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THE VULNERABILITY OF SMALLHOLDER FARMERS TO FLOODING, POVERTY, AND COPING STRATEGIES: A SYSTEMATIC REVIEW

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ABSTRACT

Flooding is a severe climate-related threat to rural livelihoods and poverty levels in Low and Middle-Income Countries (LMICs), particularly affecting vulnerable smallholder farmers. This systematic review aims to provide future research directions on the vulnerability of smallholder farmers to flooding, poverty, and coping strategies in LMICs. Specifically, the study evaluates methodologies used to assess vulnerability to flooding, its links to poverty, and identifies coping strategies employed by smallholder farmers to mitigate the impacts of flood-induced vulnerability on their livelihoods and well-being. Following the PRISMA procedure, 19 relevant studies were identified across five database searches. The findings revealed the wide use of vulnerability indices that incorporate exposure, sensitivity, and adaptive capacity to assess varying risks across localities and social groups, with strong links found between vulnerability and multidimensional poverty. Floods worsen income poverty, food insecurity, and socioeconomic inefficiency, hindering Sustainable Development Goals (SDGs) 1 and 2 progress. Common coping strategies include livelihood diversification, social capital networks, migration, loans, asset liquidation, and disaster aid, which help mitigate shocks but need strengthening to contribute to SDGs 13 and 15 targets. Key evidence gaps are individual-level/farmer vulnerability, quantitative modelling of flood-poverty linkages, assessing the impact of coping strategies on poverty, and understanding Indigenous practices. Strengthening the adaptation-development linkage through comprehensive interventions and research collaborations is crucial for enhancing farmer resilience. This review provides valuable insights for researchers and stakeholders to advance conceptual understanding and inform policies aimed at reducing the climatic and socioeconomic vulnerabilities of farmers.

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INTRODUCTION

Flooding is a significant climate-related threat, worsening livelihood challenges and poverty levels, particularly in Low-and-Middle-Income Countries (LMICs). The direct and indirect pressures exerted by floods on these vulnerable populations have far-reaching socioeconomic implications, causing asset erosion, savings depletion, injury, death, and food insecurity (Ahmad *et al.*, 2023; Ahmad *et*

al., 2020; Karim *et al.*, 2017; Parvin, 2016). This phenomenon hinders the achievement of the United Nations Development Programme (UNDP) on Sustainable Development Goals, which aim to eradicate poverty, and hunger, and promote decent work for all (UNDP, 2024; Ibrahim, 2023).

Despite the growing recognition of the interplay between flooding, vulnerability, poverty, and coping mechanisms, the existing literature remains limited, highlighting the need for localized research and interventions (Few, 2003; Danraka, 2024). Vulnerability assessments and evidence-based policies are crucial for enhancing the adaptation and resilience of smallholder farmers to climate-related risks (Ahmad *et al.*, 2023; Maganga et al., 2021; Rana et al., 2023; Zeleke *et al.*, 2021). However, there is an inadequacy of quantitative models explaining the relationships between floods and poverty, differences in vulnerability at individual levels and across diverse social groups, and assessments of coping strategies in the small farm industry (Ahmad *et al.*, 2022). Furthermore, conceptual frameworks like the vicious cycle of vulnerability shown in Figure 1, which incorporates both socioeconomic and biophysical aspects, are rarely incorporated into empirical research (IPCC, 2007). This systematic review aims to provide future research directions on the vulnerability of smallholder farmers to flooding, poverty, and coping strategies in LMICs. Specifically, the review seeks to :

- Examine the methodologies used in prior studies to assess vulnerability to flooding and its links to poverty.
- Identify the coping strategies employed by smallholder farmers to reduce the impacts of flood-induced vulnerability on their livelihoods and well-being.

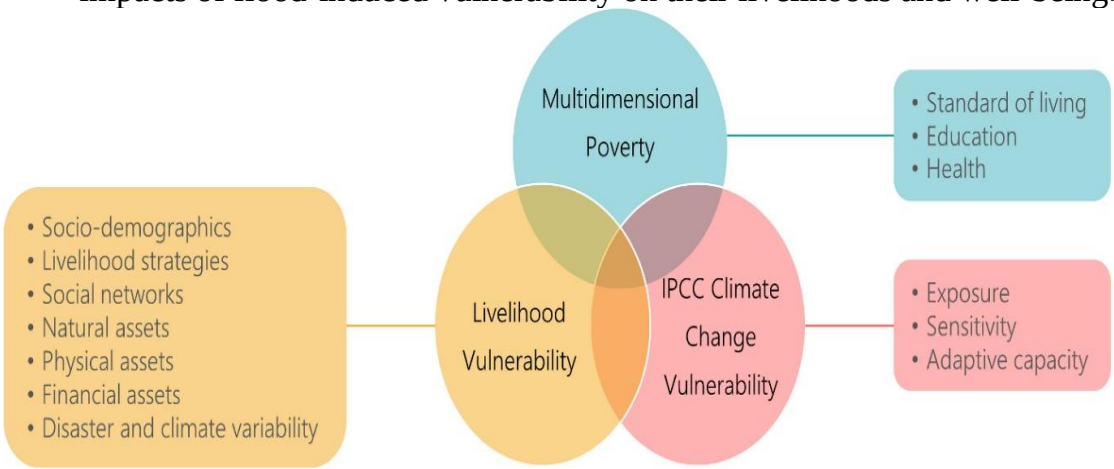

Figure (1): Vicious cycle of vulnerability associated with livelihood.

MATERIALS AND METHODS

Identification/Search strategy

Five databases (ScienceDirect, JSTOR, Wiley, SpringerLink, and Scopus) as shown in Table (1) were searched for peer-reviewed studies on smallholder farmer vulnerability, poverty and coping strategies related to flooding. The systematic review was conducted by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) procedure (Moher et al., 2009; Liberti et al.

2009). A protocol was developed for the study. Search terms combined “flooding”, “vulnerability”, “poverty” and “coping strategies” related terms with “smallholder” or “small farm” descriptors. The papers searched were only published research journals in the English language from 2010 to 2023. According to Okoli (2015), a researcher can only review articles written in easily understood languages, so the study's language choice was restricted to English. The search yielded 307 relevant research articles out of many from the five databases, 44 duplicates were removed from the list. Consequently, a total of 263 research articles were moved to Mendeley reference software for the screening phase.

Table (1): Keywords Search strings in the international database (2010-2023)

Source	String	Relevant Articles
ScienceDirect	TITLE-ABS-KEY Smallholder Farmer Vulnerability to Flooding AND poverty	43
JSTOR	TITLE-ABS-KEY (((Smallholder farmers vulnerability to flooding) AND (poverty, coping strategies)) OR (flood induced poverty, Vulnerability, flood shock, Resilience, Coping strategies, Climate change Adaptation))	19
Wiley	TITLE-ABS-KEY Smallholder farmers vulnerability to flooding and poverty AND OR Coping strategies OR flood induced AND poverty OR Vulnerability OR flood shock OR Resilience OR Climate change Adaptation	12
SpringerLink	TITLE-ABS-KEY Smallholder farmers vulnerability to flooding and poverty AND OR Coping strategies OR flood induced AND poverty OR Vulnerability OR flood shock OR Resilience OR Climate change Adaptation	218
Scopus	TITLE-ABS-KEY vulnerability, AND flood, AND poverty AND coping AND strategies	15

Source: Authors, 2024

Screening

The 263 research articles moved to Mendeley reference software in the Identification/Search strategy phase were screened in line with the research objective of this study (Keele, 2007) and journal within the fields of social sciences, environmental science, biological and agricultural sciences, and risk management. 109 research articles were screened out while 154 articles passed the screening phase.

Eligibility criteria

This stage involves examining articles relevant to this study. The researcher examined the eligibility of the 154 articles using the title, abstract, findings, and discussions of the retrieved articles, ultimately excluding 91 articles that are not in line with the study's focus on “smallholder farmer vulnerability to flooding and poverty”, “coping strategies employed” "flooding", "vulnerability", "poverty", "coping strategies", "climate change vulnerability", "flood hazard vulnerability", "food security", as well as "resilience of farming households to flood shocks" in

developing and underdeveloped countries. Quantitative and qualitative research designs were eligible for inclusion, while commentaries, conference papers, and dissertations were excluded. 63 articles were selected to undergo a comprehensive quality assessment.

Inclusion/data extraction

Full texts of the remaining 63 studies were assessed, with 44 studies excluded for reasons shown in Figure (2). Finally, 19 studies met all inclusion criteria as shown in Table 1 and were included in the review synthesis. Data extracted included year, author, title, country, vulnerability analysis method, poverty analysis method, coping strategies employed and findings of the study.

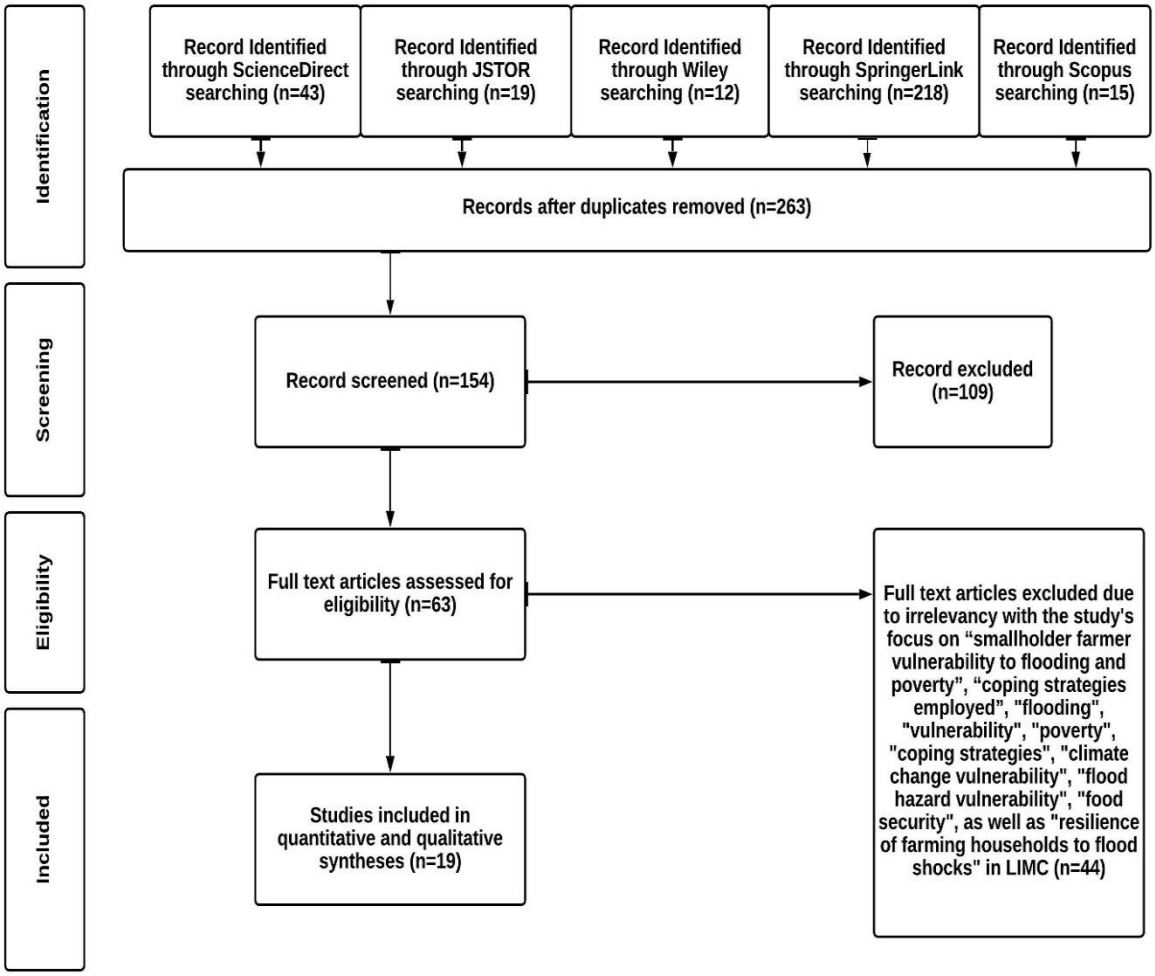

Figure (2): The PRISMA Flow Diagram

Source: Adopted from PRISMA Flow chart

Synthesis

The extracted data were analyzed to synthesize the evidence and identify gaps across three thematic areas: vulnerability assessments, poverty status, and coping strategies employed by vulnerable smallholder farmers.

Table (2): Summary of included studies

Year	Authors	Country	Vulnerability and Poverty Analysis	Coping Strategies
2012	Gentle and Maraseni	Nepal	Climate Vulnerability and Capacity Analysis (CVCA) Participatory wellbeing ranking	Withdrawal of children from school for labour work, selling of assets, selling labour in local community and seasonal migration, Crop diversification, storage of grains, cash saving, purchasing irrigated land, money lending, accessing new agricultural technologies and crop varieties, livelihood diversification
2015	Antwi *et al.*	Ghana	Total Community Vulnerability Assessment	-
2017	Mahanta and Das	India	Vulnerability as expected poverty (VEP) Poverty line	Borrowing from banks, village banking, microfinance institutions, and receiving monetary help from relatives, selling livestock, working as daily wage earners, receiving government relief
2017	Karim *et al.*	Bangladesh	Poverty line	Shelter to safe place during floods, Storage of dry food, Flood/drought tolerant crop varieties, Diversification to off-farm activities, Migration to cities, Floating vegetable gardens, Riverbank protection using sandbag
2018	Ayinde *et al.*	Nigeria	Vulnerability index	Doing nothing and trusting in God and Engaging in small-scale irrigation
2018	Derick *et al.*	Ghana	Livelihood Vulnerability Index (LVI)	-
2018	Thang	Vietnam	vulnerability as expected poverty Headcount ratio	-
2019	Jamshidi *et al*.	Iran	Household Vulnerability Index (HVI) poverty line	Changing cropping patterns and switching to less water intensive crops, utilizing modern irrigation systems like low pressure and tape irrigation, Planting drought resistant crop varieties, utilizing expert advice to manage water resources efficiently
2020	Fatoki *et al.*	Nigeria	Principal Component Analysis (PCA	integrated rural development scheme
2020	Salvucci and Santos	Mozambique	difference-in-difference approach household consumption	-
2021	Maganga *et al.*	Malawi	vulnerability to expected poverty (VEP) mixed-effects probit model	Livestock ownership and Diversification
2021	Jalal *et al.*	Bangladesh	Integrated household vulnerability vulnerability to poverty	Diversification of income sources, Mixed farming, Adoption of salinity-tolerant crop varieties, Floating gardening, and Migration to urban areas
2021	Oskorouchi and Sousa-Poza	Afghanistan	Two-stage least squares (2SLS) Consumption-based	Reducing diet quality, reducing food quantity, or skipping meals, purchasing food on credit from traders, taking out loans, receiving help from others in the community, Selling asset
2021	Zeleke *et al.*	Ethiopia	Vulnerability as expected poverty (VEP)	Selling livestock, Using credit. Participating in the productive safety net program (PSNP), Selling charcoal and firewood, Temporary migration to search for additional income-generating activities
2022	Ahmad *et al.*	Pakistan	Livelihood Vulnerability Index (LVI) and Climate Vulnerability Index (CVI) Poverty line	diversifying income sources, improving infrastructure, and increasing awareness and training

2022	Tran *et al.*	Vietnam	livelihood vulnerability index (LVI)	input subsidies, effective irrigation systems, training, and consultant services
2023	Ahamd *et al.*	Pakistan	Livelihood and climate change vulnerability indices multidimensional poverty index	
2023	Yesuph *et al.*	Ethiopia	descriptive statistics, t-tests, chi-square tests, and parametric tests multidimensional poverty	Weather-indexed insurance, women empowerment, climate change adaptation strategies
2023	Rana *et al.*	Pakistan	Livelihood Vulnerability Index (LVI) Multidimensional Poverty Index (MPI)	education, awareness campaigns about climate change, early warning systems, crop insurance, and addressing rural-urban

Source: Author's summary of reviews, 2024.

The studies were critically evaluated for conceptual and methodological consistency based on the suitability of the research design, relevance of indicators used, reliability of measurement techniques, consistency in analytical approaches, and limitations. The synthesis considered variations in vulnerability, poverty levels, and coping mechanisms across different locations, scales, and socioeconomic characteristics as shown in Table 2. Through a narrative integration approach, the review synthesized the existing evidence, identified key evidence gaps, highlighted areas requiring further research, and derived policy implications.

RESULTS AND DISCUSSION

The 19 studies meeting inclusion criteria were conducted in the 2010-2023 period, with 4 in 2021 highlighting growing research interest as shown in Figure (3_. In terms of geographic scope, Figure (4) shows that, with three research articles, Pakistan has the highest frequency (15.79% of the total). Vietnam, Bangladesh, Nigeria, Ghana, and Ethiopia have 2 research articles each (10.53% each). The remaining LIMCs, which are Afghanistan, India, Nepal, Malawi, Mozambique, Iran, and Afghanistan, all have 1 research article (5.26% each).

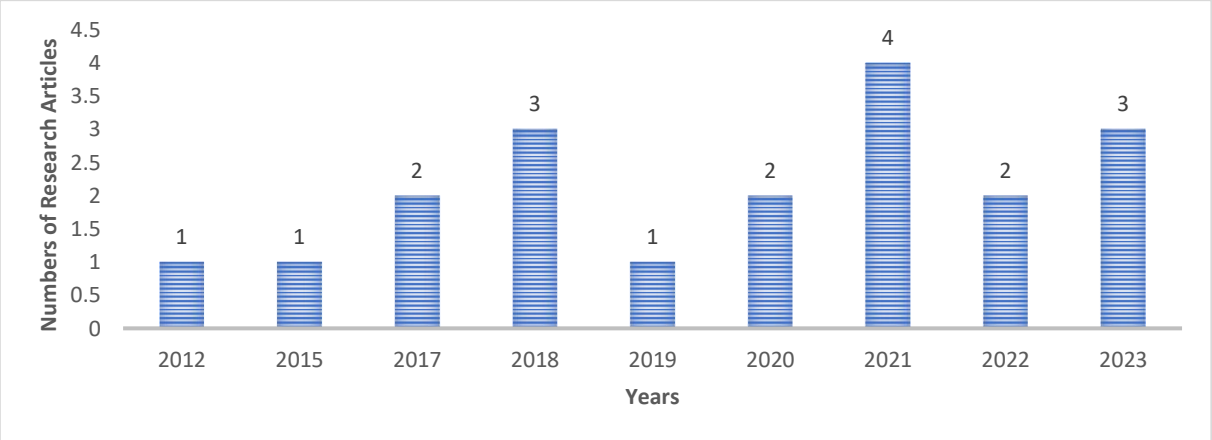

Figure (3): Research studies trends over the years

Source: Authors, 2024

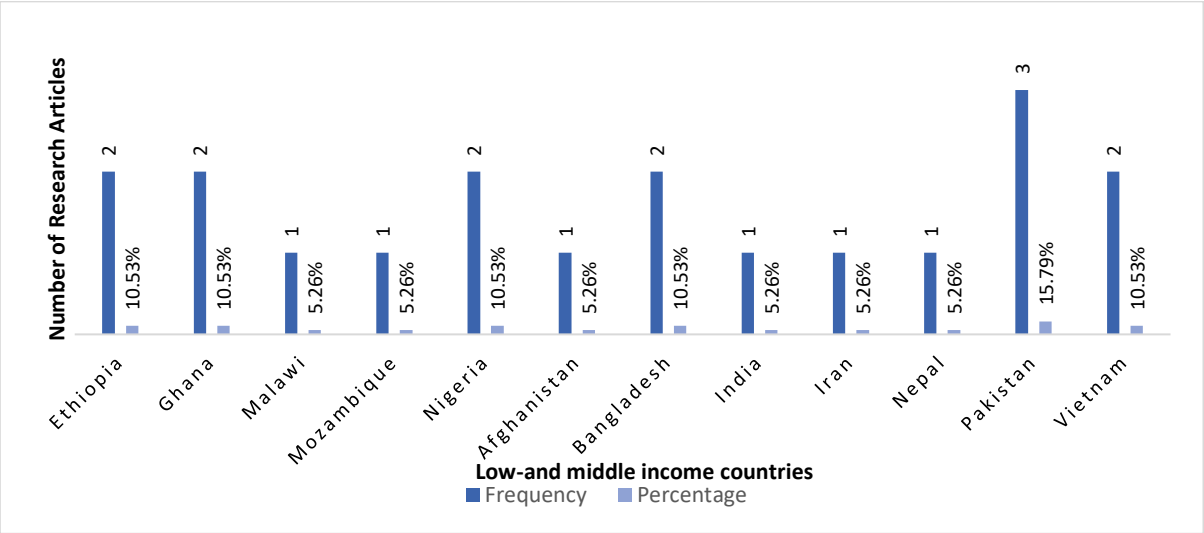

Figure (4): Research studies' geographical scope

Source: Authors, 2024

Most assessed vulnerability at the household level, with only two examining the individual level. Studies employed a range of designs from cross-sectional surveys, case studies, econometric modelling, household vulnerability index, and multidimensional index to mapping and spatial analysis. However, farmer vulnerability index and mixed methods approaches were rare.

Vulnerability assessments

Vulnerability Indices

Vulnerability assessments often employ composite indices that combine indicators of exposure, sensitivity, and adaptive capacity into a single metric, following the Intergovernmental Panel on Climate Change framework (Ahmad *et al.*, 2023; Rana *et al.*, 2023; Tran *et al.*, 2022; Derick *et al.*, 2018). The Livelihood Vulnerability Index (LVI) evaluates various dimensions, including socio-demographic profiles, livelihood strategies, social networks, health, food security, water access, exposure to natural disasters, and climate variability. The Climate Vulnerability Index (CVI) specifically gauges vulnerability by focusing on exposure to climate hazards, sensitivity to impacts, and adaptive capacity. Ahmad et al. (2022) employed the CVI, using indicators such as the degree of exposure, sensitivity, and adaptive capacity, measured through primary and secondary data sources, which are then normalized, weighted, and aggregated into an overall score.

Econometric Models

Econometric models employed in vulnerability assessments include Vulnerability as Expected Poverty (VEP) approach, which predicts the likelihood of households falling into poverty based on their current characteristics and exposure to shocks (Maganga *et al.*, 2021; Zeleke *et al.*, 2021; Mahanta and Das, 2017). Regression models, such as probit and beta regressions, are used to identify factors influencing climate change-induced poverty and determinants of vulnerability (Yesuph *et al.*, 2023; Tran *et al.*, 2022). Additionally, instrumental variable

approaches like Two-Stage Least Squares (2SLS) are employed to address potential endogeneity issues, as in Oskorouchi and Sousa-Poza's (2021) study estimating the impact of floods on food security and coping strategies.

Descriptive and Participatory Methods

Measure of central tendency, dispersion, and inferential tests (t-tests, chi-square, PCA) are used to analyze vulnerability and its determinants, providing an understanding of distribution, patterns, and underlying structures (Yesuph *et al.*, 2023; Fatoki *et al.*, 2020). Participatory methods, such as the Climate Vulnerability and Capacity Analysis (CVCA) framework and wellbeing ranking, involve engaging with community members and stakeholders to gather their perspectives, experiences, and local knowledge, complementing quantitative data for a holistic understanding of vulnerability (Gentle and Maraseni, 2012).

Poverty outcomes of flooding

Several studies consistently highlight the exacerbation of both income and multidimensional poverty among rural households affected by flooding (Ahamd *et al.*, 2023; Rana *et al.*, 2023). Flood events have been shown to erode critical financial, human, physical, and social capital assets that are essential for rural livelihoods, thus undermining their resilience (Rana *et al.*, 2023). Quantitative evidence from Mozambique reveals a significant decline of 11-17% in per capita expenditure, a key indicator of income poverty, following flood events, with poorer households bearing a disproportionately larger impact (Salvucci and Santos, 2020).

Coping strategies

Vulnerable farmers employ diverse coping strategies, both ex-ante and ex-post, to manage risks, though their effectiveness differs based on resource access. Income diversification through off-farm activities, wage labour, migration, and mixed crop-livestock farming is a common strategy (Karim *et al*., 2017; Jalal *et al.*, 2021). Agricultural practices like cultivating drought/flood-resistant crop varieties, adopting modern irrigation methods, and practising floating gardening are also adopted (Jamshidi *et al.*, 2019; Tran *et al.*, 2022; Jalal *et al.*, 2021; Karim *et al.*, 2017). Financial and social coping strategies include accessing credit from banks, microfinance, or social networks, obtaining food on credit, selling livestock or assets, and receiving community or government assistance (Oskorouchi and Sousa-Poza, 2021; Mahanta and Das, 2017; Karim *et al.*, 2017; Zeleke *et al.*, 2021). Risk management and adaptation strategies involve weather-indexed insurance, riverbank protection using sandbags, and temporary migration or seeking refuge (Yesuph *et al.*, 2023; Karim *et al.*, 2017; Gentle and Maraseni, 2012). Investing in social and human capital through social networks, education, awareness campaigns, and training can enhance resilience and adaptive capacity (Zeleke *et al.*, 2021; Derick *et al.*, 2018; Rana *et al.*, 2023; Ahmad *et al.*, 2022).

Gaps and future research

The existing literature offers valuable understandings into the vulnerability of smallholder farmers to flooding, poverty outcomes, and coping strategies. However, notable gaps calls-for attention, such as the underutilization of farmer vulnerability

indices at the individual level, the lack of comprehensive frameworks integrating biophysical and socioeconomic dimensions, inadequate localized studies at the community level, particularly in low- and middle-income countries (LMICs), and insufficient evidence on the long-term effectiveness and sustainability of coping strategies under varying climatic conditions (Ahmad *et al.,* 2023; Rana *et al.,* 2023; Nhamo *et al.,* 2020; Karim et al., 2017; Oskorouchi and Sousa-Poza, 2021). To address these gaps, future research should adopt a multidimensional approach, integrating farmer vulnerability indices, developing comprehensive conceptual frameworks, embracing participatory approaches, conducting longitudinal studies, and prioritizing the identification of adaptation pathways and policy interventions to enhance resilience and promote sustainable livelihoods among vulnerable farming communities (Ahmad *et al.,* 2022; Tran *et al.,* 2022; Gentle and Maraseni, 2012; Yesuph *et al.,* 2023).

CONCLUSIONS

The systematic review highlights the vulnerability of smallholder farmers to flooding, worsening income and multidimensional poverty in low- and middle-income countries (LMICs). Despite employing coping strategies like livelihood diversification, agricultural adaptation, financial support, social networks, and migration, significant gaps remain absence of individual farmer-level vulnerability assessments, limited comprehensive conceptual frameworks, scarcity of localized LMIC studies, and insufficient evidence on the long-term effectiveness of these strategies. The study recommends multidimensional approaches integrating farmer vulnerability indices and participatory methods, promoting diverse coping strategies including climate-smart agriculture and ecosystem-based adaptation, conducting longitudinal localized studies, promoting cross-sectoral collaborations, and advocating for comprehensive government policies that integrate poverty reduction with climate change adaptation. This review synthesizes knowledge, identifies gaps, and provides actionable recommendations to guide future research, policies, and interventions confronting poverty, floods, and climate change impacts on smallholder farmers, thereby contributing to the achievement of several SDGs.

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CONFLICT OF INTEREST

The authors acknowledged this work does not conflict with the interests of others.

مدى تعرض المزارعين أصحاب الحيازات الصغيرة للفيضانات والفقر واستراتيجيات التكيف: مراجعة منهجية

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الخلاصة

تمثل الفيضانات تهديدًا شديدًا مرتبطًا بالمناخ على سبل العيش الريفية ومستويات الفقر في البلدان تمثل الفيضانات تهديدًا شديدًا مرتبطًا بالمناخ على سبل العيش الريفية ومستويات الفقر في البلدان المنخفضة والمتوسطة الدخل، وتؤثر بشكل خاص على المزارعين أصحاب الحيازات الصغيرة الضعفاء. تهدف هذه المراجعة المنهجية إلى تقديم توجيهات بحثية مستقبلية حول مدى تعرض المزارعين أصحاب الحيازات الصغيرة للفيضانات والفقر واستراتيجيات التكيف في البلدان المنخفضة والمتوسطة الدخل. وعلى وجه التحديد، تقوم الدراسة بتقييم المنهجيات المستخدمة لتقييم مدى التعرض للفيضانات، وارتباطاتها بالفقر، وتحدد استراتيجيات التكيف التي يستخدمها المزارعون أصحاب الحيازات الصغيرة للتخفيف من آثار الضعف الناجم عن الفيضانات على سبل عيشهم ورفاههم. باتباع إجراء PRISMA، تم تحديد 19 دراسة ذات صلة عبر خمس عمليات بحث في قواعد البيانات. وكشفت النتائج عن الاستخدام الواسع النطاق لمؤشرات الضعف التي تتضمن التعرض والحساسية والقدرة على التكيف لتقييم المخاطر المختلفة عبر المحليات والفئات الاجتماعية، مع وجود روابط قوية بين الضعف والفقر متعدد الأبعاد. تؤدي الفيضانات إلى تفاقم فقر الدخل وانعدام الأمن الغذائي وعدم الكفاءة الاجتماعية والاقتصادية، مما يعيق التقدم في تحقيق هدفي التنمية المستدامة 1 و 2. وتشمل استراتيجيات التكيف الشائعة تنويع سبل العيش، وشبكات رأس المال الاجتماعي، والهجرة، والقروض، وتصفية الأصول، والمساعدات في حالات الكوارث، والتي تساعد في تخفيف الصدمات ولكنها تحتاج إلى تعزيز للمساهمة في تحقيق هدفي التنمية المستدامة 13 و15. وتتمثل الفجوات الرئيسية في الأدلة في الضعف على المستوى الفردي/المزارع، والنمذجة الكمية للروابط بين الفقر والفيضانات، وتقييم تأثير استراتيجيات التكيف على الفقر، وفهم ممارسات السكان الأصليين. إن تعزيز الارتباط بين التكيف والتنمية من خلال التدخلات الشاملة والتعاون البحثي أمر بالغ الأهمية لتعزيز قدرة المزارعين على الصمود. توفر هذه المراجعة رؤى قيمة للباحثين وأصحاب المصلحة لتعزيز الفهم المفاهيمي وتوجيه السياسات التي تهدف إلى الحد من نقاط الضعف المناخية والاجتماعية والاقتصادية للمزارعين.

الكلمات المفتاحية: مؤشر الضعف، سبل العيش، تغير المناخ، المرونة، الرفاهية.

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