

**PRIORITISATION OF NO-REGRET SOLUTIONS TO ADDRESS FOOD SYSTEM
DISRUPTION IN CENTRAL MOZAMBIQUE**

By:

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Mini-dissertation

Submitted in partial fulfilment of the requirements of

MAgric (Rural Development)

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March 2024

DECLARATION

I, Crisaldo Joao Jorge, student u19193417, declare that the dissertation, which I hereby submit for the degree MSc Agric (Rural Development) at the University of Pretoria, is my work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Signature *Crisaldo Jorge*

Date 11/04/2024

DEDICATION

To my cherished daughters, Kailanne and Malia Jorge. Your presence, laughter, and endless inspiration have propelled me through this arduous journey of discovery and learning. In your light, I've found the strength to pursue knowledge relentlessly.

To all the dreamers and seekers, may this dissertation serve as a testament to perseverance and inspire you to chase your passions fiercely, undeterred by the challenges in your path.

ACKNOWLEDGEMENTS

I am profoundly grateful to my esteemed supervisors, Dr Olwethu Loki, Dr Wegayehu Fitawek and Dr Sikwela Misery Mpuzu, for unconditional support, intellectual guidance, and consistent encouragement provided the foundation upon which this project was meticulously crafted.

I extend my heartfelt appreciation to Prof. Sheryl. Hendriks, for her steadfast belief in my capabilities, guided me during the most challenging phases of my academic journey.

I am grateful to my peers and colleagues Lukhangele Mgweba and Tshilidzi Isaac Dama from the University of Pretoria for their constant support and constructive discussions and for creating a stimulating research environment.

My co-workers at Gorongosa National Park (GNP), Orlando Pinto and Magalhaes Antonio, assisted me in collecting data. Ivete S. Guizado and Richard Musarara, for proofreading, deserve my immense recognition. Your camaraderie has transformed this journey into an unforgettable experience.

Dr Kuto Wanjala Sadiq deserves special mention for his invaluable assistance in the data analysis.

Finally, I should thank my friends Graca Manjate, Msc for nudging me to apply to the University of Pretoria and her endless encouragement and support throughout the whole period.

ABSTRACT

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Extreme weather events (floods, droughts, and cyclones) have become more frequent and severe, posing a threat to food systems. These disruptions have devastating effects on agriculture, livelihoods, and food security, particularly for vulnerable smallholder farmers. This study addresses the pressing need to prioritize "no-regret" solutions which are actionable and feasible for food system problems in Central Mozambique. The research problem is framed within Southern Africa's vulnerability to climate-related shocks, with Mozambique experiencing catastrophic events, including protracted droughts, cyclones, and flooding, that have disrupted the food system and left millions of people in severe food insecurity. The systematic review functioned as a mechanism for gathering insights from diverse studies. This data was sifted using Atlas.ti and subsequently structured into a questionnaire. Through purposive sampling, stakeholders were selected and invited to rank the items within the questionnaire. Stakeholder perspectives, including farmers, government institutions, non-governmental organizations, and academia, was gathered through purposive sampling and questionnaires to assess the viability of these strategies. Key findings show that while food assistance, particularly cash transfer programs, plays a vital role, it often functions as an ex-post intervention following disasters. Insurance-based solutions emerge as a frequently cited mechanism, showing the need for well-designed financial protection instruments. The research identifies six interconnected themes (Supply chain infrastructure, Agriculture, Education and public awareness, financial, public institutions and Research, processing and technology) that, when integrated, offer a rounded strategy for addressing food system disruptions. Given Central Mozambique's vulnerability to climate-related shocks, climate-smart agriculture emerges as a top priority. Stakeholder diversity in preferences features the complexity of addressing food system challenges. Agriculture consistently ranks as a top priority, reflecting

its central role as the primary income source for a significant population. The study recommends a broad set of actions, including adopting climate-smart agriculture practices, proactive food assistance programs, and developing financial protection instruments.

The study's outcomes conclusion presents a stakeholder-driven, rounded strategy to prioritize actions, emphasizing governance, agriculture, research and technology, education, finance, and supply chain dynamics to support policymakers, researchers, and practitioners working towards building a more resilient and sustainable food system in Central Mozambique, particularly in the context of increasing threats from extreme weather events.

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ACRONYMS AND ABBREVIATIONS

BWS	Best-Worst Scale
EMDAT	Emergence Database
CSA	Climate Smart Agriculture
FAO	Food Agriculture Organisation
FNDS	Sustainable Development
FSC	Food Security Cluster
GDP	Gross Domestic Product
GoM	Govern of Mozambique
HDI	Human Development Index
HLPE	High-Level Panel of Experts on Food Security and Nutrition
ILO	International Labour Organization
INE	Mozambique National Institute of Statistics

INGC	Institute of National Disaster Management
INGO	International Non-Governmental Organization
MINAG	Ministry of Agriculture
NNGO	National Non-Governmental Organizations
ODA	Official Development Assistance
PRISMA	Systemic Reviews and Meta-analysis Approach
SDG	Sustainable Development Goals
SETSAN	Technical Secretariat for Food Security and Nutrition
UN	United Nations
WFP	World Food Program

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Despite its considerable potential in arable land, water resources, and human capital, Africa faces significant challenges in achieving food security. While agriculture contributes approximately 40% to the continent's GDP, makes up 15% of its exports, and employs 60-80% of its population (Sikora et al., 2019), the reality is that agricultural productivity remains roughly 50% lower than other nations with middle or low incomes globally than the rest of the world (Bjornlund et al., 2020). The African food system is mainly subsistence-based (Alberaldi et al., 2021). Agriculture in Africa is predominantly carried out by smallholder farmers, who constitute 70% of the impoverished and vulnerable population living in rural areas (Eleblu et al., 2020). Unfortunately, these farmers lack access to essential technologies that could enhance food production. Their heavy reliance on rain-fed agriculture further exacerbates the problem, especially in escalating extreme weather events that threaten food production (Eleblu et al., 2020), particularly in African subsistence food systems (HLPE, 2017). These events, such as floods and droughts, became more intense and recurrent, negatively affecting the most vulnerable (Abdelradi et al., 2021).

Southern Africa has faced unprecedented extreme weather in the past 30 years (Downie, 2019; WFP, 2019). Downie (2019) states Ethiopia recorded the severe drought in 50 years, leaving more than 10 million people needing emergency food assistance. The Food Security Information Network ((FSIN), 2019) reported that Southern Madagascar faced severe drought caused by El Niño (2015 -2016), threatening about 1.35 million habitants in 2018-19 and in Mozambique, the IDAI and Kenneth tropical cyclones made massive landfall with strong winds and heavy rain across the southern and central and northern Mozambique, respectively.

A food system encompasses all processes and infrastructure to feed a population, from agricultural production to consumption. Its activities include cultivating, harvesting, processing, packaging, distribution, consumption, and disposal of food products. Food systems can be local, regional, or global, influencing our diets, health, environment, society, and economy (HLPE, 2014). However, the definitions provided by Ingram (2011), the World Food Programme (WFP) in 2017, and the Food and Agriculture Organization (FAO) in 2021 offer varied perspectives on food systems. Ingram emphasizes the activities contributing to food security outcomes, while the WFP focuses on the challenges faced by vulnerable populations within food systems. The FAO's summary of the High-Level Panel of Experts (HLPE)

definition underscores the complexity and interconnectedness of all elements within the food system. Together, these three definitions highlighted the multifaceted nature of food systems and the importance of addressing various socio-economic and environmental factors to achieve food security goals.

The three core constituents of food systems, which encompass food supply chains, food environments and consumer behaviours, that ultimately determine the nutrition, health, economic and social outcomes were influenced by various drivers, specifically Biophysical and environmental drivers, which include natural resource and ecosystem services, and climate change (HLPE, 2017).

Extreme weather is the primary food system driver and severely impacts smallholder farmers (Thompson et al., 2023). The changes in weather patterns experienced a worldwide impact on food production, leading to price spikes and income fluctuations (HLPE, 2012). According to Abdelradi et al. (2021), extreme weather changes agricultural pests and disease incidence, adverse effects on agricultural output and a general decline in the production of key crops threaten future food security. These problems were termed the “Bad Year problem”, which is when the marginalised poor people lacked access to nutritious food, basic needs and lower household purchasing power and the “Last mile problem”, which is the high cost to reach out to the hungry and poor people (WFP, 2017).

WFP (2019) assert that food systems seek to reduce food waste, promote environmental stewardship, and are expected to adapt to intense extreme weather and significantly contribute to its mitigation. These efforts should consist of adopting broader and long-term interventions, which include increased public expenditure for agriculture production, investment in infrastructure, storage facilities resistant to shocks, credit, technical assistance, access to inputs, markets and quality extension services (HLPE, 2020). Martin (2012) refers to these interventions as "no-regrets options" which were adaptive measures that offer socio-economic benefits regardless of the severity of future climate change. These measures are deemed worthwhile as they are cost-effective under current climate conditions, including variability and extremes. Furthermore, their implementation aligns with mitigating risks linked to anticipated climate changes. Conversely, the High-Level Panel of Experts (HLPE), (2017) pointed out that implementing these resilience-boosting actions poses a significant challenge, especially for smallholder farmers engaged in subsistence farming with low yields and minimal market access.

In many African countries including Mozambique, farmers adopted on-farm practices to overcome the food systems disruptions, which encompass crop diversification, crop production, promotion of local species, use of drought-resistant varieties, crop rotation and intercropping (Alhassan, 2020; Di Falco and Veronesi, 2013; Downie, 2019) although Alberaldi et al. (2021) observe that adoption of such practices was not widely embraced across Africa. Non-farm strategies consisted of the stabilisation of food prices, increase of food supply and food production, improved policies (WFP, 2021), food assistance (WFP, 2017) and the provision of social protection programmes for vulnerable groups (WFP, 2017; Zhou, 2019) were adopted.

1.2. Statement of the research problem

Globally, the food system faces severe threats due to the escalating disruptions triggered by extreme weather events, including cyclones, irregular and heavy rainfall, and droughts. These threats exacerbate socio-economic disparities and hinder efforts to achieve food security in the short term and sustainable development goals in the long term.

Extreme weather events directly impact agricultural production, causing substantial damage to vital infrastructure such as farmlands, irrigation systems, transportation networks, and storage facilities crucial for the entire food production and distribution process (Downie, 2016; WFP, 2021), often called the "farm to fork" continuum (HLPE, 2017). Consequently, these disruptions compromise the reliability and efficiency of the global food supply chain, leading to reduced yields, increased post-harvest losses, and compromised food quality, also termed as food systems systematic problems (WFP, 2017). However, it may be a common perception that no single adaptation strategy exists to meet the food system problem, as agriculture is linked to biophysical factors and relies on critical elements such as soil type and fertility, water availability, and temperature conditions. Conversely, a one-size-fits-all adaptation strategy for the food system's complex issues is inapplicable, and the demand for context-specific and multifaceted adaptation strategies is required (Lines, 2011; Mulugeta 2015). Despite the evident threat posed by extreme weather events, there exists a significant scarcity of comprehensive information regarding the interconnectedness of such biophysical elements (HLPE, 2017) and how these shocks can be addressed, particularly for African rain-fed food systems (Downie, 2016) with few technological inputs where smallholder farmers lack the resources and adaptive capacity to contend with the multifaceted challenges. Therefore, this debate remains unsettled and unresolved in development practice as well as in development

literature. This study reviews the available solutions to address the food system disruptions and determine comprehensive solutions that can be presented as no-regret to address the disruption of Central Mozambique's food system.

1.3. Research questions

The study explores the solutions to address the food system problems in the advent of extreme weather. The specific research questions addressed are:

- i. Which specific no-regret actions can be identified to effectively address the systemic challenges triggered by extreme weather events in the food system of Central Mozambique?
- ii. How can the solutions identified through the questionnaire be prioritized to ensure the resilience of the food system during extreme weather events in Central Mozambique?
- iii. How can the impact of interventions implemented to address food system disruptions in Mozambique be effectively assessed, and what recommendations can be formulated based on the evaluation for guiding future actions?

1.4. Study objective

Overall objective

The study's general objective was to evaluate the "no-regret" solutions suitable for addressing disruptions in food systems arising from extreme weather events in central Mozambique. The study was structured around three specific objectives set out below.

Specific objectives

- i. To identify the no-regret actions to address systemic problems triggered by extreme weather events in the food system in central Mozambique.
- ii. To assess how the available solutions as determined through stakeholder interviews can be prioritized to ensure the food system's resilience during extreme weather events in central Mozambique".
- iii. To assess the impact of interventions implemented to address food system disruptions in Mozambique and formulate recommendations for future actions.

1.5. Significance of the study

As the existing literature presents a myriad of strategies and reveals a lack of consensus on the best practices to address food system challenges, the study seeks to make three contributions to the gaps in knowledge on how food system problems could be addressed. First, the research

identifies countermeasures specifically tailored for central Mozambique due to the impacts of shifting extreme weather patterns on food systems, as Marghidan et al. (2023) highlighted. Second, the evidence from the research would enable the food systems stakeholders to improve their confidence to apply the solutions identified as they came from comparable contexts. Third, the research aims to fill the knowledge gap by actively involving key stakeholders in the formulation of solutions through comprehensively examining all drivers of food systems intervention responses during the design phase.

1.6. Delimitations of the study

The research focused on the food systems in disaster-prone districts of Nhamatanda and Buzi in Sofala Province, Mozambique. Target groups included farmers, aid recipients, experts from academia, NGOs, and government agencies. It analyzed studies from 2013 to 2022, given the evolving concept of food systems as of Abdelradi et al. (2021). Qualitative research methods were employed, with a systematic review being central to gathering and evaluating pertinent research from several databases. Therefore, these findings were presented to stakeholders via Google Forms for prioritization.

1.7. Layout of the dissertation

The dissertation consists of five chapters. The introductory chapter outlines the problem statement, study objectives, and research questions. Chapter two delves into the literature, covering extreme weather globally and specifically in Africa, food systems, potential solutions, and relevant empirical studies. Chapter three details the research methodology. In chapter four, the research's key findings are presented and discussed, and chapter five concludes the study and provides the summary, conclusions, and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This section reviews the literature on extreme weather impacts on food systems, the occurrence frequency in Africa, and possible solutions. The chapter further examines the underlying causes of food system disruptions, the context of food assistance and its instruments. It offers an empirical analysis of food assistance initiatives specific to Mozambique.

2.1.1. Definition of key concepts

- I. The food system is a set of activities encompassing all the elements related to the production and consumption of food and the output of these activities, including socio-economic and environmental outcomes (HLPE, 2017).
- II. Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (HLPE, 2015).
- III. Food assistance empowers food-insecure people and vulnerable communities to access nutritious food through different modalities (in-kind food transfers, cash-based transfers or vouchers, and local and regional procurement) to alleviate the root causes of hunger (WFP, 2017).
- IV. Low-regret actions are relatively low cost and provide relatively large benefits under predicted future climates (Martin, 2012).
- V. Win-win actions contribute to adaptation whilst also having other social, economic and environmental policy benefits, including those relating to mitigation. compared with no regret action (Martin, 2012).
- VI. The “bad year” problem occurs when vulnerable and marginalized households in rural areas regularly struggle to access nutritious food due to crop failure and lack of purchase power (WFP, 2017).
- VII. A systematic review is a review that uses explicit, systematic methods to collate and synthesize findings of studies that address a formulated question (Paige et al., 2020).

2.2. The worldwide frequency of extreme weather events and their impact in food system

According to Food Agriculture Organization (2021), the number of countries exposed to extreme weather has increased exponentially worldwide in the past few decades, from 76 per cent in 2000–2004 to 98 per cent in 2015–2020 (FSIN, 2021). Similarly, the number of countries exposed to more than three climate extremes such as droughts, floods, cyclones and heavy rain rose from 11 to 52 per cent in the same period. Asia, America and the Caribbean were the regions where the events increased considerably (57 per cent), followed by Africa with 49 per cent. Conversely, Africa hosts the most acutely food-insecure people (GRFC, 2020). For example, in the Horn of Africa and Southern Africa, the evidence shows that 21 per cent of the population (one in five people) faced hunger in 2020, which is more than double the proportion of any other region, such as Latin America, Caribbean and Asia with 9.1 and 9.0 per cent, respectively (FAO, 2021).

Regarding the occurrence, the last decade (2010-2019) was more turbulent for disasters than any other historical point. The annual occurrence tripled between when compared to the 1970s and 1980s (FAO, 2021) and became a new normal (Davis and Vincent, 2017). Phenomena such as cyclones, droughts, extreme temperatures, hurricanes and typhoons have caused severe weather in various regions worldwide (Luo et al., 2018). Such extreme events increased to 150 in the 2010s against 40 in the 1970s. Likewise, hydrological disasters (such as floods) doubled the occurrence of 60 compared to 30 in 1970. Therefore, the peak was verified in the 2000s when an average of 180 was registered (FAO, 2021).

Africa has experienced 1143 of the most challenging extreme weather events in the last two decades (2000 – 2019), where over 46.46,078 people died, leaving a loss of approximately US\$ 8.6 billion (EM-DAT CRED, 2019). Developing countries are highly susceptible to extreme weather events due to their greater vulnerability and lower coping capacity (Chapman et al., 2020). For example, Kenya has experienced the highest number of disasters (60 events), followed by Mozambique with 55 events. South Africa has registered 54 events (Eckstein and Schäfer, 2021; EM-DAT CRED, 2019).

Salazar-Espinoza et al. (2015) assert that droughts are the most frequent natural phenomenon. Figure 2.1 shows that droughts are more frequent and destructive than floods. They affect most people, and their effects last longer in most African countries, including Mozambique. On the other hand, floods go the opposite, affecting fewer people between 2002 and 2021.

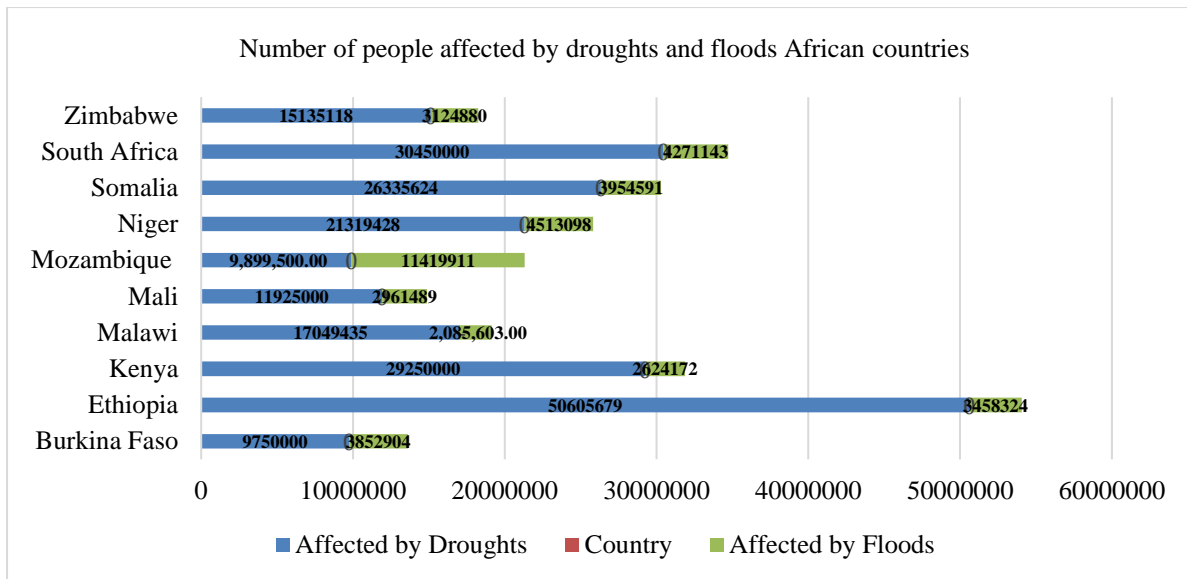


Figure 2.1: The total number of people affected in Africa countries (2002-2021)

Source: Adapted from EM-DAT, 2021

2.2.1. Overview of the Mozambican crisis context

Mozambique is prone to extreme weather, the main driver of food system disruption (Marghidan et al., 2023; WFP, 2021). The southern region is cyclically affected by droughts, while in the central region, floods and cyclones frequently occur alongside the major river basins (WFP, 2021). Moreover, in central Mozambique, this situation exacerbated the existing chronic development problem that affects 56 per cent of rural people (1.5 million people) and left 750,000 people requiring urgent assistance (Table 2.1).

These phenomena account for the decline in agriculture production (FAO, 2020). Nevertheless, agriculture is the backbone of national development and the primary food source for the poor rural population (HLPE, 2020). In Mozambique, agriculture itself employs more than 80% of the workforce (Guina et al. 2023; Mozambique National Institute of Statistics (NIS), 2022; Pernechele et al. 2018) and are dominated mainly by the familiar sector, which is around 3.7 million and responsible for 95% of the country's production (Ministry of Agriculture (MINAG), 2010). These smallholders reside in rural areas and are chronically vulnerable to climate shocks (International Food Policy Research Institute (IFPRI), 2016) that lead to food system problems ("Last mile", "Bad years", and "Good years").

Table 2.1: Number of people affected in central Mozambique

Provinces	Populations (2019)	Affected population (2019)	% of total
Inhambane	1 488 676	422	0,0
Manica	1 945 994	262 890	13,5
Sofala	2 259 248	1 190 596	52,7
Tete	2 648 941	54 721	2,1
Zambezia	5 164 732	6 035	0,1
Affected Provinces	13 507 591	1 514 664	11,2
Mozambique	27 909 798	0,1	5,4

Source: Author adaptation from EM-DAT, 2021

2.2.2. Components of food systems

A food system is a complex network of interconnected components that work together to produce, process, distribute, and consume food. Understanding the components of a food system is crucial for addressing issues related to food security, sustainability, and nutrition. The main components of a food system typically include the production, processing, manufacturing, distribution, preparation and consumption of food and the outputs of these activities, including socio-economic and environmental outcomes (HLPE, 2017).

2.2.2.1. Food system typology

HLPE (2017) assert that the food system can be viewed from a global to household perspective, meaning there is no single food system (FAO, 2013). Three broad types have emerged in this context: traditional, mixed, and modern food systems. The conventional food system is often related to rural areas. They are already constrained by long-term development failure, characterised by a lack of adequate roads, poor storage infrastructure, lack of cold storage, the prevalence of primary processing, and rare food packaging (HLPE, 2017). Conversely, in the modern food system, most people based in urban areas demand more food choices and diversified sources of income.

The mixed food systems comprise part of the characteristics of the prior two systems. Thus, all interventions must consider the multiplicity of systems with characteristics that vary from context to context and are triggered by trends in economies and societies, from local to global, in how people produce process, and acquire food (FAO, 2013).

2.2.3. Food systems in different countries

2.2.3.1. Developing countries

Agriculture holds exceptional significance on the African continent, with Alberaldi et al. (2021) noting that the African food system is predominantly rain-fed and considered among the least mechanized globally. Most farmers operate on a small scale, facing limitations in financial resources, infrastructure, and access to information. The reliance on rain-fed agriculture, however, poses a considerable vulnerability to climate change, exacerbating the challenges faced by African agriculture and jeopardizing recent strides in increasing productivity and alleviating poverty and hunger (Badiane et al., 2020; Pereira, 2017). Pereira (2017) underscores the need for context-based adaptation strategies embedded in other development processes.

2.2.3.2. Context of Mozambique

The Mozambican food system is primarily characterized by subsistence farming, with agriculture playing a pivotal role in the country's economy. In 2019, it contributed nearly 30 per cent to the GDP and employed approximately 70 per cent of the population (INE 2020; World Bank 2023). Despite its significance, the agricultural sector faces considerable vulnerabilities, including exposure to external risks such as extreme weather events, dependence on imports, and conflicts in the northern region (Benfica et al., 2023). This subsistence-based food system operates as a complex and interconnected network, encompassing various actors involved in food production, supply chain, and consumption.

2.3. The effect of extreme weather events on food system

Extreme weather is becoming more frequent and intense (WFP, 2010), hampering global food security and a key factor behind the increased malnutrition in recent years (FSIN, 2021). The frequency and intensity of climate change disrupt food systems mainly in vulnerable rural communities (Vermeulen et al., 2018; Ramirez et al., 2021) through the event's sequential occurrence rather than directly depleting their livelihood (Weldearegay and Tedla, 2018). Regular floods, cyclones, large storms, and droughts negatively affect food systems through their impact on food production, affecting availability and all other dimensions, leading to household or national food insecurity (Davis and Vincent, 2017). Their occurrence is three times more when compared with 40 to 50 years ago, and agricultural production absorbs 63% of the total impact of natural disasters (FAO, 2021). Thus, these affected countries are

concomitant, dependent on agriculture and lacking the income to acquire essential commodities through importation (Devereux and Edwards, 2004). WFP (2017) observed that it negatively impacted national and regional food, government food reserves and safety nets and increased humanitarian assistance burden in the coming decades.

The impact is immediate as it affects agriculture productivity and consequently increases imports to countries to compensate for the production deficit, interrupting the regular food supply chain and exacerbating food insecurity in the fragile existing subsistence food system (FAO, 2021). Thus, FSIN (2021) argues that all six dimensions of the food system were affected. Firstly, the dimension of availability, intrinsically tied to production, witnesses disturbances due to a marked decrease in production outputs and prevalent crop failures, which lead to an escalation in product prices. Secondly, the access dimension undergoes constraints primarily because of diminished income levels among smallholders, damaging fundamental transportation infrastructures. The third dimension, stability, is adversely influenced by heightened fluctuations in food supply and protracted volatility in incomes and prices. Conclusively, the utilisation dimension confronts challenges characterised by amplified risks associated with food safety and a higher susceptibility to disease outbreaks (HLPE, 2020).

The food system operates in a complex domain and is influenced by social, political, cultural, technological, economic, and natural environment drivers (HLPE, 2017). Thus, understanding the interconnectedness and feedback of each driver and how they lead to disruption is the goal of the food system approach (Ramirez et al., 2021).

2.3.1. Conceptualization of food system framework

The conceptual framework of the food system (depicted in Figure 2.2) illustrates the complexity and interdependent nature of its various components, crucial for achieving sustainable development.

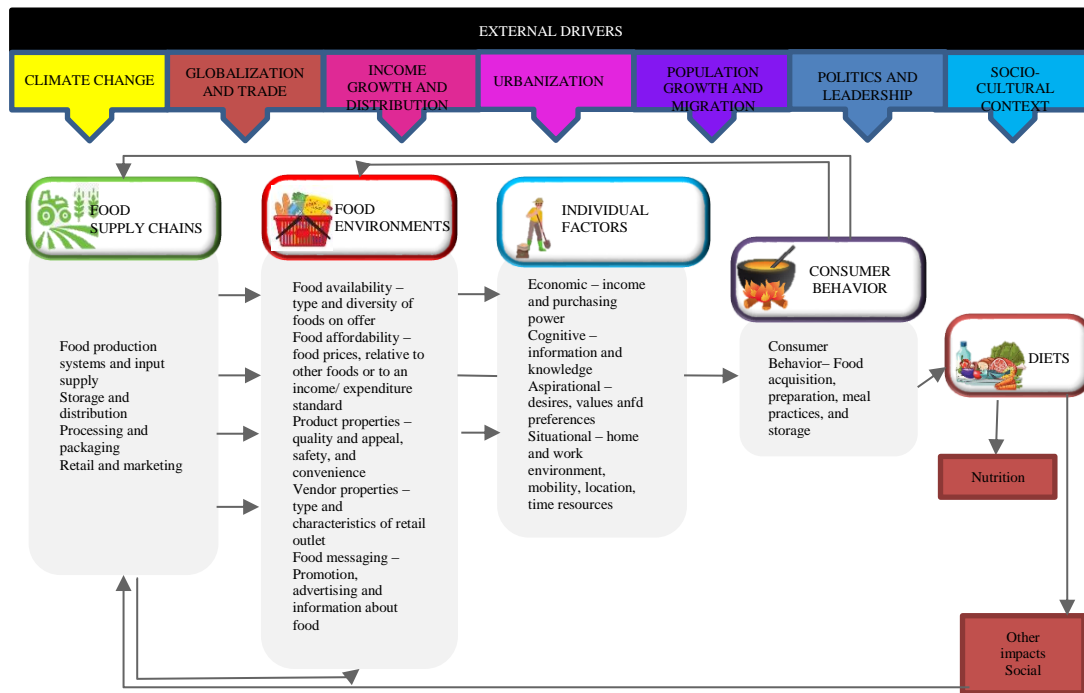


Figure 2.2: Food system framework

Source: Author adaptation from HLPE, 2017

Among the five identified drivers of food systems, this section emphasizes the Biophysical and Environmental drivers, encompassing natural resource utilization, ecosystem services, and climate change. These elements adversely affect the food supply chain (HLPE, 2017), impacting the entire production systems, storage, distribution, processing, packaging, and retail and marketing, with a notable focus on rain-fed food systems and vulnerable rural populations. Furthermore, the Biophysical and Environmental driver significantly influences the food environment, resulting in reduced food availability, affordability, and utilization, which, in turn, exacerbates food insecurity, particularly among the most vulnerable segments of the population. However, it is essential to acknowledge a critique presented by Béné et al. (2019), suggesting a potential limitation in the framework's oversimplified assumption of a linear chain from production to consumption, often referred to as the "farm to fork" model. This simplification understates the multi-causal nature of food systems, characterized by complex interactions among interdependent components.

2.4. The theoretical argument involving the food system intervention in a crisis in Mozambique

According to the UNDP (2020) Human Development Index (HDI), almost half of the Mozambican population (48.4 per cent) are in the poverty line, living with less than USD per day (World Bank, 2018). For example, in the provinces most affected by the cyclone in central Mozambique, only Tete and Manica were below the poverty threshold (42 cents), and Sofala and Zambezia were above 50% and 62% respectively). In addition, these regions are highly vulnerable and cyclically hard-hit by extreme events, contributing 25 per cent of Mozambique's Gross Domestic Product (GDP) and 64 per cent to commodities exportation (Trujillo, 2019). Meanwhile, the unequal income distribution undermines the overall poverty reduction strategy (UNDP, 2020).

2.4.1. The overview of general intervention instruments

Food assistance empowers vulnerable rural people displaced or trapped by cyclones and floods to access food. These individuals and communities facing food insecurity received various support measures, including immediate relief and longer-term solutions. These interventions included social protection programs, in-kind food transfers, cash-based transfers, vouchers, and local and regional procurement efforts in the short term (WFP, 2017). Simultaneously, long-term strategies were designed to address the underlying causes of hunger, aiming for sustained food security and resilience (WFP, 2019).

The community members who were capable and willing to participate were enrolled in cash-for-work programs. Furthermore, additional measures involving the provision of essential agricultural inputs were implemented. These inputs included the distribution of seeds and tools, fertilisers, short-cycle crops, and early maturation to boost agricultural production as the communities and households depend on agriculture for food consumption and income generation (INE, 2019).

The stakeholders involved in addressing the crisis are typically the international community led by the United Nations (UN) and its agencies, followed by the International Non-Governmental Organization (INGO) and National Non-Governmental Organizations (NNGO). These entities have worked with the Government of Mozambique (GoM) to provide humanitarian assistance and early recovery support to affected communities nationwide (UNDP, 2020).

2.4.1.1. The social protection in crisis

Social protection encompasses a range of policy measures designed to reduce and alleviate poverty and economic vulnerabilities through social assistance and insurance (HLPE, 2012). The main objective during the crisis is to prevent smallholders and households from depleting their livelihoods to buy food. In Africa, the rise of social protection is shifting, ranging from food aid to cash transfers, from emergency responses to development interventions, and ideally, to attaining government-led programmes or government-donor partnerships (HLPE, 2012). The Government of Mozambique approved the social protection law (4/2007) to protect low-income people from vulnerability to shocks (Buur and Salimo, 2018), which comprises three main pillars: non-contributory basic social security, contributory or obligatory social insurance and complementary private insurance (Government of Mozambique, 2012).

2.4.1.2. Appropriateness of social protection in crisis

Governments were reluctant when it came to the introduction of social protection programs, particularly in the form of social transfers during crises. This hesitancy can be attributed to several concerns, such as dependency among recipients, developing expectations for continuous or increased assistance and disruption of market access for agricultural produce or unintended consequences for rural livelihoods (HLPE, 2012). However, the WFP (2011) observe that Direct Social Welfare Programme (PASD) and Productive Social Welfare Programme (PASP) should be recommended intervention during natural disasters and climate change related crisis as it targets highly vulnerable people through direct food assistance and individuals willing to work through Food Assistance for Assets (FFA), respectively. Moreover, Zhou (2019) observes that the programmes have the potential to reach many people. However, this exponential growth of social assistance programmes may overwhelm the pre-existing beneficiaries. In addition, WFP (2011) argues that effectiveness varies according to beneficiaries' profiles and status, is limited, complex, and requires time and resources.

2.4.1.3. Food assistance

Food assistance is provided when the food system is disrupted, and vulnerable people and communities are deprived of essential food needs. The main is to enhance the performance of the food system (WFP, 2017). To pursue that aim, they defined systemic food assistance as improving food system performance by addressing systemic problems in given systems (WFP,

2017). The first form encompasses those interventions that enable key stakeholders to respond to, catalyse, or boost demand for quality food (safety and nutritional content) over the short term. In contrast, the second form aimed to influence the interaction within food systems over the long term. Therefore, the approach is based on demand, innovation and capacity measures, leading to broader improvements in food systems.

2.4.1.4. Food assistance instruments

The food assistance tools comprehend in-kind food transfers, commodity vouchers, physical or digital cash transfers, and cash-value vouchers that ensure the recipients' access to quality and nutritious food (Omamo et al., 2010). WFP (2017) argues it is delivered within an interconnected food systems network of source, contract, storage and transportation (WFP, 2017). Cash transfers were preferred by food assistance stakeholders (Currie et al., 2008) when compared with food transfers as they meet the beneficiary's choices (Farrington and Slater 2006) rather than providers deciding the content of food baskets even though it is appropriate for particular intervention aimed to address specific problems such as biofortification (Stevenson et al., 2008). However, WFP (2017) concludes that the cost to implement food transfer is higher when compared with cash. Therefore, this advantage does not mean that cash is always preferable in any context.

2.4.1.5. Appropriateness of food assistance in crisis

The Food Assistance Convention (FAC) reaffirmed the commitment of different stakeholders to provide food assistance that improves food security. Before FAC, the approach was a tonnage-based commitment (Lentz et al., 2013) characterised by shipping food aid abroad to needy countries. However, the lessons from the food price crises (2007-2008) highlighted the importance of implementing an effective food assistance programme to address emergencies (Lentz et al., 2013).

Barret and Gomes (2013) supported the new food assistance approaches instead of the direct traditional distribution of food aid due to timeliness, cost-effectiveness, local market efforts, recipient satisfaction, food quality, and advantage for smallholders but recommended a careful context analysis. For example, the 2004 Indian Ocean Tsunami required rapid, large-scale assistance to the population, which could not wait for traditional food aid. The prompt donation in cash and vouchers reinforced the policy change and nudged the donor to embark on cash-

based food assistance instead of more conventional, in-kind food aid (Barret et al., 2013). In addition, Bailey et al. (2015) noted that the efficiency of providing cash could leverage people's abilities to deal with the aftermath effects of crisis and disaster, either as a substitute or complement to in-kind food assistance.

2.4.2. Food system disruptions and types of food assistances in Mozambique

Mozambique faces significant food insecurity challenges (Fidalgo, 2011). Agricultural production has been severely impacted by recurring droughts since 2015. In 2017, SETSAN and FEWSNET's studies highlighted that over 2.1 million people needed humanitarian assistance as their food reserves were depleted. Therefore, for subsistence, many people depend on limited market access, consumption of wild foods, and aid (HCT Position Paper, 2017).

The period from October 2017 to May 2018 saw a rise in food aid requirements, with an early onset of the lean season anticipated. By January 2017, only 45% of the identified 2 million in need received food assistance and the trend is expected to persist until March 2017 (UNOCHA Dashboard, January 2017). The discussion above consists of a typical food system problem termed "Bad year" when vulnerable communities with low incomes, lack of purchase power, and eroded livelihoods face the negative impact of extreme weather and crop failure (WFP 2017). Therefore, the solution was mainly cash, food, and food-for-work. Zhou (2019) argues that the beneficiaries who received staple food packages monthly experienced better dietary diversity compared to those given cash transfers. Conversely, providers decide the content of food parcels in food transfers. The cash recipients could buy nutritious items and choose their purchases even though the cash injected could result in price spikes and market failure.

2.5. No-regret solutions

The term "no-regret solution" was defined by Heltberg et al. (2009) to describe strategies that offer benefits regardless of the unfolding trends in future climate scenarios. Amidst the challenges posed by climate change, "no-regret" solutions emerge as pivotal strategies aimed at effectively addressing climate uncertainty. These solutions offer tangible benefits that extend beyond climate change considerations, providing a valuable advantage (Hallegatte, 2009; Hawkes, 2020). However, It is crucial to underscore that the term "no regrets" does not imply a cost-free paradigm. Instead, it acknowledges the presence of real or opportunity costs and the existence of trade-offs inherent in the adoption of these strategies. Martin (2012) asserts that no-regrets actions are "No-regret solutions" refer to strategies or measures that are beneficial and cost-effective under current conditions and are also aligned with addressing risks

associated with climate change. These actions typically do not pose significant trade-offs with other policy objectives, meaning they can be pursued without sacrificing progress in other areas. Martin (2012) also discusses the "Low-regret actions" and "win-win actions" which are both strategies that offer significant benefits and have synergies with various policy objectives, particularly in the context of addressing climate change. However, both low-regret actions and no-regret actions are characterized by their cost-effectiveness, providing benefits that outweigh their costs. Win-win actions may also be cost-effective, depending on the specific interventions and the magnitude of additional benefits (Martin, 2012). In summary, while all three types of actions offer valuable benefits, they differ in their focus, scope, and implications. No-regret actions provide immediate benefits without trade-offs, low-regret actions emphasize benefits under future climates, and win-win actions optimize outcomes across multiple dimensions, including adaptation and broader policy objectives. In turn, Hallegatte (2009) observed that their implementation in developing countries faces significant hurdles, including financial and technology constraints, lack of information and transaction costs, and institutional and legal constraints.

2.6. Summary of the chapter

The reviewed literature is primarily centred on research that relies on expert reports concerning the intersection of food systems and extreme weather. While these studies offer valuable insights, they fall short of providing substantial data suitable for in-depth analytical purposes. This limitation results in a critical gap, leaving essential information unexplored within these publications. Consequently, there remains a scarcity of comprehensive studies addressing the intricate issue of food system disruptions triggered by extreme weather events, particularly within the African context and, more specifically, in Mozambique. The existing body of research underscores the need for more robust investigations and data-driven analyses to effectively understand, address, and mitigate the challenges posed by extreme weather on food systems in these regions, a gap this study intends to fill.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This section introduces information about the research location selected, the sampling procedure, the study's research strategy, data collection, methods, sampling procedures and ethics considerations. The research used secondary data gathered actions identified through different databases and prioritised as a no-regret action that Mozambican policymakers and other stakeholders must adopt and implement.

3.2. Description of the study area

Mozambique is in the Southern Africa region and surrounded by Tanzania, Malawi, Zambia (North), Zimbabwe (West), South Africa and Eswatini (South) and the Indian Ocean (East) (WFP, 2021). The civil war devastated it from 1977 to 1982, which destroyed critical infrastructures, ruined livelihoods, and compromised agricultural production and economic growth. Besides that, the country made a post-conflict effort to attain economic growth, and, as a result, in 2012, it rose to 7.5 per cent of its GDP (UNISDR, 2009).

Notwithstanding, over 46 per cent of people live below the poverty line. They cannot afford basic food, access to essential services, housing conditions, and education, leading the country to poor performance in HDI (UNDP, 2020). Besides that, the country has high agricultural potential that is still underutilised. The northern and central provinces are the most productive regions due to a more favourable climate (Fidalgo, 2011). Conversely, in southern and central Mozambique, consecutive droughts have severely compromised agricultural production since 2015, resulting in limited access to food and water for domestic use. Almost 84.9 per cent of Mozambicans living in rural areas constantly face food insecurity due to constrained physical access to food.

In the study area, the central region, the food system was recurrently challenged by protracted droughts and flooding along the major river basins, exacerbating food insecurity (WFP, 2021) and putting to the test the country's disaster management capacity (Salvucci and Santos, 2020). WFP (2021) asserts that Sofala, Manica and Zambezia, in central Mozambique, are the most food-insecure provinces and are highly exposed to erratic weather. The districts of Buzi and Nhamatanda (Figure 3.1) along the Beira Corridor were the most affected areas due to the burst of the Buzi and Pungwe river basins, respectively, which caused widespread flooding (Bofana et al., 2022; UNDP, 2019).

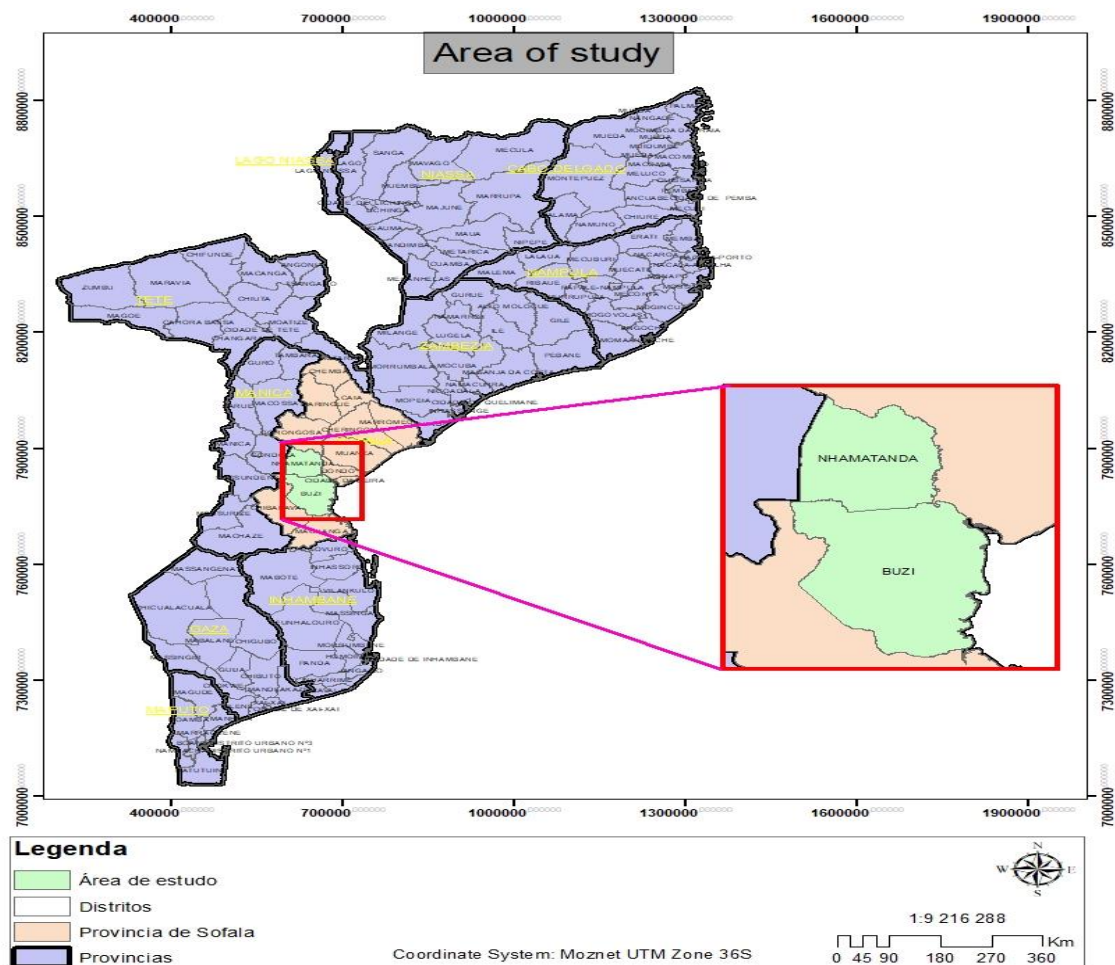


Figure 3.1: Map of the districts selected for the study in Mozambique

Source: Author's compilation

3.2.1. Population of the study area

As highlighted in Figure 3.1, Central Mozambique emerges as the most severely affected region of the country. This area, which accommodates 13.5 million individuals (INE, 2019), constituting 45% of the country's population, has faced considerable adversity.

3.3. Research approach

The research approach employed in this study is predominantly qualitative, utilizing a systematic review methodology to synthesize existing literature and inform subsequent data collection. The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines, providing a structured approach to identifying, assessing, and synthesizing relevant studies related to the research question. This design ensures a detailed

and transparent process in reviewing existing literature on the impact of extreme weather events on the food system in central Mozambique. The systematic review was complemented by a qualitative data collection process involving stakeholders from both districts (Nhamatanda and Buzi), employing purposive sampling to select participants deemed "information-rich" and relevant to the study. The data collection instruments include a structured questionnaire and interviews, aiming to capture detailed insights and opinions from key stakeholders in the food system. Thus, the research design combines the strengths of systematic review methodologies and qualitative data collection to understand the research problem better.

3.4. Research method

The research approach employed in this study is predominantly qualitative, utilizing a systematic review methodology to synthesize existing literature and inform subsequent data collection. The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines, providing a structured approach to identifying, assessing, and synthesizing relevant studies related to the research question. This design ensures a detailed and transparent process in reviewing existing literature on the impact of extreme weather events on the food system in central Mozambique.

The systematic review was complemented by a qualitative data collection process involving stakeholders from both districts (Nhamatanda and Buzi). The qualitative nature of the approach facilitates exploration of stakeholders' perspectives, allowing for a rich and contextualized understanding of the challenges faced by the food system in the aftermath of extreme weather events. The purposive sampling was employed to select participants deemed "information-rich" and relevant to the study. The data collection instruments include a structured questionnaire and interviews, aiming to capture detailed insights and opinions from key stakeholders in the food system.

The use of cluster analysis in data analysis further enhances the explanatory power of the approach by identifying patterns and relationships within the collected data. Overall, the research approach is geared towards generating in-depth insights and actionable recommendations to address the identified challenges in the food system of central Mozambique.

3.5. Sampling strategy

Sampling is a crucial aspect of research design, involving the selection of a subset of individuals or elements from a larger population for study (Creswell & Creswell, 2017). The study made of the purposive sampling method due to its alignment with the qualitative nature of the study and the need to gather in-depth insights from "information-rich" participants (Patton, 2002). Purposive sampling is particularly useful when the emphasis is on understanding diverse perspectives and capturing experiences related to the research questions (Creswell & Creswell, 2017).

The food system stakeholders were identified through the Food Security Cluster (FSC) website, leveraging the fact that these individuals are actively involved in food systems activities. Contact details were obtained through an attendance sheet and online registration, ensuring representation from various sectors involved in food systems. Morgan's (1997) rule of thumb was applied to address the potential issue of no-shows of participants through over-recruiting stakeholders by 20%.

3.5.1. Sample size for the study

The total sample size of 87 (Table 3.3) food system stakeholders who readily showed themselves available to attend the session and expressively shared opinions for the discussions were selected from the larger population of Nhamatanda and Buzi districts and among NGO and Government institutions. Invitations were sent to individuals chosen a week before the interviews through either phone calls or in-person contact by community leaders and extension workers.

The proportionate allocation method, which ensures that the sample size distribution is proportional to the population size of each category, was used. The technique ensures that each category is represented in the sample in proportion to its size in the larger population. This helps create a sample representative of the overall population, making the study findings more applicable to the entire food system stakeholder landscape. The proportionate allocation was also used because it is fair that more significant categories receive a larger share of the sample, reflecting their significance in the population. This prevents any category from being over- or under-represented, leading to a more equitable distribution of the study's focus. The sample helped the study to yield more precise estimates for each category. This is particularly important, considering the study has specific subgroups within the larger population. Precision is increased because the sample distribution mirrors the population distribution.

Table 3.1: Number of stakeholders and their industry

Stakeholders	Location	Sample size
Farmers association	Nhamatanda	18
	Buzi	18
Government institutions	National and Provincial level	16
Non-Governmental Organization (NGO)	National and Provincial level	28
Academia	National and Provincial level	7
Total		87

Source: Author compilation

3.6. Methods of data collection

This section starts with an analysis of the data from PRISMA, where identified reports were reviewed in detail to identify relevant recommended actions. Recommendations with no clear pathway to access, availability, utilisation, stability and safe food were not included. The actions were submitted to stakeholders for ranking, analysed, combed, and presented in clusters. This research process entails various techniques for collecting data from the research sample. This cross-sectional study employed semi-structured interviews and questionnaires for collecting data.

3.6.1. Types and method of data collection

3.6.1.1. Systematic Review Method

The research employed a systematic review method to gather information from various studies. Following the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines outlined by Page et al. (2020), this method aimed to comprehensively identify, assess, and synthesize relevant studies related to the research question. The PRISMA process involved 12 steps, including identifying relevant studies based on titles and abstracts, specification of inclusion and exclusion criteria, compilation of information sources, assessment of bias, presentation of results, and a general interpretation of findings. The comprehensive search strategy incorporated keywords such as food system, security, extreme weather events, etc. The review covered literature published in Portuguese and English, sourced from reputable databases like ProQuest, Science Direct, Scopus, and Google Scholar. Additionally, grey literature from Google and NGO databases, covering the period from 2013 to 2021, was included to ensure a comprehensive understanding of the evolving food system concept.

3.6.1.2. Search Strategy, Screening, and Eligibility Criteria

A search strategy was developed using the following keywords: food system, food security, food assistance, food reserve, food supply chain and extreme weather events. These keywords were chosen because they were relevant to the food systems and their systemic problems. No limitation was imposed on the geographic region, but it was limited to studies published in Portuguese and English (Liberati et al., 2009). The Boolean operators AND and OR were used as conjunctions to combine or exclude keywords in a search to identify more studies. Table one presents the keywords and syntax of phrases used to search for literature sources.

Table 3.2. Keywords used for search of the literature

No	Keywords
1	Food assistance OR food system* OR food transfer OR food aid OR cash transfer*
2	Food system* OR food value-chain OR food value chain*
3	Extreme weather OR climate change OR global warming*
4	Challenge OR problem OR obstacle OR issue*

Source: Author's compilation

The database engines ProQuest (Research Gate), Science Direct, Scopus (Elsevier Inc., Netherlands), and Google Scholar were used to identify the studies, and they are extensively used to produce systematic literature reviews in the fields of life, health, and social sciences (Do, *et al.*, 2021; Thairavalappil *et al.*, 2020). All identified sources were imported into Mendeley (Elsevier Inc.) and duplicates were removed. A complementary search for grey literature was conducted through Google and Non-Governmental Organization (NGO) databases. Grey literature covering 2013 and 2021 was collated and included reports, working papers, government documents, conference proceedings and regulatory data (Adams *et al.*, 2016). The reason for selecting this period is that the concept of the food system is relatively new and still evolving (Abdelradi *et al.*, 2021). Older literature might not give the required information about the concept.

A structured screening assessed the relevance of identified titles, abstracts and documents. The studies' titles were checked, and those that were not directly linked to food systems or linked to food systems in urban areas, man-made crises and animal studies were excluded. The second screening process consisted of reading the abstracts of all eligible full texts. Due to the multi-sectoral and interconnectedness of food systems, reports from any part of the food systems, from production to consumption, were considered for review.

3.6.1.3. Identifying relevant studies for the review

The initial body of literature consisted of 3312 studies. Mendeley removed a total of 1407 records as duplicates. The remaining 1907 single versions of the documents were selected for further screening. A further 1252 studies retrieved were excluded because they were irrelevant. The number of relevant studies was reduced to 655. The screening process involved reading the abstracts to determine their relevance by scrutinising the eligibility criteria for reports to be included for review, which included:

- All studies that reported food system disruptions triggered by extreme weather events in rural areas.
- Primary or secondary empirical studies conducted at a local level focused on the rural area and only extreme weather-related shocks.
- Studies with a clear description of the methods used, including data collection, sampling and analysis, were included.
- Studies that showed attempts to determine the reliability or validity of the data analysis serves to ensure the inclusion of studies that have employed rigorous and transparent data analysis procedures such a measurement scales or instruments used in data collection.
- Studies that provided policy recommendations to address food system disruptions and
- Real-world case studies discussed recommendations during a disaster (Misselhorn and Hendriks, 2017).

A total of 587 studies were excluded because they did not meet the above criteria. After applying the eligibility criteria, full texts for the included 68 studies were read to determine the relevance of content and 27 studies plus three identified through other sources, such as lecturer material, were exported to Mendeley and used for systematic review and presented as evidence in Figure 3.2 below.

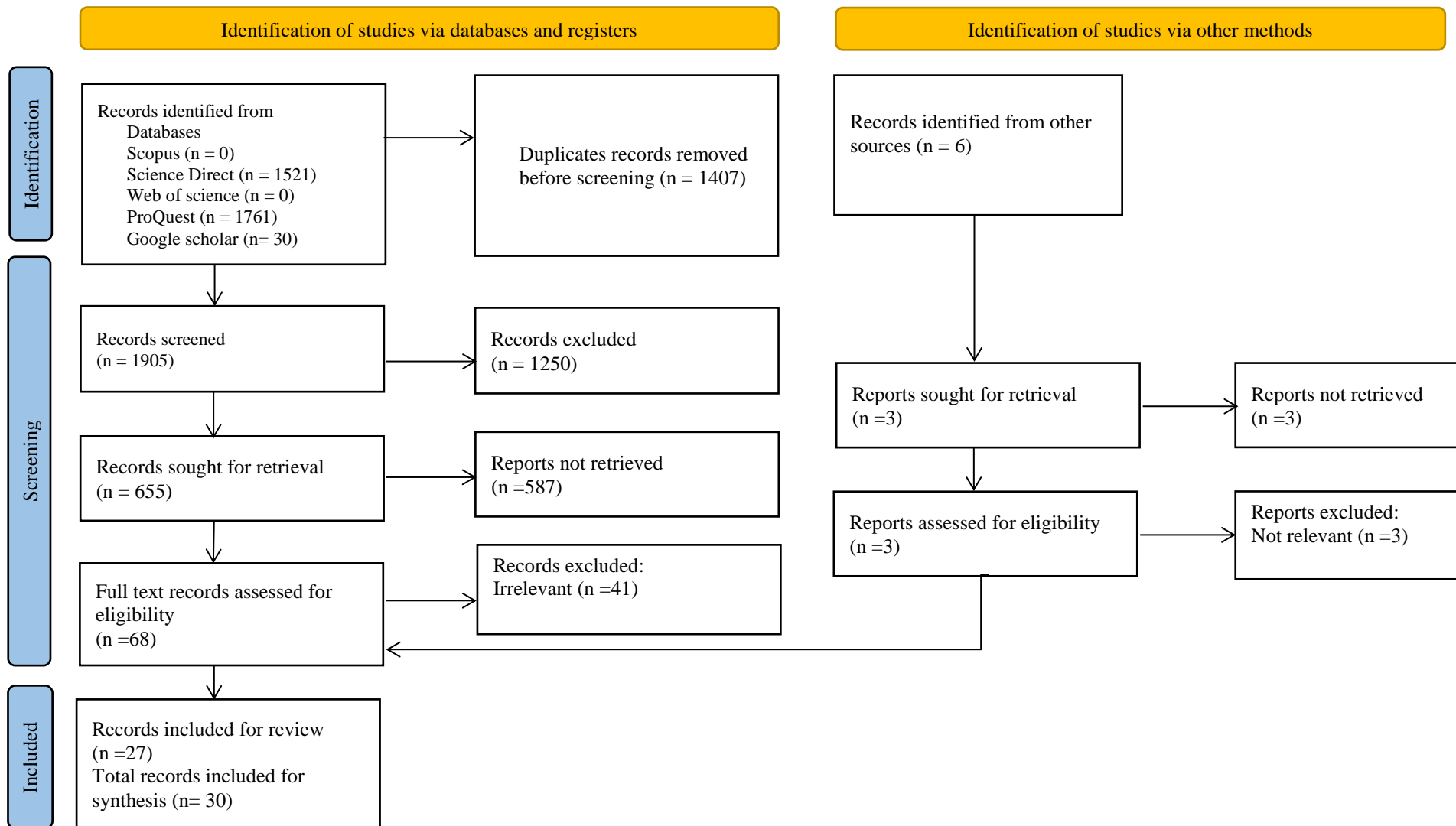


Figure 3.2: PRISMA 2020 Review flow chart for systematic reviews, which includes databases, registers and grey literature, adopted from Page et al. (2022)

Source: Author's compilation

3.6.1.4.Steps involved in a systematic review process

The first analysis step consisted of loading all 30 studies into the software Atlas.ti 9. Open coding, which refers to naming and classifying phenomena through assessing or examining the data, was used to categorise recommendations identified during the review by creating segments. In this regard, 87 relevant segments from the studies were recorded. Open coding separates the data into concepts and categories. In total, 15 similar concepts were grouped and named or labelled. The identified concepts and segments, presented in Annex 1 were used to identify actions to be considered for the prioritisation to develop no-regret solutions that are implementable, relevant and feasible.

3.6.1.5.Extract recommended actions

The identified studies were reviewed in detail to identify recommended actions relevant to the research objective. Actions aimed to address food system disruption triggered by extreme weather were extracted. Recommended actions were refined and classified according to their pathway to impact the food system. A pathway to impact each action was written, indicating how the action will affect the whole food system activities. A list of candidate actions that could address the food system problem was generated (Annexe 6).

3.6.2. Stakeholders interviews

To complement the systematic review, stakeholders were engaged using a semi-structured questionnaire. Purposive sampling was a qualitative technique to select information-rich participants from the Food Security Cluster (FSC) network. The stakeholders, including representatives from academia, government institutions, NGOs, and farmers' associations, were chosen for their expertise in food systems. The questionnaire, distributed through Google Forms, presented identified actions from the systematic review for ranking based on priority. According to Walton et al. (2023), it was imperative to distil the extensively identified actions from the studies to a manageable number suitable for a half-hour assessment before initiating the interviews.

Stakeholders were asked to select actions they considered most and least likely to address food system problems successfully, justifying their choices. The analysis of qualitative data from the questionnaires included assessing the frequency of actions ranked as 'most priority' and 'less priority' to determine potential impact and confidence levels, respectively. This participatory approach aimed to enrich and triangulate findings from the systematic review, providing a broader understanding of recommended actions.

These combined methods ensured a full-bodied and inclusive approach to data collection, incorporating a systematic and stakeholder-driven perspective to address the research objectives effectively.

3.6.3. Questionnaire

The questionnaire and consent forms were forwarded to selected participants with instructions for the interviews through Google Forms. The questionnaire with a list of identified options from a systematic review was provided to participants. The participants were first asked, “Which actions, identified through a systematic review, based on their professional experience, are more or less likely than other actions to address the food systems problems successfully”? Then, they were presented with the actions they ranked as ‘Less priority’ and asked to select up to ten they considered ‘Most priority’ to successfully address the food system problems they think should be regarded as no-regret actions. Participants were asked to justify their selection. Participants were also allowed to add a few solutions of their own choice. If justifiable, these will only be considered for prioritisation and have a clear pathway to affect the food system.

3.6.3.1. Analysis of qualitative data from questionnaires

The questionnaire findings were analysed by identifying the number of times an action was ranked ‘most priority’ to have an impact. ‘Most priority’ was considered a proxy for the potential of an action to have an effect. In contrast, ‘Less priority’ was considered a proxy for the confidence that an action would not have an impact (Walton et al., 2023). Flynn and Marley (2007) indicated that BWS could be used to gather data and a theory for respondents to provide top and bottom-ranked items from a list of attributes. Thus, any actions ranked above the average for either ‘Most priority’ or ‘Less priority’ were moved forward to prioritisation (Walton et al., 2023).

3.6.3.2. Cluster analysis

As defined by Janowitz and Schweizer (1989), cluster analysis is a technique employed to group data sets according to their resemblances across various variables. Building on this, Goswami and Chakrabarti (2012) emphasize that this method classifies samples into distinct groups based on their similarity. The approach necessitates a collection of samples and a metric for gauging their similarity or disparity. Such categorization ensures that samples within one group are congruent while those across different groups are divergent. In line with this

methodology, quartile clustering was employed for analysis. Quartiles cluster split data into four parts, each holding 25% of the total data. Q1, Q2 (median), and Q3 mark the 25%, 50%, and 75% points, respectively (Goswami and Chakrabarti, 2012).

3.7. Reliability and validity of the data collecting instruments

A rigorous pretesting was undertaken to ensure the trustworthiness of the data collected through the questionnaire. Pretesting is a crucial step in the research process that helps identify and rectify any ambiguities or issues with the questionnaire, ensuring that the instrument is valid and reliable for the intended study population (Creswell & Creswell, 2017).

3.7.1. Pretesting of the questionnaire

Before the main data collection, a pilot study was conducted to test the questionnaire. This involved administering the questionnaire to a small sample of participants not part of the study population. Thus, they were excluded from the main data collection exercise. The pre-test aimed to evaluate the clarity, relevance, and appropriateness of the questions and the overall structure of the questionnaire (Dillman, Smyth, & Christian, 2014). During the pre-test, participants were encouraged to provide feedback on confusing or unclear questions. Their responses and comments were invaluable in refining the wording of questions, ensuring that the study participants quickly understood them. Moreover, the pre-test helped gauge the time required for participants to complete the questionnaire, ensuring its feasibility in the data collection phase.

3.7.2. Refinement of the Questionnaire

Based on the feedback received during the pretest, necessary adjustments were made to enhance the clarity and precision of the questionnaire. Ambiguous questions were revised, and potential sources of confusion were addressed to minimize response errors (Fowler Jr, 2013). The refined questionnaire was then used in the main data collection process.

3.7.3. Validity and Reliability Considerations

The validity of the questionnaire was strengthened by aligning the survey items with the study's objectives. The questions were designed to capture relevant information related to the research

objectives and were informed by the systematic review findings. Content validity was further ensured by seeking input from subject matter experts and academics.

The questionnaire was structured consistently to enhance the instrument's reliability, and clear instructions were provided to the participants. Using a digital platform (Google Forms) for questionnaire administration also contributed to reliability by minimizing variations in the administration process (Dillman et al., 2014).

3.8. Choice of analytical tool

The chosen analytical tool used in this research is the systematic review method, specifically adhering to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines outlined by Page et al. (2020). The decision to employ the systematic review approach is justified by its rigorous and structured procedure, aiming to identify, assess, and synthesise all relevant studies related to the selected topic—food system disruptions triggered by extreme weather events in rural Mozambique.

The systematic review provides a standardised methodology for reviewing existing literature, ensuring a thorough examination of the available evidence. The process involves well-defined steps, from identifying relevant studies through keyword searches to screening, eligibility criteria, data extraction, and result presentation. This method aligns with the research's objectives and allows for a comprehensive analysis of actions identified through different databases, forming the basis for subsequent questionnaire development and stakeholder engagement.

Along the same lines, the systematic review method offers transparency and replicability, critical aspects ensuring the credibility and trustworthiness of the research findings. By following established guidelines like PRISMA, the research enhances the quality of evidence synthesis and interpretation. The structured approach facilitates the identification of relevant actions to address food system disruptions, contributing to the development of informed and evidence-based recommendations. Despite the challenges associated with the variability in the quality of primary studies and the intensive nature of systematic reviews, the chosen method aligns with the research's objectives. It provides a robust foundation for subsequent data collection and analysis.

Furthermore, the systematic review serves as a valuable tool for capturing the complexity of the food system challenges in central Mozambique, considering the impact of extreme weather events. The review's findings and subsequent stakeholder engagement and cluster analysis contribute to understanding the prioritised actions for mitigating food system disruptions in the study area.

3.9. Ethical considerations

Ethics approval from the University of Pretoria with reference number NAS270/2021 was approved to ensure confidentiality, anonymity and privacy. The respondents of the questionnaire were informed that the study was conducted solely for research purposes, and they were provided with a written consent form. This consent form outlined the study procedures, as well as any potential risks and benefits associated with participation. By providing this information and obtaining consent, the researchers ensured transparency and ethical conduct in their study. The respondents role in food assistance and demographic information were recorded and used for analysis. Ethical conduct in research is fundamental to upholding the scientific process's integrity, trustworthiness, and fairness. Adhering to ethical principles is not only a moral obligation but also ensures the protection of research participants' rights, well-being, and privacy. The following sections outline key ethical considerations in this study.

3.9.1. Informed Consent

Informed consent is a cornerstone of ethical research, ensuring that participants willingly and knowingly agree to participate in the study (Emanuel et al., 2000). Ethics approval from the University of Pretoria (Reference: NAS270/2021) was obtained, showing the commitment to ethical research practices. Before participation, all questionnaire respondents were provided with a written consent form detailing the study's purpose, procedures, potential risks, and benefits. This step guaranteed that participants were well-informed about their involvement and could make voluntary decisions.

3.9.2. Research Integrity

Maintaining research integrity is imperative for the credibility of findings. The research was conducted with utmost honesty, transparency, and accountability. The systematic review process followed standardized methodologies, and the questionnaire design was to ensure the reliability and validity of the data collected.

3.9.3. Compliance with regulations and guidelines

The study adhered to both nationally and institutionally relevant regulations and ethical guidelines. Ethics approval from the University of Pretoria was sought and obtained. This approval process involved thoroughly reviewing the research plan ensuring alignment with ethical standards and guidelines. Compliance with these regulations is crucial for maintaining the credibility and legitimacy of the research.

3.9.4. Data management and sharing

Data management practices were designed to prioritize confidentiality and privacy. The researchers implemented secure data storage measures to safeguard participant information. Moreover, data sharing was approached cautiously, with a commitment to preserving the anonymity of participants. Any shared data adhered to ethical standards and legal requirements.

3.9.5. Community and cultural sensitivity

Given the diverse context of the study area, community and cultural sensitivity were paramount. The research team approached participants with respect for their cultural norms and practices. Efforts were made to engage with stakeholders in a culturally competent manner, fostering an environment of trust and openness.

3.9.6. Protection of participant information under the Popi Act

In accordance with the Protection of Personal Information Act (Popi Act), the study took measures to protect participant information. This included obtaining explicit consent for data collection and ensuring that participants were aware of how their information would be handled. Confidentiality and anonymity were maintained throughout the research process, and personal details were securely stored to prevent unauthorized access.

To sum it up, ethical considerations were woven into the fabric of this research to ensure the highest standards of conduct. From obtaining informed consent to upholding participant privacy under the Popi Act, the study prioritized ethical principles to contribute to the credibility and trustworthiness of the research findings.

3.10. Summary of the chapter

This research utilised a qualitative methodology, drawing on secondary data and employing the PRISMA approach for systematic reviews. A keyword search across multiple databases yielded 30 studies, which were then analysed and coded using the Atlas.ti software. The review has resulted in six broad themes and their associated actions. Data collection was mainly achieved through a Google form questionnaire, where food system stakeholders ranked actions based on priority (Most and Least priority). Cluster analysis, specifically the Quartiles cluster, segmented the data into four equal parts. Eighty-seven stakeholders from diverse sectors were chosen from two districts in central Mozambique, both of which have experienced extreme weather events. Their selection was rooted in their involvement in food systems activities.

While the methodology was robust, it had its challenges. The quality of some of the primary studies was variable, potentially impacting the review's overall credibility. Moreover, the intensive nature of systematic reviews, regarding time and resources, posed challenges, such as the emerging research during the review process. Conducting systematic reviews can indeed be time and resource-intensive, presenting challenges when new research emerges during the review process. This issue is particularly significant in fast-evolving fields like climate science where new studies were continuously published (Bremer et al., 2019; Camps-Valls et al., 2021). To address this challenge, we employed several strategies such as the flexible review protocol which allow the inclusion of the latest identified studies that met our criteria without compromising the integrity of the review process; continuous monitoring the journal with high impact factor to ensure that we stayed informed about new studies as they were published, and; collaborated closely with subject matter experts and stakeholders who provided valuable insights and helped us navigate the rapidly evolving landscape of climate science. Their expertise helped us identify and prioritize emerging research that was most relevant to our review objectives. The University of Pretoria approved ethical considerations for the research.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents the findings of the study in three sub-subsections, ranging from key actions gathered from databases to the interconnectedness of the actions to address the systemic problems triggered by extreme weather events. Then, the actions were grouped into the specific themes to be considered as no-regret actions.

4.2. Key actions identified to address systemic problems triggered by extreme weather

This sub-section discusses the results from the general characteristics of reviewed records, the timeline, and the geographical and thematic focus of the studies. The main characteristics were the publication type, year of publication, geographical focus and thematic focus. The analysis shows that the reviewed record focused on 15 (codes), critical aspects of food systems ranging from agriculture inputs, agriculture services, food assistance, infrastructure, and supply chain.

4.2.1. Publications per year on global food systems

Figure 4.1 presented in this section offers a visual representation of the study output gathered through a systematic review of the topic of food systems over time. By tracking the number of publications per year, we aim to uncover trends, patterns, and fluctuations that underscore the dynamic nature of research within this vital field. The x-axis delineates the years under consideration, providing a temporal dimension to the data. At the same time, the y-axis quantifies the number of publications within each respective year, and the sudden spikes or declines in publication numbers may signify key events, emerging issues, or evolving priorities within the food systems and extreme weather events.

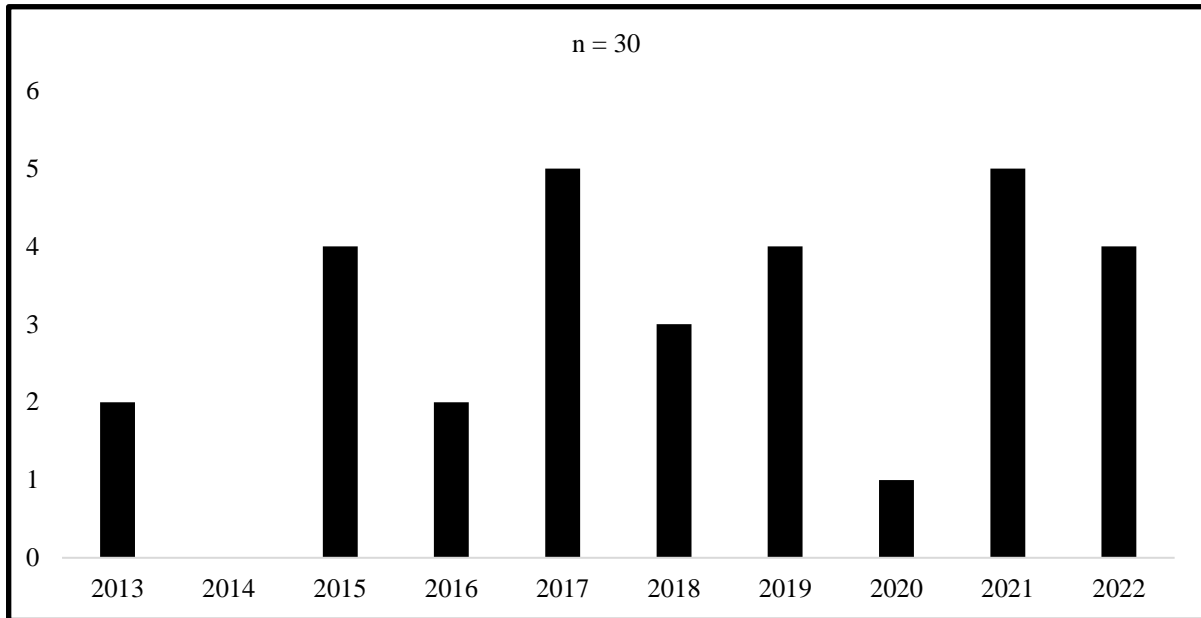


Figure 4.1: Number of publications per year

Source: Authors' computation.

The increasing interest in the food system and its vulnerabilities to weather-related shocks is evident in the literature published between 2013 and 2021. According to Gosling et al. (2022), in 2021, the United Nations (UN) Secretary-General convened the Food Systems Summit (the Summit) as part of the Decade of Action to achieve the Sustainable Development Goals (SDGs) by 2030. The Summit introduced new actions aimed at advancing progress across the seventeen SDGs, each of which relies to some extent on the development of more sustainable and equitable food systems. Southern Africa is widely recognized as a climate change 'hotspot,' with drought and extreme rainfall events adversely affecting the food systems of numerous countries (Gosling et al., 2022). Consequently, Mozambique, one of the worst affected African nations by extreme climatic events, hosted a Dialogue focused on pioneering solutions to climate change challenges. Abdelradi et al. (2021), assert that this surge is likely a response to the escalating concerns about the global food system and the tangible impacts of weather shocks observed worldwide. Thus, out of the 30 documents surveyed in the study, nine, or approximately 30%, were published between 2021 and 2022 (Figure 4.1). This uptick in publications during 2021 and 2022 underscores the growing recognition of the importance of these challenges within the academic community.

4.2.2. Study coverage or study boundary

The chart presented in Figure 4.2 provides an insightful breakdown of the geographical focus of studies within food systems. It visualises the distribution of research efforts across different geographic scopes such as global, African, and Mozambique.

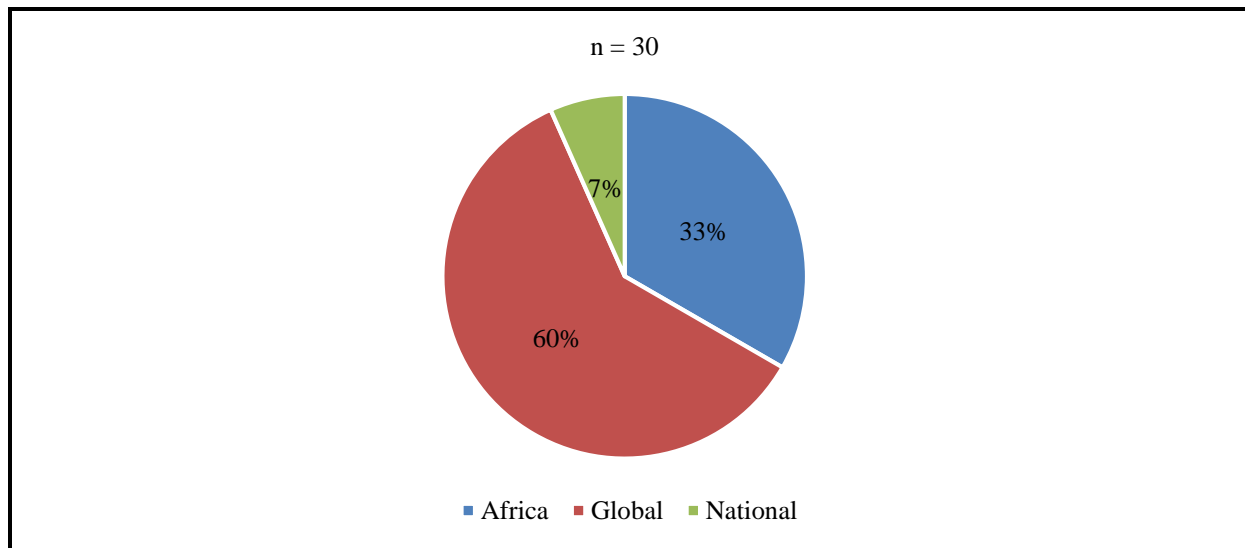


Figure 4.2: Study coverage or study boundary

Source: Authors' computation.

Regarding the geographical area, Figure 4.2 showed that 60% of the studies focused on global environments, neither conducted in other countries nor with multi-country studies, which may include Africa and National. Thus, two international studies (WOFA, 2017 and WFP, 2017) included in the review highlighted Mozambique.

Conversely, 40% of studies focus more on Africa's environment and rural communities. This number of publications means an increase in the acknowledgement of the need to resolve food system issues, as Southern Africa is highly susceptible to extreme weather events (Davis & Vincent, 2017). Within this distribution, Mozambique emerges as a specific area of interest due to its susceptibility to extreme weather conditions (Salazar-Espinoza et al., 2015). However, the chart also points out a relative scarcity of studies centred on Mozambique, comprising only 7% of the publications during the analysed period. Notable contributions from Zhou (2019) and WFP (2019) provide valuable insights into the Mozambican food system.

4.2.3. Key concepts explained

In Figure 4.3, a comprehensive overview emerges from scrutinising 30 studies conducted in the systematic review, outlining 15 overarching concepts. Notably, the most prominent concepts identified as having a higher likelihood of being considered "no-regret" to address

systemic challenges triggered by extreme weather events in the food system in Central Mozambique include climate-smart agriculture, food assistance programs, agricultural insurance mechanisms, social protection measures, and infrastructural support. These key concepts, each with more than five occurrences, signify their prominence and potential effectiveness in addressing the identified challenges.

Conversely, supply chain interventions, subsidies, agricultural inputs, and services are at the bottom of the list, each with fewer than five occurrences or concepts. This suggests a comparatively lower prevalence or emphasis on these actions in the reviewed studies. The hierarchical arrangement of these actions in Figure 4.3 provides valuable insights into the perceived priority and prevalence of various strategies in mitigating the impact of extreme weather events on the food system in Central Mozambique.

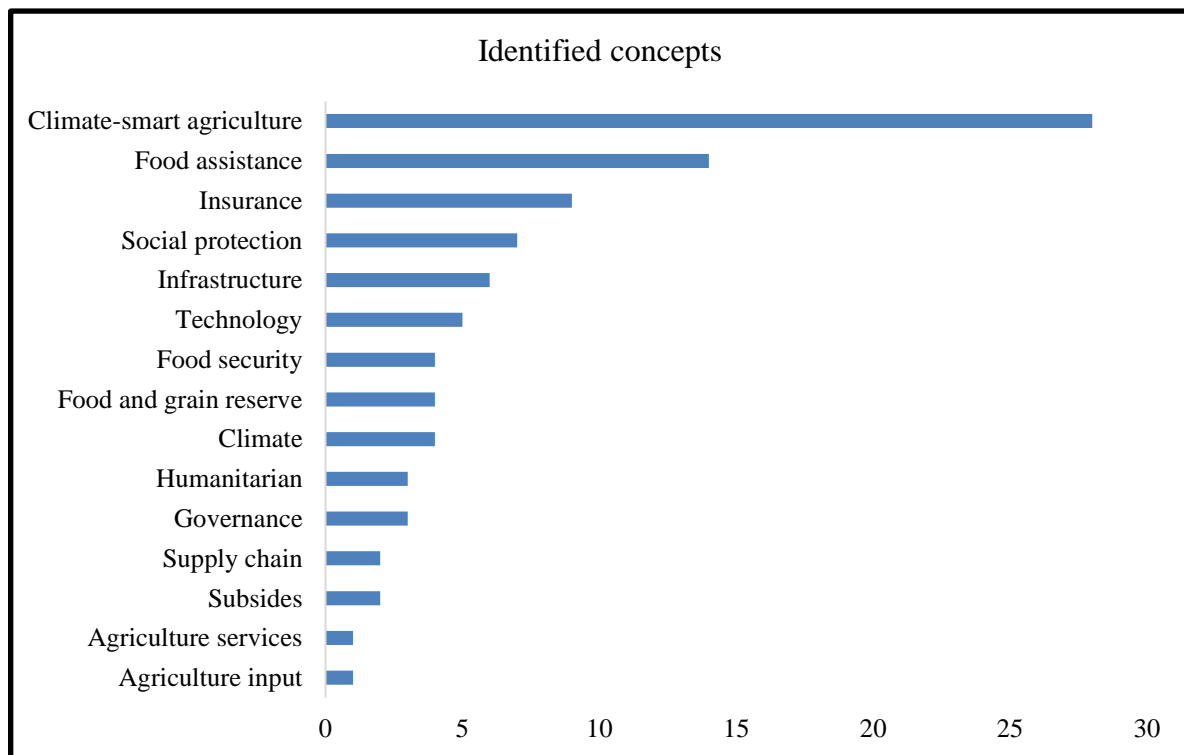


Figure 4.3: Concepts identified from the studies

Source: Authors' computation.

4.3. Interconnectedness and linkages of identified actions

The top five actions mentioned are intricately linked, forming a holistic approach to addressing food system problems. Figure 4.4 depicts a network diagram illustrating these connections among the abovementioned themes.

Climate-Smart Agriculture (CSA), as supported by various researchers (Brüssow et al., 2019; Connolly-Boutin and Smit, 2016; Cooper, 2016; Eichsteller et al., 2022; Ignaciuk, 2015; Jasper et al., 2021; Kocur-Bera, 2018; Lewis, 2017; Ncube et al., 2016; Okonjo-Iweala, 2020; Onyutha, 2019; Singh-Singh, 2017), is a fundamental element that enhances food productivity. In parallel, food assistance (Lentz et al., 2013; WFP, 2019; WOFA, 2017; Zhou, 2019) and social protection programs (FAO, 2020; Weldegebriel and Amphune, 2017; WFP, 2019; WOFA, 2017; Zhou, 2019) serve as mechanisms ensuring both immediate relief and long-term food security. These researchers reinforce the need to ensure food security for vulnerable populations. Moreover, the interconnectedness between social protection and humanitarian responses could effectively reach those in need and contribute to build resilience among vulnerable populations. Furthermore, social protection was recognized as a crucial component of governance, as it involves the development and implementation of policies and programs aimed to support individuals and communities, especially the vulnerable and marginalized. These policies and programs were designed to meet basic needs and provide protection from risks and shocks, ultimately contributing to the well-being and stability of society as a whole.

Insurance and subsidies, as indicated by research findings (Eichsteller et al., 2022; FAO, 2021; Ignaciuk, A. 2015; Okonjo-Iweala, 2020; WFP, 2019), are pivotal tools in promoting sustainable agricultural practices. Additionally, efficient supply chain infrastructure contributes to improving food availability and distribution. By recognizing and integrating these intricate interconnections among these themes, it becomes feasible to formulate strategies that bolster resilience within food systems and foster sustainable agriculture, ultimately ensuring the well-being of communities in rural areas.

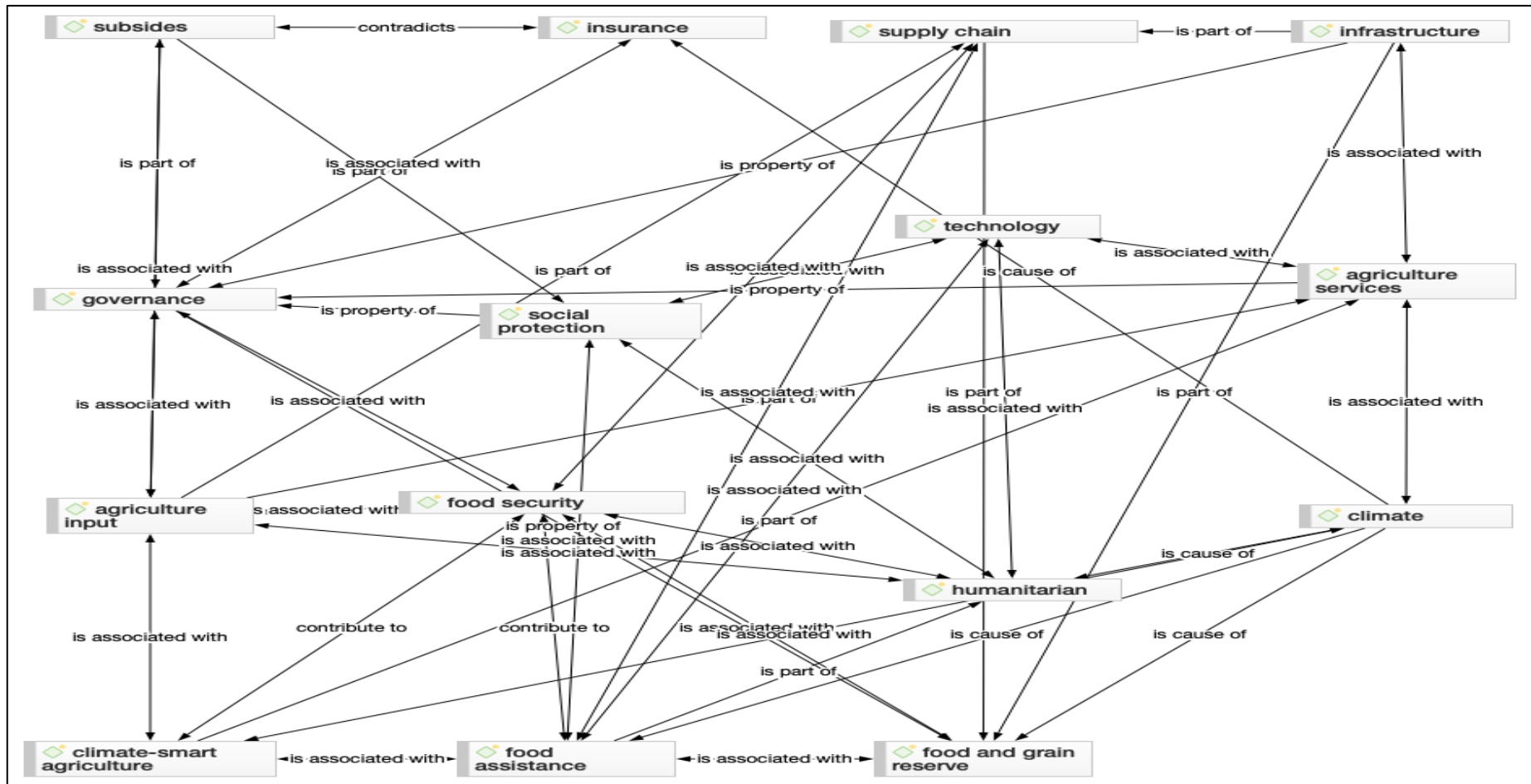


Figure 4.4: Network diagram showing linkages of identified actions

Source: Authors' computation

4.3.1. Themes identified from systematic review

Figure 4.5 illustrates the weights and distribution of specific themes across different studies. It also illustrates the six broad themes clearly, with a dominant focus on actions regarding public institutions (31%) followed by supply chain (25%) and then agriculture actions (19%). There is a relative lack of actions to tackle education, public awareness, research, processing, and technology (6% each).

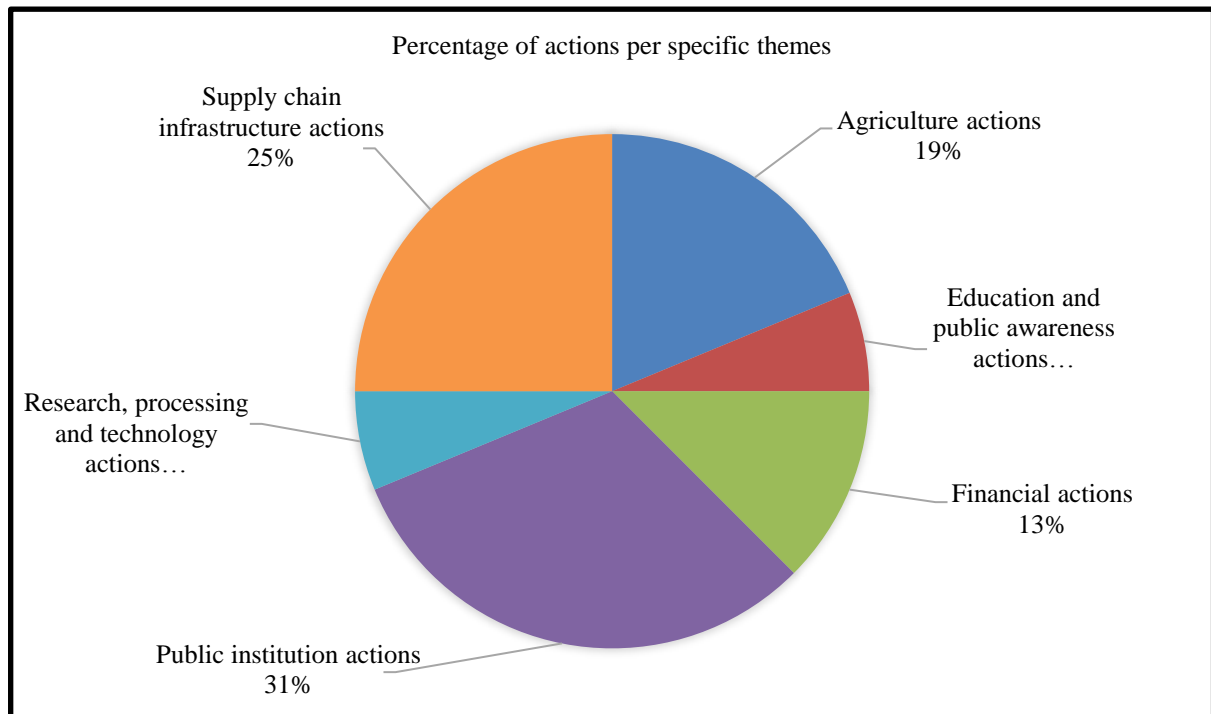


Figure 4.5: Actions identified per category

Source: Authors' computation.

Given the diversity of perspectives on what actions food systems entail, much of the reviewed literature provided insights into the concept, even though some did not explicitly refer to it. Whereas about 50% of the reviewed literature focused on agricultural and supply chain and infrastructure actions, respectively, 6% was on education and public awareness actions. From the total of 30 documents included in the review, 27% of the studies appear in three different categories, 17% appear in two different categories, 33% in one category, and one is orphan, not included in any category. However, almost all agriculture action studies appear in most other categories. While the reviewed literature can be categorised based on their overarching thematic focus.

4.4. Prioritize the available actions to address the food system disruptions

From the 30 studies chosen in the systematic review, 48 distinct recommendations were combed and distilled into 30 consolidated candidates for 'no regrets' actions. These recommendations were then presented to stakeholders via a Google form, wherein they were asked to rank each action as "most" or "least" significant. Following this, the highest-ranked recommendations were grouped and once more presented to the stakeholders for further prioritisation. The outcomes of this second round of feedback were designated as no-regret actions (Figure 4.14).

4.4.1. Agricultural actions

Agriculture is the fundamental economic sector in Mozambique, along with forestry, fisheries, and livestock and is the primary source of income and livelihood for more than 70% of people in rural areas (Eleblu et al., 2021; WFP, 2021). In addition, it operates on rain-fed food systems, which expose the sector to further climate-related shocks (Downie, 2016; WFP, 2021). In addition, the study area is the country's most food insecure, along with Tete, Manica, Inhambane, and Gaza (FEWS NET, 2021). Chapman (2020) states drought, floods, and cyclones are the most significant threats, jeopardising the agriculture sector.

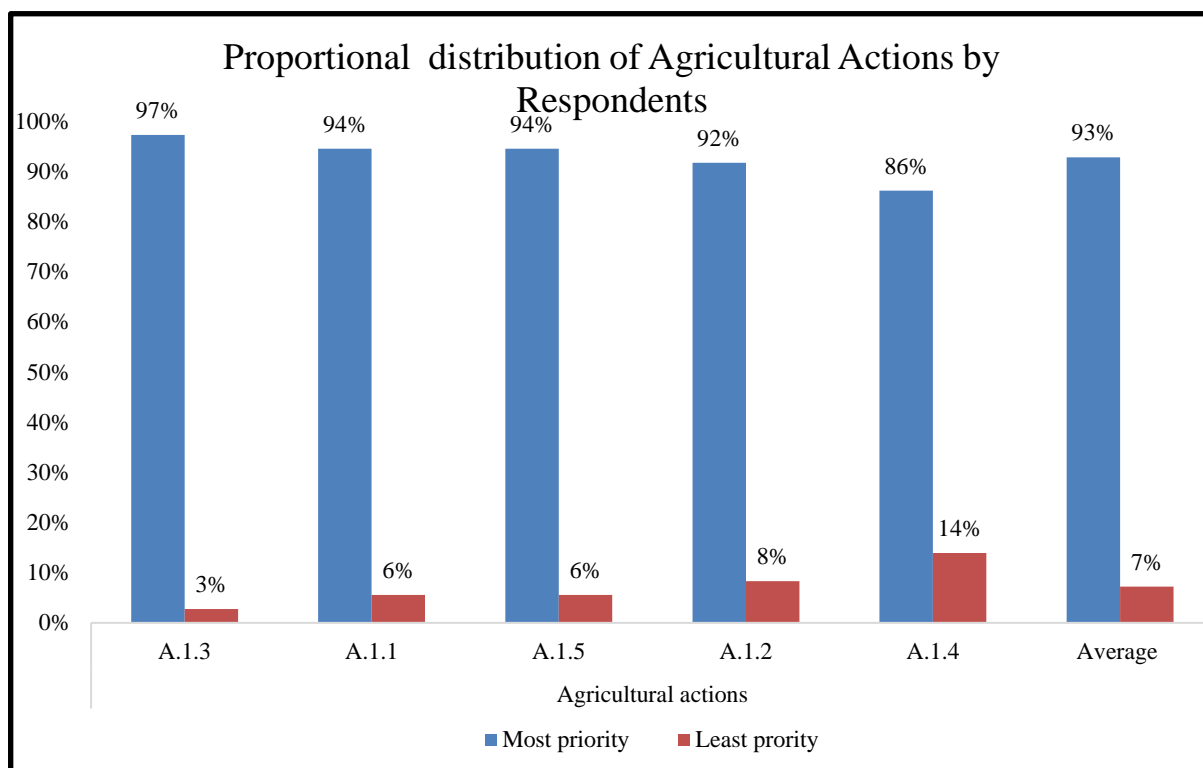
Agriculture actions enhance productivity, sustainability, and resilience in farming given the challenges posed by global issues like adverse weather, population growth, and resource constraints. According to Alhassan (2020), farmers have embraced a combined approach of on-farm and non-farm strategies to enhance their capacity to recover from climate-induced shocks. Notably, Alhassan emphasizes the significance of quality extension services, providing accurate information, and access to credit and loans as crucial components facilitating the adoption of on-farm practices as demonstrated in the figure 4.6.

The key practices among these actions are CSA, Conservation Agriculture (CA), spotlighting no-till farming to preserve soil health. On the other end, embracing crop diversification and Agroforestry can mitigate risks and provide multifaceted benefits. A total of nine out of 11 studies (Brüssow et al., 2019; Connolly-Boutin and Smit, 2016); Cooper, 2016; FAO, 2020; Ignaciuk, 2015; Jasper et al., 2021; Lewis, 2017; Ncube et al., 2016; Onyutha, 2019) presented the same recommendations regarding CSA ranging practices from organic fertilizers, short-term and drought-resistant varieties of crops, conservation farming, fast-maturing varieties, planting earlier, intercropping, crop rotation, cover cropping, traditional organic composting

and integrated crop-animal farming. Although increasingly discussed, these CSA practices were relatively recently introduced to the agricultural landscape. However, the adoption rate among smallholder farmers remains less than optimal. The inhibiting factors for the adoption include limited access to vital resources such as inputs, pertinent information, market access, and tools for risk management (Mutengwa et al., 2023; Quarshie et al., 2023). Despite these reservations, other researchers, such as Eleblu et al. (2020), argue that it promises to bring swift, beneficial changes to African food systems. This perspective is further reinforced by Mutenje et al. (2021), who underscored the economic viability of CSA practices, suggesting they are indeed worthwhile endeavours, especially for risk-averse smallholder farmers. Furthermore, the applicability of CSA practices often hinges on the specific context, tailored to individual farming community's requirements and priorities (Zougmoré et al., 2021).

4.4.1.1. The findings from semi-structured interviews

Figure 4.6 present the findings from semi-structured interviews with various food system stakeholders. Most respondents (93%) concurred that the actions related to Introduction of early mature and drought-resistant varieties, Ensure fair accessibility of the improved seeds for both informal and formal sectors, Support local farmer-based seed production and safe seed storage at the District level to ensure prompt availability after disasters, and Integration of traditional agriculture practices coupled with modern sustainable farming practices were the most critical initiatives to address food system challenges within their respective contexts. The legends of the figure were presented on Appendix 5.



Legends: A.1.3- Introduction of early mature and drought-resistant varieties; A.1.1- Ensure fair accessibility of the improved seeds for both informal and formal sectors; A.1.5- Support local farmer-based seed production and safe seed storage at the district level to ensure prompt availability after disasters; A.1.2- Integration of traditional agriculture practices coupled with modern sustainable farming practices; A.1.4- Adopt dry-season vegetable production.

Figure 4.6: Percentage of acceptance of agriculture options

Source: Authors' computation

These actions were perceived as no-regret solutions, signifying their high priority in ensuring the resilience and sustainability of food systems in the face of climate-related issues. This consensus underscores the fundamental role of these measures in mitigating the impact of climate-induced shocks on agriculture and food security. Improved seeds (actions A.1.3, A.1.1 and A.1.5) were among the most CSA practices currently promoted in southern Africa to address the effects of extreme weather (Mutengwa et al., 2023). However, its adoption by smallholder farmers was limited due to a lack of access to resources, extension service information, poverty, and lack or inadequate infrastructure (Abdelradi, 2021; WFP, 2021). The fact that some CSA practices, including those mentioned above, were already part of traditional agricultural practices justifies the less-ranked option A.1.2 (Dougill et al., 2021).

4.3.2. Research and technology actions

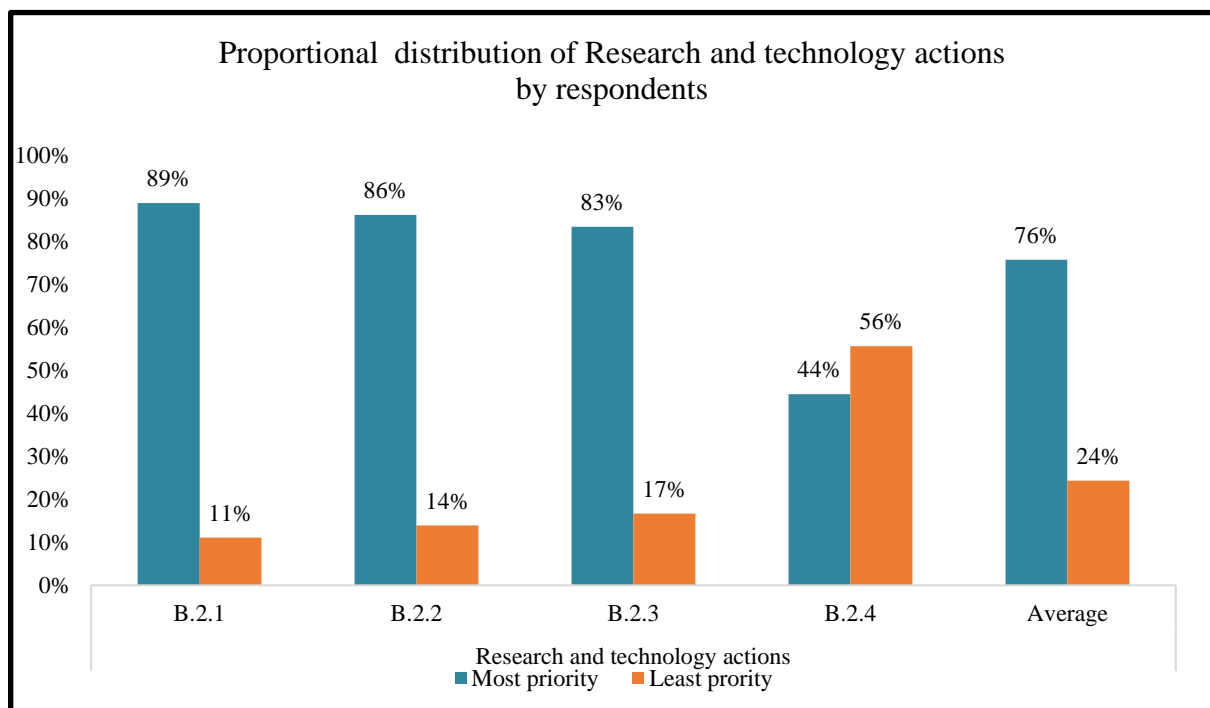
The result of systematic review entailed in four broad actions that include the adoption of small-scale irrigation schemes by smallholder farmers, the implementation of Drought Early Warning in the Food Systems (DEWS), the provision of farmers with improved seasonal meteorological

forecast information, integration of satellite data with land-based stations and radar for more detailed forecasts and live monitoring, and the implementation of digital solutions and traceability in the value chain, represents 6% of total actions identified through the studies and were presented to stakeholders for ranking.

4.3.2.1. The findings from semi-structured interviews

Based on the online questionnaire (Figure 4.7), research and technology respondents were considered the fourth most important theme to address food system problems, with 76% of respondents considering this theme the highest priority. However, the respondents have considered action Implement digital solutions and traceability in value-chain) as the least priority as it was ranked just below the average. Furthermore, the technology adoptions were constrained by a lack of financial resources to use irrigation infrastructure and develop additional technologies effectively to respond to shock before it became a crisis, as observed by WFP (2021).

The findings also observe that Action Implement digital solutions and traceability in value-chain was less ranked among the stakeholders and was not selected for the prioritization phase. Its adoption was constrained by limited technical capacity, poor historical records, lack of information systems and dissemination of early warning (WFP, 2021). The legends of the figure were presented on Appendix 5.



Legends: B.2.1- Adopt a small-scale irrigation scheme by the smallholder farmer (solar pumps driven); B.2.2- Implement Drought Early Warning in Agri-Food Systems (DEWS); B.2.3- Provide farmers with improved

seasonal meteorological forecast information, integrating satellite with land-based stations and radar for more detailed forecasts and live monitoring; B.2.4- Implement digital solutions and traceability in value-chain

Figure 4.7: Percentage of acceptance of technology actions

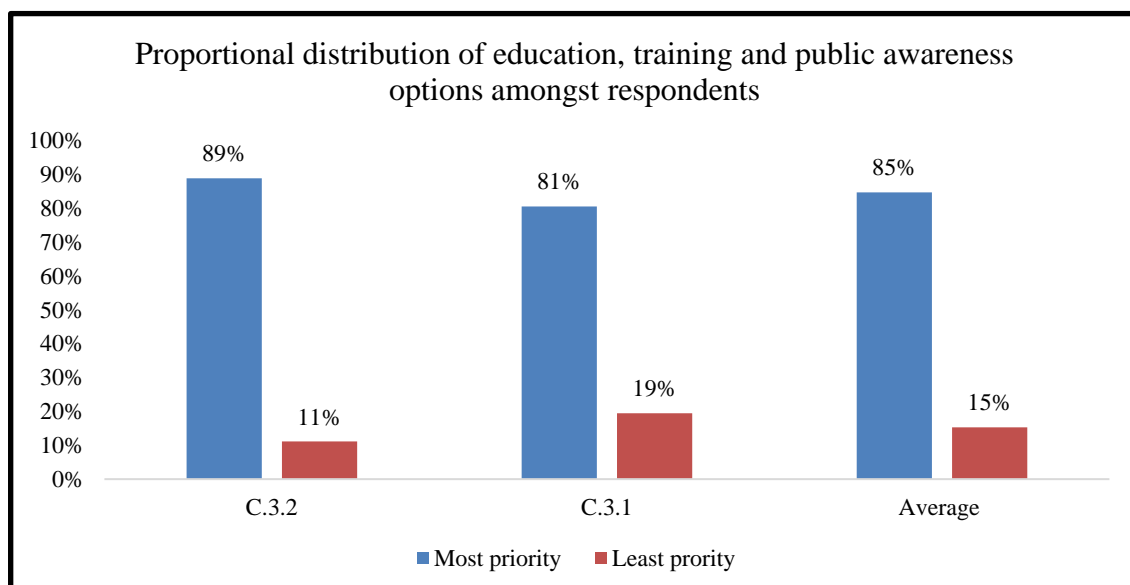
Source: Authors' computation.

4.3.3. Education, training and public awareness actions

The findings from systematic review were aligned with the research of Lewis (2017), who supports the key role of extension services in empowering farmers with tools and knowledge to navigate challenges associated with erratic weather patterns. Lewis underscores the potential of extension services in promoting practices such as cultivating drought-resistant crops, adopting sustainable water management techniques, and implementing early warning mechanisms. The observations made by Cunguara and Moder (2011) shed light on a critical challenge within the realm of extension services in Mozambique. Their research highlights a tendency for these services to target wealthier households predominantly. This targeting approach is rooted in the assumption these households are more likely to adopt existing agricultural technologies. However, the crucial limitation identified is the lack of success stemming from the failure to adapt these services to specific locations.

4.3.3.1. The findings from semi-structured interviews

Figure 4.8 showed that beyond 80% of the respondents ranked the education, training and public awareness as the most priority and the results were presented to stakeholder for prioritization. The actions include Training, education and extension services to prevent the agricultural sector from future erratic weather shocks and Use extension services to channel early warning message. The legends of the figure were presented on Appendix 5.



Legends: C.3.2- Training, education and extension services to prevent the agricultural sector from future erratic weather shocks; C.3.1- Use extension services to channel early warning message

Figure 4.8: Percentage of acceptance of education and training actions

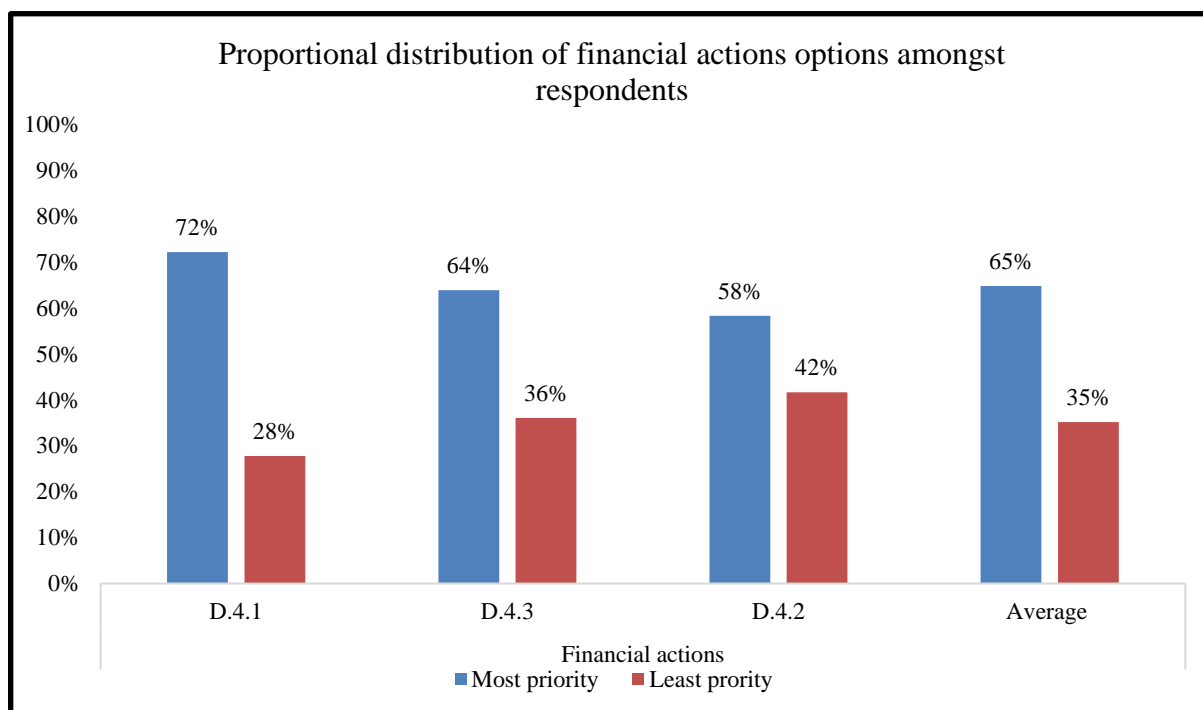
Source: Authors' computation.

4.3.4. Financial actions

Financial actions were the fourth theme most cited in the studies gathered from systematic review and represent 13% of overall actions across all themes. Insurance actions were referenced in six different studies such as Cooper (2016), Glauber et al. (2021), Kron et al. (2016), Singh-Singh (2017), and Weldegebriel and Amphune (2017). The insurance-based solutions were related to financial protection instruments that transfer risk to the insurance market. Government subsidies that can incentivise farmers to adopt specific practices or offset the costs of inputs have potentially to create moral hazard issues, wherein farmers may take on higher risks or engage in unsustainable practices because they were protected by government support.

4.3.4.1. The findings from semi-structured interviews

Figure 4.9 distils insights from stakeholders regarding three central actions presented to food systems stakeholders. These actions include adopting safety nets as shock responses embedded in social-protection systems, implementing subsidized insurance systems for agricultural producers with access to fast credits for anticipatory actions in response to forecasted seasonal droughts or high flood risks, and promoting crop insurance to overcome crop failure. The data from the stakeholder interviews reveals a substantial level of support, with 65% of respondents agreeing that financial actions possess the potential to be regarded as no-regret solutions. In these semi-structured interviews, 72% of stakeholders ranked adopting safety nets as shock response embedded in social-protection systems as the most relevant action. In contrast, the rest of the actions, D4.2 (58%) and D4.3 (64%), were ranked as below the average by stakeholders even though they appear as the most cited in four different studies (FAO, 2022; Ignaciuk, 2015; Kron et al., 2016; Singh-Singh, 2017;). The legends of the figure were presented on Appendix 5.



Legends: D.4.1- Adopting safety nets as shock response embedded in social-protection systems; D.4.3- Subsidized insurance systems for Agricultural producers, access to fast credits for anticipatory actions for forecasted seasonal drought or high risk of floods; D.4.2- Promotion of crop insurance to farmers to overcome crop failure.

Figure 4.9: Percentage of acceptance of financial actions

Source: Authors' computation.

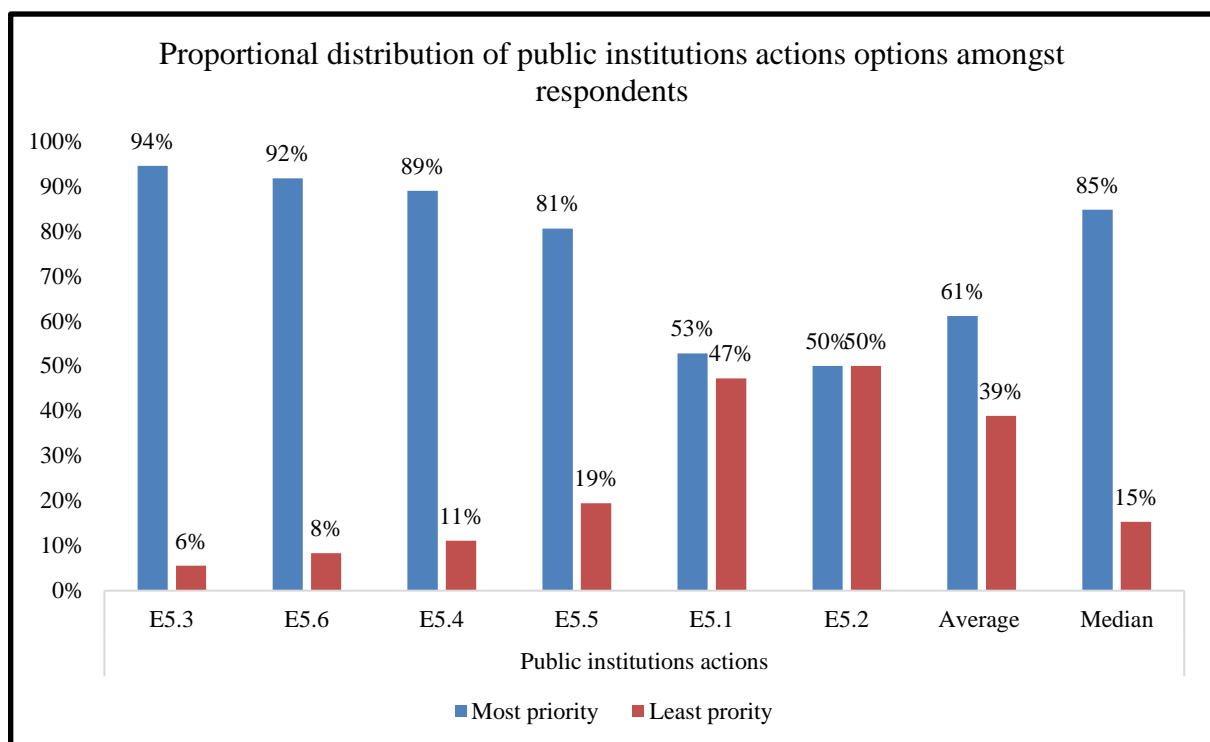
4.3.5. Public institutions actions

The actions gathered from systematic review accounts for 31% of overall actions and include Invest in on-farm irrigation and water storage infrastructures, Engaging the local government as partners and mainstreaming the activities throughout other institutional structures to achieve sustainability, Allocate at least 10% of the budget to the agricultural sector (Comprehensive Africa Agriculture Development Program - CAADP), Improve the communication infrastructures in remote rural areas to accelerate service provision, Adapt the social protection system to accommodate food assistance during the climate shock-related crisis and Cut down on external food imports by reinforcing local procurement. The legends of the figure was presented on Appendix 5.

4.3.5.1. The findings from semi-structured interviews

Figure 4.10 provides a visual representation of the percentage of acceptance of public institution actions, offering valuable insights into stakeholders' perspectives on the effectiveness and appropriateness of actions undertaken by public institutions within the

studied context, whereas 85% of the respondents have ranked as essential to address the food systems problems. Three actions (E5.3, E5.6 and E5.4) were considered top-ranked by most stakeholders (above 85%) which is comparable to what Halbherr et al. (2021) has asserted that government must engage themselves and promote public–private partnerships. However, in contrast, social protection (E5.1) and regional food source (E5.2) were considered slightly relevant by 50% of respondents in their context, contradicting studies from WOFA (2017), Paci-Green et al. (2015), Ignaciuk (2015), Onyutha (2019) and Zhou (2019).



Legends: E.5.3- Invest in on-farm irrigation and water storage infrastructures; E.5.6- Engaging the local government as partners and mainstreaming the activities throughout other institutional structures to achieve sustainability; E.5.4- Allocate at least 10% of the budget to the agricultural sector Comprehensive Africa Agriculture Development Program (CAADP); E.5.5- Improve the communication infrastructures in remote rural areas to accelerate service provision (for example, cash transfers); E.5.1- Adapt the social protection system to accommodate food assistance during the climate shock-related crisis; E.5.2- Cut down on external food imports by reinforcing local procurement.

Figure 4.10: Percentage of acceptance of public institution actions

Source: Authors' computation

4.3.6. Supply chain options

Supply chain infrastructure actions accounts for 25% of overall actions identified through systematic review. Infrastructure plays a pivotal role in streamlining the flow of agricultural products from farms to markets, minimizing post-harvest losses and guaranteeing consistent food availability (Eichsteller et al., 2022; FAO, 2021; Ignaciuk, 2015; Okonjo-Iweala, 2020; WFP, 2019). Adequate and efficient infrastructure enhances produce's swift and secure transit.

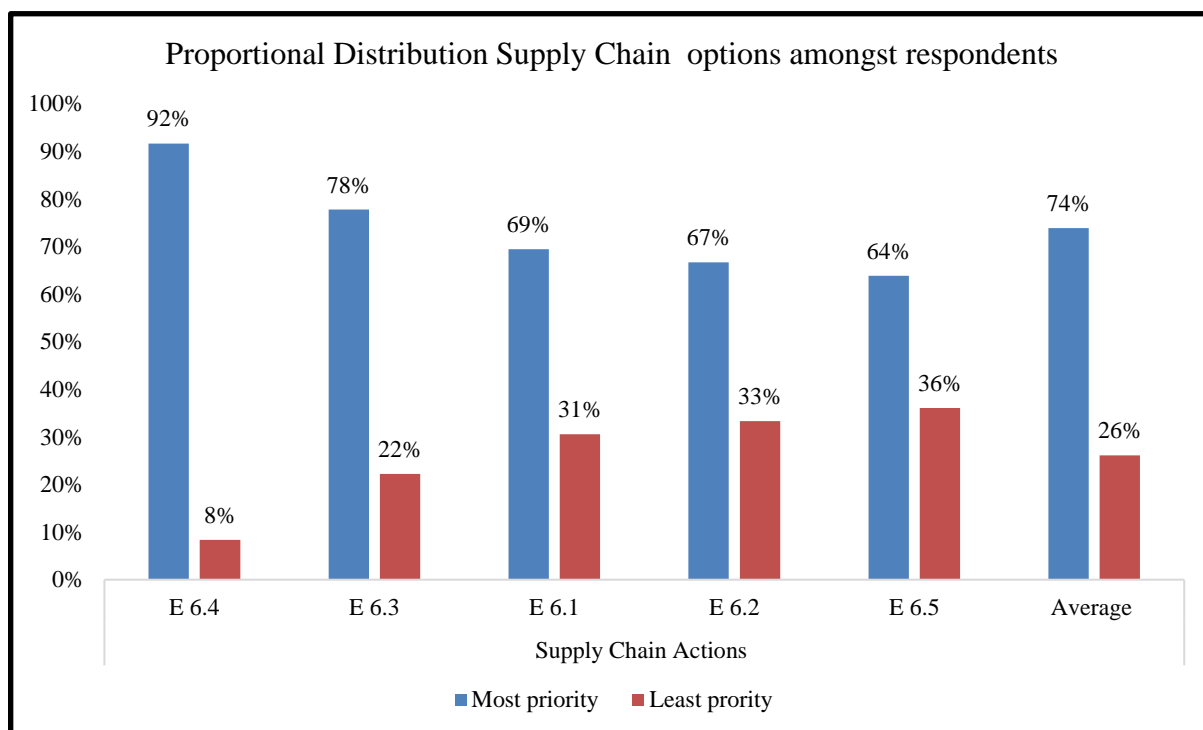
When seamlessly integrated with the supply chain, this infrastructure solidifies the end-to-end movement of agricultural goods, ensuring they reach consumers in optimal condition.

Food assistance emerges as a crucial intervention in situations characterized by deficiencies, disruptions, or breakdowns within the food system, depriving individuals and households of essential nutrition and other fundamental needs (WFP 2017). Furthermore, the statement highlights that cash transfer emerged as the most prominent instrument across five studies, being cited 14 times. This indicates the significance of cash transfer programs as a key intervention in addressing food insecurity and meeting the needs of vulnerable populations.

Recent research by Zhou (2019) and WFP (2017, 2019) underscores the potential effectiveness of food assistance interventions in influencing the dynamics of the food system in Mozambique. A pertinent observation made by Zhou and Hendriks (2017) emphasizes that strategically timing cash and food transfers to align with lean months has the potential to transform a mere need into effective demand in Mozambique. This finding is consistent with Moslehi et al. (2022), who stated that food assistance is often used as ex-post intervention (after the occurrence of disasters).

4.3.6.1. The findings from semi-structured interviews

Figure 4.11 offers a visual representation of various supply chain actions within the studied context, with a specific focus on actions related to improving food market infrastructure and establishing a food reserve. This figure aligns with the findings that indicate the top-ranking preferences among respondents. Notably, 92% of participants identified improving food market infrastructure as a priority, while 64% endorsed the Use cash over food transfers to address the food system problems. The rest of actions include Improvement of food market infrastructure, Establish food reserve, Procure local or regional food aid and organize storage and distribution methods, and Introduction of new food assistance instruments, including local and regional procurement, cash and vouchers.



Legends: F.6.5- Use cash over food transfers to address the food system problems; F.6.3-Establish food reserve; F.6.1- Procure local or regional food aid and organize storage and distribution methods; F.6.2- Introduce new food assistance instruments, including local and regional procurement, cash and vouchers; F.6.4- Improvement of food market infrastructure

Figure 4.11: Percentage of acceptance of public institution actions

Source: Authors' computation

The statement that Improvement of food market infrastructure and established food reserve were the top-ranked by 92% and 78% of respondents, respectively. The actions (E6.2, E6.3 and E6.6) received almost the same percentage, close to the average (74%) of respondents. This result is aligned with the three studies by Kuang-Sheng (2022), Lentz et al. (2013) and Paci-Green et al. (2015). Food reserve was established in African countries early in 1975 but collapsed (Torrero, 2011) due to a lack of resources to refill the reserves, the use of the reserve to balance crop failure, the high cost of maintaining and managing the system and the reluctance of donors to continue funding these initiatives (Onyekwena, 2019). Lassa et al. (2019) observe that some countries around the world have succeeded in implementing the food reserve to tackle food security, disaster response and famine early warning systems.

The Mozambican food system is predominantly subsistence-based. Once the food reserve system was meant to ensure food security, stability, and resilience affected people to save lives, price stabilization, and tackle social and economic crises, it should, according to Lines (2011) and Mulugeta (2015), be tailored to country-specific situations as the 'one size fits all'

applied in development policy design has practically failed in many developing countries mentioned above.

4.4. Thematic priority analysis

Utilizing an online questionnaire via Google Forms and in-person consultations with farmers' associations, it's evident that food system stakeholders hold diverse preferences for pivotal actions. Government institution representatives predominantly emphasized themes of "agriculture" and "public institutions". Conversely, academia was more inclined toward "education, training, and public awareness", with "agriculture" coming second. Agriculture farmers' associations held "agriculture" as their top theme, followed by "supply chain". NGOs prioritized "education, training, and public awareness" over agriculture. Notably, independent food system consultants marked a first by considering "research and technology actions", though still ranking "agriculture" above. For a thorough breakdown, refer to Table 4.7.

Table 4.1: Stakeholder themes prioritisation

Average thematic action	Government	Academia	Farmers associations	Non-governmental organization (NGO)	Independent consultants
Agricultural actions	100%	88%	100%	90%	80%
Research and technology actions	83%	75%	80%	71%	68%
Education, training and public awareness actions	83%	90%	87%	100%	64%
Financial actions	78%	73%	56%	72%	67%
Public institutions actions	94%	67%	79%	83%	64%
Supply chain actions	73%	60%	89%	70%	54%

Source: Authors' computation

4.5. Multiple thematic action priority clustering analysis

Several theories have been postulated to guide the approach to clustering, such as ordinal and percentile theories (Janowitz and Schweizer 1989). Percentile clustering groups data into specific percentiles based on their value, aiding in data analysis, score banding, risk assessment, targeted marketing, and performance evaluation. This method entails organising data, identifying appropriate percentile brackets, and subsequently clustering the data for in-depth analysis. For instance, in quartile clustering, data is segmented into four clusters based on their distribution, i.e., 0-25%, 25-50%, 50-75%, and 75-100%. The selection of clusters and their respective ranges should align with the analysis's objectives and the intrinsic nature of the data (Janowitz and Schweizer 1989). This study clustered the actions from highest to lowest preference across all investigated thematic options. It aims to articulate actions with a higher

preference for affecting food security across all the participant categories. Therefore, the following clusters were obtained after analysing the data, sorting in descending order from highest to least priority and getting the percentile clusters.

Cluster one (75-100%) encompasses 16 actions (64%), with the "agriculture" theme (A1.1, A1.2, A1.3, A1.4, and A1.5) comprising the most prominent preference at 31% (n=5) among stakeholders. Further are actions related to "public institutions" (E 5.3, E 5.4, E 5.5, and E5.6), accounting for 25% (n=4) of preferences. In the third position, "research and technology" (B 2.1, B 2.2, and B2.3) represents 19% (n=3). The remaining actions (n=4) consist of "supply chain" elements (F6.3 and F6.4) and "education, training, and public awareness" actions (C 3.1 and C 3.2), each representing 13% of the overall preferences.

Cluster two, within the 50-75% range, captures 28% (n=7) of the aggregate preferences. This cluster was characterized by "supply chain" actions (F 6.1, F 6.2, and F 6.5) constituting 60% (n=3) of its composition. All the "financial" actions, including D 4.1, D 4.2, and D 4.3, are also present, making up 100% (n=3). Meanwhile, the "public institutions" theme has a minor representation with just E 5.1, contributing 17% (n=1). Notably, this cluster revisits themes like "supply chain" and "public institutions" from the first cluster and introduces the "financial" theme with a substantial representation.

Cluster three, covering the 25-50% range, encompasses 8% (n=2) of the actions. These were divided into "public institutions" with E5.2 and "research and technology" with B2.4. This cluster primarily features actions that are residuals from cluster one or were missing in cluster two, including one distinct "orphan" action. Finally, Cluster Four, which falls within the 0-25% range, contains no assigned actions.

Table 4.2: Ranking actions across all themes in priority

Options	Action/solution	Most priority	Least priority
A.1.3	Introduction of early mature and drought-resistant varieties	97%	3%
A.1.1	Ensure fair accessibility of the improved seeds for both informal and formal sectors	94%	6%
A.1.5	Support local farmer-based seed production and safe seed storage at the district level to ensure prompt availability after disasters	94%	6%
E5.3	Invest in on-farm irrigation and water storage infrastructures	94%	6%
A.1.2	Integration of traditional agriculture practices coupled with modern sustainable farming practices	92%	8%
E.5.6	Engaging the local government as partners and mainstreaming the activities throughout other institutional structures to achieve sustainability	92%	8%
F.6.4	Improvement of food market infrastructure	92%	8%

B.2.1	Adopt a small-scale irrigation scheme by the smallholder farmer (solar pumps driven)	89%	11%
C.3.2	Training, education and extension services to prevent the agricultural sector from future erratic weather shocks	89%	11%
E.5.4	Allocate at least 10% of the budget to the agricultural sector (Comprehensive Africa Agriculture Development Program - CAADP)	89%	11%
A.1.4	Adopt dry-season vegetable production	86%	14%
B.2.2	Implement Drought Early Warning in Agri-Food Systems (DEWS)	86%	14%
B.2.3	Provide farmers with improved seasonal meteorological forecast information, integrating satellite with land-based stations and radar for more detailed forecasts and live monitoring	83%	17%
C.3.1	Use extension services to channel early warning message	81%	19%
E.5.5	Improve the communication infrastructures in remote rural areas to accelerate service provision (for example, cash transfers)	81%	19%
F.6.3	Establish food reserve	78%	22%
D.4.1	Adopting safety nets as shock response embedded in social-protection systems	72%	28%
F.6.1	Procure local or regional food aid and organize storage and distribution methods	69%	31%
F.6.2	Introduce new food assistance instruments, including local and regional procurement, cash and vouchers	67%	33%
D.4.3	Subsidized insurance systems for Agricultural producers, access to fast credits for anticipatory actions for forecasted seasonal drought or high risk of floods	64%	36%
F.6.5	Use cash over food transfers to address the food system problems	64%	36%
D.4.2	Promotion of crop insurance to farmers to overcome crop failure	58%	42%
E.5.1	Adapt the social protection system to accommodate food assistance during the climate shock-related crisis	53%	47%
E.5.2	Cut down on external food imports by reinforcing local procurement	50%	50%
B.2.4	Implement digital solutions and traceability in value-chain	44%	56%

Source: Authors' computation

Figure 4.12 visualizes stakeholder preferences from a questionnaire, presenting top-ranked actions in blue and least-ranked in red. The data is divided into three different clusters. Two-thirds of the actions correspond to cluster one (75 -100%) and focus on agriculture, public institutions, and supply chains as top-ranked. In contrast, the bottom re-emphasizes the supply chain theme from Cluster One, introduces a new financial theme, and depicts financial and some public institution themes as less favoured strategies for addressing food system challenges (Clusters Two 50-75% and Cluster Three 25-50%).

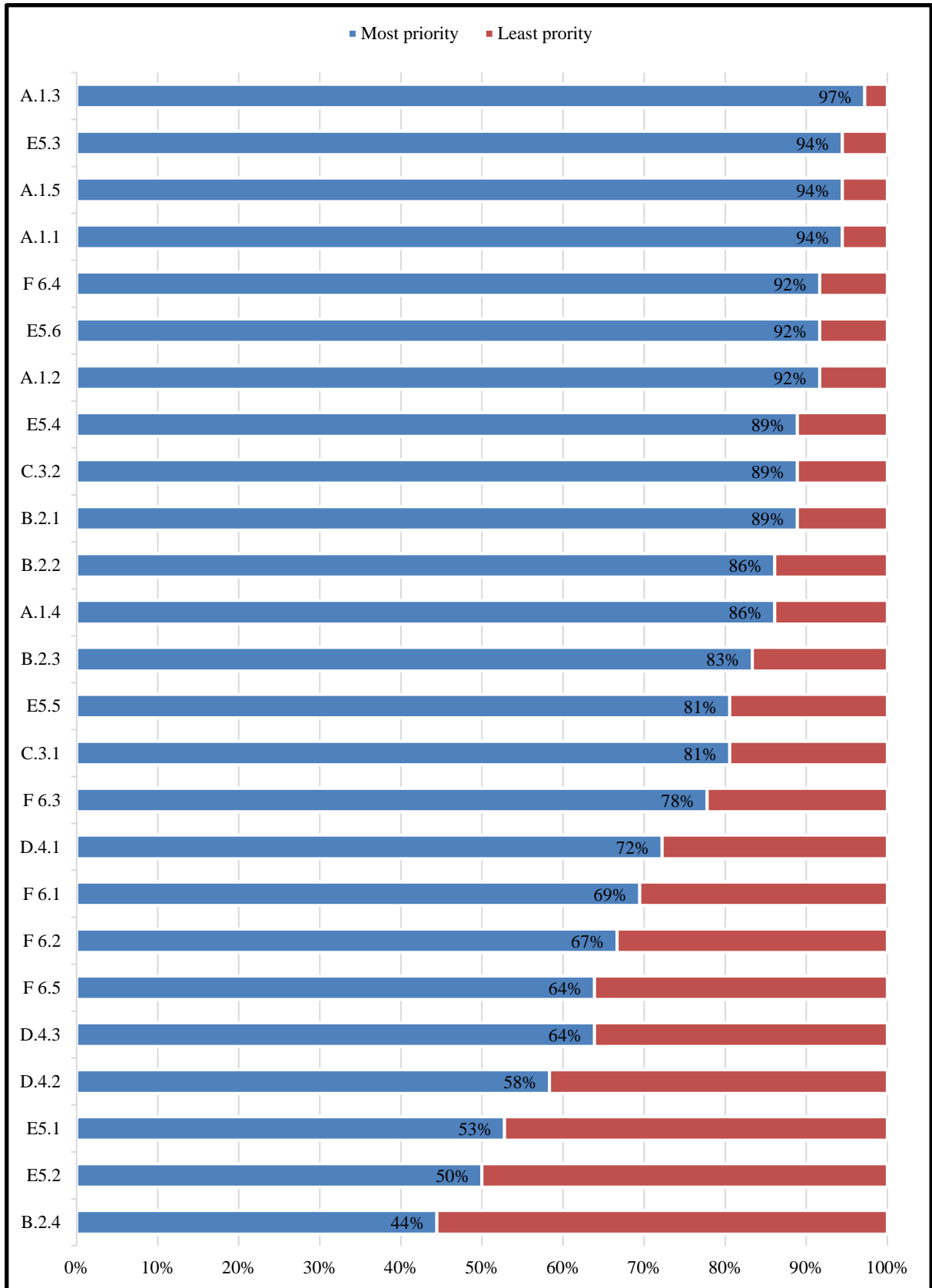


Figure 4.12: Histogram of stakeholder preferences from a questionnaire

Source: Authors' computation

4.6. Prioritisation of actions to be considered no-regret

Nineteen top-ranked actions (Annexe 6) spanning six themes were presented to stakeholders for prioritization as no-regret actions. Agriculture actions constituted 26.3% (5 actions), while public institutions and supply chains accounted for 21.1% (3 actions each). Research and technology comprised 15% and three actions, as shown in Figure 4.13 below.

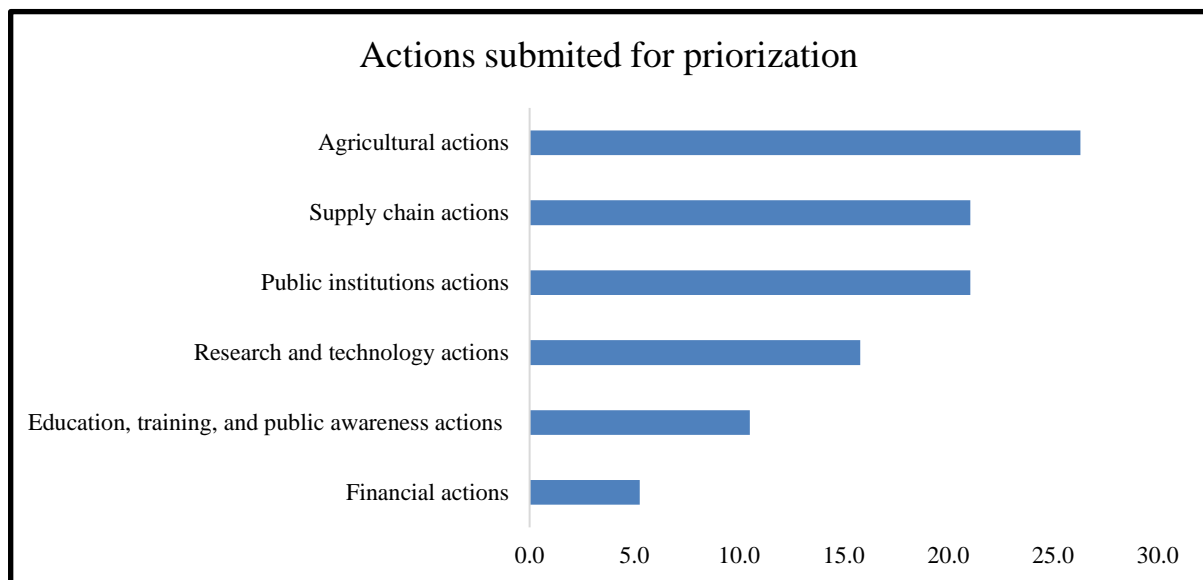


Figure 4.13: Percentage of actions submitted prioritisation

Source: Authors' computation

Agriculture themes were widely considered the most relevant, with an overwhelming 93% of online survey respondents rating them as the highest priority. Furthermore, these actions were deemed no-regret options by more than 50% of the respondents who prioritized 4 out of 5 actions. Specifically, support for local farmer-based seed production and safe seed storage at the district level, ensuring prompt availability after disasters (A.1.5), emerged as the most prioritized action, with 75% of online survey respondents in favour (12 individuals) (Figure 4.14). The Introduction of short-cycle and drought-resistant varieties to adapt to a shorter rainy season and unpredictable precipitation (A.1.3) received support from 62.5% of respondents (10 individuals). Meanwhile, ensure fair accessibility of the improved seeds for both informal and formal sectors (A.1.1) and the combination of integrating traditional agricultural practices (such as agroforestry, intercropping, crop rotation, cover cropping, traditional organic composting) with modern sustainable farming techniques (including improved seeds, agrochemicals, and machinery for agroecological practices) (A.1.2) both received 50% support from online survey respondents (8 individuals each). Therefore, with four actions (21,1%), the public institution theme submitted only one E5.3 (Invest in on-farm irrigation and water storage

infrastructures), which was prioritized as no-regret action to address food systems problems. The remaining 14 actions that received less than 50% weren't considered no-regret options even though some (E5.6 and F 6.4) were ranked as the most priority by stakeholders above 90% (Figure 4.12), and all of them were grouped in the same cluster (clusters one and two). Figure 4.14 below illustrates the actions prioritized (above 50%) and excluded (below 50%) to be considered no-regret options by the stakeholders.

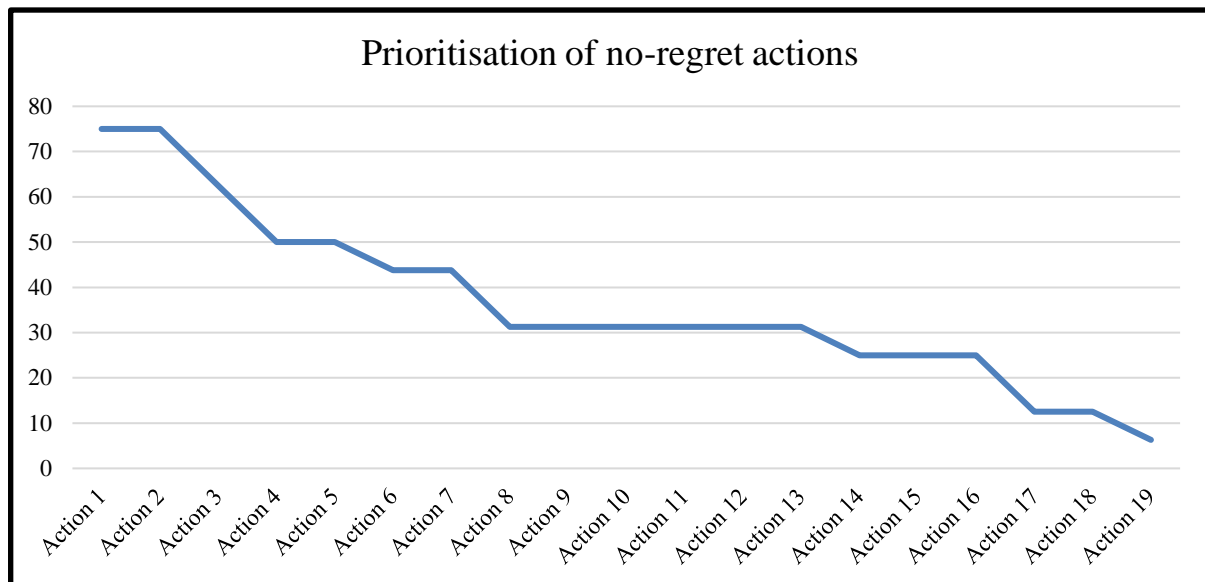


Figure 4.14: Actions prioritized as no-regret by stakeholders

Source: Authors' computation

4.6.1. Summary of the top five prioritised actions as a no-regret solution

In central Mozambique, addressing food system challenges demands innovative and effective solutions. An analysis identified five critical "no-regret" solutions that predominantly centre on agricultural actions (comprising 80% of the selected solutions), and these are: a) Ensure fairly accessibility of the improved seeds for both informal and formal sectors; b) Introduction of early mature and drought-resistant varieties; c) Integration of traditional agriculture practices coupled with modern sustainable farming practices, and; d) Support local farmer based seed production and safe seed storage at district level to ensure prompt availability after disasters. Furthermore, beyond the agricultural-centric solutions, the public institution theme is represented by one action (Invest in on-farm irrigation and water storage infrastructures) (Table 4.10).

Table 4.3: No-regret solutions selected from questionnaire

No-regret solutions	Code	Descriptions	Percentage
Solution 1	E.5.3	Invest in on-farm irrigation and water storage infrastructures	75 %
Solution 2	A.1.1	Ensure fairly accessibility of the improved seeds for both informal and formal sectors	75 %
Solution 3	A.1.3	Introduction of early mature and drought-resistant varieties	62,5 %
Solution 4	A.1.2	Integration of traditional agriculture practices coupled with modern sustainable farming practices	50 %
Solution 5	A.1.5	Support local farmer-based seed production and safe seed storage at district level to ensure prompt availability after disasters	50 %

Source: Authors' computation

4.6.1.1. Invest in various on-farm infrastructure (efficient irrigation systems) measures

The agriculture sector in Mozambique is low input, and the crops are mainly grown by smallholder farmers in a rain-fed system, making the sector highly vulnerable to climate-related shocks. As a result, the growing season is becoming more unpredictable regarding start and end dates due to a decline in rainy season duration, making planning and undertaking agricultural practices more difficult. Thus, investing in on-farm irrigation infrastructure is crucial and the most efficient adaptation solution (Ignacius, 2015). Notwithstanding, the smallholder farmers are mainly poor and cannot afford the cost of irrigation. In addition, smallholder farmers cannot address all climate impacts and rely on the government's long-term strategy for infrastructure development to improve farmer's adaptive capacity to extreme weather. Furthermore, the new infrastructure must be resilient to climate shock, go beyond the agricultural sector, be mainstreamed through inter-sectoral trade-offs in water use and, above all, provide adequate technical and financial support to smallholder farmers.

In general, the impact of the solution is to increase private benefits for farmers as the irrigated fields give higher yields, farmers can produce higher value crops, and irrigation systems increase resistance to droughts and ultimately address the bad year problem as demonstrated by Ehui et al. (2020) and Ignacius (2015).

4.6.1.2. Ensure fairly accessibility of the improved seeds for both informal and formal sectors

The primary source of seeds from Smallholder farmers in Africa and Mozambique is the informal sector, which includes farmers' stocks, social networks, and informal markets and accounts for more than 90% of the total need. In contrast, the formal sector, which encompasses private company and local agro-dealer network, only supply less than 3% (Sperling et al., 2020). As the formal sector cannot fulfil all the seed requirements for an agriculture season, the government must provide an enabling environment to the stakeholders by removing disincentives (such as agricultural subsidies, regulatory support and trade barriers). Moreover, embark on an acceleration of variety testing and approval and address the possible factors that lower adoption rates by the smallholder farmers. Onyutha (2019) and Alemu et al. (2019) observed that the public authorities, to meet farmer demand, must address the issue of the shortage of basic seed for private seed growers and increase the support and start-up funding for young seed companies and promote local seed production.

4.6.1.3. Introduction of early mature and drought-resistant varieties

The smallholder farmers mainly rely on indigenous crop varieties or seeds harvested and stored from previous season that are known to exhibit low yields, especially under stressful environmental conditions. The no-regret solution gathered by 75% of online survey participants and 30% of the reviewed studies recognized the need for the promotion of climate-smart crops among smallholder farmers that are high-yield, drought-tolerant and fast-mature as an adaptation measure should be adopted even in the absence of climate change to tackle with food system problems even though it wasn't widely embraced across Africa (Alberaldi et al., 2021).

4.6.1.4. Integration of traditional agriculture practices coupled with modern sustainable farming practices

Integrating traditional agricultural practices with modern sustainable methods offers a promising pathway to enhance agricultural productivity, sustainability, and resilience. In Mozambique, the smallholder farmers (80% of the workforce) account for 95% of the country's food production based on the subsistence-based food system. Traditional practices emphasize balance with nature and often employ crop rotation, agroforestry, intercropping, and natural pest management techniques. These methods inherently promote soil health, biodiversity, and

ecological harmony. On the other hand, modern sustainable farming introduces innovations and technologies that can amplify these benefits. For instance, precision agriculture harnesses data analytics to optimize the application of water, fertilizers, and pesticides, ensuring that crops receive just the correct number of necessary inputs reducing waste and environmental impact. Drip irrigation, a modern technique, can be paired with traditional water storage structures to enhance water-use efficiency.

Similarly, integrating current seed varieties with traditional intercropping can improve yields while maintaining biodiversity. This convergence supports food security and rural livelihoods and fosters ecological sustainability, ensuring that farming remains viable for future generations. Regrettably, this solution (A.1.2) should be preceded by education, training and public awareness actions action that got 15 per cent of on-line survey preference (Figure 4.13) and submitted for prioritization, the action C.3.2 got 43,8% preference (Action 6 on Annexe 5) below the average, consequently not considered to be a no-regret solution.

4.6.1.5. Support local farmer-based seed production and safe seed storage at the district level to ensure prompt availability after disasters

Empowering local farmers to produce and store seeds at the district level is a strategic move towards fortifying agricultural resilience, especially in disaster-prone regions. Local farmer-based seed production taps into indigenous knowledge, ensuring the cultivated seeds are well-suited to local soil, climate, and farming practices. This approach fosters biodiversity, promotes self-reliance, and reduces dependence on external seed suppliers, which account for less than 3 per cent (Sperling et al., 2020) of the country's requirements.

Furthermore, establishing safe seed storage facilities at the district level is an insurance mechanism against unexpected adversities. Natural calamities, such as floods, droughts, or pest infestations, can decimate crops, leaving communities vulnerable to food shortages. Having a local repository of seeds ensures that farming communities can swiftly rebound from such setbacks, initiating replanting efforts without awaiting external aid or facing exorbitant costs. This dual strategy of promoting local seed production coupled with district-level safe storage is a testament to the importance of foresight and preparedness.

4.6. Summary of the chapter

Chapter Four serves as a pivotal juncture in the study, presenting a meticulous examination of findings and facilitating in-depth discussions. The scrutiny of 30 studies spanning diverse locations through systematic analysis forms the bedrock of the chapter. This extensive review identified 15 overarching themes, unravelling crucial implications that shed light on the research questions. A noteworthy aspect of the chapter lies in its ability to solve these themes' intricate interconnectedness and provide a holistic understanding of the complex dynamics within food systems.

The chapter further explores the actions proposed to stakeholders within food systems, seeking their ranking and preference. Agriculture actions emerged as the top-ranked domain, underscoring the centrality of agricultural strategies in addressing systemic problems.

The integration of cluster analysis serves as a powerful tool, distilling preferences from highest to lowest ranking across all investigated thematic actions. This systematic approach surfaced five actions as prioritized, designated as no-regret solutions. These solutions, identified rigorously, pave the way for formulating informed conclusions and pragmatic recommendations in subsequent chapters.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Introduction

Chapter Five investigates the intricacies of addressing food system disruptions in Central Mozambique and begins with revisiting the study's overarching goals. The chapter captures the key findings, conclusion and recommendations. The chapter highlighted policy implications consideration, urging policymakers to adopt a complete perspective, fortify vulnerable populations, and prioritise climate-smart agriculture. The proposed comprehensive set of recommendations includes encouraging climate-smart agriculture, proactive food assistance programs, financial protection instruments, enhanced supply chain infrastructure, and integrating climate change considerations into policymaking. The chapter highlights areas warranting further research attention, such as digital innovations, early warning systems, stakeholder engagement, and understanding barriers to technology adoption for a more resilient food system in Central Mozambique.

5.2. Recap of research objectives and summary of key results

The study's general objective was to evaluate the "no-regret" solutions suitable for addressing disruptions in food systems arising from extreme weather events in central Mozambique. The study was structured around the following objectives:

- i. To identify the no-regret actions to address systemic problems triggered by extreme weather events in the food system in central Mozambique.
- ii. To assess how the available solutions as determined through stakeholder interviews can be prioritized to ensure the food system's resilience during extreme weather events in central Mozambique.
- iii. To assess the impact of interventions implemented to address food system disruptions in Mozambique and formulate recommendations for future actions.

The main findings from the study listed below showed that:

- The study analysed 30 documents published between 2013 and 2022, highlighting a growing focus on food system disruptions, particularly in response to extreme weather events. The thematic analysis of these documents identified 15 critical aspects of food systems and five broad themes, including climate-smart agriculture, food assistance, insurance, social protection programs, and infrastructure. These themes were interconnected and, when integrated, offered a comprehensive approach to addressing the challenges of the food system.

- Food assistance, particularly cash transfer programs, was cited as an important action for enhancing food systems, but it often acted as an ex-post intervention after disasters.
- Insurance-based solutions for risk transfer were mentioned frequently, emphasising the need for well-designed financial protection instruments.
- Agricultural actions related to climate-smart agriculture (CSA) were found to be a top priority across multiple studies.
- The study area in Central Mozambique is highly vulnerable to climate-related shocks like droughts, floods, and cyclones, which significantly impact the whole food system.
- Improved seeds were identified as a critical strategy for mitigating the effects of climate change, but various constraints limit adoption.
- Stakeholders highlighted the need for education, training, and extension services to increase agricultural sector resilience to climate change.
- The research has revealed that stakeholders in the food system in Central Mozambique hold diverse preferences for pivotal actions to address food system disruptions. Different groups prioritise themes, such as government representatives, academia, agriculture farmers' associations, NGOs, and independent food system consultants. This diversity in preferences highlights the complexity of addressing food system issues.
- Agriculture-related actions are consistently ranked as top priorities by various stakeholder groups. This suggests the central importance of agriculture in addressing food system disruptions in Central Mozambique, given that it is the primary source of income for a significant portion of the population.
- While research and technology actions are seen as necessary, their adoption has significant barriers. Limited financial resources and inadequate infrastructure constrain technology adoption, particularly in rainfed farming systems.
- Actions related to public institutions, such as investment in on-farm infrastructure and government engagement in promoting public-private partnerships, are recognised as crucial by stakeholders. This suggests the need for strong public sector involvement in addressing food system challenges.
- Improved food market infrastructure and established reserves are essential for food security and nutrition. Stakeholders prioritise these actions as vital components of a resilient food system.

- Stakeholders emphasised the importance of financial actions, particularly adopting food safety nets in shock-responsive social-protection systems. However, these actions are ranked lower than agriculture, public institutions, and supply chain actions.

5.3. Conclusion of the study

The study concludes that understanding the challenges and potential strategies is essential for enhancing the resilience of Central Mozambique's food system. While holding promise in alleviating food system challenges, the identified no-regret solutions reveal that smallholder farmers have already embraced these measures, albeit with limited resources and support from extension service networks. The systematic literature review emphasizes the interconnected nature of themes, highlighting the need for a comprehensive approach to strengthen food system resilience. A key finding shows the significance of:

- Agricultural Actions as a Paramount

Agricultural actions emerged as central to addressing food system disruptions in central Mozambique. Stakeholders recognized the pivotal role of agricultural practices in potentially enhancing productivity, sustainability, and resilience in farming, especially in the face of challenges posed by adverse weather events. Recommendations such as the potential adoption of early-maturing and drought-resistant crop varieties, ensuring potentially fair accessibility of improved seeds, and supporting potential local farmer-based seed production were identified as high-priority actions. These actions are considered crucial for potentially mitigating the impact of climate-related shocks on agricultural productivity and food security. Given the vulnerability of the province to climate-related shocks, prioritizing agricultural actions, especially those linked to climate-smart agriculture (CSA), is crucial. These actions are identified as "no-regret" options, and stakeholders may consider building a more resilient food system that can potentially withstand the challenges posed by extreme weather events and potentially ensure the availability of nutritious food for communities in central Mozambique.

- Education and Public Awareness play key role

Education that covers aspects of training and public awareness actions were highlighted as potentially essential components of efforts to address food system disruptions. Stakeholders recognized the pivotal role of extension services in disseminating early warning messages and promoting sustainable agricultural practices among farmers and communities. However, challenges such as inequitable targeting and inadequate adaptation of services to specific

locations need to be addressed to maximize their impact. Stakeholders should consider investing in these areas to improve the capacity of farmers to adapt to climate change and mitigate its impacts. While these solutions are promising, their effectiveness in Central Mozambique's context needs to be further validated through empirical evidence.

- Public institutions need strengthening

The study shows that public institutions play a critical role in addressing food system disruptions by implementing policies and initiatives to enhance agricultural productivity and resilience. Stakeholders emphasized the importance of actions undertaken by public institutions, particularly in areas such as on-farm irrigation infrastructure, engagement of local governments, and budget allocation to the agricultural sector. However, challenges such as inadequate communication infrastructure and limited social protection systems need to be addressed to enhance the effectiveness of public institution actions. Strengthening public institutions is potentially essential for improving coordination, resource allocation, and potentially implementation of interventions aimed at enhancing food system resilience in central Mozambique. Along the same lines, prioritizing public institutions, such as local governments, and allocating public resources to the agricultural sector are essential for building a resilient food system.

- Research and technology require attention

Research and technology actions were identified as crucial for enhancing food system resilience in central Mozambique. While stakeholders recognized the importance of initiatives such as small-scale irrigation schemes and drought early warning systems, challenges such as financial constraints and limited technical capacity hindered their potential adoption and implementation. Addressing these constraints is essential to fully leverage the research and technology solutions in food system resilience. By investing in research and technology, stakeholders aim to develop innovative solutions that can potentially mitigate the impact of climate-related shocks on agricultural productivity and food security, thereby potentially ensuring the long-term sustainability of food systems in central Mozambique. While research and technology actions are essential, overcoming barriers such as limited financial resources and infrastructure constraints is necessary to promote their adoption. Stakeholders are advised to gather evidence about how these solutions work or fail in practice in the context of Central Mozambique.

The overall conclusion of this study hinges on the need for stakeholders in Central Mozambique to have coordinated action across agriculture, public institutions, and infrastructure to address food system disruptions and build a resilient and sustainable future for the region. The study's outcomes conclusion presents a stakeholder-driven, rounded strategy to prioritize actions, emphasizing governance, agriculture, research and technology, education, finance, and supply chain dynamics. These findings are instrumental for policymakers, researchers, and practitioners working towards building a more resilient and sustainable food system in Central Mozambique, particularly in the context of increasing threats from extreme weather events.

5.4. Policy Implications based on the findings

The research findings have significant policy implications for addressing disruptions in the food systems of Central Mozambique. The following key policy implications emerge from the study:

5.4.1 Agricultural education program

Recognizing the pivotal role that education, training, and extension services play in building resilience within the agricultural sector, targeted efforts are crucial. While farmers are a primary focus for capacity building, it's essential to acknowledge that other stakeholders, such as agricultural extension workers and community leaders, also require skills and knowledge to effectively support farming communities. Policies should prioritize investment in accessible and widespread agricultural education programs, ensuring that they cater to the diverse needs of farmers and other relevant stakeholders. Moreover, training initiatives should be designed to equip farmers and extension workers with the necessary tools to adapt to changing climatic conditions, emphasizing the importance of early warning systems in mitigating the impact of extreme weather events. This approach ensures that education, training, and extension services are tailored to address specific challenges faced by different actors within the agricultural sector, thus enhancing overall resilience.

5.4.2 Financial Actions and Food Safety Nets

Financial actions emerge as a crucial aspect of policy development to support vulnerable populations during crises. The study highlights the significance of establishing effective food safety nets, particularly in shock-responsive social protection systems. Policies should be

designed to ensure the availability of financial resources that can be rapidly mobilised to provide immediate support to communities affected by extreme weather events. Furthermore, the research emphasises the potential of cash transfer programs as a proactive approach to empower vulnerable populations. Policymakers should explore and implement financial protection instruments that transfer risk to the insurance market, providing crop and flood insurance to farmers to protect against climate-driven crop failures and natural disasters.

Some of the strategies that can be considered include:

- **Resource Mobilization:** Develop strategies to mobilize the necessary financial resources for implementing financial actions and food safety nets. This could involve exploring innovative financing mechanisms, such as public-private partnerships, impact investing, or leveraging international funding sources.
- **Integration with Agricultural Programs:** Integrate financial actions and food safety nets into broader agricultural programs to ensure their effectiveness and sustainability. This integration could include incorporating financial literacy training into extension services, linking food safety net programs with agricultural insurance schemes, or establishing revolving funds for agricultural inputs.

5.5. Recommendations

Based on the findings and conclusions, the recommendations mentioned, below, targeted at various stakeholders involved in food systems particularly in the context of extreme weather in Central Mozambique. These stakeholders may include Governments and policy makers; International organizations; Non-Governmental Organizations (NGOs) and civil society; private sector; Agricultural input suppliers; Research and academic institutions and Communities and vulnerable populations.

- Encourage the adoption of climate-smart agriculture practices that enhance productivity and resilience among smallholder farmers. Agricultural extension services, agricultural NGOs, farmer cooperatives, and government agricultural agencies should play this critical role.
- Agricultural input suppliers, market information systems, agricultural extension services, and farmer cooperatives should ensure access to inputs, information, markets, and risk-management tools to facilitate adoption.
- Develop food assistance programs that are not only reactive but also proactive, focusing on both immediate relief and long-term food security. Government agencies, NGOs, and

international organizations involved in food assistance programs should consider the potential of cash transfer programs to empower vulnerable populations.

- Design and implement financial protection instruments that transfer risk to the insurance market. Insurance companies, government agencies, and financial institutions should provide crop and flood insurance to farmers to protect against climate-driven crop failures and natural disasters.
- Government agencies, private sector stakeholders involved in infrastructure development, and agricultural cooperatives should enhance supply chain infrastructure, including food market infrastructure, to improve the availability and distribution of food. Moreover, invest in on-farm infrastructure measures like efficient irrigation systems.
- Incorporate climate change considerations into general policymaking, particularly in agricultural and development policies. Government policymakers, agricultural development agencies, and environmental organizations should consider allocating public expenditures to support the agricultural sector's resilience and sustainability.
- Promote vocational training and educational opportunities for climate-adaptable farming techniques. Utilize extension services to provide early warning mechanisms for addressing drought and other climate-related challenges. Agricultural training institutes, extension services, and farmer cooperatives can play this critical role.
- Engage local governments as partners and integrate project processes within institutional structures to improve service provision and enhance intervention sustainability. Local government authorities, community leaders, and development agencies are best placed for such functions.
- Given the Mozambique central region's vulnerability to climate-related shocks, invest in climate-smart agriculture (CSA) practices, including drought-resistant crop varieties, diversification, and agricultural insurance, to enhance food system resilience. The Agricultural research institutions, agricultural input suppliers, and farmer cooperatives should play a center stage in facilitating those services.
- Agricultural training institutes, extension services, and farmer cooperatives should develop and expand education, training, and extension services for farmers to equip them with the knowledge and tools needed to adapt to climate change and mitigate its impacts.
- Implement food safety nets in shock-responsive social-protection systems to financially support vulnerable populations during crises. Government social protection agencies,

NGOs, and international organizations should consider to explore options for subsidized insurance systems and crop insurance for agricultural producers.

- Promote collaboration with local governments and integrate project processes within institutional structures to improve service provision and enhance the sustainability of interventions in the agricultural sector.
- Focus on improving food market infrastructure to ensure the availability and affordability of nutritious foods, especially in vulnerable areas. Government agencies, private sector stakeholders, and agricultural cooperatives are better placed to play such important roles.
- Reconsider and tailor food reserve strategies to the specific needs and challenges of the region to ensure adequate food security and disaster preparedness. Government agencies responsible for food security, agricultural cooperatives, and humanitarian organizations are the targets on this.
- Despite being ranked lower by stakeholders, Research institutions, technology developers, and government agencies should consider carrying research and technology actions. Continue investing in digital innovations and early warning systems for the long-term benefit of the food system.
- Central Mozambique should prioritize agricultural actions, including the introduction of drought-resistant crop varieties and improving seed access. Agricultural extension services, seed suppliers, and farmer cooperatives should consider supporting local farmer-based seed production and safe seed storage is critical.
- Improve food market infrastructure and establish reserves to ensure food security and nutrition, especially during disruption. Government agencies, private sector stakeholders, and agricultural cooperatives are better placed on those roles.
- To enhance food system resilience, adopt financial actions, particularly food safety nets in social-protection systems. These actions should complement efforts in agriculture, public institutions, and technology. Government social protection agencies, financial institutions, and humanitarian organizations are some of the key targets on this recommendation.

5.6. Areas of further research

Despite being ranked lower by stakeholders, the importance of research and technology actions in addressing disruptions in Central Mozambique's food systems should not be overlooked. The study shows a need for additional research to look deeper into these areas, focusing on digital innovations and early warning systems for the long-term benefit of the food system.

5.6.1. Research in digital innovations

The research shows that digital innovations can potentially play a transformative role in addressing food system disruptions. Further research is essential to explore and harness the power of digital technologies in agriculture. This includes investigating the adoption of precision farming techniques, remote sensing, and data analytics to enhance agricultural productivity and resilience. Policymakers and researchers should collaborate to understand the challenges and opportunities associated with the integration of digital innovations into agricultural practices. Moreover, exploring the role of blockchain technology in supply chain transparency and efficiency could contribute to creating a resilient food system.

5.6.2. Early Warning Systems

The study shows the importance of early warning systems in mitigating the impact of extreme weather events on the food system. Further research is needed to refine and improve existing early warning mechanisms, taking into account the specific vulnerabilities of Central Mozambique. This research could explore the integration of advanced meteorological technologies, satellite imagery, and machine learning algorithms to enhance the accuracy and timeliness of early warnings. Along the same lines, understanding the socio-economic factors that influence the effectiveness of early warning communication and response systems is crucial. This research could inform the development of more targeted and culturally sensitive early warning strategies.

5.6.3. Stakeholder engagement in research

To ensure the relevance and effectiveness of future research initiatives, there is a need for increased stakeholder engagement. This involves actively involving local communities, government representatives, agricultural associations, NGOs, and other key actors in the research process. Collaborative research efforts can facilitate a more comprehensive understanding of the on-the-ground realities and enable the co-creation of solutions. Future research should aim to bridge the gap between scientific knowledge and practical, community-driven strategies to enhance the food system's resilience.

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ANNEXES

Annex 1: The identified concepts and segments

Concepts	Theme	Title	Author (Year)
Investment in more resilient seeds; Technologies to improve irrigation efficiency	Agriculture input	<ul style="list-style-type: none"> Adapting Agriculture to Climate: A role for public policies 	<ul style="list-style-type: none"> Ignaciuk, 2015
Improved extension services	Agriculture services	<ul style="list-style-type: none"> Building sustainable and resilient food systems in Asia and the Pacific 	<ul style="list-style-type: none"> FAO, 2020
Subsidising their insurances against loss of yields or income; Help farmer's reduce their exposure to extreme risks; Partially subsidise crop and income insurances	Subsidise	<ul style="list-style-type: none"> Adapting Agriculture to Climate: A role for public policies 	<ul style="list-style-type: none"> Ignaciuk, 2015
Regional food supply; Market and trade policy reform	Supply chain	<ul style="list-style-type: none"> Does the global food system have an Achilles' heel? How regional food systems may support resilience in regional disasters World Food Assistanctance 2017: Taking Stock and Looking Ahead 	<ul style="list-style-type: none"> Paci-Green et al., 2015 WFP 2017
Public-private partnerships; Involving the local government as partners; Different levels of government to support farmers' adaptation to drought; Water sources protection; water conservancy; Infrastructure development; Weather modification to water-	Governance	<ul style="list-style-type: none"> Drought aspects – fostering resilience through insurance Public-private partnership in enhancing farmers' adaptation to drought- Insights from the Lujiang Flatland in the Nu River (Upper Salween) valley Mainstreaming Climate Change Adaptation into Rural Development Plans in Vietnam—How to Build Resilience at the Interface of Policy and Practice 	<ul style="list-style-type: none"> Kron et al., 2016 Zhang et al, 2018 Halbherr et al., 2021

saving, Improvement of water-use-efficiency; Strict water management,			
Emergency export reserve; Stockpile emergency food reserves; District stocks	Humanitarian	<ul style="list-style-type: none"> • Bilateral emergency export reserve mechanism under climate change • Revisiting Emergency Food Reserve Policy and Practice under Disaster and Extreme Climate Events 	<ul style="list-style-type: none"> • Kuang-Sheng, 2022 • Lassa, 2019
Early warning mechanisms	Climate	<ul style="list-style-type: none"> • Adapting Agriculture to Climate: A role for public policies • The role of agriculture in poverty escapes in Kenya–Developing capabilities approach in the context of climate change • Understanding climate as a driver of food insecurity in Ethiopia 	<ul style="list-style-type: none"> • Ignaciuk, 2015 • Eichstelle et al., 2022 • Lewis, 2017
Size of public grain reserves; Emergency food reserves; Food reserves; Public food reserves	Food and grain reserve	<ul style="list-style-type: none"> • Bilateral emergency export reserve mechanism under climate change • Insights into countries’ exposure and vulnerability to food trade shocks from network- based simulations • World Food Assistance 2017: Taking Stock and Looking Ahead 	<ul style="list-style-type: none"> • Kuang-Sheng, 2022 • Grassia et al., 2022 • WFP, 2017
Diversifying the incomes; Access to income diversifying options; Storage of food; Nutrition-specific and nutrition-sensitive interventions	Food security	<ul style="list-style-type: none"> • Understanding climate as a driver of food insecurity in Ethiopia • Livelihood resilience in the face of recurring floods: Empirical evidence from Northwest Ethiopia • World Food Assistance 2017: Taking Stock and Looking Ahead 	<ul style="list-style-type: none"> • Lewis 2017 • Weldegebriel et al., 2017 • WFP 2017
E-commerce platforms; Irrigation technologies; E-agriculture; Drought early warning systems (DEWSs); Digital innovations in value-chain integration and tracking	Technology	<ul style="list-style-type: none"> • African food insecurity in a changing climate • Building sustainable and resilient food systems in Asia and the Pacific • Drought Early Warning in Agri-Food Systems • World Food Assistance 2017: Taking Stock and Looking Ahead 	<ul style="list-style-type: none"> • Onyutha, 2019 • FAO, 2020 • van Ginkel, 2021 • WFP 2017
Irrigation systems; Infrastructure construction and maintenance, Climate-proof rural infrastructure; irrigation; Food supply chain infrastructure and services; Drinking water	Infrastructure	<ul style="list-style-type: none"> • Adapting Agriculture to Climate: A role for public policies • Building sustainable and resilient food systems in Asia and the Pacific • The role of agriculture in poverty escapes in Kenya–Developing a capabilities approach in the context of climate change • World Food Assistance 2017: Taking Stock and Looking Ahead 	<ul style="list-style-type: none"> • Ignaciuk, 2015 • FAO, 2020 • Eichstelle et al., 2022 • WFP 2017 • FAO, 2020

supply systems; Water-saving irrigation		<ul style="list-style-type: none"> Public-private partnership in enhancing farmers' adaptation to drought- Insights from the Lujiang Flatland in the Nu River (Upper Salween) valley; 	
Social transfers; safety nets; with social assistance; transfers of cash or food, health, education and food-for-work; Public works; Cash or food, health, education and food-for-work; Food safety nets within shock-responsive; Social protection systems	Social protection	<ul style="list-style-type: none"> Building sustainable and resilient food systems in Asia and the Pacific. Livelihood resilience in the face of recurring floods: Empirical evidence from Northwest Ethiopia Provide unconditional cash transfers and link to social protection by aligning certain design features and involving MGCAS and INAS; World Food Assistanctance 2017: Taking Stock and Looking Ahead. An assessment of the potential for food assistance to improve household food security in crisis situations: evidence from Mozambique; 	<ul style="list-style-type: none"> FAO 2020 Weldegebriel et al., 2017 WFP, 2019 WFP 2017 Zhou, 2019
Agricultural insurance; Disaster assistance; Drought insurance; Agricultural input subsidization; Cargo nets; flood insurance schemes; Insurance against crop failure; Crop insurance during climate-driven; Crop failure or during crop damage by natural disasters; Subsidies from the government	Insurance	<ul style="list-style-type: none"> Design Principles for Agricultural Risk Management Policies, Organisation for Economic Cooperation and Development (OECD); Drought aspects - fostering resilience through insurance; Livelihood resilience in the face of recurring floods: Empirical evidence from Northwest Ethiopia Livelihood resilience in the face of recurring floods: Empirical evidence from Northwest Ethiopia Rural household vulnerability to climate risk in Uganda Public-private partnership in enhancing farmers' adaptation to drought- Insights from the Lujiang Flatland in the Nu River (Upper Salween) valley 	<ul style="list-style-type: none"> Glauber et al., 2021 Kron et al., 2016 Weldegebriel et al., 2017 Cooper, 2016 Singh-Singh 2017
Local and regional procurement; food procured locally and distribution of cash; provide unconditional cash transfers and link to social protection; provision of cash transfers; in-kind food transfers; cash transfers; Cash transfers –	Food assistance	<ul style="list-style-type: none"> On The Choice and Impacts of Innovative International Food Assistance Instruments The Timeliness and Cost-Effectiveness of the Local and Regional Procurement of Food Aid Provide unconditional cash transfers and link to social protection by aligning certain design features and involving MGCAS and INAS; World Food Assistanctance 2017: Taking Stock and Looking Ahead 	<ul style="list-style-type: none"> Lentz et al., 2013 Lentz et al., 2013 WFP, 2019 WFP, 2017

physical and digital; Cash vouchers – physical and digital; Food purchase			
<p>Changing cropping dates or varieties; Changing cropping dates or varieties; Adapt to weather variability and to shifts in temperature and precipitation; Invest in various on-farm infrastructure measures; Maintenance of vegetation cover, stubble fields, forecrop post-harvest remnants; Mulch at 30% of the area of arable land in farms located in areas exposed to water erosion; Shifting to drought-tolerant crops and fast-maturing varieties; Planting trees; Using soil and water conservation; Modified, temperature resistant seed; Changing crop varieties; Irrigation farming; Drought-resistant crop; Short-term and drought-resistant varieties; Planting short-maturing varieties and/or strategic planting; Integrated crop- animal farming; Cover cropping Traditional organic</p>	Climate-smart agriculture	<ul style="list-style-type: none"> • A safe space of rural areas in the context of the occurrence of extreme weather events—A case study covering a part of the Euroregion Baltic Adapting Agriculture to Climate • Adapting Agriculture to Climate: A role for public policies • African food insecurity in a changing climate: The roles of science and policy • Climate change as a driver of food insecurity in the 2007 Lesotho-South Africa drought • The role of agriculture in poverty escapes in Kenya – Developing a capabilities approach in the context of climate change Rural household vulnerability • Climate change, household vulnerability and smart agriculture: The case of two South African provinces • Climate change as a driver of food insecurity in the 2007 Lesotho- South Africa drought • Understanding climate as a driver of food insecurity in Ethiopia • The link between smallholders’ perception of climatic changes and adaptation in Tanzania • Rural household vulnerability to climate risk in Uganda • Traditional agriculture: A climate-smart approach for sustainable food production • Public-private partnership in enhancing farmers’ adaptation to drought- Insights from the Lujiang Flatland in the Nu River (Upper Salween) valley 	<ul style="list-style-type: none"> • Kocur-Bera, 2018 • Ignaciuk, 2015 • Onyutha, C., 2019 • Connolly-Boutin, 2016 • Eichstelle et al., 2022 • Ncube et al., 2016 • Jasper et al., 2021 • Lewis, K., 2017 • Cooper, 2016 • Singh-Singh, 2017 • Brüssow et al., 2019

composting; Intercropping; Changing crop types; efficient irrigation systems or water storage; adopting zero tillage; early planting; Crop rotation;			
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Source: Author compilation

Annexe 2: Codes identified through Atlas.ti

Column1	2013 Gr= 5; GS= 2	2014 Gr= 0; GS= 0	2015 Gr=1 3; GS=4	2016 Gr= 6; GS= 2	2017 Gr=3 1; GS=5	2018 Gr= 7; GS= 3	2019 Gr=1 1; GS=4	2020 Gr= 4; GS= 1	2021 Gr=1 1; GS=6	2022 Gr= 4; GS= 3	Total s
○ agriculture input Gr=1	0	0	1	0	0	0	0	0	0	0	1
○ agriculture services Gr=1	0	0	0	0	0	0	0	1	0	0	1
○ climate Gr=4	0	0	2	0	1	0	0	0	1	0	4
○ climate-smart agriculture Gr=28	0	0	6	2	8	4	1	0	6	0	27
○ Food and grain reserve Gr=4	0	0	0	0	1	0	0	0	0	3	4
○ food assistance Gr=14	5	0	0	0	5	0	4	0	0	0	14
○ food security Gr=4	0	0	0	1	3	0	0	0	0	0	4
○ governance Gr=3	0	0	0	1	1	0	1	0	1	0	4
○ humanitarian Gr=3	0	0	0	0	0	2	0	0	0	1	3
○ infrastructure Gr=6	0	0	1	0	2	0	0	1	1	0	5
○ insurance Gr=9	0	0	0	2	6	0	1	0	1	0	10
○ social protection Gr=7	0	0	0	0	2	0	4	1	0	0	7
○ subsidies Gr=2	0	0	2	0	0	0	0	0	0	0	2

○ supply chain Gr=2	0	0	1	0	1	0	0	0	0	0	2
○ technology Gr=5	0	0	0	0	1	1	0	1	1	0	4
Totals	5	0	13	6	31	7	11	4	11	4	92

Annexe 3: Documents selected for the present review

N	Authors	Title	Actions
Agricultural actions			
6	FAO, 2020	Building sustainable and resilient food systems in Asia and the Pacific	Adopt resistant crop varieties and diversification practices
1	Kocur-Bera, K., 2018	A safe space of rural areas in the context of the occurrence of Extreme Weather Events—A case study covering a part of the Euroregion Baltic	Agroforestry, intercropping, crop rotation, cover cropping, traditional organic composting and integrated crop-animal farming can be adopted as the model practices for a climate-smart approach.
2	Ignaciuk, A., 2015	Adapting Agriculture to climate change: A role for public policies	Change cropping dates or varieties to adapt to weather variability and shifts in temperature and precipitation. Implement drought or heat-resistant crops and new varieties and switch to a multi-crop system.
4	Onyutha, C., 2019	African food insecurity in a changing climate: The roles of science and policy	Adopt of stress-tolerant crop varieties Ensure little or no restriction to accessibility of the new seeds by the smallholder farmers as well as both private and public seed systems
24	Singh-Singh, 2017	Traditional agriculture: A climate-smart approach for sustainable food production	Increase adaptive capacity and resilience to shocks at multiple levels, from farm to national level Integration of traditional agriculture practices such as agroforestry, intercropping, crop rotation, cover cropping, traditional organic composting and integrated crop-animal farming coupled with modern sustainable farming practices such as improved seeds, agrochemicals and machinery for agroecological techniques
23	Cooper, 2016	Rural household vulnerability to climate risk in Uganda	Plant of drought-resistant crops, planting earlier, planting short-maturing varieties
22	Brüssow et al., 2019	The link between smallholders' perception of climatic changes and adaptation in Tanzania	Introduction of short-term and drought-resistant varieties of crops to account for a shorter rainy season and less predictable precipitation
18	Lewis, K., 2017	Understanding climate as a driver of food insecurity in Ethiopia	Introduce drought-resilient crops

14	Jasper et al., 2021	Climate change as a driver of food insecurity in the 2007 Lesotho-South Africa drought	Implement adaptation measures, such as improved drought monitoring, drought-resilient crops and planting strategies
13	Ncube et al., 2016	Climate change, household vulnerability and smart agriculture: The case of two South African provinces	Use of plant drought-resistant crops, organic fertiliser and conservation farming
7	Connolly-Boutin, L. and Smit, B., 2016	Climate change, food security, and livelihoods in sub-Saharan Africa.	Shift to drought-tolerant crops and fast-maturing varieties Adopt dry-season vegetable production
Supply chain infrastructure actions			
17	Lassa et al., 2019	Revisiting Emergency Food Reserve Policy and Practice under Disaster and Extreme Climate Events	Implement stockpile emergency food reserves for food security and disaster preparedness
12	Grassia et al., 2022	Insights into countries' exposure and vulnerability to food trade shocks from network-based simulations	Establish food reserve
21	Lentz et al., 2013	On The Choice and Impacts of Innovative International Food Assistance Instruments	Introduce new food assistance instruments, including local and regional procurement, cash and vouchers
16	Kuang-Sheng, H. 2022	Bilateral emergency export reserve mechanism under climate change	Establish a bilateral emergency export reserve mechanism under climate change
8	Paci-Green et al., 2015	Does the global food system have an Achilles' heel? How regional food systems may support resilience in regional disasters	Ensure local and regional food availability, organized storage and distribution method
25	Lentz et al., 2013	The timeliness and cost-effectiveness of the local and regional procurement of food aid	Procure local or regional food aid
28	WOFA, 2017	World Food Assistance 2017: Taking Stock and Looking Ahead	Improvement of food market infrastructure.
23	Cooper, 2016	Rural household vulnerability to climate risk in Uganda	Ensure food storage to buffer livelihoods from failed crop production
27	Zhou, 2019	An assessment of the potential for food assistance to improve household food security in crisis situations: evidence from Mozambique	Use of cash transfers over food transfers because cash transfers to address the "lean season" and "last mile" systemic problem
26	WFP, 2019	Cash transfers and vouchers in response to drought in Mozambique	Provide unconditional cash transfers and link to social protection by aligning certain design features and involving MGCAS and INAS
25	Lentz et al., 2013	The Timeliness and Cost-Effectiveness of the Local and Regional Procurement of Food Aid	Encourage more cash-based food assistance programming in place of more traditional, in-kind food aid
28	WOFA, 2017	World Food Assistance 2017: Taking Stock and Looking Ahead	Provide in-kind food assistance, cash transfers
30	Cevik, S. and Jalles, J.T., 2023.	For whom the bell tolls: Climate change and income inequality. Energy Policy	Enhancing physical resilience through smart infrastructure investments
Financial actions			
6	FAO, 2021	Building sustainable and resilient food systems in Asia and the Pacific	Design of financial protection instruments that transfer risk to the insurance market

19	Weldegebriel, Z.B. and Amphune, B.E., 2017.	Livelihood resilience in the face of recurring floods: Empirical evidence from Northwest Ethiopia	Use of safety nets implemented in the form of public works that are relevant to minimizing exposure to recurring flood hazards
15	Kron et al., 2016	Drought aspects – fostering resilience through insurance	Establish crop and drought insurance for agricultural production
24	Singh-Singh, 2017	Traditional agriculture: A climate-smart approach for sustainable food production	Give sufficient crop insurance to farmers during climate-driven crop failure or crop damage by natural disasters such as floods and drought.
11	Glauber et al., 2021	Design Principles for Agricultural Risk Management Policies	Restrict government subsidies to cover administrative costs and, at most, losses from catastrophic risks. Promote agricultural insurance programme.
2	Ignaciuk, A., 2015	Adapting Agriculture to climate change: A role for public policies	Governments assist farmers by partially subsidising their insurance against loss of yields or income.
Education and public awareness actions			
18	Lewis, K., 2017	Understanding climate as a driver of food insecurity in Ethiopia	Use extension services to reduce the impact of drought through early warning mechanisms
10	Eichsteller et al., 2022	The role of agriculture in poverty escapes in Kenya – Developing a capabilities approach in the context of climate change	Transferable skills, represented by vocational training and educational opportunities for climate-adaptable farming, including fertilizer and pesticide-conscious farming techniques
2	Ignaciuk, A. 2015	Adapting Agriculture to Climate Change	Training, education and extension services may also increase the resilience of the agricultural sector to future climate change
10	Eichsteller et al., 2022	The role of agriculture in poverty escapes in Kenya – Developing a capabilities approach in the context of climate change	Promote vocational training and educational opportunities for climate-adaptable farming, including fertilizer and pesticide-conscious farming techniques, use of modified, temperature-resistant seeds and livestock
Research, processing and technology actions			
28	WOFA, 2017	World Food Assistance 2017: Taking Stock and Looking Ahead	Implement Demand-led, ICT-based, benchmark-driven investments to upgrade retailer supply chain management
6	FAO, 2021	Building sustainable and resilient food systems in Asia and the Pacific	They were promoting E-agriculture platforms that use new information and communication technologies applications in the farm sector that integrate smallholder farmers to eliminate transaction costs and improve service delivery efficiency. For example, sensors monitor soil quality, water demand, and soil nutrition and temperature; remote monitoring and systems are connected with meteorological stations.
9	van Ginkel, M. and Biradar, C., 2021	Drought Early Warning in Agri-Food Systems	Implement Drought Early Warning in Agri-Food Systems (DEWS)
4	Onyutha, C., 2019	African food insecurity in a changing climate: The roles of science and policy	Use of small-scale (motorized pumps driven by solar energy) irrigation for the smallholder farmer

3	Okonjo-Iweala, N., 2020	Africa can play a leading role in the fight against climate change. Foresight Africa, pp.49-52.	Promote e-commerce platforms that integrate smallholder farmers into value chains and enable them to eliminate the transaction costs of locating demand, determining prices, and improving efficiency in service delivery.
2	Ignaciuk, A. 2015	Adapting Agriculture to Climate Change	Provide farmers with Improved seasonal meteorological forecast information, integrating satellite with land-based stations and radar for more detailed forecasts and live monitoring
Public institution actions			
28	WOFA, 2017	WFood Assistancetance 2017: Taking Stock and Looking Ahead	Reform and strengthening of food platforms in shock-responsive social protection systems
8	Paci-Green et al., 2015	Does the global food system have an Achilles' heel? How regional food systems may support resilience in regional disasters	Re-balances the dependence on foods supplied through imports extended long supply chains, as well as increasing reliance on regional food sources
6	FAO, 2021	Building sustainable and resilient food systems in Asia and the Pacific	Mainstreaming disaster and climate risk management in agriculture for resilient food systems
2	Ignaciuk, A., 2015	Adapting Agriculture to climate change: A role for public policies	Invest in various on-farm infrastructure measures, such as more efficient irrigation systems or water storage.
4	Onyutha, C., 2019	African food insecurity in a changing climate: The roles of science and policy	Allocation of at least 10% of public or national expenditures to the agricultural sector (CAADP)
27	Zhou, 2019	An assessment of the potential for food assistance to improve household food security in crisis situations: evidence from MozambiThe que	The Mozambican government prioritises telecommunications technology infrastructure development in remote rural areas to facilitate easier transfers of cash to poor households
15	Kron et al., 2016	Drought aspects – fostering resilience through insurance	Ensure the agricultural insurance system approach in the public-private-private partnerships can provide the adequate legal, institutional and organizational framework in which insurance products and other risk management tools can work efficiently and in favour of all parties involved
20	Halbherr et al., 2021	Mainstreaming Climate Change Adaptation into Rural Development Plans in Vietnam—How to Build Resilience at the Interface of Policy and Practice	Engaging the local government as partners and integrating project processes within institutional structures to improve service provision and increase the sustainability of intervention

Annex 4: Interview questionnaire

Research project title: The prioritisation of no-regret solutions to address food system disruption in central Mozambique.

Dear Sir/Madam,

Thank you for agreeing to participate in this project aimed to prioritise the no-regret options to address the food system in Mozambique. To this end, ethical procedures for the University of Pretoria (Application ID: NAS270/2021) will be strictly followed during this interview

process. The interview will take about 30 minutes. As mentioned in the consent form, we don't anticipate any risks associated with your participation. All participants must sign and submit the consent form before the interviews.

Stakeholder details

Name of participant: _____

Name of industry/Sector _____

Role/Responsibility _____

Date of the interview _____

Guidance to be followed:

- Below is a list of recommended actions identified through a systematic review with the potential to address the food system problems.
- Read all the actions and select the most relevant ones so no policymaker will regret them. The actions must be plausible, with a clear pathway to impact, feasible (no hard trade-offs) and sustainable.
- Selection is made by ticking the "most" or "least" box.
- Each action has two options to provide top and bottom-ranked actions by ticking either most or least.
- The selected options will be analysed and used to develop no-regret options

List of recommended actions identified from systematic review

Agricultural actions		More likely	Most likely
1.	Adopt smart climate agriculture (resistant crop varieties and diversification practices, Maintenance of vegetation cover, organic fertiliser and conservation farming)		
2.	Ensure little or no restriction to accessibility of the new seeds by the smallholder farmers as well as both private and public seed systems		
3.	Integrate traditional and modern agricultural practices		
Comments:			
Research and technology actions			
4.	Promote e-commerce platforms that integrate smallholder farmers to eliminate transaction costs and improve efficiency in service delivery.		
Comments:			
Education, training and public awareness actions			
5.	The training, education and extension services to increase the resilience of the agricultural sector to future climate change		
Comments:			
Supply chain actions			

6.	Implement stockpile emergency food reserves for food security and disaster preparedness		
7.	Procure locally or regionally food aid organized storage and distribution method		
8.	Introduce new food assistance instruments, including local and regional procurement, cash and vouchers		
Comments:			
Financial actions			
9.	Design of financial protection instruments that transfer risk to the insurance market		
Comments:			
Public institutions actions			
10	Mainstream climate change in general policymaking, not least in agricultural and development policies		
11	Reform and strengthening of food platforms in shock-responsive social protection systems		
12	Re-balances the dependence on foods supplied through imports and extended supply chains, as well as increasing reliance on regional food sources		
13	Invest in various on-farm infrastructure measures, such as more efficient irrigation systems or water storage.		
14	Allocation of at least 10% of public or national expenditures to the agricultural sector (CAADP)		
15	Prioritise telecommunications technology infrastructure development in remote rural areas to facilitate easier transfers of cash to poor households		
Comments:			

Any comments and actions you think should be considered:

Annexe 5: Stakeholder respondents list

#	Name	Institution	Contact
Government respondents			
1	Acubar Batista	MADER	acubarb@yahoo.com.br
2	Amilcar Pereira	MADER/DPP	amilcarfrederico@gmail.com
3	Anabela Manhica	AGRA	bellapmanhica@gmail.com
4	Duque Wilson	MADER/CCSA	duquewilson2@gmail.com
5	Jose Goncalo	MADER	jmgoncalo@yahoo.com
6	Julio Cesar	MADER	Costa.chm@gmail.com
7	Leonel Biosse	MIC	leobiosse@gmail.com
8	Lidia Abiba	MIMAIP	lidia.abiba@gmail.com
9	Miguel Langa	MIMAIP	miguel.langa@proazul.gov.mz
10	Vanda Castelo	MIMAIP	vandaicastelo@gmail.com
11	Francisco Sambo	MTA	francisco.sambo@gmail.com
12	Tomas Siteo	CESE	sitoetoms@gmail.com
13	Moreze Joaquim Cauzande	DPA	mcauzande@gmail.com
14	Fernando Chimbuia	SDAE	feenandoarmandochimbuia@gmail.com
15	Miguel Rabeca	SDAE	miguelainoque@gmail.com
16	Antonio Pacheco Dias Lima	SETSAN	pachecoleo69@yahoo.com.br
Non-Governmental Organization (NGO)			
17	Brasilino das Neves	FAO	brasilino1979@gmail.com

18	Hercilia Hamela	SPEED	hercilia_Hamela@speed-program.com
19	Jan Low	CIP	J.LOW@cgiar.org
20	Joao Carrilho	OMR	jcarrilhoster@gmail.com
21	Joao Mutondo	CCSA	joao.mutondos@gmail.com
22	Nelson Nguilaze	USAID	nguilaze@usaid.gov
23	Nimo Wiredu	IITA	anwiredu@gmail.com
24	Paulo Mole	AGRA	pmole@agra.org
25	Elsa Mapilele	USAID	emapilele@usaid.gov
26	Micheal Yemane	SCI	m.yemane@savethechildren.org.uk
27	Augusto Massalonga	WFP	amassalonga@gmail.com
28	Saul Butters	CARE	saul.butters@care.org
29	Pablo Rodrigues	WFP	pab.decastro@gmail.com
30	Ana Matsimbe	SETSAN	anamatsimbe1@gmail.com
31	Giuseppe Selvaggi	OXFAM	Giuseppe.Selvaggi@oxfam.org
32	Morgado	IDE	hmorgado@ideglobal.org>
33	Antonio Rocha	SNV	arocha@snv.org
34	Martinus Ruijten	GIZ-GIAE	maru@ip-consult.de
35	Kuziwa Makamanzi	FH Association	kmakamanzi@fh.org
36	Salomao Tembe	Oxfam	salomao.tembe@oxfam.org
37	Mogas Jaime Canhe	UNDP	mogas.canhe@undp.org
38	Jan Verlaak	FAO	jan.verlaak@fao.org
39	Rassul Nassigo	IFRC	rassul.nassigo@ifrc.org
40	Leonor Joaquim Domingos	USAID	ldomingos@usaid.gov
41	Charmaine Goncalves	WATER AID	charmainedellavedova@gmail.com
42	Graca Manjate	AGHA KHAN	gracamanjate@gmail.com
43	Jelle van den Akker	Resilient	vandenakkerjelle@gmail.com
Academia			
44	Rafael Uiane	Consultor	ruaiene@gmail.com
45	Richard Hanson	Consultor	ranson_wv@yahoo.com
46	Carmen Munhequete	Consultor	carmen.munhequete@gmail.com
47	Rogério Chiulele	UEM	chiulelerogério@gmail.com
48	Danilo Alberto Ribeiro	ISPM	daniloribeiro_a@yahoo.com.br
49	Marla Mujovo	UNZAMBEZE	marla.mujovo@uzambeze.ac.mz
50	Lucas Chiao	UEM	lucas.chiau@gmail.com
Mozambique farmers association			

Annexe 6: Legend of candidate actions for no-regret

Options	Theme code	Descriptions	%
Option 1	E.5.3	Invest in on-farm irrigation and water storage infrastructures	75
Option 2	A.1.1	Ensure fair accessibility of the improved seeds for both informal and formal sectors	75
Option 3	A.1.3	Introduction of early mature and drought-resistant varieties	62,5
Option 4	A.1.2	Integration of traditional agriculture practices coupled with modern sustainable farming practices	50
Option 5	A.1.5	Support local farmer-based seed production and safe seed storage at the district level to ensure prompt availability after disasters	50
Option 6	C.3.2	Training, education and extension services to prevent the agricultural sector from future erratic weather shocks	43,8
Option 7	F.6.4	Improvement of food market infrastructure	43,8
Option 8	F.6.2	Introduce new food assistance instruments, including local and regional procurement, cash and vouchers	31,3
Option 9	D.4.1	Adopting safety nets as shock response embedded in social-protection systems	31,3
Option 10	B.2.3	Provide farmers with improved seasonal meteorological forecast information, integrating satellite with land-based stations and radar for more detailed forecasts and live monitoring	31,3
Option 11	A.1.4	Adopt dry-season vegetable production	31,3
Option 12	B.2.2	Implement Drought Early Warning in Agri-Food Systems (DEWS)	31,3
Option 13	B.2.1	Adopt a small-scale irrigation scheme by the smallholder farmer (solar pumps driven)	31,3
Option 14	E.5.5	Improve the communication infrastructures in remote rural areas to accelerate service provision (for example, cash transfers)	25
Option 15	C.3.1	Use extension services to channel early warning message	25
Option 16	E.5.4	Allocate at least 10% of the budget to the agricultural sector (Comprehensive Africa Agriculture Development Program - CAADP)	25
Option 17	F.6.1	Procure local or regional food aid and organize storage and distribution methods	12,5
Option 18	E.5.6	Engaging the local government as partners and mainstreaming the activities throughout other institutional structures to achieve sustainability	12,5
Option 19	F.6.3	Establish food reserve	6,3

Annexe 7: Ethics approval letter



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences
Ethics Committee
E-mail: ethics.nas@up.ac.za

25 July 2023

ETHICS SUBMISSION: LETTER OF APPROVAL

Dr O Loki
Department of Agricultural Economics Extension and Rural Development
Faculty of Natural and Agricultural Science
University of Pretoria

Reference number: NAS270/2021

Project title: The prioritisation of no-regret solutions to address food system disruption in central Mozambique

Dear Dr O Loki,

We are pleased to inform you that your submission conforms to the requirements of the Faculty of Natural and Agricultural Sciences Research Ethics Committee.

Please note the following about your ethics approval:

- Please use your reference number (NAS270/2021) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.
- Please note that ethical approval is granted for the duration of the research (e.g. Honours studies: 1 year, Masters studies: two years, and PhD studies: three years) and should be extended when the approval period lapses.
- The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.
- **If Applications using GM permits:** If the GM permit expires before the end of the study, please make an amendment to the application with the new GM permit before the old one expires
- **If Applications using Animals:** NAS ethics recommendation does not imply that Animal Ethics Committee (AEC) approval is granted. The application has been pre-screened and recommended for review by the AEC. Research may not proceed until AEC approval is granted.

Post approval submissions including application for ethics extension and amendments to the approved application should be submitted online via the Ethics work centre.

We wish you the best with your research.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'VJ Maharaj'.

Prof VJ Maharaj
Chairperson: NAS Ethics Committee