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Building Food Resilience Against Floods: A Systematic Review of Absorptive, Adaptive and Transformational Strategies

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Abstract

Food resilience in flood-prone areas is a growing concern due to the increasing frequency and severity of floods caused by climate change. Floods can damage agricultural systems, disrupt supply chains, and lead to food insecurity, especially in vulnerable regions, including developing countries. This study then aims to identify and evaluate strategies to enhance food resilience in flood-prone areas by synthesizing existing research into absorptive, adaptive, and transformational capacities. It also seeks to develop an integrated framework to address short- and long-term food security challenges. A systematic literature review (SLR) was conducted following the PRISMA framework. The Scopus database was used to identify 325 articles published between 2010 and 2024. After a rigorous screening and eligibility process, 38 studies were selected for thematic and scientometric analysis to identify trends, methodologies, and strategies. The findings highlight three key resilience capacities: absorptive, adaptive, and transformational. Absorptive capacity focuses on minimizing immediate impacts through water management and drainage infrastructure. Adaptive capacity emphasizes medium-term adjustments, including diversified crops, Climate-smart agriculture, and improved supply chains. Transformational capacity addresses long-term structural reforms, such as biotechnology applications and integrated farming systems. Combining these strategies offers a holistic approach to building sustainable food systems resilient to floods. Addressing food security in flood-prone areas requires a proactive, multi-dimensional approach that incorporates absorptive, adaptive, and transformational capacities. The integrated framework developed in this study provides insights for policymakers, researchers, and stakeholders to create sustainable and resilient food systems amid climate variability and flood risks.

Keywords: *Food Resilience, Flood Management, Absorptive Capacity, Adaptive Capacity, Transformational Capacity, Systematic Literature Review.*

Introduction

Food resilience in flood-prone areas has emerged as a pressing issue, particularly in the face of increasing climate change impacts. Climate change has intensified the frequency and severity of natural disasters (Handayani et al., 2020), including floods, posing significant challenges to food systems and security (Ani et al., 2022). Food security encompasses the availability, accessibility, stability, and sustainable utilization of food resources (Clapp et al., 2022). Floods threaten these dimensions by damaging infrastructure, disrupting agricultural production, and destabilizing food supply chains, especially in developing countries (Mirzabaev et al., 2023).

In rural regions, particularly in agrarian economies such as Indonesia, floods cause direct damage to crops, leading to losses in agricultural yields and income (Shrestha et al., 2021). Prolonged inundation results in crop failure, while increased pest and disease outbreaks further exacerbate the problem. This not only affects local farmers but also threatens national food supplies. For example, frequent flooding in Indonesia has led to disruptions in transportation infrastructure, hindering food distribution and exacerbating shortages in affected areas.

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Beyond immediate damage, floods have long-term socioeconomic impacts, including price instability caused by reduced agricultural productivity. Food price surges disproportionately affect low-income households, which spend a significant portion of their income on food. Thus, floods present interconnected environmental, economic, and social challenges that compromise food security and community resilience.

While past research has examined the effects of floods on food systems, most studies have focused on isolated aspects, such as post-disaster recovery or crop damage mitigation. However, few studies have explored comprehensive, integrated frameworks addressing resilience across all stages of disaster management. Existing research often prioritizes short-term interventions without accounting for long-term strategies to strengthen systemic resilience. In countries like Indonesia, responses to floods are frequently reactive, focusing on post-disaster recovery efforts, such as infrastructure repairs and food aid, rather than proactive measures, such as early warning systems, adaptive land-use practices, or technological innovations. These reactive approaches are costly and insufficient for building long-term resilience.

Given these challenges, this study aims to fill existing gaps by identifying and evaluating strategies to strengthen food resilience against floods. This systematic literature review synthesizes approaches categorized into absorptive, adaptive, and transformational capacities. Absorptive capacity minimizes immediate impacts, adaptive capacity promotes flexibility through technological and behavioral adjustments, and transformational capacity focuses on long-term structural reforms to build sustainable food systems.

This review also highlights the integration of these approaches to create a holistic framework for flood resilience. It examines strategies implemented across different geographical contexts to assess their effectiveness and scalability. Ultimately, the findings aim to inform policymakers, researchers, and practitioners in designing sustainable and proactive solutions to address food security challenges in flood-prone regions worldwide.

This paper is structured as follows: Section 2 outlines the methodology used in conducting this SLR, including data collection, screening, and analysis techniques. Section 3 presents the findings, focusing on the geographical distribution of studies, key strategies, and resilience frameworks. Section 4 provides a detailed discussion on the integration of absorptive, adaptive, and transformational strategies, emphasizing their role in building flood resilience. Section 5 concludes the paper by summarizing key insights and highlighting future research directions.

Methodology

This systematic literature review (SLR) is structured based on the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) framework, which involves four main stages—identification, screening, eligibility assessment, and inclusion (Moher et al., 2010). A thorough search was conducted using the Scopus database, widely recognized for its extensive repository of high-quality academic literature (Abrizah et al., 2013; Mongeon & Paul-Hus, 2016; Talwar et al., 2021). The search utilized keywords such as "food," "flood," and "resilient" or "resilience" to capture relevant studies, ensuring variations of related terms were included.

To ensure reliability, all selected sources underwent a validation process. Peer-reviewed articles were prioritized to maintain academic rigor. The relevance and credibility of each source were assessed based on journal impact factors, citation counts, and alignment with the research objectives. Additionally, studies with explicit methodologies and clear frameworks for analysis were given preference. To maintain quality and relevance, the inclusion criteria targeted peer-reviewed articles published between 2010 and 2024, focusing on food systems, resilience strategies, and flood impacts, and written in English. Materials excluded from the review included conference proceedings, book chapters, and non-English publications.

The initial search retrieved 325 articles. Following a screening process based on titles and abstracts, 79 articles were selected as meeting the inclusion criteria, specifically addressing food resilience strategies

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related to floods. Studies such as Khan et al. (2021), which primarily discussed vulnerability mapping without proposing practical solutions, were excluded. The eligibility phase involved an in-depth review of full texts to confirm that the studies directly contributed to food resilience strategies, ultimately narrowing the selection to 38 articles for synthesis (see Figure 1).

In analyzing and presenting the collected articles, both science mapping and qualitative approaches were applied. Scientometric analyses were employed as part of the science mapping approach to identify patterns, trends, and research clusters within the selected studies. Meanwhile, the qualitative approach classified the articles based on their level of analysis, research methods, geographic focus, and the types of resilience strategies discussed. Special attention was given to evaluating the role and effectiveness of socio-economic, infrastructural, and technological interventions in enhancing food system resilience. This dual approach allowed for a comprehensive assessment of both quantitative trends and qualitative insights within the reviewed literature.

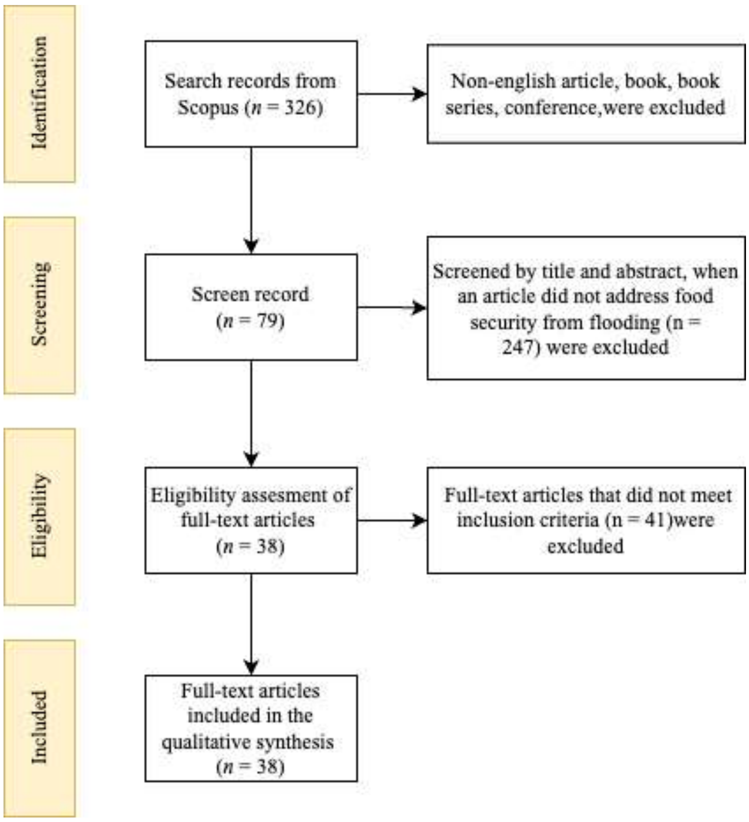

Figure 1. Result of the PRISMA Framework

Results

Descriptive Statistics

Figure 2 shows publication trends, starting with one article each in 2006, 2010, 2012, and 2016. A gradual increase occurred in 2014, 2015, and 2020, with two articles published each year. Publications continued to rise with three articles in 2021, 2022, and 2023, and peaked in 2024 with nine articles. This trend reflects the growing academic response to food resilience strategies influenced by climate change during these years. Trends revealed a notable increase in publications, peaking in 2024 with nine articles. This surge highlights growing academic attention to climate change impacts, particularly after 2023 was recorded as the hottest year globally since 1850, which exacerbated extreme weather events, including floods (Zhang et al., 2024).

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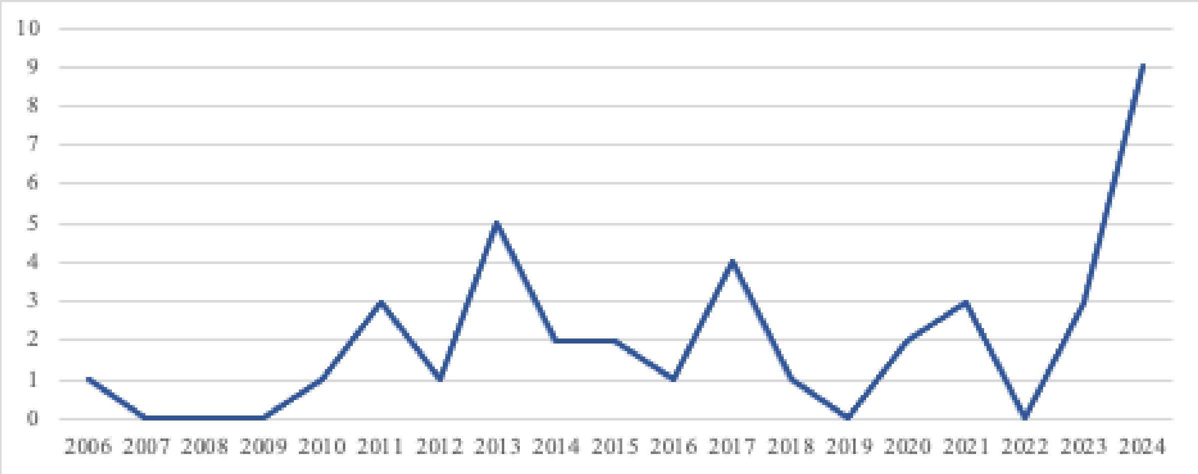

Figure 2. Number of Articles Per Year

A total of 29 scientific journals were identified as relevant sources for this research area. As illustrated in Figure 3, the journals contributing the most were Regional Environmental Change, Cogent Food and Agriculture, Jamba: Journal of Disaster Risk Studies, International Journal of Disaster Risk Reduction, Heliyon, and Frontiers in Sustainable Food Systems, each publishing two articles. The remaining 25 journals contributed one article each. This distribution highlights the interdisciplinary nature of the research, encompassing disaster risk reduction, food systems, sustainability, and climate adaptation.

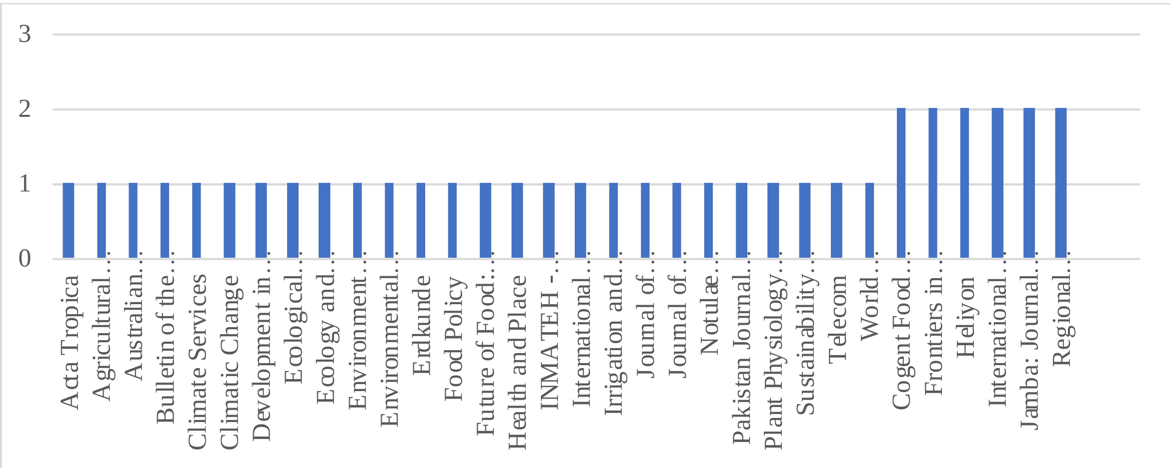

Figure 3. Number of Top Published Journals

Geographical Context

The extracted articles cover various regions that face significant challenges due to flooding. The primary focus is on Bangladesh, which accounts for four studies, highlighting its high vulnerability to floods and the challenges it faces in ensuring food security. Additionally, regions such as South Africa, Australia, China, Ghana, Kenya, Vietnam, and Zimbabwe are each represented by two studies, emphasizing the particular attention given to developing countries in Africa and Asia that are prone to climate change and flood-related impacts.

Studies in areas such as Amazonia, Southeast Asia, Botswana, Ecuador, Ethiopia, Gambia, India, the United Kingdom, Ireland, Cambodia, South Korea, Pakistan, Tanzania, Thailand, and Zambia are each represented by one study. While these regions have fewer studies, they demonstrate localized strategies for addressing food security challenges caused by floods. Examples include crop diversification, the adoption of Climate-Smart Agriculture technologies, and the construction of adaptive infrastructure.

In addition, six studies focus on a global scale, providing broader perspectives and innovative solutions to address food system vulnerabilities globally. Global studies often emphasize integrative approaches, such as Integrated Land and Water Management and enhancing community resilience capacity. The diversity of regions covered in the literature reflects the universal nature of food security challenges caused by floods, yet highlights the need for context-specific strategies based on local policies, geographical conditions, and socio-economic factors. These findings reinforce the necessity for flexible and adaptive solutions to address flood-related threats to food security worldwide.

Keywords Co-occurrence

Next, we used VOSViewer to visualize keywords co-occurrence analysis (see Figure 4), aiming to map the co-occurred keywords and group them into several research clusters. It is performed to explain the structure and internal composition of the research domain as well as to reveal the frontier (Hu et al., 2019). The map can be used to elucidate the knowledge structure of the research theme and it might help to identify the potential research opportunities in the future. Several clusters are derived; the key clusters are discussed as the following.

The green cluster (namely, adaptation, vulnerability, and food security) highlights adaptation strategies, vulnerability, and food security as focal themes. Keywords like adaptation emphasize its role as a cornerstone for improving food resilience in flood-prone areas. Adaptation strategies involve modifying agricultural systems, adopting advanced production techniques, and implementing policies to address flood impacts driven by climate change. The link between adaptation and food insecurity underscores the importance of ensuring food availability and accessibility to stabilize food systems during disruptions caused by floods. The keyword vulnerability reflects the sensitivity of food systems to floods, including declines in food quality due to soil degradation and crop damage. Connections to climatic risks highlight the need for effective risk management strategies to minimize losses. Local adaptation practices, such as Molapo farming, leverage fertile post-flood soils to boost agricultural productivity. This practice exemplifies how localized approaches can mitigate farmer vulnerabilities and promote sustainable food resilience.

The red cluster (namely, flood risks, fisheries, and environmental management) focuses on flood risks, fisheries, and environmental management. Keywords such as floods and risk assessment emphasize the importance of understanding and mitigating flood risks, particularly within fisheries and related ecosystems. Fisheries are crucial yet vulnerable food sources affected by infrastructure damage, fish losses, and altered water conditions caused by floods. Adaptation strategies include developing flood-resistant hatcheries and managing adaptive fish species like Oreochromis niloticus to mitigate risks. Keywords such as climatology, air temperature, and climate-related risks highlight the interconnectedness of climate variability, flood frequency, and food production stability. This cluster advocates for integrated approaches, such as flood-resistant aquaculture, adaptive fish management, and operational planning, to enhance resilience in the fisheries sector.

The orange cluster (namely, smart agriculture and innovative technologies) emphasizes the role of smart technologies and innovative approaches in addressing the impacts of climate change and floods. Central keywords such as climate smart agriculture and internet of things indicate that smart agricultural technologies are primary solutions for improving food productivity and mitigating climate risks. Climate smart agriculture integrates concepts such as agriculture and environmental science, agricultural development, and climate smart villages, which illustrate the combination of technology and environmental management to create resilient agricultural systems. Connections to keywords like agroforestry and environmental benefits highlight integrative approaches that combine farming practices with environmental protection, preserving land productivity while delivering ecosystem benefits. The study emphasizes that applying smart technologies in agriculture helps farmers adapt to climate change and flood risks while improving production efficiency and reducing vulnerability to disasters. Overall, the orange cluster underscores the importance of modern technologies and data-driven approaches in creating intelligent,

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adaptive, and sustainable agricultural systems. The integration of technologies such as the internet of things, climate smart villages, and agroforestry practices is key to achieving food resilience amid global challenges, including climate change-induced flooding.

The blue cluster (namely, perceptions and coping strategies) addresses perceptions, adaptation strategies, and environmental factors. Keywords such as perception, environmental factor, natural disaster, and coping strategy emphasize the importance of public understanding of floods and the strategies implemented to mitigate their impacts.

The yellow cluster (namely, food security and resilience) focuses on food security, floods, and resilience. Keywords such as social capital, food systems, and climate shocks highlight the importance of holistic disaster management approaches. This cluster also links floods with changes in global food systems and efforts to build social resilience through social capital utilization and disaster management strategies.

The purple cluster (namely, agricultural research and food production) relates to agricultural research and food production affected by floods. Keywords such as food supply, agricultural research, crop yield, and sub-Saharan Africa reflect the importance of scientific research in developing flood-resistant farming methods and practices. This focus also addresses the challenges faced by developing countries in maintaining stable food production amid climate change threats.

The pink cluster (genetic innovations and biotechnology) focuses on agricultural production innovations and genetic technologies. Keywords such as CRISPR, crops, and agriculture greenhouse emphasize the role of advanced technologies in developing flood-resistant and climate-resilient crop varieties. This approach highlights the importance of biotechnology innovation in supporting global food resilience in disaster-prone areas.

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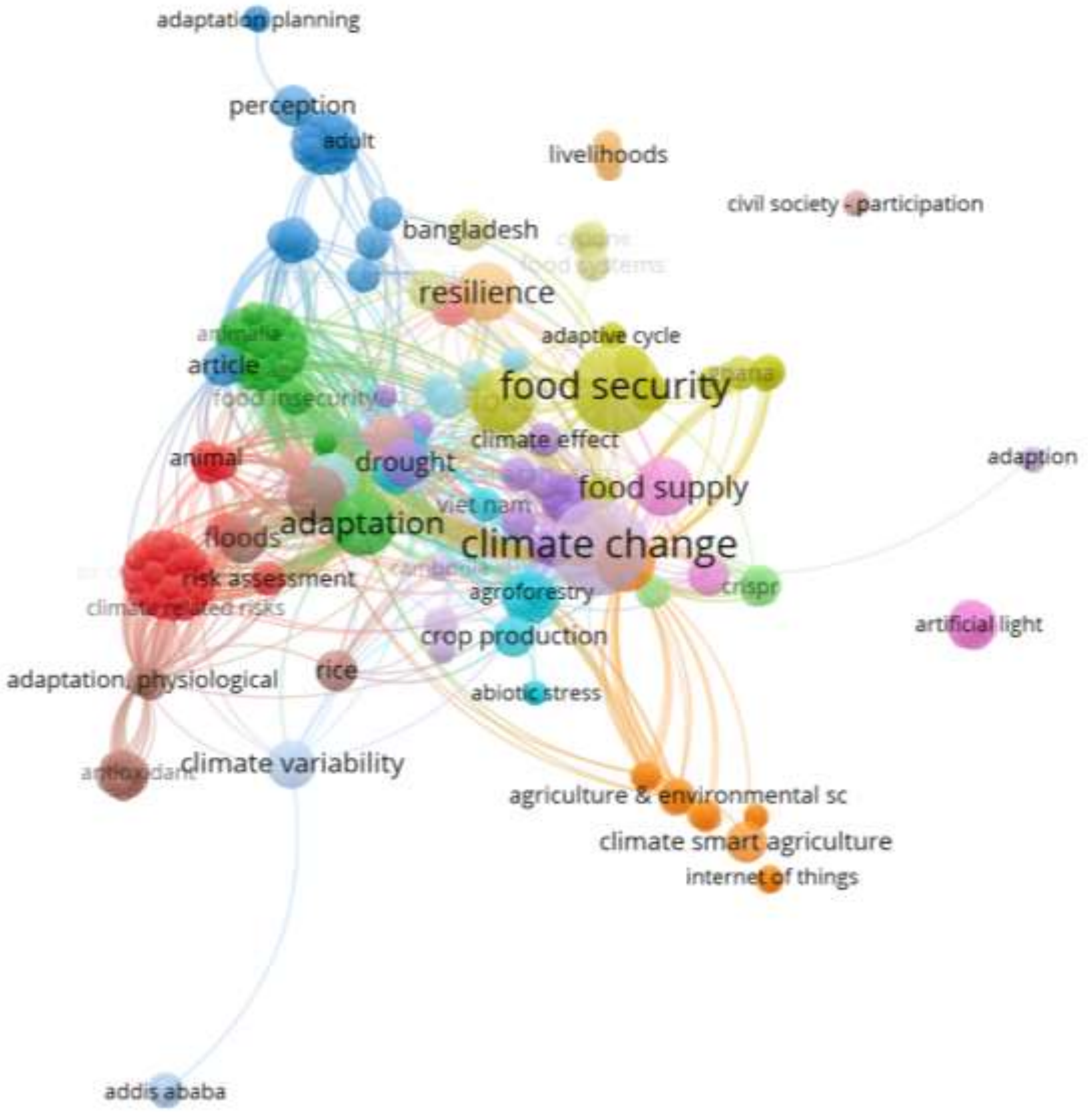

Figure 4. Keywords Co-Occurrence Network

Discussion

Food security in flood-prone areas remains a critical issue, particularly as climate change continues to increase the frequency and intensity of floods (Nguyen et al., 2023). Flooding not only damages infrastructure and agricultural lands but also disrupts food availability, accessibility, and stability (Sam et al., 2021). Comprehensive strategies are crucial to mitigating flood impacts, adapting food systems to changing conditions, and restoring resilience after disasters (Han & Kasperson, 2011; MacMahon et al., 2015). These strategies must incorporate technical, social, and policy-oriented approaches that can be applied across multiple scales, from local communities to national frameworks.

Resilience strategies are often categorized into three primary capacities—absorptive, adaptive, and transformational (Smith & Frankenberger, 2018). Articles in this SLR in which implemented the particular strategy are shown in Table 1.

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Table 1. Resilience Strategies from the SLR

Article	Absorptive Capacity	Adaptive Capacity	Transformational Capacity
Fraser (2006)		✓	
Ray-Bennett et al. (2010)			✓
Barker & Turner (2011)			✓
Han & Kasperson (2011)	✓		
Codjoe & Owusu (2011)			✓
Swaminathan & Kesavan (2012)		✓	
Ashraf et al. (2013)			✓
Nguyen et al. (2013)		✓	✓
Ahmed et al. (2013)		✓	
Nguyen & James (2013)		✓	
Keck & Etzold (2013)		✓	
Xiao et al. (2014)		✓	✓
Moench (2014)	✓	✓	
MacMahon et al. (2015)	✓		
Uppanunchai et al. (2015)	✓	✓	
Kruger (2016)		✓	
Mavhura (2017a)		✓	
Ngwenya et al. (2017)		✓	
Olaniyan (2017)		✓	
Mavhura (2017b)			✓
Smith & Frankenberger (2018)	✓	✓	
Bairagi et al. (2020)		✓	
Alhassan (2020)		✓	
Liru & Heinecken (2021)		✓	
Da Cunha Ávila et al. (2021)		✓	✓
Kakamoukas et al.(2021)		✓	
Ferdushi et al. (2023)	✓	✓	
Alotaibi (2023)		✓	
Murphy et al. (2023)		✓	
Njogu et al. (2024)	✓	✓	
Ringeisen et al. (2024)		✓	
Mwakyusa et al. (2024)		✓	
Degefu & Kifle (2024)		✓	
Galarza-Villamar et al. (2024)		✓	
Basu et al. (2024)		✓	
Akpa (2024)		✓	
Găgeanu et al. (2024)		✓	
Maulu et al. (2024)		✓	

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Absorptive capacity focuses on minimizing immediate risks, such as land damage and crop losses, while promoting rapid recovery. Pre-flood mitigation measures, including water catchment management and drainage infrastructure, are essential to safeguarding agricultural productivity and reducing flood-related impacts (Njogu et al., 2024). Collaborative efforts between governments, local communities, and private sectors also strengthen supply chains and ensure emergency food distribution during crises (MacMahon et al., 2015).

Adaptive capacity emphasizes adjustments to reduce vulnerabilities through technologies, information, and diversification strategies. For example, Climate-Smart Agriculture (CSA) integrates agroforestry, crop diversification, and flood-tolerant crops to enhance resilience (Degefu & Kifle, 2024; Valenzuela et al., 2023). Urban strategies, such as flexible food networks in cities like Dhaka, along with voluntary resource-sharing practices among households, further reinforce adaptability during floods (Keck & Etzold, 2013; Galarza-Villamar et al., 2024). For instance, farmers in Kakamega County have adopted crop diversification by planting maize, beans, and cassava to minimize risks from floods or droughts (Liru & Heinecken, 2021).

Transformational capacity focuses on long-term structural changes, including biotechnology developments like CRISPR to create flood-resistant crops (Ahmed et al., 2013; Ringeisen et al., 2024) and mixed farming systems integrating crops and livestock to sustain productivity (Kakamoukas et al., 2021). Flood-resistant aquaculture, involving adaptive fish species and resilient hatcheries, ensures stable protein sources during crises (Uppanunchai et al., 2015). Biodiversity conservation, including seed banks and floating storage systems, further safeguards food security by protecting genetic resources (Swaminathan & Kesavan, 2012). Integrative approaches, such as basin-level water and land management, highlight the importance of cross-sectoral collaboration to address flood-related risks effectively. These approaches emphasize sustainable practices, including wetland restoration and soil management, to build resilience while supporting agricultural productivity (Barker & Turner, 2011).

Finally, we propose the integration of absorptive, adaptive, and transformational strategies which provides a holistic framework for building flood resilience. Combining short-term mitigation, medium-term adjustments, and long-term structural changes ensures flexibility and sustainability. For example, absorptive measures stabilize immediate conditions, adaptive strategies refine practices, and transformational actions create future-proof systems. This integrated approach strengthens food security against floods through comprehensive interventions.

Figure 5 depicts the conceptual diagram which illustrates an integrated framework for enhancing food resilience against floods, emphasizing the interaction between three key capacities—absorptive, adaptive, and transformational—connected through a central integrated approach. The absorptive capacity, represented in the outermost layer, focuses on immediate measures to minimize the impact of floods and ensure rapid recovery. It highlights strategies such as water catchment management, drainage systems, and emergency food storage to protect agricultural lands and preserve food supplies during crises. These interventions act as the first line of defense, stabilizing the food system in the short term.

The next layer, adaptive capacity, builds upon absorptive strategies by introducing medium-term solutions to enhance flexibility and preparedness. It emphasizes Climate-Smart Agriculture practices, crop diversification, and flexible food networks, enabling farmers to adjust their production systems to cope with recurring floods and changing climate patterns. Examples include agroforestry, flood-tolerant crop varieties, and urban food networks that improve access to resources during disruptions. This capacity allows communities to sustain food production while reducing vulnerabilities to future flood events.

At the core of the diagram is the transformational capacity, which focuses on long-term structural changes that create sustainable and climate-resilient food systems. It incorporates biotechnology innovations, such as CRISPR-modified crops, flood-resistant aquaculture, and mixed farming systems that integrate livestock and crop production. These transformational strategies enable farmers to adapt to extreme climate conditions and develop robust agricultural practices that ensure food security in the face of persistent flood risks.

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The integrated approach, represented at the center of the framework, connects the three capacities through arrows, demonstrating their dynamic interaction and complementarity. This approach emphasizes that absorptive strategies stabilize immediate conditions, adaptive practices refine responses, and transformational measures build long-term resilience. By integrating these strategies, the framework provides a holistic model for addressing food security challenges caused by floods, ensuring sustainable production systems, and reducing vulnerabilities over time. Visual elements, including crops, water infrastructure, and fish farming, reinforce the practical applications of each capacity, making the framework both visually engaging and conceptually comprehensive.

Figure 5. Resilience Capacity Framework

Conclusion

Food resilience in flood-prone areas is an increasingly urgent issue as climate change continues to amplify the frequency and severity of floods. Flooding damages infrastructure, disrupts food production, and threatens food availability, accessibility, and stability. Therefore, comprehensive mitigation strategies

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incorporating technical, social, and policy-driven approaches are essential to minimize impacts, adapt systems to climate variability, and restore post-disaster resilience.

Effective resilience strategies focus on three key capacities—absorptive, adaptive, and transformational. Absorptive capacity minimizes immediate impacts through water catchment management, drainage infrastructure, and emergency food storage. Adaptive capacity facilitates adjustments using technologies, diversified crops, and Climate-Smart Agriculture to address medium-term risks. Transformational capacity promotes long-term structural changes, such as biotechnology (e.g., CRISPR-modified crops), flood-resistant aquaculture, and integrated farming systems.

Beyond agriculture, the fisheries sector must also adopt flood-resilient practices, including infrastructure upgrades and adaptive fish species to withstand floods. Mixed farming systems that integrate crops, livestock, and aquaculture can further enhance resilience by offering diverse income streams and food sources. Collaboration among governments, communities, and stakeholders plays a pivotal role in building robust and sustainable systems. Additionally, biodiversity conservation and genetic engineering innovations offer tools for developing flood-tolerant crops, ensuring food security under changing climatic conditions. Overall, this framework not only mitigates immediate flood impacts but also strengthens long-term adaptability and resilience. Through cross-sector collaboration and technological innovation, food systems in flood-prone areas can achieve greater sustainability and stability.

Future research should focus on scaling up these strategies, testing their effectiveness in diverse contexts, and advancing technologies to ensure food security in the face of growing climate challenges.

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