). Women, income use and nutrition quality: effects of women's decision-making in rural households in Cameroon. *Agriculture and Food Security*, *13*(1), 1–20. https://doi.org/10.1186/s40066-024-00480-6

Start Network. (2020). *ARC Replica pay-out: Senegal 2020. Internal Evaluation*. *December*. https://reliefweb.int/report/senegal/arc-replica-payout-senegal-2020-internal-evaluation

Stephens, E. C., Jones, A. D., & Parsons, D. (2018). Agricultural systems research and global food security in the 21st century: An overview and roadmap for future opportunities. *Agricultural Systems*, *163*, 1–6. https://doi.org/10.1016/j.agsy.2017.01.011

Stifel, D., & Minten, B. (2017). Market Access , Well-being , and Nutrition : Evidence from Ethiopia. *World Development*, *xx*(Essp Ii). https://doi.org/10.1016/j.worlddev.2016.09.009

Sultan, B., & Gaetani, M. (2016). Agriculture in West Africa in the twenty-first century: Climate change and impacts scenarios, and potential for adaptation. *Frontiers in Plant Science*, *7*(AUG2016), 1–20. https://doi.org/10.3389/fpls.2016.01262

Sun, Q., Fu, C., Bai, Y., Oduor, A. M. O., & Cheng, B. (2023). *Livelihood Diversification and Residents ' Welfare : Evidence from Maasai Mara National Reserve*.

Suparna, P. (2020). Analysis of Main Components Status of Food Security at Village/Sub-District Level in Yogyakarta Special Region. *Jurnal Matematika "MANTIK," 6*(1), 30–37. https://doi.org/10.15642/mantik.2020.6.1.30-37

Sweileh, W. M. (2020). Bibliometric analysis of peer - reviewed literature on food security in the context of climate change from 1980 to 2019. *Agriculture & Food Security*, 1–15. https://doi.org/10.1186/s40066-020-00266-6

Tadesse, A., Li, K., Helton, J., Huang, J., & Ansong, D. (2025). The Links Between Community-Based Financial Inclusion and Household Food Availability: Evidence from Mozambique. *Foods*, *14*(2), 1–14. https://doi.org/10.3390/foods14020212

Tafesse, A., Ayele, G., Ketema, M., & Geta, E. (2016). Food Security and Adaptation Strategies to Climate Change in Eastern Ethiopia. *Econ.Res*, *5*(6), 81–88. https://doi.org/10.11648/j.eco.20160506.11

Tamako, N., & Chitja, J. M. T. (2017). Does social capital play a role in climate change

adaptation among smallholder farmers for improving food security and livelihoods? *Journal of Consumer Sciences, Special Edition Food and Nutrition Challenges in Southern Africa*, *2*, 16–27.

Thamaga-chitja, J. M., Tamako, N., & Ojo, T. O. (2025). *Implications of Land Ownership Heterogeneity on Household Food Security : A Case Study of Urban Farming in Pietermaritzburg , KwaZulu-Natal Province*. 1–16.

The World Bank Group. (2023). *Mozambique: Country Climate and Development Report*. https://documents1.worldbank.org/curated/en/099113023154021937/pdf/P1771520fcab7a0930aca102c9d7107d4cc.pdf

The World Bank Group. (2025). *CLIMATE RISK COUNTRY PROFILE, MOZAMBIQUE*. https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/17258-WB_Mozambique Country Profile-WEB.pdf

Thomas, D. S. G., & Twyman, C. (2005). Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environmental Change*, *15*(2), 115–124. https://doi.org/10.1016/j.gloenvcha.2004.10.001

Toromade, A. S., Soyombo, D. A., & Kupa, E. (2024). *Reviewing the impact of climate change on global food security : Challenges and solutions*. *September*. https://doi.org/10.51594/ijarss.v6i7.1300

Turner, B. L., Kasperson, R. E., Matson, P. A., Mccarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). *A framework for vulnerability analysis in sustainability science*. *100*(14).

UN Women. (2022a). *GENDER ANALYSIS IN TECHNICAL AREAS : Climate and Disaster Risk Finance and Insuarance*. https://knowledge.unwomen.org/sites/default/files/2022-12/Gender Analysis Guidance-final.pdf

UN Women. (2022b). *Handbook on Gender Mainstreaming for Gender Equality Results*. https://knowledge.unwomen.org/sites/default/files/2022-02/Handbook-on-gender-mainstreaming-for-gender-equality-results-en.pdf

UN Women. (2024). *Progress on the Sustainable Development Goals: The Gender Snapshot 2024*. https://www.unwomen.org/sites/default/files/2024-09/progress-on-the-sustainable-

development-goals-the-gender-snapshot-2024-en.pdf

UN Women. (2026). *Executive Board of the United Nations Entity for Gender Equality and the Empowerment of Women Report of the Under-Secretary-General / Executive Director* (Vol. 07261, Issue May). https://docs.un.org/en/unw/2026/2

UNDRR. (2023). *Analysis of Barriers in Financing and Operationalizing Linkages Between Anticipatory Action and Social Protection Systems*. 6. https://www.undrr.org/contact-us

UNFCCC. (2016). *The Paris Agreement*. https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

Usman, M. A., & Haile, M. G. (2022). Market access, household dietary diversity and food security: Evidence from Eastern Africa. *Food Policy*, *113*, 102374. https://doi.org/10.1016/j.foodpol.2022.102374

van Oort, P. A. J., & Zwart, S. J. (2018). Impacts of climate change on rice production in Africa and causes of simulated yield changes. *Global Change Biology*, *24*(3), 1029–1045. https://doi.org/10.1111/gcb.13967

Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. (2012). Climate change and food systems. *Annual Review of Environment and Resources*, *37*, 195–222. https://doi.org/10.1146/annurev-environ-020411-130608

Von Braun, J., & Kennedy, E. T. (1994). *Agricultural Commercialization, Economic Development, and Nutrition*.

Weldearegay, S. K., & Tedla, D. G. (2018). Impact of climate variability on household food availability in Tigray, Ethiopia. *Agriculture and Food Security*, *7*(1), 1–10. https://doi.org/10.1186/s40066-017-0154-0

WFP. (2020). *The evidence base on Anticipatory Action*. *May*, 1–46. https://docs.wfp.org/api/documents/WFP-0000110236/download/?_ga=2.78704468.1909757493.1678139892-263477493.1677935196

WFP. (2021). *Food security and climate change, the pressing reality of Mozambique*. *May*, 4.

WFP. (2024). *WFP Mozambique Country Brief. December 2024*. https://docs.wfp.org/api/documents/WFP-

0000164099/download/?_ga=2.107543621.691249365.1741763123-806104240.1741763123

WFP. (2025a). *Anticipatory Action Learning and Validation Workshop Report*. *May*.

WFP. (2025b). *WFP's evidence base on Anticipatory Action 2015-2024. Synthesis of 16 studies on the effectiveness of Anticipatory Action* (Issue April).

WFP. (2025c). *WFP's evidence base on Anticipatory Action 2015-2024. Synthesis of 16 studies on the effectiveness of Anticipatory Action*. *April*. https://www.anticipation-hub.org/Documents/Reports/WFP_evidence_base_Anticipatory_Action_2015-2024.pdf

WFP. (2025d). *WFP Mozambique Country Brief*. *January*, 2025–2026. https://reliefweb.int/report/mozambique/wfp-mozambique-country-brief-january-2025

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). *At Risk Second Edition: Natural Hazards, People's Vulnerability and Disasters*. https://www.researchgate.net/publication/323368943_At_Risk_Natural_Hazards_People's_Vulnerability_and_Disasters?__cf_chl_f_tk=O9HQAGeSs4y6kKKbeRKSFhmz1agQSTIVHbgVIqcSBqk-1782907606-1.0.1.1-H1b62ZkgPSAuVCcP6bhf4hZp9haS2l37b.krQC6BmvM

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*.

World Bank. (2017). *Climate-Smart Agriculture in Mozambique*. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA-in-Mozambique.pdf

World Bank. (2020). *Nutrition Smart Agriculture in Mozambique*. https://documents1.worldbank.org/curated/en/392721597038541068/pdf/Nutrition-Smart-Agriculture-in-Mozambique.pdf

World Bank. (2023). *A New Era in Development. Sustainable, Inclusive, and Resilient Development*. *2*(March).

World Bank. (2024). Mozambique - Agriculture Support Policy Review. *Mozambique - Agriculture Support Policy Review*. https://doi.org/10.1596/41958

World Bank. (2025). *CLIMATE RISK COUNTRY PROFILE MOZAMBIQUE*.

World Bank Group. (2023). *Mozambique Gender Assessment. Leveraging women and girls'*

potential. https://documents1.worldbank.org/curated/en/099091823092039842/pdf/P1772130ebf8690b50b0ff0231c20e8894f.pdf

World Bank Group. (2024). *World Bank Group Gender Strategy 2024 – 2030: Accelerate Gender Equality to End Poverty on a Livable Planet*. https://documents1.worldbank.org/curated/en/099061124182033630/pdf/BOSIB17e6952570c51b49812a89c05be6a4.pdf

Wubetie, H. T., Zewotir, T., & Mitku, A. A. (2024). *The spatial e ects of the household ' s food insecurity levels in Ethiopia : by ordinal geo-additive model*.

Yadav, S. S., Hegde, V. S., Habibi, A. B., Dia, M., & Verma, S. (2019). Climate Change, Agriculture and Food Security. *Food Security and Climate Change*, *February*, 1–24. https://doi.org/10.1002/9781119180661.ch1

Zeleke, T., Beyene, F., Deressa, T., Yousuf, J., & Kebede, T. (2021). Vulnerability of smallholder farmers to climate change-induced shocks in east hararghe zone, ethiopia. *Sustainability (Switzerland)*, *13*(4), 1–19. https://doi.org/10.3390/su13042162

7.0 Annex

Annex 1: Principal Component Analysis of Household Dietary Patterns

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.049	0.412	0.256	0.256
Comp2	1.636	0.633	0.205	0.461
Comp3	1.003	0.090	0.125	0.586
Comp4	0.912	0.132	0.114	0.700
Comp5	0.781	0.092	0.098	0.798
Comp6	0.689	0.099	0.086	0.884
Comp7	0.589	0.249	0.074	0.957
Comp8	0.341	.	0.043	1.000
Variable	Comp1	Comp2	Comp3	Unexplained
FCS_cereals	0.170	0.180	0.888	0.097
FCS_Pulse	0.300	-0.444	0.124	0.478
FCS_Dairy	0.337	0.250	-0.307	0.571
FCS_Proteins	0.429	-0.186	-0.118	0.553
FCS_Veg	-0.196	0.669	0.086	0.182
FCS_Fruits	0.318	0.413	-0.205	0.472
FCS_Fats	0.488	-0.017	0.178	0.481
FCS_Sugar	0.455	0.234	-0.085	0.480
Rotated components				
Variable	Comp1	Comp2	Comp3	Unexplained
FCS_cereals	-0.018	-0.040	0.921	0.097
FCS_Pulse	0.024	0.538	0.111	0.478
FCS_Dairy	0.482	-0.074	-0.179	0.571
FCS_Proteins	0.315	0.362	-0.050	0.553
FCS_Veg	0.108	-0.678	0.151	0.182
FCS_Fruits	0.511	-0.221	-0.058	0.472
FCS_Fats	0.359	0.254	0.276	0.481
FCS_Sugar	0.515	0.006	0.058	0.480

Annex 2: MCA of Household Vulnerability and Resilience Profiles

		Overall		Dimension_1			Dimension_2		
Categories	Mass	Quality	%inert	Coord	Sqcorr	Contrib	Coord	Sqcorr	Contrib
CP1_cat									
Low	0.074	0.664	0.199	1.947	0.659	0.279	0.253	0.005	0.005
Medium	0.067	0.629	0.140	-1.027	0.238	0.071	-1.952	0.392	0.256
High	0.059	0.675	0.133	-1.261	0.331	0.094	1.901	0.344	0.214
CP2_cat									
Low	0.074	0.677	0.117	-1.050	0.324	0.081	1.621	0.353	0.193
Medium	0.060	0.630	0.144	-1.046	0.212	0.065	-2.171	0.417	0.281
High	0.067	0.667	0.206	2.096	0.666	0.293	0.156	0.002	0.002
Sex									
Female	0.099	1.067	0.020	0.657	0.978	0.043	-0.293	0.089	0.008
Male	0.101	1.067	0.020	-0.643	0.978	0.042	0.287	0.089	0.008
Shocks									
No	0.004	0.517	0.005	0.633	0.171	0.002	1.331	0.346	0.008
Yes	0.196	0.517	0.000	-0.014	0.171	0.000	-0.029	0.346	0.000
Food_Insec									
Secure	0.092	1.155	0.009	-0.421	0.839	0.016	0.383	0.316	0.013
Insecure	0.108	1.155	0.008	0.358	0.839	0.014	-0.325	0.316	0.011

Dimension	Principal Inercia	Percent	Cumulative Percentage
Dim 1	0.07	46.83	46.83
Dim 2	0.03	21.37	68.19
Dim 3	0.00	0.04	68.23
Total	0.1481135	100	

CHAPTER FIVE: ARTICLE / PAPER TWO (1872538)

Climate Shocks, Livelihoods, and Household Food Security in Rural Mozambique: Evidence from Guijá District.

Martha Among Adeke[12*], Luís Artur[12], Sandre José Macia[12]

[1]Department of Economics and Rural Development, Faculty of Agronomy and Forest Engineering, Eduardo Mondlane University, Maputo, Mozambique

[2]Centre of Excellence in Agri-Food Systems and Nutrition (CE-AFSN), Eduardo Mondlane University, Maputo, Mozambique.

*** Correspondence:**

Martha Among Adeke

amomartha23@gmail.com

Keywords: Climate change[1], food insecurity[2], livelihoods[3], adaptive capacity[4], Mozambique[5]

1.0 Abstract

Climate change is intensifying food insecurity across the globe, hitting harder drought-prone rural areas of low-income countries. Yet, limited empirical evidence explains how climate exposure, household adaptive capacity and everyday making of a living jointly shape food security at the local level. This study examines the patterns and determinants of household food security in Guijá district, Mozambique, one of the country's most climate-stressed regions due to recurrent droughts, floods, erratic rainfall and high temperatures. These climate shocks pose serious threats to agriculture-based livelihoods, food security, water access, and overall household welfare particularly because the majority of the population depends on small-scale, rain-fed subsistence farming as their primary economic activity. Using cross-sectional survey data from 407 households, food security was assessed through the Food Consumption Score (FCS), complemented by the Household Dietary Diversity Score (HDDS) and the Household Hunger Scale (HHS). The study applied Multiple Correspondence Analysis (MCA) and K-Means Cluster Analysis to explore the interplay of livelihoods, climate factors and food security outcomes. Descriptive statistics and binary logistic regression identified key determinants of food security, while cluster analysis revealed distinct livelihood patterns. Results indicate that 67.6% of households were food insecure, with notable spatial disparities across communities. Although female-headed households experienced higher levels of food

insecurity, gender was not a statistically significant determinant after controlling for socioeconomic and environmental factors. Instead, food security was strongly associated to income levels, income diversification, market access, land-use change, and ownership of productive assets particularly motorcycles. Irregular rainfall significantly reduced the likelihood of food security. Four household typologies emerged, with food security probabilities ranging from 0.43 among market-integrated households to 0.09 among wage-dependent households. These findings highlight the need for targeted, livelihood-sensitive, and climate-resilient interventions focused on promoting livelihood diversification, improving market and financial access, strengthening climate-smart land management, and supporting household asset accumulation for enhanced resilience.

2.0. Introduction

Climate change is among the most pressing global development challenges of the twenty-first century with profound environmental, economic and social implications. Rising global temperatures, shifting precipitation patterns and increasing frequency and intensity of extreme weather events, largely driven by anthropogenic greenhouse gas emissions, are disrupting agricultural systems and rural livelihoods worldwide (Feulner, 2017; Marie et al., 2020; Soares et al., 2019). These changes threaten agricultural production, exacerbate poverty and undermine household food insecurity, particularly in regions where livelihoods depend heavily on climate-sensitive natural resources. Their impacts are especially severe where households have limited adaptive capacity, defined as the ability of individuals, households or systems to adjust to climate variability, minimize potential damages, exploit emerging opportunities and cope with the consequences of climatic shocks and stresses (IPCC, 2007a).

Sub-Saharan Africa is widely recognized as one of the most vulnerable regions to climate variability because of its heavy reliance on rain-fed agriculture, widespread poverty and structural development constraints (Deressa, 2007; Harvey et al., 2014; Omotoso et al., 2023). Agricultural production across this region is highly sensitive to rainfall variability and extreme weather events, while adaptation is constrained by limited access to climate-smart technologies, financial services, infrastructure and effective institutional support (Omokpariola et al., 2025; Thomas & Twyman, 2005). Consequently, climate variability not only reduces agricultural productivity but also amplifies existing socioeconomic inequalities by weakening livelihoods and limiting households' ability to respond effectively to environmental shocks (Few, 2003; World Bank, 2023).

Within this context, smallholder farming households occupy a central position in the climate-food security nexus. Although smallholder farms account for the majority of agricultural holdings globally, many households remain highly vulnerable to food insecurity because their livelihoods depend directly on climate-sensitive agricultural production (IFPRI, 2005; Lowder et al., 2016; Sanchez & Swaminathan, 2005; World Bank, 2024). Climate-related shocks including droughts, floods and erratic rainfall reduce crop yields, livestock productivity and household income, often leading to asset depletion and the adoption of adverse coping strategies. These impacts often trigger asset depletion and force households to adopt negative coping strategies. As these shocks persist, they disrupt the availability, access and utilization

of food. This, in turn intensifies food insecurity and malnutrition (O'Brien et al., 2004; Pörtner, 2023; Tafesse et al., 2016; Toromade et al., 2024; Weldearegay & Tedla, 2018).

These challenges are reflected in the persistence of global food insecurity, with about 673 million people experiencing hunger worldwide in 2024, including nearly 307 million in SSA (FAO et al., 2025). The disproportionate burden borne by climate-sensitive agricultural regions is particularly evident in countries such as Mozambique, where heavy dependence on rain-fed agriculture and recurrent climate shocks continue to undermine rural livelihoods and household food security.

Mozambique provides a particularly relevant example of the interaction between climate vulnerability, agrarian dependence and persistent food insecurity. Approximately 98% of farming households rely on rain-fed agriculture, while more than 80% of the labour force depends on agriculture for its livelihoods (Ministério da Agricultura e Desenvolvimento Rural, 2023; World Bank, 2024). Consequently, fluctuations in rainfall and extreme weather events have direct implications for agricultural production, household incomes and food security. These challenges are reflected in Mozambique's ranking of 107th out of 127 countries in the 2024 Global Hunger Index (Concern Worldwide & Welt Hunger Hilfe, 2024). Furthermore, according to the Integrated Food Security Phase Classification (IPC), millions of Mozambicans continue to experience acute food insecurity, with many households classified in Crisis (Phase 3) or Emergency (Phase 4), particularly following El Niño-induced droughts and severe flooding events (IPC, 2023, 2025a, 2025b, 2026).

Within Mozambique, the southern provinces experience some of the country's highest levels of climatic risk, Gaza province has been particularly affected by recurrent droughts, floods, erratic rainfall and increasing temperatures, all of which have intensified livelihood vulnerability and food insecurity (IPC, 2023; Salite, 2019). Guijá district represents one of the province's most climate-exposed areas because livelihoods remain heavily dependent on rain-fed subsistence agriculture, with limited livelihood diversification and constrained adaptive capacity. Understanding how households respond to these climatic pressures is therefore essential for identifying locally appropriate climate-resilient and nature-based strategies capable of strengthening both food security and ecosystem sustainability.

Food insecurity, however, is not only shaped by climatic exposure but also by socioeconomic and institutional inequalities that influence households' capacity to adapt. In Mozambique,

women constitute a substantial proportion of the agricultural labour force but frequently face constraints in accessing land, credit, agricultural inputs, extension services and decision-making opportunities (Ministério da Agricultura e Desenvolvimento Rural, 2023; World Bank, 2024; World Bank Group, 2023). These inequalities may limit adaptive capacity and increase vulnerability to climate-related shocks, particularly in contexts characterized by male out-migration and increasing care responsibilities (Jost et al., 2015). Nevertheless, empirical evidence on gender differences in food security remains mixed and context-specific (McCordic et al., 2021), suggesting that food security outcomes are not only shaped by gender but also by broader socioeconomic conditions, livelihood assets and institutional support.

Although considerable research has examined climate variability and food insecurity in SSA, several important knowledge gaps remain. First, relatively few studies have simultaneously examined climate-related shocks, livelihood strategies, socioeconomic characteristics and gender within a single analytical framework. Second, many studies continue to rely on a single indicator of food security despite growing recognition that food insecurity is multidimensional, encompassing food consumption, dietary quality and hunger experiences. Third, localized evidence from highly climate-vulnerable districts such as Guijá remains limited, despite continued investments in climate adaptation and rural development (Ministry of Land and Environment, 2021; The World Bank Group, 2025). These gaps limit understanding of how climatic and socioeconomic factors interact to shape household food security and adaptive capacity in vulnerable rural settings.

To address this gap, this study examines the relationship between climate variability, livelihood strategies and household food security among smallholder farming households in Guijá district, Mozambique. Specifically, the study aims to: (1) assess household food security status using multidimensional indicators; (2) examine the effects of climate-related shocks on livelihood activities and food security outcomes; (3) analyze how livelihood assets and socioeconomic characteristics influence household food security; and (4) explore how gender-related inequalities shape vulnerability and adaptive capacity within smallholder livelihood systems.

The study contributes to the literature in three important ways. First, it provides localized empirical evidence from Guijá district, one of the most climate-vulnerable yet understudied rural areas in southern Mozambique. Second, unlike studies relying on a single food security measure, it adopts a multidimensional approach by integrating the Food Consumption Score, Household Dietary Diversity Score and Household Hunger Scale. Third, it applies the

Sustainable Livelihoods Framework to examine how climate variability, livelihood assets and socioeconomic factors jointly shape household food security outcomes. By integrating these dimensions within a single analytical framework, the study advances understanding of the structural drivers of food insecurity and highlights pathways through which climate-resilient and nature-based interventions can strengthen household resilience.

Overall, the study provides context-specific evidence to inform geographically targeted, livelihood-sensitive and climate-resilient policies in rural Mozambique. In doing so, it contributes to broader efforts to strengthen household resilience, promote sustainable food systems and advance the objectives of the United Nations Sustainable Development Goals, particularly SDG 2 (Zero Hunger) and SDG 13 (Climate Action).

2.1 Conceptual Framework: The Sustainable Livelihoods Framework (SLF)

This study is anchored in the Sustainable Livelihoods Framework (SLF), which provides a comprehensive, people-centered lens for analyzing how rural households construct and sustain livelihoods under conditions of environmental and socioeconomic change. The SLF conceptualizes a livelihood as comprising the capabilities, assets and activities required for a means of living and defines sustainability in terms of the capacity to cope with and recover from shocks while maintaining or enhancing assets without degrading the natural resource base (DFID, 1999; Scoones, 1998).

The framework is organized around five forms of capital namely; human, natural, financial, physical and social which households mobilize within a broader vulnerability context shaped by shocks, long-term trends and seasonality (DFID, 1999; Scoones, 2009). Access to these assets is mediated by transforming structures and processes, including institutions, policies and social relations, which determine the range of livelihood strategies available and the distribution of outcomes. Because access to livelihood assets is often unequally distributed across gender, socioeconomic status and geographic location (DFID, 1999), the SLF is particularly useful for examining differential vulnerability and resilience among rural households.

In this study, the SLF provides the analytical foundation for understanding how climate-related shocks interact with livelihood assets, institutional support and gender relations to influence household food security. Climate change is therefore viewed not only as an environmental challenge but also as a factor that shapes livelihood opportunities and vulnerability through its

effects on access to and utilization of livelihood capitals (Adger, 2006; Chambers & Conway, 1992).

2.2 Climate Change, Livelihoods and Household Food Security

2.2.1 Vulnerability Context

Agriculture remains the dominant livelihood strategy for rural households in sub-Saharan Africa (SSA) and is highly sensitive to climatic variability, particularly in rain-fed production systems (Morton, 2007; Niang et al., 2014). Climate change affects food systems through rising temperatures, altered precipitation patterns, increased frequency of extreme events and altered carbon dioxide concentrations, with varying consequences across locations and over time (Porter et al., 2014; Vermeulen et al., 2012). These climatic changes reduce agricultural productivity, increase production uncertainty and disrupt rural livelihoods.

Although elevated CO_2 concentrations may stimulate photosynthesis and enhance crop growth through a fertilization effect (Lamichaney et al., 2021) these potential gains are often offset by negative outcomes, including reduced nutritional quality of staple crops and increased yield instability under heat and water stress (El Bilali et al., 2020; Mekonnen et al., 2021; Sultan & Gaetani, 2016). Within the SLF, these climatic changes constitute external shocks and stresses operating within the vulnerability context that directly affect households' natural capital through land degradation and declining water availability, physical capital through damage to infrastructure and storage facilities and financial capital through reduced agricultural incomes and increased production risks.

Smallholder farmers are particularly vulnerable because their livelihoods heavily depend on climate sensitive natural resources while possessing limited capacity to anticipate, absorb and recover from climatic shocks (Harvey et al., 2014; Hertel & Rosch, 2010; Jalane et al., 2021; McDowell & Hess, 2012). Limited financial capital constrains investment in improved seed, irrigation technologies and other adaptation measures while deficiencies in human and social capital reduce access to climate information, technical knowledge and collective action necessary for effective adaptation (Adger, 2003; Dorward et al., 2009; Harvey et al., 2014). Consequently, vulnerability is not only determined by exposure to climatic hazards but also by households' differential access to livelihood assets and their capacity to mobilize these resources. Within the SLF, vulnerability therefore emerges from the interaction between

environmental shocks and the socioeconomic conditions that determine households' ability to respond and adapt.

2.2.2. Institutional Processes and Structures

A central component of the SLF is the role of transforming structures and processes which include governance systems, institutions, organizations, policies, legislation and social norms that shape households' access to livelihood assets and opportunities (DFID, 1999; Scoones, 1998). Institutions comprise the formal and informal rules, organizations and governance arrangements that influence how resources are accessed, allocated and managed (North, 1990; Ostrom, 1990). Rather than directly determining livelihood outcomes, they mediate households' ability to access and utilize the five livelihood capitals, thereby shaping livelihood strategies, adaptive capacity and resilience.

Within climate-vulnerable agrarian systems, institutional processes influence food security by determining access to agricultural extension services, climate information, secure land tenure, financial services, markets and rural infrastructure. Effective governance and coordinated institutions facilitate the adoption of climate-smart and sustainable land management practices, strengthen market participation and support long-term investments in productive resources (Aryal et al., 2018; Meinzen-Dick et al., 2019; Opoku et al., 2026). Conversely, weak governance, insecure land tenure, inadequate infrastructure and fragmented institutional arrangements constrain livelihood diversification and reduce households' capacity to adapt to climatic shocks (IPCC, 2022). Within the SLF, institutions therefore link the vulnerability context with livelihood assets by creating the enabling environment through which households build resilience and improve food security.

2.2.3 Livelihood Outcome (Food Security)

Within the SLF, food security is conceptualized as a key livelihood outcome resulting from the interaction between the vulnerability context, livelihood assets, transforming structures and processes, and household livelihood strategies. It encompasses four interrelated dimensions: availability, access, utilization and stability (FAO et al., 2022). Climate change influences these dimensions through multiple and interconnected pathways. Food availability may be constrained through reduced agricultural productivity, crop failure and increased yield variability resulting from droughts, floods, temperature stress and erratic rainfall (IPCC, 2001; Yadav et al., 2019). Food access may be constrained by reduced household incomes, increased food prices and weakened purchasing power (El Bilali et al., 2020), while disruptions to

transport networks, market and rural infrastructure further limit physical access to food (Gregory et al., 2005; Hussain et al., 2016).

Climate change may also affect food utilization by reducing dietary diversity and increasing exposure to climate-sensitive diseases, including vector-borne diseases and water- and food-borne illnesses which undermine nutritional status and overall wellbeing (IPCC, 2007a; Schmidhuber & Tubiello, 2007). Recurrent climatic shocks further undermine food stability by progressively eroding livelihood assets, disrupting income sources and weakening households' resilience to future shocks (Harvey et al., 2014).

Importantly, food insecurity does not arise solely from reductions in agricultural production. Within the SLF, food security outcomes reflect the combined influence of climatic stressors, household asset endowments, institutional processes and livelihood strategies. Structural factors such as poverty, inequality, market access, governance quality, extension services and land tenure mediate households' ability to adapt and sustain food security under changing climatic conditions. Consequently, the SLF provides a comprehensive framework for understanding how climate change interacts with socioeconomic and institutional conditions to shape livelihood resilience and household food security.

2.3 Adaptation strategies and Resilience

Within the SLF, households respond to climatic and socioeconomic shocks by adopting livelihood strategies that reduce vulnerability and sustain livelihood outcomes (DFID, 1999). Adaptation strategies refer to adjustments in natural or human systems in response to actual or anticipated climatic conditions that reduce potential harm or enable households to take advantage of emerging opportunities (Hisali et al., 2011). The choice and effectiveness of adaptation strategies are largely determined by households' access to livelihood capitals and the broader institutional environment.

Common adaptation strategies among smallholder farming households include livelihood diversification, changes in land use and cropping systems, adoption of improved crop varieties, adjustments in planting calendars, water conservation, irrigation and engagement in non-farm income-generating activities (Below et al., 2010; Daba et al., 2025; Deressa et al., 2009; Etana et al., 2021; Jiri et al., 2017). These strategies reduce dependence on climate-sensitive agriculture, spread livelihood risk and strengthen households' capacity to cope with climatic

variability. However, their effectiveness depends on households' access to productive assets, financial resources and institutional support.

Closely linked to adaptation is resilience, defined as the capacity of livelihood systems to absorb, recover from and adapt to climatic and socioeconomic shocks while maintaining essential livelihood functions (Adger, 2000; Folke, 2016; IPCC, 2007a). Within the SLF, resilience is reflected in households' ability to sustain food security and livelihood outcomes despite recurring shocks. Strengthening resilience therefore requires investments in diversified livelihoods, sustainable land management, social protection and inclusive institutions that enhance households' adaptive capacity over time while reducing long-term vulnerability (Barrett et al., 2001; Ellis, 2000).

2.4 Gender, Livelihood Inequalities and Differential Vulnerability

Gender is a cross-cutting dimension within the SLF because it shapes how individuals access, control and benefit from livelihood assets, institutional processes and livelihood opportunities (DFID, 1999; Scoones, 1998). Rather than influencing livelihood outcomes directly, gender mediates access to natural, financial, human, physical and social capital through socially constructed roles, responsibilities and power relations. Consequently, women and men often experience climate risks differently because they possess unequal capacities to anticipate, adapt to and recover from environmental shocks (Vermeulen et al., 2012).

Across many rural settings, women face persistent constraints in accessing productive resources, including land, credit, extension services, agricultural inputs, climate information and decision-making processes (FAO, 2023b; Niang et al., 2014; Nyasimi, Mary & Huyer, 2017). These inequalities are reinforced by institutional arrangements, customary tenure systems and social norms that influence households' opportunities to diversify livelihoods and adopt climate adaptation strategies. Consequently, gender differences in food security often reflect unequal access to livelihood capitals rather than gender itself.

Climate change can further exacerbate these inequalities by increasing women's labor burdens, reducing livelihood options and limiting participation in household and community decision-making (Jost et al., 2015; Le Masson, 2016; Nyasimi & Huyer, 2017). Within the SLF, gender therefore influences both vulnerability and resilience by shaping households access to livelihood assets, institutional support and adaptation opportunities. This perspective provides

the theoretical basis for examining whether differences in household food security reflect the gender of the household head itself or underlying inequalities in access to livelihood resources and adaptive capacity.

2.5 Operationalization of Variables and Analytical Relationships

Guided by the Sustainable Livelihoods Framework (SLF), this study examines the relationships among climate change exposure, livelihood capitals, adaptive capacity, gender, institutional support and household food security. Climate change exposure constitutes the primary independent variable and is represented by household's experiences of climatic stresses and shocks, including changes in rainfall and temperature patterns, droughts, floods, cyclones, and their perceived effects on agricultural production and livelihoods (Annex 3).

The dependant variable is household food security, measured by using a multidimensional approach that incorporated the Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), Household Hunger Scale (HHS), and food-related coping strategies. Together, these indicators capture key dimensions of food security, namely availability, access, utilization, and stability.

Livelihood capitals and adaptive capacity are treated as mediating variables that influence how households respond to climatic shocks and translate available resources into food security outcomes. Livelihood capitals are operationalized through indicators of human, natural, financial, physical, and social capital, including education, household demographics, land ownership, income sources, asset ownership, access to credit, market participation, extension services, climate information, and social networks. Adaptive capacity is reflected in households' access to resources, information, training, and the adoption of adaptation measures such as crop diversification, drought-tolerant varieties, irrigation, soil and water conservation, and livelihood diversification.

Gender and institutional support are conceptualized as moderating variables that shape access to livelihood resources and influence households' ability to respond to climate-related stresses. Gender is operationalized through household-head sex, and household headship status, while institutional support is measured through access to extension services, climate information, markets, credit, and other support mechanisms.

The analytical framework assumes that climate change exposure affects household food security both directly and indirectly through its effects on livelihood capitals and adaptive

capacity. Households with stronger livelihood assets and greater adaptive capacity are expected to be more resilient to climate shocks, while gender and institutional support may moderate these relationships by shaping access to resources and adaptation opportunities. Accordingly, household food security is conceptualized as an outcome of interactions among climatic, livelihood, socioeconomic, institutional and gender-related factors.

3.0 Materials and Methods

3.1 Study Area

The research was conducted in Guijá district, located in Gaza province in southern Mozambique (Figure 2). Administratively, the study area is structured hierarchically, with the district as the highest unit, subdivided into administrative posts which in turn comprise multiple communities. These communities constitute the lowest-level units and form the primary context for household livelihoods and local socio-economic interactions. The district was purposively selected based on three interrelated characteristics. First, Guijá experiences recurrent droughts and pronounced rainfall variability, reflecting high exposure to climate-related shocks. Second, livelihoods are predominantly based on rain-fed smallholder agriculture, increasing sensitivity to climatic fluctuations (FEWS NET, 2025a). Third, the district has been consistently classified in Crisis and Emergency phases by the Integrated Food Security Phase Classification, indicating persistent acute food insecurity (IPC, 2023). Together, these features render Guijá an analytically appropriate context for examining the intersection of climate variability, livelihoods, and household food security within a gender-differentiated framework.

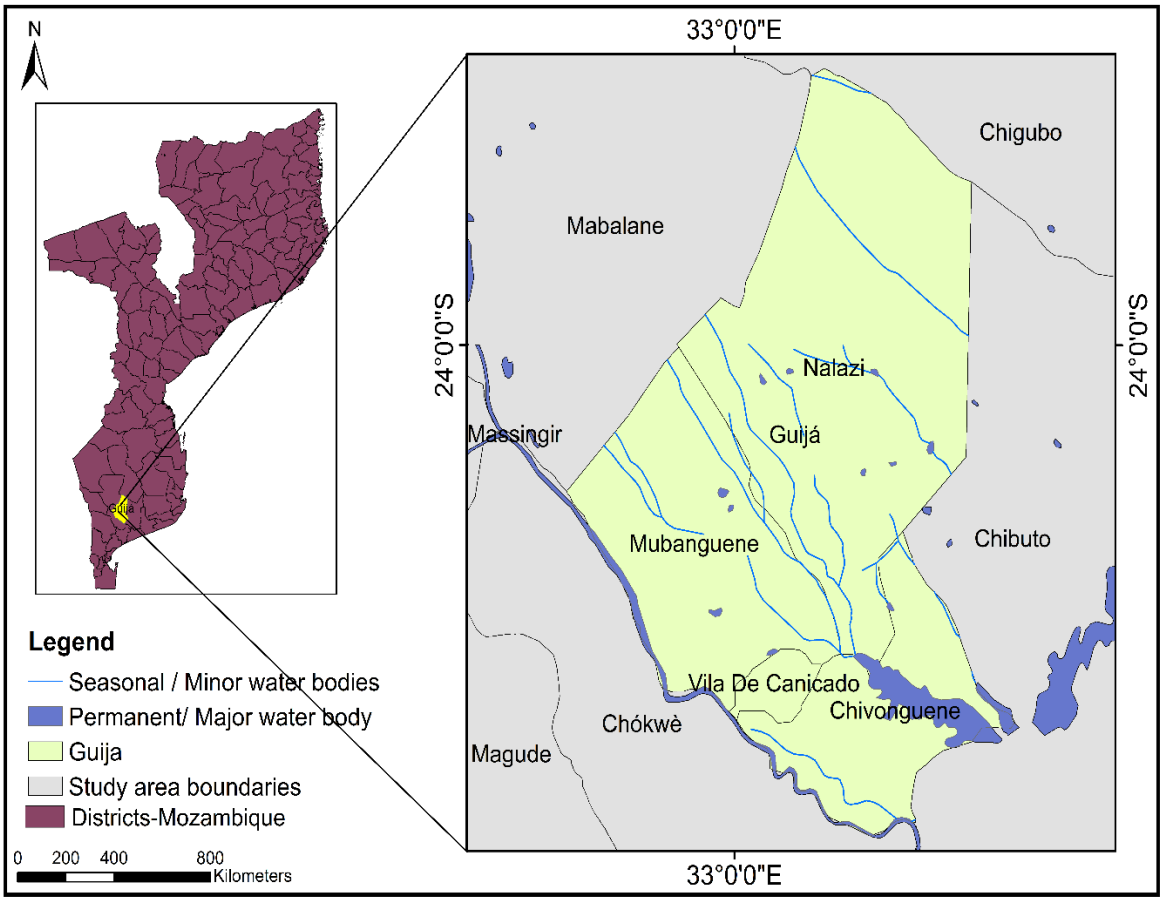


Figure 2: A map showing the study area and water bodies

Source: Authors, 2026

3.2 Study Design

This study employed a cross-sectional quantitative research design to examine the relationship among climate variability, livelihood systems, and household food security among smallholder farming households in Guijá district. Guided by SLF, the design focused on how climate-related shocks, livelihood assets, adaptation strategies, and socioeconomic characteristics influence food security outcomes, while considering gender as a cross-cutting dimension of vulnerability. The design enabled the assessment of food security, livelihood conditions, and associated socio-economic factors at a single point in time, including comparisons between male- and female-headed households. Although cross-sectional designs do not permit causal inference or capture changes over time, they provide an efficient approach for identifying associations among climate-related exposures, livelihood characteristics, gender-related factors, and household food security outcomes.

Specifically, the study examined the interaction between climate variability, livelihood strategies, and household food security outcomes among smallholder farming households in Guijá district. It analyzed livelihood activities, income and food sources, exposure to climate-related shocks and extreme events, socioeconomic characteristics, dietary diversity outcomes, adaptation strategies, and household coping mechanisms. Gender was incorporated through the analysis of male- and female-headed households in consideration of how gender-related inequalities in access to livelihood resources may influence vulnerability and adoptive capacity. This multidimensional approach enabled a comprehensive assessment of the interactions among climate variability, livelihood systems, gender dynamics, socioeconomic conditions and food security outcomes.

3.3 Sampling Strategy

A multi-stage sampling design was employed to select households for this study in Guijá district. This approach was appropriate given the rural setting, spatial heterogeneity of livelihoods, and the absence of a complete and up-to-date household sampling frame, a common limitation in rural sub-Saharan African contexts (Babbie, 2013; Fottrell & Byass, 2008).

In the first stage, all four administrative posts namely, Nalazi, Mubangoene, Caniçado, and Chivongoene were included to capture spatial variation in livelihood systems, market access, and food security conditions across the district. Including multiple administrative posts allowed the study to account for localized environmental, institutional, and socio-economic differences influencing household food security outcomes.

In the second stage, community-level mapping was conducted with the assistance of local leaders and guides to identify settlement patterns and facilitate navigation within each administrative post. The role of local guides was limited to community entry and orientation; they were not involved in selecting households. This step ensured ethical access and reduced coverage errors in the absence of formal household registers (Fottrell & Byass, 2008).

In the third stage, households were selected using a structured random walk systematic sampling procedure. Enumerators began from a predetermined central landmark, typically a local school or village meeting point identified through community mapping exercises and selected every third households along the route. This approach facilitated systematic coverage of settlements while reducing interviewer discretion in household selection.

Despite its practical suitability in contexts where household lists are unavailable, random walk sampling has recognized methodological limitations. Household selection may be influenced by settlement patterns, accessibility, and interviewer movement, potentially introducing selection bias and reducing the probability of reaching more isolated households (Fottrell & Byass, 2008).

To minimize these risks, enumerators followed a standardized protocol, commenced from predefined community landmarks, maintained a fixed sampling interval, and received uniform training on household selection procedures. The use of a systematic interval of every third household also presents a potential risk of periodicity bias if household arrangements follow regular spatial patterns that coincide with the sampling interval (Babbie, 2013). This risk was reduced by varying starting points across communities and applying the procedure across multiple settlements, thereby improving sample coverage and representativeness.

At each selected household, enumerators verified eligibility based on the study's focus on male- and female-headed households. Female-headed households included those where a woman was the primary decision-maker and responsible for household management, such as when she was widowed, divorced, or single. Male-headed households were those where a man was recognized as the primary household head or main provider, including cases where he was temporarily absent but remained responsible for household provision and decision-making. If a selected household did not meet the inclusion criteria or declined participation, the next eligible household was approached.

While household headship is widely used as a gender-disaggregation criterion in rural household surveys, it may not fully capture intra-household gender dynamics, decision-making processes, or bargaining power among household members. Consequently, the findings should be interpreted as reflecting differences between male- and female-headed households rather than the broader gendered experiences of all individuals within households. Overall, this procedure ensured a transparent and systematic household selection process while maintaining methodological rigor in a rural context where comprehensive sampling frames were unavailable.

3.4 Sample Size Determination

The target population comprised all smallholder farming households in Guijá district, estimated at 17,538 households according to the most recent census data from the national institute of statistics (Instituto Nacional de Estatística (INE), 2017). The sample size was determined using Cochran's formula for estimating proportions in large population (Cochran, 1977).

$$n_0 = \frac{z^2 p(1-p)}{e^2} \qquad (1)$$

$$n_1 = \frac{n_0}{1+\frac{n_0-1}{N}}$$

In the absence of prior district-level estimates of food insecurity prevalence, a population proportion (p) of 0.5 was assumed. The use of a 50 percent proportion maximizes variability and produces the most conservative sample size estimate, thereby improving statistical precision. With a 95 percent confidence level (Z = 1.96) and a 5 percent margin of error (e = 0.05), the initial sample size for an infinite population was calculated at 384 households.

Applying a finite population correction for N = 17,538 reduced the required sample to 376 households. An additional 8 percent adjustment was incorporated to account for potential non-response and incomplete questionnaires, resulting in a final target sample of 407 households. This sample size was deemed sufficient to support logistic regression estimation and gender-disaggregated analysis.

3.5 Data Collection and Measures

Data were collected electronically using KoboCollect, a mobile data collection platform that allows real-time entry of responses and incorporates validation checks to reduce missing or inconsistent data during interviews. Data collection was conducted between 20 July and 02 August 2025, coinciding with the post-harvest period in southern Mozambique's predominantly rain-fed agricultural systems. This timing is typically associated with relatively improved food security and nutrition, as households rely on recently harvested food stocks. However, irregular rainfall during the 2024–2025 agricultural season affected production in Gaza province, suggesting that the observed outcomes may still reflect underlying vulnerabilities despite the post-harvest timing.

The questionnaire was developed from established food security and livelihoods assessment frameworks, drawing primarily on standardized measures used by the Food and Agriculture Organization (FAO) and the World Food Program (WFP). Prior to the main survey, the questionnaire was pre-tested among 15 households in a comparable rural community with characteristics similar to those of the study area to assess question clarity, interview duration, cultural appropriateness, translation accuracy, logical sequencing of questions and response categories. Based on the results, minor revisions were made to simplify wording, improve logical flow of sections and ensure the reliability of the survey instrument.

Following these preparations, primary data were collected through structured face-to-face interviews with household heads using a pre-designed questionnaire. The survey captured information on household demographic characteristics, livelihood activities, agricultural production, income sources, access to productive resources, household food security and climate-related shocks. Climate-related shocks were measured using households' self-reported experiences of major climatic events, including drought, flooding, irregular rainfall and rainfall variability. For each event, respondents were asked whether they experienced it during the reference agricultural season and to classify its perceived severity using predefined response categories (not severe and severe). These variables were intended to capture households' perceived exposure to climate-related shocks and their impacts on agricultural production and livelihoods rather than objectively measured meteorological conditions thus, the severity categories should be interpreted as indicators of perceived climatic impacts rather than the actual intensity of climatic events.

Respondents were also asked whether they had observed changes in the suitability of their land for agricultural production during the reference agricultural season. Referred to as *land-use change*, this variable captured households' perceptions of changes in agricultural land suitability and cropping patterns rather than the implementation of specific conservation or ecosystem-based land management practices. Enumerators conducting the interviews were fluent in Portuguese and the predominant local language, Xitsonga (locally referred to as Shangana), which facilitated effective communication with respondents.

Daily quality control procedures were undertaken by the lead researchers to ensure data quality. Quality-control procedures included checks for completeness, logical consistency, duplicate entries, missing responses, GPS verification, and adherence to skip patterns. Any inconsistencies identified were discussed with enumerators during daily debriefing sessions

and corrected where possible through field verification. These procedures enhanced the reliability and accuracy of the final dataset. All procedures adhered to ethical research standards, including voluntary participation, prior informed consent, and the protection of respondent confidentiality.

3.6 Data Analysis

The data were analyzed using Stata version 17. The analysis proceeded in three stages:

1. Descriptive analysis: Households were classified as either food secure or food insecure based on their Food Consumption Scores (FCS) from a seven-day recall period.
2. Inferential analysis: A binary logistic regression model was employed to identify socio-economic and demographic determinants of household food security.
3. Multivariate approach: Applying two interconnected multivariate statistical techniques: Multiple Correspondence Analysis (MCA) and K-Means cluster analysis.

Household food security was operationalized using a multidimensional analytical framework that integrates three standardized indicators: the Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), and Household Hunger Scale (HHS). For regression analysis, the Food Consumption Score (FCS) served as the primary outcome variable and was used to classify households as food secure or food insecure. The HDDS and HHS were analyzed as complementary indicators to capture dietary diversity and experiential dimensions of food insecurity, respectively. This approach ensured analytical consistency while providing a more comprehensive assessment of household food security across multiple dimensions.

The household served as the unit of analysis, and all food consumption measures were assessed at the household level. For each indicator, a food item or food group was considered consumed if it was eaten by the majority of household members during the specified recall period, consistent with established household-level food security assessment protocols.

3.6.1 Econometric Model

To identify determinants of household food security, a binary logistic regression model was applied, given that the dependent variable (household food security status) is dichotomous. The logit model was chosen because it is a best suited technique to model the dependent variable's variation given a set of independent variables. Furthermore, the model is flexible, easy to use and interpret (Fernandes et al., 2020). The model estimates the probability of the household

being food insecure conditional on both socio-economic (e.g., income, household size, education) and biophysical (e.g., irregular rainfall, land use changes) characteristics.

The general form is:

$$logit_{\pi} = \beta_0 + \sum_{i=1}^{9} \beta_i X_i + \varepsilon_i \qquad (2)$$

Where:

πi = probability of a household being food insecure, β0 = intercept, β1… βp = regression coefficients, X1i…., Xpi = predictor variables. εi = error term, X_1- Household head Sex; X_2 – Income level; X_3– Household size; X_4- Administration post; X_5- Access to extension services; X_6- Irregular rainfall; X_7- Income diversification; X_8- Food consumption pattern change; X_9- Market access; X_{10}- Land use changes; X_{11}- Motorcycle ownership; X_{12}- Education level of household head.

3.6.2 Multivariate and K-Means Cluster Analysis Approach

To examine patterns in livelihood strategies, food access options, and household typologies, this study employed a two-stage econometric procedure combining Multiple Correspondence Analysis (MCA) and k-means cluster analysis. This integrated approach is widely applied in livelihood and food security research to uncover latent structures in categorical data and to classify households into internally homogeneous and externally heterogeneous groups (Greenacre, 2017).

The objective of this procedure was to (i) reduce the dimensionality of multiple categorical indicators related to livelihood activities, food sources, and coping strategies, and (ii) construct empirically grounded household typologies that reflect underlying vulnerability and resilience profiles.

Multiple Correspondence Analysis (MCA) was first applied to a set of categorical variables capturing primary and secondary livelihood activities, agricultural diversification, off-farm income engagement, market dependence, food purchase patterns, own-production reliance, social safety net participation, and food-related coping strategies. MCA extends principal component analysis to nominal and ordinal variables by transforming categorical data into a complete disjunctive (indicator) matrix and decomposing it using a chi-square (χ^2) distance metric (Greenacre & Blasius, 2006).

Formally, MCA is based on the decomposition of an indicator (or Burt) matrix, where the χ^2 statistic measures deviations between observed and expected frequencies under the assumption of independence. Categories located proximally in the factorial space are statistically associated, while extracted dimensions represent the principal gradients structuring livelihood strategies and food access configurations.

Each dimension's contribution is summarized by its eigenvalue (λ), representing the share of total inertia explained. Because MCA uses indicator coding, raw eigenvalues tend to inflate explained variance. To correct for this bias, Benzécri's adjustment was applied to obtain a more accurate estimate of substantive inertia. The corrected eigenvalue is expressed as:

$$\check{\lambda} = \frac{D.N_{var}}{D-1}\left(\lambda - \frac{1}{k}\right)^2 \qquad (3)$$

where $\check{\lambda}$ is the corrected eigenvalue, (D) is the total number of individuals (households), N_{var} is the number of active variables, and (k) is the total number of categories. Only dimensions with substantively meaningful corrected inertia and clear interpretability were retained for subsequent clustering.

Factor scores derived from the retained MCA dimensions were then used as inputs into a k-means cluster analysis to construct household typologies. This sequential approach—dimensionality reduction followed by clustering—reduces multicollinearity and noise while ensuring compatibility with distance-based partitioning algorithms (Hair et al., 2019).

The k-means algorithm partitions observations into (k) clusters by minimizing the within-cluster sum of squared deviations from cluster centroids. Formally, the optimization problem is:

$$\min_{C_{1,\dots}C_k} \sum_{r=1}^{k} \sum_{i \epsilon c_r} \| z_i - u_r \|^2 \qquad (4)$$

where z_i represents the MCA factor score vector for household (i), and u_r denotes the centroid of cluster (r) (Hartigan & Wong, 1979; MacQueen, 1967). The algorithm iteratively assigns households to clusters based on Euclidean distance and updates centroids until convergence is achieved.

The optimal number of clusters was determined using a combination of statistical criteria (including the elbow method, within-cluster sum of squares, and silhouette statistics) and

substantive interpretability consistent with livelihood systems theory. Each resulting cluster represents a distinct household typology characterized by shared patterns of livelihood diversification, market integration, production orientation, and food access strategies.

Overall, the combined use of MCA and k-means clustering provides a rigorous multivariate framework for identifying multidimensional livelihood–food security profiles. By capturing latent structures in categorical livelihood data and translating them into empirically derived typologies, this approach strengthens the analytical foundation for subsequent econometric modelling of vulnerability, resilience, and gender-responsive climate-smart agricultural outcomes.

3.6.3 Gender-Differentiated Effects of Climate Shocks on Household Food Security

To account for heterogeneity in household vulnerability, gender is treated as a structural modifier of food security outcomes rather than a simple control variable (Quisumbing et al., 2014). Given the binary nature of food security status, the analysis employs a binary logistic regression model to estimate the probability that household i is food secure:

$$P_i = \Pr(Y_i = 1 \mid X_i, C_i, G_i) \qquad (5)$$

where $Y_i$denotes household food security status, $X_i$represents socioeconomic characteristics, $C_i$captures climate-related shocks, and $G_i$indicates gender (e.g., gender of the household head).

The baseline gender-differentiated model is specified as:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ki} + \sum_{j=1}^{J} \gamma_j \ C_{ji} + \delta G_i \qquad (6)$$

To assess whether climate shocks affect male- and female-headed households differently, interaction terms between gender and climate variables are included:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ki} + \sum_{j=1}^{J} \gamma_j \ C_{ji} + \delta G_i + \sum_{j=1}^{J} \theta_j \ (C_{ji} \times G_i) \quad (7)$$

The interaction coefficients θ_j capture gender-differentiated effects of climate shocks. A negative and significant θ_j indicates that climate stressors disproportionately reduce food security among female-headed households.

The logistic framework is appropriate for dichotomous outcomes and ensures predicted probabilities remain within the [0,1] interval (Cameron, A. Colin & Trivedi, 2005; Wooldridge, 2010). To enhance interpretation and policy relevance, gender-specific marginal effects were computed to quantify how climate shocks influence food security across different household types.

4.0 Results

4.1 Respondent Characteristics

The socioeconomic characteristics of the 407 surveyed households indicate conditions commonly associated with livelihood vulnerability. Nearly half of households (45.95%) comprised seven or more members, exceeding the national average of five and indicating a predominance of larger-than-average households while only 16.46% had small household sizes (1–3 members). The gender distribution of household heads was nearly balanced (51.60% male; 48.40% female), allowing for gender-disaggregated analysis (Table 4).

Educational attainment was limited: 59.95% of respondents had only primary education, and 26.54% had never attended school. Only 13.02% had reached secondary education. The majority of respondents were aged 30–59 years (66.34%), indicating a predominantly mature farming population with limited youth participation. Marital patterns were dominated by cohabiting households (56.76%), followed by widowed (18.18%) and single (16.46%) respondents (Table 4).

Income distribution underscored widespread poverty, as 73.71% of households were classified as low income (≤6,000 MZN), and only 0.25% fell within the upper-middle-income category (Table 4).

Table 4. Showing Sociodemographic characteristics of the respondents

Household Size	Freq.	Percent	Cum.
Small (1-3 members)	67	16.46	16.46
Medium (4-6 members)	153	37.59	54.05
Large (7+ members)	187	45.95	100.00
Total	407	100.00	
Sex			
Female	197	48.40	48.40
Male	210	51.60	100.00
Total	407	100.00	
Education Level			
Informal education	2	0.49	0.49
Primary	244	59.95	60.44
Secondary	53	13.02	73.46
Never attended school	108	26.54	100.00
Total	407	100.00	
Age			
18-29	26	6.39	6.39
30-44	112	27.52	33.91
45-59	158	38.82	72.73
60+	111	27.27	100.00
Total	407	100.00	
Marital Status			
Married	19	4.67	4.67
Divorced	16	3.93	8.60
Single	67	16.46	25.06
Widowed	74	18.18	43.24
Cohabiting	231	56.76	100.00
Total	407	100.00	
Monthly Income			
Low Income (≤6,000 MZN)	300	73.71	73.71
Lower Middle (6,001-20,000 MZN)	106	26.04	99.75
Upper Middle (20,001-50,000 MZN)	1	0.25	100.00
Total	407	100.00	

Household size and Age classification adopted from Instituto Nacional de Estatística (National Statistical Institute of Mozambique) (INE, 2024), Income classification based on Purchasing Power Parities (PPP) (Foster et al., 2025).

4.2 Household Food Security Status

Food security status was assessed using the Food Consumption Score (FCS). Results indicate high prevalence of household food insecurity, with 67.57% of households classified as food insecure, meaning that more than two-thirds experienced inadequate dietary frequency and quality.

Food insecurity varied significantly across communities ($\chi^2 = 18.5214$, $p = 0.000$). Nalazi recorded the highest prevalence (81.67%), followed by Mubangoene (73.72%) and Caniçado

(69.44%), while Chivongoene showed comparatively lower but still substantial food insecurity (55.48%). These findings highlight pronounced intra-district spatial disparities (Table 5).

Although food insecurity was slightly more prevalent among female-headed households (71.07%) than male-headed households (64.29%), the difference was not statistically significant ($\chi^2 = 2.1324$, $p = 0.144$).

Table 5: Household Food Security Status by Community, and Household Head Sex

Category	Group	Food Insecure (%)	Food Secure (%)	χ^2	p-value
Overall FCS	Total (n = 407)	67.57	32.43	–	–
Community	Caniçado	69.44	30.56	18.5214	0.000
	Chivongoene	55.48	44.52		
	Mubangoene	73.72	26.28		
	Nalazi	81.67	18.33		
Sex of household head	Female-headed	71.07	28.93	2.1324	0.144
	Male-headed	64.29	35.71		

4.2.1 Factors Associated with Household Food Security

Binary logistic regression was used to examine the factors associated with household food security. The model was statistically significant (LR $\chi^2(12) = 108.15$, $p < 0.001$) explaining 23.68% of variation in household food security (Pseudo $R^2 = 0.2368$) and correctly classifying 77.84% of households.

Income level emerged as a factor strongly associated to food security: higher-income households were three times more likely to be food secure (odds ratio (OR) = 3.06, $p < 0.001$). Income diversification also significantly increased the likelihood of food security (OR = 2.35, $p = 0.003$), suggesting that households with diversified income sources were more likely to be food secure. Adaptive consumption adjustments (OR = 2.72, $p = 0.047$) and market access (OR = 2.37, $p = 0.040$) was further associated to improved food security outcomes as indicated in Table 6.

Climatic and spatial factors were also associated with household food security. Households reporting irregular rainfall had significantly lower odds of being food secure (OR = 0.56, $p < 0.001$), suggesting that perceived rainfall unpredictability was associated with greater food insecurity among smallholder households. Conversely, households reporting land-use changes had approximately three times more likely to be food secure than those reporting no such changes (OR = 3.05, $p = 0.003$).

Motorcycle ownership was likewise positively associated with household food security (OR = 6.51, p = 0.007, 95% CI: 1.69–25.14) (Table 6). However, the wide confidence interval indicates considerable uncertainty around this estimate and suggests that the magnitude of the association should be interpreted with caution. Given the cross-sectional nature of the data, the observed associations for motorcycle ownership, market access and perceived land suitability change reflect statistical relationships and should not be interpreted as evidence of causality

Sex of household head, household size, education and extension access were not statistically significant predictors of household food security after structural and resource-related factors were controlled.

Table 6. Showing Factors Associated with Household Food Security Status

Food security	Odds ratio	Std. err.	z	P>z	[95% conf.	interval]
Gender						
Male	1.2440	0.3362	0.81	0.419	0.7324	2.1128
Income level	3.0648	0.9309	3.69	0.000	1.6899	5.5582
Household size	0.7946	0.1440	-1.27	0.204	0.5571	1.1334
Admin Post	0.6087	0.1085	-2.79	0.005	0.4292	0.8632
Extension access	0.9280	0.2600	-0.27	0.789	0.5358	1.6070
Irregular rain	0.5619	0.0895	-3.62	0.000	0.4113	0.7677
Income diversification	2.3510	0.6745	2.98	0.003	1.3398	4.1253
Consumption pattern change	2.7156	1.3648	1.99	0.047	1.0141	7.2721
Market access	2.3665	0.9950	2.05	0.040	1.0381	5.3950
Land changes	3.0511	1.1312	3.01	0.003	1.4753	6.3100
Motorcycle	6.5132	4.4887	2.72	0.007	1.6873	25.1427
Education level	1.1595	0.1790	0.96	0.338	0.8567	1.5692
cons	0.0222	0.0362	-2.33	0.020	0.0009	0.5436

4.3 Household Dietary Diversity (HDDS)

Dietary quality was assessed using the Household Dietary Diversity Score (HDDS). Only 13.02% achieved high diversity. These results suggest that although many households may maintain food consumption frequency, dietary diversity remained limited.

Dietary diversity differed significantly across communities ($\chi^2 = 40.8817$, $p < 0.001$). Nalazi recorded the poorest outcomes (41.67% low dietary diversity), whereas Mubangoene showed relatively stronger performance. No significant differences were observed by sex of household head ($\chi^2 = 0.9717$, $p = 0.615$) (Table 7).

Ordered logistic regression indicated that households reporting land-use changes were more likely to have higher dietary diversity ($\beta = 0.859$, $p = 0.001$). Lower-middle income households were also more likely to achieve higher dietary diversity than low-income households ($\beta = 0.575$, $p = 0.031$). In contrast, Nalazi administrative post was significantly less likely to have higher dietary diversity ($\beta = -1.703$, $p = 0.001$). Gender was not significantly associated with household dietary diversity, reinforcing the greater importance of resource access and spatial factors over household headship status (Annex 4)

Table 7: Household Dietary Diversity by Sex of Household Head and Community

Category	Group	Low DD (%)	Medium DD (%)	High DD (%)	χ^2	p-value
Overall HDDS	Total	17.20	69.78	13.02	–	–
Community	Caniçado	19.44	58.33	22.22	40.8817	0.000
	Chivongoene	14.19	68.39	17.42		
	Mubangoene	10.26	80.77	8.97		
	Nalazi	41.67	51.67	6.67		
Sex of household head	Female	15.74	72.08	12.18	0.9717	0.615
	Male	18.57	67.62	13.81		

4.4 Household Hunger Severity (HHS)

The Household Hunger Scale (HHS) provided a measure of severe food deprivation. Overall, 79.12% of households experienced little or no hunger, 20.39% moderate hunger and 0.49% severe hunger. Hunger varied significantly by community ($\chi^2 = 18.1219$, $p = 0.006$), with Nalazi recording the highest severity levels (Table 8).

Gender differences were not statistically significant ($\chi^2 = 0.0038$, $p = 0.998$) (Table 8). Ordered logistic regression showed that households reporting land-use changes were less likely to experience higher levels of household hunger ($\beta = -1.289$, $p < 0.001$) while lower-middle income status was also associated with lower hunger levels ($p = 0.025$) (Annex 5).

The predictive margins further showed that households reporting land use changes had a substantially higher predicted probability of experiencing little or no hunger (84.6%) than households reporting no such changes (62.6%). Correspondingly, the predicted probability of moderate hunger declined from 36.3% to 15.1%, while severe hunger remained uncommon, decreasing from 1.1% to 0.3%. These patterns were virtually identical for female- and male-headed households (Annex 6 & Annex 7), indicating that the association between reported land change suitability for agricultural production and/or changes in the crops cultivated and

household hunger was consistent across household headship, consistent with the non-significant gender interaction effects observed in the regression model

Table 8: Household Hunger Severity by Sex of Household Head and Community

Category	Group	Little Hunger (%)	Moderate Hunger (%)	Severe Hunger (%)	χ^2	p-value
Overall HHS	Total	79.12	20.39	0.49	–	–
Community	Caniçado	94.44	5.56	0.00	18.1219	0.006
	Chivongoene	85.16	14.19	0.65		
	Mubangoene	73.72	26.28	0.00		
	Nalazi	68.33	30.00	1.67		
Sex of household head	Female	79.19	20.30	0.51	0.0038	0.998
	Male	79.05	20.48	0.48		

4.5 Livelihood and Food Options of Respondents in Guijá District

The analysis combined Multiple Correspondence Analysis (MCA) and hierarchical cluster analysis to examine the structure and typologies of household livelihoods in Guijá district. The two techniques provided complementary insights: MCA identified the underlying dimensions structuring livelihood variation, while cluster analysis grouped households into empirically distinct livelihood types based on those dimensions.

4.5.1 Multiple Correspondence Analysis (MCA)

The MCA extracted ten dimensions, of which the first five were retained due to their substantive contribution to explaining variation in livelihood activities (Annex 8).

Dimension 1 (34.17% of total inertia) represented the principal axis of differentiation and contrasted informal, subsistence-oriented, and low-income activities with formal wage and salaried employment and other stable, monetized income sources. This dimension captured the core gradient of economic security.

Dimension 2 (11.19%) reflected market-oriented agricultural engagement, distinguishing households involved in crop, fruit, livestock, and forest product sales from those primarily producing for subsistence.

Dimension 3 (7.29%) characterized vulnerable and irregular income strategies, including petty trade, shepherding, remittance dependence, and small-scale natural resource sales.

Dimensions 4 (3.92%) *and 5* (1.51%) captured more specialized livelihood orientations, particularly forest-based production, artisanal activities, and skilled value-added work.

Collectively, these five dimensions revealed a multidimensional livelihood spectrum ranging from highly vulnerable, subsistence-based strategies to diversified, market-integrated, and wage-based livelihoods with greater economic stability.

4.5.2 Cluster Analysis

Using the retained MCA dimensions as input variables, hierarchical cluster analysis identified four distinct livelihood clusters, each representing a coherent combination of income sources, market engagement, and livelihood security (Annex 9).

Cluster 1 (5.41%) – Highly Vulnerable, Low-Return Livelihoods. This group was characterized by strong negative scores on the primary MCA dimensions. Households relied predominantly on subsistence farming, irregular crop and fruit sales, shepherding, alcohol sales, and remittances. Engagement in wage employment and commercial agriculture was minimal, indicating limited coping capacity and high livelihood insecurity.

Cluster 2 (53.56%) – Semi-Vulnerable Mixed Livelihoods. The largest cluster combined petty trading, sporadic wage labor, small-scale agricultural commercialization, and remittances. While some diversification and partial market integration were evident, income streams remained unstable, and households continued to face economic precarity.

Cluster 3 (8.60%) – Market-Integrated and Resource-Enhanced Livelihoods. Households in this cluster scored positively on the market-oriented and resource-based dimensions. They actively engaged in commercial agriculture, forest product sales, and artisanal production, demonstrating stronger diversification, productivity, and market connectivity.

Cluster 4 (32.43%) – Wage- and Salary-Based Livelihoods. Defined by strong positive alignment with the economic security dimension, this group depended primarily on stable wage and salaried employment, including public sector jobs, private employment, and non-farm enterprises. These households exhibited relatively higher economic security and reduced dependence on agricultural or natural resource extraction.

Together, the MCA and cluster analysis demonstrated pronounced socio-economic differentiation within the study population. The MCA established the structural axes of livelihood variation, while the cluster analysis translated these dimensions into four empirically

grounded livelihood typologies. Although over half of households fell within the semi-vulnerable mixed-livelihood group, a substantial share relied on wage-based employment, and smaller but critical segments represented either acute vulnerability or strong market integration. These distinctions provide a robust analytical foundation for designing climate-smart and gender-responsive interventions tailored to the specific constraints, capacities, and risk profiles of each livelihood group.

4.6 Gender-Differentiated Effects of Climate Shocks on Household Food Security

Table 9 presents the results of the binary logistic regression model examining the effects of climate shocks and gender interactions on household food security among smallholder farming households.

The coefficient for male-headed households was positive but not statistically significant ($\beta = 0.372$, $p = 0.491$), indicating that, after controlling for climate shocks, there was no statistically significant difference in the likelihood of food security between male- and female-headed households. This finding suggests that gender of household head alone does not independently determine food security outcomes once environmental stressors are accounted for.

Among the climate-related variables, severe insufficient rainfall was negatively associated with household food security ($\beta = -0.893$, $p = 0.042$), indicating that households reporting severe rainfall deficits were less likely to be food secure. Severe flooding ($\beta = 1.030$, $p = 0.012$) and severe rainfall variability ($\beta = 1.310$, $p = 0.004$) were positively associated with food security.

The interaction terms between gender and climate shocks were also statistically insignificant across all specifications. This suggests that the effects of climate shocks on household food security did not differ systematically between male- and female-headed households in this sample. In other words, climate stressors appear to affect household food security similarly regardless of the gender of the household head.

Finally, the model constant was negative and statistically significant ($\beta = -1.236$, $p = 0.002$), indicating a relatively low baseline probability of food security when all explanatory variables are held at zero.

Overall, the results indicated that rainfall-related shocks particularly insufficient rainfall and rainfall variability played a more decisive role in shaping household food security outcomes than gender alone. ***While female-headed households are often assumed to be more***

vulnerable, the findings suggest that structural climate exposure may be a more immediate determinant of food security among smallholder farming households in the study area.

Table 9. Estimates of climate shocks and gender effects on household food security

Variables	Coefficient (β)	Std. Err.	z	p-value	[95% conf.	interval]
Gender (Ref: Female-headed)						
Male-headed	0.372	0.540	0.69	0.491	−0.686	1.431
Climate shocks						
Severe drought	−0.788	0.515	−1.53	0.126	−1.798	0.222
Severe temperature	0.349	0.399	0.88	0.382	−0.432	1.130
Severe insufficient rainfall	−0.893	0.438	−2.04	0.042	−1.752	−0.034
Severe flooding	1.030	0.408	2.53	0.012	0.231	1.829
Severe cyclones	−0.216	0.978	−0.22	0.826	−2.133	1.702
Severe storms	−1.217	1.270	−0.96	0.338	−3.707	1.273
Severe rainfall variability	1.310	0.455	2.88	0.004	0.418	2.202
Interaction terms (Male × Shock)						
Male × Drought	0.362	0.696	0.52	0.603	−1.002	1.726
Male × Temperature	−0.324	0.536	−0.60	0.546	−1.375	0.727
Male × Insufficient rainfall	0.114	0.571	0.20	0.842	−1.006	1.234
Male × Flooding	−0.791	0.565	−1.40	0.161	−1.898	0.316
Male × Cyclones	0.203	1.381	0.15	0.883	−2.504	2.910
Male × Storm	−0.509	1.731	−0.29	0.769	−3.902	2.884
Male × Rainfall variability	0.208	0.618	0.34	0.736	−1.003	1.420
Constant	−1.236	0.393	−3.15	0.002	−2.007	−0.466

4.6.1 Gender-Specific Marginal Effects of Climate Shocks on Household Food Security

Table 10 presents the gender-specific marginal effects of climate shocks on the probability of household food security. Severe insufficient rainfall significantly reduced food security for both household types, decreasing the probability by 14.7 percentage points for female-headed households (dy/dx = −0.147, p = 0.023) and by 15.3 percentage points for male-headed households (dy/dx = −0.153, p = 0.023).

Conversely, rainfall variability (a measure of how unpredictable rainfall is) was positively associated with the probability of household food security for both household types, raising the probability by 23.6 percentage points for female-headed households (p = 0.002) and by 31.9 percentage points for male-headed households (p < 0.001). Flooding was also positively associated with the probability of household food security among female-headed households (dy/dx = 0.205, p = 0.018), though the effect was not significant for male-headed households.

Other shocks including drought, temperature extremes and cyclones did not show statistically significant effects. However, storms significantly reduced food security among male-headed households (dy/dx = −0.263, p = 0.018). Overall, the results highlight rainfall-related shocks

as the most influential climatic drivers of household food security, with broadly similar effects across gender groups.

Table 10. Marginal Effects of Climate Shocks on Household Food Security by Gender of Household Head

Climate Shock	Gender	dy/dx	Std. Err.	z	p-value	[95% conf.	interval]
Drought	Female	-0.143	0.094	-1.52	0.128	-0.328	0.041
	Male	-0.088	0.096	-0.91	0.363	-0.276	0.101
Temperature	Female	0.061	0.069	0.88	0.377	-0.074	0.195
	Male	0.005	0.073	0.07	0.945	-0.138	0.148
Insufficient rainfall	Female	-0.147	0.065	-2.27	0.023	-0.274	-0.020
	Male	-0.153	0.067	-2.28	0.023	-0.284	-0.021
Flooding	Female	0.205	0.087	2.37	0.018	0.035	0.374
	Male	0.050	0.083	0.60	0.549	-0.113	0.213
Cyclone	Female	-0.036	0.158	-0.23	0.819	-0.347	0.274
	Male	-0.003	0.198	-0.01	0.990	-0.391	0.385
Storm	Female	-0.167	0.126	-1.32	0.185	-0.414	0.080
	Male	-0.263	0.111	-2.36	0.018	-0.481	-0.044
Rainfall variability	Female	0.236	0.077	3.08	0.002	0.086	0.386
	Male	0.319	0.078	4.07	0.000	0.165	0.472

5.0 Discussions

5.1 Household Food Security Status: A Multidimensional and Spatially Differentiated Reality

The findings reveal that food insecurity in Guijá district is predominantly structural rather than episodic, arising from the combined effects of climate exposure, livelihood constraints and spatial inequalities. Evidence from the Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS) and Household Hunger Scale (HHS) reveals a nuanced pattern: although households generally maintained sufficient food consumption to avoid severe hunger, dietary diversity remained low. This finding is consistent with evidence from rural smallholder systems where households often prioritize maintaining minimum caloric intake through inexpensive staple foods while reducing consumption of more diverse and nutrient-rich foods during periods of livelihood stress (Hirvonen et al., 2017; Murendo et al., 2020). Such consumption smoothing may prevent acute hunger in a short term but often results to persistent nutritional vulnerability.

Taken together, these findings a pattern of hidden food insecurity, whereby households maintain food consumption sufficient to avoid severe hunger while continuing to experience poor dietary quality and nutritional adequacy (Pereira & Hodge, 2015). Unlike hidden hunger,

which specifically refers to deficiencies in essential micronutrients despite adequate caloric intake (Muthayya et al., 2013), hidden food insecurity reflects broader limitations in dietary diversity, food quality and the long-term sustainability of household food access. This pattern has been widely reported in climate-vulnerable rural settings where recurrent livelihood stress compels households to prioritize food quantity over dietary quality, thereby reducing resilience to future climatic and economic shocks (FAO et al., 2022; Maxwell et al., 2013).

Food insecurity was also spatially differentiated across administrative posts, reflecting variations in agro-ecological conditions, climate exposure, infrastructure and market access. Communities highly dependent on rain-fed subsistence agriculture and with limited non-farm opportunities, particularly the Nalazi administrative post, exhibited greater vulnerability. These findings highlight the importance of place-based factors within the Sustainable Livelihoods Framework, where access to livelihood assets, services and opportunities varies across locations.

Differences in agro-ecological potential, market connectivity, rural infrastructure and access to livelihood opportunities are likely to influence households' capacity to diversify income sources, adopt adaptive practices and cope with climatic shocks, thereby contributing to the observed spatial disparities in food security. Similar spatial disparities have been documented across sub-Saharan Africa, where differences in agro-ecological conditions, market integration and infrastructure development contribute to uneven food security outcomes (Morton, 2007; The World Bank Group, 2025). Consistent with these studies, the present findings demonstrate that household food security is not only shaped by household socioeconomic characteristics but also by the spatial distribution of livelihood opportunities, institutional support and adaptive capacity.

5.2 Livelihood Strategies and the Limits of Diversification

Livelihood structure emerged as a fundamental determinant of household food security in Guijá district. Consistent with the Sustainable Livelihoods Framework, households combined agricultural, natural resource-based, wage and non-farm activities to spread risk and sustain their livelihoods under conditions of climatic and economic uncertainty. The positive association between income diversification and household food security suggests that households with multiple income sources were better able to buffer fluctuations in agricultural production and maintain access to food than those relying on a single livelihood activity. Similar findings have been reported in several sub-Saharan African countries, where

diversified livelihood portfolios strengthen resilience by reducing dependence on rain-fed agriculture and providing alternative income during periods of climatic stress (Barrett et al., 2001; Ellis & Freeman, 2004; Loison, 2015).

However, the findings also demonstrate that diversification alone is insufficient to guarantee improved food security. The predominance of mixed and semi-vulnerable livelihood clusters suggests that diversification in Guijá largely reflects a survival strategy rather than a pathway to economic advancement. Many households appear to diversify because returns from agriculture alone are inadequate to meet household needs, forcing them to combine several low-return activities instead of investing in more productive livelihood opportunities. Consequently, diversification spreads livelihood risks but may generate only limited improvements in household welfare. This finding supports the distinction between distress diversification and opportunity-driven diversification described by (Barrett et al., 2001), where households diversify either because they are compelled to cope with shocks or because they possess sufficient assets to exploit new economic opportunities. The predominance of the former suggests that diversification in the study area is constrained by limited productive assets, weak market integration and restricted access to remunerative employment.

In contrast, households engaged in market-integrated and resource-enhanced livelihoods exhibited comparatively stronger food security, indicating that the quality of livelihood opportunities is more important than the mere number of livelihood activities undertaken**.** Engagement in commercial agriculture, artisanal production and forest-based enterprises provides more stable income streams, greater market participation and opportunities for value addition, thereby strengthening households' ability to access food and diversify diets (Adjognon et al., 2016; Carletto et al., 2017; Haggblade et al., 2010; Harris & Orr, 2014; Von Braun & Kennedy, 1994). These findings suggest that livelihood diversification contributes most effectively to food security when it is supported by productive assets, functioning markets and opportunities for higher-value economic activities.

An equally important finding was the relatively weak performance of wage-dependent households. Although wage employment is often regarded as a pathway out of poverty, the results suggest that the security of employment depends on its quality rather than on participation alone. In rural Guijá, wage opportunities are likely to be informal, seasonal and poorly remunerated, limiting their capacity to provide stable household income or protect against food price fluctuations (Bernstein, 2010; Headey & Martin, 2016; Maxwell et al., 2013;

OECD, 2024). This finding highlights the importance of distinguishing between secure and precarious employment when evaluating the contribution of non-farm livelihoods to household food security.

The livelihood typologies further illustrate that households occupying the most vulnerable clusters remain constrained by limited livelihood assets and dependence on subsistence agriculture and remittances, conditions that are characteristic of poverty traps (Carter & Barrett, 2006). Taken together, these findings suggest that improving household food security requires more than promoting livelihood diversification alone. Rather, interventions should strengthen households access to productive assets, remunerative markets, financial services and higher-value livelihood opportunities so that diversification becomes a pathway to resilience and accumulation rather than merely a copying strategy.

5.3 Economic Capacity and Climate Resilience

Economic capacity emerged as a key determinant of household food security, reinforcing the central proposition of the SLF that financial and physical assets enable rural households to absorb shocks and sustain livelihoods under conditions of uncertainty (DFID, 1999; Scoones, 1998). Beyond increasing purchasing power, higher incomes provide households with greater flexibility to diversify food sources, invest in productive activities and smooth consumption during periods of climatic or economic stress. Similar relationships have been consistently reported across sub-Saharan Africa where higher income strengthen resilience by improving households' capacity to cope with production failures and market disruptions (Barrett et al., 2001; D'Errico & Giuseppe, 2018; Niazi et al., 2025).

The importance of assets extended beyond income alone. Market access and productive assets particularly land and motorcycle ownership, were also associated with household food security, suggesting that households benefit not only from the resources they possess but also from their ability to convert those resources into livelihood opportunities. Improved mobility enhances access to markets, agricultural inputs and employment opportunities (Kassie et al., 2014; Mwangi et al., 2020; Rajasooriar & Soma, 2022; Shifat et al., 2025). Similarly, productive land investments enhance agricultural productivity and strengthen adaptive capacity (Egerson et al., 2025; Thamaga-chitja et al., 2025).. These findings reinforce the SLF by illustrating how financial, physical and natural capital interact to strengthen household resilience.

The positive association between land-use changes and household food security suggests that households reporting adjustments in agricultural production conditions were more likely to be food secure than those reporting no such changes. These adjustments may reflect responses to changing environmental conditions through modifications in crop choice or land management. However, because this study did not identify the specific practices adopted, it is not possible to determine whether these changes involved ecosystem-based approaches, conservation practices, agricultural expansion or other forms of land management.

Nevertheless, the findings have important implications for Nature-based solutions, which are defined as actions that protect, sustainably manage and restore ecosystems while simultaneously addressing societal challenges and enhancing human well-being (IUCN, 2020). Although specific nature-based interventions were not directly assessed in this study, ecosystem-based practices such as agroforestry, conservation agriculture, soil and water conservation and ecosystem restoration have been widely shown to improve soil fertility, increase water retention and strengthen ecosystem resilience under climate stress (IUCN, 2020; Seddon et al., 2020). Future interventions in Guijá district could therefore promote these practices as potential strategies for strengthening household food security and climate resilience. However, further research is needed to determine which ecosystem-based practices are currently adopted and how they influence household food security.

Alongside these socioeconomic factors, climatic stress remained a significant constraint on household food security. The negative association between irregular rainfall and food security highlights the continued vulnerability of rain-fed agricultural systems to climate variability. Households reporting irregular rainfall experienced lower odds of food security, suggesting that persistent unpredictability in rainfall undermines agricultural planning, reduces production stability and limits households' ability to secure consistent food supplies. Similar findings have been reported across southern Africa where rainfall variability remains a major driver of food insecurity among smallholder farming households (Cristhina et al., 2025; Hübler et al., 2025; Matchaya et al., 2022). These effects are often exacerbated by inadequate infrastructure, weak institutional support and limited access to productive resources, which constrain households' adaptive capacity and resilience (Dessie et al., 2022; Wubetie et al., 2024).

The contrasting association observed across rainfall-related variables further demonstrate that climate-food security relationships are highly context-specific. While irregular and insufficient rainfall were consistently associated with lower food security, the positive statistical

associations observed for flooding and rainfall variability should not be interpreted as evidence that these climatic events improve household welfare. Rather, they suggest that households' experiences of climate shocks differ according to their livelihood assets, adoptive strategies and resource endowments. In flood-prone farming systems such as Guijá, for example, some households may temporarily benefit from residual soil moisture, flood-recession cultivation or other locally adapted production practices, whereas others remain highly vulnerable depending on their livelihood assets and capacity to respond to climatic stress. These findings therefore illustrate that the influence of rainfall-related shocks on food security cannot be generalized across households or climatic events.

This interpretation is consistent with the SLF which conceptualizes climate shocks as part of the vulnerability context whose effects are mediated by households' access to natural, financial, physical, human and social capital (DFID, 1999; Scoones, 1998). Accordingly, similar climatic events may generate different food security outcomes depending on the households' livelihood assets, adaptive capacity and institutional support. This perspective is further supported by (IPCC, 2022), which emphasize that climate impacts are not only shaped by hazard exposure but also by vulnerability and adaptive capacity. Collectively, these findings highlight the need to strengthen livelihood assets, institutional support and ecosystem based adaptation to enhance resilience among smallholder farming households.

5.4 Gender, Livelihood Assets and Structural Determinants Food Security

The findings suggest that household food security in Guijá is shaped more by access to livelihood assets than by the gender of the household head itself. Although female-headed households exhibited slightly higher levels of food insecurity descriptively, these differences disappeared after accounting for income, livelihood assets, market access and other socioeconomic factors. This indicates that disparities in food security are more closely associated with unequal access to productive resources than with household headship alone.

This finding contrasts with studies from sub-Saharan Africa that report greater food insecurity among female-headed households due to persistent inequalities in access to land, labor, credit and agricultural inputs (Doss et al., 2015; Njuki et al., 2022; World Bank Group, 2023). However, it is consistent with growing evidence that gender differences become less pronounced once differences in livelihood assets and economic opportunities are adequately accounted for. Studies have consistently shown that improving women's access to productive

resources, incomes and decision making enhances household dietary diversity and food security regardless of headship (Jemaneh & Shibeshi, 2023; Larson et al., 2019; Soh Wenda et al., 2024). The present findings therefore suggest that the apparent gender gap in food security may largely reflect unequal access to livelihood capitals rather than gender itself.

This interpretation aligns closely with the SLF, which recognizes gender as a cross-cutting social factor that shapes access to and control over natural, financial, human, physical and social capital (DFID, 1999; Scoones, 1998). Accordingly, gender influences food security primarily through its effects on access to productive resources, livelihood diversification and adaptive capacity rather than acting as an independent determinant of food security. Policies should therefore focus on reducing structural inequalities in access to productive resources and other livelihood assets rather than targeting household headship alone.

The absence of statistically significant effects for education, household size and extension service access further reinforces the multidimensional nature of household food security. Although these variables are widely recognized as important determinants of agricultural productivity and rural livelihoods, their influence may be mediated through broader socioeconomic conditions such as income, productive assets, market participation and livelihood diversification. Within the SLF, this finding illustrates that individual livelihood capitals rarely operate in isolation; instead, food security emerges from the interaction of multiple assets, institutional processes and contextual factors. This underscores the need for integrated interventions that simultaneously strengthen household assets, market opportunities and institutional support rather than focusing on single determinants in isolation.

5.5 Conclusion

This study demonstrates that household food security in Guijá district is closely associated with economic capacity, livelihood diversification, market access, productive assets, adaptive land-use practices and climate exposure. Higher income levels, diversified livelihoods, market access, land-use adaptation and motorcycle ownership were positively associated with food security, whereas irregular rainfall and spatial location were associated with lower odds of households being food secure.

Although descriptive differences existed between male- and female-headed households, gender did not emerge as an independent predictor once socioeconomic and livelihood factors were

controlled for, suggesting that gendered disadvantages operate indirectly through access to resources and livelihood opportunities.

The findings indicate that food insecurity in Guijá district is chronic, structurally embedded and spatially differentiated. Policy responses should therefore prioritize climate-resilient and Nature-Based Solutions, including agroforestry, conservation agriculture, sustainable land management, ecosystem restoration and soil and water conservation, alongside livelihood diversification, improved rural market infrastructure and targeted support for asset accumulation. Integrating these ecosystem-based approaches with climate-smart agriculture can strengthen household resilience while simultaneously improving food security and environmental sustainability.

5.6 Recommendations

Based on the empirical findings, addressing chronic food insecurity in Guijá district requires integrated, geographically targeted, and livelihood-sensitive interventions. Policies should prioritize strengthening household economic resilience through income diversification, improved access to productive assets and credit, and enhanced market integration supported by investments in rural infrastructure and value chains. Income diversification initiatives should focus on expanding access to non-farm employment opportunities, small-scale enterprise development, vocational skills training, and value-added agricultural activities, while market integration efforts should emphasize improvements in feeder roads, storage facilities, market information systems, and farmer participation in value chains.

Climate-adaptive and nature-based agricultural systems including agroforestry, conservation agriculture, sustainable land management, soil and water conservation, ecosystem restoration, small-scale irrigation, drought-tolerant crops and climate-smart practices should be scaled up to reduce dependency on erratic rainfall while strengthening ecosystem resilience and household food security. Extension services currently playing a limited role, should be strengthened and tailored to context-specific and market-linked models that align with local livelihood realities. Implementation of these interventions will require coordinated action among district and municipal authorities, the Ministry of Agriculture and Rural Development, agricultural extension services, the National Institute for Disaster Risk Management and Reduction (INGD), development partners, Non-Governmental Organizations and farmer cooperatives operating within the district.

Finally, interventions must address structural barriers particularly inequitable access to land, assets, credit, and decision-making power that indirectly shape food insecurity outcomes, ensuring that resilience-building strategies are inclusive and socially responsive. Particular attention should be given to strengthening women's access to productive resources and financial services, given the indirect role of gendered inequalities in shaping food security outcomes. Social protection programs targeting highly vulnerable and wage-dependent households should also be expanded to reduce exposure to income and food consumption shocks.

In terms of implementation, short-term priorities (1–2 years) should focus on strengthening social protection mechanisms, improving access to climate information and extension services, and supporting household livelihood diversification. Medium-term interventions (3–5 years) should prioritize investments in rural market infrastructure, irrigation development, value-chain strengthening, and financial inclusion. Long-term strategies (beyond 5 years) should address structural constraints through land tenure reforms, climate-resilient infrastructure development, and policies that promote inclusive rural transformation.

To ensure effectiveness, intervention programs should incorporate robust monitoring and evaluation systems using measurable indicators related to household food security, income diversification, market participation, adoption of climate-smart agricultural practices, and access to productive assets. Periodic assessments should evaluate the efficiency, effectiveness, relevance, and sustainability of implemented interventions, allowing for adaptive management and evidence-based policy refinement over time.

5.7 Limitations and Implications for Future Research

This study is subject to several limitations. First, the cross-sectional design restricts causal inference and limits the ability to capture seasonal and interannual variability in food security outcomes. Second, while the integration of Food Consumption Score (FCS), Household Hunger Scale (HHS), and Household Dietary Diversity Score (HDDS) strengthens multidimensional assessment, the analysis remains primarily quantitative and does not fully capture intra-household dynamics or power relations influencing food access. Third, climatic exposure was assessed using households' self-reported experiences of climatic events rather than objective meteorological or agro-ecological data. Consequently, the classification of severe and not severe climate events reflects respondents' perceived impacts on their

livelihoods rather than the physical intensity of rainfall, flooding or temperature extremes. While perception-based measures are valuable for understanding household vulnerability and behavioral responses, they may be influenced by recall bias and individual experiences. Future research should integrate household survey data with meteorological records and spatial climate datasets to strengthen the assessment of climate-food security relationships.

Future research should adopt longitudinal or panel designs to examine the temporal dynamics of food insecurity and resilience. Mixed-method approaches incorporating qualitative inquiry would deepen understanding of gendered power relations, adaptive strategies, and institutional effectiveness. Further investigation into the interaction between climate variability, market systems, and livelihood transitions would also enhance policy relevance, particularly in disaster-prone rural contexts.

5.8 Overall Contribution

This study contributes to food security scholarship by providing fine-grained, community-level evidence of the structural and spatial determinants of chronic food insecurity within a climate-vulnerable district. By integrating consumption-based (FCS), experiential (HHS), and dietary quality (HDDS) indicators, it advances multidimensional measurement approaches beyond single-metric assessments.

The findings challenge simplified assumptions regarding livelihood diversification, wage employment, and gender, demonstrating that food security outcomes are mediated primarily through asset ownership, income structures, market integration, and decision-making power.

Methodologically, the study strengthens localized empirical analysis in rural, disaster-prone settings. Substantively, it underscores the need for integrated, geographically differentiated and structurally informed policy responses. By integrating livelihood assets, institutional processes, climate exposure and multidimensional food security indicators, the study extends application of the Sustainable Livelihoods Framework while demonstrating how nature-based solutions can be embedded within livelihood-based adaptation strategies in climate-vulnerable agrarian systems.

6.0 Ethical statement

6.1 Credit authorship contribution statement

Martha Among Adeke: Investigation, designing methodology, methodology, data curation, visualization, formal analysis, writing the original draft and funding acquisition.

Luís Artur: conceptualization, supervision, reviewing & editing, validation and project administration.

Sandre José Macia: Methodology, formal analysis, review and editing, visualization.

All authors read and approved the final manuscript.

6.2 Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

6.3 Funding

This publication will be funded by the regional Center of Excellence in Agrifood Systems and Nutrition (CE-AFSN).

6.4 Data availability

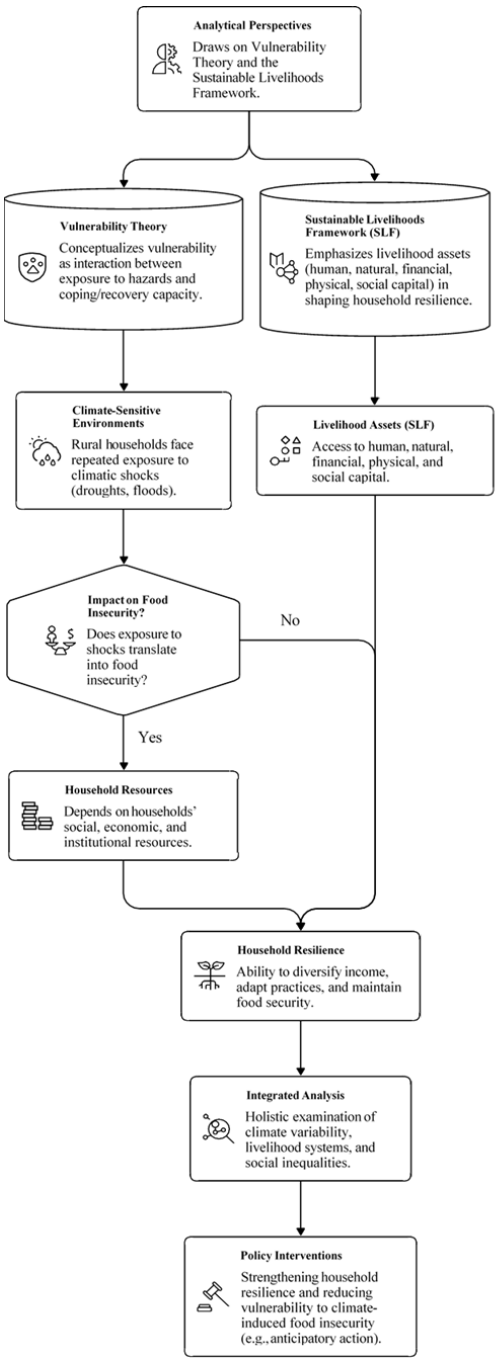
Data will be made available on request.

6.5 Acknowledgments

The authors would like to express their sincere gratitude to the administrators of Guijá district and the local communities within the district Additionally, we thank the respondents who generously shared their time and insights, contributions that were invaluable to this study. Furthermore, we extend our appreciation to the Regional Center of Excellence in Agrifood Systems and Nutrition (CE-AFSN) for funding this publication.

7.0 Annexes

Annex 3: Showing analytical framework for climate-induced food insecurity



Source: Authors 2026, Adapted from DFID, 1999

Annex 4: Ordered logistic regression for Household Dietary Diversity (HDDS)

Variable	Coefficient	Std. Error	z	p-value
Gender (ref: Female)				
Male	−0.048	0.222	−0.22	0.829
Income level (ref: Low)				
Lower middle	0.575	0.267	2.16	0.031
Upper middle	0.486	2.135	0.23	0.820
Administrative post (ref: Caniçado)				
Chivongoene	−0.127	0.428	−0.30	0.766
Mubangoene	−0.277	0.439	−0.63	0.528
Nalazi	−1.703	0.495	−3.44	0.001
Land-use change (Yes)	0.859	0.260	3.30	0.001
Market access	−0.163	0.319	−0.51	0.609
Household size	−0.278	0.152	−1.83	0.067
Lack of irrigation	0.191	0.235	0.81	0.416
Education level	−0.045	0.129	−0.35	0.730
Age	−0.126	0.128	−0.98	0.326

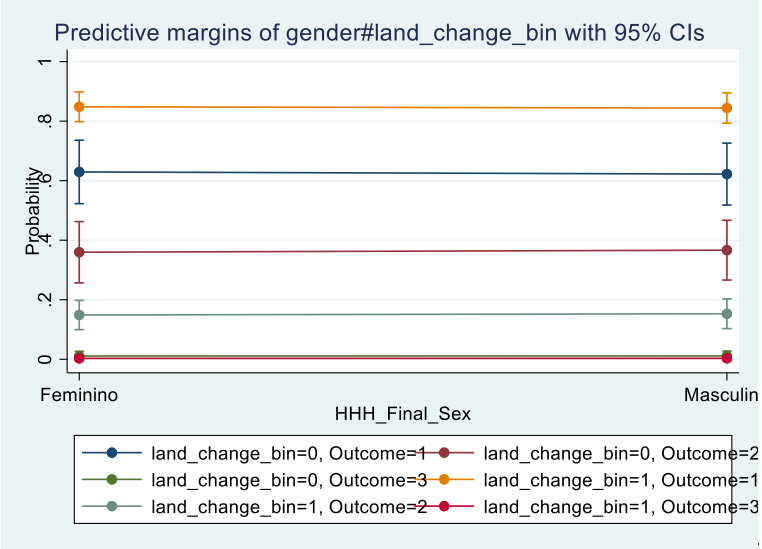
Annex 5: Ordered logistic regression results for Household Hunger Severity (HHS)

Variable	Coefficient	Std. Error	z	p-value
Gender (Male)	0.034	0.262	0.13	0.895
Income (Lower middle)	−0.803	0.358	−2.25	0.025
Income (Upper middle)	−11.299	451.648	−0.03	0.980
Mubangoene	1.785	0.781	2.28	0.022
Nalazi	2.156	0.813	2.65	0.008
Land-use change (Yes)	−1.289	0.285	−4.52	0.000
Market access	−0.506	0.353	−1.43	0.151
Household size	0.154	0.179	0.86	0.390
Lack of irrigation	−0.267	0.285	−0.93	0.350

Annex 6: Predicted Probabilities of HHS by Land-Use Change and Household Head Sex

Sex of household head	Land-use change	Little / No Hunger	Moderate Hunger	Severe Hunger
Overall	No	0.626	0.363	0.011
	Yes	0.846	0.151	0.003
Female-headed	No	0.629	0.360	0.011
	Yes	0.848	0.149	0.003
Male-headed	No	0.622	0.367	0.011
	Yes	0.844	0.153	0.003

Annex 7: Predicted probabilities of HHS by gender and land-use change



Annex 8: MCA Dimension Contributions and Retained Axes

MCA Dimension	Inertia Explained %	Cumulative %	Interpretation
Dimension 1	34.17	34.17	Formal wage-based vs. informal/ subsistence livelihoods
Dimension 2	11.19	45.35	Market-oriented agricultural production
Dimension 3	7.29	52.65	Subsistence-oriented & vulnerable livelihoods
Dimension 4	3.92	56.56	Forest-based and artisanal activities
Dimension 5	1.51	58.07	Skilled informal & value-added artisanal work
Dimensions 6–10	<1 each	~100	Minimal explanatory value

Annex 9: Integrated Livelihood Clusters and their Structural Positioning Across MCA Dimensions in Guijá district

Cluster	Livelihood Type	Households (%)	Dominant MCA Dimensions	High-Contribution Livelihood Activities	Overall Profile
1	Highly Vulnerable, Low-Return	5.41	Dim 1–3 (negative coordinates)	Crop sale; Remittances; Fruit sale; Shepherding	Subsistence-based activities, irregular income sources, weak market integration, and high livelihood insecurity (high contribution, negative coordinates, strong squared correlations).

2	Semi-Vulnerable Mixed Livelihoods	53.56	Dim 1 (mild negative), Dim 3 (positive)	Petty trading; Remittances	Diversified but unstable income sources, partial market engagement, moderate contribution and mixed coordinates reflecting transitional livelihood status.
3	Market-Integrated & Resource-Enhanced	8.60	Dim 2 and Dim 4 (positive coordinates)	Crop sale; Fruit sale; NTFP sale; Wooden products	Commercial agriculture and forest/artisanal production, strong market connectivity, high positive contribution with moderate squared correlations.
4	Wage- and Salary-Based Secure	32.43	Dim 1 (positive coordinates)	Government employment; Private salaried work; Shopkeeping	Stable wage employment and non-farm enterprises, relatively high economic security, positive coordinates and strong structural alignment with the economic security dimension.

8.0 References

Adger, W. N. (2000). *Social and ecological resilience : are they related ? 3*, 347–364. https://sci-hub.africa/10.1191/030913200701540465

Adger, W. N. (2003). *Social Capital , Collective Action , and Adaptation to Climate Change*. *79*(4), 387–404. https://doi.org/10.1111/j.1944-8287.2003.tb00220.x

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Adjognon, S. G., Liverpool-tasie, L. S. O., & Reardon, T. A. (2016). Agricultural input credit in Sub-Saharan Africa : Telling myth from facts. *Food Policy*. https://doi.org/10.1016/j.foodpol.2016.09.014

African Development Bank Group. (2024). *CLIMATE RESILIENT FOOD & NUTRITION SECURITY FOR WOMEN, YOUTH & SMALLHOLDERS (CREFONS) P_MZ-AA0-045* (Issue October). https://www.afdb.org/sites/default/files/documents/projects-and-operations/mozambique_-_climate_resilient_food_nutrition_security_for_women_youth_smallholders_project_crefons.pdf?utm_source=chatgpt.com

Armand, A., Attanasio, O., Carneiro, P., & Lechene, V. (2021). The effect of gender-targeted conditional cash transfers on household expenditures: Evidence from a randomized experiment. *Economic Journal*, *130*(631), 1875–1897. https://doi.org/10.1093/EJ/UEAA056

Aryal, J. P., Rahut, D. B., Maharjan, S., & Erenstein, O. (2018). Factors affecting the adoption of multiple climate-smart agricultural practices in the Indo-Gangetic Plains of India. *Natural Resources Forum*, *42*(3), 141–158. https://doi.org/10.1111/1477-8947.12152

Babbie, E. (2013). *The Practice of Social Research* (Thirteenth).

Baker, J., Nicholas, T., Afonfoso, F., & Artur, L. (2020). *Inter-Agency Humanitarian Evalution of the Response to Cyclone Idai in Mozambique*. *August*. https://link.springer.com/article/10.1186/s41018-024-00162-9

Bandara, J. S., & Cai, Y. (2014). The impact of climate change on food crop productivity, food prices and food security in South Asia. *Economic Analysis and Policy*, *44*(4), 451–465.

https://doi.org/10.1016/j.eap.2014.09.005

Barrett, C. B., Reardon, T., & Webb, P. (2001). *Nonfarm income diversification and household livelihood strategies in rural Africa : concepts , dynamics , and policy implications*. *26*, 315–331.

Below, T., Astrid, A., Rosemarie, S., & Sieber, S. (2010). *Micro-level Practices to Adapt to Climate Change for African Small-scale Farmers*. *February*. https://cgspace.cgiar.org/server/api/core/bitstreams/4f498680-b006-429f-85b6-ad4e7e7bb5a4/content

Béné, C., Headey, D., Haddad, L., & Grebmer, K. Von. (2016). *Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations*. *8*(1), 123–138. https://doi.org/10.1007/s12571-015-0526-x

Bernstein, H. (2010). *CLASS DYNAMICS OF AGRARIAN CHANGE*.

Bohle, H. G., Downing, T. E., & Watts, M. J. (1994). Climate change and social vulnerability. *Global Environmental Change*, *4*(1), 37–48. https://doi.org/10.1016/0959-3780(94)90020-5

Brauw, A. De. (2025). *Cost- Effectiveness of Anticipatory Action*. *February*, 0–16.

Cameron, A. Colin & Trivedi, P. K. T. (2005). *Microeconomics; Methods and Applications*.

Carletto, C., Corral, P., & Guelfi, A. (2017). Agricultural commercialization and nutrition revisited : Empirical evidence from three African countries. *Food Policy*, *67*, 106–118. https://doi.org/10.1016/j.foodpol.2016.09.020

Carter, M. R., & Barrett, C. B. (2006). *The Journal of Development The economics of poverty traps and persistent poverty : An asset-based approach*. https://doi.org/10.1080/00220380500405261

Chambers, R., & Conway, G. R. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century*. https://www.researchgate.net/publication/248535825_Sustainable_rural_livelihoods_practical_concepts_for_the_21st_century

Cochran, W. G. (1977). Sampling Techniques, Third Edition, Page 75 read with 51. In *John*

Wiley and Sons, Inc.

Concern Worldwide & Welt Hunger Hilfe. (2024). *Global Hunger Index 2024 : Mozambique*. *October*, 2024.

Costella, C., McCord, A., Aalst, M. van, Holmes, R., Ammoun, J., & Barca, V. (2021). Social protection and climate change: Scaling up ambition. *Social Protection Approaches to COVID-19 Expert Advice Service (SPACE)*, *October*. https://doi.org/10.13140/RG.2.2.15187.91680

Cristhina, M., Pinto, L., Mirzabaev, A., & Qaim, M. (2025). Effects of recurrent rainfall shocks on poverty and income distribution in rural Ecuador. *World Development*, *195*(June), 107107. https://doi.org/10.1016/j.worlddev.2025.107107

D'Errico, M., & Giuseppe, S. Di. (2018a). Resilience mobility in Uganda : A dynamic analysis. *World Development*, *104*, 78–96. https://doi.org/10.1016/j.worlddev.2017.11.020

D'Errico, M., & Giuseppe, S. Di. (2018b). Resilience mobility in Uganda : A dynamic analysis. *World Development*, *104*, 78–96. https://doi.org/10.1016/j.worlddev.2017.11.020

Daba, B., Regasa, T., & Mammo, S. (2025). *Impacts of climate change and variability on rural livelihoods and adaptation strategies in Ethiopia : a review paper*. *April*, 1–8. https://doi.org/10.3389/fclim.2025.1563176

de Estatística (INE), I. N., & Program., T. D. H. S. (2024). Mozambique DHS, 2022-23 - Final Report (Portuguese). *Rockville, Maryland, USA: INS, INE, and ICF*. https://www.dhsprogram.com/pubs/pdf/FR389/FR389.pdf%0AMozambique%0ADHS, %0A2022-23%0A-%0AFinal%0AReport%0A(Portuguese)

Deressa, T. (2007). Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian Approach. *Social Science Research Network*, *4342*(July), 32-pp. https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-4342

Deressa, T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). *Determinants of farmers ' choice of adaptation methods to climate change in the Nile Basin of Ethiopia*. *19*, 248–255. https://doi.org/10.1016/j.gloenvcha.2009.01.002

Dessie, Z. G., Zewotir, T., & North, D. (2022). The spatial modification effect of predictors on household level food insecurity in Ethiopia. In *Scientific Reports* (Issue 0123456789).

Nature Publishing Group UK. https://doi.org/10.1038/s41598-022-23918-y

DFID. (1999). Sustainable Livelihoods Guidance Sheets. *Sustainable Livelihoods Guidance Sheets*, 10. https://www.staff.ncl.ac.uk/david.harvey/AEF873/Development/DfIDSustLiv.pdf

Dorward, A., Anderson, S., Nava, Y., Pattison, J., Paz, R., Rushton, J., & Sanchez, V. E. (2009). *Hanging In, Stepping up and Stepping Out : Livelihood Aspirations and Strategies of the Poor*. https://d1wqtxts1xzle7.cloudfront.net/46030696/HangingInDIP-libre.pdf?1464485519=&response-content-disposition=inline%3B+filename%3DHanging_in_stepping_up_and_stepping_out.pdf&Expires=1774378588&Signature=fu74ASduLBLLjROM1who8iGvvjV-e-dCCa-zT8KvlVM8GfVA1d

Doss, C., Chiara, K., Peterman, A., Quisumbing, A., & van den Bold, M. (2015). *Gender inequalities in ownership and control of land in Africa : myth and reality* (Vol. 46). https://doi.org/10.1111/agec.12171

Doss, C. R. (2017). *Women and agricultural productivity : Reframing the Issues*. *February*, 35–50. https://doi.org/10.1111/dpr.12243

Egah, J., Zakari, S., Idrissou, L., Kotobiodjo, N., El Ghazi, I., Baco, M. N., & Kestemont, M. P. (2023). Eliciting the gender income influences on household's food security in west africa. *Heliyon*, *9*(6). https://doi.org/10.1016/j.heliyon.2023.e17408

Egerson, D., Kpegba-Fiaboe, E. E., & Christian, A. K. (2025). Understanding food (In) security through land and livelihoods: Evidence from longitudinal household data. *Journal of Rural Studies, 119,* 103750. https://doi.org/10.1016/j.jrurstud.2025.103750

El Bilali, H., Bassole, I. H. N., Dambo, L., & Berjan, S. (2020). Climate change and food security. *Agriculture and Forestry*, *66*(3), 197–210. https://doi.org/10.17707/AgricultForest.66.3.16

Ellis, F. (2000). *RURAL LIVELIHOOD DIVERSITY IN DEVELOPING COUNTRIES : EVIDENCE AND POLICY IMPLICATIONS*. *40*, 1–10.

Ellis, F., & Freeman, H. A. (2004). *Journal of Development Rural Livelihoods and Poverty Reduction Strategies in Four African Countries*.

http://dx.doi.org/10.1080/00220380410001673175 PLEASE

Etana, D., Snelder, D. J. R. M., & Wesenbeeck, C. F. A. Van. (2021). *The Impact of Adaptation to Climate Change and Variability on the Livelihood of Smallholder Farmers in Central Ethiopia*.

FAO. (2008). Climate change and food security. *Agriculture and Forestry*, *66*(3), 197–210. https://doi.org/10.17707/AgricultForest.66.3.16

FAO. (2011). *FAO at work 2010–2011: Women -Key to Food Security*. 24. www.fao.org

FAO. (2015). *Climate change and food security: risks and responses*.

FAO. (2016a). *Climate change and food security: risks and responses. Rome, Italy: FAO* (Issue September). https://www.fao.org/3/i5188e/i5188e.pdf

FAO. (2016b). The state of food and agriculture: Climate change, agriculture and food security. In *Scottish Geographical Magazine* (Vol. 71, Issue 2). https://doi.org/10.1080/00369225508735601

FAO. (2017). The Future of Food and Agriculture: Trends and Challenges. In *The future of food and agriculture: trends and challenges* (Vol. 4, Issue 4). www.fao.org/publications%0Ahttp://www.fao.org/3/a-i6583e.pdf%0Ahttp://siteresources.worldbank.org/INTARD/825826-1111044795683/20424536/Ag_ed_Africa.pdf%0Awww.fao.org/cfs%0Ahttp://www.jstor.org/stable/4356839%0Ahttps://ediss.uni-goettingen.de/bitstream/han

FAO. (2018). *Mongolia. Impact of Early Warning Early Action. Protecting the livelihoods of herders from a dzud winter*. 32. http://www.fao.org/emergencies/fao-in-action/ewea/en/

FAO. (2019). *Colombia. Impact of Early Warning Early Action. Boosting food security and social cohesion on the frontline of the migration crisis Food*. 32. http://www.fao.org/emergencies/fao-in-action/ewea/en/

FAO. (2020). *Applying an inclusive and equitable approach to anticipatory action*.

FAO. (2021a). *The Impact of Disasters and Crises on Agriculture and Food Security*. https://doi.org/10.4060/cb3673en

FAO. (2021b). *The State of Food and Agriculture: Making Agrifood Systems More Resillient*

to Shocks and Stesses. https://doi.org/10.4060/cb4476en

FAO. (2023a). The impact of disasters on agriculture and food security. Avoiding and Reducing Losses through Investment in Resilience. In *The impact of disasters on agriculture and food security 2023*. https://doi.org/10.4060/cc7900en

FAO. (2023b). The status of women in agrifood systems. In *The status of women in agrifood systems*. https://doi.org/10.4060/cc5343en

FAO, IFAD, UNICEF, WFP, & WHO. (2024). *The State of Food Security and Nutrition in the World: Financing to End Hunger, Food Insecurity and Malnutrition in All its Forms*.

FAO, IFAD, UNICEF, WFP, & WHO. (2022). *The State of Food Security and Nutrition in the World. Repurposing food and agricultural policies to make healthy diets more affordable*. https://doi.org/10.4060/cc0639en%0A

FAO, IFAD, UNICEF, WFP, & WHO. (2025). *The state of Food security and Nutrition in the World 2025 – Addressing high food price inflation for food security and nutrition. Rome. https://doi.org/10.4060/cd6008en*. https://doi.org/10.1016/S2213-8587(22)00220-0

Fekete, A. (2024). Natural Hazards and Climate Change Impacts on Food Security and Rural–Urban Livelihoods in Mozambique—A Bibliometric Analysis and Framework. *Earth (Switzerland)*, *5*(4), 761–783. https://doi.org/10.3390/earth5040040

Fernandes, A. A. T., Filho, D. B. F., da Rocha, E. C., & da Silva Nascimento, W. (2020). Read this paper if you want to learn logistic regression. *Revista de Sociologia e Politica*, *28*(74), 1/1-19/19. https://doi.org/10.1590/1678-987320287406EN

Feulner, G. (2017). Global Challenges: Climate Change. *Global Challenges*, *1*(1), 5–6. https://doi.org/10.1002/gch2.1003

Few, R. (2003). Flooding, vulnerability and coping strategies: Local responses to a global threat. *Progress in Development Studies*, *3*(1), 43–58. https://doi.org/10.1191/1464993403ps049ra

FEWS NET. (2025a). *Crisis (IPC Phase 3) outcomes expected in south , center , and north*. *October 2024*. https://fews.net/southern-africa/mozambique/food-security-outlook/october-2024/print

FEWS NET. (2025b). *Seasonal improvements likely short-lived following below-average 2025 harvest Key Messages*. *July*, 2024–2026. https://fews.net/southern-africa/mozambique/key-message-update/july-2025/print

Folke, C. (2016). *Resilience (Republished)*. *21*(4). https://www.researchgate.net/profile/Carl-Folke/publication/311621233_Resilience_Republished/links/5878c3ce08aebf17d3be2463/Resilience-Republished.pdf?origin=publication_detail&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InNpZ251cCIsInBhZ2UiOiJwdWJsaWNhdGlvbkRvd2

Foster, E., Jolliffe, D. M., Ibarra, G. L., Lakner, C., & Tettah-Baah, S. (2025). Global Poverty Revisited Using 2021 PPPs and New Data on Consumption. *Global Poverty Revisited Using 2021 PPPs and New Data on Consumption*, *June*. https://doi.org/10.1596/1813-9450-11137

Fottrell, E., & Byass, P. (2008). *Population survey sampling methods in a rural African setting : measuring mortality*. *11*. https://doi.org/10.1186/1478-7954-6-2

Freduah, B. S., MacCarthy, D. S., Adam, M., Ly, M., Ruane, A. C., Timpong-Jones, E. C., Traore, P. S., Boote, K. J., Porter, C., Adiku, S. G. K., Gbangou, T., Ludwig, F., van Slobbe, E., Greuell, W., Kranjac-Berisavljevic, G., Spear, D., Selato, J. C., Mosime, B., Nyamwanza, A. M., … Ertsen, M. W. (2019). Contextualising seasonal climate forecasts by integrating local knowledge on drought in Malawi. *Climate Services*, *141*(May), 31–36. https://doi.org/10.1016/j.cliser.2021.100268%0Ahttps://doi.org/10.1016/j.cliser.2019.05.001

Gadiso, W. J., Alemu, B. A., & Shete, M. (2024). Unpacking regional variations of multidimensional food security in rural Ethiopia: insights for policy. *International Journal of Social Economics*, *51*(5), 585–603. https://doi.org/10.1108/IJSE-02-2023-0139

Greenacre, M. (2017). *Correspondence Analysis in Practice* (Third edit). https://www.perlego.com/book/1575804/correspondence-analysis-in-practice-pdf

Greenacre, M., & Blasius, J. (2006). *Multiple Correspondence Analysis and Related Methods*.

Gregory, P. J., Ingram, J. S. I., & Brklacich, M. (2005). Climate change and food security.

Philosophical Transactions of the Royal Society B: Biological Sciences, *360*(1463), 2139–2148. https://doi.org/10.1098/rstb.2005.1745

Haggblade, S., Hazell, P., & Reardon, T. (2010). The Rural Non-farm Economy : Prospects for Growth and Poverty Reduction. *World Development*, *38*(10), 1429–1441. https://doi.org/10.1016/j.worlddev.2009.06.008

Hair, J. F. J., Black, W. C., Babin, B. J., Anderson, R. E., Black, W. C., & Anderson, R. E. (2019). *Multivariate Data Analysis, Eighth Edition*. https://doi.org/10.1002/9781119409137.ch4

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., & Vogt-Schilb, A. (2016). *Shock waves. Managing the impacts of Climate Change on Poverty*. https://www.researchgate.net/publication/283642157_Shock_Waves_Managing_the_Impacts_of_Climate_Change_on_Poverty/link/56531bef08aeafc2aabaee4f/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19

Harris, D., & Orr, A. (2014). Is rainfed agriculture really a pathway from poverty ? *Agricultural Systems*, *123*, 84–96. https://doi.org/10.1016/j.agsy.2013.09.005

Hartigan, A., & Wong, M. A. (1979). *A K-Means Clustering Algorithm*. https://doi.org/10.2307/2346830

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., Rajaofara, H., & MacKinnon, J. L. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1639). https://doi.org/10.1098/rstb.2013.0089

Headey, D. D., & Martin, W. J. (2016). *The Impact of Food Prices on Poverty and Food Security*. https://doi.org/10.1146/annurev-resource-100815-095303

Hertel, T. W., & Rosch, S. D. (2010). Climate change, agriculture, and poverty. *Applied Economic Perspectives and Policy*, *32*(3), 355–385. https://doi.org/10.1093/aepp/ppq016

Hirvonen, K., Taffesse, A. S., & Hassen, I. W. (2017). *Seasonality and household diets in Ethiopia*. *19*(13), 1723–1730. https://doi.org/10.1017/S1368980015003237

Hisali, E., Birungi, P., & Buyinza, F. (2011). Adaptation to climate change in Uganda : Evidence from micro level data. *Global Environmental Change*, *21*(4), 1245–1261. https://doi.org/10.1016/j.gloenvcha.2011.07.005

Hübler, M., Ogenrwoth, B., Walusimbi, R., Ssali, P., Bonabana, J., & Kyamanywa, S. (2025). The impact of weather shocks on food security in Uganda : a panel regression analysis. *Food Security*, 957–978. https://doi.org/10.1007/s12571-025-01542-8

Hussain, A., Rasul, G., Mahapatra, B., & Tuladhar, S. (2016). Household food security in the face of climate change in the Hindu-Kush Himalayan region. *Food Security*, *8*(5), 921–937. https://doi.org/10.1007/s12571-016-0607-5

IFPRI. (2005). The Future of Small Farms: Proccedings of a Research Workshop. *The Future of Small Farms: Proceedings of a Research Workshop. 2005. Wye, UK, June 26-29, 2005*, 362. http://pdf.usaid.gov/pdf_docs/Pnado609.pdf#page=362

IFRC. (2022). *Early Warning and Anticipatory Action*. 5–8.

IFRC. (2025). *Strengthening National Disaster Risk Management Systems through the integration of Anticipatory Action*. https://www.ifrc.org/sites/default/files/2025-09/Strengthening_National_Disaster_Risk_Management_Systems_through_integration_of_anticipatory_action.pdf

IFRC, FAO, WFP, OCHA, & Network, S. (2022). Enabling Anticipatory Action to Scale to Address the Challenge of the Climate Crisis. *Disasters*, *46*(1), 95–118. https://doi.org/10.1111/disa.12467

Instituto Nacional de Estatística (INE). (2017). *Gaza quadro 6. Chefes de agregado familiar por estado civil, segundo área de residência, distrito e sexo. Província de Gaza, 2017*.

IPC. (2023). *Mozambique Current Acute Food Insecurity*. *March*.

IPC. (2025a). *MOZAMBIQUE : IPC Acute Food Insecurity Snapshot | October 2024 - March 2025*. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/COMBINED_IPC_Mozambique_Acute_Food_Insecurity_Oct2024_Mar2025_Snapshot_English.pdf

IPC. (2025b). *MOZAMBIQUE: IPC Acute Food Insecurity Snapshot |. October 2024*, 2025. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Mozambique_Acute_

Food_Insecurity_Aug2024_Mar2025_Snapshot_English.pdf

IPC. (2026). *MOZAMBIQUE: IPC Acute Food Insecurity Snapshot |. MARCH*, 2026. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/COMBINED_IPC_Mozambique_Acute_Food_Insecurity_Oct2025_Mar2026_Snapshot.pdf

IPCC. (2007a). *Climate Change: Impacts, Adapataions and Vulnerability*. https://doi.org/10.1016/B978-008044910-4.00250-9

IPCC. (2021). *Climate Change 2021 The Physical Science Basis Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://doi.org/10.1017/9781009157896.

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://doi.org/10.1017/9781009325844.Front

IPCC. (2023). *Climate Change: 2023 Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf

IPCC, I. P. on C. C. (2001). Climate Change: Impacts, Adaptation & Vulnerability. *Ipcc Working Group*, 10032. http://www.ipcc.ch/ipccreports/tar/wg2/index.htm

IPCC, I. P. on C. C. (2007b). Climate change 2007. The Physical Science Basis. In *Weather* (Issue 8). https://doi.org/10.1256/wea.58.04

IPCC, I. P. on C. C. (2007c). *The Intergovernmental Panel on Climate Change*. https://doi.org/10.1201/b11064-39

Jalane, O. I., da Silva, E. V., & Sopchaki, C. H. (2021). Subsistence Agriculture and Climate Change: Cases of the Districts of Magude and Moamba (South of Mozambique). *Revista de Geociencias Do Nordeste*, *7*(2), 123–130. https://doi.org/10.21680/2447-3359.2021v7n2ID21231

Jemaneh, S. A., & Shibeshi, E. M. (2023). Women empowerment in agriculture and its effect on household food security : evidence from Gamo Zone of Southern Ethiopia. *Agriculture & Food Security*, 1–26. https://doi.org/10.1186/s40066-023-00437-1

Jiri, O., Mafongoya, P. L., & Chivenge, P. (2017). *Building climate change resilience through adaptation in smallholder farming systems in semi-arid Zimbabwe*. https://doi.org/10.1108/IJCCSM-07-2016-0092

Jollife, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *374*(2065). https://doi.org/10.1098/rsta.2015.0202

Jolliffe, I. . ., & Cadima, J. (2016). *Principal Component Analysis : A Review and Recent Developments*. https://doi.org/doi.org/10.1098/rsta.2015.0202

Jolliffe, I. . T. (2002). *Principal Component Analysis, Second Edition* (Second Edi). http://cda.psych.uiuc.edu/statistical_learning_course/Jolliffe I. Principal Component Analysis (2ed., Springer, 2002)(518s)_MVsa_.pdf

Jones, C., Guerten, N., Hillesland, M., & Koechlein, E. (2020). *Applying an inclusive and equitable approach to anticipatory action*. https://wrd.unwomen.org/sites/default/files/2021-11/CB1072EN.pdf

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bistrom, M. L., Nelson, S., & Kristjanson, P. (2015). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development*, *8*(2), 133–144. https://doi.org/10.1080/17565529.2015.1050978

Karmakar, R., Das, I., Dutta, D., & Rakshit, A. (2016). Potential Effects of Climate Change on Soil Properties: A Review. *Science International*, *4*(2), 51–73. https://doi.org/10.17311/sciintl.2016.51.73

Kassie, M., Ndiritu, S. W., & Stage, J. (2014). *What Determines Gender Inequality in Household Food Security in Kenya ? Application of Exogenous Switching Treatment Regression*.

Lamichaney, A., Tewari, K., Basu, P. S., Katiyar, P. K., & Singh, N. P. (2021). Effect of elevated carbon-dioxide on plant growth, physiology, yield and seed quality of chickpea (Cicer arietinum L.) in Indo-Gangetic plains. *Physiology and Molecular Biology of Plants*, *27*(2), 251–263. https://doi.org/10.1007/s12298-021-00928-0

Larson, J. B., Castellanos, P., & Jensen, L. (2019). Gender , household food security , and dietary diversity in western Honduras. *Global Food Security*, *20*(March 2018), 170–179. https://doi.org/10.1016/j.gfs.2019.01.005

Le Masson, V. (2016). Gender and resilience: from theory to practice. *BRACED Knowledge Manager*, 60. https://odi.cdn.ngo/media/documents/10224.pdf

Levine, S., Wilkinson, E., Weingärtner, L., & Mall, P. (2020). Anticipatory action for livelihood protection: A collective endeavour. *ODI Working Paper 580*, 1–36.

Loison, S. A. (2015). Rural Livelihood Diversification in Sub-Saharan Africa : A Literature Review Rural Livelihood Diversification in Sub-Saharan Africa : A Literature Review. *The Journal of Development Studies*, *51*(9), 1125–1138. https://doi.org/10.1080/00220388.2015.1046445

Lowder, S. K., Skoet, J., & Raney, T. (2016). The Number , Size , and Distribution of Farms , Smallholder Farms , and Family Farms Worldwide. *World Development*, *87*, 16–29. https://doi.org/10.1016/j.worlddev.2015.10.041

MacQueen, J. (1967). *SOME METHODS FOR CLASSIFICATION AND ANALYSIS OF MULTIVARIATE OBSERVATIONS*. *233*(233), 281–297.

Maia, R. da, Nhambiu, B., Cuna, J., Amid, U., Vilanculos, A., & Machele, J. (2019). *Forecasts for Anticipatory Humanitarian Action (FATHUM). Mozambique Country-Specific Risk and Vulnerability Profile Report*. *July*. https://www.anticipation-hub.org/Documents/Reports/Mozambique_Risk_Profile_Report_Final_July_2019.pdf

Marie, M., Yirga, F., Haile, M., & Tquabo, F. (2020). Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon*, *6*(4). https://doi.org/10.1016/j.heliyon.2020.e03867

Matchaya, G. C., Tadesse, G., & Kuteya, A. N. (2022). Rainfall shocks and crop productivity in Zambia: Implication for agricultural water risk management. *Agricultural Water Management*, *269*, 107648. https://doi.org/10.1016/j.agwat.2022.107648

Maxwell, D., Coates, J., & Vaitla, B. (2013). *How Do Different Indicators of Household Food Security Compare ? Empirical Evidence from Tigray*. *August*.

McCordic, C., Riley, L., & Raimundo, I. (2021). Household food security in Maputo: the role

of Gendered Access to education and employment. *Development Southern Africa*, *38*(5), 816–827. https://doi.org/10.1080/0376835X.2021.1932423

McDowell, J. Z., & Hess, J. J. (2012). Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Global Environmental Change*, *22*(2), 342–352. https://doi.org/10.1016/j.gloenvcha.2011.11.002

Meinzen-Dick, R., Quisumbing, A., Doss, C., & Theis, S. (2019). Women's land rights as a pathway to poverty reduction: Framework and review of available evidence. *Agricultural Systems*, *172*(November 2017), 72–82. https://doi.org/10.1016/j.agsy.2017.10.009

Mekonnen, A., Tessema, A., Ganewo, Z., & Haile, A. (2021). Climate change impacts on household food security and farmers adaptation strategies. *Journal of Agriculture and Food Research*, *6*, 100197. https://doi.org/10.1016/j.jafr.2021.100197

Miller, C. M., Tsoka, M., & Reichert, K. (2011). The impact of the Social Cash Transfer Scheme on food security in Malawi. *Food Policy*, *36*(2), 230–238. https://doi.org/10.1016/j.foodpol.2010.11.020

Ministério da Agricultura e Desenvolvimento Rural. (2023). *INQUÉRITO AGRÁRIO INTEGRADO 2023*. *1383*, 1–11. https://www.agricultura.gov.mz/wp-content/uploads/2024/09/Inquerito-Agrario-Integrado-IAI-2023.pdf

Ministry of Land and Environment. (2021). *Update of the First Nationally Determined Contribution to the United Nations Framework Convention on Climate Change, Mozambique*. 2020–2025.

Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(50), 19680–19685. https://doi.org/10.1073/pnas.0701855104

Murendo, C., Kairezi, G., & Mazvimavi, K. (2020). Resilience capacities and household nutrition in the presence of shocks . Evidence from Malawi. *World Development Perspectives*, *20*(June 2019), 100241. https://doi.org/10.1016/j.wdp.2020.100241

Muthayya, S., Rah, J. H., Sugimoto, J. D., Roos, F. F., & Black, R. E. (2013). *The Global Hidden Hunger Indices and Maps : An Advocacy Tool for Action*. *8*(6), 1–12. https://doi.org/10.1371/journal.pone.0067860

Mwangi, V., Owuor, S., Kiteme, B., Giger, M., Jacobi, J., & Kirui, O. (2020). *Linking Household Food Security and Food Value Chains in North West Mt . Kenya*. 1–15.

Niang, I., Ruppel, O. C., Abdrobo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. *Postcolonialism*, 217–235. https://doi.org/10.1002/9781119316817.ch17

Niazi, R., Liu, A., Han, J., Hassan, S., Elham, H., & Osewe, M. (2025). *Household Income Diversification and Food Insecurity : A Case Study of Afghanistan*. 1–24.

Njuki, J., Eissler, S., Malapit, H., Meinzen-dick, R., Bryan, E., & Quisumbing, A. (2022). A review of evidence on gender equality , women ' s empowerment , and food systems. *Global Food Security*, *33*(February), 100622. https://doi.org/10.1016/j.gfs.2022.100622

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. https://doi.org/10.1017/CBO9780511808678.003

Nyasimi, Mary & Huyer, S. (2017). Closing the Gender Gap in Agriculture. *Gender, Technology and Development*, *20*(2), 105–116. https://doi.org/10.1177/0971852416643872

Nyasimi, M., & Huyer, S. (2017). Background: the gender gap in agriculture under a changing climate. *Agriculture for Development*, *30*, 2015–2018. https://cgspace.cgiar.org/rest/bitstreams/114804/retrieve

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L., & West, J. (2004). Mapping vulnerability to multiple stressors: Climate change and globalization in India. *Global Environmental Change*, *14*(4), 303–313. https://doi.org/10.1016/j.gloenvcha.2004.01.001

ODI & CCS. (2024). *Climate change and human security implications for humanitarian, development, disaster and climate risk management in Mozambique*. www.odi.org/en/publications/meeting-report-climate-change-human-

OECD. (2024). *Breaking the Vicious Circles of Informal Employment and Low-Paying Work*.

Ogundeji, A. A. (2022). Adaptation to Climate Change and Impact on Smallholder Farmers' Food Security in South Africa. *Agriculture (Switzerland)*, *12*(5). https://doi.org/10.3390/agriculture12050589

Omokpariola, D. O., Agbanu-kumordzi, C., Samuel, T., Kiswii, L., Moses, G. S., & Adelegan, A. M. (2025). *Climate change , crop yield , and food security in Sub-Saharan Africa*.

Omotoso, A. B., Letsoalo, S., Olagunju, K. O., Tshwene, C. S., & Omotayo, A. O. (2023). Climate change and variability in sub-Saharan Africa: A systematic review of trends and impacts on agriculture. *Journal of Cleaner Production*, *414*, 137487. https://doi.org/10.1016/j.jclepro.2023.137487

Opoku, S., Jacobs, B., & Cunningham, R. (2026). The role of institutions in enhancing climate change adaptation by smallholder farmers in the Talensi district of Ghana. *Environmental Development*, *57*(September 2025), 101341. https://doi.org/10.1016/j.envdev.2025.101341

Ostrom, E. (1990). *Governing the Commons. The Evolution of Institutions for Collective Action*.

Pereira, R. A., & Hodge, A. (2015). *Editorial Food insecurity : a critical public health nutrition concern*. *18*(16), 2893–2894. https://doi.org/10.1017/S136898001500292X

Popat, M., Rathod, K., Artur, L., Perez, E. C. De, Sharma, A., Beca, N., & Sant, C. Van. (2024). Anticipatory actions : lessons from the storm Ana in Mocuba district , Mozambique. *Journal of International Humanitarian Action*, *9*. https://doi.org/10.1186/s41018-024-00162-9

Pople, A., Hill, R., Dercon, S., & Brunckhorst, B. (2021). Anticipatory Cash Transfers in Climate Disaster Response. *CSAE Working Paper*, *07*(April 2021). https://static1.squarespace.com/static/61542ee0a87a394f7bc17b3a/t/616ad24fdbfca62188f8e614/1634390614711/FINAL%2BAnticipatory_Cash_Transfers_in_Climate_Disaster_Response%2B%28for%2BWP%29%2BF3.pdf

Porter, J. R., Xie, L., Challinor, A. J., Cochrane, K., Howden, S. M., Iqbal, M. M., Lobell, D. B., Travasso, M. I., Aggarwal, P., Hakala, K., & Jordan, J. (2014). *Food security and food production systems. In Climate Change 2014: Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects*. 485–534. https://doi.org/10.1017/CBO9781107415379.012

Pörtner, H.-O. . R. H. . A. I. . A. C. A. R. A. P. A. E. A. R. A. B. B. B.-F. R. B. K. R. B. J. B. K. B. M. A. C. (2023). Climate Change2022: Impacts, Adaptation and Vulnerability.

Contribution of Working Group II to the Sixth Assessment Report of theIntergovernmental Panel on Climate Change. In *Climate Change 2022 – Impacts, Adaptation and Vulnerability*. https://doi.org/10.1017/9781009325844.Front

Quisumbing, A. R., Meinzen-Dick, R., Raney, T. L., Croppenstedt, A., Behrman, J. A., & Peterman, A. (2014). Gender in agriculture: Closing the knowledge gap. *Gender in Agriculture: Closing the Knowledge Gap*, 1–444. https://doi.org/10.1007/978-94-017-8616-4

Raffo-Babici, V., Calderon-Cisneros, J., Peralta-Gamboa, D., & Coloma-Casanova, A. (2025). Multidimensional analysis of access to resources and its relationship with food security in vulnerable populations. *Clinical Nutrition Open Science*, *61*, 317–328. https://doi.org/10.1016/j.nutos.2025.05.001

Rajasooriar, D., & Soma, T. (2022). Food access , mobility , and transportation : a survey and key informant interviews of users of non-profit food hubs in the City of Vancouver before and during the COVID-19 crisis. *BMC Public Health*, 1–18. https://doi.org/10.1186/s12889-021-12434-9

Risk-informed Early Action Partnership (REAP). (2021). *Country case studies Mozambique*. 1–13. https://www.anticipation-hub.org/Documents/Case_Studies/REAP_-_Mozambique.pdf

Rothwell, D. W., & Chang-Keun, H. (2010). *Exploring the Relationship Between Assets and Family Stress Among Low-Income Families*. *59*(October), 396–407. https://doi.org/10.1111/j.1741-3729.2010.00611.x

Salite, D. (2019). Explaining the uncertainty : understanding small-scale farmers ' cultural beliefs and reasoning of drought causes in Gaza Province , Southern Mozambique Intergovernmental Panel on Climate Change Statistical Package for Social Sciences. *Agriculture and Human Values*, *36*(3), 427–441. https://doi.org/10.1007/s10460-019-09928-z

Sanchez, P. A., & Swaminathan, M. S. (2005). Cutting world hunger in half. *Science*, *307*(5708), 357–359. https://doi.org/10.1126/science.1109057

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences of the United States of America*,

104(50), 19703–19708. https://doi.org/10.1073/pnas.0701976104

Scoones, I. (1998). *SUSTAINABLE RURAL LIVELIHOODS A FRAMEWORK FOR ANALYSIS IDS WORKING PAPER 72*. https://opendocs.ids.ac.uk/articles/report/Sustainable_Rural_Livelihoods_A_Framework_for_Analysis/26473384?file=48230770

Scoones, I. (2009). Livelihoods perspectives and rural development. *Journal of Peasant Studies*, *36*(1), 171–196. https://doi.org/10.1080/03066150902820503

Shifat, Z. F., Alam, M. J., *, Ismat Ara Begum, M. A. I., Sarma, P. K., And, & McKenzie, A. M. (2025). *The association between household ' s asset ownership and food security : panel data evidence from Bangladesh*. *January*, 1–13. https://doi.org/10.3389/fsufs.2024.1479410

Soares, J. C., Santos, C. S., Carvalho, S. M. P., Pintado, M. M., & Vasconcelos, M. W. (2019). Preserving the nutritional quality of crop plants under a changing climate: importance and strategies. *Plant and Soil*, *443*(1–2), 1–26. https://doi.org/10.1007/s11104-019-04229-0

Soh Wenda, B. D., Fon, D. E., Molua, E. L., & Longang, S. G. (2024). Women, income use and nutrition quality: effects of women's decision-making in rural households in Cameroon. *Agriculture and Food Security*, *13*(1), 1–20. https://doi.org/10.1186/s40066-024-00480-6

Start Network. (2020). *ARC Replica pay-out: Senegal 2020. Internal Evaluation*. *December*. https://reliefweb.int/report/senegal/arc-replica-payout-senegal-2020-internal-evaluation

Stephens, E. C., Jones, A. D., & Parsons, D. (2018). Agricultural systems research and global food security in the 21st century: An overview and roadmap for future opportunities. *Agricultural Systems*, *163*, 1–6. https://doi.org/10.1016/j.agsy.2017.01.011

Stifel, D., & Minten, B. (2017). Market Access , Well-being , and Nutrition : Evidence from Ethiopia. *World Development*, *xx*(Essp Ii). https://doi.org/10.1016/j.worlddev.2016.09.009

Sultan, B., & Gaetani, M. (2016). Agriculture in West Africa in the twenty-first century: Climate change and impacts scenarios, and potential for adaptation. *Frontiers in Plant Science*, *7*(AUG2016), 1–20. https://doi.org/10.3389/fpls.2016.01262

Sun, Q., Fu, C., Bai, Y., Oduor, A. M. O., & Cheng, B. (2023). *Livelihood Diversification and Residents ' Welfare : Evidence from Maasai Mara National Reserve*.

Suparna, P. (2020). Analysis of Main Components Status of Food Security at Village/Sub-District Level in Yogyakarta Special Region. *Jurnal Matematika "MANTIK," 6*(1), 30–37. https://doi.org/10.15642/mantik.2020.6.1.30-37

Sweileh, W. M. (2020). Bibliometric analysis of peer - reviewed literature on food security in the context of climate change from 1980 to 2019. *Agriculture & Food Security*, 1–15. https://doi.org/10.1186/s40066-020-00266-6

Tadesse, A., Li, K., Helton, J., Huang, J., & Ansong, D. (2025). The Links Between Community-Based Financial Inclusion and Household Food Availability: Evidence from Mozambique. *Foods*, *14*(2), 1–14. https://doi.org/10.3390/foods14020212

Tafesse, A., Ayele, G., Ketema, M., & Geta, E. (2016). Food Security and Adaptation Strategies to Climate Change in Eastern Ethiopia. *Econ.Res*, *5*(6), 81–88. https://doi.org/10.11648/j.eco.20160506.11

Tamako, N., & Chitja, J. M. T. (2017). Does social capital play a role in climate change adaptation among smallholder farmers for improving food security and livelihoods? *Journal of Consumer Sciences, Special Edition Food and Nutrition Challenges in Southern Africa*, *2*, 16–27.

Thamaga-chitja, J. M., Tamako, N., & Ojo, T. O. (2025). *Implications of Land Ownership Heterogeneity on Household Food Security : A Case Study of Urban Farming in Pietermaritzburg , KwaZulu-Natal Province*. 1–16.

The World Bank Group. (2023). *Mozambique: Country Climate and Development Report*. https://documents1.worldbank.org/curated/en/099113023154021937/pdf/P1771520fcab7a0930aca102c9d7107d4cc.pdf

The World Bank Group. (2025). *CLIMATE RISK COUNTRY PROFILE, MOZAMBIQUE*. https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/17258-WB_Mozambique Country Profile-WEB.pdf

Thomas, D. S. G., & Twyman, C. (2005). Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environmental Change*, *15*(2),

115–124. https://doi.org/10.1016/j.gloenvcha.2004.10.001

Toromade, A. S., Soyombo, D. A., & Kupa, E. (2024). *Reviewing the impact of climate change on global food security : Challenges and solutions*. *September*. https://doi.org/10.51594/ijarss.v6i7.1300

Turner, B. L., Kasperson, R. E., Matson, P. A., Mccarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). *A framework for vulnerability analysis in sustainability science*. *100*(14).

UN Women. (2022a). *GENDER ANALYSIS IN TECHNICAL AREAS : Climate and Disaster Risk Finance and Insuarance*. https://knowledge.unwomen.org/sites/default/files/2022-12/Gender Analysis Guidance-final.pdf

UN Women. (2022b). *Handbook on Gender Mainstreaming for Gender Equality Results*. https://knowledge.unwomen.org/sites/default/files/2022-02/Handbook-on-gender-mainstreaming-for-gender-equality-results-en.pdf

UN Women. (2024). *Progress on the Sustainable Development Goals: The Gender Snapshot 2024*. https://www.unwomen.org/sites/default/files/2024-09/progress-on-the-sustainable-development-goals-the-gender-snapshot-2024-en.pdf

UN Women. (2026). *Executive Board of the United Nations Entity for Gender Equality and the Empowerment of Women Report of the Under-Secretary-General / Executive Director* (Vol. 07261, Issue May). https://docs.un.org/en/unw/2026/2

UNDRR. (2023). *Analysis of Barriers in Financing and Operationalizing Linkages Between Anticipatory Action and Social Protection Systems*. 6. https://www.undrr.org/contact-us

UNFCCC. (2016). *The Paris Agreement*. https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

Usman, M. A., & Haile, M. G. (2022). Market access, household dietary diversity and food security: Evidence from Eastern Africa. *Food Policy*, *113*, 102374. https://doi.org/10.1016/j.foodpol.2022.102374

van Oort, P. A. J., & Zwart, S. J. (2018). Impacts of climate change on rice production in Africa and causes of simulated yield changes. *Global Change Biology*, *24*(3), 1029–1045.

https://doi.org/10.1111/gcb.13967

Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. (2012). Climate change and food systems. *Annual Review of Environment and Resources*, *37*, 195–222. https://doi.org/10.1146/annurev-environ-020411-130608

Von Braun, J., & Kennedy, E. T. (1994). *Agricultural Commercialization, Economic Development, and Nutrition*.

Weldearegay, S. K., & Tedla, D. G. (2018). Impact of climate variability on household food availability in Tigray, Ethiopia. *Agriculture and Food Security*, *7*(1), 1–10. https://doi.org/10.1186/s40066-017-0154-0

WFP. (2020). *The evidence base on Anticipatory Action*. *May*, 1–46. https://docs.wfp.org/api/documents/WFP-0000110236/download/?_ga=2.78704468.1909757493.1678139892-263477493.1677935196

WFP. (2021). *Food security and climate change, the pressing reality of Mozambique*. *May*, 4.

WFP. (2024). *WFP Mozambique Country Brief. December 2024*. https://docs.wfp.org/api/documents/WFP-0000164099/download/?_ga=2.107543621.691249365.1741763123-806104240.1741763123

WFP. (2025a). *Anticipatory Action Learning and Validation Workshop Report*. *May*.

WFP. (2025b). *WFP's evidence base on Anticipatory Action 2015-2024. Synthesis of 16 studies on the effectiveness of Anticipatory Action* (Issue April).

WFP. (2025c). *WFP's evidence base on Anticipatory Action 2015-2024. Synthesis of 16 studies on the effectiveness of Anticipatory Action*. *April*. https://www.anticipation-hub.org/Documents/Reports/WFP_evidence_base_Anticipatory_Action_2015-2024.pdf

WFP. (2025d). *WFP Mozambique Country Brief. January*, 2025–2026. https://reliefweb.int/report/mozambique/wfp-mozambique-country-brief-january-2025

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). *At Risk Second Edition: Natural Hazards, People's Vulnerability and Disasters*.

https://www.researchgate.net/publication/323368943_At_Risk_Natural_Hazards_People's_Vulnerability_and_Disasters?__cf_chl_f_tk=O9HQAGeSs4y6kKKbeRKSFhmz1agQSTIVHbgVIqcSBqk-1782907606-1.0.1.1-H1b62ZkgPSAuVCcP6bhf4hZp9haS2l37b.krQC6BmvM

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*.

World Bank. (2017). *Climate-Smart Agriculture in Mozambique*. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA-in-Mozambique.pdf

World Bank. (2020). *Nutrition Smart Agriculture in Mozambique*. https://documents1.worldbank.org/curated/en/392721597038541068/pdf/Nutrition-Smart-Agriculture-in-Mozambique.pdf

World Bank. (2023). *A New Era in Development. Sustainable, Inclusive, and Resilient Development*. *2*(March).

World Bank. (2024). Mozambique - Agriculture Support Policy Review. *Mozambique - Agriculture Support Policy Review*. https://doi.org/10.1596/41958

World Bank. (2025). *CLIMATE RISK COUNTRY PROFILE MOZAMBIQUE*.

World Bank Group. (2023). *Mozambique Gender Assessment. Leveraging women and girls' potential*. https://documents1.worldbank.org/curated/en/099091823092039842/pdf/P1772130ebf8690b50b0ff0231c20e8894f.pdf

World Bank Group. (2024). *World Bank Group Gender Strategy 2024 – 2030: Accelerate Gender Equality to End Poverty on a Livable Planet*. https://documents1.worldbank.org/curated/en/099061124182033630/pdf/BOSIB17e6952570c51b49812a89c05be6a4.pdf

Wubetie, H. T., Zewotir, T., & Mitku, A. A. (2024). *The spatial e ects of the household ' s food insecurity levels in Ethiopia : by ordinal geo-additive model*.

Yadav, S. S., Hegde, V. S., Habibi, A. B., Dia, M., & Verma, S. (2019). Climate Change, Agriculture and Food Security. *Food Security and Climate Change*, *February*, 1–24. https://doi.org/10.1002/9781119180661.ch1

Zeleke, T., Beyene, F., Deressa, T., Yousuf, J., & Kebede, T. (2021). Vulnerability of smallholder farmers to climate change-induced shocks in east hararghe zone, ethiopia. *Sustainability (Switzerland)*, *13*(4), 1–19. https://doi.org/10.3390/su13042162

CHAPTER SIX: INTEGRATED DISCUSSION

6.1 Introduction

This chapter advances an integrative interpretation of the findings from the two empirical studies, moving beyond parallel discussion toward a conceptually unified explanation of climate-induced food insecurity in Mozambique. It critically examines how climatic shocks, livelihood systems, gender relations, and institutional responses interact across scales to shape household food security outcomes. By situating these findings within broader theoretical and empirical debates, the chapter contributes to ongoing discussions on resilience, vulnerability, and anticipatory governance, while drawing out implications for policy, practice and future research.

6.2 Synthesis of Findings Across Papers

6.2.1 Climate Variability and Household Food Security

The findings from both studies demonstrate that climate variability remains a fundamental driver of household food insecurity in Mozambique. Across the study sites, recurrent droughts, erratic rainfall and other climate-related shocks constrained agricultural production, disrupted livelihood activities and reduced households' ability to maintain adequate food consumption. These findings reinforce the growing consensus that climate variability affects food security through multiple pathways by simultaneously reducing food availability, weakening household purchasing power, limiting food access and undermining livelihood stability (FAO, 2023a). Similar observations have been reported across sub-Saharan Africa, where rainfall variability continues to be one of the strongest determinants of agricultural productivity and rural food insecurity (Hübler et al., 2025; Matchaya et al., 2022).

Importantly, the results indicate that climate-related food insecurity is neither spatially uniform nor solely determined by exposure to climatic hazards. The first study demonstrated significant provincial differences in household food security, while the second study identified substantial variation among administrative posts within Guijá district. These findings suggest that households experiencing similar climatic events may face markedly different food security outcomes depending on their agro-ecological conditions, livelihood opportunities, market access and institutional support. This observation supports vulnerability scholarship, which argues that vulnerability is socially differentiated and reflects the interaction between exposure, sensitivity and adaptive capacity rather than exposure alone (Costella et al., 2021; DFID, 1999;

FAO, 2016b, 2016a; Jost et al., 2015). It also aligns with studies from Mozambique and elsewhere in southern Africa showing that differences in infrastructure, market integration and access to productive resources explain much of the spatial heterogeneity in food security outcomes (FEWS NET, 2025a; The World Bank Group, 2025).

Another important contribution of this study is the evidence that food insecurity extends beyond insufficient food consumption. Although severe hunger was relatively uncommon in Guijá district, the combined use of the FCS, HDDS and HHS revealed persistent deficiencies in dietary diversity and food quality. This finding suggests the presence of hidden food insecurity, where households avoid acute hunger but remain nutritionally vulnerable because their diets rely heavily on low-cost staple foods. Similar patterns have been documented in climate-sensitive rural areas, where households prioritize caloric sufficiency over dietary quality during periods of climatic stress, resulting in poor nutritional outcomes despite apparently acceptable food consumption (Hirvonen et al., 2017; Murendo et al., 2020; Pereira & Hodge, 2015). These findings further reinforce the multidimensional nature of food security proposed by the (FAO, 2016a), which emphasizes that food security encompasses availability, access, utilization and stability rather than food quantity alone.

Collectively, these findings suggest that climate variability should not be viewed solely as an environmental problem but as a catalyst that interacts with existing socioeconomic and institutional vulnerabilities to shape household food security. This interpretation is consistent with recent (IPCC, 2022) assessments, which argue that the impacts of climate change are increasingly determined by underlying inequalities in access to resources, infrastructure, services, and adaptive capacity. Consequently, interventions aimed at improving household food security in climate-vulnerable regions should move beyond increasing agricultural production to address the broader structural factors that determine households' ability to anticipate, absorb and recover from climatic shocks.

6.2.2 Livelihood Systems, Assets and Household Resilience

A consistent finding across both studies is that household food security is fundamentally shaped by the nature of livelihood systems and access to productive assets. While climate variability constitutes an important source of risk, its effects are mediated by households' capacity to mobilize livelihood resources, diversify income sources and engage with markets. Households possessing stronger livelihood assets, including livestock, land, financial resources and market access, consistently exhibited better food security outcomes than households’ dependent on

low-return subsistence activities. These findings support a substantial body of literature demonstrating that livelihood assets strengthen households' capacity to absorb climatic shocks, smooth consumption and reduce vulnerability to food insecurity (Béné et al., 2016; D'Errico & Giuseppe, 2018b).

Livelihood diversification emerged as an important strategy for reducing vulnerability, but the findings suggest that its effectiveness depends on the quality rather than simply the number of livelihood activities. In Guijá district, households engaged in multiple income-generating activities generally exhibited better food security outcomes than households relying exclusively on rain-fed agriculture. However, many diversified households remained food insecure because diversification often involved combining several low-return and highly climate-sensitive activities. This finding is consistent with (Barrett et al., 2001; Ellis & Freeman, 2004; Loison, 2015), who argue that diversification in many rural African contexts reflects a coping strategy driven by necessity rather than a pathway towards economic accumulation. Consequently, diversification alone cannot be assumed to enhance resilience unless it enables households to access higher and more stable sources of income.

The findings further demonstrate the importance of productive assets and financial capital in strengthening household resilience. Livestock ownership, credit access, market participation, and mobility-enhancing assets such as motorcycles were all positively associated with household food security. Livestock not only serve as productive assets but also as savings mechanisms and buffers against climatic shocks, enabling households to smooth consumption during periods of agricultural failure (Sun et al., 2023; Tadesse et al., 2025). Likewise, access to financial resources enables households to invest in agricultural production, adopt improved technologies and avoid distress sales of productive assets during crises (World Bank Group, 2023). These findings reinforce evidence that asset accumulation and financial inclusion are central components of climate resilience in smallholder farming systems (Béné et al., 2016; Carter & Barrett, 2006).

Market access also emerged as a critical determinant of food security across both studies. Households with better market integration were more likely to diversify their livelihoods, access agricultural inputs and purchase food during periods of production shortfalls. Similar findings have been reported across sub-Saharan Africa, where rural market integration reduces transaction costs, increases agricultural profitability and enhances household resilience to climatic shocks (Carletto et al., 2017; Stifel & Minten, 2017; Usman & Haile, 2022). However,

the benefits of market participation depend on adequate infrastructure, purchasing power and stable market conditions. In remote rural communities characterized by weak transport systems and volatile food prices, market access alone may be insufficient to improve food security outcomes.

Conversely, the relatively limited effects of irrigation, agricultural training and extension services suggest that technical interventions alone are insufficient to enhance resilience where broader structural constraints persist. Although these interventions are widely promoted as climate adaptation strategies, their effectiveness depends on complementary investments in infrastructure, institutions, input markets and financial services. Similar observations have been made across drought-prone regions of sub-Saharan Africa, where the benefits of climate-smart agricultural technologies are often constrained by weak extension systems, limited water availability and barriers to technology adoption (World Bank, 2024). Collectively, these findings suggest that strengthening household resilience requires integrated approaches that combine livelihood diversification, productive asset accumulation, market development and supportive institutional environments rather than isolated technical interventions.

6.2.3 Gender and Household Food Security

The findings demonstrate that gender remains an important dimension of household food security, although its influence operates primarily through differential access to livelihood resources rather than household headship alone. In the first study, female-headed households experienced significantly higher levels of food insecurity than male-headed households among non-beneficiaries, reflecting persistent gender inequalities in access to productive resources, agricultural inputs, credit and decision-making opportunities. These findings are consistent with extensive evidence from sub-Saharan Africa showing that women frequently encounter structural barriers that constrain agricultural productivity, adaptive capacity and household welfare (C. Doss et al., 2015; FAO, 2011; World Bank Group, 2023).

However, the second study found that household headship was not a statistically significant predictor of food security once livelihood assets, income, market access and other socioeconomic characteristics were controlled for. Rather than contradicting the findings of the first study, this suggests that gender influences food security indirectly through unequal access to livelihood capitals and economic opportunities. Similar conclusions have been reached by (C. Doss et al., 2015; Jemaneh & Shibeshi, 2023; Larson et al., 2019), who argue that observed gender disparities in agricultural and food security outcomes often diminish after accounting

for differences in resource endowments and economic capacity. Consequently, gender should be understood as a structural determinant of vulnerability that shapes access to productive resources rather than as an independent predictor of food security.

The findings also provide encouraging evidence regarding the role of gender-responsive interventions. Among households participating in anticipatory action, the disparity in food security between female- and male-headed households was substantially reduced. Although the cross-sectional design precludes causal inference, this pattern suggests that interventions which improve women's access to productive resources, financial support and early assistance may contribute to narrowing gender inequalities in food security outcomes. Previous studies similarly report that interventions targeting women often generate broader household welfare gains because women tend to allocate a greater proportion of resources towards food, child nutrition and household wellbeing (Egah et al., 2023; FAO et al., 2022; Soh Wenda et al., 2024).

These findings reinforce the growing recognition that gender-responsive approaches should extend beyond ensuring equal participation to addressing the structural constraints that limit women's adaptive capacity. International frameworks increasingly emphasize that effective climate adaptation and anticipatory action require equitable access to climate information, productive assets, finance and decision-making processes (FAO, 2020; UN Women, 2022a, 2026). Strengthening women's access to these resources is therefore likely to enhance not only gender equity but also overall household resilience to climate variability.

6.2.4 Anticipatory Action as a Pathway to Household Resilience

One of the most important contributions of this dissertation is the empirical evidence supporting anticipatory action as a strategy for reducing household vulnerability to climate-related food insecurity. The findings from Study I demonstrate that households participating in anticipatory action interventions were significantly more likely to be food secure than comparable non-beneficiary households. These findings contribute to the growing evidence that early interventions implemented before forecasted hazards can reduce humanitarian losses, protect productive assets and stabilize household consumption (FAO, 2018; IFRC, 2025; Levine et al., 2020; Start Network, 2020).

Nevertheless, the findings also indicate that anticipatory action should not be viewed as a standalone solution to climate-induced food insecurity. Across both studies, households possessing stronger livelihood assets, diversified income sources, better market access and

greater economic capacity consistently exhibited higher levels of food security. These observations suggest that the effectiveness of anticipatory action depends on households' existing capacities to utilize early support and translate it into improved livelihood outcomes. Similar conclusions have been reached by (Baker et al., 2020) and (Popat et al., 2024), who argue that the effectiveness of anticipatory action depends on enabling conditions, including functioning markets, infrastructure, institutional capacity and access to complementary livelihood resources.

The findings further suggest that anticipatory action and long-term resilience building should be viewed as complementary rather than competing approaches. Early interventions can reduce immediate losses and prevent negative coping strategies during climatic shocks, while investments in livelihood diversification, productive assets, market development and gender equality strengthen households' capacity to manage future risks. This interpretation is consistent with emerging resilience literature, which emphasizes that sustainable food security requires combining short-term shock-responsive interventions with longer-term investments that address the structural drivers of vulnerability (Béné et al., 2016; FAO, 2021b).

Overall, the integrated findings of this dissertation suggest that the effectiveness of anticipatory action is greatest when implemented within broader livelihood and food system strategies that strengthen household adaptive capacity before, during and after climate-related shocks. Such an integrated approach is particularly relevant for Mozambique, where recurrent droughts interact with chronic poverty, limited livelihood opportunities and persistent gender inequalities to shape household food security outcomes.

6.3 Theoretical Implications

This dissertation contributes to the theoretical understanding of household food security under climate variability by providing empirical evidence that supports and extends both Vulnerability Theory and the Sustainable Livelihoods Framework (SLF). Collectively, the findings demonstrate that household food security is not solely determined by exposure to climatic hazards but by the interaction between climatic shocks, livelihood assets, socioeconomic conditions, institutional support and gender relations. These findings reinforce the multidimensional nature of vulnerability and resilience while highlighting the importance of integrating institutional interventions into existing theoretical perspectives.

The findings provide strong support for Vulnerability Theory, which conceptualizes vulnerability as a function of exposure, sensitivity and adaptive capacity rather than exposure

to hazards alone. Although households across the study areas experienced similar climatic shocks, food security outcomes varied considerably according to livelihood resources, market access, gender dynamics and participation in anticipatory action interventions. This suggests that climate variability acts as a stressor whose impacts are mediated by pre-existing social, economic and institutional conditions. The observed spatial differences in food security further demonstrate that vulnerability is context-specific and socially differentiated, supporting the argument that vulnerability reflects the unequal distribution of resources and capacities within communities rather than the magnitude of climatic hazards alone.

The findings also reinforce the explanatory value of the Sustainable Livelihoods Framework by demonstrating that access to livelihood capitals remains central to household resilience under climate variability. Human, financial, physical, natural and social assets collectively shaped households' capacity to diversify livelihoods, maintain agricultural production, access markets and sustain food security during climatic shocks. Consistent with the SLF, households possessing stronger livelihood assets generally experienced better food security outcomes than those with limited resources. However, the findings also suggest that livelihood diversification alone does not necessarily enhance resilience. Many households engaged in multiple livelihood activities yet remained food insecure because these activities generated limited and unstable returns. This extends the Sustainable Livelihoods Framework by emphasizing that the quality, profitability and sustainability of livelihood strategies are as important as diversification itself when explaining household resilience.

An important theoretical contribution of this dissertation lies in demonstrating the role of institutions, particularly anticipatory action, in mediating the relationship between climate variability and household food security. While the SLF recognizes transforming structures and processes as influencing access to livelihood assets, institutional interventions often receive limited empirical attention within applications of the framework. The findings show that anticipatory action was associated with reduced food insecurity and reduced gender disparities among beneficiary households. These results suggest that institutional mechanisms should not simply be viewed as contextual factors but as active determinants of adaptive capacity that influence how households mobilize livelihood assets and respond to climate-related risks. This finding therefore complements both the Vulnerability Theory and the SLF by highlighting the importance of proactive disaster risk management in reducing vulnerability before hazards materialize.

The dissertation also contributes to theoretical discussions on gender and vulnerability. The findings indicate that gender does not merely influence household food security through household headship but through unequal access to productive resources, livelihood opportunities, financial capital and decision-making processes. Once these structural inequalities were considered, the independent effect of household headship became less pronounced. This finding supports gender and development scholarship, which conceptualizes gender as a system of socially constructed power relations that shapes differential access to resources and adaptive capacity rather than simply representing differences between female- and male-headed households. It further suggests that analyses of vulnerability should move beyond demographic characteristics to incorporate the structural processes through which gender inequalities influence resilience and food security outcomes.

Finally, the integrated findings suggest that vulnerability and resilience should be understood as complementary rather than opposing concepts. While Vulnerability Theory explains why certain households are more susceptible to climate-related food insecurity, the Sustainable Livelihoods Framework identifies the livelihood resources and strategies through which households can strengthen their adaptive capacity. The findings further demonstrate that anticipatory action provides a practical mechanism for translating resilience into action by enabling households to protect assets, stabilize food consumption and reduce reliance on negative coping strategies before climatic shocks occur. Consequently, this dissertation advances an integrated perspective in which vulnerability, livelihood assets, gender relations and institutional support interact dynamically to shape household food security under climate variability. This integrated understanding provides a stronger conceptual basis for designing climate adaptation and anticipatory action interventions in vulnerable rural communities.

6.4 Practical and Policy Implications

The findings of this dissertation have important practical and policy implications for strengthening household food security and resilience to climate variability in Mozambique and other climate-vulnerable regions of sub-Saharan Africa. Collectively, the results demonstrate that improving food security requires integrated interventions that address both the immediate impacts of climate shocks and the underlying socioeconomic conditions that shape household vulnerability.

The positive association between anticipatory action and household food security provides empirical support for scaling up forecast-based and anticipatory interventions within national

disaster risk management systems. The findings indicate that early interventions implemented before the onset of drought can reduce food insecurity and help households protect productive assets and avoid negative coping strategies. These results support ongoing efforts by the Government of Mozambique, INGD, the WFP and other humanitarian partners to institutionalize anticipatory action as part of national disaster preparedness and response systems. Rather than replacing conventional humanitarian assistance, anticipatory action should complement existing disaster risk reduction and social protection programmes by enabling earlier, more cost-effective responses to forecasted climate hazards.

The findings further suggest that anticipatory action should be integrated with long-term livelihood development programmes. While early assistance improved short-term food security outcomes, household resilience remained strongly influenced by livelihood assets, income diversification, market access and productive resources. Consequently, investments in climate-resilient agriculture, irrigation, livestock production, rural enterprises, financial inclusion and market infrastructure remain essential for reducing chronic vulnerability. Such integrated approaches are more likely to generate sustainable improvements in food security than interventions that focus exclusively on emergency response or agricultural production.

The study also highlights the need to strengthen livelihood diversification policies. Although households engaging in multiple livelihood activities generally exhibited better food security outcomes, diversification was not universally associated with resilience because many households relied on low-return and climate-sensitive activities. This finding suggests that development programmes should prioritize opportunities that improve the productivity and profitability of livelihood activities rather than encouraging diversification alone. Expanding access to agricultural value chains, vocational skills, rural finance and off-farm employment opportunities would provide households with more stable sources of income and reduce dependence on climate-sensitive livelihoods.

An important policy implication relates to gender-responsive programming. The findings demonstrate that gender inequalities continue to influence household food security through unequal access to productive resources, livelihood opportunities, finance and decision-making. At the same time, anticipatory action appeared to reduce disparities between female- and male-headed households, suggesting that appropriately designed interventions can promote both equity and resilience. Policymakers should therefore ensure that anticipatory action, agricultural extension, climate information services and social protection programmes

explicitly address gender-related barriers by promoting equitable access to productive assets, financial services, climate information and participation in community decision-making. Such measures are consistent with international commitments to gender equality and climate-resilient development.

The observed spatial variation in food security outcomes also underscores the importance of place-based and context-specific interventions. Significant differences among provinces and administrative posts indicate that households exposed to similar climatic hazards experience different levels of vulnerability depending on local livelihood systems, infrastructure, market access and institutional capacity. National policies should therefore avoid uniform intervention strategies and instead use localized vulnerability assessments and early warning information to prioritize resources and tailor interventions according to local conditions.

Finally, the findings have implications for food security monitoring and programme evaluation. The combined use of the Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), and Household Hunger Scale (HHS) revealed dimensions of food insecurity that would not have been captured by a single indicator. Development partners and government agencies should therefore adopt multidimensional food security assessment approaches that capture not only food consumption but also dietary quality, hunger and livelihood vulnerability. Such comprehensive monitoring systems would improve targeting, strengthen programme evaluation and support evidence-based decision-making in climate-sensitive regions.

Overall, the findings suggest that strengthening household food security under increasing climate variability requires a transition from reactive crisis response towards integrated resilience-building strategies. Policies that combine anticipatory action with investments in resilient livelihoods, gender equality, market development and locally tailored interventions are likely to generate more sustainable improvements in household food security and adaptive capacity than isolated sectoral interventions.

6.5 Limitations

Despite the strengths of this dissertation, including the use of standardized food security indicators, robust statistical analyses and evidence from two complementary studies, several limitations should be acknowledged.

First, both studies employed cross-sectional research designs, which limited the ability to establish causal relationships between climate variability, anticipatory action, livelihood

characteristics and household food security. The findings therefore demonstrate statistically significant associations rather than causal effects. Furthermore, the cross-sectional data capture household conditions at a single point in time and may not adequately reflect the dynamic nature of vulnerability, resilience and food security under recurrent climatic shocks.

Second, Study I relied on a secondary dataset collected by the WFP. Although the dataset was generated using rigorous sampling procedures and standardized survey instruments, the researcher had limited control over the original study design, questionnaire development, variable selection and data collection process. Consequently, the analysis was restricted to the variables available in the dataset and potentially important determinants of household food security, including some institutional, behavioural and contextual factors, could not be examined.

Third, the dissertation relied predominantly on quantitative household survey data, with limited qualitative evidence to explain the social and institutional processes underlying the observed relationships. While the quantitative analyses identified significant associations between climate variability, livelihoods, gender, anticipatory action and household food security, they were less able to capture household perceptions, decision-making processes, gender norms and community experiences that shape vulnerability and resilience. Integrating qualitative methods could have provided a richer understanding of the mechanisms through which these factors interact.

Fourth, several food security indicators, particularly the FCS, are based on relatively short recall periods and therefore primarily reflect recent household food consumption. Although the inclusion of the HDDS and HHS provided complementary perspectives, these indicators may not fully capture seasonal fluctuations or longer-term changes in household food security, particularly in highly climate-variable environments.

Finally, although the study included communities from several drought-prone areas of Mozambique, the findings should be interpreted within the specific geographic, socioeconomic and institutional contexts in which the research was conducted. Caution is therefore required when generalizing the results to other regions with different climatic conditions, livelihood systems or policy environments.

Notwithstanding these limitations, the integration of two complementary studies, the application of validated food security measures and the use of advanced statistical techniques provide a robust empirical basis for understanding the relationships among climate variability,

livelihoods, gender, anticipatory action and household food security in climate-vulnerable communities.

6.6 Recommendations for Future Research

Although this dissertation provides important insights into the relationships among climate variability, livelihoods, gender, anticipatory action and household food security, several areas warrant further investigation.

First, future studies should employ longitudinal or panel study designs to examine how household food security and livelihood resilience evolve over time in response to recurrent climatic shocks and anticipatory action interventions. The cross-sectional nature of the present study limited the ability to establish causal relationships or capture dynamic changes in household vulnerability and adaptive capacity. Longitudinal research would provide stronger evidence on the long-term effectiveness and sustainability of anticipatory action and other resilience-building interventions.

Second, this dissertation relied primarily on quantitative household survey data, with limited qualitative evidence to explain the social and institutional processes underlying observed relationships. Future research should adopt mixed-methods approaches that combine quantitative analysis with qualitative techniques such as in-depth interviews, focus group discussions and participatory rural appraisal. Such approaches would provide a deeper understanding of household decision-making, gender relations, coping strategies and the contextual factors influencing the adoption and effectiveness of anticipatory action.

Third, further research is needed to examine the long-term impacts and cost-effectiveness of anticipatory action interventions. While this study demonstrates a positive association between anticipatory action and household food security, little evidence exists on whether these benefits are sustained beyond the immediate post-shock period or how they compare with conventional humanitarian response mechanisms. Future evaluations should therefore assess the durability of programme impacts and the economic efficiency of anticipatory action under different climatic and institutional contexts.

Fourth, the findings indicate that livelihood quality and access to productive assets are more important determinants of household food security than livelihood diversification alone. Future studies should therefore investigate which combinations of livelihood strategies, asset portfolios and institutional support mechanisms most effectively enhance household resilience

under different climatic conditions. Such evidence would inform the design of more targeted livelihood development programmes in climate-vulnerable regions.

Finally, the study was conducted in drought-prone communities in Mozambique, and the findings may not fully reflect conditions in other agro-ecological or socioeconomic contexts. Future comparative studies across different climatic zones and countries would improve understanding of how local environmental, institutional and socioeconomic conditions influence the effectiveness of anticipatory action and other resilience-building interventions. Comparative analyses would also help identify context-specific and transferable strategies for strengthening household food security under increasing climate variability.

CHAPTER SEVEN: GENERAL CONCLUSION

7.1 Summary of Major Findings

This study set out to examine the drivers of climate-induced food insecurity and the role of anticipatory and structural interventions in Mozambique. The findings demonstrate that food insecurity is chronic, multidimensional, and structurally embedded, shaped by the interaction of climatic shocks, livelihood systems, spatial inequalities, and institutional responses.

Climate shocks particularly drought act as stress multipliers, exacerbating pre-existing vulnerabilities rather than constituting isolated causes. Livelihood systems play a central role, with evidence showing that low-return diversification strategies fail to deliver meaningful resilience gains, while market-integrated and higher-return activities are associated with improved outcomes.

Anticipatory action emerges as a promising resilience-building approach, capable of stabilizing consumption and protecting assets before shocks occur. However, its effectiveness is context-dependent, influenced by market functionality, infrastructure, and institutional capacity.

Gender inequalities are shown to be structurally embedded but modifiable through targeted interventions, while economic capacity, asset ownership, and market access remain the most decisive determinants of food security.

7.2 Contribution to Knowledge

This study makes several contributions to the literature.

First, it provides empirical evidence on the effectiveness of anticipatory action in improving food security outcomes within a high-risk climate context, contributing to a still-emerging field of research.

Second, it advances understanding of spatial and structural determinants of vulnerability, demonstrating that food insecurity is territorially embedded and shaped by systemic inequalities.

Third, it challenges conventional assumptions regarding livelihood diversification, showing that outcomes depend on returns and market integration rather than diversification alone.

Fourth, it contributes to gender and resilience scholarship by demonstrating how gendered vulnerabilities can be mitigated through inclusive institutional design.

Finally, the study advances methodological approaches by integrating multidimensional food security indicators and multivariate analytical techniques to capture the complexity of resilience dynamics.

7.3 Final Remarks

The findings of this study underscore that addressing food insecurity in climate-vulnerable contexts requires a fundamental shift from reactive, short-term interventions to integrated, anticipatory, and structurally informed approaches. While anticipatory action offers a critical entry point for mitigating the immediate impacts of climate shocks, its transformative potential depends on broader investments in markets, infrastructure, and social equity.

Ultimately, building resilient and food-secure systems in Mozambique demands multi-scalar, context-specific, and inclusive strategies that address both the symptoms and structural drivers of vulnerability. Without such an integrated approach, efforts to enhance resilience are likely to remain partial and uneven.

MERGED REFERENCES

Adger, W. N. (2000). *Social and ecological resilience : are they related ? 3*, 347–364. https://sci-hub.africa/10.1191/030913200701540465

Adger, W. N. (2003). *Social Capital , Collective Action , and Adaptation to Climate Change*. *79*(4), 387–404. https://doi.org/10.1111/j.1944-8287.2003.tb00220.x

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Adjognon, S. G., Liverpool-tasie, L. S. O., & Reardon, T. A. (2016). Agricultural input credit in Sub-Saharan Africa : Telling myth from facts. *Food Policy*. https://doi.org/10.1016/j.foodpol.2016.09.014

African Development Bank Group. (2024). *CLIMATE RESILIENT FOOD & NUTRITION SECURITY FOR WOMEN, YOUTH & SMALLHOLDERS (CREFONS) P_MZ-AA0-045* (Issue October). https://www.afdb.org/sites/default/files/documents/projects-and-operations/mozambique_-_climate_resilient_food_nutrition_security_for_women_youth_smallholders_project_crefons.pdf?utm_source=chatgpt.com

Armand, A., Attanasio, O., Carneiro, P., & Lechene, V. (2021). The effect of gender-targeted conditional cash transfers on household expenditures: Evidence from a randomized experiment. *Economic Journal*, *130*(631), 1875–1897. https://doi.org/10.1093/EJ/UEAA056

Aryal, J. P., Rahut, D. B., Maharjan, S., & Erenstein, O. (2018). Factors affecting the adoption of multiple climate-smart agricultural practices in the Indo-Gangetic Plains of India. *Natural Resources Forum*, *42*(3), 141–158. https://doi.org/10.1111/1477-8947.12152

Babbie, E. (2013). *The Practice of Social Research* (Thirteenth).

Baker, J., Nicholas, T., Afonfoso, F., & Artur, L. (2020). *Inter-Agency Humanitarian Evalution of the Response to Cyclone Idai in Mozambique*. *August*. https://link.springer.com/article/10.1186/s41018-024-00162-9

Bandara, J. S., & Cai, Y. (2014). The impact of climate change on food crop productivity, food prices and food security in South Asia. *Economic Analysis and Policy*, *44*(4), 451–465. https://doi.org/10.1016/j.eap.2014.09.005

Barrett, C. B., Reardon, T., & Webb, P. (2001). *Nonfarm income diversification and household livelihood strategies in rural Africa : concepts , dynamics , and policy implications*. *26*, 315–331.

Below, T., Astrid, A., Rosemarie, S., & Sieber, S. (2010). *Micro-level Practices to Adapt to Climate Change for African Small-scale Farmers*. *February*. https://cgspace.cgiar.org/server/api/core/bitstreams/4f498680-b006-429f-85b6-ad4e7e7bb5a4/content

Béné, C., Headey, D., Haddad, L., & Grebmer, K. Von. (2016). *Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations*. *8*(1), 123–138. https://doi.org/10.1007/s12571-015-0526-x

Bernstein, H. (2010). *CLASS DYNAMICS OF AGRARIAN CHANGE*.

Bohle, H. G., Downing, T. E., & Watts, M. J. (1994). Climate change and social vulnerability. *Global Environmental Change*, *4*(1), 37–48. https://doi.org/10.1016/0959-3780(94)90020-5

Brauw, A. De. (2025). *Cost- Effectiveness of Anticipatory Action*. *February*, 0–16.

Cameron, A. Colin & Trivedi, P. K. T. (2005). *Microeconomics; Methods and Applications*.

Carletto, C., Corral, P., & Guelfi, A. (2017). Agricultural commercialization and nutrition revisited : Empirical evidence from three African countries. *Food Policy*, *67*, 106–118. https://doi.org/10.1016/j.foodpol.2016.09.020

Carter, M. R., & Barrett, C. B. (2006). *The Journal of Development The economics of poverty traps and persistent poverty : An asset-based approach*. https://doi.org/10.1080/00220380500405261

Chambers, R., & Conway, G. R. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century*. https://www.researchgate.net/publication/248535825_Sustainable_rural_livelihoods_practical_concepts_for_the_21st_century

Cochran, W. G. (1977). Sampling Techniques, Third Edition, Page 75 read with 51. In *John Wiley and Sons, Inc.*

Concern Worldwide & Welt Hunger Hilfe. (2024). *Global Hunger Index 2024 : Mozambique*.

October, 2024.

Costella, C., McCord, A., Aalst, M. van, Holmes, R., Ammoun, J., & Barca, V. (2021). Social protection and climate change: Scaling up ambition. *Social Protection Approaches to COVID-19 Expert Advice Service (SPACE), October*. https://doi.org/10.13140/RG.2.2.15187.91680

Cristhina, M., Pinto, L., Mirzabaev, A., & Qaim, M. (2025). Effects of recurrent rainfall shocks on poverty and income distribution in rural Ecuador. *World Development*, *195*(June), 107107. https://doi.org/10.1016/j.worlddev.2025.107107

D'Errico, M., & Giuseppe, S. Di. (2018a). Resilience mobility in Uganda : A dynamic analysis. *World Development*, *104*, 78–96. https://doi.org/10.1016/j.worlddev.2017.11.020

D'Errico, M., & Giuseppe, S. Di. (2018b). Resilience mobility in Uganda : A dynamic analysis. *World Development*, *104*, 78–96. https://doi.org/10.1016/j.worlddev.2017.11.020

Daba, B., Regasa, T., & Mammo, S. (2025). *Impacts of climate change and variability on rural livelihoods and adaptation strategies in Ethiopia : a review paper*. *April*, 1–8. https://doi.org/10.3389/fclim.2025.1563176

de Estatística (INE), I. N., & Program., T. D. H. S. (2024). Mozambique DHS, 2022-23 - Final Report (Portuguese). *Rockville, Maryland, USA: INS, INE, and ICF*. https://www.dhsprogram.com/pubs/pdf/FR389/FR389.pdf%0AMozambique%0ADHS, %0A2022-23%0A-%0AFinal%0AReport%0A(Portuguese)

Deressa, T. (2007). Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian Approach. *Social Science Research Network*, *4342*(July), 32-pp. https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-4342

Deressa, T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). *Determinants of farmers ' choice of adaptation methods to climate change in the Nile Basin of Ethiopia*. *19*, 248–255. https://doi.org/10.1016/j.gloenvcha.2009.01.002

Dessie, Z. G., Zewotir, T., & North, D. (2022). The spatial modification effect of predictors on household level food insecurity in Ethiopia. In *Scientific Reports* (Issue 0123456789). Nature Publishing Group UK. https://doi.org/10.1038/s41598-022-23918-y

DFID. (1999). Sustainable Livelihoods Guidance Sheets. *Sustainable Livelihoods Guidance Sheets*, 10.

https://www.staff.ncl.ac.uk/david.harvey/AEF873/Development/DfIDSustLiv.pdf

Dorward, A., Anderson, S., Nava, Y., Pattison, J., Paz, R., Rushton, J., & Sanchez, V. E. (2009). *Hanging In, Stepping up and Stepping Out : Livelihood Aspirations and Strategies of the Poor*. https://d1wqtxts1xzle7.cloudfront.net/46030696/HangingInDIP-libre.pdf?1464485519=&response-content-disposition=inline%3B+filename%3DHanging_in_stepping_up_and_stepping_out.pdf&Expires=1774378588&Signature=fu74ASduLBLLjROM1who8iGvvjV-e-dCCa-zT8KvlVM8GfVA1d

Doss, C., Chiara, K., Peterman, A., Quisumbing, A., & van den Bold, M. (2015). *Gender inequalities in ownership and control of land in Africa : myth and reality* (Vol. 46). https://doi.org/10.1111/agec.12171

Doss, C. R. (2017). *Women and agricultural productivity : Reframing the Issues*. *February*, 35–50. https://doi.org/10.1111/dpr.12243

Egah, J., Zakari, S., Idrissou, L., Kotobiodjo, N., El Ghazi, I., Baco, M. N., & Kestemont, M. P. (2023). Eliciting the gender income influences on household's food security in west africa. *Heliyon*, *9*(6). https://doi.org/10.1016/j.heliyon.2023.e17408

Egerson, D., Kpegba-Fiaboe, E. E., & Christian, A. K. (2025). Understanding food (In) security through land and livelihoods: Evidence from longitudinal household data. *Journal of Rural Studies*, *119*, 103750. https://doi.org/10.1016/j.jrurstud.2025.103750

El Bilali, H., Bassole, I. H. N., Dambo, L., & Berjan, S. (2020). Climate change and food security. *Agriculture and Forestry*, *66*(3), 197–210. https://doi.org/10.17707/AgricultForest.66.3.16

Ellis, F. (2000). *RURAL LIVELIHOOD DIVERSITY IN DEVELOPING COUNTRIES : EVIDENCE AND POLICY IMPLICATIONS*. *40*, 1–10.

Ellis, F., & Freeman, H. A. (2004). *Journal of Development Rural Livelihoods and Poverty Reduction Strategies in Four African Countries*. http://dx.doi.org/10.1080/00220380410001673175 PLEASE

Etana, D., Snelder, D. J. R. M., & Wesenbeeck, C. F. A. Van. (2021). *The Impact of Adaptation to Climate Change and Variability on the Livelihood of Smallholder Farmers in Central Ethiopia*.

FAO. (2008). Climate change and food security. *Agriculture and Forestry*, *66*(3), 197–210. https://doi.org/10.17707/AgricultForest.66.3.16

FAO. (2011). *FAO at work 2010–2011: Women -Key to Food Security*. 24. www.fao.org

FAO. (2015). *Climate change and food security: risks and responses*.

FAO. (2016a). *Climate change and food security: risks and responses. Rome, Italy: FAO* (Issue September). https://www.fao.org/3/i5188e/i5188e.pdf

FAO. (2016b). The state of food and agriculture: Climate change, agriculture and food security. In *Scottish Geographical Magazine* (Vol. 71, Issue 2). https://doi.org/10.1080/00369225508735601

FAO. (2017). The Future of Food and Agriculture: Trends and Challenges. In *The future of food and agriculture: trends and challenges* (Vol. 4, Issue 4). www.fao.org/publications%0Ahttp://www.fao.org/3/a-i6583e.pdf%0Ahttp://siteresources.worldbank.org/INTARD/825826-1111044795683/20424536/Ag_ed_Africa.pdf%0Awww.fao.org/cfs%0Ahttp://www.jstor.org/stable/4356839%0Ahttps://ediss.uni-goettingen.de/bitstream/han

FAO. (2018). *Mongolia. Impact of Early Warning Early Action. Protecting the livelihoods of herders from a dzud winter*. 32. http://www.fao.org/emergencies/fao-in-action/ewea/en/

FAO. (2019). *Colombia. Impact of Early Warning Early Action. Boosting food security and social cohesion on the frontline of the migration crisis Food*. 32. http://www.fao.org/emergencies/fao-in-action/ewea/en/

FAO. (2020). *Applying an inclusive and equitable approach to anticipatory action*.

FAO. (2021a). *The Impact of Disasters and Crises on Agriculture and Food Security*. https://doi.org/10.4060/cb3673en

FAO. (2021b). *The State of Food and Agriculture: Making Agrifood Systems More Resillient to Shocks and Stesses*. https://doi.org/10.4060/cb4476en

FAO. (2023a). The impact of disasters on agriculture and food security. Avoiding and Reducing Losses through Investment in Resilience. In *The impact of disasters on agriculture and food security 2023*. https://doi.org/10.4060/cc7900en

FAO. (2023b). The status of women in agrifood systems. In *The status of women in agrifood*

systems. https://doi.org/10.4060/cc5343en

FAO, IFAD, UNICEF, WFP, & WHO. (2024). *The State of Food Security and Nutrition in the World: Financing to End Hunger, Food Insecurity and Malnutrition in All its Forms*.

FAO, IFAD, UNICEF, WFP, & WHO. (2022). *The State of Food Security and Nutrition in the World. Repurposing food and agricultural policies to make healthy diets more affordable*. https://doi.org/10.4060/cc0639en%0A

FAO, IFAD, UNICEF, WFP, & WHO. (2025). *The state of Food security and Nutrition in the World 2025 – Addressing high food price inflation for food security and nutrition. Rome. https://doi.org/10.4060/cd6008en*. https://doi.org/10.1016/S2213-8587(22)00220-0

Fekete, A. (2024). Natural Hazards and Climate Change Impacts on Food Security and Rural–Urban Livelihoods in Mozambique—A Bibliometric Analysis and Framework. *Earth (Switzerland), 5*(4), 761–783. https://doi.org/10.3390/earth5040040

Fernandes, A. A. T., Filho, D. B. F., da Rocha, E. C., & da Silva Nascimento, W. (2020). Read this paper if you want to learn logistic regression. *Revista de Sociologia e Politica*, *28*(74), 1/1-19/19. https://doi.org/10.1590/1678-987320287406EN

Feulner, G. (2017). Global Challenges: Climate Change. *Global Challenges*, *1*(1), 5–6. https://doi.org/10.1002/gch2.1003

Few, R. (2003). Flooding, vulnerability and coping strategies: Local responses to a global threat. *Progress in Development Studies*, *3*(1), 43–58. https://doi.org/10.1191/1464993403ps049ra

FEWS NET. (2025a). *Crisis (IPC Phase 3) outcomes expected in south , center , and north*. *October 2024*. https://fews.net/southern-africa/mozambique/food-security-outlook/october-2024/print

FEWS NET. (2025b). *Seasonal improvements likely short-lived following below-average 2025 harvest Key Messages*. *July*, 2024–2026. https://fews.net/southern-africa/mozambique/key-message-update/july-2025/print

Folke, C. (2016). *Resilience (Republished)*. *21*(4). https://www.researchgate.net/profile/Carl-Folke/publication/311621233_Resilience_Republished/links/5878c3ce08aebf17d3be2463/Resilience-Republished.pdf?origin=publication_detail&_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZS

I6InNpZ251cCIsInBhZ2UiOiJwdWJsaWNhdGlvbkRvd2

Foster, E., Jolliffe, D. M., Ibarra, G. L., Lakner, C., & Tettah-Baah, S. (2025). Global Poverty Revisited Using 2021 PPPs and New Data on Consumption. *Global Poverty Revisited Using 2021 PPPs and New Data on Consumption*, *June*. https://doi.org/10.1596/1813-9450-11137

Fottrell, E., & Byass, P. (2008). *Population survey sampling methods in a rural African setting : measuring mortality*. *11*. https://doi.org/10.1186/1478-7954-6-2

Freduah, B. S., MacCarthy, D. S., Adam, M., Ly, M., Ruane, A. C., Timpong-Jones, E. C., Traore, P. S., Boote, K. J., Porter, C., Adiku, S. G. K., Gbangou, T., Ludwig, F., van Slobbe, E., Greuell, W., Kranjac-Berisavljevic, G., Spear, D., Selato, J. C., Mosime, B., Nyamwanza, A. M., … Ertsen, M. W. (2019). Contextualising seasonal climate forecasts by integrating local knowledge on drought in Malawi. *Climate Services*, *141*(May), 31–36. https://doi.org/10.1016/j.cliser.2021.100268%0Ahttps://doi.org/10.1016/j.cliser.2019.05.001

Gadiso, W. J., Alemu, B. A., & Shete, M. (2024). Unpacking regional variations of multidimensional food security in rural Ethiopia: insights for policy. *International Journal of Social Economics*, *51*(5), 585–603. https://doi.org/10.1108/IJSE-02-2023-0139

Greenacre, M. (2017). *Correspondence Analysis in Practice* (Third edit). https://www.perlego.com/book/1575804/correspondence-analysis-in-practice-pdf

Greenacre, M., & Blasius, J. (2006). *Multiple Correspondence Analysis and Related Methods*.

Gregory, P. J., Ingram, J. S. I., & Brklacich, M. (2005). Climate change and food security. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *360*(1463), 2139–2148. https://doi.org/10.1098/rstb.2005.1745

Haggblade, S., Hazell, P., & Reardon, T. (2010). The Rural Non-farm Economy : Prospects for Growth and Poverty Reduction. *World Development*, *38*(10), 1429–1441. https://doi.org/10.1016/j.worlddev.2009.06.008

Hair, J. F. J., Black, W. C., Babin, B. J., Anderson, R. E., Black, W. C., & Anderson, R. E. (2019). *Multivariate Data Analysis, Eighth Edition*.

https://doi.org/10.1002/9781119409137.ch4

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., & Vogt-Schilb, A. (2016). *Shock waves. Managing the impacts of Climate Change on Poverty*. https://www.researchgate.net/publication/283642157_Shock_Waves_Managing_the_Impacts_of_Climate_Change_on_Poverty/link/56531bef08aeafc2aabaee4f/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19

Harris, D., & Orr, A. (2014). Is rainfed agriculture really a pathway from poverty ? *Agricultural Systems*, *123*, 84–96. https://doi.org/10.1016/j.agsy.2013.09.005

Hartigan, A., & Wong, M. A. (1979). *A K-Means Clustering Algorithm*. https://doi.org/10.2307/2346830

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., Rajaofara, H., & MacKinnon, J. L. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1639). https://doi.org/10.1098/rstb.2013.0089

Headey, D. D., & Martin, W. J. (2016). *The Impact of Food Prices on Poverty and Food Security*. https://doi.org/10.1146/annurev-resource-100815-095303

Hertel, T. W., & Rosch, S. D. (2010). Climate change, agriculture, and poverty. *Applied Economic Perspectives and Policy*, *32*(3), 355–385. https://doi.org/10.1093/aepp/ppq016

Hirvonen, K., Taffesse, A. S., & Hassen, I. W. (2017). *Seasonality and household diets in Ethiopia*. *19*(13), 1723–1730. https://doi.org/10.1017/S1368980015003237

Hisali, E., Birungi, P., & Buyinza, F. (2011). Adaptation to climate change in Uganda : Evidence from micro level data. *Global Environmental Change*, *21*(4), 1245–1261. https://doi.org/10.1016/j.gloenvcha.2011.07.005

Hübler, M., Ogenrwoth, B., Walusimbi, R., Ssali, P., Bonabana, J., & Kyamanywa, S. (2025). The impact of weather shocks on food security in Uganda : a panel regression analysis. *Food Security*, 957–978. https://doi.org/10.1007/s12571-025-01542-8

Hussain, A., Rasul, G., Mahapatra, B., & Tuladhar, S. (2016). Household food security in the face of climate change in the Hindu-Kush Himalayan region. *Food Security*, *8*(5), 921–

937. https://doi.org/10.1007/s12571-016-0607-5

IFPRI. (2005). The Future of Small Farms: Proccedings of a Research Workshop. *The Future of Small Farms: Proceedings of a Research Workshop. 2005. Wye, UK, June 26-29, 2005*, 362. http://pdf.usaid.gov/pdf_docs/Pnado609.pdf#page=362

IFRC. (2022). *Early Warning and Anticipatory Action*. 5–8.

IFRC. (2025). *Strengthening National Disaster Risk Management Systems through the integration of Anticipatory Action*. https://www.ifrc.org/sites/default/files/2025-09/Strengthening_National_Disaster_Risk_Management_Systems_through_integration_of_anticipatory_action.pdf

IFRC, FAO, WFP, OCHA, & Network, S. (2022). Enabling Anticipatory Action to Scale to Address the Challenge of the Climate Crisis. *Disasters*, *46*(1), 95–118. https://doi.org/10.1111/disa.12467

Instituto Nacional de Estatística (INE). (2017). *Gaza quadro 6. Chefes de agregado familiar por estado civil, segundo área de residência, distrito e sexo. Província de Gaza, 2017*.

IPC. (2023). *Mozambique Current Acute Food Insecurity*. *March*.

IPC. (2025a). *MOZAMBIQUE : IPC Acute Food Insecurity Snapshot | October 2024 - March 2025*. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/COMBINED_IPC_Mozambique_Acute_Food_Insecurity_Oct2024_Mar2025_Snapshot_English.pdf

IPC. (2025b). *MOZAMBIQUE: IPC Acute Food Insecurity Snapshot |. October 2024*, 2025. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Mozambique_Acute_Food_Insecurity_Aug2024_Mar2025_Snapshot_English.pdf

IPC. (2026). *MOZAMBIQUE: IPC Acute Food Insecurity Snapshot |. MARCH*, 2026. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/COMBINED_IPC_Mozambique_Acute_Food_Insecurity_Oct2025_Mar2026_Snapshot.pdf

IPCC. (2007a). *Climate Change: Impacts, Adapataions and Vulnerability*. https://doi.org/10.1016/B978-008044910-4.00250-9

IPCC. (2021). *Climate Change 2021 The Physical Science Basis Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate*

Change. https://doi.org/10.1017/9781009157896.

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://doi.org/10.1017/9781009325844.Front

IPCC. (2023). *Climate Change: 2023 Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf

IPCC, I. P. on C. C. (2001). Climate Change: Impacts, Adaptation & Vulnerability. *Ipcc Working Group*, 10032. http://www.ipcc.ch/ipccreports/tar/wg2/index.htm

IPCC, I. P. on C. C. (2007b). Climate change 2007. The Physical Science Basis. In *Weather* (Issue 8). https://doi.org/10.1256/wea.58.04

IPCC, I. P. on C. C. (2007c). *The Intergovernmental Panel on Climate Change*. https://doi.org/10.1201/b11064-39

Jalane, O. I., da Silva, E. V., & Sopchaki, C. H. (2021). Subsistence Agriculture and Climate Change: Cases of the Districts of Magude and Moamba (South of Mozambique). *Revista de Geociencias Do Nordeste*, *7*(2), 123–130. https://doi.org/10.21680/2447-3359.2021v7n2ID21231

Jemaneh, S. A., & Shibeshi, E. M. (2023). Women empowerment in agriculture and its effect on household food security : evidence from Gamo Zone of Southern Ethiopia. *Agriculture & Food Security*, 1–26. https://doi.org/10.1186/s40066-023-00437-1

Jiri, O., Mafongoya, P. L., & Chivenge, P. (2017). *Building climate change resilience through adaptation in smallholder farming systems in semi-arid Zimbabwe*. https://doi.org/10.1108/IJCCSM-07-2016-0092

Jollife, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *374*(2065). https://doi.org/10.1098/rsta.2015.0202

Jolliffe, I. . ., & Cadima, J. (2016). *Principal Component Analysis : A Review and Recent Developments*. https://doi.org/doi.org/10.1098/rsta.2015.0202

Jolliffe, I. . T. (2002). *Principal Component Analysis, Second Edition* (Second Edi).

http://cda.psych.uiuc.edu/statistical_learning_course/Jolliffe I. Principal Component Analysis (2ed., Springer, 2002)(518s)_MVsa_.pdf

Jones, C., Guerten, N., Hillesland, M., & Koechlein, E. (2020). *Applying an inclusive and equitable approach to anticipatory action*. https://wrd.unwomen.org/sites/default/files/2021-11/CB1072EN.pdf

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bistrom, M. L., Nelson, S., & Kristjanson, P. (2015). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development*, *8*(2), 133–144. https://doi.org/10.1080/17565529.2015.1050978

Karmakar, R., Das, I., Dutta, D., & Rakshit, A. (2016). Potential Effects of Climate Change on Soil Properties: A Review. *Science International*, *4*(2), 51–73. https://doi.org/10.17311/sciintl.2016.51.73

Kassie, M., Ndiritu, S. W., & Stage, J. (2014). *What Determines Gender Inequality in Household Food Security in Kenya ? Application of Exogenous Switching Treatment Regression*.

Lamichaney, A., Tewari, K., Basu, P. S., Katiyar, P. K., & Singh, N. P. (2021). Effect of elevated carbon-dioxide on plant growth, physiology, yield and seed quality of chickpea (Cicer arietinum L.) in Indo-Gangetic plains. *Physiology and Molecular Biology of Plants*, *27*(2), 251–263. https://doi.org/10.1007/s12298-021-00928-0

Larson, J. B., Castellanos, P., & Jensen, L. (2019). Gender , household food security , and dietary diversity in western Honduras. *Global Food Security*, *20*(March 2018), 170–179. https://doi.org/10.1016/j.gfs.2019.01.005

Le Masson, V. (2016). Gender and resilience: from theory to practice. *BRACED Knowledge Manager*, 60. https://odi.cdn.ngo/media/documents/10224.pdf

Levine, S., Wilkinson, E., Weingärtner, L., & Mall, P. (2020). Anticipatory action for livelihood protection: A collective endeavour. *ODI Working Paper 580*, 1–36.

Loison, S. A. (2015). Rural Livelihood Diversification in Sub-Saharan Africa : A Literature Review Rural Livelihood Diversification in Sub-Saharan Africa : A Literature Review. *The Journal of Development Studies*, *51*(9), 1125–1138.

https://doi.org/10.1080/00220388.2015.1046445

Lowder, S. K., Skoet, J., & Raney, T. (2016). The Number , Size , and Distribution of Farms , Smallholder Farms , and Family Farms Worldwide. *World Development*, *87*, 16–29. https://doi.org/10.1016/j.worlddev.2015.10.041

MacQueen, J. (1967). *SOME METHODS FOR CLASSIFICATION AND ANALYSIS OF MULTIVARIATE OBSERVATIONS*. *233*(233), 281–297.

Maia, R. da, Nhambiu, B., Cuna, J., Amid, U., Vilanculos, A., & Machele, J. (2019). *Forecasts for Anticipatory Humanitarian Action (FATHUM). Mozambique Country-Specific Risk and Vulnerability Profile Report*. *July*. https://www.anticipation-hub.org/Documents/Reports/Mozambique_Risk_Profile_Report_Final_July_2019.pdf

Marie, M., Yirga, F., Haile, M., & Tquabo, F. (2020). Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon*, *6*(4). https://doi.org/10.1016/j.heliyon.2020.e03867

Matchaya, G. C., Tadesse, G., & Kuteya, A. N. (2022). Rainfall shocks and crop productivity in Zambia: Implication for agricultural water risk management. *Agricultural Water Management*, *269*, 107648. https://doi.org/10.1016/j.agwat.2022.107648

Maxwell, D., Coates, J., & Vaitla, B. (2013). *How Do Different Indicators of Household Food Security Compare ? Empirical Evidence from Tigray*. *August*.

McCordic, C., Riley, L., & Raimundo, I. (2021). Household food security in Maputo: the role of Gendered Access to education and employment. *Development Southern Africa*, *38*(5), 816–827. https://doi.org/10.1080/0376835X.2021.1932423

McDowell, J. Z., & Hess, J. J. (2012). Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Global Environmental Change*, *22*(2), 342–352. https://doi.org/10.1016/j.gloenvcha.2011.11.002

Meinzen-Dick, R., Quisumbing, A., Doss, C., & Theis, S. (2019). Women's land rights as a pathway to poverty reduction: Framework and review of available evidence. *Agricultural Systems*, *172*(November 2017), 72–82. https://doi.org/10.1016/j.agsy.2017.10.009

Mekonnen, A., Tessema, A., Ganewo, Z., & Haile, A. (2021). Climate change impacts on household food security and farmers adaptation strategies. *Journal of Agriculture and Food Research*, *6*, 100197. https://doi.org/10.1016/j.jafr.2021.100197

Miller, C. M., Tsoka, M., & Reichert, K. (2011). The impact of the Social Cash Transfer Scheme on food security in Malawi. *Food Policy*, *36*(2), 230–238. https://doi.org/10.1016/j.foodpol.2010.11.020

Ministério da Agricultura e Desenvolvimento Rural. (2023). *INQUÉRITO AGRÁRIO INTEGRADO 2023*. *1383*, 1–11. https://www.agricultura.gov.mz/wp-content/uploads/2024/09/Inquerito-Agrario-Integrado-IAI-2023.pdf

Ministry of Land and Environment. (2021). *Update of the First Nationally Determined Contribution to the United Nations Framework Convention on Climate Change, Mozambique*. 2020–2025.

Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(50), 19680–19685. https://doi.org/10.1073/pnas.0701855104

Murendo, C., Kairezi, G., & Mazvimavi, K. (2020). Resilience capacities and household nutrition in the presence of shocks . Evidence from Malawi. *World Development Perspectives*, *20*(June 2019), 100241. https://doi.org/10.1016/j.wdp.2020.100241

Muthayya, S., Rah, J. H., Sugimoto, J. D., Roos, F. F., & Black, R. E. (2013). *The Global Hidden Hunger Indices and Maps : An Advocacy Tool for Action*. *8*(6), 1–12. https://doi.org/10.1371/journal.pone.0067860

Mwangi, V., Owuor, S., Kiteme, B., Giger, M., Jacobi, J., & Kirui, O. (2020). *Linking Household Food Security and Food Value Chains in North West Mt . Kenya*. 1–15.

Niang, I., Ruppel, O. C., Abdrobo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. *Postcolonialism*, 217–235. https://doi.org/10.1002/9781119316817.ch17

Niazi, R., Liu, A., Han, J., Hassan, S., Elham, H., & Osewe, M. (2025). *Household Income Diversification and Food Insecurity : A Case Study of Afghanistan*. 1–24.

Njuki, J., Eissler, S., Malapit, H., Meinzen-dick, R., Bryan, E., & Quisumbing, A. (2022). A review of evidence on gender equality , women ' s empowerment , and food systems. *Global Food Security*, *33*(February), 100622. https://doi.org/10.1016/j.gfs.2022.100622

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. https://doi.org/10.1017/CBO9780511808678.003

Nyasimi, Mary & Huyer, S. (2017). Closing the Gender Gap in Agriculture. *Gender, Technology and Development*, *20*(2), 105–116. https://doi.org/10.1177/0971852416643872

Nyasimi, M., & Huyer, S. (2017). Background: the gender gap in agriculture under a changing climate. *Agriculture for Development*, *30*, 2015–2018. https://cgspace.cgiar.org/rest/bitstreams/114804/retrieve

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L., & West, J. (2004). Mapping vulnerability to multiple stressors: Climate change and globalization in India. *Global Environmental Change*, *14*(4), 303–313. https://doi.org/10.1016/j.gloenvcha.2004.01.001

ODI & CCS. (2024). *Climate change and human security implications for humanitarian, development, disaster and climate risk management in Mozambique*. www.odi.org/en/publications/meeting-report-climate-change-human-

OECD. (2024). *Breaking the Vicious Circles of Informal Employment and Low-Paying Work*.

Ogundeji, A. A. (2022). Adaptation to Climate Change and Impact on Smallholder Farmers' Food Security in South Africa. *Agriculture (Switzerland)*, *12*(5). https://doi.org/10.3390/agriculture12050589

Omokpariola, D. O., Agbanu-kumordzi, C., Samuel, T., Kiswii, L., Moses, G. S., & Adelegan, A. M. (2025). *Climate change , crop yield , and food security in Sub-Saharan Africa*.

Omotoso, A. B., Letsoalo, S., Olagunju, K. O., Tshwene, C. S., & Omotayo, A. O. (2023). Climate change and variability in sub-Saharan Africa: A systematic review of trends and impacts on agriculture. *Journal of Cleaner Production*, *414*, 137487. https://doi.org/10.1016/j.jclepro.2023.137487

Opoku, S., Jacobs, B., & Cunningham, R. (2026). The role of institutions in enhancing climate change adaptation by smallholder farmers in the Talensi district of Ghana. *Environmental Development*, *57*(September 2025), 101341. https://doi.org/10.1016/j.envdev.2025.101341

Ostrom, E. (1990). *Governing the Commons. The Evolution of Institutions for Collective Action*.

Pereira, R. A., & Hodge, A. (2015). *Editorial Food insecurity : a critical public health nutrition*

concern. *18*(16), 2893–2894. https://doi.org/10.1017/S136898001500292X

Popat, M., Rathod, K., Artur, L., Perez, E. C. De, Sharma, A., Beca, N., & Sant, C. Van. (2024). Anticipatory actions : lessons from the storm Ana in Mocuba district , Mozambique. *Journal of International Humanitarian Action*, *9*. https://doi.org/10.1186/s41018-024-00162-9

Pople, A., Hill, R., Dercon, S., & Brunckhorst, B. (2021). Anticipatory Cash Transfers in Climate Disaster Response. *CSAE Working Paper*, *07*(April 2021). https://static1.squarespace.com/static/61542ee0a87a394f7bc17b3a/t/616ad24fdbfca62188f8e614/1634390614711/FINAL%2BAnticipatory_Cash_Transfers_in_Climate_Disaster_Response%2B%28for%2BWP%29%2BF3.pdf

Porter, J. R., Xie, L., Challinor, A. J., Cochrane, K., Howden, S. M., Iqbal, M. M., Lobell, D. B., Travasso, M. I., Aggarwal, P., Hakala, K., & Jordan, J. (2014). *Food security and food production systems. In Climate Change 2014: Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects*. 485–534. https://doi.org/10.1017/CBO9781107415379.012

Pörtner, H.-O. . R. H. . A. I. . A. C. A. R. A. P. A. E. A. R. A. B. B. B.-F. R. B. K. R. B. J. B. K. B. M. A. C. (2023). Climate Change2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of theIntergovernmental Panel on Climate Change. In *Climate Change 2022 – Impacts, Adaptation and Vulnerability*. https://doi.org/10.1017/9781009325844.Front

Quisumbing, A. R., Meinzen-Dick, R., Raney, T. L., Croppenstedt, A., Behrman, J. A., & Peterman, A. (2014). Gender in agriculture: Closing the knowledge gap. *Gender in Agriculture: Closing the Knowledge Gap*, 1–444. https://doi.org/10.1007/978-94-017-8616-4

Raffo-Babici, V., Calderon-Cisneros, J., Peralta-Gamboa, D., & Coloma-Casanova, A. (2025). Multidimensional analysis of access to resources and its relationship with food security in vulnerable populations. *Clinical Nutrition Open Science*, *61*, 317–328. https://doi.org/10.1016/j.nutos.2025.05.001

Rajasooriar, D., & Soma, T. (2022). Food access , mobility , and transportation : a survey and key informant interviews of users of non-profit food hubs in the City of Vancouver before and during the COVID-19 crisis. *BMC Public Health*, 1–18.

https://doi.org/10.1186/s12889-021-12434-9

Risk-informed Early Action Partnership (REAP). (2021). *Country case studies Mozambique*. 1–13. https://www.anticipation-hub.org/Documents/Case_Studies/REAP_-_Mozambique.pdf

Rothwell, D. W., & Chang-Keun, H. (2010). *Exploring the Relationship Between Assets and Family Stress Among Low-Income Families*. *59*(October), 396–407. https://doi.org/10.1111/j.1741-3729.2010.00611.x

Salite, D. (2019). Explaining the uncertainty : understanding small-scale farmers ' cultural beliefs and reasoning of drought causes in Gaza Province , Southern Mozambique Intergovernmental Panel on Climate Change Statistical Package for Social Sciences. *Agriculture and Human Values*, *36*(3), 427–441. https://doi.org/10.1007/s10460-019-09928-z

Sanchez, P. A., & Swaminathan, M. S. (2005). Cutting world hunger in half. *Science*, *307*(5708), 357–359. https://doi.org/10.1126/science.1109057

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(50), 19703–19708. https://doi.org/10.1073/pnas.0701976104

Scoones, I. (1998). *SUSTAINABLE RURAL LIVELIHOODS A FRAMEWORK FOR ANALYSIS IDS WORKING PAPER 72*. https://opendocs.ids.ac.uk/articles/report/Sustainable_Rural_Livelihoods_A_Framework_for_Analysis/26473384?file=48230770

Scoones, I. (2009). Livelihoods perspectives and rural development. *Journal of Peasant Studies*, *36*(1), 171–196. https://doi.org/10.1080/03066150902820503

Shifat, Z. F., Alam, M. J., *, Ismat Ara Begum, M. A. I., Sarma, P. K., And, & McKenzie, A. M. (2025). *The association between household ' s asset ownership and food security : panel data evidence from Bangladesh*. *January*, 1–13. https://doi.org/10.3389/fsufs.2024.1479410

Soares, J. C., Santos, C. S., Carvalho, S. M. P., Pintado, M. M., & Vasconcelos, M. W. (2019). Preserving the nutritional quality of crop plants under a changing climate: importance and strategies. *Plant and Soil*, *443*(1–2), 1–26. https://doi.org/10.1007/s11104-019-04229-0

Soh Wenda, B. D., Fon, D. E., Molua, E. L., & Longang, S. G. (2024). Women, income use and nutrition quality: effects of women's decision-making in rural households in Cameroon. *Agriculture and Food Security*, *13*(1), 1–20. https://doi.org/10.1186/s40066-024-00480-6

Start Network. (2020). *ARC Replica pay-out: Senegal 2020. Internal Evaluation*. *December*. https://reliefweb.int/report/senegal/arc-replica-payout-senegal-2020-internal-evaluation

Stephens, E. C., Jones, A. D., & Parsons, D. (2018). Agricultural systems research and global food security in the 21st century: An overview and roadmap for future opportunities. *Agricultural Systems*, *163*, 1–6. https://doi.org/10.1016/j.agsy.2017.01.011

Stifel, D., & Minten, B. (2017). Market Access , Well-being , and Nutrition : Evidence from Ethiopia. *World Development*, *xx*(Essp Ii). https://doi.org/10.1016/j.worlddev.2016.09.009

Sultan, B., & Gaetani, M. (2016). Agriculture in West Africa in the twenty-first century: Climate change and impacts scenarios, and potential for adaptation. *Frontiers in Plant Science*, *7*(AUG2016), 1–20. https://doi.org/10.3389/fpls.2016.01262

Sun, Q., Fu, C., Bai, Y., Oduor, A. M. O., & Cheng, B. (2023). *Livelihood Diversification and Residents ' Welfare : Evidence from Maasai Mara National Reserve*.

Suparna, P. (2020). Analysis of Main Components Status of Food Security at Village/Sub-District Level in Yogyakarta Special Region. *Jurnal Matematika "MANTIK," 6*(1), 30–37. https://doi.org/10.15642/mantik.2020.6.1.30-37

Sweileh, W. M. (2020). Bibliometric analysis of peer - reviewed literature on food security in the context of climate change from 1980 to 2019. *Agriculture & Food Security*, 1–15. https://doi.org/10.1186/s40066-020-00266-6

Tadesse, A., Li, K., Helton, J., Huang, J., & Ansong, D. (2025). The Links Between Community-Based Financial Inclusion and Household Food Availability: Evidence from Mozambique. *Foods*, *14*(2), 1–14. https://doi.org/10.3390/foods14020212

Tafesse, A., Ayele, G., Ketema, M., & Geta, E. (2016). Food Security and Adaptation Strategies to Climate Change in Eastern Ethiopia. *Econ.Res*, *5*(6), 81–88. https://doi.org/10.11648/j.eco.20160506.11

Tamako, N., & Chitja, J. M. T. (2017). Does social capital play a role in climate change

adaptation among smallholder farmers for improving food security and livelihoods? *Journal of Consumer Sciences, Special Edition Food and Nutrition Challenges in Southern Africa*, *2*, 16–27.

Thamaga-chitja, J. M., Tamako, N., & Ojo, T. O. (2025). *Implications of Land Ownership Heterogeneity on Household Food Security : A Case Study of Urban Farming in Pietermaritzburg , KwaZulu-Natal Province*. 1–16.

The World Bank Group. (2023). *Mozambique: Country Climate and Development Report*. https://documents1.worldbank.org/curated/en/099113023154021937/pdf/P1771520fcab7a0930aca102c9d7107d4cc.pdf

The World Bank Group. (2025). *CLIMATE RISK COUNTRY PROFILE, MOZAMBIQUE*. https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/17258-WB_Mozambique Country Profile-WEB.pdf

Thomas, D. S. G., & Twyman, C. (2005). Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environmental Change*, *15*(2), 115–124. https://doi.org/10.1016/j.gloenvcha.2004.10.001

Toromade, A. S., Soyombo, D. A., & Kupa, E. (2024). *Reviewing the impact of climate change on global food security : Challenges and solutions*. *September*. https://doi.org/10.51594/ijarss.v6i7.1300

Turner, B. L., Kasperson, R. E., Matson, P. A., Mccarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). *A framework for vulnerability analysis in sustainability science*. *100*(14).

UN Women. (2022a). *GENDER ANALYSIS IN TECHNICAL AREAS : Climate and Disaster Risk Finance and Insuarance*. https://knowledge.unwomen.org/sites/default/files/2022-12/Gender Analysis Guidance-final.pdf

UN Women. (2022b). *Handbook on Gender Mainstreaming for Gender Equality Results*. https://knowledge.unwomen.org/sites/default/files/2022-02/Handbook-on-gender-mainstreaming-for-gender-equality-results-en.pdf

UN Women. (2024). *Progress on the Sustainable Development Goals: The Gender Snapshot 2024*. https://www.unwomen.org/sites/default/files/2024-09/progress-on-the-sustainable-

development-goals-the-gender-snapshot-2024-en.pdf

UN Women. (2026). *Executive Board of the United Nations Entity for Gender Equality and the Empowerment of Women Report of the Under-Secretary-General / Executive Director* (Vol. 07261, Issue May). https://docs.un.org/en/unw/2026/2

UNDRR. (2023). *Analysis of Barriers in Financing and Operationalizing Linkages Between Anticipatory Action and Social Protection Systems*. 6. https://www.undrr.org/contact-us

UNFCCC. (2016). *The Paris Agreement*. https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

Usman, M. A., & Haile, M. G. (2022). Market access, household dietary diversity and food security: Evidence from Eastern Africa. *Food Policy*, *113*, 102374. https://doi.org/10.1016/j.foodpol.2022.102374

van Oort, P. A. J., & Zwart, S. J. (2018). Impacts of climate change on rice production in Africa and causes of simulated yield changes. *Global Change Biology*, *24*(3), 1029–1045. https://doi.org/10.1111/gcb.13967

Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. (2012). Climate change and food systems. *Annual Review of Environment and Resources*, *37*, 195–222. https://doi.org/10.1146/annurev-environ-020411-130608

Von Braun, J., & Kennedy, E. T. (1994). *Agricultural Commercialization, Economic Development, and Nutrition*.

Weldearegay, S. K., & Tedla, D. G. (2018). Impact of climate variability on household food availability in Tigray, Ethiopia. *Agriculture and Food Security*, *7*(1), 1–10. https://doi.org/10.1186/s40066-017-0154-0

WFP. (2020). *The evidence base on Anticipatory Action*. *May*, 1–46. https://docs.wfp.org/api/documents/WFP-0000110236/download/?_ga=2.78704468.1909757493.1678139892-263477493.1677935196

WFP. (2021). *Food security and climate change, the pressing reality of Mozambique*. *May*, 4.

WFP. (2024). *WFP Mozambique Country Brief. December 2024*. https://docs.wfp.org/api/documents/WFP-

0000164099/download/?_ga=2.107543621.691249365.1741763123-806104240.1741763123

WFP. (2025a). *Anticipatory Action Learning and Validation Workshop Report*. *May*.

WFP. (2025b). *WFP's evidence base on Anticipatory Action 2015-2024. Synthesis of 16 studies on the effectiveness of Anticipatory Action* (Issue April).

WFP. (2025c). *WFP's evidence base on Anticipatory Action 2015-2024. Synthesis of 16 studies on the effectiveness of Anticipatory Action*. *April*. https://www.anticipation-hub.org/Documents/Reports/WFP_evidence_base_Anticipatory_Action_2015-2024.pdf

WFP. (2025d). *WFP Mozambique Country Brief*. *January*, 2025–2026. https://reliefweb.int/report/mozambique/wfp-mozambique-country-brief-january-2025

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). *At Risk Second Edition: Natural Hazards, People's Vulnerability and Disasters*. https://www.researchgate.net/publication/323368943_At_Risk_Natural_Hazards_People's_Vulnerability_and_Disasters?__cf_chl_f_tk=O9HQAGeSs4y6kKKbeRKSFhmz1agQSTIVHbgVIqcSBqk-1782907606-1.0.1.1-H1b62ZkgPSAuVCcP6bhf4hZp9haS2l37b.krQC6BmvM

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*.

World Bank. (2017). *Climate-Smart Agriculture in Mozambique*. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA-in-Mozambique.pdf

World Bank. (2020). *Nutrition Smart Agriculture in Mozambique*. https://documents1.worldbank.org/curated/en/392721597038541068/pdf/Nutrition-Smart-Agriculture-in-Mozambique.pdf

World Bank. (2023). *A New Era in Development. Sustainable, Inclusive, and Resilient Development*. *2*(March).

World Bank. (2024). Mozambique - Agriculture Support Policy Review. *Mozambique - Agriculture Support Policy Review*. https://doi.org/10.1596/41958

World Bank. (2025). *CLIMATE RISK COUNTRY PROFILE MOZAMBIQUE*.

World Bank Group. (2023). *Mozambique Gender Assessment. Leveraging women and girls'*

potential. https://documents1.worldbank.org/curated/en/099091823092039842/pdf/P1772130ebf8690b50b0ff0231c20e8894f.pdf

World Bank Group. (2024). *World Bank Group Gender Strategy 2024 – 2030: Accelerate Gender Equality to End Poverty on a Livable Planet*. https://documents1.worldbank.org/curated/en/099061124182033630/pdf/BOSIB17e6952570c51b49812a89c05be6a4.pdf

Wubetie, H. T., Zewotir, T., & Mitku, A. A. (2024). *The spatial e ects of the household ' s food insecurity levels in Ethiopia : by ordinal geo-additive model*.

Yadav, S. S., Hegde, V. S., Habibi, A. B., Dia, M., & Verma, S. (2019). Climate Change, Agriculture and Food Security. *Food Security and Climate Change*, *February*, 1–24. https://doi.org/10.1002/9781119180661.ch1

Zeleke, T., Beyene, F., Deressa, T., Yousuf, J., & Kebede, T. (2021). Vulnerability of smallholder farmers to climate change-induced shocks in east hararghe zone, ethiopia. *Sustainability (Switzerland)*, *13*(4), 1–19. https://doi.org/10.3390/su13042162

APPENDICES

1. Approved Proposal for the Next Phase

UNIVERSIDADE
EDUARDO
MONDLANE

FACULDADE DE AGRONOMIA E ENGENHARIA FLORESTAL

DEPARTAMENTO DE ECONOMIA E DESENVOLVIMENTO RURAL
MESTRADO EM MUDANÇAS CLIMATICAS EM SISTEMAS AGRARIOS

Acta de Avaliação de Projecto de Investigação

No dia 7 do mês de **Março** do ano de **2025** na Faculdade de Agronomia e Engenharia Florestal da Universidade Eduardo Mondlane, o/a sr/a **Martha Among Adeke** apresentou e defendeu o seu projecto de investigação com o título **"Climate change ang food security: a case of climate-associated household food insecurity among smallholder farmers in Guija district"**

O JÚRI FOI ASSIM CONSTITUIDO:

PRESIDENTE Prof. Doutor Hélder Zavale Helder Zavale

SUPERVISOR Prof. Doutor Luís Artur

AVALIADOR Doutor Meizal Popat

A DELIBERAÇÃO SOBRE A CLASSIFICAÇÃO FOI A SEGUINTE:

O PROJECTO FOI [1] Aceite

PRESIDENTE	SUPERVISOR	AVALIADOR
Helder Zavale		

A Directora Adjunta para pós-graduação

(Doutora Sílvia N.D.Maússe Sitoe,Engª)

[1] ACEITE/ NÃO ACEITE (Neste caso indicar as razões)

2. Data Collection tool

CLIMATE CHANGE AND HOUSEHOLD FOOD SECURITY SURVEY IN GUIJA DISTRICT

Greetings. We are students from Eduardo Mondlane University, and we are researching on climate change impacts on household food security. We would like to ask you a few questions in regards to this, and this activity will last less than an hour. Your identity will be concealed in the data that is made available to the public. The information you provide will be used exclusively for research purposes; Your answers will not affect any benefits or grants you may receive now or in the future. You can withdraw from the study at any time, and if there are questions you do not prefer to answer, we respect your right not to answer them.

Do you agree to be part of this study?

Could we kindly proceed with the study if you consent? If;

☐ NO, kindly stop here ☐ YES, proceed.

***NB:** Tick (✓) where applicable*

SECTION A1: PARTICIPANT IDENTIFICATION

A1: General information

i.	Date of interview	
ii.	Name of interviewer	
iii.	Household number	
iv.	Division	Chivonguene
		Nalazi
		Canicado
		Mubanguene
v.	GPS coordinates	

SECTION A2: SOCIODEMOGRAPHIC FACTORS

1.	Respondent name (*only capture one name e.g. Grace*)	
2.	Respondent sex	Male
		Female
3.	Is the respondent the household head?	Yes
		No
4.	Relationship with household head	
5.	Age of respondent	
6.	Household Head sex	Male
		Female

7.	Household Head age		
8.	Household size /No. of people currently staying in the household	Males	
		Females	
		Youth (18 & above)	
		Children (< 17 yrs)	
		Elderly (65yrs >)	
9.	Level of education of household head		No school attended
			Informal
			Primary
			Secondary
			Tertiary
			Degree
			Masters
			PhD
10.	Marital status		Single
			Married
			Divorced
			Widowed

SECTION B: LIVELIHOODS

1. List activities that your household has developed to make a living over the last 12 months. Tick what is applicable and Rank them in order of relevance.

No.	**Activity**	**Tick**	**Rank**
1.	Pensions		
2.	Government job		
3.	Salaried job in the private sector (companies, hotels, restaurants)		
4.	Service provider (milling, taxi/bus/trishaw driver)		
5.	Petty trading		
6.	Sale of crops/vegetables		
7.	Sale of animal/products		
8.	Remittances from inside Mozambique		
9.	Remittances from abroad		
10.	Sale of fruits		
11.	Collection and sale of firewood		
12.	Sale of other wooden products (timber, bamboo, palm leaves)		
13.	Sale of non-timber forest products (orchids) and wild food products (plants/animals)		
14.	Mining and/ or quarrying		
15.	Caretaker of livestock/ shepherd		
16	Sale of products (sap, jaggery, alcoholic products)		
17.	Agriculture wage labor		
18.	Non-agricultural wage labor		
19.	Sale of handicrafts (carving, baskets, mats, pottery)		
20.	Skilled labor/artisan (carpentry, masonry, fishing)		
21.	Trade, commerce, shopkeeper		

b.) How many people are involved in the main activity?

No.	Category		Number
1.	Men	>18 yrs.	
		<18yrs.	
2.	Female	<18yrs.	
		>18yrs	
3.	Children < 17yrs old		

2. a) What do you estimate to be the total monthly income out of all that your household does?

……

b.) Is this amount for the last 30 days typical of an average month, or does your household usually earn more or less?

a). Less ☐ b) The same ☐ c) More ☐ d). Don't know ☐

3. What assets does your household currently own at the household and on the farm?

No.	**Assets**	**Tick**
1	House	
2	Car	
3	Motor cycle	
4	Tractor	
5	Tv	
6	Refrigerator	
7	Oven	
8	Air conditioner	
9	Land	
10	Animals	
12	Others	

4. Do you currently have land to perform agricultural activities?

Yes ☐ No. ☐

b) What is the status of the land that you have?

Owned ☐ Rented ☐

5. a) Do you currently have access to financial resources/ credit?

Yes ☐ No. ☐

b) If Yes; from who? Kindly tick an option from the following.

No.	**Resource source**	**Tick**
1.	Financial institution	

2.	Family & friends	
3.	Group Savings (VSLA)	
4.	NGO's	
5.	Farmer cooperatives	
6.	Others (specify)	

6. Do you have access to markets?

Yes ☐ No ☐

b) How far is the closet market to you?

Near ☐ Far ☐ Extremely far ☐

c) Are you satisfied with the market that you have access to?

Yes ☐ No. ☐

d) Rate the extent of your satisfaction (***Scale of 1- 3; 1- Not satisfied, 2 Satisfied and 3- extremely satisfied)***

1(Not satisfied) ☐ 2 (Satisfied) ☐ 3 (Extremely satisfied) ☐

e) do you have access to sell your produce in that market?

Yes ☐ ☐ No

f) If no, what are the reasons why not.

No.	Reasons	Tick
1.	Distance	
2.	Monopoly (market entry)	
3.	Poor transport facilities	
4.	Good pricing	
5.	Inadequate market infrastructure	
6.	Poor quality produce	
7.	Long chain of middle men	
8.	Changes in demand and supply	
9.	Lack of storage facilities	

7. a) Do you have access to market information?

Yes ☐ No. ☐

b) If Yes; to what extent.

Negligible ☐ 2. Very less ☐ 3. Less ☐ 4. Enough ☐ 5. Full ☐

SECTION C: CLIMATE CHANGE MODULE

1. What is your perception of climate change and its impacts? Tick what is possible (✓)

No.	**Perceptions of climate change**	**Yes=1 /No=0**	**Increase**	**Decrease**
1.	Changes in rainfall			
2.	Changes on the pattern/timing of rainfall			
3.	Changes in temperature			
4.	Occurrence of extreme weather events (drought, floods etc.)			
5.	Affected ability to grow crops/ raise livestock			
6.	Changes in the water levels in water bodies			
7.	Others (specify)			

2. What are you perceived effects of climate change impacts on agriculture?

No.	**Impacts on agriculture**	**Yes=1 /No=0**	**Increase**	**Decrease**
1.	Climate change affected your ability to grow crops			
2.	Have you noticed changes in types of crops growing well in your area			
3.	Have pests & diseases become of more or less of a problem to your crops			
4.	Have climate change impacts affected your ability to raise livestock			
5.	Have you noticed a reduction in yield			
6.	Have you changed your cropping season			
7.	Have you changed crops you grow			
8.	Others (specify)			

3. a) What are the impacts of climate change on livelihoods?

No.	**Livelihood impact**	**Tick**	**Rank**
1.	Yield reduction		
2.	Income losses		
3.	Reduction in the number of livestock & poultry		
4.	Death of livestock		
5.	Increase in pest and disease outbreaks and spread		
6.	Creation of new diseases and pests		
7.	Increase in post-harvest losses (storage & transport)		
8.	Reduced water availability		
9.	Reduced water quality		
10.	Salinization of coastal areas		
11.	Destruction of infrastructure and property		
12.	Crop damages		
13.	Reduced productivity in various sectors		
14.	Loss of livelihood		
15.	Increased poverty		
16.	Increased inequality		
17.	Conflicts		

18.	Others (specify)		

b). What are the different livelihood adaptation strategies have you adopted?

No.	Adaptation strategy	Tick
1.	Diversification of livelihood activity	
2.	Adoption of drought-resistant varieties	
3.	Adoption of irrigation	
4.	Soil & water management	
5.	Adjusting livestock populations	
6.	Adjusting grazing practices	
7.	Diversifying income sources	
8.	Migration	
9.	Changing consumption patterns	
10.	Others (specify)	

c). What factors hinder your adaptation strategies to climate change?

No.	Factor	Tick	Rank
1.	Limited resources		
2.	Limited Information		
3.	Perception/ beliefs		
4.	Socio-economic factors e.g. household size, education		
5.	Inadequate extension service		
6.	Policies		
7.	Lack of support		
8.	Others (specify)		

4. Impacts of climate change effects on food availability, access and nutrition

No.	Food security pillars	Yes=1 /No=0	Increase	Decrease
Food availability				
1.	Have you noticed reduced production/ yields in some areas			
2.	Have you noticed changes in suitability of land for crop production / changes in crops grown			
3.	Have you noticed changes in precipitation patterns			
4.	Have you noticed changes in growing seasons?			
5.	Have you noticed a prevalence of diseases?			
6.	Have you noticed changes in feed quality			
Food Access				
1.	Have you noticed changes in staple food prices?			

2.	Has climate change made it more difficult for you to access food markets or stores			
3.	Have you noticed shortages of certain foods due to climate-related disruptions?			
4.	Have you had to adjust your diet due to changes in food availability or price?			
5.	Have you noticed disruptions in the distribution of goods?			
6.	Have you noticed changes in transportation costs			
Nutrition				
1.	Have you noticed changes in the quality /variety of food available at your household?			
2.	Have you noticed changes in the health status of your family members?			
3.	Have you noticed changes in dietary patterns and food preferences in your household?			
4.	Have you noticed changes in nutrient deficiencies due to changes in food supply?)			
5.	Have you noticed food / crop safety challenges due to climate change impacts?			

5. a) Has your household witnessed or currently witnessing changes in prevailing weather conditions?

Yes ☐ ☐ No.

b) Which climate change has greatly impacted on your livelihood sources and what was the severity of the impact of climate change event on your livelihood?

(Scale of 1-3; 1- Extremely severe,2- Severe, 3-Not severe). Indicate by number of severities

No	**Climate change event**	**Severity (1-3)**
1.	Drought	
2.	Heat weaves/ high temperatures	
3.	Inadequate rainfall	
4.	Flooding	
5.	Cyclone	
6.	Storms	
7.	Others, specify	

6. Do you have access to extension services or technical support for farming?

Yes. ☐ ☐ No.

7. What is the source of climate information in the household? Tick what is possible (✓)

No.	Source of information	Tick
1.	Extension officer	
2.	Radio	
3.	Television	
4.	Fellow farmers	
5.	Mobile phones	
6.	Others (Specify)	

8. Have you received any support or training to help you adapt to climate change?

Yes ☐ No. ☐

9. Are you currently using any climate change adaptation strategy?

Yes ☐ No. ☐

b). If Yes**,** what are the climate change adaptation measures employed by the farmers? Tick what is possible (✓)

No.	Climate change adaptation measures	Tick
1.	Use of improved seeds	
2.	Growing short maturing variety	
3.	Livestock diversification	
4.	Livestock number reduction	
5.	Changing planting and harvesting dates	
6.	Income source diversification	
7.	Soil and water conservation	
8.	Irrigation	
9	Drought resistant crops	
10	Mixed farming	
11	Minimum tillage	
12	Crop and residue management	
13.	Altering cropping location	
14.	Improved water efficiency use	
15.	Altering livestock species/ breeds	
16.	Modifying breeding and grazing time	

10. Have you found these adaptation measures to be helpful to you and to what extent?

Yes ☐ ☐ No.

b) (1-Not helpful, 2-Helpful, and 3-Extremely helpful); choose based on the scale.

1. ☐ 2. ☐ 3. ☐

SECTION C: FOOD SECURITY MODULE

1. I would like to ask you about all the different foods that your household members have eaten in the last 7 days and yesterday (past 24hrs). Could you please tell me how many days in the past week your household has eaten the following foods? (for each food, ask what the primary source of each food item eaten that week was, as well as the second main source of food, if any)

Food Group	**FCS**	**HDDS**	**Source**
Ask questions for each type of food. Starts with the question for 7 days of the week asking all food groups Then ask the question from the last 24 hours	Indicate number of times eaten **in the last 7 days** (0 to 7 days)	Indicate number of times eaten **in the last 24 hours/yesterday**? (breakfast, lunch, dinner) 1= Yes, 0= No	**Source of the product** **1** = Own production **2** = Purchase **3** = Exchanged/Traded goods or service **4** = Borrowed **5** = Received as gifts **6** = Food aid **7** = Others, specify
1. **Cereals:** Maize, sorghum, rice, wheat, millet			
2. **Orange tubers and root tubers (Vit A);** Pumpkin, carrots, orange/yellow sweet potatoes			
3. **White tubers and roots:** Fresh cassava, dried cassava, yams, fresh sweet potato (white)			
4. **Dark green leafy vegetables:** Cassava leaves, pumpkin leaves, sweet potato leaves, spinach, kale, bean leaves			
5. **Other vegetables:** tomatoes, peppers, cabbage, okra, garlic, kale, onion, cabbage, eggplant, lettuce			
6. **Vitamin A rich fruits:** Ripe mangoes, papaya, grape fruits, oranges			
7. **Other fruits:** Plum, Ata, Guava, Lemon, Bullocks Heart, Coconut, Cashew, Pineapple, Avocado, Banana, Guava, Pear, Peach, Passion Fruit, Tangerine, Lemon			
8. **Meat**: Beef, pork, lamb, goat, rabbit, veal, poultry **Organ meat:** Liver, kidneys, intestines, heart, others **Other meat**: Mice, rats, other rodents, snails, and larvae			
9. **Eggs:** poultry bird eggs			

10. **Fish:** Fresh or dried fish or seafood; e.g. tilapia Small dried fish etc.			
11. **Legumes:** Cowpeas, butter beans, pigeon peas, jugo beans, green beans, lentils, sesame			
12. **Dairy products;** Milk, cheese, yogurt, or other dairy products			
13. **Oil and fat;** mayonnaise or butter			
14. **Sugar and candies;** Sweets, juice & carbonated drinks (sodas)			
15. **Condiments;** coffee, tea, salt, spices			

2. I would like to ask you about the frequency of food absence in your household in the last 30 days. Could you please tell me how many days in the past month did this occur in your household?

No.	Household Hunger Scale (HHS)	Frequency	Response
1.	In the last 4 weeks (30 days), did you worry that your household would not have enough food?	0= No (skip to Q2) 1= Yes	
1.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
2.	In the past 4 weeks (30 days), were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0= No (skip to Q3) 1= Yes	
2.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
3.	In the past 4 weeks (30 days), did you or any household member have to eat a limited variety of foods due to a lack of resources?	0= No (skip to Q4) 1= Yes	
3.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
4.	In the past 4 weeks (30 days), did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0= No (skip to Q5) 1= Yes	
4.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
5.	In the past 4 weeks (30 days), did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0= No (skip to Q6) 1= Yes	

5.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
6.	In the past 4 weeks (30 days), did you or any household member have to eat fewer meals in a day because there was not enough food?	0= No (skip to Q7) 1= Yes	
6.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
7.	In the past 4 weeks (30 days), was there ever no food to eat of any kind in your house because of lack of resources to get food?	0= No (skip to Q8) 1= Yes	
7.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
8.	In the past 4 weeks (30 days), did you or any household member go a whole day and night without eating anything because there was not enough food?	0= No (skip to Q9) 1= Yes	
8.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	
9.	In the past 4 weeks (30 days), did you or any household member go to sleep at night hungry because there was not enough food?	0= No 1= Yes	
9.a)	How often did this happen?	1= Rarely (1 or 2 times) 2 = Sometimes (3 -10 times) 3 = Often (more than 10 times)	

3. How often did your household have to adopt the following strategies because they did not have enough food or money to buy it in the last 7 day

No.	**Copying strategy**	**Frequency per week (*Scale of 0-7*)**
1.	Turn to less expensive or less preferred foods	
2.	Borrow food/help from friends/family	
3.	Decrease quantities in the meals	
4.	Reduce adult consumption for children to eat	
5.	Adjusting consumption patterns (Time)	
6.	Others (Specify)	

4. What livelihood adaptation/ coping strategies did your household have to adopt to in the past 30 days due to lack of money to buy food?

Survival strategies regarding food consumption in the last 30 days (Livelihood Coping (LHC))		
In the last 30 days, was there anyone in your household who had to adopt the following strategies due to lack of food or lack of money to buy food? ***(ask for each option)*** 1 = Yes 2= No, because we did not have a lack of food or money 3= No, because it has not yet been necessary to use this mechanism 4 = No, because I have already sold this asset or carried out this activity in the last 12 months 5= Not applicable		
No.	**Livelihood Coping Strategy**	**Response**
1.	Sell household goods: radio, TV, refrigerator, furniture, etc.	
2.	Sell goods or means of production: Agricultural and non-agricultural work tools	
3.	Rent/Sell land or house	
4.	Asking for money/ begging or borrowing	
5.	Spend reserves or savings	
6.	Taking children out of school	
7.	Consume seeds	
8.	Beg for alms	
9.	Borrow food or buy food on credit	
10.	Sell the last animals, females	
11.	Reduce non-food expenditure on health and education	
12.	Sell more animals than usual	
13.	Harvest green crops that are still ripening	
14.	Increased consumption of wild foods	

5. In the past 1-year, what difficulties have negatively impacted your household's ability to meet your food needs?

No.	**Shock**	**Tick all difficulties identified by the household**
1.	Loss of employment/ reduced salary	
2.	Sickness/ health expenditures	
3.	Death of household head	
4.	High food prices	
5.	Debt to reimburse	
6.	Insecurity/ thefts	
7.	Crop disease	
8.	Animal disease/death	
9.	Lack of irrigation water	
10.	Bad climate (poor crop yield/harvest)	
11.	No market	
12.	Others specify	

3. Informed Consent Document

This study, titled "Climate Shocks, Livelihoods, and Household Food Security in Rural Mozambique: Evidence from Guijá district," is being conducted by Martha Among Adeke, a masters of climate change in agrarian systems student at Eduardo Mondlane University. The study seeks to explore the relationship between climate variability, rural livelihood systems, and household food security outcomes in Guijá district. You are being invited to participate because your household is located in this community and chosen for participation in the study, and your experiences are essential for understanding how households cope with climate-related challenges.

Purpose of the study

The purpose of the study is to assess the extent of household food security, examine the effects of climate shocks such as droughts and irregular rainfall, and analyse how livelihood strategies, asset ownership, and market access influence resilience and vulnerability. The findings are expected to contribute to improved policy formulation and the design of interventions aimed at strengthening climate resilience and food security in rural Mozambique.

Procedures

Your participation in the study will involve taking part in an interview in which you will be asked questions about your household's socio-economic characteristics, sources of livelihood, experiences with climate shocks, food consumption patterns, and coping strategies during periods of food shortage. The interview is expected to last approximately 30 to 45 minutes, and about 420 households will be included in the study.

Risks and Discomforts

With regard to risks and discomforts, there are no anticipated physical or psychological risks associated with your participation. However, you may experience minor inconvenience related to the time required to complete the interview. You are free to decline to answer any question that makes you uncomfortable.

Benefits

Although there are no direct monetary rewards, the benefits of participation lie in contributing to research that aims to improve food security and livelihood resilience in your community and similar contexts. The study findings may inform policies and

development programs that address climate-related vulnerabilities. Participants may also receive general feedback about the study outcomes where feasible.

Confidentiality

All information collected will be handled with strict attention to confidentiality. Your identity will not be recorded, and instead, codes will be used to ensure anonymity. The data will only be accessed by the research team, stored securely in password-protected electronic files, and any physical documents will be kept under lock and key. Your personal information will not be disclosed in any reports, publications, or presentations.

Voluntary Participation

Your participation is entirely voluntary, and you have the right to refuse to participate or to withdraw from the study at any time without any penalty or negative consequences. Choosing not to participate will not affect you in any way, and there are no costs associated with participating in this study.

Questions and Contact Information

If you have any questions or require further clarification, you may contact the principal investigator, Martha Among Adeke, through the provided contact details (Mobile no. +258 878999747). All concerns will be addressed promptly and respectfully.

Statement of Consent

By agreeing to participate, you provide your informed consent, confirming that the study has been clearly explained to you, that you understand its purpose and procedures, and that you voluntarily agree to take part. You also acknowledge that your identity will remain confidential and that you may withdraw from the study at any time without consequence.

Participant Name: …….

Signature/ Thumbprint: …….

Witness Name: ……

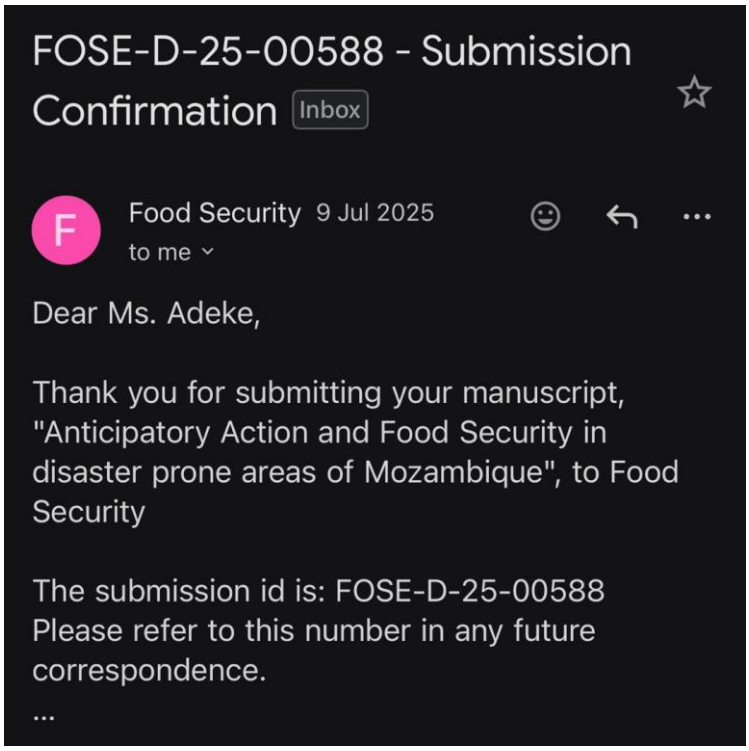
Signature/ Thumbprint: …….

Interviewer Name: ……...

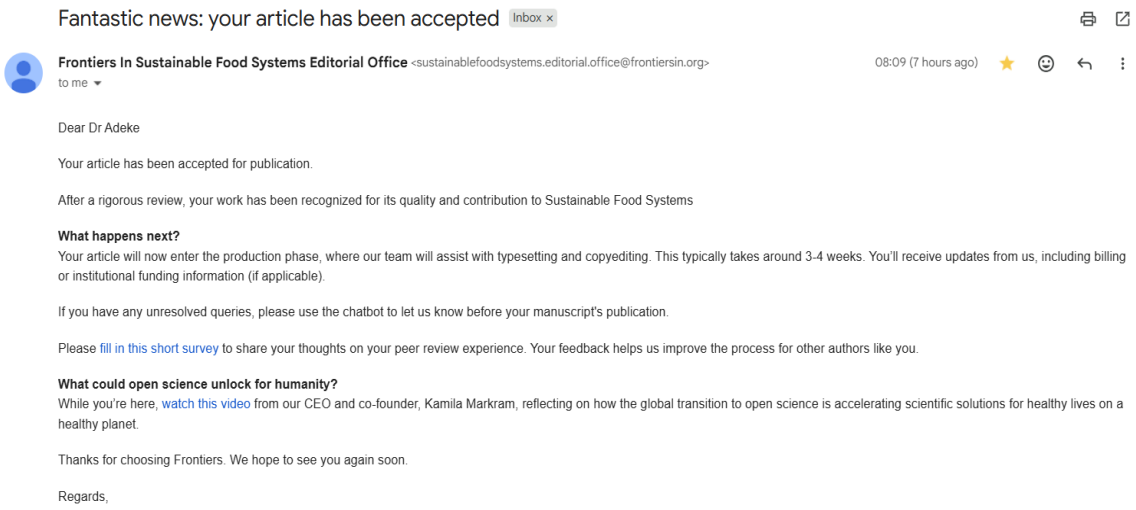
Signature/ Thumbprint: ……

4. Proof of publication

Paper 1.



Paper 2.


Fantastic news: your article has been accepted Inbox ×

Frontiers In Sustainable Food Systems Editorial Office <sustainablefoodsystems.editorial.office@frontiersin.org> 08:09 (7 hours ago)
to me

Dear Dr Adeke

Your article has been accepted for publication.

After a rigorous review, your work has been recognized for its quality and contribution to Sustainable Food Systems

What happens next?
Your article will now enter the production phase, where our team will assist with typesetting and copyediting. This typically takes around 3-4 weeks. You'll receive updates from us, including billing or institutional funding information (if applicable).

If you have any unresolved queries, please use the chatbot to let us know before your manuscript's publication.

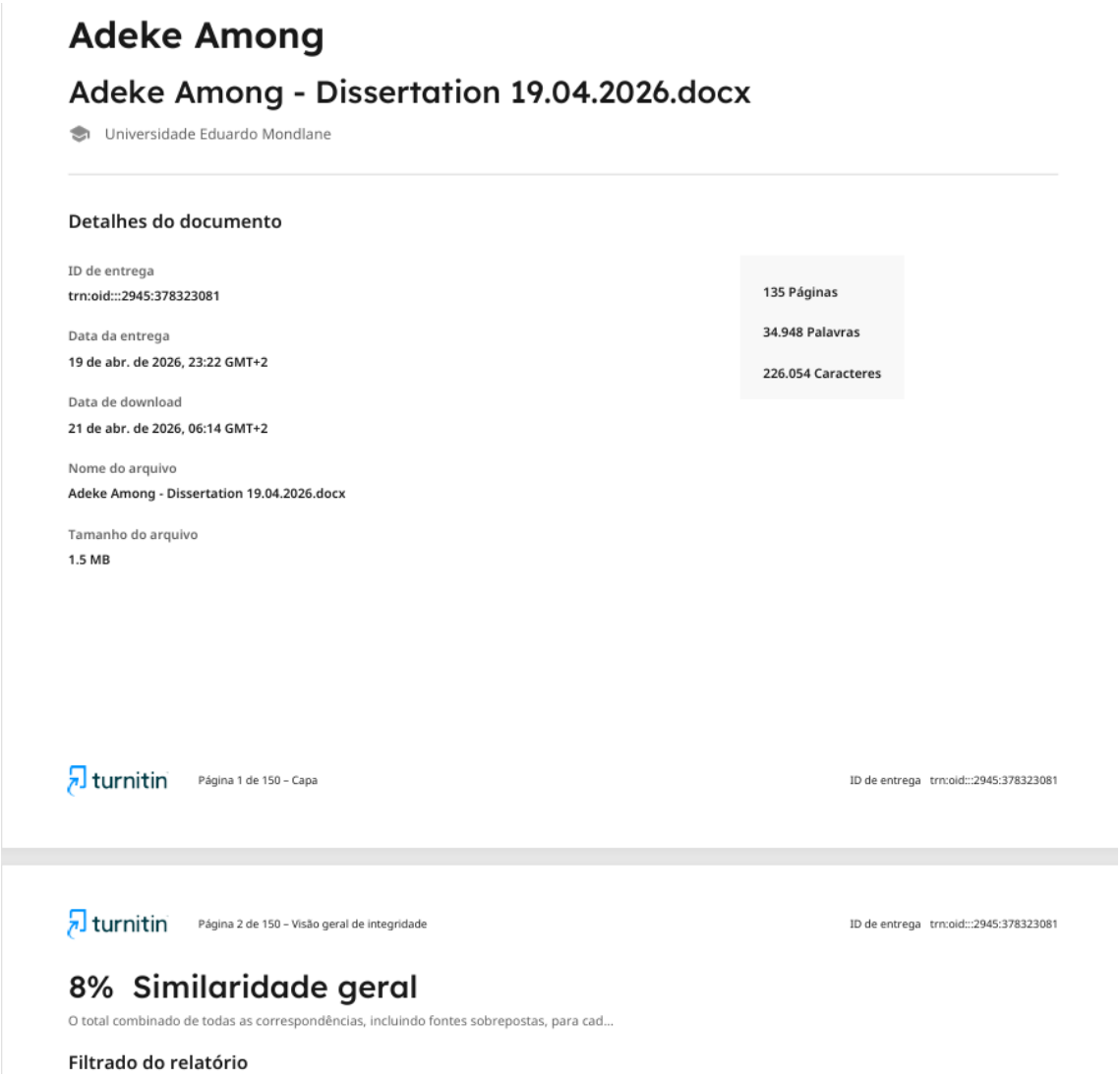
Please fill in this short survey to share your thoughts on your peer review experience. Your feedback helps us improve the process for other authors like you.

What could open science unlock for humanity?
While you're here, watch this video from our CEO and co-founder, Kamila Markram, reflecting on how the global transition to open science is accelerating scientific solutions for healthy lives on a healthy planet.

Thanks for choosing Frontiers. We hope to see you again soon.

Regards,

5. Plagiarism Report



Adeke Among

Adeke Among - Dissertation 19.04.2026.docx

Universidade Eduardo Mondlane

Detalhes do documento

ID de entrega
trn:oid:::2945:378323081

Data da entrega
19 de abr. de 2026, 23:22 GMT+2

Data de download
21 de abr. de 2026, 06:14 GMT+2

Nome do arquivo
Adeke Among - Dissertation 19.04.2026.docx

Tamanho do arquivo
1.5 MB

135 Páginas

34.948 Palavras

226.054 Caracteres

turnitin Página 1 de 150 – Capa ID de entrega trn:oid:::2945:378323081

turnitin Página 2 de 150 – Visão geral de integridade ID de entrega trn:oid:::2945:378323081

8% Similaridade geral

O total combinado de todas as correspondências, incluindo fontes sobrepostas, para cad...

Filtrado do relatório