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Systematic Review

A Study on the Research Clusters in the Humanitarian Supply Chain Literature: A Systematic Review

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Abstract: *Background:* The humanitarian supply chain (HSC) literature has observed significant growth in past years. The wide range of research areas and the interdisciplinary nature of humanitarian work have generated the need to examine and classify the literature. Previous reviews have examined particular research domains such as quality, data analytics, performance measurement, and dynamics capabilities. This article examines the HSC literature, tracing its evolution and proposing a systematic review and roadmap for future researchers. *Method:* We adopted bibliometric, network, and citation analyses to extract insights into the HSC literature. *Results:* The integrated approach helped map the previous literature and identified research keywords, clusters, authors' collaborative network, and seven research fields. The literature classification and clustering were performed for the articles published before the literature surge during the COVID-19 pandemic to avoid potential biases that could arise from the significant increase in HSC research published during this period. *Conclusions:* Some of the original contributions to this article include the classification of research clusters and the identification of emerging research topics in the HSC domain. Our findings indicate research opportunities in the sustainability, performance measurement, and innovation aspects of the HSC. This study provides potential research roadmaps for future research in this field.

Keywords: humanitarian supply chain; disaster management; humanitarian logistics; literature review; bibliometrics and network analysis

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1. Introduction

The rate of occurrence of disasters has magnified in recent years. The Centre for Research on the Epidemiology of Disasters (CRED) [1] reported a 74.45% increase in the number of disaster occurrences from 1980 to 1999 to 2000–2019. These disasters led to a USD 2.97 trillion loss worldwide. The increased rate of disasters has generated the need to execute efficient humanitarian operations. Humanitarian operations have gained considerable attention from the humanitarian supply chain (HSC) stakeholders. The fire-fighting practice of Humanitarian Organizations (HOs) has evolved into a more structured and complex network of multiple stakeholders managing various relief activities. Fontainha et al. [2] identified ten HSC stakeholders and segregated them into three groups—public, private, and people. The design and implementation of HSC depend on the type of disaster, disaster intensity, stakeholders involved, geography, and others. Van Wassenhove [3] characterizes the success of humanitarian operations when relief efforts fulfill the urgent need of disaster victims sustainably within the shortest possible time while utilizing minimum resources.

The HSC literature comprises multidisciplinary research drawing from a range of topics, concepts, theories, modeling, and practice from mathematics, geography, operation research, chemical engineering, and the management domain. The amalgamation of diverse subject domains often complicates the evolution of the HSC literature. Researchers counter overwhelming circumstances while understanding and propagating the HSC literature.

Occasionally the research gap remains unclear or served from the different subject fields. For example, pharmaceutical convergence during a disaster has been studied substantially from the pharmacy domain. However, management researchers rarely address its operational aspect [4].

Several attempts have been made to consolidate the HSC literature and present a structured approach to identify the research opportunities. Both Scopus and Webofscience reported 29 review articles with the keyword "humanitarian supply chain". We reviewed these 29 documents and present the scope, findings, and limitations or remarks of the most recent, relevant, and structured review articles in Table 1. We further ran the queries "humanitarian supply chain" or "humanitarian operations" or "humanitarian logistics" or "emergency logistics" or "disaster relief operations" or "disaster logistics" or "humanitarian relief operations" on the Scopus databases search criteria title, abstract, keywords and found 3743 documents. Figure 1 illustrates the rapidly growing publishing trend until November 2024 by plotting the number of documents between 2000 and 2025. The sudden dip in Figure 1 after 2023 can be explained by the remaining months in 2024 and in press articles for 2025.

Table 1. Recent reviews in the domain of HSCs.

S.NO.	Objective	Articles Reviewed	Outcome	Limitations/Remarks	Source
1	Review article related to HSC and sustainability	44	Reported five research avenues focusing on sustainability, performance measurement, aid distribution, data analytics, and coordination	Authors focused on sustainable HSCs and proposed a framework focusing on stakeholder network	[5]
2	Review article related to HSC digitalization and performance measurement	25	Highlight the slow growth and fragmentation in the HSC performance measurement literature	Focused on the reporting of humanitarian organization	[6]
3	Explored the on the use of climate-related information for humanitarian operations	77	Reported following three key themes: usability, collaboration, and coordination for the use of climate information in HSCs	Proposed a three-phase framework: development, adoption, and operation phases for using climate information	[7]
4	Reviewed the supplier selection literature in HSCs	30	Proposed various research avenues related to supplier evaluation, uncertainty, integration, unreliability, and procurement	Reported multiple improvement avenues in suppliers' management in HSC	[8]
5	Review article related to HSC performance measurement (PM)	83	Identified two key streams- and contextual-based PMs and predictive and simulation PMs	Reported limited implementation of PM system in practice	[9]
6	Explore dynamic capabilities (DC) view in HSC management.	9	Reported that DC is still in its infancy and mainly focused on post-disaster performance.	Highlighted the significance of DCs in HSCs and introduced factors dynamically affecting HSCs	[10]

Table 1. *Cont.*

S.NO.	Objective	Articles Reviewed	Outcome	Limitations/Remarks	Source
7	Review technological development in HSC	342	Proposed four streams of future research that includes adoption of technologies, challenges, and benefits in different disasters	Performed a bibliometric analysis; thus, content received limited attention	[11]
8	Metaheuristics application in HSCs	78	Reported significant contributions to facility location and post-disaster operations	Recommend developing non-deterministic and multi-period problem	[12]
9	Reviewed organization theory (OT) in HSCs	25	Identified eight OTs and suggested exploration of four less applied OTs	Aimed to resolve the behaviors challenge in HSCs	[13]
10	Reviewed humanitarian aid and proposed a decentralized aid deployment framework (DAHD)	65	Highlighted the urbanization of humanitarian aid and suggested that a decentralized model can support a sustainable aid deployment framework	Focused review that takes into account different aid deployment frameworks and studies to highlight the research gap	[14]
11	Reviewed the quality management literature in HSCs	61	Identified enablers, challenges, and theory development approach for quality enhancement in HSCs	Suggested using empirical and case study research methods for enhancing quality management in HSCs	[15]
12	Opportunity for big data analytics in the HSC	28	Reported applications of different analytical tools in managing humanitarian operations	Highlighted the need to use unstructured data to provide relief	[16]
13	Explore methodologies for conducting a comprehensive literature review and its application in the performance measurement in HSCs	52	Reviewed six types of methods for literature review. Further divided the performance measurement-related literature into mitigation, preparedness, response, and recovery phases	Article presents a qualitative content analysis on the HSC literature that caters to the performance measurement	[17]
14	Review and propose a framework for HSC PM	66	Reported that PM frameworks are novel and used a case study	Suggested exploring the lack of PM implementation in the HSC	[18]

It can be observed from Table 1 that performance measurement in HSCs is one of the key focus areas for many studies and has been reviewed four times. Further, a comprehensive analysis of the literature catering to the different subdomain areas of the humanitarian and disaster relief operations has not been conducted previously. Thus, this article aims to provide a systematic review of the HSC literature. We accessed the existing literature relevant to the HSC, disaster response, performance measurement and improvement, resource management, and humanitarian logistics (HLs). The article presents an awareness of the current state of the HSC literature, highlights the literature's limitations, and recognizes the desirable area of contribution. We adopted a structured and scientific method to analyze 1565 documents related to HSCs and disaster relief operations. The article adopts a bibliometric, network, and citation analyses using the page rank method.

The remainder of this review article is structured as follows. Section 2 provides the research methodology and descriptive statistics of the HSC literature. Section 3 presents the bibliometric analysis and discusses the evolution of the HSC literature. Section 4 presents network analysis. We identified and discussed research clusters in this section based on the citation analysis and discussed their implications. Section 5 concludes the work and presents the limitations of this research.

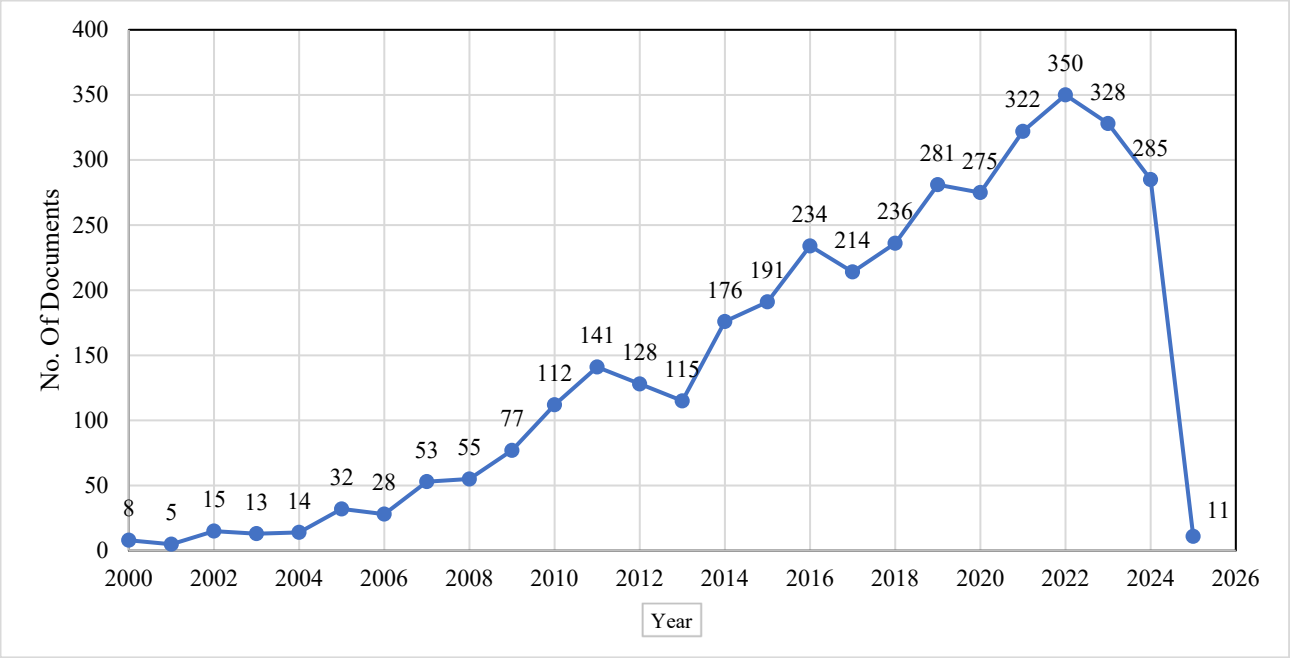

Figure 1. Publishing trend in the domain of the HSC.

2. Methodology

The review of the literature is an essential step in research progress. It gives a historical overview of the disciplines and extracts the policy and practice [19]. A literature review can be described as an empirically and methodologically controlled approach to analyzing content within the discipline context. A systematic literature review involves an iterative process of defining relevant search terms, searching the literature, and finishing the analysis [20]. Systematic literature reviews eliminate selection bias and objectively summarize the previous literature. The process helps identify potential research gaps and delineate the boundary of knowledge [21]. A systematic literature review of the HSC literature is conducted in this study following the PRISMA procedure. The PRISMA checklist and flowchart based on the PRISM procedure are provided in Files S1 and S2 in the Supplementary Materials section of this paper. We adopted bibliometric and network analyses to review the HSC literature. The integrated methodology helped ensure the domain's fidelity, entirety, and thorough scope. The following steps were followed to obtain an in-depth understanding of research in the HSC:

Planning: A proposal outlining the need for the literature review and review protocol was developed. In this step, we finalized keywords that can accommodate a comprehensive range of the literature in the Scopus database search. Finalized keywords were "humanitarian supply chain" or "humanitarian operations" or "humanitarian logistics" or "emergency logistics" or "disaster relief operations" or "disaster logistics" or "humanitarian relief operations". The keywords were developed considering the focus of the study on the supply chain and operations of humanitarian work. Terms such as "Emergency operations", "emergency response" were ignored as the terms are inclined towards the medical domain.

Searching: We used the "title, abstract, keywords" search in the Scopus database for the selected keywords. The search resulted in a total of 2654 documents.

Screening: We established the following inclusion and exclusion criteria.

Inclusion: Peer-reviewed research articles from the period between 2000 and 2021. The subject areas considered were engineering, business, management and accounting, computer science, decision science, social science, mathematics, economics, earth and planetary science, econometrics and finance, environmental, energy, material science, chemical engineering, and multidisciplinary.

Document types considered were as follows: Article, book chapter, review, and book.

Exclusion criteria: Languages other than English were removed. Conference papers were removed due to the limited availability of proceedings.

The screening step removed 1089 documents. Further analysis was conducted on the raw data set of 1565 documents. Out of 1565 documents, 86.4% were research journals, 6.6% were book chapters, 5.6% were review articles, and 1.4% were books. Table 2 highlights the top 10 subject areas that contributed to the searched database.

Table 2. The top 10 subject areas.

Subject Area	Documents
Business, Management, and Accounting	673
Engineering	526
Decision Sciences	473
Social Sciences	444
Computer Science	344
Mathematics	163
Economics, Econometrics, and Finance	125
Earth and Planetary Sciences	96
Environmental Science	89
Medicine	35

Table 3 illustrates the top five journals and the distribution of their contributions each year. These articles accounted for 23.13% of selected documents. Other notable journals with more than 20 contributions included *Socio-Economic Planning Sciences* with 34 articles, *Computers and Industrial Engineering* with 31 articles, *Transportation Research Part E Logistics and Transportation Review* with 29 articles, *International Journal of Production Economics* with 21 documents, and *International Journal of Production Research* with 20 documents.

Table 3. Top five journals contributing to the area of HSCs.

Year	Journals				
	European Journal of Operational Research	Journal of Humanitarian Logistics and Supply Chain Management	Annals of Operations Research	Production and Operations Management	International Journal of Disaster Risk Reduction
2001	1				
2004			1		
2010				1	
2011		10			
2012		8			
2013	1	10	2	1	
2014	1	13	2	10	1
2015	1	16			4
2016	8	13	1	5	4
2017	2	14	2	6	7
2018	13	20	4	3	7
2019	7	20	35	8	
2020	6	17	13	9	8
2021	6	18	11	5	7
Total	46	159	71	48	38

Analysis: Considering the scope of this study, we employed multiple analysis techniques for analyzing these documents. Data analysis was performed in the following three phases—bibliometric analysis, network analysis, and thematic analysis.

Reporting: Reporting components included synthesizing evidence into the practice and extraction of the recommendations, which are presented at the end of this article.

In the following subsection, we present the findings of the analysis conducted on the selected database. In the first phase, we performed a bibliometric analysis to thoroughly examine the author and affiliation statistics. This phase helps uncover and identify the key researchers, universities, and geographic regions that have demonstrated a substantial contribution in HSC research. In the second phase, we conducted an in-depth network analysis using the VOSviewer (version 1.6.17) software [22]. This involved examining the co-citation network and performing data clustering techniques using the Gephi (version 0.9.2) and bibexcel (version 2016-02-20) software tools [23,24]. The insights gleaned from these analyses provide a deeper understanding of the interconnections and relationships within the HSC research landscape. Finally, the last phase of our analysis focuses on a detailed thematic analysis, which allows us to delve into the various research themes, topics, and areas of focus that have emerged within the HSC literature. This comprehensive multi-faceted approach provides a holistic view of the existing body of knowledge and highlights the key trends and developments in this important field of study.

3. Bibliometric Analysis

This phase focuses on the authors, titles, journals, publication years, keywords, abstract, affiliations, and references. This phase, along with the network analysis, helps in the classification of the literature and identifies subfields. Table 4 illustrates the key contributing authors and citations received by their documents. The list is sorted in order of citations received to represent the author's influence based on the documents published. Van Wassenhove emerged as the most significant contributor to the field, followed by Kovács and Tatham. The results divulge that Balcik, Beamon, and Spens made a significant contribution to the development of the HSC domain with a limited number of publications.

Table 4. Key contributing authors and citations received.

Author	Documents	Citation
Van Wassenhove, L.N.	31	2593
Kovács, G.	30	1805
Balcik B.	5	1373
Beamon B.M.	4	1256
Sheu J.-B.	10	1049
Holguín-Veras, J.	13	937
Tatham, P.	32	933
Spens K.M.	8	929
Jaller M.	10	845
Heaslip G.	14	212
Oloruntoba, R.	13	590
De Leeuw S.	13	293
Leiras A.	13	209
Dubey, R.	12	602

The collaboration ties between key authors were extracted using the VOSviewer tool. VOSviewer creates visual representations of relationships in the research literature. Instead of using a traditional graph layout, VOSviewer positions nodes based on their relatedness—the closer two nodes are, the stronger their connection. It groups closely related items into "clusters", represented by different colors. VOSviewer uses visualization of similarity techniques to produce clusters. The number of clusters can be adjusted using a "resolution parameter", with higher values resulting in more, smaller clusters. To achieve

this, VOSviewer employs a sophisticated optimization algorithm called the "smart local moving algorithm", developed by Waltman and Van Eck [25].

For this analysis, a threshold with a minimum number of two documents and a minimum number of 300 citations was considered—35 authors qualified for this list. Four clusters marked with green, yellow, red, and blue emerged in this exercise and are shown in Figure 2. The largest cluster, represented visually by the color red, contained 14 authors. The second largest cluster, shown in green, included 12 authors. The third group, depicted in blue, had six authors, including Wassenhove and Holguin, the two most frequent publishers in the data set. Finally, the smallest group, represented by yellow, consisted of Altey, Dubey, and Gunasekaran. The clusters highlighted can be leveraged by researchers and newcomers in the HSC domain to foster new collaborations. By connecting with other researchers in the field, there is potential to reduce research costs, streamline research processes, and expedite the dissemination of findings. Moreover, given the interdisciplinary nature of HSCs, fostering collaborations across different subject areas such as geography, civil engineering, and economics can lead to innovative interdisciplinary research.

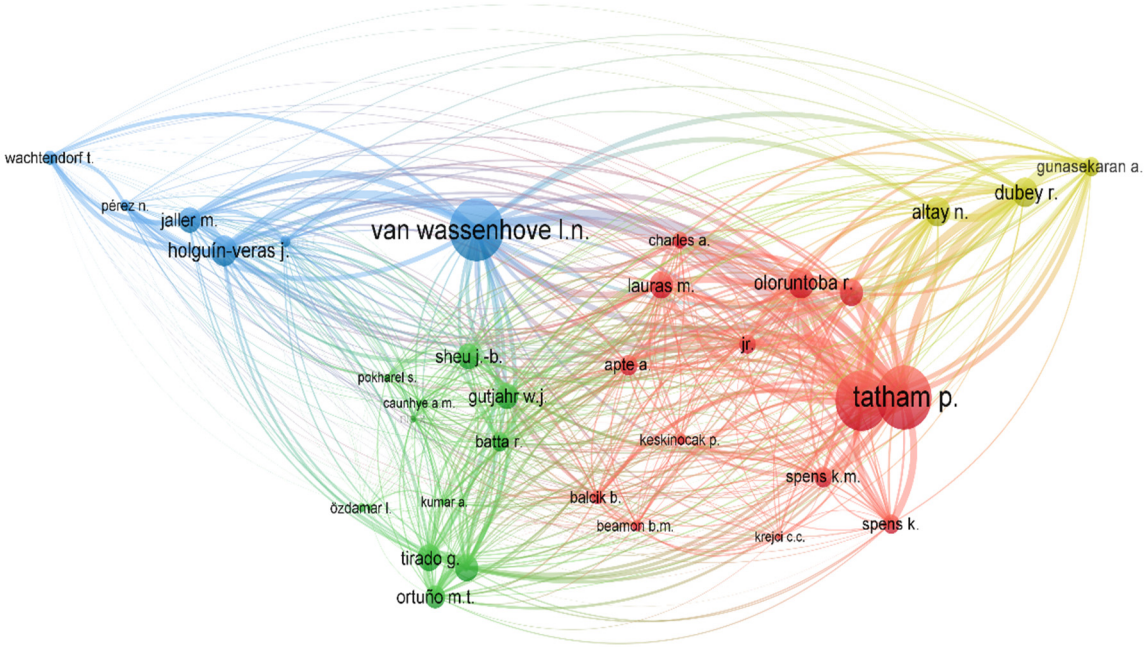

Figure 2. Collaborative network of influential authors.

Next, we identified the geographical location of author-affiliated organizations. The classification of documents based on the location is illustrated in Figure 3. Figure 3 highlights that the significant number of contributions were from the United States, China, United Kingdom, India, France, and Australia. However, a different pattern emerges when we look at the top 10 affiliated organizations and their location in Table 5. Europe tops the list with four organizations representing the region's highly concentrated nature of authors' affiliations. Figure 3 also illustrates the number of articles from the top contributing countries. Figure 3 further demonstrates the geographical dispersion of research groups and how the HSC literature has attracted global attention. Surprisingly, African nations have limited contributions. However, many of the African nations are at the receiving end of substantial humanitarian aid [26]. This highlights the need for more localization in HSC research. It is clear that documents originating from China and India belong to multiple organizations highlighting the distributed nature of work in these two countries. The distribution of these articles and locations represents the worldwide interest in HSC-related research. However, when comparing the top contributing countries and organizations to the Global Climate

Risk Index, the distribution appears mismatched [27]. Only India appeared in the most affected countries list and produced a significant number of documents.

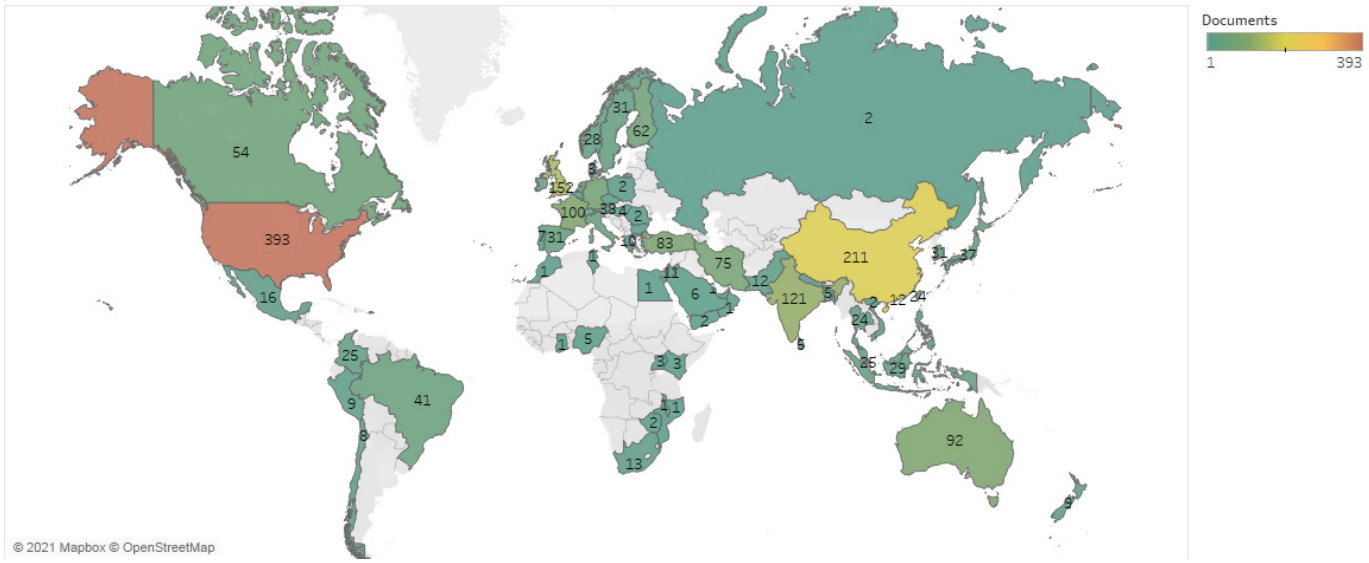

Figure 3. Documents classified based on geographical locations.

Table 5. Top contributing organizations and their locations.

Affiliation	Documents	Location
Hanken School of Economics	52	Finland
INSEAD, Europe	36	France
University of Tehran	29	Iran
Griffith University	39	Australia
Rensselaer Polytechnic Institute	20	New York
Iran University of Science and Technology	19	Iran
Vrije Universiteit Amsterdam	17	Netherlands
National University of Singapore	15	Singapore
Lunds Universitet	15	Sweden
University at Buffalo, The State University of New York	15	New York

Furthermore, we analyzed all the keywords from 1565 documents. Keywords can be used to introduce a paper's content. Co-occurrence analysis assumes that keyword groups indicate underlying themes, and their co-occurrence reveals theme associations. A keyword's importance is measured by its frequency or total link strength (TLS) within a network. Higher TLS signifies greater influence. In Figure 4, node size corresponds to TLS (larger nodes, higher TLSs). Connecting lines represent links, with thicker lines indicating central, major research areas within a cluster. A total of 6443 keywords were extracted, including indexed and author keywords. Figure 4 illustrates the co-occurrence network of keywords in the domain of the HSC. Thirty-eight keywords were selected by removing the keywords with less than 30 occurrences. Four different clusters can be identified with yellow, red, blue and green colors. The critical keywords in the co-occurrence diagram are HLs, disaster, disaster prevention, emergency services, logistics, disaster management, optimization, decision-making, and emergency logistics. The current section presents findings related to research productivity, impact, geographical distribution, and influence of authors. While bibliometric analysis can quantify research impact and trends, it does not reveal the relationships and structures within the field. Network analysis complements this by examining connections through co-citation, co-authorship, and keyword networks, revealing how research, authors, and institutions are linked. By integrating bibliometric

analysis with network analysis, this study goes beyond citation counts to understand how ideas propagate, identify core research communities, and reveal isolated or emerging fields.

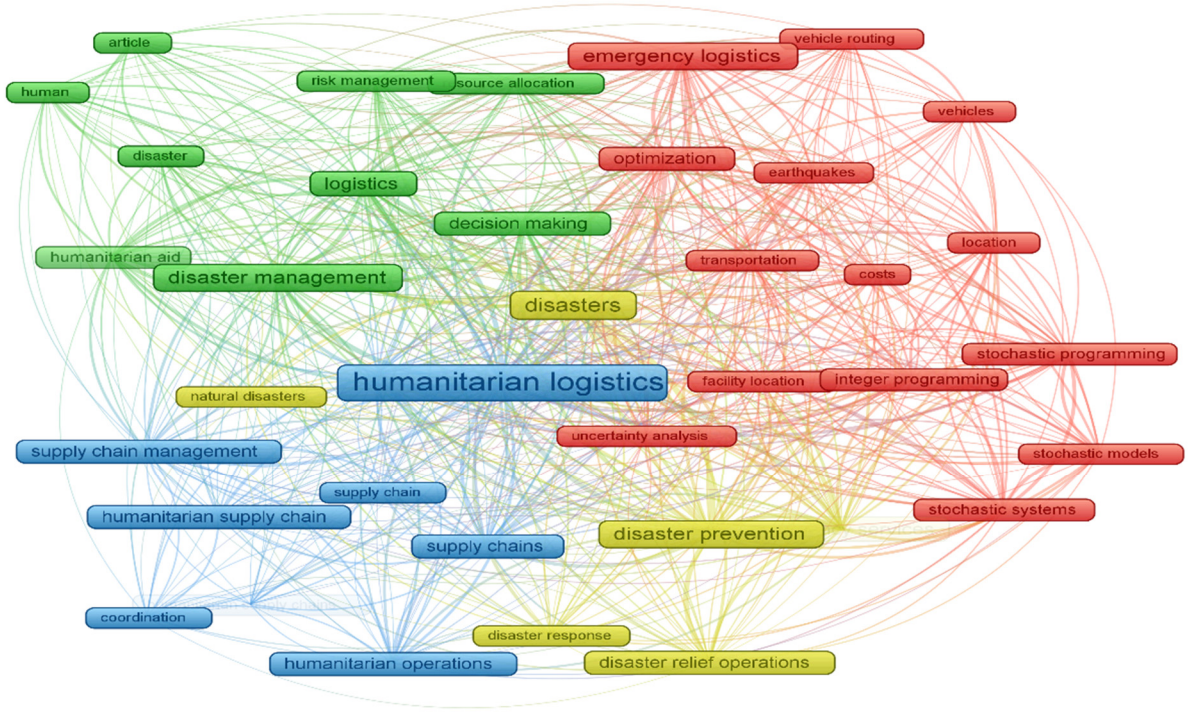

Figure 4. Co-occurrence network of keywords.

4. Network Analysis and Literature Mapping

In this phase, we conducted citation, co-citation, and page rank analysis, including literature classification using data clustering. PageRank analysis was conducted to identify the "prestige" of the documents. Page et al. [28] introduced PageRank to calculate the quality ranking of the webpage. Ranking signifies both the prestige and popularity of the webpage [29]. Fahimnia et al. [20] adopted PageRank to find the citation link between documents related to supply chain risk management. The rationale to adopt the PageRank analysis is that a highly cited paper might not be the most prestigious paper despite having a strong correlation with two matrices. The prestige (*PR*) of document *D* can be calculated using the following equation.

$$PR(D) = \frac{(1 - DF)}{TD} + DF\left(\frac{PR(CT_1)}{CS(CT_1)} + \ldots + \frac{PR(CT_n}{CS(CT_n)}\right) \quad (1)$$

Here, document *D* has been cited by document CT_1,... CT_n among *TD* documents and document CT_i has $CS(CT_i)$ citations. Here, *TD* is the total number of documents, *CS* is number of citations, and *CT* identifies the particular document. *DF* is a damping factor varying from 0 to 1. *DF* represents the proportion of random walk that propagates down the citations. For this study, we adopted a *DF* value of 0.5, similar to other documents analyzing citations [20]. The calculated value of PageRank for the top 10 cited documents is shown in Table 6. Values indicate that highly cited documents are not necessarily the most prestigious ones. Table 6 shows the top 10 documents as per citations received by them in the Scopus database. This analysis helped in identifying the popularity of the documents. All the documents were at least a decade old, and landmark articles such as [3] remain relevant today and inspire many humanitarian researchers. Two documents from *Transportation Research Part E* ranked in this list, highlighting the journals' quality contribution in humanitarian research. Even though the journal did not rank in Table 3, its

contribution is unparalleled and humanitarian researchers can focus on curating articles more suited to this journal.

Table 6. The top 10 documents according to the citation.

Document	Journals/Source Title	Citations	PageRank
[3]	*Journal of the Operational Research Society*	860	0.000802
[30]	*Annals of Operations Research*	656	0.000496
[31]	*International Journal of Physical Distribution & Logistics Management*	632	0.001199
[32]	*International Journal of Logistics Research & Applications*	629	0.000932
[33]	*Empire of Humanity: A History of Humanitarianism*	579	0.000725
[34]	*Transportation Research Part E: Logistics and Transportation Review*	516	0.000988
[35]	*International Journal of Production Economics*	497	0.001503
[36]	*Socio-Economic Planning Sciences*	487	0.002081
[37]	*Transportation Research Part E: Logistics and Transportation Review*	390	0.000483
[38]	*European Journal of Operational Research*	320	0.000489

Furthermore, we conducted a co-citation analysis on the selected documents. The co-citation network is an exploratory data analysis that employs graph theory to investigate the data structure [20]. It helps highlight the research topics under a domain by identifying the clusters of documents referenced together. The nodes of networks can be grouped into clusters or modules according to the edge density. For co-citation networks, a cluster represents a group of interconnected publications within a specific research area. These publications can be loosely connected to publications in other areas. Data clustering is used as a classification tool to group publications, enabling topological analysis of co-citation networks. Such analysis helps identify topics, interrelationships, and collaboration patterns, as illustrated in Figure 5. These clusters are more likely to cover comparable topics or be linked [39]. The emerged co-citation network shown in Figure 5 consisted of the node representing the documents and edges or linkages representing the nodes' co-occurrences in other documents. Three clusters were identified using VOSviewer by selecting a minimum number of 30 citations of cited references.

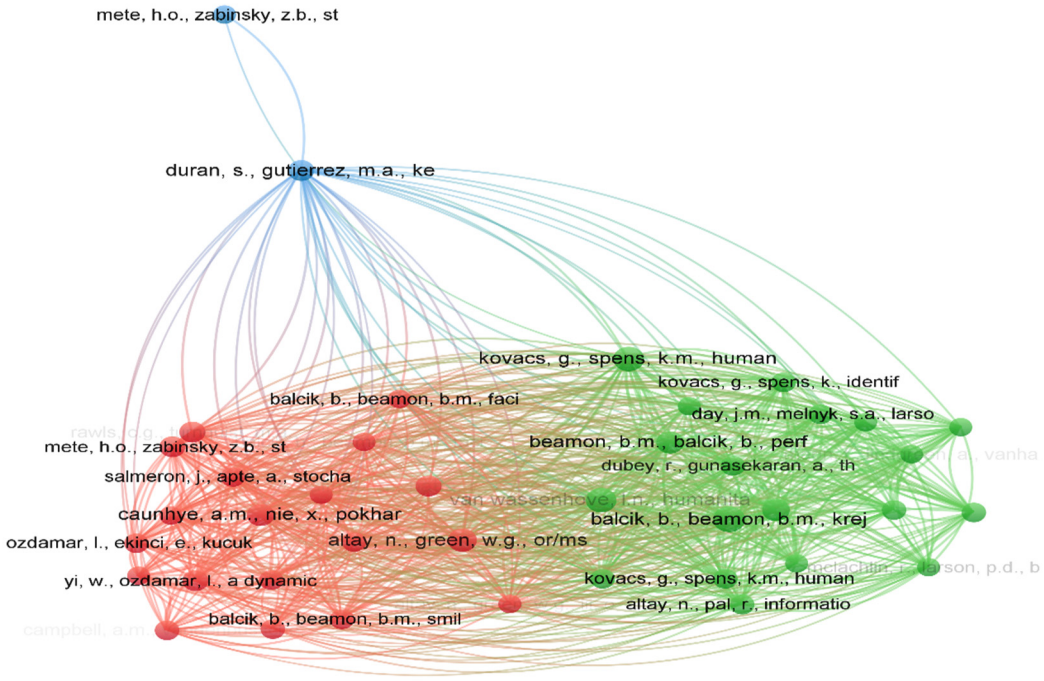

Figure 5. Co-citation network of the selected documents.

Next, we performed data clustering on a co-citation network using gephi tool. Data clustering helps classify a similar set of documents, exploring themes and collaboration patterns across a research domain. In a co-citation network, nodes can be grouped into different clusters or modules based on the density of the edges. A module can contain nodes with more density of the edges among the nodes of the same module compared with another module [40] Data clustering is supported by the pattern that a well-connected publication in the co-citation network will have a limited connection to documents in different clusters. Data clustering analysis using a co-citation network has been widely adopted in the operations and supply chain domain [41,42]. We used the default data clustering tool available on Gephi, which uses the Louvain algorithm. For the analysis, the modularity index appeared at 0.24, indicating a strong relationship among the cluster nodes. Analysis resulted in seven clusters from the filtered network of 762 nodes and 45,638 edges. Figure 6 illustrates the positioning of and interface among clusters. The scope of each research cluster was defined based on key documents and their keywords. The second round of keyword co-occurrence analysis was performed for each cluster. The naming was carried out considering the target scope of documents and the clusters identified in the co-occurrence analysis.

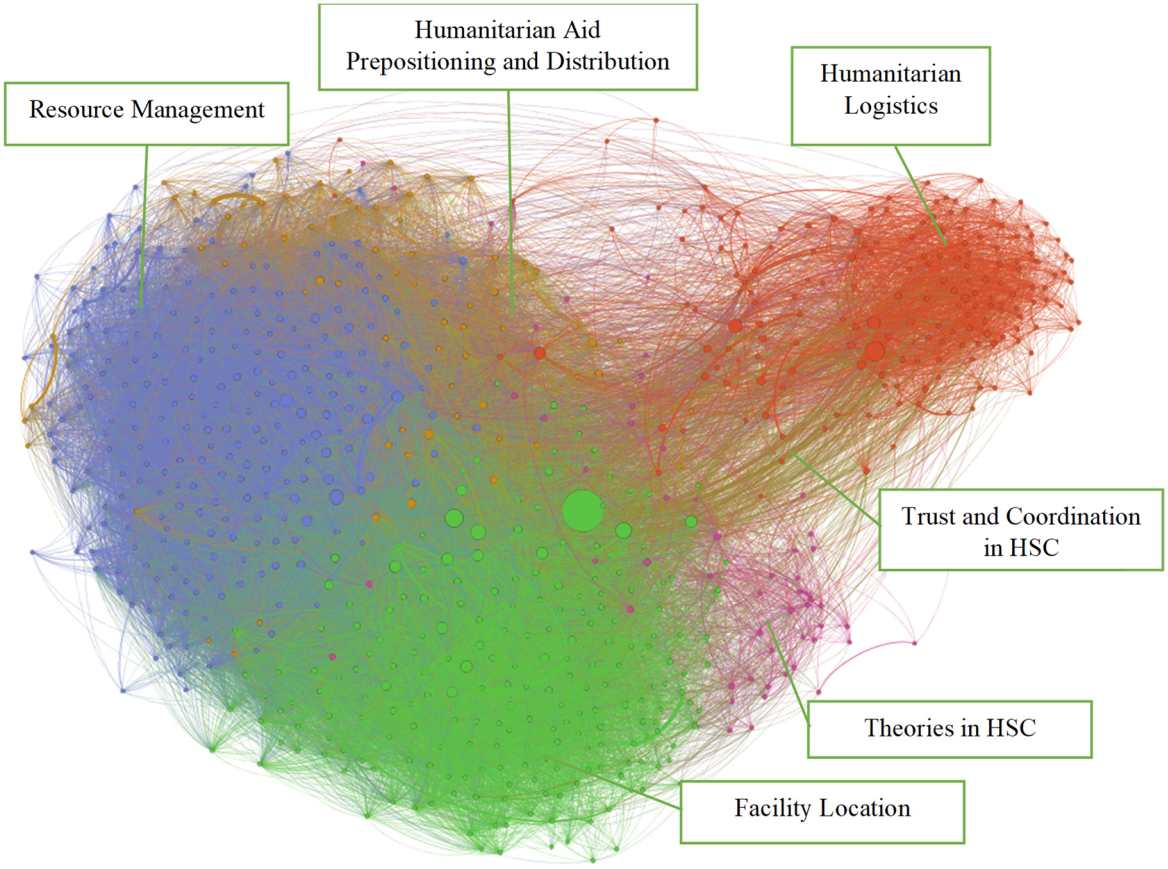

Figure 6. Literature cluster using modularity analysis.

A group of humanitarian researchers was consulted for the naming process. The expert panel reviewed the most cited documents of each cluster and the highest-ranked document in the page rank analysis. Based on their understanding and experience, the panel suggested different names for each cluster. The naming of clusters was finalized after multiple iterations. Four clusters are also highlighted in Figure 2—Resource management, Logistics, Facility Location, and Coordination. During the data clustering and naming process, a few documents were found related to more than one cluster. The possible reason is that clustering was performed based on the citation, not the scope of the document.

However, this analysis helped frame the research gaps and interacting patterns among different research clusters within the domain. Seven clusters are illustrated in Figure 6 and were identified using Gephi's modularity tool to represent foundational research areas contributing key knowledge, concepts, theories, tools, and techniques in the HSC. Node size reflected the article PageRank, indicating citation count and prestige. Clusters identified with the name facility location and resource management showed stability and maturity of the subfield. In comparison, the clusters identified with humanitarian logistics, theories in HSC, and humanitarian aid, and pre-positioning and distribution exhibited robust and sustainable growth and were expected to continue expanding. Cluster 7 contained only 33 documents. Thus, it was challenging to distinguish cluster 7 in Figure 6. Table 7 presents the attributes of different clusters and lead documents of that cluster. Next, we discussed each cluster and highlighted the need for improvement.

Table 7. Clusters' attributes.

Cluster	Number of Documents	Research Scope	Documents
1	226	Facility Location	[30,35,40–42]
2	217	Resource Management	[43–45]
3	217	Humanitarian Logistics	[46–50]
4	87	Theories in HSC	[3,51–53]
5	240	Trust and Coordination in HSC	[54–57]
6	32	Performance Measurement in HSC	[58–61]
7	88	Humanitarian Aid Pre-positioning and Distribution	[32,62–64]

4.1. Facility Location

Various types of facilities were covered under the facility location problem. The literature has addressed medical facilities, shelter, relief warehouse, debris removal, and general emergency services locations. The facility location problem in relief operations has been covered by the literature using optimization and MCDM models. Trivedi and Singh [57] reported that more than 52% of documents catering to facility location problems consider the case of the pre-positioning warehouse, 24% serve the temporary shelter, 13% cater to the medical facility, and the remaining 11% cater to the other locations such as schools, etc. Robles et al. [12] highlighted that facility location is one of the most addressed problems in the humanitarian literature. Bayraktar et al. [58] proposed a mobile facility location problem to aid enroute refugees. Balcik and Beamon [32] considered facility location and stock pre-positioning problems. They determined the number of facilities to be opened, location of the facilities, capacity, and resource allocation.

Chang et al. [37] developed a decision-making tool for flood emergency logistics. They determined the optimal location of rescue rooms and allocated resources under capacity constraints. Duran et al. [44] determined the configuration network of the pre-positioned warehouse for a large HO. Rennemo et al. [43] proposed a three-stage stochastic programming model for determining the facility, resource allocation, and distribution planning. Roh et al. [59] empirically identified factors for considering facility location. For the comprehensive understanding of facility location problems and research work, readers are advised to refer to the review conducted by [41,57,61,62]. It can be inferred from these results that HLs in HSCs has attained a certain level of maturity with multiple contributions over the years. With many optimization solutions available for practitioners, researchers need to explore the practical applications of developed models. This domain will continue growing with the integration of more technological breakthroughs. Future research themes include bridging the gap between practices and the literature, incorporating flexibility and resiliency, making humanitarian facilities sustainable and building theoretical and practical models for facilitating equity in HSC operations.

4.2. Resource Management

Appropriate availability of relief resources at the right time is critical for reducing the victims suffering from disasters. Thus, managing relief resources is one of the most critical tasks of HSCs. However, the availability of limited resources constraints the effectiveness of relief operations and creates various managerial complexities. The overwhelming situation during ongoing relief operations requires optimal utilization of resources for effective operations. Resource allocation, resource estimation, and resource distribution have been extensively studied in the HSC literature [36]. Resource management concerns both pre-disaster preparation and post-disaster operations. The majority of pre-disaster resource management studies cater to the facility location problem, stock pre-positioning, and evacuation. Post-disaster operations cover the management of resources to distribute relief material, rescue, and waste removal.

Ben-Tal et al. [45] catered to demand uncertainty in HSCs by formulating a multi-period transportation problem. Lin et al. [63] considered a multi-item, multi-vehicles, multi-periods, soft time windows, and split delivery strategy scenario to propose a logistics model for aid distribution. Rath and Gutjahr [46] proposed a three-objective warehouse location-routing problem for resource management in the sudden onset of disaster. Rodríguez-Espíndola et al. [64] proposed a disaster preparedness system that can assist decision-making in the case of multiple organizations. Yu et al. [65] formulated a multi-period resource allocation problem considering human suffering. Fiorini et al. [66] explored and provided several recommendations for the resource management aspect of HSC from the perspective of human resources. Zhang et al. [67] examined multiple resource centers and proposed a fuzzy probability constraint model to minimize the cost. Rahiminia et al. [68] considered the management of waste in a medical center and proposed a queueing-inventory model to control the congestion.

From the above discussion, it is apparent that the literature has accessed resource management from operational and economic aspects. However, the sustainability aspect in the resource management literature has received limited attention. Previously, the sustainability-related literature has dealt with network designing, framework development, assessment modelling, issue identification, and Decision Support System (DSS) development for relief operations [69–72]. Even after the decade-long contribution mentioned above, the need for studies catering to sustainability and circular economy (CE) in relief operations has been recently highlighted by [18]. Zarei et al. [72] also highlighted that sustainability in relief operations is often ignored. Several authors have warned about the negligence of sustainability in relief operations in both practice and research [69]. The literature within this cluster can be extended by exploring potential future research themes, such as the engagement of local businesses for resource management, decentralization, exploring mechanisms for resource sharing across multiple organizations, incorporating robustness and circularity, adopting emerging technologies and intelligence/generative DSS, exploring carbon reduction, and energy-saving strategies and advancing coordination mechanisms.

4.3. Humanitarian Logistics

Thomas and Kopczak [73] defined HLs as "the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of meeting the vulnerable end beneficiary's requirements". HLs involve coordination and collaboration between many stakeholders for relief operations [74]. Other essential functions of humanitarian response, including preparedness measures, resource planning, material procurement, transport management, storage, and tracking of relief material, can also be identified under HLs.

HL is an essential component of HSCs and plays a critical risk management role in reducing disruption. The integration between HSCs and HLs determines the success of humanitarian operations. Highlighting the importance of HLs in disaster operations, Van Wassenhove [3] mentioned that disaster relief is 80% logistics. HSCs transform HL activities

into a more strategic approach of integrating diverse stakeholders and operational process for achieving organizational goals. This transformation facilitates resource sharing and goal sharing on a broader level. The cross-functional collaboration derived from the integration of HLs and HSCs enables sustainable performance improvement.

The research focusing on HLs has evolved over the years. Multiple authors have reviewed the trend and milestones in HL research within the past 15 years [17,75–78]. Kovács and Spens [78] identified several challenges associated with HLs. The humanitarian literature has discussed these issues and approached them from different perspectives. Lack of coordination among different HSC stakeholders emerged as one of the most critical topics in the HL literature [75,79]. Jahre and Jensen [80] explored cluster thinking and proposed a theoretical framework to resolve coordination issues in HSCs.

Maon et al. [81] analyzed best practices of CSCs and their applicability for HLs. They further highlighted various characteristics and challenges of HLs. Holguín-Veras et al. [47] compared characteristics of HLs to commercial logistics and presented differences and commonalities. Berkoune et al. [48] formulated a transportation problem minimizing transportation duration under capacity constraints. Garrido et al. [82] formulated a resource allocation in the case of a flood. They quantified the impact of the various intervening logistic parameter. Van der Laan et al. [83] performed an empirical analysis of the demand planning and distribution operations at an HO. They reported various opportunities to improve HLs. Baharmand et al. [84] used quantitative and qualitative methods to identify transportation risks and ranked them. Tavana et al. [85] formulated mixed-integer linear programming to model the multi-echelon HL network. Their model considers the warehouse location, inventory management, and routing decisions. Buluc et al. [86] proposed a routing model for mobile child-friendly spaces that can provide education and psychological support to refugee children. Ajam et al. [87] catered to the restoration of damaged roads by proposing a mathematical model that considers coordination among different teams.

It was observed that HLs have been an active research topic in recent years. The literature has proposed frameworks, theories, and formatted various optimization models to improve the performance of HLs. However, the congestion caused in HLs due to inappropriate unsolicited donations has received limited attention [47,64,88]. Several documents have mentioned the problem, but solutions development remains stagnant. The HL literature needs to explore the scalability of transport and information networks, mechanisms to manage material convergence and volunteer convergence, volunteer training using gamification, and the integration of a cluster approach to minimize instances of repetition. Other potential research themes worthy of exploration are risk assessment, forecasting, demand planning, behavioral aspects, and application of emerging technologies such as digital twins for decision-making and scenario visualization.

4.4. Theories in HSC

This cluster contains various pioneer documents that were foundational in the HSC literature. Van Wassenhove [3] presented the complexities of HSCs and provided opportunities to explore the best practices of the Commercial Supply Chain (CSC). Oloruntoba and Gray [49] investigated the HSC characteristics and assessed the agility principle's applicability in HSCs. Beamon and Kotleba [89] initiated the development of an inventory management system for HSCs. They identified system factors affecting the performance of inventory management and analyzed various inventory management strategies. Jahre et al. [50] developed a preliminary theoretical framework to analyze HLs. Abidi et al. [90] showed a framework of the fourth-party logistics services concept in HSCs. Ülkü et al. [91] explored donor psychology to relieve the negative impact of the unsolicited donation. They provided insights into the behavioral and decision-making aspect of donors. Siawsh et al. [92] used socio-technical systems theory to understand the power role in purchasing decisions. Refugee relief is another niche that has emerged in recent years. In this domain, Abushaikha et al. [93] proposed a theory of informal supply networks to identify the cultural traditions, behavior codes, and development of refugee camp networks. Potential

themes for theory development are cultural sensitivities, integration of socio-technical systems, system thinking approach, and community engagement. Future research should also explore the donors' decision-making and the dynamics of non-profit entities such as transporters and suppliers.

4.5. Trust and Coordination in HSCs

Trust is a core concept of management and positively impacts supply chain performance [94]. Trust is essential among supply chain stakeholders for information exchange and efficient operational execution. Lack of trust is one of the significant barriers to effective supply chain management [94]. In the context of HSCs, the hastily formed nature of the network prohibits the application of trust-facilitated collaboration and coordination. Trust in the HSCs has been addressed by multiple authors. Tatham and Kovács [51] presented a model of swift trust for HSCs. Jahre and Jensen [80] explored the concept of the cluster for enhanced coordination among HSC stakeholders. They highlighted the need to develop a collaborative performance measurement system to synchronize the decisions related to the inventory and other operational aspects. Soosay and Hyland [95] reviewed the supply chain collaboration literature and discussed the trust dependent collaboration in the HSC.

Bealt et al. [52] worked on enhancing trust between HOs and local service providers. They analyzed variables influencing the formation of partnerships and collaboration among HSC stakeholders. Kabra and Ramesh [96] empirically examined the critical factors, including trust in the HSC. Dubey et al. [97] empirically investigated the application of swift trust for achieving coordination in HSCs. They highlighted that swift trust is the missing link for successful relief operations. Lu et al. [98] explored the factors promoting swift trust and its impact on HSC coordination. Altay et al. [99] explored the interdependency among HSC stakeholders and its influence on performance. Schiffling et al. [100] examined the application of swift trust in supporting co-opetition in the HSC.

The development of a collaborative relationship facilitates efficient decision-making and problem-solving. Wankmüller and Reiner [101] found and reviewed 202 articles on collaboration, coordination, and cooperation in HSCs. They highlight that forecasting, replenishment, and collaborative planning are the most sought-after aspect of coordination. Rutkowski et al. [102] conducted a case study to investigate the procurement of personal protective equipment for a donation center. They suggested building a public–private collaboration space for innovative procurement strategies. L'Hermitte et al. [103] explored the strategic dimension of agile HSCs and reported collaboration as one of the most sought-after strategies. Jahre [104] also reported similar findings and discussed collaborations to improve inventory management activities.

A detailed analysis of the previous literature reveals that collaboration has been discussed extensively for the sustainable performance improvement of the HSC. The recent literature highlights the need to build a robust integrative system to facilitate collaborative activities. Further, there is a need to develop innovative coordination mechanisms for inventory planning, forecasting and replenishment decision, and resource allocations. Future research themes in this cluster include the incorporation of resiliency, swift trust in digital networks, mechanisms for prudent information sharing, expanding transparency, integration between local and global stakeholders, cross-cultural dynamics relationship management, co-opetition, ethical aspects, and trust repair.

4.6. Humanitarian Aid Pre-Positioning and Distribution

Pre-positioning relief supplies at the strategic location has been a widely adopted practice to reduce operational challenges during relief distribution. Pre-positioning enhances the capability to combat the uncertainty and urgency of relief work. Inventory pre-positioning reduces the lead time and improves the post-disaster response [105]. However, the cost and maintenance of pre-positioning goods limit the adoption of this strategy [32]. Facility location, capacity, and stock decision are critical elements of pre-positioning. Distribution systems require decisions regarding resource allocation, network design, and demand esti-

mation. In recent years, humanitarian researchers have actively pursued the pre-positioning of relief supply and distribution from both theoretical and application aspects.

Sheu [34] developed an optimization model for relief material distribution. Salmerón and Apte [55] formulated a two-stage stochastic optimization determining budget allocation for relief asset pre-positioning. Afshar and Haghani [64] developed a comprehensive model controlling the flow of relief material from procurement to distribution. Huang et al. [106] explored performance metrics for routing and resource distribution activities. Tofighi et al. [107] determined the location and inventory level for a two-echelon HL network using a two-stage stochastic programming approach. They also provided a distribution plan for the network minimizing time, cost, and shortage of demand. In this cluster, underserved topics include forecasting, supplier selection, and planning in the HSC. Developing cost-effective pre-positioning strategies that are flexible, resilient, and robust is one of the critical research themes in this cluster. Other themes include exploring suppliers' selection criteria, decentralizing pre-positioned material, incorporating climate resiliency, dynamics resource allocation, managing resource shortfall and surplus, and managing regulatory and custom challenges. Research should also explore the adoption of technology for relief distribution, such as drones, to access hard-to-reach areas.

4.7. Performance Measurement in HSC

Research on performance measurement intended for relief work was propagated 20 years ago by Beamon [108]. Since then, researchers have contributed rigorously to various aspects of Hos' performance measurements. Davidson [109] developed a Performance Measurement Framework (PMF) with four critical matrices. After that, several authors proposed frameworks for measuring the performance of HOs [18,110]. Beamon and Balcik [111] compared performance measurements in HSCs with CSCs and proposed a relief work framework and performance matrices. Their study concluded that PMS could assist in decision-making, improve efficiency, and increase accountability with transparency. Zhang and Fu [112] integrated an Analytic Hierarchy Process (AHP), a data envelopment analysis, to measure emergency logistics performance. Santarelli et al. [113] studied the articles related to performance measurement to understand factors that contribute to the success of HSCs. They found the KPIs that are in practice among the HOs. Anjomshoae et al. [114] aimed to incorporate the uncertainty of relief operations in PMS. They proposed a fuzzy number-based PMS that can account for qualitative input.

A review paper published by Abidi et al. [53] asked for efficient and suitable data acquisition. The author favored the implementation of a robust information network that can serve the donor community. Agarwal et al. [18] found 66 unique papers proposing a framework measuring performance for HSCs. They found that 37.8% of the framework were unverified. This section indicates that the performance measurement for HOs is an ongoing area of research and needs multidimensional improvements. Readers can refer to the following reviews for a comprehensive understanding of performance-related research in the context of the HSC [9,17,94,115]. Managing performance measurement issues requires the development of the literature that focuses on utilizing innovative technologies, such as data analytics, AI, and blockchain, to improve data acquisition, information-sharing, and transparency in performance measurement. Additionally, the development of standardized PMF and benchmarks can enhance the consistency and comparability of HO performance across different contexts. Ethical considerations, such as the fair allocation of resources and the protection of vulnerable populations, should also be integrated into the PMS. The digital transformation of HSCs can enable real-time performance monitoring and facilitate data-driven decision-making, ultimately enhancing humanitarian operations' overall effectiveness and efficiency.

This section enhances understanding of the HSC literature growth, particularly the complex relationships and structures underpinning the HSC literature development. These findings illuminate HSC clusters and dynamics, enabling scope for targeted research extensions and potential network propagations. Clustering analysis provides insights by

grouping similar research domains, enabling a focused examination of their distinction and interdisciplinary scope. A detailed discussion of the implications of these findings is provided in the next section.

5. Conclusions and Future Research Directions

This article provides a systematic overview of over 1500 articles catering to HSCs published before COVID-19. This review uniquely demonstrates the development of the HSC literature and their linkages. Study findings indicate that the field has grown significantly in the past two decades, as evidenced by the number of articles and dedicated journals like the *Journal of Humanitarian Logistics and Supply Chain Management*. The HSC literature has addressed various operational and strategic aspects using both quantitative and qualitative approaches. The key contribution of this study and its implications for the humanitarian researcher can be identified as follows.

Network and clustering analyses indicate that the majority of the existing research emphasizes mathematical modeling and theory development. However, the areas of reconstruction and rehabilitation remain relatively understudied within the four phases of disaster management. The top-producing journals in this field come from diverse publishing houses and academic societies, reflecting the broad range of researchers involved. Geographically, the majority of researchers are based in the United States, Europe, the UK, China, India, Iran, and Australia. Similarly, leading research institutions are primarily located in Europe, Iran, Australia, New York, and Singapore. African regions are underrepresented in this essential and relevant domain. Overall, the body of the humanitarian supply chain literature can be categorized into seven main research clusters: resource management, HLs, facility location, humanitarian aid pre-positioning and distribution, trust and coordination, performance measurement, and theories in HSCs. These research clusters highlight the multifaceted nature of the HSC domain and the diverse perspectives that scholars have brought to this important field of study.

The network analysis reveals productive collaboration among HSC researchers. This study identifies and reports critical networks, author clusters, and universities actively involved in HSC research, offering potential networking avenues for budding researchers and practitioners. Additionally, we observed that African countries have significantly low contributions even though several humanitarian operations are actively engaged in the regions. The discovered shortfall may generate the rationale that the literature lacks the perspective of the disaster victims. Conversely, many authors have discussed interviews with people from this region. This finding emphasizes the need for greater inclusion of researchers and development of the HSC research infrastructure in the disaster-affected regions.

The citation analysis and emerged cluster gives insight into the literature evolutions and potential subfield within HSCs. Critical research gaps were reported in the performance measurement, HSC network design, HSC sustainability, and resource utilization clusters. Performance measurement remains a challenging yet essential aspect of HSCs, with the limited implementation of several frameworks proposed in the past [9]. Future research should explore the complexities associated with performance measurement and propose solutions to implement PMS. The results also highlight the need to consider the heterogeneity of relief materials in transportation, storage, and disposal. Previous studies emphasized the importance of sustainability in HSCs, which can benefit operations in the long term. Circular economy, an emerging concept with significant potential, is attracting attention across disciplines and could bring substantial benefits to the humanitarian domain by developing theories, frameworks, models, applications, and DSS. There is scope to explore the cross-fertilization of circular economy, sustainability, and digitalization and whether it can improve the performance of HSCs. Future research should focus on technological development and information infrastructure to engage diverse HSC stakeholders. Existing studies underscore the importance of information fusion and digitalization for

effective emergency management [116]. HSC stakeholders may also review top-down approaches and explore coordination mechanisms to engage smaller stakeholders.

Several research themes have been identified and described in this study, along with each cluster that future researchers can use to expand the humanitarian literature. Focus on bridging the gap between practice and the literature, enhancing flexibility, resilience, and sustainability in operations, and developing models that promote equity are essential for HSCs. Including local businesses in resource management and decentralization can help with rehabilitation goals. Innovative resource-sharing solutions across organizations can improve delivery and help meet sustainability goals. In HLs, the scalability of transport and information networks, volunteer training and risk assessment are potential research themes. Research in theory development should integrate cultural sensitivities, socio-technical systems, and system thinking while addressing stakeholder dynamics. Developing trust in digital networks is an emerging and challenging aspect of the HSC. HSC stakeholders also need efficient information sharing and transparency. Resilient pre-positioning strategies, supplier selection, and integrating climate resilience and technology in the disaster-preparedness phase require suitable theory and model development. Several themes proposed in this study emphasize enhancing operational flexibility, resilience, and sustainability in HSC.

Future researchers can leverage these findings to extend HSC research. HSC practitioners are encouraged to magnify their participation so that HSC research becomes more grounded and practical. Practitioners' insights can be invaluable in developing practical and field-ready solutions. Furthermore, there is a pressing need to integrate expertise from diverse disciplines such as geography, civil engineering, social sciences, and economics. Interdisciplinary research offers promising avenues for innovative solutions, particularly in funding mechanisms and aid distribution. Emerging technologies have the potential to streamline funding processes. However, realizing this potential requires robust research to frame policies, establish protocols, and propose solutions. A promising avenue can be the development of research clusters or centers of excellence in humanitarian research across different continents to fuel HSC research.

This review acknowledges a few limitations. First, it focuses solely on English-language publications, potentially excluding valuable insights from other languages. Second, article categorization is subjective and may vary based on reviewer or expert opinions. Third, the study does not cover a few subfields in detail, such as volunteer management and funding mechanisms, which need further investigation. Finally, the study excludes post-COVID-19 research due to concerns about potential duplication and lack of peer review in preprints. Future research could address these limitations by including the non-English literature, exploring alternative categorization approaches, investigating specific subfields in-depth, and incorporating content analysis to provide cluster-specific research directions.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/logistics8040128/s1, File S1: PRISMA Checklist. File S2: PRISMA Framework.

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