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RESEARCH PAPER

Measuring Humanitarian Supply Chain Resilience under Natural Hazards: A Methodological Typology and Cross-Phase Research Agenda

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ABSTRACT
Natural hazards place humanitarian supply chains under pressure by damaging infrastructure, increasing uncertainty, and making the delivery of relief assistance more difficult. Although humanitarian supply chain resilience has become an important topic in logistics and disaster management research, the way it is measured remains fragmented across hazard contexts, methodological approaches, and disaster phases. This paper reviews how humanitarian supply chain resilience has been assessed under natural hazard conditions through a PRISMA-guided systematic literature review of 54 studies identified through searches in the Scopus and Web of Science databases and published between 2014 and May 2026.
The analysis combines descriptive results, VOS viewer keyword co-occurrence mapping, and a coding framework covering hazard context, methodological family, resilience phase, measurement focus, and contribution to humanitarian decision-making. The results show that floods and earthquakes receive attention, while cyclones, typhoons, landslides, droughts, and cascading hazards remain less represented. Optimization models are the common methodological family, followed by multi-criteria decision-making, simulation, statistical and probabilistic modeling, qualitative case-based approaches, AI/data-driven methods, and hybrid decision-support models.
The review also shows that most studies emphasize operational indicators, including response time, cost, routing efficiency, facility location, accessibility, and relief allocation. Coordination capacity, deprivation cost, social vulnerability, recovery, organizational learning, and feedback between disaster phases are weakly integrated into existing measurement frameworks. The paper contributes by developing a methodological typology of humanitarian supply chain resilience measurement approaches and by proposing a hazard-sensitive and cross-phase research agenda for future studies.

KEYWORDS: *Humanitarian supply chain resilience; Natural hazard; Disaster; Systematic review.*

1. Introduction

Natural hazards are placing pressure on emergency management systems worldwide. Earthquakes, floods, landslides, cyclones, hurricanes, and extreme weather events can disrupt infrastructure, isolate affected communities, and generate urgent needs for relief supplies, medical support, shelter, and logistics coordination [1]. In Morocco, the 2023 Al Haouz earthquake and recurrent flooding events illustrate the human, territorial, and operational consequences of such hazards [2]. Previous studies have shown that disaster impacts are often intensified by inadequate planning, weak coordination, and ineffective management of relief operations across pre-disaster, response, and post-disaster phases [3]. This highlights the need to strengthen humanitarian supply chain resilience (HSCR) in natural hazard contexts to ensure efficient, timely, and effective relief operations under high-risk and rapidly evolving conditions.

Although existing systematic literature reviews have examined humanitarian supply chain resilience across different disruption contexts, limited attention has been given to how HSCR is measured specifically under natural hazards. The literature remains fragmented in terms of the indicators used, the methodological approaches adopted, and the alignment of measurement methods with disaster resilience phases. Recent research on sustainable logistics and supply chain resilience has highlighted the fragmented development of resilience studies, supporting the need for more focused analyses in specific logistics contexts [4].

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Consequently, practitioners still lack consolidated evidence-based frameworks to assess HSCR in the face of disruptions generated by floods, earthquakes, landslides, cyclones, hurricanes, and other natural hazards.

This study addresses these gaps through a dual-method approach. First, a PRISMA-guided systematic literature review is conducted to identify, screen, and analyze studies on HSCR measurement under natural hazards. Second, the review is complemented by VOSviewer co-occurrence analysis to map the structure of the field and identify its main research areas. This study analyzes the main resilience measurement methods used in the literature and examines their alignment with disaster resilience phases: preparedness, response, recovery, and learning.

The purpose of this research is to answer the research questions:

RQ1. How has research on humanitarian supply chain resilience under natural hazards evolved over the period 2014–May 2026?

RQ2. What are the main research areas and thematic clusters in humanitarian supply chain resilience under natural hazards?

RQ3. What measurement methods and methodological approaches have been used to assess humanitarian supply chain resilience under natural hazards, and how do they align with disaster resilience phases?

2. Review Methodology

A systematic literature review design was used, with the PRISMA framework serving as a guide for the identification, screening, eligibility assessment, and inclusion of studies [5]. PRISMA was selected because it provides a transparent and reproducible process for identifying, screening, assessing, and selecting relevant studies. This approach was considered suitable because the objective of the review is not only to count publications, but also to understand how HSCR measurement has developed, which methods have been used, and how these methods relate to the different phases of disaster resilience. The review followed four steps. First, records were retrieved from Scopus and Web of Science. Second, duplicate records were removed, and the remaining studies were screened using their titles, abstracts, and keywords. Third, the full texts of relevant studies were examined by the eligibility criteria. Finally, the selected studies were coded according to their publication characteristics, hazard context, methodological family, measurement focus, and disaster resilience phase.

2.1. Search strategy

The database search was completed in May 2026. To capture recent developments while maintaining a defined review window, the search covered studies published from 2014 to May 2026. Scopus and Web of Science were used because of their coverage of peer-reviewed research in logistics, supply chain management, operations management, disaster management, and industrial engineering. The search string in Table 1 was structured around four keywords: humanitarian logistics/supply chain, resilience, natural hazards, and measurement or assessment. Equivalent queries were applied in both databases and adapted to their specific search fields.

2.2. Eligibility and selection criteria

The Eligibility and Selection Criteria (Table2) were defined before the screening stage to ensure transparency and consistency in the screening process. Studies were retained when they addressed humanitarian supply chains, humanitarian logistics, disaster relief logistics, or emergency logistics in relation to resilience or resilience-related concepts under natural hazard contexts. The review retained journal articles and conference papers because humanitarian logistics is an applied field where relevant methodological contributions are published in proceedings. Literature reviews, systematic reviews, and bibliometric reviews were excluded from the analytical corpus to focus on empirical, conceptual, modeling, and decision-support contributions. However, review papers were used when necessary to support the conceptual background. Studies dealing with biological hazards or pandemics were excluded unless they explicitly addressed emergency logistics or humanitarian supply chain issues connected to natural hazard-related disaster response.

2.3. Screening and eligibility process

After completing the database, all records retrieved from Scopus and Web of Science were exported in Zotero. Duplicate records were then identified and removed before the screening stage. The remaining records were screened based on titles, abstracts, and keywords to assess their relevance to humanitarian supply chain resilience measurement under natural hazard. The initial search identified 129 records, including 67 from Scopus and 62 from Web of Science. After removing 22 duplicates, 107 records remained for screening. During the title, abstract, and keyword screening stage, 38 records were excluded. Among these, seven were review papers

or secondary studies, and 31 were excluded because they did not match the review focus on humanitarian supply chain resilience, resilience-related measurement, or natural hazard/disaster-related logistics.

Full texts were then sought for 69 records. Fourteen reports could not be retrieved despite searches through DOI links, publisher platforms, Google Scholar, Zotero PDF retrieval, and available institutional access. The remaining 55 full-text studies were assessed for eligibility. One study was excluded after full-text assessment because it did not provide a contribution to HSCR measurement. Finally, 54 studies were retained in the final corpus.

Tab.1. Search strategy and database results

Database	Search field	Search string	Period	Document type	Language	Number
Scopus	Title, Abstract, Keywords	("humanitarian supply chain" OR "humanitarian logistics" OR "disaster relief logistics" OR "relief supply chain") AND resilien* AND ("natural disaster*" OR "natural hazard*" OR earthquake* OR flood* OR hurricane* OR cyclone* OR drought* OR landslide*) AND (measurement OR assessment OR evaluation OR indicator* OR metric* OR model* OR framework)	2014–May 2026	Articles and conference papers	English	67
Web of Science	Topic (TS: Title, Abstract, Author Keywords, Keywords)	("humanitarian supply chain" OR "humanitarian logistics" OR "disaster relief logistics" OR "relief supply chain") AND resilien* AND ("natural disaster*" OR "natural hazard*" OR earthquake* OR flood* OR hurricane* OR cyclone* OR drought* OR landslide*) AND (measurement OR assessment OR evaluation OR indicator* OR metric* OR model* OR framework)	2014–May 2026	Articles and proceedings papers	English	62

Tab.2. Inclusion and exclusion criteria

Criterion	Inclusion criteria	Exclusion criteria
Document type	Journal articles and conference papers/proceedings papers	Book chapters, editorials, notes, reports, theses, and non-academic documents
Study focus	Humanitarian supply chains, humanitarian logistics, disaster relief logistics, emergency logistics	Commercial supply chains without a humanitarian or disaster relief context
Resilience focus	Studies addressing resilience or related concepts such as robustness, flexibility, agility, preparedness, response, recovery, vulnerability reduction, continuity, or adaptability	Studies without a resilience-related focus
Hazard context	Natural hazards, disaster relief, multi-hazard events, or disaster-related humanitarian logistics	Studies unrelated to disasters or humanitarian contexts
Review type	Original empirical, conceptual, modeling, methodological, or decision-support studies	Literature reviews, systematic reviews, and bibliometric reviews are excluded from the analytical corpus
Full-text access	Full text available through database access, DOI, publisher platform, Google Scholar, or institutional access	Full text not retrieved after reasonable search

The study selection process is detailed in the PRISMA flow diagram presented in Appendix A, Figure 1.

3. Results

3.1. Analysis of scientific research

To address RQ1, this section examines the development of research on humanitarian supply chain resilience under natural hazards. The analysis is based on the corpus of 54 studies and focuses on publication trends, main publication outlets, and document types.

3.1.1. Number of publications per year

Figure 2 presents the distribution of publications from 2014 to May 2026. The results show that research on HSCR under natural hazards has been developed during the first years of the period, with a limited number of publications between 2014 and 2018. This suggests that the topic was emerging during this period.

From 2019, the number of publications increased, although the trend remained irregular. The number of publications increases in 2024 and 2025, suggesting academic interest in measuring HSCR under natural hazards. This recent growth reflects the diversification of methods used to study HSCR, particularly the increasing use of optimization models, MCDM, simulation, AI-based methods, and hybrid decision-support tools. Although the trend is positive, annual variation suggests that HSCR measurement under natural hazards remains an evolving research area.

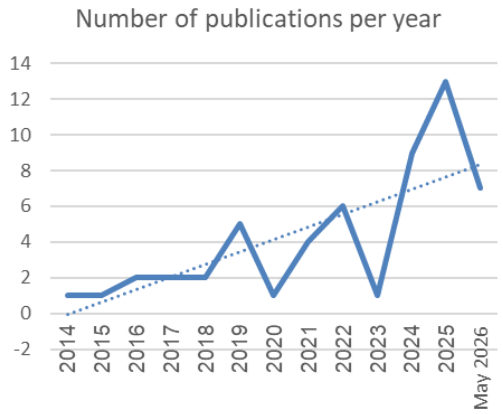

Fig.1. Number of publications per year

3.1.2. Leading Publication Outlets

Figure 3 presents the journal publication that contributed more than two papers to the reviewed corpus. The results show that the literature is concentrated in a small number of journals. Sustainability is the most represented journal with eight papers, followed by the Journal of Humanitarian Logistics and Supply Chain Management with five papers. Other journals, including Water, Systems, Natural Hazards, Annals of Operations Research, the European Journal of Operational Research, and the International Journal of Disaster Risk Reduction, each contributed two papers.

This distribution confirms the interdisciplinary nature of HSCR research. While some journals are related to humanitarian logistics and disaster risk, others belong to operations research, systems analysis, sustainability, and hazard-specific research. This indicates that HSCR measurement is shaped by contributions from multiple academic communities, rather than a single disciplinary tradition.

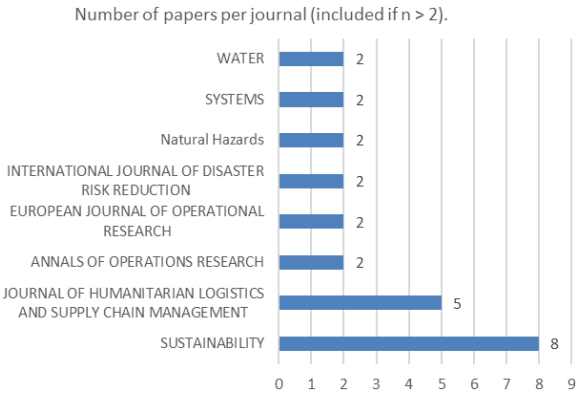

Fig.2. Number of papers per journal

3.1.3. Distribution by document type

Figure 4 presents the distribution of the reviewed studies by document type.

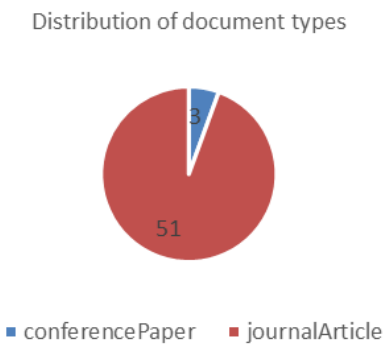

Fig.3. Distribution of document types

The corpus is mainly composed of journal articles, representing 51 studies, while conference papers represent three studies. This confirms that the review is primarily based on peer-reviewed journal literature, while still including relevant conference

contributions. The inclusion of conference papers is justified by the applied nature of humanitarian logistics, where methodological and decision-support developments may first appear in conference proceedings. However, the dominance of journal articles reinforces the academic reliability of the final corpus.

3.2. Identification of research areas

This section addresses RQ2 by examining the main research areas in HSCR measurement under natural hazards. A keyword co-occurrence analysis was conducted using VOSviewer to visualize the thematic structure of the field.

Figure 5 shows that litearture is organized around interconnected areas. The central area includes terms such as "humanitarian supply chain", "relief", "information", "disaster response", and "infrastructure". This suggests that the HSCR is built around the coordination of resources, information flows, and infrastructure during disaster response.

A second area is related to operational decision-support, with terms such as "problem", "relief supply", "relief item", "evacuation", "MDC", and "relief network". These terms indicate the importance of optimization and modeling approaches for allocation, evacuation, routing, and relief distribution problems.

A third area reflects hazard-specific and capacity-related issues, including "capacity", "landslide", "typhoon disaster", "disaster chain", "disaster prevention", and "indicator". This suggests growing attention to natural hazard specificity and resilience assessment indicators. Another thematic area emphasizes governance and stakeholder coordination, with terms such as "stakeholder", "community", "government", "humanitarian organization", "barrier", and "effective response". This confirms that HSCR is not only an operational issue, but also depends on institutional coordination, collaboration, and information sharing among multiple actors.

Finally, terms such as "supply", "transportation system", "flood disaster", "rainstorm", "equity", and "UAVs" point to emerging concerns related to transport resilience, last-mile delivery, technology-supported response, and equitable access to relief.

Overall, the keyword analysis identifies five main research areas: disaster response and information coordination, operational decision-support, hazard-specific capacity assessment, stakeholder and governance issues, and transport or technology-supported relief operations.

The keyword co-occurrence network generated with VOS viewer is provided in Appendix B, Figure 1.

4. Analysis

4.1. Analysis of the reviewed studies by disaster context

The 54 selected studies were first classified according to their disaster or hazard context. This classification shows that HSCR measurement under natural hazards remains unequally distributed across hazard types (Table 3).

Flood, flash flood, and rainstorm contexts represent the largest group, with 17 studies, corresponding to 31.5% of the corpus. These studies address relief allocation, transportation accessibility, response time, supply capability, and resilience indicators.

Earthquake and seismic contexts follow, with 16 studies, representing 29.6% of the corpus. They focus on facility location, network flexibility, inventory pre-positioning, evacuation, road accessibility, and relief distribution.

Cyclone, typhoon, and hurricane-related studies account for seven studies, or 13.0% of the corpus. These studies examine preparedness activities, humanitarian supply chain barriers, disaster chains, demand estimation, and route robustness. Landslide and disaster-chain contexts remain marginal, with one study, representing 1.9% of the corpus. Finally, 13 studies, or 24.1%, adopt a general or multi-hazard disaster context.

Overall, floods and earthquakes dominate HSCR measurement research under natural hazards, while cyclones, typhoons, hurricanes, landslides, and cascading hazards remain comparatively underrepresented. This imbalance confirms the need for more hazard-sensitive measurement frameworks that account for the disruption mechanisms associated with each type of natural hazard.

4.2. Main HSCR measurement methods identified in the literature

To answer RQ3, the 54 selected studies were classified according to their methodological family (Table 4) This classification provides an understanding of how HSCR is measured.

Optimization is the dominant methodological family, with 22 studies. These models support facility location, routing, relief allocation, inventory pre-positioning, evacuation, road rehabilitation, and network design under uncertainty. They measure resilience through operational variables such as cost, response time, accessibility, unmet demand, service level, and network robustness.

MCDM approaches represent five studies. They are used to prioritize resilience indicators, preparedness activities, barriers, and risk mitigation strategies. Simulation, statistical/probabilistic modeling, AI/data-driven approaches, qualitative case-based studies, and hybrid decision-support models complete the corpus. These approaches extend HSCR measurement toward dynamic scenarios, stakeholder coordination, risk modeling, real-time information, demand estimation, digital response, and integrated decision support. However, several methods still require validation in real humanitarian operations.

4.3. Alignment of measurement methods with disaster resilience phases

The reviewed studies were analyzed according to their alignment with disaster resilience phases: preparedness, response, recovery, and learning or continuous improvement [60] The results show a concentration on preparedness and response (Table 5).

Preparedness is addressed through facility location, inventory pre-positioning, risk mitigation, supplier selection, road accessibility, and resilience indicator prioritization. This phase is represented in optimization and MCDM studies, which aim to improve the capacity of humanitarian supply chains before a disaster occurs. Response is the most visible phase across the corpus. It is addressed through relief distribution, routing, allocation, evacuation, transportation accessibility, demand satisfaction, response time, and service level. This confirms that HSCR measurement is largely oriented toward immediate operational performance during disasters. Recovery is less systematically developed. Some studies consider recovery through road rehabilitation, post-disaster logistics, accessibility restoration, deprivation cost, or community recovery.

Tab.3. Distribution of studies by hazard context

Hazard/ disruption context	No. of studies	Percentage	Dominant methodological families	Main measurement emphasis	Observed gap
Flood/flash flood/ rainstorm	17	31.5%	Optimization, MCDM, AI/data-driven, simulation, statistical/probabilistic modeling	Relief allocation, resilience indicators, accessibility, transportation disruption, response time, supply capability	Need for stronger longitudinal recovery and learning indicators beyond response/ accessibility
Earthquake/ seismic	16	29.6%	Optimization, hybrid decision-support, AI/ data-driven, qualitative case-based, simulation	Facility location, network flexibility, pre-positioning, road accessibility, evacuation, and relief distribution	Need for stronger integration of post-disaster learning and cross-phase feedback mechanisms
Cyclone/typhoon /hurricane	7	13.0%	MCDM, AI/data-driven, optimization, statistical/ probabilistic modeling, qualitative case-based	Preparedness barriers, disaster chains, demand estimation, relief distribution, route robustness	Hazard-specific studies remain fewer and often focus on preparedness or response rather than full-cycle resilience
Landslide/disaster	1	1.9%	Optimization	Emergency distribution under secondary disruptions	Cascading and compound hazards require more integrated HSC-specific measurement frameworks
General/multi-hazard disaster	13	24.1%	Optimization, hybrid decision-support, qualitative case-based, statistical/probabilistic modeling, AI/data-driven	Network design, resource allocation, evacuation, viability, digital response, and decision support	Generic scenarios support modeling but may hide hazard-specific disruption mechanisms

Tab.4. Main methodological families used for HSCR measurement

Methodological family	No. of studies	Main methods/ techniques	Measurement focus	Studies included in this methodological family	Gaps
Optimization	22	MILP, stochastic programming, robust optimization, goal programming, Markov decision process, genetic algorithms, network design models	Facility location, routing, allocation, pre-positioning, evacuation, response time, cost, accessibility, unmet demand	[6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27]	Strong operational decision support but limited integration of social vulnerability, learning, and long-term recovery
MCDM	5	AHP, ANP, DEMATEL, TOPSIS, VIKOR, ISM, MICMAC, fuzzy MCDM	Resilience indicators, barriers, preparedness activities, risk mitigation strategies, stakeholder coordination	[28], [29], [30], [31], [32]	Captures multi-actor factors but depends on expert judgment and subjective weighting
Simulation	3	Agent-based simulation, GIS, traffic simulation, multi-agent modeling, network robustness analysis	Dynamic disruption behavior, supply capability, road/ network accessibility, scenario testing	[33], [34], [35]	Useful for dynamic settings but dependent on assumptions and data availability
Statistical/ probabilistic modeling	6	Bayesian networks, mixed logit, discrete choice modeling, PLS-SEM, SEM, fsQCA, mean–variance network model	Risk transmission, deprivation cost, performance evaluation, capability-performance relationships	[36], [37], [38], [39], [40], [41]	Supports risk and relationship analysis but provide limited direct operational guidance
Qualitative case-based	5	Case studies, interviews, content analysis, social network analysis, interorganizational case analysis	Coordination, governance, organizational culture, stakeholder collaboration, barriers, field constraints	[42], [43], [44], [45], [46]	Provides contextual insight but limited generalizability and comparability across cases
AI/data-driven	8	Machine learning, deep learning, reinforcement learning, blockchain, social media analytics, UAV routing, digital platforms	Demand estimation, route selection, UAV delivery, aid tracking, situational awareness, adaptive response	[47], [48], [49], [50], [51], [52], [53],[54]	High potential for real-time HSCR measurement but requires reliable data infrastructure and validation
Hybrid decision-support	5	ML-MCDM, optimization-MCDM, fuzzy-MCDM, field-based flexibility framework, sentiment analysis and route selection	Integrated resilience assessment and decision support	[55], [56], [57], [58], [59]	Rich analytical perspective but often complex and insufficiently validated in field operations

However, recovery is often treated as an extension of response rather than as a distinct phase with specific indicators.

Learning and continuous improvement are the least developed dimensions. Few studies explicitly examine how post-disaster experience, organizational

memory, feedback loops, or lessons learned are integrated into future preparedness. This represents a limitation because resilience should be understood as a continuous and adaptive process, not only as the ability to respond to immediate disruptions. Overall, the phase-based analysis shows that HSCR measurement is still dominated by preparedness and response. Recovery, learning, and continuous improvement remain comparatively underdeveloped. This imbalance limits the ability of current frameworks to capture resilience as a full-cycle and adaptive process across natural hazard contexts.

5. Discussion

The 54 studies reviewed provide an updated overview of how humanitarian supply chain resilience (HSCR) has been measured under natural hazards. The findings show that the field has grown over the last decade and has become methodologically diverse. However, several conceptual and methodological gaps remain.

A first gap concerns the unequal representation of natural hazards. Floods and earthquakes are the most frequently studied contexts, while cyclones, typhoons, hurricanes, landslides, droughts, and cascading hazards remain less represented. This imbalance limits the development of hazard-sensitive measurement frameworks. Natural hazards affect humanitarian supply chains through disruption mechanisms. Floods isolate communities and reduce transport accessibility; earthquakes damage warehouses, roads, and distribution nodes; while cyclones and typhoons disrupt infrastructure, communication systems, energy networks, and relief distribution activities. A second gap concerns the fragmentation of HSCR measurement. The reviewed studies use indicators, including cost, response time, accessibility, unmet demand, facility availability, coordination, information sharing, flexibility, deprivation cost, and recovery capacity. While this diversity shows that resilience is a multidimensional concept, it also reduces comparability across studies. Operational indicators are treated separately from organizational and human-centered dimensions, which makes it difficult to assess HSCR as an integrated capability. Consequently, the field lacks a consolidated measurement framework that connects operational performance, coordination mechanisms, social vulnerability, recovery capacity, and learning processes.

A third limitation concerns the dominance of preparedness and response phases. Most studies focus on facility location, inventory pre-positioning, routing, relief allocation, evacuation, and response time. These dimensions are essential for humanitarian logistics, but they capture what happens before and during disruption. Recovery, learning, organizational memory, and continuous improvement remain less developed. This is a gap because resilience should not be limited to immediate response; it should also include the capacity to learn from past disruptions and improve future preparedness [60].

The methodological analysis also shows the dominance of optimization models. These approaches support operational decisions related to network design, routing, facility location, relief allocation, and resource planning. However, they capture resilience mainly through operational performance indicators and give less attention to stakeholder coordination, institutional constraints, social vulnerability, and post-disaster learning. By contrast, MCDM and qualitative approaches examine less tangible dimensions, such as coordination, information transparency, preparedness barriers, governance, and inter-organizational collaboration.

Hybrid, AI-driven, and data-driven approaches offer directions for HSCR measurement. Methods such as machine learning, deep learning, social media analytics, UAV-based routing, blockchain, Bayesian networks, and hybrid decision-support models strengthen demand estimation, situational awareness, route selection, and adaptive response.

Tab.5. Alignment of methodological families with disaster resilience phases

	No.	Prevention	Resistance	Response	Recovery	Continuous improvement
Optimization	22	✓	✓	✓	△	—
MCDM	5	✓	✓	△	△	—
Simulation	3	✓	△	✓	△	—
Statistical	6	✓	✓	△	△	△
Qualitative case-based	5	✓	✓	✓	△	△
AI/data-driven	8	✓	△	✓	△	△
Hybrid decision-support	5	✓	✓	✓	△	△
Note: ✓= strongly represented; △= partially represented; —= weakly represented or absent						

However, their contribution depends on the availability of reliable data, validation in real humanitarian settings, and integration into decision-making processes used by humanitarian actors.

These findings suggest that future research should move beyond isolated measurement approaches. Attention should be given to underrepresented but high-impact hazards, particularly cyclones, typhoons, landslides, droughts, and cascading events. Second, future frameworks should combine operational indicators with organizational, social, and human-centered dimensions such as coordination, equity, deprivation, vulnerability, and learning. Third, researchers should develop cross-phase measurement frameworks that connect preparedness, response, recovery, and continuous improvement. Finally, greater attention should be given to validating proposed models with real humanitarian data and field-based evidence.

6. Conclusion

This paper presented a systematic literature review of humanitarian supply chain resilience measurement under natural hazards over the period 2014–May 2026. Based on a PRISMA-guided process, 54 studies retrieved from Scopus and Web of Science were retained and analyzed. The study examined publication trends, research areas, methodological families, hazard contexts, and the alignment of measurement approaches with disaster resilience phases.

The review shows that research on HSCR under natural hazards has increased over time and has become methodologically diverse. The field is no longer limited to general discussions of resilience, but includes optimization models, MCDM approaches, simulation, statistical and probabilistic modeling, qualitative case-based research, AI/data-driven approaches, and hybrid decision-support methods.

The findings also reveal gaps. First, HSCR measurement is unequally distributed across hazard types: floods and earthquakes receive more attention, whereas cyclones, typhoons, landslides, droughts, and cascading hazards are less explored. Second, measurement approaches remain fragmented, making it difficult to compare operational, organizational, and human-centered indicators across studies. Third, preparedness and response dominate literature, while recovery, learning, and continuous improvement are insufficiently developed.

This study contributes to literature in three ways. First, it provides an updated synthesis of HSCR measurement studies under natural hazards. Second, it proposes a methodological typology that goes beyond the broad qualitative, quantitative, and hybrid classification. Third, it shows the need for hazard-sensitive and phase-based measurement frameworks that integrate operational performance, stakeholder coordination, deprivation reduction, recovery capacity, and post-disaster learning.

Future research should prioritize underrepresented natural hazards, develop integrated cross-phase resilience frameworks, and combine predictive modeling with organizational learning and field validation. Moving in this direction would help shift HSCR measurement from fragmented approaches toward more comprehensive frameworks that support timely, equitable, and effective humanitarian relief operations.

Like any systematic literature review, this study has limitations. The review was limited to Scopus and Web of Science and to English-language publications. Some potentially relevant full texts could not be retrieved. In addition, the classification of studies by methodological family and disaster phase involves an interpretive coding process. Despite these limitations, the study provides a structured basis for understanding current HSCR measurement approaches and for guiding future research in humanitarian logistics under natural hazards.

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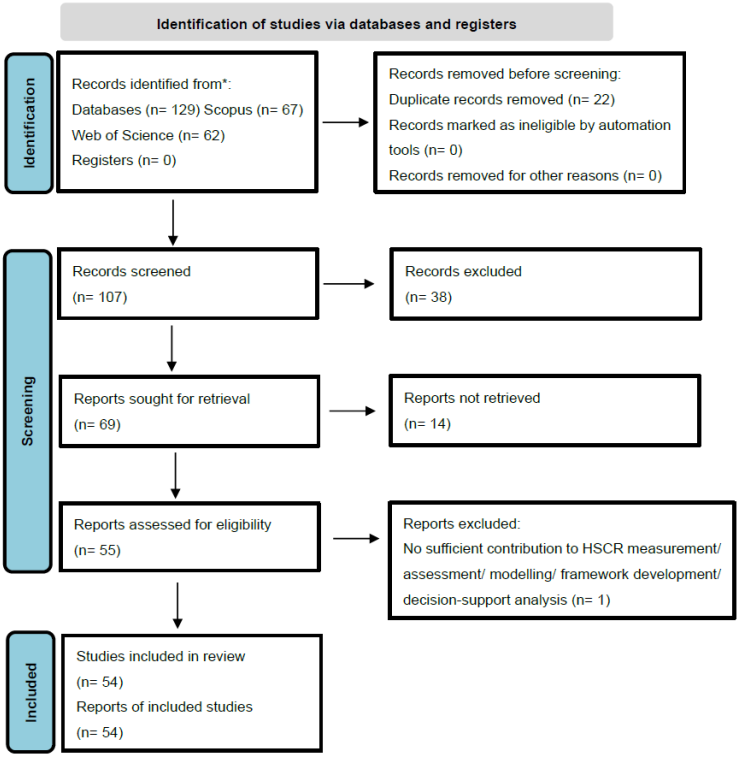
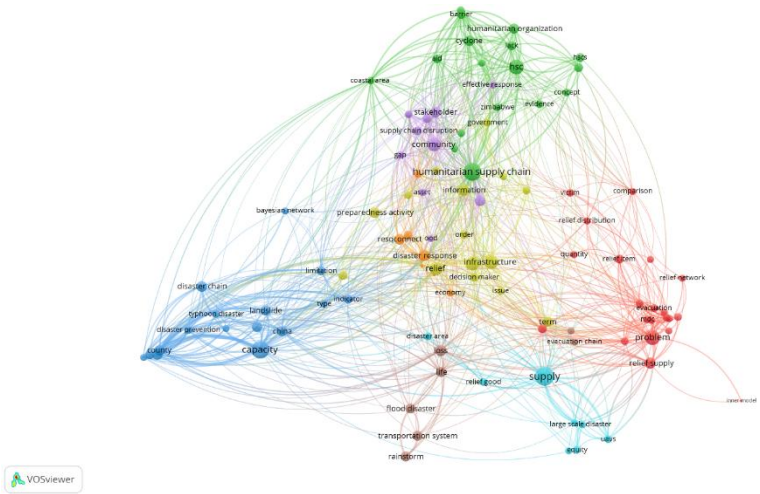
Appendix A



PRISMA flow diagram

Appendix B



Keyword co-occurrence network

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