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What Strategies Are Effective to Support Food Security in Slow-Onset Disasters? A Mixed-Method Systematic Review of the Literature

Hiep N. Le[1,2,3,4] | Ernesta Sofija[1] | Neil Harris[1] | Reny Noviasty[1] | Thu Nguyen[5] | Hai Phung[1]

[1]School of Medicine and Dentistry, Griffith University, Gold Coast, Queensland, Australia | [2]An Giang University, Long Xuyen, Vietnam | [3]Vietnam National University, Ho Chi Minh City, Vietnam | [4]Health and Agricultural Policy Research Institute, University of Economics Ho Chi Minh City, Ho Chi Minh City, Vietnam | [5]College of Public Health Medical and Veterinary Sciences, James Cook University, Douglas, Queensland, Australia

Correspondence: Hai Phung (hai.n.phung@griffith.edu.au)

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ABSTRACT

Having access to food is a human entitlement and one of the essential goals of the sustainable development agenda. Despite growing concern about the impact of slow-onset disasters on food security, most interventions have primarily targeted sudden-onset disasters. As such, there has been limited attention to understanding the effectiveness of adaptation strategies in safeguarding food security during disaster events. The aim of this research was to synthesize all existing evidence on the effectiveness of adaptation strategies in addressing food insecurity during gradual-onset disasters. This study employs Hadley et al.'s food security framework to examine the effectiveness of existing adaptation strategies in mitigating food insecurity concerns during slow-onset disasters. A mixed-method systematic review was conducted using five electronic databases up to July 2023 and followed the guidelines regarding the convergent segregated approach to synthesize the findings. The review showed that most studies (94.1%) focused on drought, neglecting other slow-onset disasters. The strategies mostly focused on ensuring the availability and accessibility of food while giving little attention to food utilization. Most food security components have somewhat identified their effectiveness, except for food safety, with no studies exploring it. Findings from the mixed-methods approach also highlight the double-edged effects of adaptation strategies and the notable absence of reliable intervention evidence using randomized controlled trials. It is crucial for future research to broaden the scope to include the less studied types of slow-onset disasters. Emphasizing neglected and underutilized species, along with food safety aspects, might unveil novel approaches to boost food utilization in fluctuating climates. Given the heterogeneous nature of slow-onset disaster impacts, it is important to explore these dynamic and context-specific aspects of adaptation strategies in different conditions. Utilizing methods like randomized controlled trials in future research will enhance the evidence base.

1 | Introduction

Ensuring a consistent provision of food is critical for the attainment of sustainable development and global well-being (UN General Assembly 2015). According to Tamburino et al. (2020), attaining SDG 2, which aims to eradicate hunger completely, is of paramount significance. Every individual has the fundamental human right to adequate and safe sustenance

Abbreviations: FAO, Food and Agriculture Organization; MMAT, The Mixed Methods Appraisal Tool; MYE, Maize yield equivalent; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis; RCTs, Randomized Controlled Trials; SD, Standard Deviation; SDG, Sustainable Development Goal; US$, US dollar.

that satisfies their preferences and dietary needs for a vigorous and well-balanced way of life. The term used to refer to this state of affairs is food security (FAO 1996). In the current era, marked by escalating environmental uncertainties and a rising incidence of gradual-onset catastrophes, mitigating food insecurity has become a crucial issue for communities throughout the globe (Edwards et al. 2011; Umar et al. 2017). Droughts, desertification, increasing temperatures, salinization, sea level rise, land and forest degradation, biodiversity loss, ocean acidification, and glacial retreat are examples of slow-onset disasters that can severely affect food systems, exacerbating vulnerability and undermining food security (Funk et al. 2019; Le et al. 2024; Privara and Přívarová 2019; United Nations—Headquarters United Nations Office for Disaster Risk Reduction 2015).

Droughts, characterized by prolonged periods of water scarcity, significantly impede agricultural output, resulting in crop failure, livestock losses, and diminished water resources for irrigation (Ahmad et al. 2022; Bogale and Erena 2022). Desertification occurs when formerly fertile regions undergo a transformation that renders them uninhabitable for livestock and agriculture due to climate change and non-sustainable land use (Burrell et al. 2020; Schlesinger et al. 1990). The rise in sea levels poses a threat to low-lying coastal areas, where saltwater intrusion contaminates freshwater sources and reduces arable land, directly affecting food production and livelihoods (Essink et al. 2010; Hereher 2010; Ruane et al. 2013). In addition to these examples, substantial evidence exists demonstrating the effects of other slow-onset disasters on food security (Aubry-Wake et al. 2022; Cassotta 2021; Fisher and Christopher 2007; Hsiao et al. 2019; Molotoks et al. 2017; Oladimeji 2020; Szabo et al. 2015).

Unlike sudden-onset catastrophes that require an instant reaction, slow-onset disasters transpire gradually over extended periods of time, spanning months or years (Mamuji and Kchouk 2018; United Nations General Assembly 2016). This may be one of the reasons why slow-onset disasters receive less attention compared to those with a rapid onset. Media coverage tends to overemphasize sudden-onset disasters while underreporting slow-onset disasters (Mamuji and Kchouk 2018). Research suggests that such discrepancies in media attention result in a disparity in funding, with sudden-onset disasters receiving excessive financial support compared to the insufficient funding allocated to slow-onset disasters (Mamuji and Kchouk 2018). This has long-lasting effects on food insecurity, increases the vulnerability of affected populations, and impedes effective response and recovery efforts (Privara and Přívarová 2019; Staupe-Delgado and Rubin 2022). Therefore, addressing the challenges of food insecurity under the impacts of a neglected climatic event like slow-onset disasters is necessary and requires a comprehensive understanding of the effectiveness of strategies that support food security during such crises.

Although many strategies hold promise (Mekonnen et al. 2021; Molotoks et al. 2021), there is currently no systematic review that integrates qualitative and quantitative data regarding the effectiveness of solutions to mitigate food insecurity in gradual-onset catastrophes mapped to a comprehensive framework (Hadley et al. 2023). The Food and Agriculture Organization (FAO) released a widely accepted food security framework in 2008, which is considered one of the most prominent frameworks for understanding food security (Food Agriculture Organization 2008). Nonetheless, the absence of sociocultural elements and the failure to provide conceptualizations for each pillar have drawn criticism (Chan et al. 2018; Myers et al. 2017). Considering these shortcomings, Savary et al. (2020) dissected the FAO's pillars and created a comprehensive six-component framework to clarify food security. Despite this broadened scope, sociocultural factors continued to be overlooked. To address this limitation, Hadley et al. (2023) propelled the argument that religious convictions, customary dietary behaviours, and culinary techniques collectively influence individuals' food procurement and utilization (Musaiger 1993; Owino 2019).

Cultural norms and social dynamics significantly influence dietary behaviours, choices, and the perception of appropriate or desirable foods within a community (Monterrosa et al. 2020; Playdon et al. 2022). For instance, while some societies view meat as a fundamental and affluent food item (Giacoman et al. 2021), others predominantly adhere to vegetarian diets due to environmental or ethical considerations (Šmugović et al. 2021). Additionally, traditional ways of preparing and eating food significantly influence food security. Age-old preservation and food processing techniques, including drying, smoking, and fermenting, are vital in many cultures (Mandisvika et al. 2015). These practices are particularly important in areas where modern preservation techniques are scarce, thereby contributing to year-round food availability (Raghavan et al. 2022). Moreover, religious convictions frequently dictate certain eating limitations or fasting, which have an impact on the nutritional composition and quantity of food consumed. One example is the fasting observed during Ramadan, which alters individuals' dietary patterns and illuminates the ways in which fasting impacts energy balance and dietary practices (Lessan et al. 2018). Hence, a sociocultural understanding of these factors is crucial in addressing food security, considering the significance of food utilization. Effective and long-lasting food security strategies require a comprehensive comprehension of these cultural nuances (Gurney et al. 2015; Hammelman and Hayes-Conroy 2014). Cultural sensitivity and adaptability in policies and interventions are essential to ensure their effectiveness and sustainability (Hammelman and Hayes-Conroy 2014). Recognizing and integrating these sociocultural elements allows for more inclusive food security approaches, catering to the varied requirements of different communities while respecting their cultural heritage.

Therefore, adopting Hadley et al.'s framework (Figure 1) in this systematic literature review helps it overcome the limitations of two previous systematic reviews on food security adaptation strategies (Epule et al. 2017; Hadley et al. 2023). While Epule et al. (2017) conducted a systematic study of existing measures to adapt to climate change, including addressing food insecurity, the study did not adopt the eight-component framework to assess effective adaptations. This omission may result in

FIGURE 1 | A food security framework with eight components proposed by Hadley et al. (2023).

challenges in discerning which aspects of food security are adequately addressed by the adaptations and which aspects remain neglected and necessitate further intervention. Hadley et al. (2023) adopted the eight-component analytic framework in their review; however, the study used the eight components to explain the mechanisms behind food insecurities in the setting of climate-related emergencies without assessing adaptation effectiveness. The present systematic review employs the framework developed by Hadley et al. (2023), comprising eight components of food security organized around three pillars, to direct the quantitative and qualitative examination of eight themes. These themes facilitate the assessment of adaptation strategies' effectiveness pertaining to different aspects of food security during gradual-onset catastrophes.

In this review, the following research questions are examined:

1. What adaptation strategies to support food security have been evidenced for the different types of slow-onset disasters?
2. What adaptation strategies are associated with the various food security components in gradual-onset catastrophes?
3. What is the effectiveness of adaptation strategies to resolve food security during disasters with a gradual onset?

This study is important for three key reasons. Firstly, it identifies optimal strategies for enhancing food security, enabling efficient resource allocation. Secondly, it facilitates learning from successes and failures to inform future interventions, preventing ineffective approaches and promoting successful practices. Lastly, it offers a framework-driven, evidence-based approach for mitigating food insecurity during disasters with a gradual onset, enhancing effectiveness and sustainability in decision-making for policymakers, practitioners, and stakeholders.

2 | Methods

2.1 | Protocol and Registration

The research used the Joanna Briggs Institute's (JBI) convergent segregated approach. This strategy was specifically devised for mixed-method systematic reviews and was executed in strict adherence to the procedures outlined by the JBI (Aromataris and Munn 2020; Lizarondo et al. 2020). This review also follows the guidelines set out by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) with the 2020 version (Page et al. 2021). The review's registration number is CRD42023447123, which has been submitted to the International Prospective Register of Systematic Reviews (PROSPERO).

2.2 | Criteria for Inclusion and Exclusion

The Manual for Evidence Synthesis published by the JBI served as the guidelines for the selection of studies eligible for this review (Aromataris and Munn 2020; Lizarondo et al. 2020). The PICO framework was used to analyze the quantitative aspect, specifically emphasizing the Population, Intervention, Comparator, and Outcomes. Similarly, the Pico framework was used for the qualitative component, with a specific emphasis on the Population, Phenomenon of Interest, and Context.

2.2.1 | Population

This study focused on evaluating the effectiveness of interventions, adaptations, strategies, or programs that were designed to mitigate food insecurity in the event of gradual-onset catastrophes, with an emphasis on the global population.

2.2.2 | Intervention

These inclusion criteria applied to quantitative studies or those incorporating quantitative elements in mixed-methods research, provided that the studies evaluated the effectiveness of an intervention, strategy, adaptation, or program in improving food security during disasters with a gradual onset.

2.2.3 | Comparison

The study included quantitative studies, or their quantitative aspects in mixed-methods research, which compared the effectiveness of different adaptations intended to bolster food security in gradual-onset catastrophes. A variety of comparator categories were utilized in this study, encompassing both the passive and active comparison groups. A passive comparison group consisted of participants who did not participate in any specialized intervention during their study participation. In contrast, an active comparison group was characterized as one whose members were fundamentally involved in the research and participated in one or more specific interventions.

2.2.4 | Outcomes

Quantitative studies, or the quantitative facets of mixed-methods research, were selected if they demonstrated the effectiveness of adaptations in enhancing food security during disasters with a gradual onset. Quantitative effectiveness pertains to the degree of success achieved by a particular intervention, adaptation, strategy, or program in reaching its quantifiable goals, as determined through statistical analysis. It encompassed the evaluation of changes or enhancements to predetermined numerical indicators. These indicators may include but are not limited to metrics concerning food supply, rates of malnutrition, agricultural productivity, economic earnings, or other measurable variables.

2.2.5 | Phenomenon of Interest

These inclusion criteria were applied to the qualitative aspects of this review. The studies were incorporated into the analysis if they assessed the perspectives, notions, or encounters of the participants concerning the effectiveness (positive or negative) of interventions, adaptations, strategies, or programs designed to enhance food security during gradual-onset catastrophes.

2.2.6 | Context

The inclusion criteria encompassed research studies that assessed the effectiveness of adaptation measures in bolstering food security amidst gradual-onset disasters (e.g., droughts, desertification, and rising temperatures) across any setting, including farms, households, communities, geographic locations, and countries.

2.2.7 | Types of Studies

This study encompassed a diverse array of studies, including mixed-methods, either qualitative or quantitative research. Our qualitative research efforts integrated a diverse range of methodologies, such as action research, grounded theory, exploratory research, phenomenology, ethnography, interpretative description, and narrative inquiry. A variety of qualitative data sources were utilized for this review, including focus groups, semi-structured interviews, observational data, documentary analysis, field notes, case studies, visual and auditory data, participant diaries, internet data, life histories, and artifacts. Concerning quantitative research, non-randomized studies, randomized controlled trials, and descriptive studies were all included in our inclusion criteria. As for mixed-methods research, studies were included if their quantitative, qualitative, or both components met the criteria. All mixed-methods study designs were considered, including convergent, sequential exploratory, and sequential explanatory designs.

There were no limitations imposed on the date of publishing. Studies that did not satisfy the specified inclusion criteria and underwent peer review (including conference proceedings, abstracts, letters to the editor, dissertations, editorials, commentaries, and magazine articles) or without having full-text access to the article in English were excluded. In addition, neither protocol nor review articles were considered. Nevertheless, the references excluded from these sources were examined in line with the comprehensive search method.

2.3 | Literature Search Strategy

A literature search strategy was executed on July 13–14, 2023 in consultation with the university's librarian. Embase, Web of Science Core Collection, GreenFILE, MEDLINE (via Ovid), and CINAHL were the databases examined to find possibly relevant publications. The search was performed using a combination of specified index phrases and keywords (Appendix S1). Only research involving humans and published in English was included. In addition, citation chaining was performed by conducting a thorough examination of all papers included in the review and relevant systematic review reference lists.

2.4 | Study Selection

The review procedure was conducted systematically by utilizing the Covidence Online Software (https://www.covidence.org). Each article's title and abstract were evaluated independently by two authors (HNL and RN). If any disagreements arose throughout this procedure, a third reviewer (HP) would settle them. Two authors (HNL and RN) also independently evaluated the full-text articles. In situations requiring decision-making, the co-authors (ES, NH, HP, and TN) were consulted for assistance. The study group effectively resolved any arisen conflicts through the attainment of a consensus.

2.5 | Data Extraction

The first author (NHL) was responsible for extracting the data for all the studies based on standardized forms developed for this review and reviewed by the other authors. A 10% sample was given to the second reviewer (RN) for independent extraction and comparison. The data extraction forms were double-checked to ensure their precision, uniformity, and exhaustiveness by a third author (HP). The extracted data from the articles encompassed several key elements. These included authorship, publication year, country where the research was conducted, and study details such as design, target population, sample size, and participant characteristics. Additionally, the data encompassed information on the type of slow-onset disaster studied, adaptation descriptions, data sources, measurement tools, effective evaluation methods, food security measured, including eight components, measure efficiency, and description.

2.6 | Appraisal of Studies

To evaluate the studies' methodological rigour, the Mixed Methods Appraisal Tool (MMAT) was used (Hong et al. 2018). This instrument allows for the simultaneous assessment of quantitative, qualitative, and mixed-methods research (Pace et al. 2012). All included articles' methodology sections were independently assessed by two reviewers (HNL and RN). From

these sections, each reviewer classified the research as qualitative, quantitative descriptive, randomized controlled trials (RCTs), non-randomized, or mixed-methods study. The study was subsequently graded according to the responses to the MMAT criteria for each area of satisfaction. As illustrated by Hong et al. (2018), methodological quality indicators encompass aspects such as the appropriateness of the research approach, sampling methodology, and data collection processes, the integrity of the intervention, and the integration of results. A third reviewer (HP) was consulted when the reviewers were unable to reach a consensus on the score.

It is discouraged to identify deficiencies in the research methodology using a single numerical value (Hong et al. 2018). Therefore, it is not recommended to calculate an aggregate numerical score based on the evaluations of each criterion. We alternatively categorized research according to the quality of its methodologies, whereby studies deemed of lesser quality were those that satisfied 60% or fewer of the MMAT criteria, while studies deemed of higher quality fulfilled 60% or more of the principles. In addition, a thorough summary of our assessments for every criterion was furnished. All eligible studies were included in our evaluation without regard to their MMAT ratings, as no study was excluded based on methodological quality (Hong et al. 2018).

2.7 | Synthesis of Results

This study separately synthesized the quantitative and qualitative data before integrating the results using a convergent segregated three-stage approach (Aromataris and Munn 2020; Lizarondo et al. 2020). The gathered evidence was systematically arranged and synthesized to formulate a comprehensive analysis. Stern et al. (2020) highlight that such a methodology is particularly effective when the objective of the review encompasses various facets or dimensions of a specific phenomenon. The collected articles were first organized based on "themes or coding frames" identified by qualitative content analysis (Hall and Steiner 2020; Hsieh and Shannon 2005; Schreier 2012). The study used a blend of directed and conventional content analysis methodologies to discover themes and subthemes. Directed content analysis involves deriving themes from prior concepts or research findings, while conventional content analysis directly extracts themes from the text itself (Hsieh and Shannon 2005). As a result, Hadley et al.'s framework on food security (Hadley et al. 2023) offered eight specific areas for analysis. The study's subthemes were identified via an inductive reading of the text. During this phase, two researchers meticulously examined each of the selected articles, analyzing the effectiveness of the strategies connected to food security in a thorough and detailed manner. Once the themes and subthemes were identified, the review continued to quantify the amount of research that focused on each subtheme.

In the subsequent stage, a narrative synthesis was performed on the quantitative data to emphasize and convey the overarching conclusions derived from the entire set of data (Siddaway et al. 2019). A meta-analysis was not considered appropriate for this review since the chosen papers included a wide range of metrics, study aims, and participants.

An analysis was finally conducted incorporating a blend of qualitative and quantitative data. This process entailed aligning and structuring both quantitative and qualitative data coherently, forming a logical line of argumentation to yield a holistically configured analysis. In instances where such configuration proved unfeasible, the findings were delineated in a narrative format (Aromataris and Munn 2020).

3 | Results

A total of 8012 studies in total were discovered following a review of the existing literature. Upon eliminating the duplicate studies, the remaining count was 6177. Following the screening of titles and abstracts, an extra 98.0% (5992/6117) of the studies were discarded. After thoroughly examining the full text of all 122 remaining articles, a total of 32 (26.2%) were eventually selected for inclusion. We discovered two more records by examining the reference lists of included papers. Hence, in total, 34 studies were included in the synthesis (Figure 2).

3.1 | Characteristics of Included Studies

Table 1 indicates that more than half (58.8%) of the studies were non-randomized quantitative research. Quantitative randomized controlled trials were absent from all studies. The studies were conducted across 15 countries spanning two continents, primarily in Africa (29 studies). Notably, Kenya had the highest number of studies, totalling six (Gebre et al. 2023b; Kabubo-Mariara and Mulwa 2019; Liru and Heinecken 2021; Midega et al. 2015; Ndiritu and Muricho 2021; Ogada et al. 2020), followed by Tanzania with five (Brüssow et al. 2017; Gebre et al. 2023a; Ires 2021; Midega et al. 2015; Theodory 2021).

The trend of publishing studies evaluating the effectiveness of adaptations to food security during gradual-onset disasters began to emerge after 2010, with the highest number occurring in 2021 (eight studies). In addition, each year, 2017, 2019, and 2020 had four studies published. Among the 34 studies included in the analysis, 12 solely employed a single adaptation strategy to enhance food security during gradual-onset catastrophes. The remaining studies combined at least two adaptation strategies in their approaches. Moreover, the studies predominantly focused on farmer households, with only two centring on pastoralists (Ndiritu and Muricho 2021) and indigenous communities (Zhang et al. 2016). The sample size ranged from 33 to 2084 participants (median 395; mean 461.2, SD 453.4). A comprehensive table detailing all the included studies is provided in Appendix S2.

3.2 | Results of Quality Appraisal

The methodological quality across the 34 studies displayed variation. Specifically, a lower level of methodological quality was indicated by 41.2% of the research, or 14 out of 34, which did not meet 60% of the requirements set by the MMAT (Brüssow et al. 2017; Chidavaenzi et al. 2021; Gebru et al. 2021; Ires 2021; Kamara et al. 2023; Kebebe and Shibru 2017; Martey

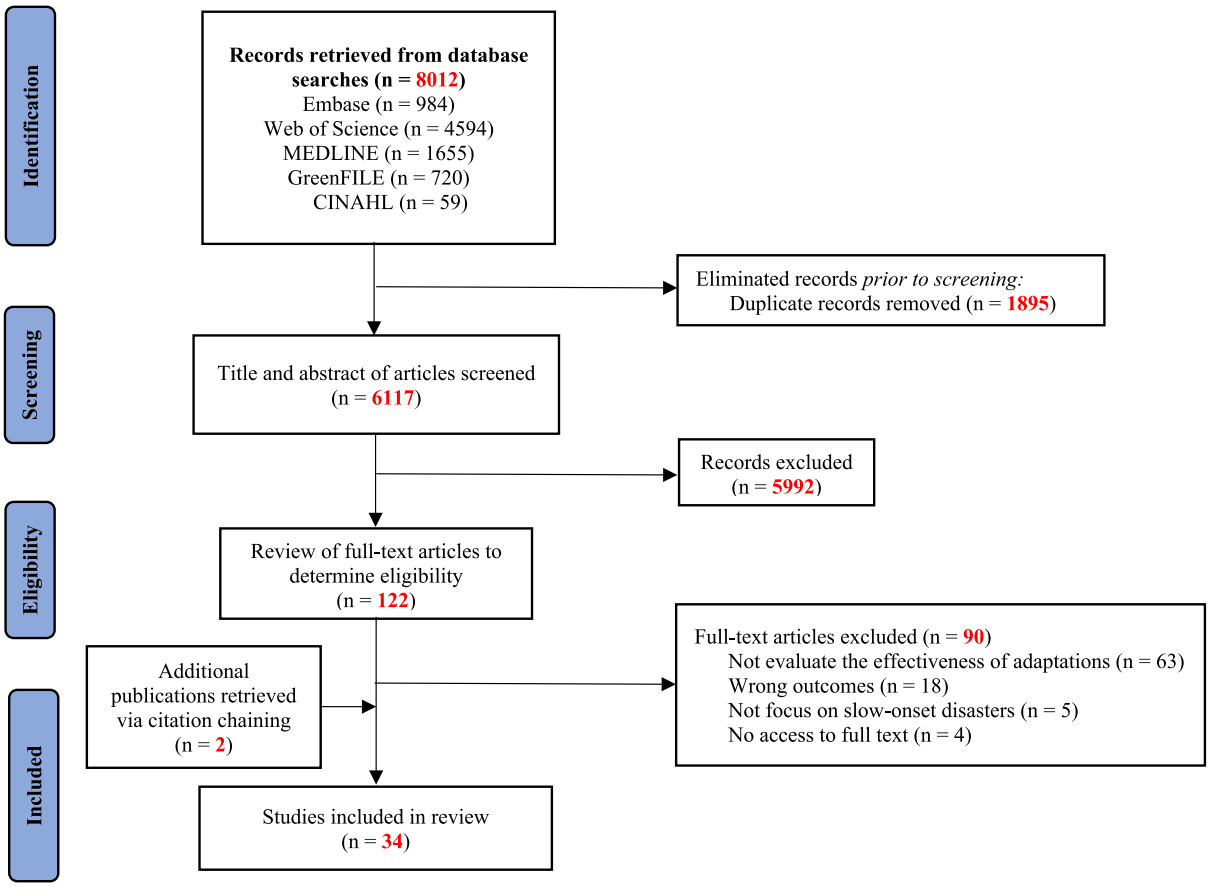

FIGURE 2 | PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

et al. 2020; Mavesere and Dzawanda 2023; Midega et al. 2015; Ndiritu and Muricho 2021; Seydou et al. 2023; Theodory 2021; Zakari et al. 2022; Zingiro et al. 2014). Conversely, with higher methodological quality, 58.8% (20 out of 34) of the studies satisfied over 60% of the standards (Amadu et al. 2020; Amare and Simane 2018; Asante et al. 2021; Atube et al. 2022; Bairagi et al. 2020; Chitongo 2019; Gebre et al. 2023a, 2023b; Kabubo-Mariara and Mulwa 2019; Lam et al. 2022; Lei et al. 2016; Liru and Heinecken 2021; Mashinini et al. 2011; Muzerengi and Tirivangasi 2019; Ngango and Hong 2021; Ogada et al. 2020; Patnaik and Das 2017; Sileshi et al. 2019; Wossen et al. 2017; Zhang et al. 2016). Ratings provided by the reviewers for each methodological quality criterion can be found in Appendix S3.

3.3 | Types of Slow-Onset Disasters

Within the 34 studies included, the evaluation of adaptation effectiveness in addressing food security primarily focused on four types of slow-onset disasters: drought, land and forest degradation, increasing temperature, and salinization (Figure 3). Notably, most of these studies (94.1%) centered around drought, while the remaining three types had a significantly smaller representation, each accounting for $<15.0\%$ of the total (Asante et al. 2021; Atube et al. 2022; Kabubo-Mariara and Mulwa 2019; Kebebe and Shibru 2017; Lam et al. 2022; Midega et al. 2015; Patnaik and Das 2017; Sileshi et al. 2019).

3.4 | Level of Adaptation Associated With Food Security Components in Slow-Onset Disasters

Figure 4 illustrates that most food security components were somewhat addressed, except for component 7, food safety—with no studies addressing it. However, there was a dominant focus on Component 1, accounting for 91.2% of the total, followed by Component 5 at 47.1%. Component 3 had two qualitative studies (Theodory 2021; Zhang et al. 2016) but no quantitative or mixed-method studies. Only two quantitative non-randomized studies (Ndiritu and Muricho 2021; Patnaik and Das 2017) covered Component 4, and Component 8 had just one qualitative study (Liru and Heinecken 2021).

3.5 | The Effectiveness of Adaptations

Table 2 and Appendix S4 illustrate that the most extensive array of strategies was found within the two pillars of food availability and food access, with limited action plans in the food utilization pillar. When evaluating the effectiveness of these strategies in enhancing food security, Component 1 stood out with six strategies demonstrating a 100% positive effectiveness rate. These strategies encompassed livestock practice (Chitongo 2019; Lei et al. 2016; Liru and Heinecken 2021; Ndiritu and Muricho 2021; Theodory 2021), intercropping (Chitongo 2019; Lei et al. 2016; Liru and Heinecken 2021; Midega et al. 2015; Zakari et al. 2022), water management (Gebru et al. 2021; Kabubo-Mariara and

TABLE 1 | Characteristics overview of included studies.

Characteristics	Details
Research type	Non-randomized Quantitative (20 studies, 58.8%): Amadu et al. (2020), Atube et al. (2022), Bairagi et al. (2020), Brüssow et al. (2017), Gebre et al. (2023a, 2023b), Kabubo-Mariara and Mulwa (2019), Kamara et al. (2023), Kebebe and Shibru (2017), Martey et al. (2020), Mashinini et al. (2011), Midega et al. (2015), Ndiritu and Muricho (2021), Ngango and Hong (2021), Ogada et al. (2020), Patnaik and Das (2017), Sileshi et al. (2019), Wossen et al. (2017), Zakari et al. (2022), Zingiro et al. (2014)
	Mixed-Methods (10 studies, 29.4%): Amare and Simane (2018), Asante et al. (2021), Chidavaenzi et al. (2021), Chitongo (2019), Gebru et al. (2021), Ires (2021), Lam et al. (2022), Lei et al. (2016), Mavesere and Dzawanda (2023), Seydou et al. (2023)
	Qualitative (4 studies, 11.8%): Liru and Heinecken (2021), Muzerengi and Tirivangasi (2019), Theodory (2021), Zhang et al. (2016)
	Randomized Controlled Trials (0 studies, 0%)
Geographic distribution of studies	African countries (29 studies, 85.3%): Amadu et al. (2020), Amare and Simane (2018), Asante et al. (2021), Atube et al. (2022), Brüssow et al. (2017), Chidavaenzi et al. (2021), Chitongo (2019), Gebre et al. (2023a, 2023b), Gebru et al. (2021), Ires (2021), Kabubo-Mariara and Mulwa (2019), Kamara et al. (2023), Kebebe and Shibru (2017), Liru and Heinecken (2021), Martey et al. (2020), Mashinini et al. (2011), Mavesere and Dzawanda (2023), Midega et al. (2015), Muzerengi and Tirivangasi (2019), Ndiritu and Muricho (2021), Ngango and Hong (2021), Ogada et al. (2020), Seydou et al. (2023), Sileshi et al. (2019), Theodory (2021), Wossen et al. (2017), Zakari et al. (2022), Zingiro et al. (2014)
	Asia (5 studies, 14.7%): Bairagi et al. (2020), Lam et al. (2022), Lei et al. (2016), Patnaik and Das (2017), Zhang et al. (2016)
Publication year distribution	2023 (5 studies, 14.7%): Gebre et al. (2023a, 2023b), Kamara et al. (2023), Mavesere and Dzawanda (2023), Seydou et al. (2023)
	2022 (3 studies, 8.8%): Atube et al. (2022), Lam et al. (2022), Zakari et al. (2022)
	2021 (8 studies, 23.5%): Asante et al. (2021), Chidavaenzi et al. (2021), Gebru et al. (2021), Ires (2021), Liru and Heinecken (2021), Ndiritu and Muricho (2021), Ngango and Hong (2021), Theodory (2021)
	2020 (4 studies, 11.8%): Amadu et al. (2020), Bairagi et al. (2020), Martey et al. (2020), Ogada et al. (2020)
	2019 (4 studies, 11.8%): Chitongo (2019), Kabubo-Mariara and Mulwa (2019), Muzerengi and Tirivangasi (2019), Sileshi et al. (2019)
	2017 (4 studies, 11.8%): Brüssow et al. (2017), Kebebe and Shibru (2017), Patnaik and Das (2017), Wossen et al. (2017)
	Other years (6 studies, 17.6%): Amare and Simane (2018), Lei et al. (2016), Mashinini et al. (2011), Midega et al. (2015), Zhang et al. (2016), Zingiro et al. (2014)
Adaptation strategies	Single Adaptation Strategy (12 studies, 35.3%): (Chidavaenzi et al. (2021), Gebru et al. (2021), Kamara et al. (2023), Martey et al. (2020), Mashinini et al. (2011), Mavesere and Dzawanda (2023), Muzerengi and Tirivangasi (2019), Ngango and Hong (2021), Seydou et al. (2023), Sileshi et al. (2019), Wossen et al. (2017), Zingiro et al. (2014))
	Multiple Adaptation (22 studies, 64.7%): Amadu et al. (2020), Amare and Simane (2018), Asante et al. (2021), Atube et al. (2022), Bairagi et al. (2020), Brüssow et al. (2017), Chitongo (2019), Gebre et al. (2023a, 2023b), Ires (2021), Kabubo-Mariara and Mulwa (2019), Kebebe and Shibru (2017), Lam et al. (2022), Lei et al. (2016), Liru and Heinecken (2021), Midega et al. (2015), Ndiritu and Muricho (2021), Ogada et al. (2020), Patnaik and Das (2017), Theodory (2021), Zakari et al. (2022), Zhang et al. (2016)

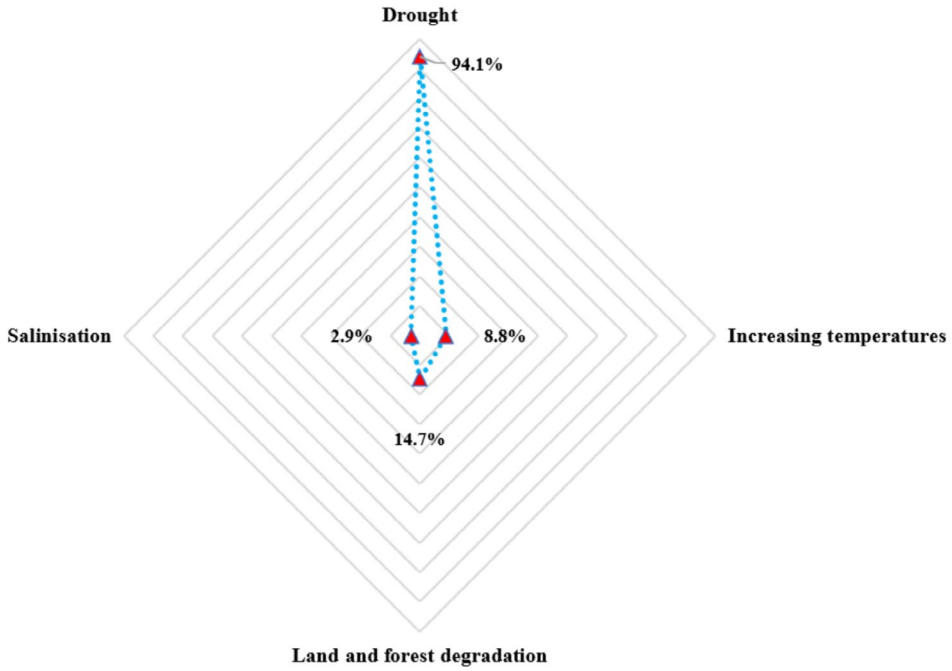

FIGURE 3 | Types of slow-onset disasters that studies addressed.

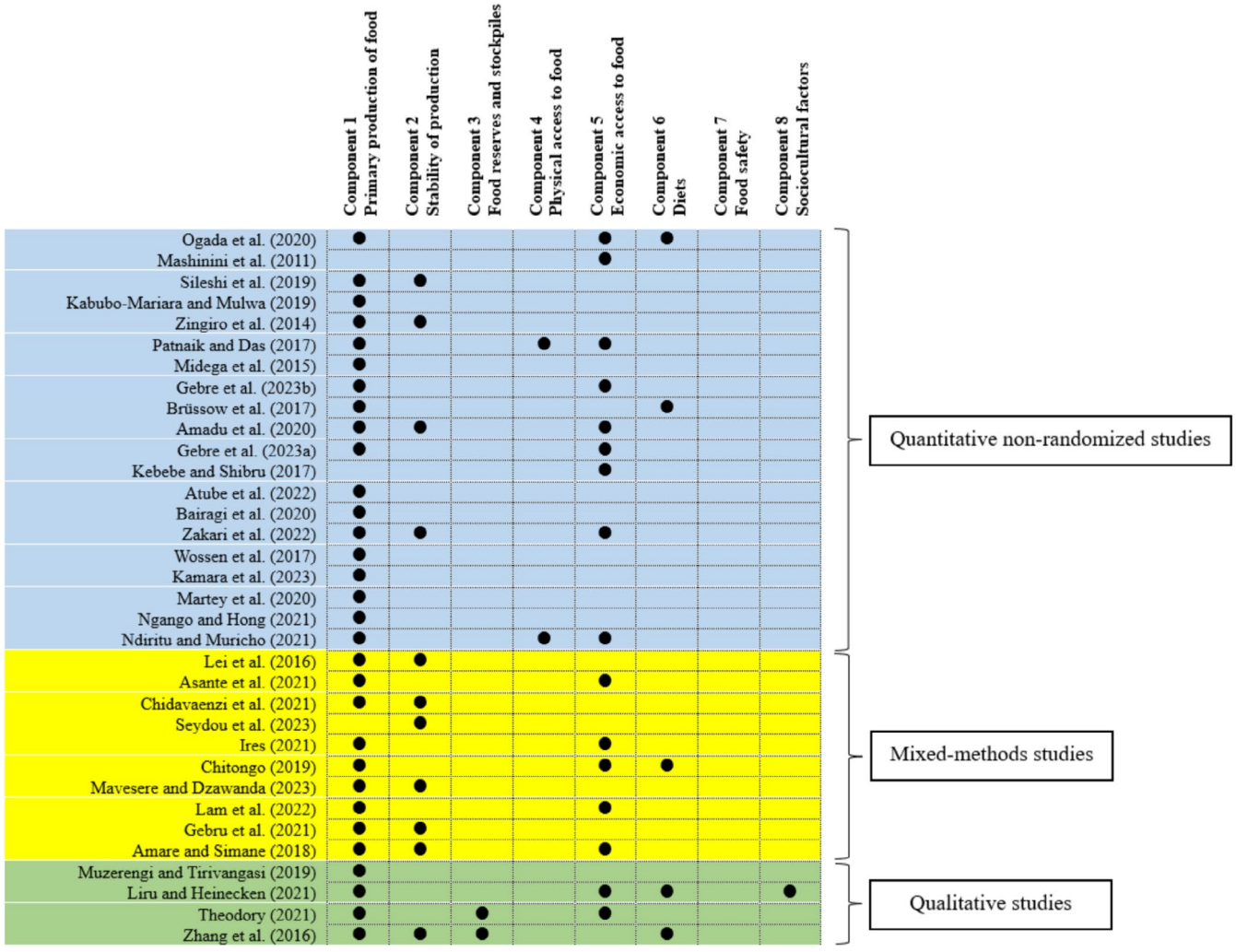

FIGURE 4 | Studies in response to gradual-onset disasters align with the food security components.

TABLE 2 | The effectiveness of adaptations to mitigate food insecurity in gradual-onset catastrophes ($N = 34$).

Food security pillar	Component/ Themes	Strategy/Subthemes	Number of studies issued the strategy	References—Effectiveness		
				Number of studies demonstrated positive outcome	Number of studies demonstrated negative outcome	Number of studies demonstrated unclear outcome
Food availability	Component 1—Primary food production	Climate tolerant varieties	15	10 Ogada et al. (2020), Midega et al. (2015), Gebre et al. (2023a), Gebre et al. (2023b), Bairagi et al. (2020), Zakari et al. (2022), Wossen et al. (2017), Chitongo (2019), Liru and Heinecken (2021), Theodory (2021)	3 Atube et al. (2022), Ires (2021), Lam et al. (2022)	2 Kamara et al. (2023), Martey et al. (2020)
		Irrigation	9	7 Atube et al. (2022), Asante et al. (2021), Zakari et al. (2022), Ngango and Hong (2021), Lei et al. (2016), Chidavaenzi et al. (2021), Amare and Simane (2018)		2 Ires (2021), Lam et al. (2022)
		Agronomic practices	7	5 Zakari et al. (2022), Atube et al. (2022), Asante et al. (2021), Bairagi et al. (2020), Amare and Simane (2018), Chitongo (2019)	2 Atube et al. (2022), Lam et al. (2022)	
		Crop diversification	6	5 Kabubo-Mariara and Mulwa (2019), Gebre et al. (2023b), Brüssow et al. (2017), Zakari et al. (2022), Liru and Heinecken (2021)		1 Atube et al. (2022)
		Livestock practice	5	5 Liru and Heinecken (2021), Chitongo (2019), Theodory (2021), Ndiritu and Muricho (2021), Lei et al. (2016)		
		Intercropping	5	5 Midega et al. (2015), Zakari et al. (2022), Chitongo (2019), Liru and Heinecken (2021), Lei et al. (2016)		
		Water management	5	5 Kabubo-Mariara and Mulwa (2019), Ndiritu and Muricho (2021), Gebru et al. (2021), Zingiro et al. (2014), Patnaik and Das (2017)		
		Farming model	4	4 Amadu et al. (2020), Mavesere and Dzawanda (2023), Muzerengi and Tirivangasi (2019)		1 Lam et al. (2022)
		Soil, water, and agricultural conservation practices	4	3 Sileshi et al. (2019), Amare and Simane (2018), Chitongo (2019)	1 Atube et al. (2022)	
		Growing early maturing crops	3	2 Gebre et al. (2023b), Gebre et al. (2023a)		1 Atube et al. (2022)
		Planting time	3	2 Kabubo-Mariara and Mulwa (2019), Gebre et al. (2023a)		1 Atube et al. (2022)

(Continues)

TABLE 2 | (Continued)

Food security pillar	Component/ Themes	Strategy/Subthemes	Number of studies issued the strategy	References—Effectiveness		
				Number of studies demonstrated positive outcome	Number of studies demonstrated negative outcome	Number of studies demonstrated unclear outcome
		Crop varieties	2	1 Kabubo-Mariara and Mulwa (2019)		1 Atube et al. (2022)
		Tree planting	2	2 Brüssow et al. (2017), Atube et al. (2022)		
		Weather advisory	1	1 Bairagi et al. (2020)		
		Landrace crops	1	1 Zhang et al. (2016)		
	Component 2—Stability of food production	Soil, water, and agricultural conservation practices	3	3 Sileshi et al. (2019), Amare and Simane (2018), Chitongo (2019)		
		Water management	3	3 Zingiro et al. (2014), Gebru et al. (2021), Chidavaenzi et al. (2021)		
		Farming model	2	2 Amadu et al. (2020), Mavesere and Dzawanda (2023)		
		Weather advisory	1	1 Seydou et al. (2023)		
		Crop diversification	1	1 Zakari et al. (2022)		
		Landrace crops	1	1 Zhang et al. (2016)		
	Component 3—Food reserves and stockpile	Food reserve	2	2 Theodory (2021), Zhang et al. (2016)		

(Continues)

TABLE 2 | (Continued)

Food security pillar	Component/ Themes	Strategy/Subthemes	Number of studies issued the strategy	References—Effectiveness		
				Number of studies demonstrated positive outcome	Number of studies demonstrated negative outcome	Number of studies demonstrated unclear outcome
Food access	Component 4—Physical access	Physical land and water infrastructure	2	2 Patnaik and Das (2017), Ndiritu and Muricho (2021)		
	Component 5—Economic access	Income diversification	10	7 Gebre et al. (2023a), Gebre et al. (2023b), Zakari et al. (2022), Amare and Simane (2018), Asante et al. (2021), Chitongo (2019), Theodory (2021)	3 Lam et al. (2022), Ires 2021, Liru and Heinecken 2021	
		Capacity building and economic support	3	3 Patnaik and Das (2017), Kebebe and Shibru (2017), Amadu et al. (2020)		
		Selling assets	3	2 Gebre et al. (2023a), Ndiritu and Muricho (2021)	1 Liru and Heinecken (2021)	
		Migration	2	1 Asante et al. (2021)	1 Lam et al. (2022)	
		Input Trade Fairs	1	1 Mashinini et al. (2011)		
		Use of precautionary savings	1	1 Gebre et al. (2023a)		
		Improved livestock breeds	1		1 Ogada et al. (2020)	
Food utilization	Component 6—Diets	Food harvest from agricultural activities	2	2 Brüssow et al. (2017), Chitongo (2019)		
		Priority food for children	1		1 Liru and Heinecken (2021)	
		Traditional edible plant foods	1	1 Zhang et al. (2016)		
	Component 8—Sociocultural factors	Feed the children first, or skip meals	1		1 Liru and Heinecken (2021)	
		Gender equity	1	1 Liru and Heinecken (2021)		
		Knowledge sharing	1	1 Liru and Heinecken (2021)		

Mulwa 2019; Ndiritu and Muricho 2021; Patnaik and Das 2017; Zingiro et al. 2014), tree planting (Atube et al. 2022; Brüssow et al. 2017), weather advisory (Bairagi et al. 2020), and landrace crops (Zhang et al. 2016).

Various types of adaptation in Component 1 were described in both quantitative and qualitative studies. According to Ndiritu and Muricho (2021), livestock practices among climate change adapters significantly improved food security, with 85.9% of adapters being food secure compared to only 68.3% of non-adapters. The probability of food security dropped significantly for adapters who did not adapt, from 81% to 38% (Ndiritu and Muricho 2021). Moreover, non-adapters could experience a substantial increase in food security, from 62% to 80%, if they also underwent adaptation to climate change (Ndiritu and Muricho 2021). In the qualitative studies, Theodory (2021) reported that livestock farming, particularly in wetlands, has significantly contributed to the fortification of agricultural systems against the perils of drought and climate change. Participants who engaged in livestock farming in wetlands reported: "Those who respond positively and dare to undertake their farming in the wetlands always get better harvests" (Theodory (2021), p. 55). Similar findings were described by Liru and Heinecken (2021), Lei et al. (2016), and Chitongo (2019), where participants reported the benefits of livestock farming in providing food, generating income, serving as a source of power for food production and reducing vulnerability to food insecurity. These benefits were more evident in long drought seasons as reflected by one elderly female participant: "I started with 5 chicks and now I have 90 local breeds. During dry periods when food is limited, I just sell one chicken and am able to buy sugar, cooking oil, cooking flour, salt and other things that I need for household consumption" (Liru and Heinecken (2021), p. 8).

Intercropping is another adaptation strategy highlighted for efficiently utilizing limited soil moisture, ensuring its availability throughout the crop growing season (Chitongo 2019). Farmers adopting this strategy can significantly increase household income and have a 7%–9% higher chance of achieving food security than those not intercropping (Zakari et al. 2022). Qualitatively, intercropping, in general, is recognized for its ability to boost crop yields through faster growth rates, weed reduction, and pest and disease control while also minimizing resource use and maximizing output (Liru and Heinecken 2021; Midega et al. 2015). Additionally, intercropping enhances soil fertility, mainly through nitrogen-fixing leguminous crops (Liru and Heinecken 2021).

Households that adapted their water management practices to address slow-onset disasters achieved significantly higher agricultural yields, harvesting an annual maize yield equivalent to 4877 kg/ha, in contrast to 3238 kg/ha for households that did not adapt, representing a 33.6% increase in yield for adapters (Kabubo-Mariara and Mulwa 2019). Another study revealed that water management adopters demonstrated greater food security, with 85.9% being food secure, while non-adopters faced higher food insecurity rates at 31.7% (Ndiritu and Muricho 2021). Qualitative studies show that water harvesting technologies increase agricultural productivity by promoting crop diversification, improving the condition of degraded land, preserving environmental quality, and bolstering resilience against drought, thus ensuring a sufficient and nutritious food supply (Gebru et al. 2021). The implementation of rainwater collection ponds resulted in a significant rise in farm family earnings, with an estimated gain of US$149 per acre. This initiative also promoted the adoption of yield-enhancing inputs, contributing to enhanced crop production and higher revenue (Gebru et al. 2021; Patnaik and Das 2017; Zingiro et al. 2014). Furthermore, users of these technologies outperformed non-users in meeting standard calorie requirements, thereby ensuring a balanced and nutritious diet, which, in turn, enhances food security (Gebru et al. 2021).

Notably, despite climate-tolerant varieties being the most researched in Component 1, these strategies yield mixed results. On the one hand, qualitative studies (Theodory 2021; Liru and Heinecken 2021) point out the primary advantage of utilizing drought-resistant crops in adapting to the harsh conditions brought about by climate change. As noted by Theodory (2021), households can substantially reduce the probability of their members experiencing hunger by cultivating crops resistant to drought, including cassava and sweet potatoes. The significance of this strategy in long drought seasons was emphasized by those who participated in the focus group discussion: "My household plants drought resistant crops every year as a strategy to adapt to climate change impacts. If you don't plant drought resistant crops such as sweet potatoes and cassava you put your family at risk of hunger" (Theodory (2021), p. 56). Furthermore, the study by Liru and Heinecken (2021) also elaborates on this point and mentions the proactive approach of planting drought-resistant varieties like cassava and a specific type of sorghum (the red one) in anticipation of less rain or prolonged dry periods. These crops can survive short rains and mild droughts, thus providing a reliable source of sustenance: "When we predict less rain or a prolonged dry period, we decide to plant drought-resistant crops such as cassava and some variety of sorghum (the red one); these are able to do well even during the short rains and can also overcome mild droughts" (Liru and Heinecken (2021), p. 8). The limitations, however, of drought-resistant crops cannot be disregarded. Ires (2021) points out that the arid tolerance and productivity of these crops are not absolute, specifically regarding hybrid seeds. This is mainly because "adequate water still has to be available for irrigation to ease water stress and for these seeds to yield the expected high harvest (i.e., 8–9 tons per hectare)" (Ires (2021), p. 12).

The strategies including irrigation, crop diversification, farming models, growing early maturing crops, planting time, and crop varieties had both positive and unclear outcomes (Atube et al. 2022; Ires 2021; Lam et al. 2022). Regarding irrigation, for example, multiple studies show positive outcomes such as increased yields of crops like beans and maize (Atube et al. 2022; Lei et al. 2016; Ngango and Hong 2021), improved household income (Chidavaenzi et al. 2021; Lei et al. 2016; Zakari et al. 2022), food security (Amare and Simane 2018), and crop productivity through different irrigation technologies (Chidavaenzi et al. 2021). However, there are instances where irrigation did not significantly increase paddy production (Ires 2021) or was inaccessible to many farmers due to resource and infrastructure constraints (Lam et al. 2022). Similarly, crop diversification strategies have shown positive impacts, such as increased food production (Brüssow et al. 2017; Kabubo-Mariara and

Mulwa 2019), food security status (Brüssow et al. 2017; Gebre et al. 2023b; Zakari et al. 2022), and household income (Brüssow et al. 2017; Zakari et al. 2022). Yet, there were also instances when there was no noticeable disparity in crop yields between those who used crop rotation techniques and those who did not (Atube et al. 2022).

Meanwhile, Components 2, 3, and 4 all exhibit strong track records, with every proposed strategy achieving a positive outcome. Component 5, on the other hand, had mixed results. Among the seven strategies outlined for Component 5, three stood out with a 100% positive effectiveness rate, including capacity building and economic support (Amadu et al. 2020; Kebebe and Shibru 2017; Patnaik and Das 2017), input trade fairs (Mashinini et al. 2011), and precautionary savings utilization (Gebre et al. 2023a). The remaining strategies in this component showed inconsistent effectiveness.

The areas that received capacity-building and economic support strategies witnessed a remarkable 16% increase in the value of crop production compared to control regions, with farmers in project households even achieving higher crop revenues, surpassing non-beneficiaries, especially in areas with poorer outcomes (Patnaik and Das 2017). Furthermore, the adoption of alternative livelihood activities has led to an increase in both grain output and family earnings, while the implementation of natural resource management technologies has enabled adapter households to augment their monthly income by US$35 through the sale of fruit and tree seedlings at the local market (Kebebe and Shibru 2017). Moreover, aid financing has proven to effectively mitigate food insecurity, especially in rural, resource-poor regions where rainfed agriculture is prevalent (Amadu et al. 2020).

Despite the income diversification strategy has proven effectiveness in enhancing household income (Chitongo 2019; Theodory 2021; Zakari et al. 2022), food security status (Gebre et al. 2023a, 2023b), and calorie intake (Amare and Simane 2018), concerns have arisen regarding double-edged effects including environmental degradation or a resurgence of gender-based-violence (Liru and Heinecken 2021). An income diversification strategy employed by women in Lugari, Kenya, to enhance food security due to climate change was through cutting down trees: "When life becomes very difficult and I have no food, I just get to the forest and cut some wood, dry them and take to the market. Another option is to burn charcoal and sell in the nearby centre to get cash" (Liru and Heinecken (2021), p. 7). The practice of diversifying income through activities like deforestation for charcoal production exacerbates climate change implications, notably through droughts, by diminishing water retention areas and altering precipitation patterns. Moreover, the failure to replant trees results in exposed soil, leaving it vulnerable to erosion and susceptible to windstorms (Liru and Heinecken 2021). In addition, income diversification strategies, such as women engaging in employment far from their homes, have been correlated with an increase in gender-based violence (GBV) (Liru and Heinecken 2021). This shift toward external employment results in women spending reduced time on traditional domestic responsibilities, such as childcare, cooking, and other household duties. The challenge of fulfilling family and household chores, compounded by the necessity of departing early and returning late, has been identified as a factor exacerbating GBV. A female participant in a focus group discussion shared her experiences: "During drought, we as women have so many duties, we look for income-generating activities far away from home and at times we have to get basic household needs such as water from afar, yet during that time most women are beaten by their husbands and sent away because their husbands feel that they have not performed their roles. Such incidents are very common during dry periods or scarcity" (Liru and Heinecken (2021), p. 6).

Components 6 and 8 had a more limited number of strategies, with each of them showcasing two strategies that achieved a 100% positive result (Brüssow et al. 2017; Chitongo 2019; Liru and Heinecken 2021). Component 6 emphasizes the significance of food sources and diverse agricultural practices to guarantee food security during droughts. According to the findings of Brüssow et al. (2017), food harvesting from trees enhanced food security. Adopters showed a higher intake of protein and greater food diversity, indicating the efficacy of integrating tree-based foods into agricultural practices. Similarly, Chitongo (2019) underscored the positive role of livestock, which not only provides direct food sources such as milk and meat but also contributes to the economy and agricultural processes. In addition, the importance of traditional edible plant foods in combating food scarcity during droughts was also emphasized. In a qualitative study, Zhang et al. (2016) showed the positive impact of relying on landrace crops and famine plants because "during a drought period, many pests will accrue; they will eat up the sprouts of seed crops, but potato and turnip roots can escape and they can grow again once the rain has fallen." The fact that these plants can survive severe droughts and still provide basic nutritional needs highlights their importance in traditional diets and as a safety net during food crises.

Component 8 underscores the significance of gender equity and knowledge sharing. Liru and Heinecken (2021) highlighted the positive impact of knowledge sharing among women, facilitated through community groups. These groups provide not only financial and material support but also training and networking opportunities, which are essential for coping with climate challenges. One woman in the Amani women group in Malava, India, reported: "The group has helped me to access loans as a member during times of scarcity, it has uplifted me financially, provided me with different forms of training and has often linked us to other farmer organisations" (Liru and Heinecken (2021), p. 8). In contrast, Components 5, 6, and 8 each contained one strategy that displayed negative effects, specifically improving livestock breeds markedly diminishes household income by 76% in Component 5 (Ogada et al. 2020) and feeding the children first, or skipping meals in Components 6 and 8 (Liru and Heinecken 2021).

4 | Discussion

This study aimed to synthesize existing literature on adaptation strategies in slow-onset disasters. As such, it makes three main contributions to the existing broad literature: (i) offering the first systematic review to identify the association between food security adaptation strategies and different types of slow-onset disasters; (ii) taking a framework-based approach in assessing

the effectiveness of the adaptation strategies; and (iii) providing comprehensive evidence on the effectiveness of adaptation strategies to promote food security in climatic disasters. What follows will discuss our key findings, policy implications, and areas for future research.

4.1 | Association Between Adaptation Strategies and Types of Slow-Onset Disasters

One of the objectives of this study was to ascertain the evidence of adaptation strategies in multiple types of slow-onset disasters. Given the findings revealing a predominant focus on droughts within the research on slow-onset disasters, the review calls for further investment in less-studied types of gradual-onset catastrophes, including sea level rise, biodiversity loss, ocean acidification, desertification, and glacial retreat. When it comes to desertification, further investment is needed to implement restorative practices, including reforestation, soil conservation, and rotational grazing, to rejuvenate degraded lands, enhance soil fertility, bolster agricultural productivity, and stabilize the food supply (Hasan et al. 2022; Lense et al. 2022). Future research ought to concentrate on ascertaining the effectiveness of sustainable land management approaches in mitigating the adverse impacts on food production and accessibility in arid regions. Moreover, an exploration of the interplay between biodiversity loss and food security is warranted to assess how conservation endeavors, habitat restoration, and the preservation of indigenous crop varieties bolster food security in ecosystems experiencing biodiversity decline.

Addressing the effects of ocean acidification requires implementing adaptive strategies such as the development of resilient aquaculture systems to ensure the continuity of seafood supplies for populations at risk. Future research should be directed toward species resistant to changing oceanic conditions and designing aquaculture systems that replicate natural habitats (Clements and Chopin 2016). Furthermore, coastal regions, particularly those vulnerable to sea-level rise, necessitate innovative adaptation strategies such as integrated coastal zone management to safeguard food production. More research is required to examine the strategic management and oversight of water and land resources in coastal regions to ensure the sustainability of coastal food production (Chen and Pearson 2015). Lastly, future research is warranted to determine the most effective strategies for glacial-fed river basins to manage their water resources to enhance food security (Milner et al. 2017).

4.2 | Relevance of the Framework in Assessing the Effectiveness of Adaptation Strategies

Using the eight-component analytical framework, this study is, as far as we are aware, the first systematic review of the effectiveness of adaptation measures in enhancing food security during slow-onset catastrophes. The review's implications are substantial, as it offers empirical validation for adaptation strategies that have the potential to alleviate the detrimental effects of gradual-onset catastrophes on food security (Table 2).

This review emphasizes that the aspect of food utilization receives less attention, whereas the focus of adaptation strategies is mostly on the pillars of food availability and food access. Neglecting the food utilization pillar in policymaking can lead to situations where communities have access to food but fail to derive optimal nutritional benefits, which can have long-term health and development consequences (Brandt et al. 2023; Opitz et al. 2016). This review, therefore, calls for a holistic approach to promote nutrition security by developing nutrition education programs, training cooking techniques, and promoting a diversified and balanced diet (Atoloye et al. 2022; Hasan et al. 2019). In addition, additional strategies are required to encourage local people to take proactive measures to ensure food safety. It will be beneficial to implement comprehensive community education and training programs on safe food handling, hygiene practices, and innovative food processing technologies such as solar drying, smoking, and fermenting (Bohm et al. 2022; Campbell et al. 1998; Marrez et al. 2022). Guaranteeing food safety practices, particularly in regions susceptible to slow-onset disasters, is critical for effective food utilization.

Moreover, this systematic review reveals the vital role of traditional edible plant foods in effectively bolstering food utilization in slow-onset disasters (Zhang et al. 2016). Hence, this review calls for the expansion of research in this area, including the exploration of neglected and underutilized species (NUS) as a means to enhance food security during gradual-onset catastrophes. NUS are often rich in essential nutrients, contributing to dietary diversity, combating micronutrient deficiencies, and improving nutritional outcomes (Hunter et al. 2019; Li et al. 2020). Characteristically, NUS are exceptionally adapted to their marginal and adverse local environments (Dansi et al. 2012). Their remarkable adaptability renders them indispensable in the face of gradual-onset catastrophes, as they flourish in conditions where conventional crops might perish (Dansi et al. 2012). In addition, NUS often have deep cultural significance and are linked to the traditional knowledge of local communities (Mugiyo et al. 2021). Researching and promoting these species can aid in preserving cultural practices and indigenous knowledge systems. Furthermore, the promotion of NUS offers tangible economic benefits to local communities, especially smallholder farmers, by diversifying income sources and fostering rural development (Mabhaudhi et al. 2017). As a result, focusing on NUS enhances food sovereignty, empowering communities to maintain resilient local food systems and reinforcing their autonomy and adaptive capacity in the face of gradual-onset catastrophe challenges.

4.3 | Effectiveness of Adaptation Strategies

The effectiveness of adaptation strategies in this review remains an unresolved question. Our findings show that several adaptation strategies within Component 1 demonstrate mixed outcomes (Atube et al. 2022; Ires 2021; Lam et al. 2022). This variability arises from the heterogeneous nature of slow-onset disaster impacts across different regions and communities (Yuan et al. 2022). Policymakers must therefore understand the complex and context-specific aspects inherent in adapting to slow-onset disasters as well as how various strategies can

be tailored and applied in diverse environmental, cultural, and socioeconomic settings. This highlights the need for future research to employ comparative case studies to unravel this complexity (Cheng 2019). Such an approach would allow for an in-depth exploration of how different contexts influence the effectiveness of these strategies, providing critical insights into the conditions under which they are most effective (Saleh et al. 2013). By comparing diverse implementations, researchers can identify key factors contributing to the success or failure of these strategies, offering valuable guidance for policymakers and practitioners (Willis et al. 2016).

The mixed-methods approach utilized in this review is crucial to comprehend the intricate dynamics of double-edged effects adaptation strategies. For example, the strategy of income diversification, often hailed for its economic benefits as evidenced quantitatively, reveals a different narrative when assessed qualitatively, uncovering social repercussions such as gender-based violence (Liru and Heinecken 2021). Similarly, the practice of tree cutting, while quantitatively beneficial for immediate income enhancement, has qualitative implications that manifest as long-term environmental degradation, thereby undermining the sustainability of this adaptation strategy (Liru and Heinecken 2021). These instances underscore the essential need for a holistic approach in future research, one that is intricately informed by the human security theory (UNDP 1994). This theory encompasses a broad spectrum of human well-being, including personal, community, food, economic, health, environmental, and political security, and requires the incorporation of both quantitative and qualitative evidence (UNDP 1994). Such an approach is pivotal in developing sustainable adaptation strategies, ensuring they are effective, viable, and beneficial over the long term, without causing inadvertent harm. The comprehensive insights gained from this mixed-methods review enrich the academic discourse and are instrumental in guiding the development of robust, multifaceted adaptation measures.

In addition, although the paper commendably acknowledges the comprehensive mixed-methods review of strategies for food security adaptation in the context of gradual-onset catastrophes, it simultaneously illuminates a significant gap in the current body of research: the notable absence of Randomized Controlled Trials (RCTs). The absence of RCTs, a methodological cornerstone for establishing cause-and-effect relationships with a high degree of certainty, presents a clear directive for future research (Susser 1991). Incorporating RCTs would provide a level of empirical rigor and control not currently prevalent in the field (Augustinus et al. 2022). This approach would enable researchers to systematically evaluate the true effectiveness of adaptation strategies, offering robust, generalizable evidence that can inform policy and practice.

4.4 | Limitations

There are some limitations that apply to this systematic review. The inclusion criteria primarily focused on published peer-reviewed articles in English, which may introduce publication bias, as relevant unpublished data or studies in other languages were not included. Another potential limitation was the inclusive approach to study selection, wherein all studies fulfilling the eligibility criteria were incorporated, regardless of their methodological quality. This approach raises concerns about the risk of bias and methodological rigor, which are crucial in mixed-methods systematic reviews. To mitigate these concerns, each study underwent a comprehensive assessment using the most recent version of the Mixed Methods Appraisal Tool (MMAT) (Hong et al. 2018). To enhance the review's rigor and promote transparency, a detailed table was constructed to display the MMAT ratings for each criterion of every included study, and this was fully documented in the review.

Moreover, given the mixed-methods nature of this review, there lies a potential challenge in merging findings from diverse research methodologies into a cohesive synthesis (Thompson Coon et al. 2020). To navigate potential complexities during the synthesis and integration phases, established guidelines for mixed-methods systematic reviews were followed throughout the procedure (Stern et al. 2020). Additionally, each team member independently evaluated the overall interpretation of the evidence. The lead author deeply engaged with the entire evidence base, providing thorough reflection and transparent reporting on the integration process, especially when addressing discrepancies between quantitative and qualitative outcomes. This approach ensured a deeper understanding and clearer insights into the collected evidence. In addition, the review team members were strategically designed to include experts from varied research domains, such as quantitative and qualitative research methodologies, mixed-methods systematic reviews, food science, agriculture, evaluation research, and health promotion. The diverse expertise of the team members offered valuable insights and ensured a comprehensive approach, addressing both the content and methodological facets of the review effectively. This interdisciplinary collaboration further guided the review process and contributed to its overall quality and relevance.

5 | Conclusion

The main aim of this systematic review was to comprehensively assess the effectiveness of food security adaptation strategies in response to gradual-onset catastrophes. It uncovered a significant gap in evaluating these strategies, emphasizing the critical need for an evidence-based approach. This systematic review offers an initial, thorough assessment of adaptation strategies to bolster food security during gradual-onset catastrophes. It achieves this by employing a mixed-method approach that combines quantitative and qualitative evidence with a framework-based methodology to understand the multifaceted nature of food security. Most research focused on addressing drought, while other slow-onset disasters were largely neglected. The review highlights effective strategies within the realms of food availability and access, yet underscores a significant lacuna in addressing the critical aspect of food utilization. This gap necessitates a comprehensive approach to mitigating food insecurity, transcending the confines of access and availability to include nutritional, health, and safety considerations. For future research directions, expanding the investigative scope to encompass a broader range of slow-onset disasters is imperative. This expansion should include a thorough exploration of adaptation

strategies across diverse environmental, cultural, and socio-economic contexts. The integration of methodologies such as randomized controlled trials would contribute to a more robust body of evidence. Moreover, incorporating neglected and underutilized species, alongside food safety considerations, could open new pathways for enhancing food security under changing climatic conditions. Finally, adopting a human security theory perspective would provide a more profound understanding of how these strategies can fortify the overall well-being and resilience of communities afflicted by slow-onset disasters.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that supports the findings of this study are available in the Supporting Information of this article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.