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Smallholder farmers' adaptation at the climate–conflict nexus: a systematic review

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In conflict-affected settings, smallholder farmers' adaptation is complex due to the interconnected nature of social, environmental, and economic vulnerabilities. While many studies have systematically reviewed the causal pathways between conflict and climate, less attention has been given to synthesizing evidence on how smallholder farmers adapt to climate change and contextual vulnerabilities in these settings. Knowledge on adaptation at the climate–conflict nexus remains scattered across disciplines, highlighting the need for a systematic review to consolidate evidence and inform resilience-building strategies. This study aimed to systematically review empirical literature on smallholder farmers' adaptation to climate change in conflict-affected areas, providing an integrated understanding of adaptation strategies at the climate–conflict nexus. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, a one-time search of scholarly literature was conducted on November 29, 2024, using the terms "climate change," "conflict," "adaptation," and "smallholder farmers" and their synonyms, across three databases: Web of Science Core Collection, Scopus, and ProQuest. Eligible studies were peer-reviewed, empirical, published in English between 2004 and 2024, and focused on how smallholder farmers respond to climate change in conflict contexts. Theoretical studies, non-peer-reviewed work, or studies that did not address both conflict and climate change or did not focus on smallholder farmers were excluded. A hybrid approach was used to extract and synthesize data from the selected studies. Most studies were concentrated in the Global South, with growing attention from 2016 to 2024, reflecting increased awareness of the climate–conflict nexus. The review identified eleven integrated strategies for addressing interwoven vulnerabilities in conflict-affected settings. However, 67% of studies did not link adaptive capacities to specific vulnerabilities, and one-third did not consider how adaptation is shaped by power relations within social hierarchies. These findings underscore the need for further research on socially stratified adaptation in conflict-affected contexts and highlight the importance of context-specific policies for smallholder farmers. By consolidating fragmented evidence, this review provides guidance for development agencies, local governments, and NGOs in designing integrated climate–conflict interventions that strengthen resilience, reduce vulnerability, and promote sustainable livelihoods.

KEYWORDS

adaptation, climate change, conflicts, interwoven vulnerabilities, smallholder farmers, systematic review

1 Introduction

As extreme climatic events and unpredictable weather patterns grow in frequency and intensity due to climate change and increasing climate variability (IPCC, 2001), societies affected by war and civil conflict are among the most severely impacted (ICRC, 2020). Globally, more than half of the twenty countries that are most vulnerable and least prepared to adapt to the effects of climate change are simultaneously experiencing the consequences of historic or ongoing conflict (ND-GAIN, 2024). Conflict is broadly defined as a situation in which there are differences of opinion or interest between individuals, groups, or organizations. It is a condition that arises when parties perceive their goals, values, or interests as being opposed or negatively affected by others (Amanda et al., 2024; Khovivah et al., 2024). This perception of incompatibility often leads to a competitive struggle or active disagreement, which can manifest in various forms, ranging from verbal disputes to physical violence (Marsella, 2011; Sushko and Bakhanovich, 2024). A simplification of Glasl's conflict ladder describes five steps of escalation from disagreement over, personification/blame, polarization, threats and pressure, limited use of force, to escalation to full-scale war (Glasl, 1997). Although there is controversy about climate-conflict interactions and causal pathways (Scheffran et al., 2012), the role of conflict as a driver of vulnerability to climate change is becoming recognized as more important than the role of climate change as a causal factor in conflict in many contexts (Barnett and Adger, 2007; Sitati et al., 2021). Several empirical studies reveal that conflicts affect nearly all dimensions of human development, including economic stability, physical safety, infrastructure, environmental quality, health, education, and sociocultural cohesion (Gates et al., 2012). Conflict lowers societies' capacity to adapt, increasing the cost of adaptation actions against climate change impacts (Crawford et al., 2015). IPCC (2023) emphasized the urgent need for adaptation action to address intensifying risks to vulnerable populations in areas likely to experience climate shocks and the enduring impacts of conflicts. However, most adaptation planning in countries significantly affected by conflict lacks strategic conflict considerations (Remling and Meijer, 2024).

While many studies have systematically reviewed the causal pathways between conflict and climate change (Sakaguchi et al., 2017; Scartozzi, 2021; Xie et al., 2024), these studies primarily focus on understanding how climate variability and extreme events may contribute to the onset or escalation of conflicts, or conversely, how conflict can exacerbate vulnerability to climate impacts. Those bodies of research have provided valuable insights into the causes—such as resource scarcity (Forsyth and Schomerus, 2013), displacement (Krause and Segadlo, 2021), and governance breakdown (Krause and Segadlo, 2021)—and consequences—including food insecurity (Sassi and Thakare, 2022), loss of livelihoods, and environmental degradation (Forsyth and Schomerus, 2013)—of the climate–conflict nexus. However, less attention has been given to the adaptive responses of smallholder farmers who are directly experiencing these compounded stressors. The nature of this problem is inherently multifaceted. Smallholder farmers in conflict-affected areas face interwoven vulnerabilities that are social, economic, and environmental, which interact and reinforce one another. These interconnected vulnerabilities

complicate adaptation (Brooks and Adger, 2005), making it challenging to develop generalized strategies without context-specific evidence.

Consequently, the existing knowledge on adaptation at the climate–conflict nexus remains fragmented and scattered across disciplines, including agriculture, development studies, and conflict research. There is no consolidated synthesis of how smallholder farmers navigate these intersecting challenges, what strategies they employ, and how effective these strategies are under conditions of protracted or acute conflict. This gap highlights the urgent need for a systematic review to integrate empirical evidence, identify patterns and best practices, and inform the design of interventions and policies that build resilience in highly vulnerable, conflict-affected farming communities.

A study by Sitati et al. (2021), is a rare exception providing a systematic review of climate change adaptation in conflict-affected countries. Their work represents a solid and valuable contribution, synthesizing evidence across seven global sectors, including health, urban settlements, water and sanitation, and coastal ecosystems. However, while their systematic review advances understanding at a broad, cross-sectoral level, it offers limited insights and recommendations specifically tailored to smallholder farmers in the Global South—arguably one of the most vulnerable populations facing the compounded pressures of climate change and conflicts. Moreover, Sitati et al.'s (2021) review scope was restricted to “armed” forms of conflict. Building on Mitchell's broader definition of conflict, we argue that smallholder farmers are affected by a wider spectrum of conflict types, both armed and unarmed. These include local land and resource disputes (Mugerwa and Ojiambo, 2017), social and community conflicts (Vaughan, 2004), ethnic and religious conflicts (Smooha, 2002), political violence (Kalyvas, 2003) and others. Each of these forms of conflict interacts differently with farmers' adaptive capacities, shaping their strategies and resilience in distinct ways.

In light of these limitations, our study constitutes a novel contribution by conducting a comprehensive systematic literature review focused explicitly on smallholder farmers in conflict-affected contexts. Using the updated PRISMA 2020 framework (Page et al., 2021), we systematically examined trends, patterns, and gaps in the existing literature to provide conceptual clarity of the adaptation strategies smallholder farmers employ to navigate overlapping vulnerabilities. We identify knowledge gaps where smallholder farmers' experiences remain underrepresented and generate policy-relevant insights that can inform interventions tailored to the realities of smallholder farmers in such complex contexts.

The impetus for this study can be understood in two main dimensions: first, to strengthen the scholarly body of literature by consolidating fragmented evidence into a coherent synthesis; and second, to ensure that adaptation research or interventions speak directly to the needs of smallholder farmers in conflict-affected regions. The significance of this work lies in its ability to bridge disciplinary silos while placing smallholder farmers at the forefront. Ultimately, this study makes contributions to both scholarly and practical domains. For the academic community, it provides a systematic synthesis that not only consolidates existing evidence but also advances theoretical understanding on adaptation in conflict-affected contexts. For policymakers, practitioners, and local

institutions, this study offers evidence-based recommendations to guide resilience-building interventions for smallholder farmers.

Our review was guided by the following research question(s): What are the bibliographic characteristics of scientific literature addressing smallholder farmers' adaptation to climate change in conflict-affected areas? What are the methodological characteristics of empirical studies focusing on smallholder farmers' adaptation to climate change in conflict-affected areas? What strategies for climate change adaptation and vulnerability reduction in conflict-affected areas are discussed in scientific research? What adaptation strategies are proven empirically effective in which contexts, and what barriers impede effective adaptation in conflict-affected environments?

2 Review methods

2.1 Scholarly search and literature screening procedure

A one-time search of scholarly literature was conducted in the three databases, Web of Science Core Collection (Clarivate), Scopus and ProQuest (Central Database), on November 29th, 2024. The Web of Science database provides high-quality metadata that supports comprehensive bibliometric analysis (Aria and Cuccurullo, 2017a) with wide coverage, and most records in English (Arezoo et al., 2013). ProQuest offers a mix of peer-reviewed journals, books, dissertations, and other scholarly resources, with a strong emphasis on full-text content. Scopus offer even broader coverage range, including non-peer-reviewed material, enabling identification of a wider literature (Burnham, 2006).

Searches were conducted using the keywords "climate change," "conflict," "adaptation," and "smallholder farmers" and their synonyms. Boolean operators such as "AND," "OR," and "NOT," in combination with parentheses (), truncation (*), and wildcards (!), were applied to develop search strings (Appendix A1). Additional searches were performed using backward and forward search techniques in the Web of Science database to retrieve articles cited in the relevant identified pieces of literature and those that cited the identified articles. The Web of Science, Scopus, and ProQuest final query strings yielded 3,017, 3,819, and 934 hits, respectively. In total, 7,770 hits were realized based on the search strings.

To enhance contextual fit, the results were filtered based on predefined database subject categories (Appendix A2), reducing the results to 2,448, 2,321, and 657 for Web of Science, Scopus, and ProQuest, respectively. Additional searches based on backward and forward searches on the Web of Science yielded a further 68 relevant publications, totaling 5,494 records. The total publications were subjected to deduplication first in Zotero and later in the Covidence software. The deduplication process eliminated 1,871 publications, leaving 3,623 for screening.

The screening of scholarly articles was carried out with assiduity by two independent reviewers using Covidence, following the eligibility criteria detailed in Table 1. During the initial stage, titles and abstracts were carefully examined, leading to the exclusion of 3,462 publications and the identification of 161 articles for full-text review. Each full-text PDF was then accessed, downloaded, and independently evaluated by both reviewers, ensuring a transparent, rigorous, and unbiased selection process that captured all studies meeting the predefined criteria.

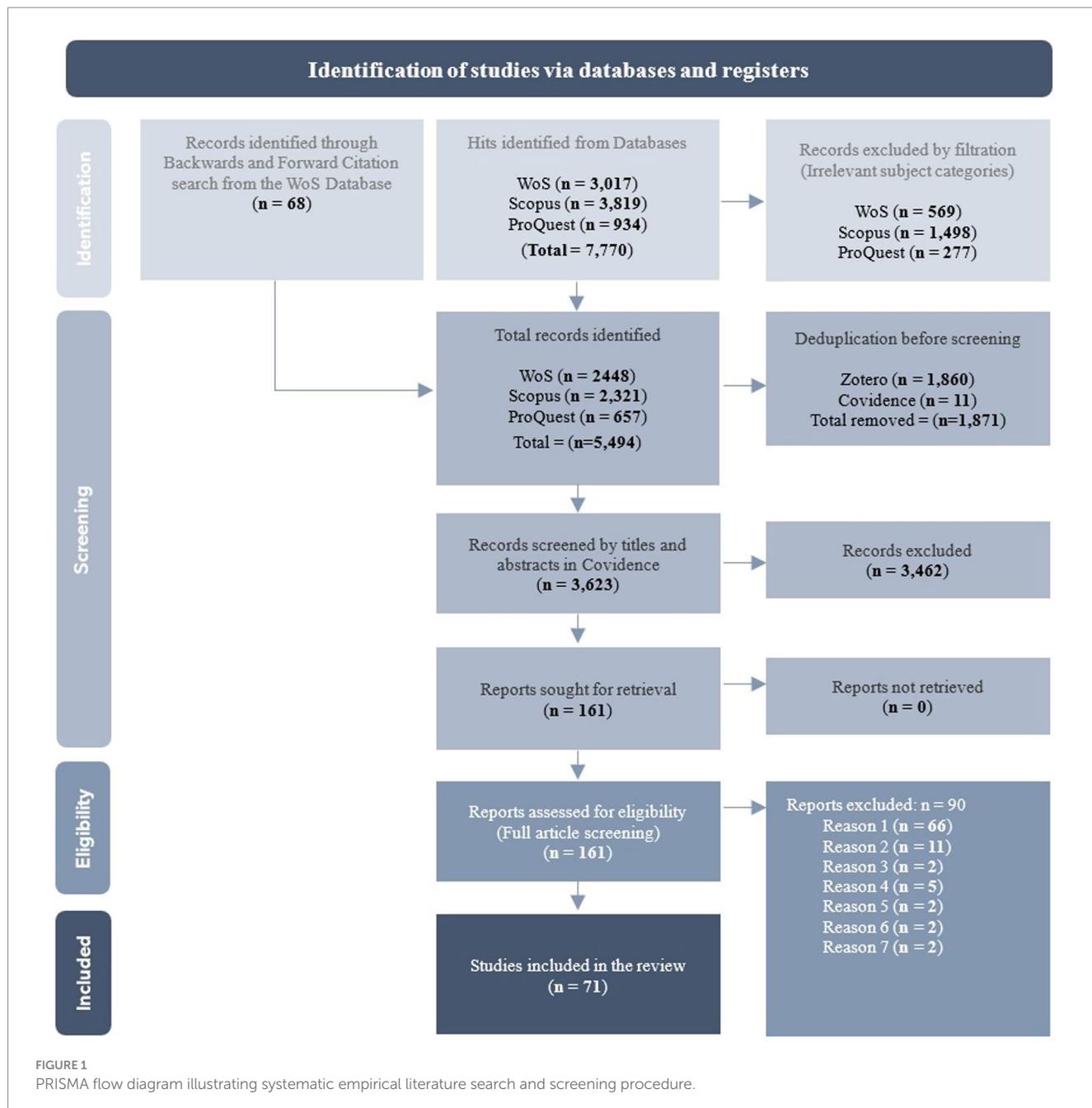
TABLE 1 Predefined inclusion and exclusion criteria used for the publication screening process.

Concept	Inclusion factor	Exclusion factor
Population	• Smallholder farmers	• Non-farming-related population
Context	• Adaptation to climate change and contextual factors in conflict-affected areas.	• Adaptation or mitigation actions in stable areas
Outcomes	• Empirical reports on how smallholder farmers in conflict-affected areas respond to climate change contextual challenges. • Responses related to resilience-building actions by farmers in smallholder agriculture in conflict-affected areas	• Context-irrelevant study • Responses are rather than recommended and actions • Adaptation strategies with limited applicability to smallholder agriculture (Measures outside the scope of smallholder resilience building).
Study types	• Empirical studies	• Studies with no empirical data, theoretical or simulated studies, and previous reviews
Publication status	• Articles, Books, Book Chapters, Book Reviews, Proceedings Papers, Conference Papers and Conference Proceedings • Full Text, Peer-Reviewed, Available online	• Grey literature – i.e. non-indexed (i.e. doi or ISBN) • Preprints • Review articles • Retracted publications or ones with notice
Timeframe	• 2004–2024 (Topical scholarly evidence)	• Papers published outside the quoted timeframe
Language	• Articles indexed in English	• Articles indexed in a language other than English

After the full text screening, an inter-rater reliability analysis produced a Cohen's Kappa coefficient (κ) of 1, indicating unwavering concordance. The probability of random agreement (P_e) was 0.51, suggesting that a significant portion of the agreement was beyond chance. The total number of scholarly articles that met all the eligibility criteria during the full-text screening was 71. A total of 90 articles were excluded mainly because they were found to be contextually irrelevant to the predefined inclusion criteria. The identification procedure for empirical literature and the screening process workflow is depicted in the PRISMA diagram in Figure 1.

2.2 Literature quality appraisal

Since the systematic literature review is a mixed-methods review, we used the Mixed-Method Appraisal Tool (MMAT) to evaluate eligible studies based on their design's rigour, transparency, and



validity in a quality appraisal process. The MMAT (Hong et al., 2018) was applied to both qualitative and quantitative components to determine how potential sources of bias were addressed. The tool includes specific questions for each study design, including qualitative, quantitative descriptive, and mixed methods. These questions, adapted from Mohamed Shaffril et al. (2025), are summarized in Table 2.

2.3 Data extraction procedure

A hybrid data extraction approach (Ye et al., 2024) was employed to enhance the efficiency and accuracy of data collection. The procedure involved an initial machine-assisted extraction with Elicit AI, followed by manual verification of the extracted data against the

original full texts by two independent reviewers. Data extraction focused on bibliographic variables (title, authors, year, journal, citations), methodological variables (methods used, research design), contextual variables (biophysical characteristics, conflict type, climatic hazards), and analytical variables (vulnerability frameworks, adaptation strategies, effective strategies, barriers). These variables were coded to enable structured synthesis across studies. The manual validation procedure primarily focused on resolving inconsistencies and ensuring that nuanced study methodological characteristics and findings were accurately captured in the data extraction template. Disagreements between independent reviewers that arose during validation were resolved through discussion and consensus. The hybrid data extraction approach was more time-efficient, while maintaining a high level of accuracy and quality control.

TABLE 2 Quality appraisal questions.

Design	Quality criteria
Qualitative	Q1. Is the qualitative approach appropriate to answer the research question?
	Q2. Are the qualitative data collection methods adequate to address the research question?
	Q3. Are the findings adequately derived from the data?
	Q4. Does data sufficiently substantiate the interpretation of results?
	Q5. Is there coherence between qualitative data sources, collection, analysis, and interpretation?
Quantitative	Q1. Is the sampling strategy relevant to address the research question?
	Q2. Is the sample representative of the target population?
	Q3. Are the measurements appropriate?
	Q4. Is the risk of nonresponse bias low?
	Q5. Is the statistical analysis appropriate to answer the research question?
Mixed methods	Q1. Is there an adequate rationale for using mixed methods design to address the research question?
	Q2. Are the different components of the study effectively integrated to answer the research question?
	Q3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?
	Q4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?
	Q5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?

In this study, we followed Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD), United Nations Children's Fund (UNICEF), World Food Programme (WFP), & World Health Organization (WHO) (2021) conceptualization of smallholders as farmers cultivating less than two hectares, though definitions vary by region and context, and conflict-affected settings as environments where violent conflict, political instability, insecurity or local resource-based conflict disrupt social, economic, and institutional systems (UNDP, 2016). We also defined adaptation strategies as actions undertaken by smallholder farmers to reduce vulnerability to both climate and conflict-induced hazards in conflict-affected environments. This definition is adapted from the Intergovernmental Panel on Climate Change (IPCC, 2014), which broadly conceptualizes adaptation as adjustments in ecological, social, or economic systems in response to actual or expected climate-induced stimuli and their effects.

2.4 Data analysis

The data analysis involved comparing findings from the eligible studies by combining, summarizing, and interpreting them to derive cohesive conclusions. Specifically, bibliometric, content, and thematic analysis methods were used to analyze the data and answer the research questions (Wallin, 2005a). We performed a Bibliometric analysis following the standard guidelines provided by (Donthu et al., 2021) to

systematically map the scientific landscape of climate adaptation in conflict-affected contexts. Bibliometrics provided a quantitative approach for examining scholarly production and influence, enabling the identification of patterns, trends, and gaps in the literature (Wallin, 2005b). The analysis was conducted using the R package Bibliometrix (Aria and Cuccurullo, 2017b), designed for scientometric research, with outputs visualized through diagnostic plots and maps.

Spatial patterns of scientific production were examined by aggregating publication data at the country level and representing them via choropleth mapping. This established cartographic method (Aria and Cuccurullo, 2017b; Brewer, 1994; Dent et al., 2009; Ellegaard and Wallin, 2015a) allowed for the visualization of regional disparities and varying levels of research engagement.

Year-wise publication data were compiled and visualized as a time series, enabling the identification of temporal trends in adaptation research in the conflict context. This approach unveiled the evolution of research activity over time, periods of stagnation, fluctuations in scholarly output and provided insight into the developmental trajectory of the field (Ellegaard and Wallin, 2015b).

Author-assigned keywords were aggregated and analyzed to construct a co-occurrence network, where nodes represented individual keywords and edges denoted their joint appearance within the same article. The network of co-occurrence analysis was performed to identify clusters of related concepts and track the evolution of topics. Clustering algorithms (Jain, 2010) were applied to identify thematic groupings, thereby revealing dominant research themes and emerging conceptual clusters within the field (Donthu et al., 2021; Zupic and Čater, 2015).

Citation data were extracted for all included articles, and the most highly cited publications were identified and visualized in a bar chart, with author names and countries of origin highlighted. This analysis served to pinpoint influential scholars and institutions, thereby mapping intellectual leadership and knowledge hubs in the domain, while also revealing the global orientation of knowledge production patterns (Moed, 2005).

Journal source analysis was conducted to assess relative contributions, using treemap visualization to illustrate publication distribution across outlets following established bibliometric methods for identifying core journals and dissemination patterns (Aria and Cuccurullo, 2017c; Ellegaard and Wallin, 2015a; Zupic and Čater, 2015). By integrating spatial, temporal, and thematic analyses, the bibliometric techniques generated a holistic diagnostic map of adaptation research in conflict-affected contexts.

We also assessed the methodological characteristics of empirical studies on smallholder farmers' climate adaptation in conflict-affected contexts through descriptive statistics derived from frequency counts, allowing for a structured overview of research designs and approaches followed by authors of included papers. The use of descriptive statistics in systematic reviews is methodologically appropriate, as it facilitates the summarization of study characteristics and the identification of patterns across included studies.

Before the analysis, we developed a deductive coding framework based on a set of predefined codes derived from existing literature (Fereday and Muir-Cochrane, 2006). This coding scheme was then systematically applied to the extracted data. To categorize adaptation strategies, we applied a thematic or domain-based categorization method. Adaptation strategies extracted from each study were manually categorized into thematic groups using an inductive coding approach in NVivo (Version 12) [Computer software]

(QSR-International, 2020). The frequency of each adaptation strategy was then recorded, with counts linked to specific challenges. These distributions were visualized through bubble plots, chord diagrams, and Sankey plots, enabling the identification of dominant strategies, interconnections among themes, and flows of adaptation responses across challenges.

The reported barriers to adaptation were classified into nine categories: institutional, environmental, psychological, behavioral, political, technosstructural, sociocultural, and information (Table 3). A thematic or domain-based approach was employed to group barriers identified across the various studies. These adaptation barriers were visualized using a clustered heatmap generated in R. In this study, we conceptualized barriers as material, institutional, or normative, referring to circumstances that impede adaptation within the specific constraints of post-conflict settings.

In this study, we anchored our analysis in Scoones' Sustainable Livelihood Framework (Scoones, 1998), which provided a structured lens to examine farmers' exposure to climate and conflict risks, the adaptation strategies they employ, and the barriers that constrain their adaptive capacities in conflict-affected settings.

3 Results and discussion

The MMAT revealed a disparity in quality, with most studies employing a rigorous methodological approach, including clear research questions, relevant sampling strategies, data collection methods, and suitable analytical methods. Nevertheless, some studies (19.7%, $n = 14$) exhibited a problematic methodological design, influencing their aggregate quality, and were approached with caution. Mixed-method studies generally displayed superior methodological rigour compared to other designs.

3.1 What are the bibliographic characteristics of scientific literature addressing smallholder farmers' adaptation to climate change in conflict-affected areas?

3.1.1 Geographical pattern of scientific production

The spatial pattern of scientific production across the selected studies is presented in Figure 2. Most of the included empirical studies are concentrated in the Global South, particularly in sub-Saharan Africa, South Asia, and Latin America. The included 71 studies took place in 35 countries, with Ethiopia contributing the highest ($n = 11$). This is followed by Kenya ($n = 6$), Nigeria ($n = 5$), Afghanistan and Tanzania ($n = 4$ each), Cameroon, Ghana, Philippines ($n = 3$ each), Pakistan, Palestine, Uganda, Sri Lanka, Syria, Burkina Faso ($n = 2$ each), and the rest of the countries: Angola, Bangladesh, Benin, Brazil, Burundi, Columbia, DRC, Georgia, Guatemala, India, Iran, Isreal, Myanmar, Niger, Nepal, Rwanda, Sierra Leone, South Sudan, Sudan, Vietnam, Yemen ($n = 1$ each). The studies included are predominantly concentrated in the world's low-income countries, disproportionately affected by both protracted conflicts and high climate variability (ICRC, 2020). Moreover academic scholarship on climate adaptation in conflict-affected contexts remains limited, a pattern consistent with

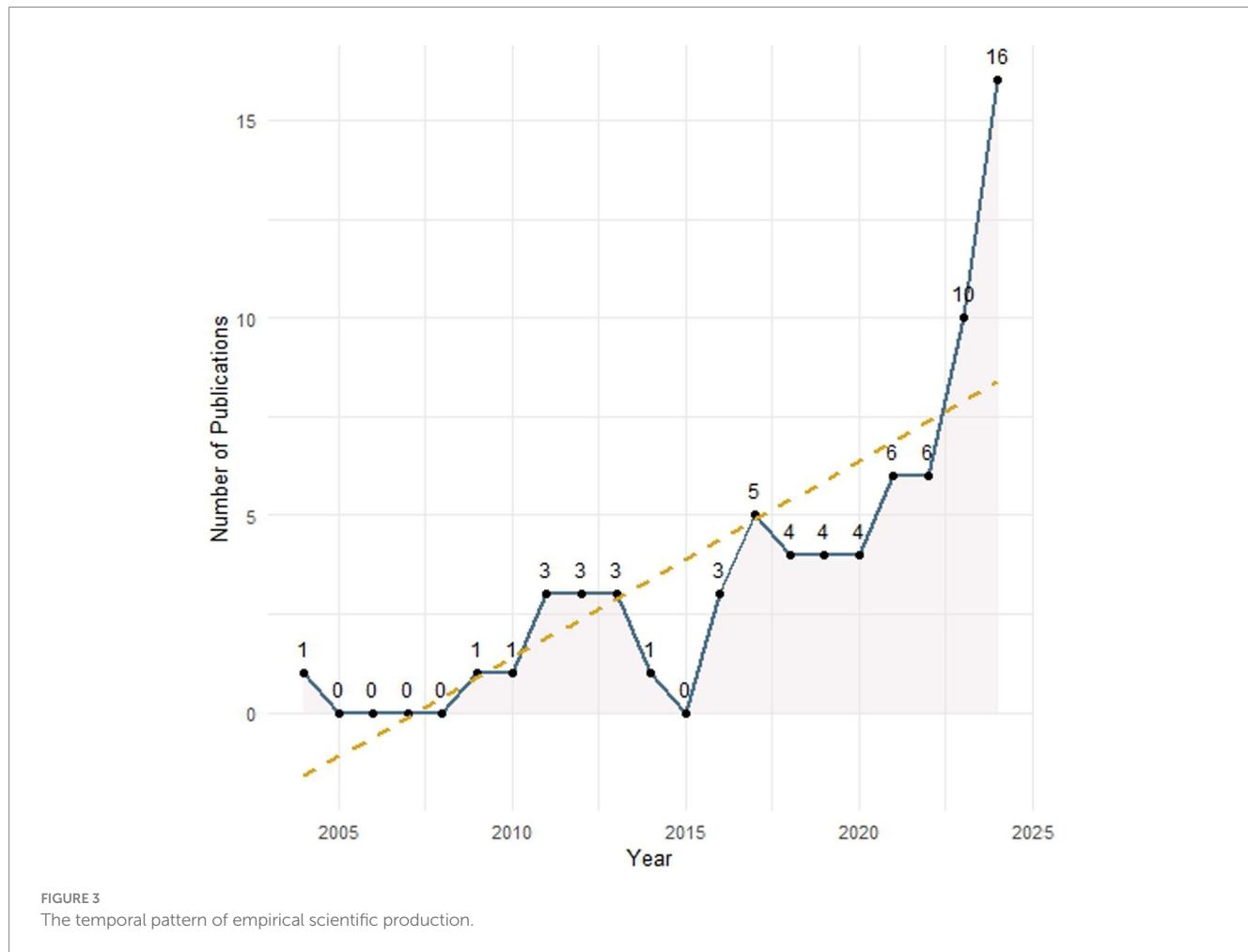
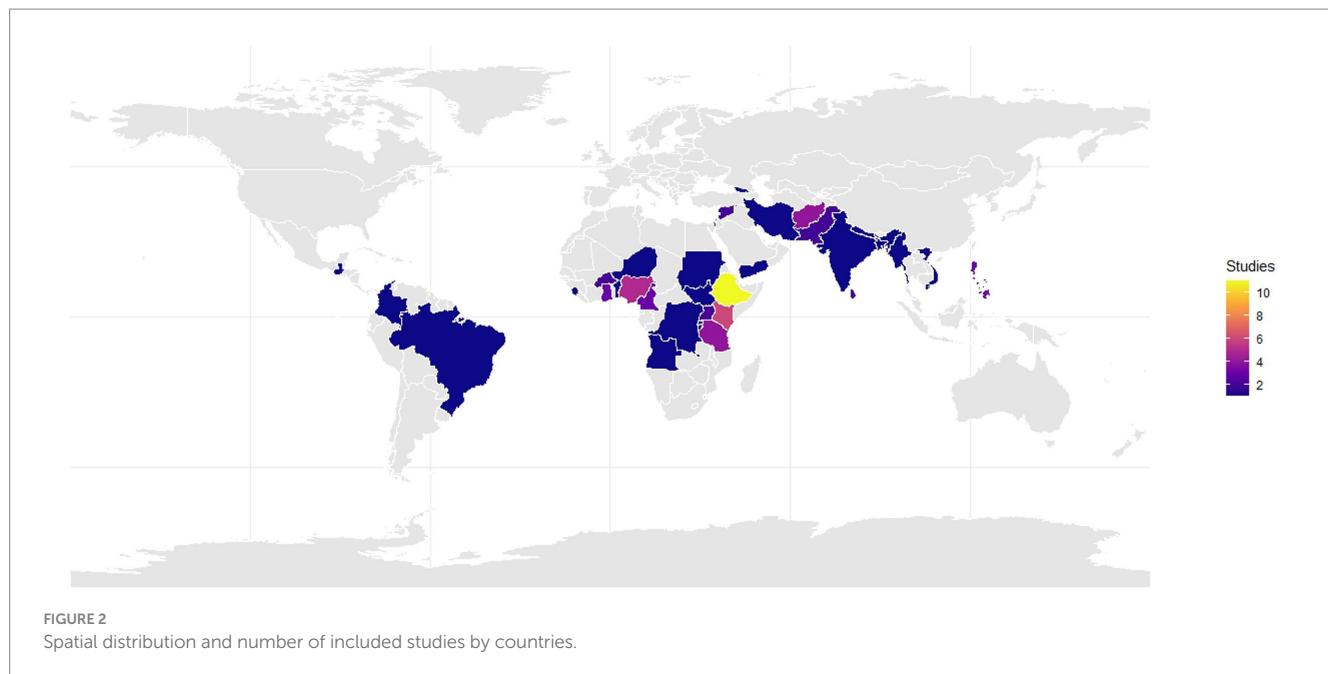
TABLE 3 Conceptualized categories of barriers to smallholder farmers' adaptation to climate change in conflict-affected settings.

Barrier types	How they were conceptualized
Institutional barriers	Barriers associated with weak, absent, or non-responsive institutions responsible for governance, extension, land management, and conflict resolution (Moser and Ekström, 2010).
Environmental barriers	Physical or ecological factors that hinder adaptation by smallholder farmers (Eisenack et al., 2014).
Psychological barriers	Barriers that are related to internal mental or emotional well-being that prevent or reduce willingness to adapt (Gifford, 2011).
Behavioral barriers	Barriers associated with established habits, social norms, or reluctance to change that hinder the adoption of new practices (Eisenack et al., 2014).
Political barriers	Barriers associated with power imbalances, governance failures, politically motivated exclusion, or corruption (Moser and Ekström, 2010).
Fiscal (Financial) barriers	Economic constraints that limit the capacity to invest in adaptation (Biesbroek et al., 2009).
Technosstructural barriers	Barriers associated with a lack of supportive infrastructure and technology needed for adaptation (Moser and Ekström, 2010).
Sociocultural barriers	Social and cultural norms that limit adaptive behaviors, often gendered (Orlove et al., 2010).
Informational barriers	Barriers related to a lack of access to, or understanding of, relevant climate and adaptation knowledge (Moser and Ekström, 2010)

the observations of Sitati et al. (2021). The scarcity of studies examining adaptation within the climate–conflict nexus appears to be driven both by the absence of substantial adaptation initiatives on the ground and by the relatively small pool of active researchers working in these fragile contexts. This gap underscores the need for research on adaptation in regions of the Global South affected by conflict, as well as in overlooked conflict-affected areas of the Global North. Notably, countries such as Ethiopia, Nigeria, and Afghanistan that exhibit comparatively higher volumes of publications benefited from targeted climate change adaptation programs supported by multilateral and bilateral funding mechanisms (Adaptation-Fund, 2024; Sitati et al., 2021). Such financial flows—channeled through instruments like the Adaptation Fund—likely stimulated both practical adaptation activities and the accompanying research outputs, thereby reinforcing the uneven geography of knowledge production in this field.

3.1.2 Temporal pattern of scientific production

Despite the visibly increasing trend in scientific production, the number of publications per year experienced a considerable dip in 2015 (Figure 3). 18.3% ($n = 13$) of the studies included were published between 2004 and 2015. 81.7% ($n = 58$) were published between 2016 and 2024, indicating a significant surge in relevant research activity during this period. The increasing number of adaptation studies focusing on smallholder farmers in conflict-affected areas between 2016 and 2024 may have several explanations. One reason could be



the impact of the global policy shift (2015, Paris Agreement, esp. Article 7 on adaptation, SDGs, esp. SDG 13 and 16), focusing on leaving no one behind (IPCC, 2023; UN, 2015; UNFCCC, 2015).

Other reasons for the increase may be the growing focus on climate-conflict (Buhaug and von Uexkull, 2021; Kouibi, 2019). The focus on the climate-conflict nexus, mainly by the International Security and

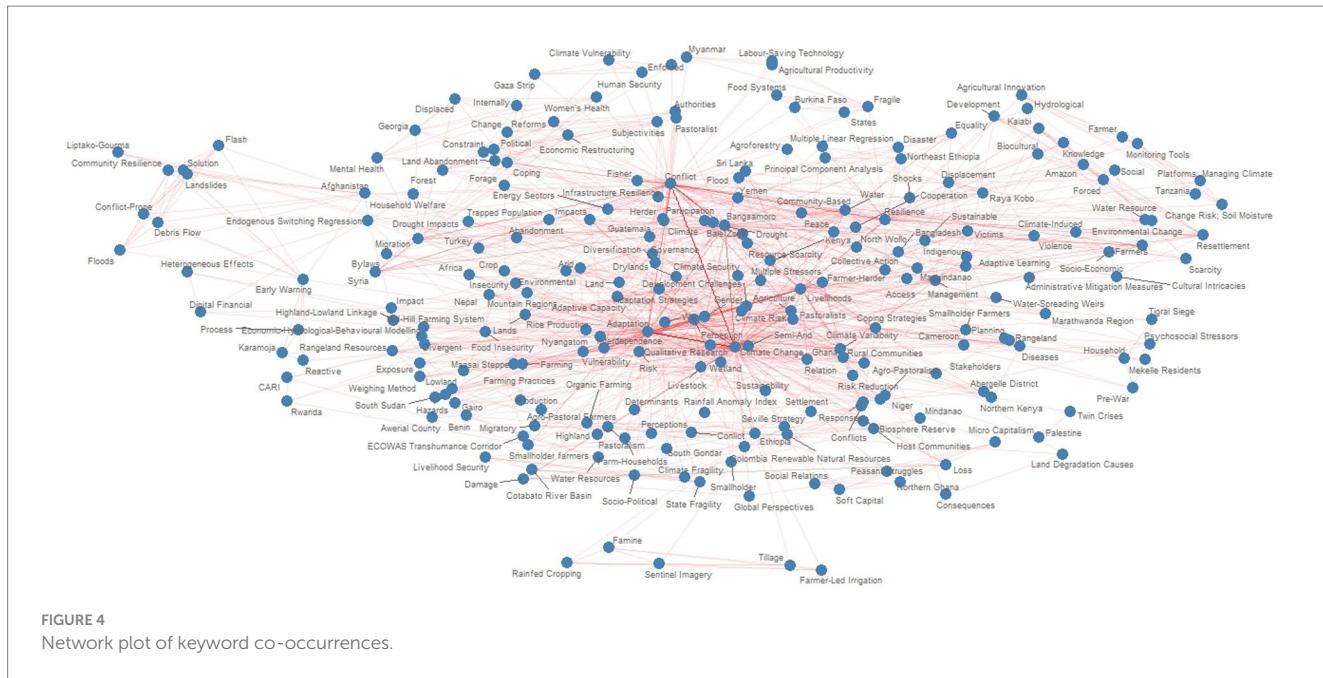


FIGURE 4
Network plot of keyword co-occurrences.

Political Bodies (United Nations Security Council, European Union, and the African Union), Research and Advisory Institutions (Intergovernmental Panel on Climate Change, — especially Fifth Assessment Report, Stockholm International Peace Research Institute, International Crisis Group) and Development and Humanitarian Agencies (United Nations Development Programme, World Bank, and International Monetary Fund) increased through policy dialogs, security reports and risk assessments (UN, 2019). The increased focus likely emerged because researchers, policymakers, and security institutions recognized that climate change can be a threat multiplier by exacerbating social, economic, and political vulnerabilities. Another reason for the increasing trend in adaptation studies in conflict-affected settings might be due to the influence of donors and development agencies (FAO, 2021; World-Bank, 2020), executing integrated programming and funding climate-resilient livelihoods in fragile settings (UNDP, 2021; Gaston et al., 2023; World-Bank-Group, 2024). The influence of donors and development agencies in conflict-affected areas has increased due to the humanitarian imperative (Grayson and Khouzam, 2023) and emphasis on anticipatory and resilient programs (Anticipation-Hub, 2024).

3.1.3 Network of keyword co-occurrence

To explore thematic patterns and the evolving structure of research in the field, we conducted a keyword co-occurrence analysis. Figure 4 presents the resulting network, which visualizes how keywords from the included studies are interconnected. In this network, each node represents a keyword, and red lines between nodes indicate co-occurrence relationships. The thickness of these lines reflects the strength of the connection, with thicker lines highlighting keywords that frequently appear together, thereby revealing clusters of closely related concepts and the underlying thematic structure of the literature. Keywords from which a high density of lines (edges) radiate typically reflect higher conceptual

importance. The keywords “*conflict*,” “*climate change*,” “*drought*,” “*water*,” “*adaptation*,” “*livelihoods*,” and “*resilience*” exhibit high centrality, indicating that they are profound or rapidly evolving themes across disciplines. This configuration aligns with earlier bibliometric and systematic reviews that identified climate change, water scarcity, drought, and livelihood insecurity as recurring entry points into the climate–conflict debate (Ngamu, 2023; Raleigh and Kniveton, 2012). Besides, the centrality of adaptation and resilience signals a shift in scholarly focus from diagnosing the climate–conflict nexus to examining adaptive pathways, echoing Sitati et al. (2021) and IPCC (2023), who emphasized the importance of adaptation strategies in fragile settings. This focus signals a turn toward actionable knowledge, promoting policy to enhance smallholder farmers’ ability to cope and pursue transformation into fragile settings.

3.1.4 Authors of the most cited publications and their origins

The most cited publication among the included studies was a catalytic study by Eriksen and J. Lind (2009a), which earned 417 citations, followed by Korf (2004) with 197 citations, and Chandra et al. (2017) with 191 citations (Figure 5). These highly cited publications played a crucial role in advancing understanding and providing a framework for studying smallholder farmers’ adaptation in conflict-affected areas, whether through introducing novel theories, refining existing methodological approaches, or providing empirical evidence upon which subsequent research has been built and further developed. The top two most cited authors originate from the Global North (Norway and Germany), probably because they were the first movers in the domain, from 2004 to 2009. Another reason could be a factor related to publications originating from the Global North, attracting greater recognition and more citations. The least cited among the top ten most cited, originates from Uganda (Egeru, 2016). The low citation of some papers

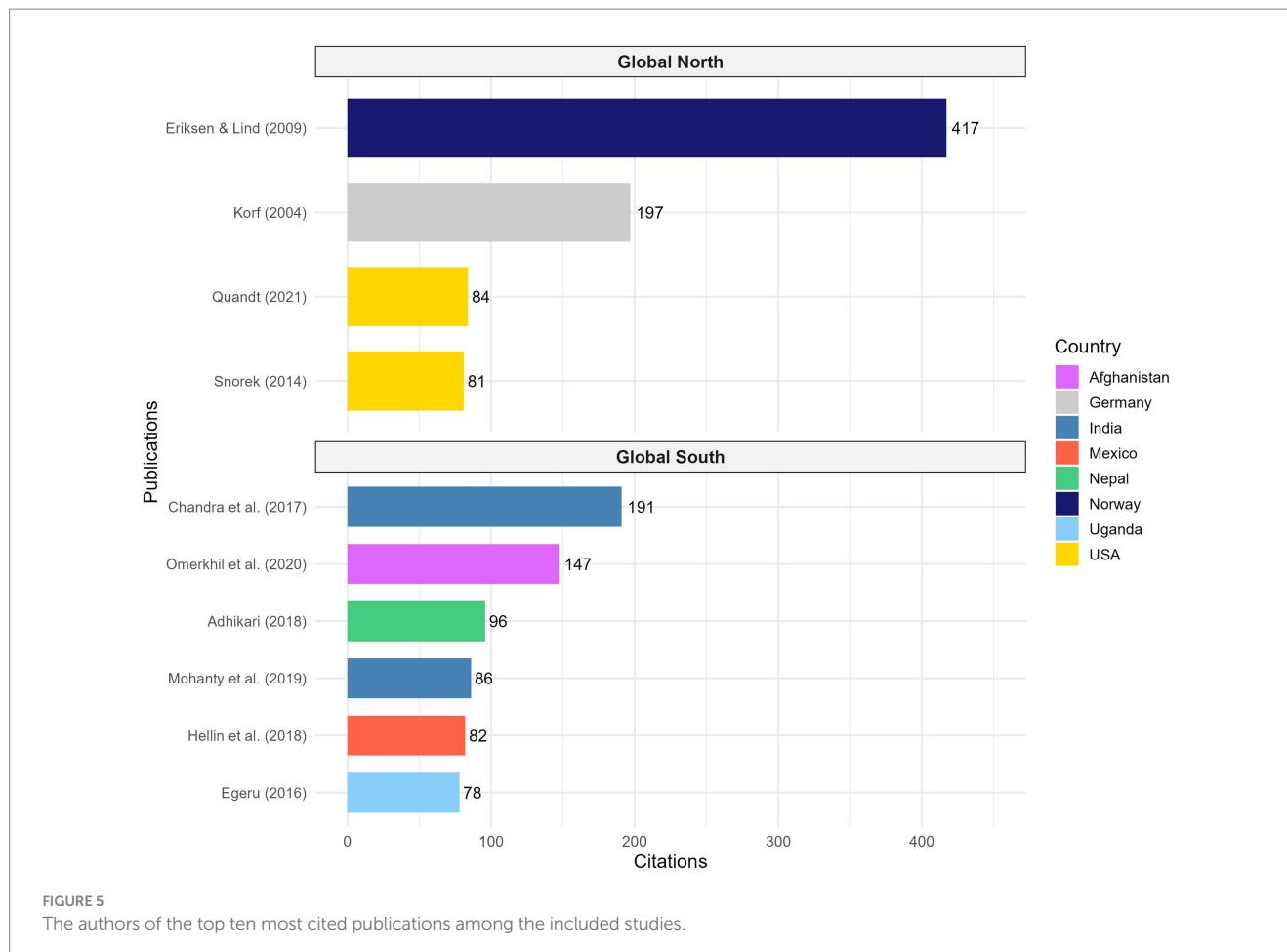


FIGURE 5

The authors of the top ten most cited publications among the included studies.

produced in the global south could be due to a combination of structural, systemic, and perception-related factors. The citation patterns underscore both the novelty and importance of amplifying Global South scholarship in adaptation research (Sitati et al., 2021). Correcting these imbalances is essential for developing an evidence base that is both inclusive and representative (Nakamura et al., 2023). Enhancing the visibility of Global South scholarship—via systematic reviews, equitable citation practices, and cross-regional collaboration—can strengthen adaptation programs and policy design, ensuring that strategies draw on diverse contexts and lived experiences (Connell, 2020).

3.1.5 Journals' relative contributions

We analyzed empirical studies sourced from a diverse range of contributing journals, reflecting the full spectrum of research on the subject. Among the 71 included studies, the highest proportion was published in the Climate and Development Journal, which contributed 5.63% of the total studies (Figure 6). This was followed by the International Journal of Disaster Risk Reduction, the Climate Risk Management journal, and Heliyon, each contributing 4.22%, demonstrating these journals' role in publishing relevant research in the field. Journals such as International Soil and Water Conservation Research, Journal of Arid Environments, Mountain Research and Development, The Journal of Development Studies, Sustainable Environment, and World Development each contributed 2.18% equally. Journals with lower relative contributions are likely those

with a limited audience or niche scope, low impact and visibility. The spread of publications across journals reflects the interdisciplinary nature of adaptation research in conflict contexts. Core outlets like Climate and Development and Climate Risk Management have become central platforms bridging science and policy (Biesbroek et al., 2013; Ford et al., 2015), while development-focused journals such as World Development and The Journal of Development Studies emphasize socio-economic and institutional dimensions of adaptation (Eriksen et al., 2015; Ribot, 2010). Ecological niche journals, including the Journal of Arid Environments and Mountain Research and Development, provide habitat-specific insights, although with a narrower reach. Together, these contributions map the knowledge architecture of adaptation scholarship in conflict settings.

3.2 What are the methodological characteristics of empirical studies focusing on smallholder farmers' adaptation to climate change in conflict-affected areas?

3.2.1 Methodological approaches followed by the authors of the included studies

While mixed-methods approaches are well-suited for unpacking the complexity of smallholder farmers' adaptation in conflict-affected

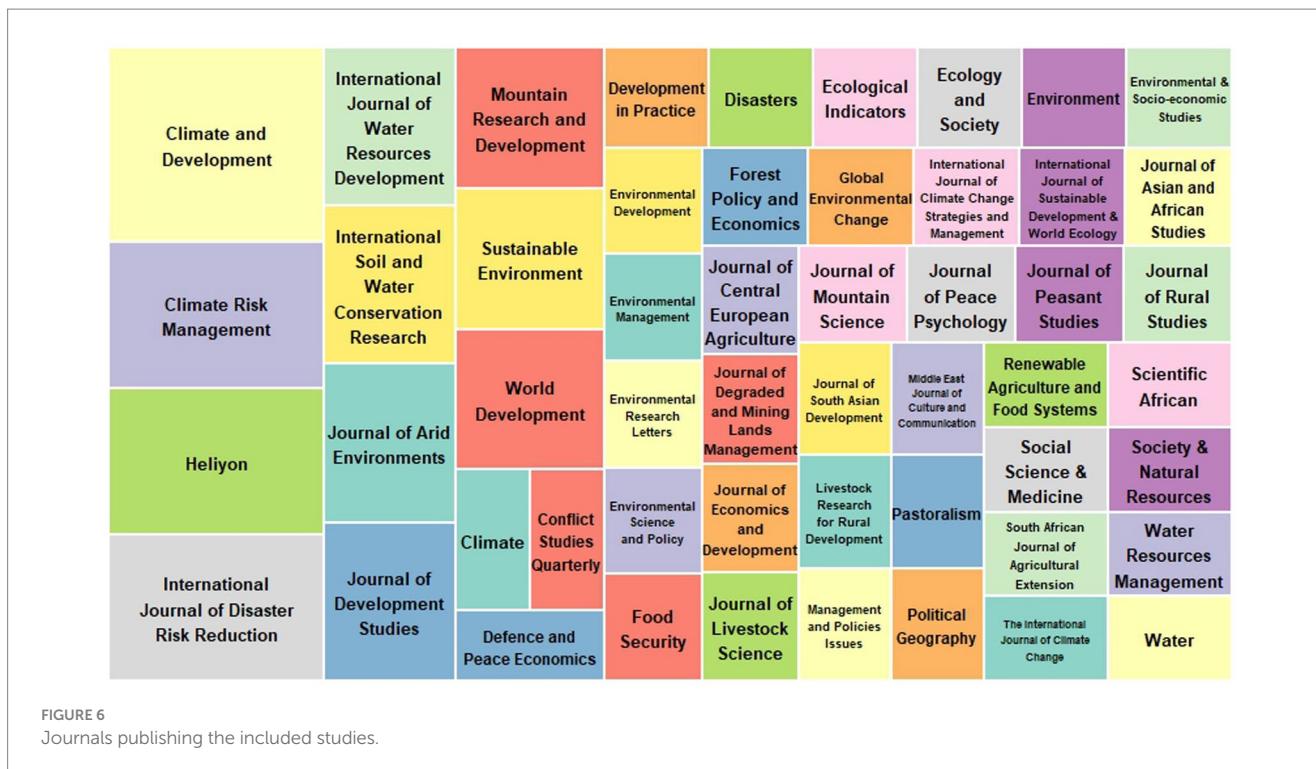


FIGURE 6

Journals publishing the included studies.

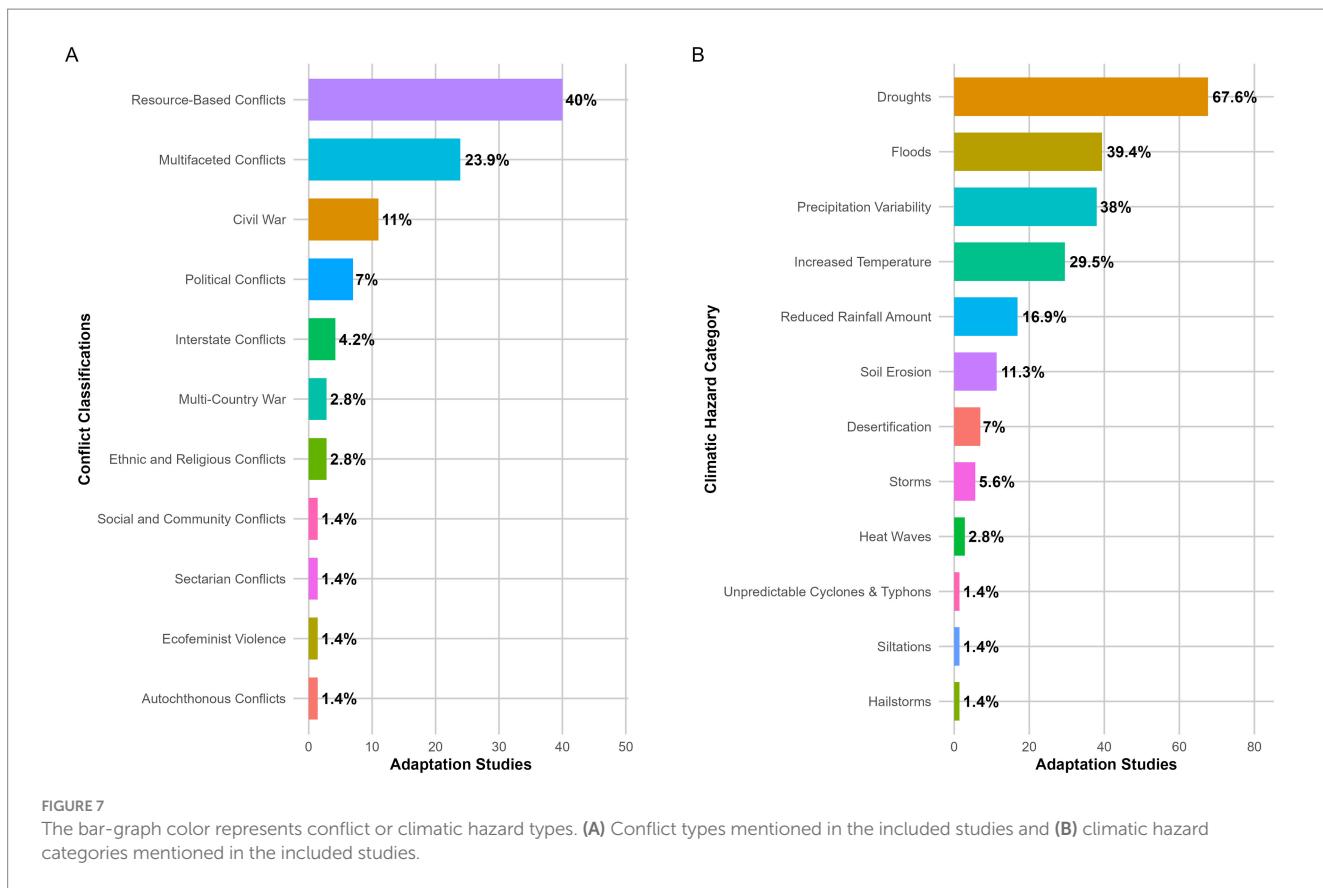
settings, where both quantifiable impacts and nuanced social dynamics are at play (Creswell, 2014) — mixed-methods remain relatively less common than single-method approaches combined. Only 39.43% of the reviewed studies employed mixed-methods approaches, with the majority (60.57%) mainly relying on single-method approaches. The proportion of studies that applied single-method approaches likely missed opportunities for gaining context-specific and holistic insights, particularly in complex conflict settings where both quantifiable outcomes and lived experiences matter. Considering research design, only 21.1% ($n = 16$) of the studies that mainly applied mixed-method approaches used an exploratory sequential design (Creswell and Plano Clark, 2017). This implies that up to 78.9% of the studies that mainly applied mixed methods approaches had limited depth of integration between the two data strands, reducing the studies' ability to capture context-specific dimensions of farmers' adaptation. 25.3% ($n = 18$) of the studies included applied a case study design, whereas 21.1% ($n = 15$) used descriptive designs, and 7% ($n = 5$) used an ethnographic research design. Other research designs applied include convergent parallel (5.6%, $n = 4$), correlational design (4.2%, $n = 3$), phenomenological design (4.2%, $n = 3$), grounded theory (2.8%, $n = 2$). Narrative design, quasi-experimental design, explanatory sequential design, explanatory design, descriptive design, and correlational and case study design each contributed to only 1.4% ($n = 1$) of the studies included. This mapping of methodological approaches reveals a significant shortfall in innovation. A broader application of integrated mixed-methods designs would allow for richer insights into adaptation processes, especially in contexts shaped by power relations, social hierarchies, and intersecting vulnerabilities. Diversifying research designs—such as incorporating ethnography—would not only deepen the evidence base but also improve the applicability and transferability of findings across conflict-affected settings (Landaverde et al., 2022).

3.2.2 Vulnerability assessment context addressed in studies

A significant proportion of the included studies - 84.5% ($n = 60$) - did not explicitly assess smallholder farmers' vulnerability within the conflict-affected settings, thereby reducing the relevance of these studies for generating context-relevant insights. The vulnerability assessment frameworks used included: IPCC framework (IPCC, 2001) ($n = 1$), Sustainable Livelihoods Framework (SLF) (DFID, 1999) ($n = 5$), Comprehensive Approach to Risk Informed decision-making framework ($n = 1$), UNDP adaptation policy framework ($n = 1$), divergent adaptation framework ($n = 1$), Climate-related Disaster Community Resilience framework ($n = 1$) and lastly, the context, collective action institutions, and action arena (associated with the Institutional Analysis and Development Framework) (Ostrom, 2009).

3.2.3 Conflict types and climatic hazards cited as vulnerability factors

Most studies have addressed smallholder farmers' adaptation in locations primarily affected by resource-based conflicts (Figure 7A). Relatively few studies have explored people's adaptive responses in locations suffering the impacts of multifaceted conflicts (e.g., resource-based conflicts + political violence), which are characterized by complexity, unpredictability, and interconnected risks. Other conflict types identified as climate change vulnerability amplifiers included civil wars, political conflicts, interstate conflicts, multi-country wars, ethnic and religious conflicts, ecofeminist violence, autochthonous conflicts, sectarian conflicts, and social and community conflicts. As seen in Figure 7B, the main climatic hazards mentioned in the included studies were primarily water-related climatic hazards: droughts, floods, precipitation variability, and increased temperatures. Other water-related hazards mentioned in the reviewed studies include reduced rainfall amount, soil erosion,



desertification, storms, heatwaves, unpredictable cyclones and typhoons, siltation, and hailstorms. Except for heatwaves, limited attention has been given to non-water-related climatic hazards such as cold spells/frost, strong winds, wildfires, dust storms, lightning storms, extreme UV radiation, and climate-induced pest and disease outbreaks.

3.2.4 The link between vulnerabilities and smallholder farmers' capacity to adapt to climate change in conflict-affected environments

Less than half of the studies (32.4%, $n = 23$) explicitly explored the link between vulnerabilities and smallholder farmers' capacity to adapt. Approximately 67% of the studies failed to investigate the interdependence between vulnerability and adaptive capacities, leading to an incomplete understanding of resilience dynamics. Failing to explore this link, some studies provided a partial picture, oversimplifying how farmers cope with and adapt to different exposure factors in conflict-affected settings. In the few studies that explored the link, the evidence shows that people's capacity to adapt in conflict-affected areas is weakened by vulnerabilities such as constrained access to resources necessary for adaptation (Abdulai and Smucker, 2024; Baderha et al., 2024; Bangura et al., 2013; Delina et al., 2024a; Egeru, 2016; Elagib et al., 2017; Gebeyehu et al., 2021; Huho and Ngaira, 2012; Kogachi and Shaw, 2023; Mason et al., 2011; Muok et al., 2021; Tseer, 2023), reduced cooperation and eroded social cohesion, affecting traditional adaptation response (Castro, 2019; Eriksen and Lind, 2009a; Muok et al., 2021) and socioeconomic upheaval (Chandra et al., 2017; Gebeyehu et al., 2021; Lelenguyah et al., 2023) that disproportionately affect already vulnerable groups,

deepening their vulnerability. In conflict-affected settings, where smallholder farmers face a complex interplay of vulnerabilities (Mach et al., 2019), exploring the link between people's vulnerabilities and adaptive capacity supports the identification of leverage points where interventions can effectively build resilience.

3.3 What strategies for climate change adaptation and vulnerability reduction in conflict-affected areas are discussed in scientific research?

3.3.1 Strategies for addressing climate change impacts in conflict-affected areas

The most frequent (instead 90%) climate-related hazards addressed in the literature are water-related (Figure 8). Several strategies were employed to address water-related climatic hazards, including coping [Short-term, reactive measures (Van Valkengoed and Steg, 2024)], incremental [Gradual, small-scale adjustments (IPCC, 2014)], and transformational strategies [Large-scale, systemic changes (IPCC, 2014)]. Drought received the most adaptive responses in the literature as a water-related climatic hazard. Coping strategies for managing drought challenges include traditional weather forecasts, temporary migration, spending savings, sowing twice (in case of crop failure), relying on social networks and social capital (community ties), safety nets, rain-making rituals, and distress borrowing. Incremental adaptation strategies included water harvesting, tree planting, soil and water conservation practices, on-farm diversification, livelihood diversification, land use

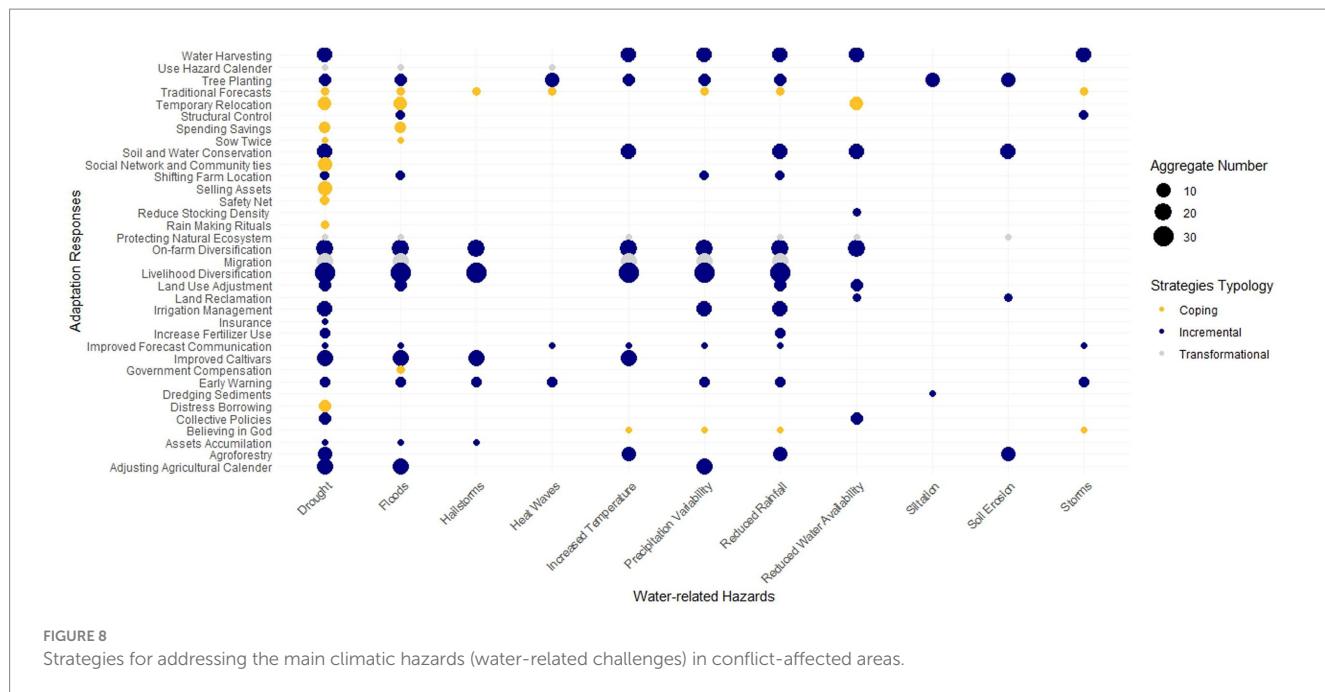


FIGURE 8

Strategies for addressing the main climatic hazards (water-related challenges) in conflict-affected areas.

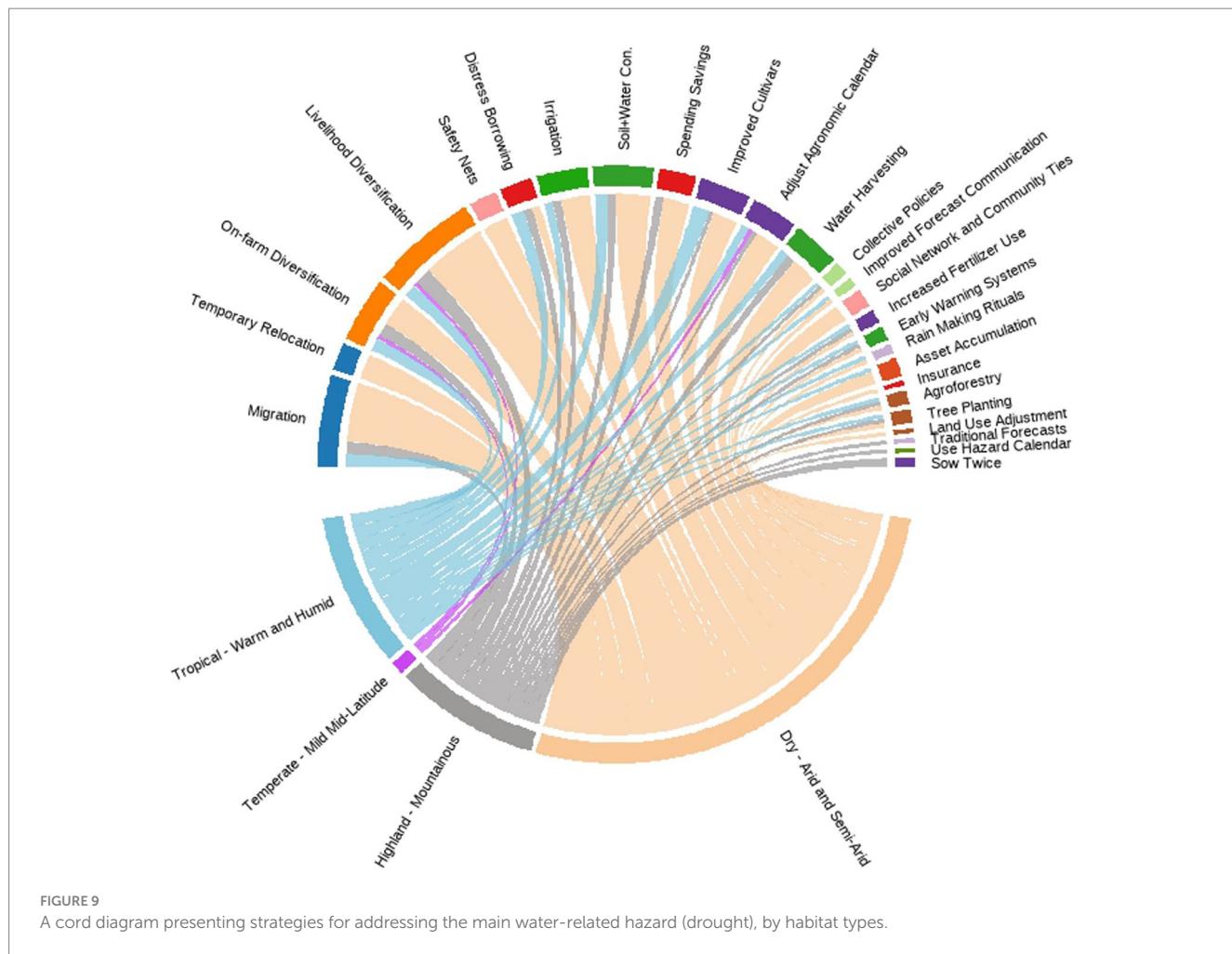


FIGURE 9

A cord diagram presenting strategies for addressing the main water-related hazard (drought), by habitat types.

adjustment, irrigation management, insurance, increased fertilizer use, improved forecast communication, early warning systems, improved cultivars, collective policies, asset accumulation, agroforestry, and adjusting the agronomic calendar. The main transformational adaptation strategy identified in the literature for addressing drought and other water-related hazards was migration – a strategy that involves fundamental changes in people's lives and livelihoods, often resulting in displacement across regions or even countries.

3.3.2 Strategies for addressing the main climatic challenge (droughts) by habitat types

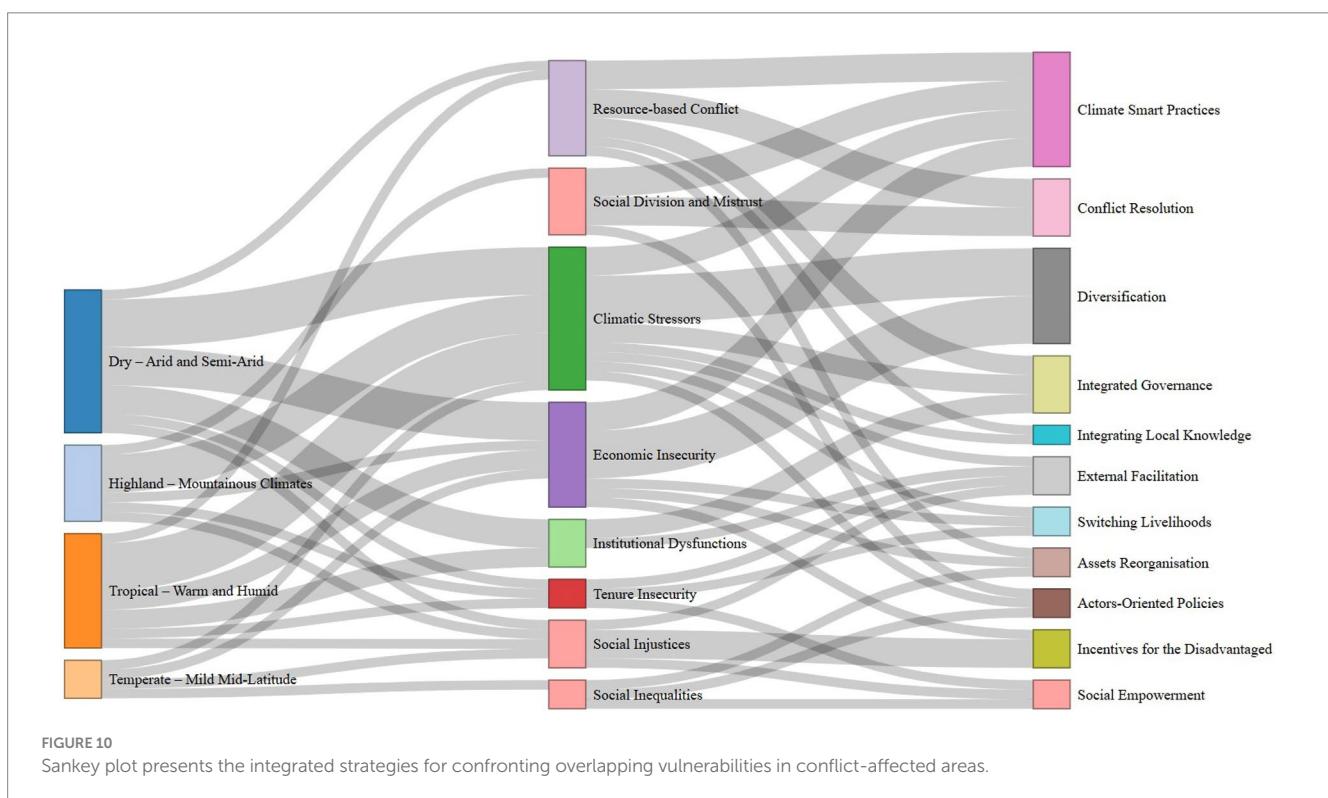
In dry-arid and semi-arid habitats, the most frequently used adaptations for drought hazards include migration, livelihood diversification, on-farm diversification, soil and water conservation practices and irrigation (Figure 9). Other less frequently used strategies identified in dry-arid and semi-arid habitats are land use adjustment, tree planting, agroforestry, insurance, rain-making rituals, early warnings, increased fertilizer use and collective policies (e.g., community-based natural resources management). In tropical-warm humid habitats, the use of improved crop cultivars dominates the adaptation strategy portfolio for drought management. Other frequently used strategies for managing drought hazards in the Tropical-Warm Humid habitats include on-farm diversification, livelihood diversification, migration, soil and water conservation and distress borrowing. In highland-mountainous habitats, livelihood diversification, off-farm diversification and migration were the most common strategies for managing drought challenges. Other strategies identified as unique to highland-mountainous habitats include sowing twice in case of initial crop failure, as well as the use of hazard calendars and traditional forecasts. The temperate-mild mid-altitude habitats had the fewest strategies for adapting to

the drought challenge. The only three strategies mentioned are livelihood diversification, on-farm diversification and adjusting agronomic calendars. Generally, the dry-arid and semi-arid habitats have greater frequencies of strategies for addressing the drought challenge, probably due to greater climate variability (drought probability), a long history of environmental pressure leading to rich traditional ecological knowledge for managing droughts, and institutional and policy influences.

3.3.3 Strategies for navigating dual challenges in conflict-affected areas

Smallholder farmers in conflict-affected areas face overlapping climatic and non-climatic hazards (Mach et al., 2019), with adaptive capacity further constrained by compounded vulnerabilities (FAO, 2021). Our systematic review identified eleven (11) integrated strategies for navigating eight (8) categories of vulnerabilities across four (4) biophysical gradients (Figure 10).

- Climate-smart practices: Climate-smart practices are increasingly promoted as a strategic approach for navigating complex and overlapping challenges that include climate change impacts and social division and mistrust (Sultana and Thompson, 2017), economic insecurity (Quandt and McCabe, 2017) and resource-based conflicts (Amede et al., 2022; Minale et al., 2024). An example can be found in a study by Sultana and Thompson (2017), which demonstrated that climate-smart water management practices adopted by the farming community in Baragaon, Bangladesh, not only enhanced cooperation (social cohesion and trust) among farmers and improved water access but also helped mitigate resource-based conflicts.
- Diversification: Next to climate-smart practices is diversification, which is widely confirmed by the literature as a critical strategy



for simultaneously addressing climatic stressors and economic insecurity in conflict-affected contexts (Delina et al., 2023; Gebeyehu et al., 2021; Huho and Ngaira, 2012; Omerkhil et al., 2020; Ullah et al., 2024). For example, in the community conflict-affected Philippines' Cotabato River Basin, people navigated the interwoven stressors (climatic and conflict-induced poverty) by practising agricultural and non-agricultural diversification. The non-agricultural livelihood options involved setting up small businesses (locally known as sari-sari stores), offering transportation services (e.g., pedicab driving/bike taxi), and vending local delicacies (Delina et al., 2023).

- **Integrated governance:** Other dual-purpose strategies include integrated governance, mainly for addressing resource-based conflict, climatic stressors, and institutional dysfunction in conflict-affected settings (Delclaux et al., 2010; Hamisi et al., 2012; Hellin et al., 2018; Ullah et al., 2024; Van Huynh et al., 2019). Medina et al. (2025a) reinforce the argument that integrated governance is central to adaptation in conflict-affected settings. Their institutional comparison demonstrates that the success of adaptation depends on governance systems' ability to address resource conflicts, climate pressures, and institutional weaknesses in tandem.
- **Conflict resolution:** Conflict resolution emerged as an important strategy for addressing resource-based conflicts, social division, and mistrust that pose significant barriers to adaptation (Amede et al., 2022; Borsdorff et al., 2011; Eriksen and Lind, 2009b; Sultana and Thompson, 2017).
- **Integrating local knowledge:** Local knowledge was often integrated to address climatic stressors and resource-based conflicts (Amede et al., 2022; Kongnso, 2022; Minale et al., 2024; Sultana and Thompson, 2017). In Bangladesh, (Sultana and Thompson, 2017), local farming communities organized and managed water collectively, leveraging their deep traditional understanding of seasonal water behaviors. The local inclusive participation—especially from often-excluded groups—helped reduce resource-based conflict and promoted water access and efficiency in use.
- **External facilitation:** External facilitation was mainly used to navigate social inequalities, tenure insecurity, institutional dysfunction, and climatic stressors (Chandra et al., 2017; Sultana and Thompson, 2017).
- **Switching livelihoods:** In some cases, people adapt to interwoven vulnerabilities by switching livelihoods (Dinc and Eklund, 2024; Tubi and Feitelson, 2016). This strategy was primarily employed to adapt to increasing climatic stress, tenure insecurity, and economic instability in conflict-affected settings. In the civil war-affected Syria, some smallholder farmers switched their livelihoods from crop farming to animal husbandry, trades (e.g., selling live sheep, diesel fuel, fruits and vegetables), or even short-term labor migration (e.g., for construction work, portage) to larger cities in Syria or other countries (mainly Lebanon) (Dinc and Eklund, 2024). Another example is the case of Bedouin herders and Jewish farmers in Israel's northern Negev, who adapted to drought by shifting their economic activities toward non-climate-sensitive sectors (construction and industry for the Bedouins, and alternative income sources such as orchards for the Jewish settlements) (Tubi and Feitelson, 2016).
- **Actor-oriented policies:** Actor-oriented policies were identified as a strategy for addressing climate change impacts, social division and mistrust, and social inequalities. For example, in the

multifaceted conflicts in the province of Maguindanao in the Philippines, an actor-oriented adaptation policy is evident in local-level undertakings where farmers, community elders, religious leaders, and local government offices co-manage environmental and conflict-related threats. Further, multi-sectoral and intra-religious dialogs strengthened social cohesion, allowing communities to co-design security and adaptation strategies with local authorities (Delina et al., 2024a).

- **Asset reorganization:** Asset reorganization emerged as a strategy for addressing economic insecurities in climate risk-prone areas suffering conflict impacts (Delina et al., 2024b; Tubi and Feitelson, 2016), social inequalities and resource-based conflict (Delina et al., 2024a).
- **Incentives to the disadvantaged:** In some instances, incentives to the disadvantaged emerged as a strategy for addressing social inequalities and economic insecurities (Sultana and Thompson, 2017).
- **Social empowerment:** Social empowerment has been applied to address social injustices, inequalities (Sultana and Thompson, 2017; Ullah et al., 2024), and tenure insecurities (Amede et al., 2022).

These strategies illustrate the multidimensional nature of adaptation in conflict-affected contexts, where responses must simultaneously address climatic stressors and entrenched social, economic, and institutional vulnerabilities. The prominence of climate-smart practices and diversification resonates with broader adaptation scholarship that emphasizes integrated, multi-benefit approaches (Sultana and Thompson, 2017; Huho and Ngaira, 2012). Strategies such as livelihood switching, actor-oriented policies, and asset reorganization exemplify the adaptive ingenuity of communities under duress and demonstrate how adaptation is mediated by governance structures, power asymmetries, and social capital (Adger et al., 2009; Eriksen et al., 2015; Ribot, 2010). The identification of dual-purpose strategies in conflict-affected settings is novel, as adaptation scholarship has often focused more on strategies addressing climate change and their barriers than on dual-purpose ones.

3.4 What adaptation strategies are proven empirically effective in which contexts, and what barriers impede effective adaptation in conflict-affected environments?

3.4.1 Empirically proven effective strategies in conflict-affected settings

Although a growing body of literature examines how smallholder farmers adapt to challenges in conflict-affected areas, the number of studies that specifically assess the success of these adaptation strategies is relatively limited. Only 9.86% ($n = 7$) of the studies explicitly mentioned whether the adaptation strategies successfully solved the challenges. In Sri Lanka, for example, a study revealed that cultivating alliances with power holders was considered effective for addressing contextual vulnerabilities associated with the impacts of the civil war. Korf, in his research, relied on qualitative evidence on stabilized or expanded livelihoods and empirically linked them to local political connections and context. In Burkina Faso, extensive social networks have been empirically shown to play a critical role in mitigating the impacts of jihadist-led armed conflict on food system actors in

conflict-affected regions (Maitre d'Hôtel et al., 2023). Similarly, in Pakistan, women's social networks and community ties were reportedly effective for climate-induced disaster management and risk reduction in areas affected by ecofeminist violence (Ullah et al., 2024). In Afghanistan, early warning information provided by community volunteers was considered best for addressing flash flood hazards caused by intense rainfall, linked to climate change, in the war-prone villages of Badakhshan (Mohanty et al., 2019). In Tanzania, empowering local communities through traditional institutions has been proven effective for sustainable natural resource management and climate change adaptation in areas affected by resource-based conflict (Hamisi et al., 2012). In Burundi, on the other hand, the adoption of digital financial services through mobile platforms has been empirically proven effective in enhancing food security in areas affected by civil war, by reducing reliance on consumption-related coping strategies (Atta-Aidoo et al., 2024). In Ethiopia, prioritizing cropping in areas less vulnerable to civil war-related disruptions and shifting to different crop types were found to be effective adaptation strategies, offering ways to improve food security and resilience (Nyssen et al., 2023). To measure the effectiveness of such an adaptation strategy, the authors utilized a combination of transect walks and sentinel satellite imagery to map and analyze the cropped area before and during the war (2020 vs. 2021). Still in Ethiopia, relying on communal aid (social solidarity) was found effective for empowering communities to address challenges and rebuilding livelihoods (Nyssen et al., 2023). The scarcity of studies that explicitly evaluate the success of adaptation strategies underscores a critical gap in current scholarships. Without systematic assessment, research risks remaining largely descriptive, offering limited guidance on what works in fragile and conflict-affected contexts. Exploring successful adaptation strategies in such settings is novel and essential, as it provides rare empirical evidence of resilience under conditions of compounded vulnerability. Unveiling these effective practices, particularly those rooted in social networks, institutional empowerment, and psychological resilience, not only enriches academic understanding but also offers transferable lessons for adaptation programs and policy development in other conflict-affected regions.

3.4.2 The dynamics of adaptation across smallholder farmers' social hierarchies in conflict-affected contexts

In conflict-affected environments, adaptation processes are deeply conditioned by power relations that determine who can access resources, participate in decision-making, secure institutional support, and ultimately exercise agency in responding to climate risks (O'Brien and Leichenko, 2000). Yet more than one-third of the reviewed studies (35.2%) did not explicitly examine adaptation as a function of power variation, leaving critical blind spots in understanding how social, economic, historical violence, and biophysical gradients shape vulnerability and adaptation actions. This omission limits insight into how relations of dominance and subordination structure adaptive opportunities for different groups of smallholder farmers, particularly across gender, age, economic class, displacement/violence history and biophysical gradients. This implies that these studies did not provide an adequate understanding of how different social hierarchies of smallholder farmers experience and navigate intersecting vulnerabilities, as a function of relations of dominance and subordination, in locations affected by conflicts. Specifically, current

research offers a limited understanding of how smallholder farmers, positioned within distinct power gradients, experience and respond to intersecting vulnerabilities in conflict-affected settings, where adaptation trajectories are profoundly shaped by patterns of social dominance, subordination, and differential access to resources. Attention to and disaggregation of the underlying power structures provide a nuanced understanding of adaptation among smallholder farmers of different demographic profiles, supporting the development of inclusive, effective, and contextually grounded resilience strategies.

Among the studies that explicitly examined power relations (64.78%), a significant proportion (58.69%) demonstrated that power fundamentally shapes entitlements, access, and control over resources, thereby directly enabling or constraining adaptation outcomes. These findings highlight that adaptation is not a neutral process; rather, it is deeply embedded within broader social, economic, and political structures that determine who can act, how they can act, and with what level of effectiveness. This aligns closely with Ribot's (2010) argument that adaptation cannot be separated from questions of access and distribution, as inequities in power relations inherently produce inequities in resilience. In other words, the capacity of individuals or communities to respond to compounded risks in conflict-affected contexts is inextricably linked to their position within existing hierarchies of power, and failure to recognize this linkage can lead to misinformed adaptation strategies that fail to reach those most vulnerable.

Addressing these underlying power structures is therefore essential for designing resilience strategies that are both inclusive and contextually relevant, especially in conflict- and climate-affected settings, where poverty is dynamic and multidimensional. In such cases, vulnerability frameworks offer a practical lens to assess adaptive capacity through exposure, sensitivity, and access to assets, livelihoods, education, and institutions (IPCC, 2014). Doing so allows policymakers and practitioners to identify barriers to equitable adaptation, target interventions to marginalized groups, and ensure that adaptation efforts do not inadvertently reinforce existing inequalities. Conversely, neglecting to account for these variations risks perpetuating the very disparities that adaptation research seeks to mitigate, while obscuring how intersecting vulnerabilities shaped by gender, age, economic status, social displacement, historical violence, or biophysical gradients are experienced differently across social hierarchies in conflict-affected contexts. A nuanced understanding of these power-mediated dynamics is thus critical for fostering adaptive capacity that is both effective and socially just.

3.4.3 Barriers to effective adaptation in conflict-affected environments?

Figure 11 shows the patterns of specific categories of barriers to smallholder farmers' adaptation in conflict-affected settings, by region as a clustered heatmap. The figure underscores how barrier profiles in conflict-affected settings are not only regionally differentiated but also systematically patterned. The row dendrogram illustrates similar profiles in terms of common barriers across the areas. Africa and Asia are clustered closely together, indicating that they share a pattern of high frequency of multiple categories of barriers. The clustering of Africa and Asia indicates the dominance of institutional and technocratic barriers, aligning with prior studies that emphasize weak governance, inadequate infrastructure, and restricted technological access as key obstacles to adaptation in fragile settings (Adger et al., 2009; Eriksen et al., 2015). South America, Europe, and North America form another

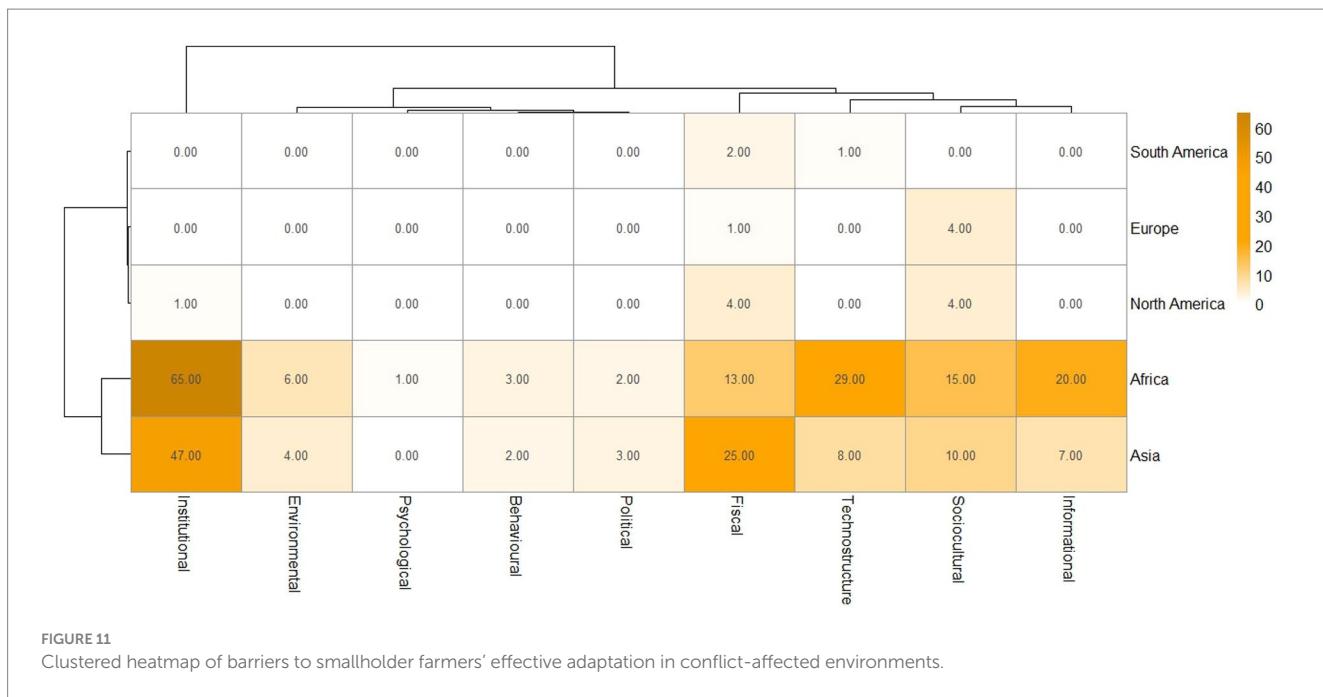


FIGURE 11

Clustered heatmap of barriers to smallholder farmers' effective adaptation in conflict-affected environments.

similar profile, with sparse and zero-barrier reporting. The column dendrogram illustrates the similarity between barrier types in terms of their frequency of occurrence across different regions. Informational, sociocultural, technocratic, and fiscal barriers demonstrated co-occurrence patterns. Barrier types clustered together may indicate shared systemic challenges. Institutional barriers appear to be distinctive and dominant, especially in the Global South. Psychological and political barriers are isolated types of barriers.

Focusing on frequency (cells of the heatmap), starting with Africa, the greatest proportion of barriers reported are institutional ($n = 65$) and technocratic ($n = 29$) barriers. The greater emphasis on institutional and technocratic barriers likely reflects the authors' focus on governance, infrastructure, and technological access. This emphasis, however, risks obscuring other critical dimensions. For instance, the near absence of attention to psychological barriers in the literature—despite their salience in conflict environments—suggests a blind spot in adaptation research. Studies in humanitarian and conflict psychology have long emphasized how trauma, habitual risk aversion, and latent violence potential shape decision-making and adaptive behavior (Appiah-Boateng and Bukari, 2023; El-Khani et al., 2016). Yet these insights remain marginal in agricultural adaptation scholarship, even though they interact with social and economic inequalities to constrain agency and resilience (Medina et al., 2025b). The co-occurrence of informational, sociocultural, technocratic, and fiscal barriers further points to systemic entanglements, consistent with findings that adaptation challenges are rarely discrete but instead mutually reinforcing (Biesbroek et al., 2009; Moser and Ekström, 2010). The sparse reporting of barriers in Europe and South America raises interpretive ambiguity. Whether this reflects genuinely lower salience or simply limited scholarly attention, as cautioned by Ford et al. (2015), remains unresolved. Overall, these patterns underscore the importance of adopting a broader diagnostic lens that brings neglected categories—especially psychological and political barriers—into focus, while recognizing their place within the wider systemic constraints of adaptation in conflict-affected contexts.

3.5 Limitations of the findings

Despite the contributions of our study, the limitations must be acknowledged. The geographic concentration of studies in the Global South may constrain generalizability to other regions, particularly conflict-affected Global North. Besides, the temporal scope considered in this systematic review (2004–2024) may exclude earlier work or very recent studies. The disciplinary fragmentation at the climate–conflict nexus may have led to uneven representation of perspectives. However, despite these constraints, the review consolidates fragmented evidence and highlights critical gaps and opportunities for future research. Lastly, the choice of language (English) and exclusion of grey literature may have excluded some relevant studies.

4 Conclusion and recommendations

Smallholder farmers in conflict-affected settings face compounded vulnerabilities from both climate change and protracted violence. This systematic review consolidates scattered evidence, revealing that most studies are concentrated in low-income regions of the Global South, disproportionately exposed to climate variability and conflict (ICRC, 2020). Research attention has grown since 2016, reflecting heightened awareness of the climate–conflict nexus (Weidmann, 2016) and global policy shifts such as the Paris Agreement and the Sustainable Development Goals (SDG 13 and SDG 16). Methodologically, mixed-methods approaches remain underrepresented, limiting holistic insights into adaptation where both quantifiable outcomes and lived experiences matter. Few studies explicitly assessed vulnerability within conflict contexts or linked vulnerabilities to adaptive capacities. Diversification emerged as the most common adaptation strategy, yet many studies overlooked how adaptation dynamics are shaped by power relations and social hierarchies. Future research should prioritize integrated mixed-methods designs, vulnerability assessments, and socially stratified analyses. Policy and practice must

build upon empirically proven strategies while tailoring interventions to local contexts, ensuring resilience-building efforts are inclusive, context-sensitive, and sustainable.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/supplementary material.

Author contributions

DR: Conceptualization, Methodology, Validation, Investigation, Data curation, Writing – review & editing, Funding acquisition, Writing – original draft, Formal analysis, Visualization, Software, Resources. CO: Data curation, Methodology, Project administration, Conceptualization, Resources, Validation, Writing – review & editing, Supervision. MN: Data curation, Project administration, Resources, Validation, Writing – review & editing, Software, Methodology, Conceptualization, Supervision, Investigation.

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Conflict of interest

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Supplementary material

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