Review

Humanitarian Logistics Prioritization Models: A Systematic Literature Review

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Abstract: *Background:* Disasters have caused suffering across the world throughout history. Different types of disaster events can manifest themselves in different ways, originating from natural phenomena, human actions and their interconnected interactions. In recent years, organizations in charge of disaster management have faced a series of challenges in humanitarian logistics, leading to an increasing consideration of the use of models of prioritization, in most multi-criteria models, to define the best alternatives for more assertive and strategic decision-making. *Methods:* This article aims to conduct a systematic review of the literature on the application of prioritization models in humanitarian logistics. To this end, an analysis was carried out of 40 articles, indexed in the Scopus or Web of Science databases. *Results:* The descriptive analysis revealed that the majority of applications are aimed at dealing with sudden-onset natural-induced disasters. However, there are still gaps in relevant areas, such as addressing inventory management problems at a tactical decision level. *Conclusions:* The development of prioritization models necessitates the integration of various methodologies, combining optimization models with multi-criteria decision analysis to yield superior outcomes. It is advised to incorporate four distinct criteria—efficiency, effectiveness, equity, and sustainability—to ensure a comprehensive assessment of the decision-making process.

Keywords: prioritization model; multi-criteria decision analysis; humanitarian logistics; systematic literature review

1. Introduction

Throughout history, numerous disasters have affected society. Disasters are events that disrupt the normal activities of a society or community, resulting in human, material, economic, or environmental losses that exceed the affected community's capacity for recovery using only its own resources [1].

Disasters can be classified according to their origin and onset speed [2]. Regarding origin, disasters can be classified as natural-induced disasters (e.g., floods or earthquakes) or human-made disasters (e.g., chemical spills or mass migrations). Regarding onset speed, they can be classified as sudden-onset disasters (e.g., tornadoes or terrorist attacks) or slow-onset disasters (such as droughts or political crises).

The earthquake and tsunami in Southeast Asia in 2004 demonstrated the need for greater knowledge and tools to address large-scale disasters [2]. Since then, humanitarian logistics has attracted growing interest, involving universities, governments, and other organizations engaged in this field [3].

Currently, this topic is crucial as it contributes to achieving Sustainable Development Goal 11.5, which aims to reduce deaths from disasters and disaster-related vulnerability,

especially in light of the continuous increase in the average annual number of natural-induced disasters [4]

Humanitarian logistics is the process of efficiently planning, implementing, and controlling the flow and storage of goods, materials, and related information from the point of origin to the point of consumption, with the aim of alleviating the suffering of people in vulnerable situations [2].

The activities involved in humanitarian logistics have characteristics that make logistics operations more complex, such as the dynamic nature of the problem, resource scarcity, the disruption of transportation and communication networks, and the inability to predict demand, resulting in significant levels of uncertainty [5,6]. In catastrophic events, where local supplies are mostly destroyed, private sector supply chains are severed, and distribution complexity escalates, outside help becomes the primary source of relief [7]. This situation underscores the critical need for effective prioritization models. Developing these models is inherently challenging, as they must balance trade-offs between efficiency, effectiveness, and equity [8]. Given this challenging scenario, the use of prioritization models plays a fundamental role in humanitarian logistics [9].

Prioritization involves organizing and ranking alternatives based on a specific perspective [9]. Prioritization models fall into the following categories: multi-criteria, multi-criteria heuristics, and empirical prioritization [9].

Multi-criteria models assist individuals in making choices that reflect their preferences, enabling the identification of the most advantageous alternatives among those available [10]. Multi-criteria heuristics is an approach used for complex problems and offers effective solutions within a reasonable computational time [11] Finally, empirical prioritization denotes an approach distinct from formal models, as highlighted by [9].

In humanitarian logistics, there has been a notable increase in the popularity of research employing prioritization models to optimize operations in humanitarian logistics, especially multi-criteria models [12]. These approaches enable the enhancement of the overall performance of these operations [13].

Implementing prioritization models in humanitarian logistics presents practical challenges. One notable issue is the discord between the criteria favored by the academic community and the preferences and priorities of field practitioners [14]. Additionally, addressing the complexity of post-disaster situations, where support systems are impacted and dynamically changing, is essential [7].

The primary focus of prioritization models is to conduct decision-making in accordance with the interests of the involved parties, even in circumstances of doubt, uncertainty, conflicts, and competition among various viewpoints. In this type of analysis, several relevant aspects can be taken into consideration [13].

Based on everything that has been presented, the purpose of this article is to answer the following research question: What is the current state of knowledge regarding prioritization models developed in the context of humanitarian logistics? The intention is to conduct a descriptive analysis based on the selected articles and discuss potential research directions.

The contributions of this study lie in a comprehensive analysis of the existing literature, surpassing mere description to pinpoint challenges and potential research directions. Particularly noteworthy is its introduction of an extended classification from [8], which now includes sustainability alongside efficiency, effectiveness, and equity.

After this introduction, the rest of the article is organized as follows. In Section 2, we detail the adopted methodology, addressing the criteria for data collection and the selection of categories for the literature review. The results obtained, organized according to the selected categories, are presented in Section 3. A discussion of the results is addressed in Section 4. Finally, some concluding remarks and possibilities for future research related to the topic are outlined in Section 5.

2. Materials and Methodology

A systematic literature review entails the comprehensive identification, evaluation, and interpretation of relevant research in a specific area [15]. According to [16], this process involves critically analyzing articles related to a theme or research question. In this article, we conducted a systematic literature review focused on prioritization models employed in the context of humanitarian logistics.

The methodology adopted for the systematic review is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology [17], which includes the following phases: identification, screening, data extraction and reporting of relevant literature. The PRISMA checklist for Systematic Review [17] is in Table S1, and the OSF (Open Science Framework) register of this review are listed in the Supplementary Materials section of this paper.

During the identification phase, articles were sourced from two databases, Scopus and Web of Science, utilizing keywords listed in Table 1. The two databases were selected due to the configuration of the largest catalogues of indexed journals [18]. Only articles categorized as such, in their final stage, published until 2023, and written in English were considered for inclusion.

Table 1. Searched keywords groups.

Keyword Group 1	Keyword Group 2
prioritization model	humanitarian logistic
multi-criteria	humanitarian operation
	disaster management

Figure 1 shows a flowchart of our research based on the PRISMA method. Initially, 250 articles were identified (156 from Scopus and 94 from Web of Science) using specified keywords and filters, with additional consideration for articles in their final stage of publication and written in English. Subsequently, 78 duplicate articles were removed from the analyzed databases.
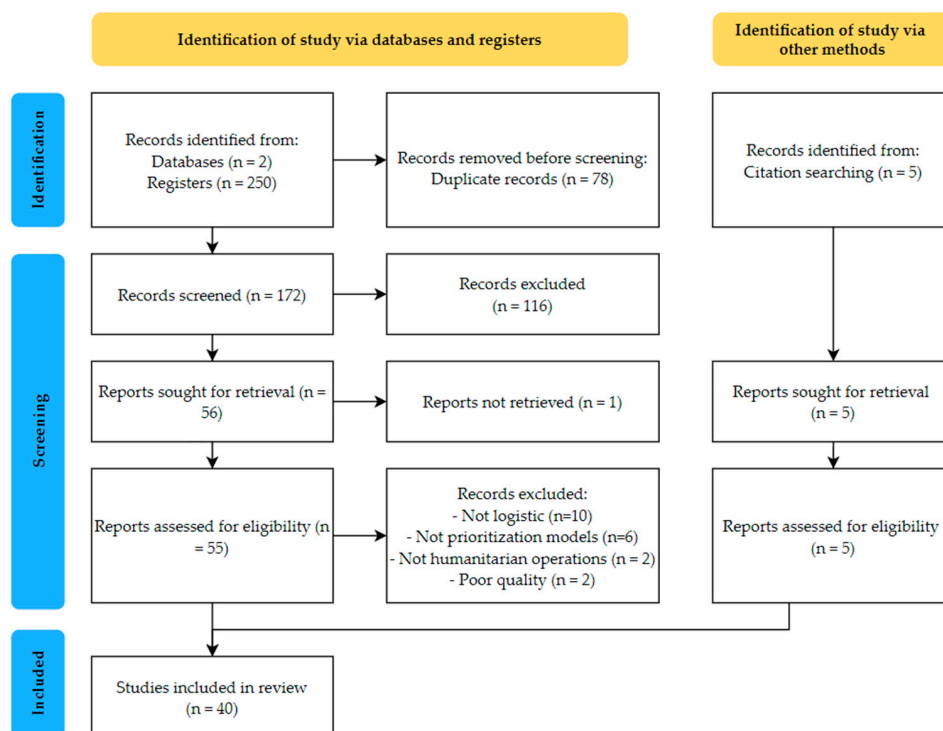

Figure 1. Flowchart of research based on PRISMA method.

During the screening phase, following abstract analysis, 116 articles were excluded from the sample due to lack of relevance to the research topic, with the majority focusing on disaster-risk mapping. Subsequently, efforts were made to retrieve the articles, resulting in only one article not being retrieved. A full-text reading was then conducted of the remaining 55 articles, of which 20 were further excluded for not addressing the topic of interest. Ultimately, 35 articles were selected via databases for further analysis.

Following this, a snowballing technique was employed, which entailed conducting citation searches on all the accepted full-text papers. Judgment was utilized to decide whether to pursue these further, leveraging the effectiveness of this technique in identifying high-quality articles, as noted in [19]. Through this process, 5 additional articles were identified via citation searching. Finally, the remaining 40 articles were analyzed and classified by two reviewers.

During the data extraction phase, our study utilized a categorization inspired by the research conducted by [20] in the context of humanitarian logistics. This categorization includes general information, type of disaster, phase of the disaster lifecycle, decision-making level, and type of problem. Additionally, a specific category pertaining to the prioritization approach was incorporated.

The categories used in this work are presented as follows:

- General information: Considers the name of the journal, country of the case study, and year of publication of the article.
- Disaster type: Considers the classification of disasters proposed by [5], which distinguishes between natural and human-made disasters, as well as the onset speed, categorized as sudden or slow.
- Disaster lifecycle stage: Divided into four phases—mitigation, preparedness, response, and recovery [8]. The mitigation phase aims to reduce society's vulnerability to a hazardous event. The preparedness phase aims to establish strategies and develop the necessary skills to ensure the success of response and reconstruction operations. The response phase begins immediately after the disaster occurs and aims to alleviate the suffering of affected people. Finally, the recovery phase aims to recover and/or improve the community's functioning [21].
- Decision-making level: Divided into three levels—strategic, tactical, and operational. Each involves long-term, medium-term, and short-term decisions [22].
- Type of problem: Divided into three types—location, inventory, and transportation [22]. The first is related to spatial aspects. The second involves demand estimation and inventory policies. Finally, the third is related to distribution and subsequent activities.
- Prioritization Model: Involves the object of prioritization, the method used, the number of criteria used in the modeling, and the type of criterion used. The classification proposed by [23] was adopted, which categorizes criteria into three groups: efficiency (such as cost), effectiveness (such as time, coverage, distance traveled, reliability, and safety), and equity.

3. Results

The results of the systematic literature review are organized into the following sections based on the selection of categories presented in Section 2, which include general information, the type of disaster, the phase of the disaster lifecycle, decision-making level, type of problem, and prioritization models.

3.1. General Information

The general information presented in this section considers the countries used as case studies, articles by year, and articles by journals.

Table 2 presents the number of articles with case studies applied to different countries and regions, providing crucial insights into research on prioritization models applied to humanitarian logistics. Iran stands out as the leader with eight articles, representing 24% of the total, indicating significant engagement in this field. Most of these articles are related

to activities following an earthquake, which is one of the main disasters occurring in this country (e.g., [24]). Haiti and Turkey follow closely, each with four articles. Additionally, it is interesting to note the geographical diversity of the research, covering countries such as China, Indonesia, France, Brazil, and others.

Table 2. Number of articles per country in case studies.

Quantity	Case Study
11	Iran
4	Haiti, Turkiye
2	China, Indonesia, France, Brazil, Pakistan, Multinational
1	Thailand, Canada, Italy, Germany, Nigeria, Bangladesh, Southern African Development Community

Figure 2 displays the distribution of articles per year, revealing fluctuations in publication trends. In 2011, only one article was published, followed by two articles in 2014. The year 2016 saw a notable surge with five articles. However, in 2017, there was a decline, with only one article published. Starting from 2018, there has been a discernible increase in articles focusing on prioritization models, maintaining a steady output of four to six articles annually.

Figure 2. Number of articles per year.

Regarding articles by journal, Table 3 reveals that the journal with the highest number of articles on prioritization models in the context of humanitarian logistics is *Sustainability*, with four articles. Most of the listed journals have only one article related to the research topic.

Table 3. Number of articles by journal.

Quantity	Journal
4	*Sustainability*
3	*International Journal of Disaster Risk Reduction, Annals of Operations Research*
2	*Computers and Operations Research, Journal of Humanitarian Logistics and Supply Chain Management*

Table 3. *Cont.*

Quantity	Journal
1	*Applied Soft Computing, Asian Journal of Shipping and Logistics, Buildings, Civil Engineering Journal, European Journal of Operational Research, International Journal of Critical Infrastructure Protection, International Journal of Emergency Services, International Journal of Geographical Information Science* *International Journal of Information Technology and Decision Making, International Journal of System Assurance Engineering and Management, International Journal of Systems Science: Operations and Logistics, Journal of Enterprise Information Management, Journal of Environmental Planning and Management, Journal of Global Optimization, Journal of Heuristics, Journal of Systems Science and Systems Engineering, Mathematics, Natural Hazards Review, Omega (United Kingdom), Optimization Letters, Production, Production and Operations Management, Quality and Quantity, Scientia Iranica, Transportation Research Part E: Logistics and Transportation Review, Urban, Planning and Transport Research*

3.2. Disaster Type

In this section, results are presented regarding the disaster studied in the articles, as well as whether it is classified as a sudden-onset or slow-onset disaster, as well as a natural or human-made disaster, following the classification provided by [5].

Out of the 40 selected articles, only 28 explicitly mention a disaster, suggesting that the remaining 12 may encompass comprehensive approaches applicable to various types of disasters.

Figure 3 depicts the distribution of applications based on the type of disaster. The results indicate a stronger emphasis on sudden-onset disasters compared to slow-onset disasters, as well as a greater focus on nature-induced disasters over anthropogenic ones.
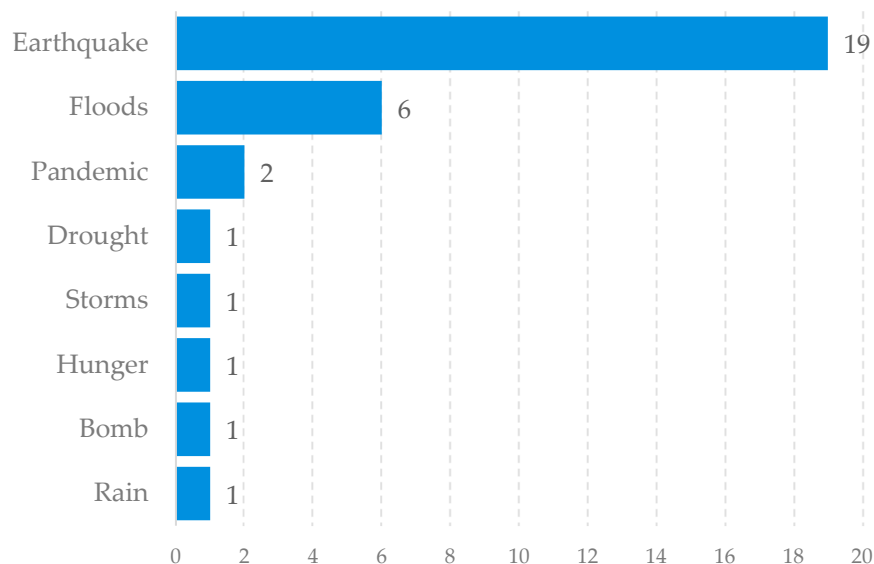
Figure 3. Number of articles by disaster.

It was observed that the majority of the analyzed studies are related to earthquakes, with 19 articles, which belong to the sudden-onset category and are considered of natural origin. One of the most studied cases in this category is the 2010 Haiti earthquake (e.g., [11,25]). Another important observation is that cases come from countries corresponding to the authors' affiliation country, for example, Iran (e.g., [26]) and Turkey (e.g., [27]), which are countries with a high seismic risk.

The second most studied type of disaster was floods, with six articles. Following that, pandemics were studied in two articles. The other researched disasters include bomb explosions, drought, storms, famine and cyclones, with only one article each.

In Figure 4, disasters are presented according to the classification provided by [5]. Regarding the origin of the disaster, it is observed that nature-induced disasters significantly represent the majority compared to human-made disasters, with only one article found studying a human-made disaster. Regarding the onset speed, it is observed that slow-onset disasters, which develop gradually over years, are less studied compared to sudden-onset disasters, which occur suddenly and unpredictably, without the possibility of adequate and rapid preparation or response. In summary, human-made disasters and slow-onset disasters are less studied concerning the application of prioritization models in humanitarian logistics.
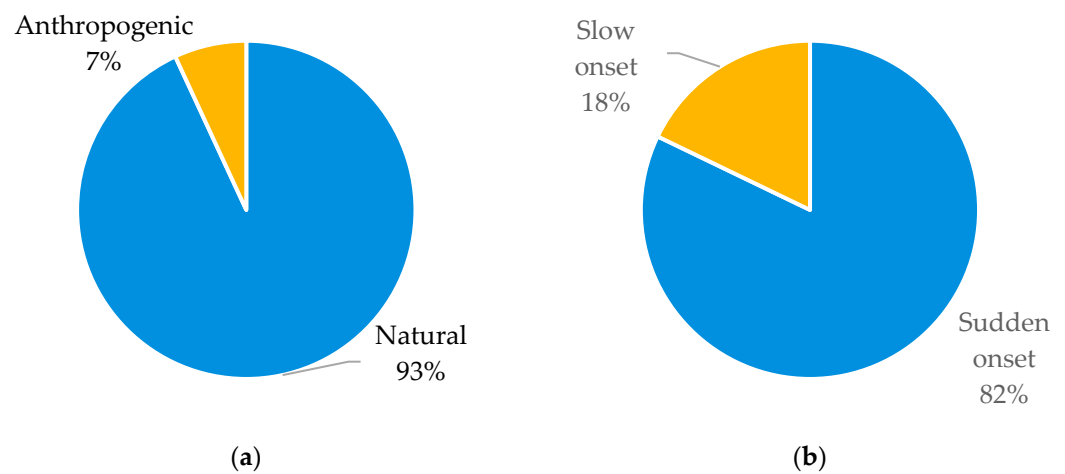

(**a**)   (**b**)

Figure 4. Number of articles by type of disaster. (**a**) Disasters by origin; (**b**) disasters by onset speed.

3.3. Disaster Lifecycle Stage

In this section, the results related to the phases of the disaster lifecycle investigated in the articles are presented. Four phases are considered: mitigation, preparedness, response, and recovery, as defined by [8].

In Figure 5, the percentage of articles related to each phase can be observed. The most studied phase is preparedness, representing 49% of the total articles. The second most addressed phase is response, accounting for 33% of the articles. Finally, the mitigation and recovery phases are the least studied, each contributing only 9% of the total articles.
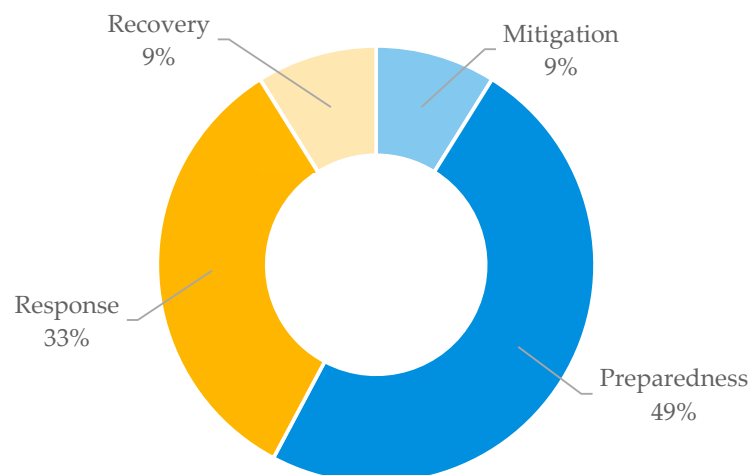

Figure 5. Number of articles by disaster lifecycle stage.

The mitigation phase aims to reduce the risks and threats associated with disasters through proactive strategies [21]. An example is the study by [28], which evaluates investments in projects to increase disaster resilience in communities. Another study is related to the selection of sites for mitigating sources of sand and dust storms [29]. Additionally, there is an article discussing the selection of emergency assembly areas after earthquakes [27].

The preparedness phase involves planning response teams and structuring action plans to deal with various types of disasters [21]. Most articles are related to location problems, such as shelter locations (e.g., [30]) and the location of humanitarian aid supply depots (e.g., [31]). Additionally, evacuation planning (e.g., [32]) and innovative topics, including the identification of strategic streets for humanitarian operations (e.g., [33]) and partner selection (e.g., [12]), are studied.

The response phase occurs when teams take action to deal with different situations, providing relief and medical supplies to victims. Its goal is to alleviate the suffering of those affected [21]. Mainly, activities such as the distribution of humanitarian aid supplies (e.g., [25,34,35]) are studied. Other activities analyzed in this phase include prioritizing areas damaged post-disaster ([36]) and searching for missing persons (e.g., [26]).

The recovery phase encompasses the rehabilitation of damaged infrastructure, the resumption of normal activities, and support to communities [21]. In this phase, the recovery of bridges and roads (e.g., [25]) and the selection of reconstruction projects (e.g., [37]) have been studied.

3.4. Decision Level

In this section, the results related to the level of decision-making focused on by the articles are presented. The three levels of classification of [22] are considered, encompassing strategic, tactical, and operational levels. These three decision-making levels are interdependent and complementary, ensuring that humanitarian logistics is efficient, effective, and capable of meeting the needs of populations affected by humanitarian crises.

In Figure 6, it is noticeable that the majority of articles are focused on the strategic level, involving long-term decisions, representing 60% of the total. Next, we have the operational level, which addresses short-term decisions, with 32.5% of the articles. Lastly, we have the tactical level, related to medium-term decisions, accounting for only three articles, corresponding to 7.5% of the total.
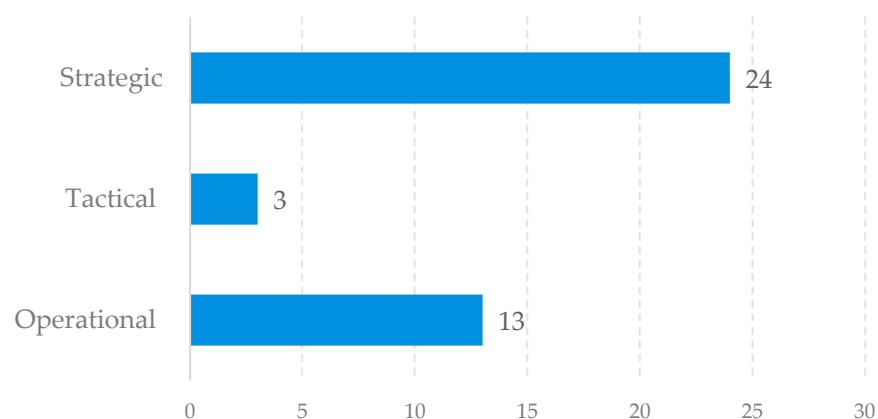
Figure 6. Number of articles by decision-making level.

The strategic level involves long-term decisions that have a direct impact on logistics operations [22], including the development of logistics policies, the identification of new intervention areas, and the establishment of long-term partnerships. For this level, concerning humanitarian logistics, mainly articles related to the location of humanitarian aid supply depots were found (e.g., [38]). Articles related to investments in projects (e.g., [28]) and the design of humanitarian supply chains (e.g., [39]) were also identified.

The tactical level refers to medium-term decisions aimed at optimizing operations and available resources [22], such as inventory planning, resource allocation to affected areas, the coordination of partnerships with other organizations, and the adaptation of logistics strategies as needed. At this level, the selection of supply partners (e.g., [12]), shelter location (e.g., [30]), and the identification of strategic highways in the road network (e.g., [33]) are studied.

The operational level involves short-term activities and decisions made in day-to-day operations [22], including the management of immediate resources such as transportation, storage, and the distribution of supplies, field team coordination, and the execution of logistical plans. At this level, most articles are related to transportation issues (e.g., [40]). Additionally, other issues such as the location of post-disaster field hospitals (e.g., [41]) are studied.

3.5. Problem Type

In this section, results regarding the type of problem are presented. For this purpose, the classification of [22] was used, which divides the problems into three categories: location, transportation, and inventory. The most studied activities in the research will be presented below.

In Figure 7, the number of articles by type of problem and decision-making level is shown. It was observed that the majority of prioritization models in humanitarian logistics are related to location problems, with 20 articles representing 50% of the total and with most of these articles focused on long-term decisions. Next, 37.5% of the articles are related to transportation, where most of the articles are oriented towards the strategic and operational levels. Finally, it was found that inventory-related problems are significantly less studied, with only five articles, with three of them oriented towards long-term decisions, one towards medium-term decisions, and one towards short-term decisions.
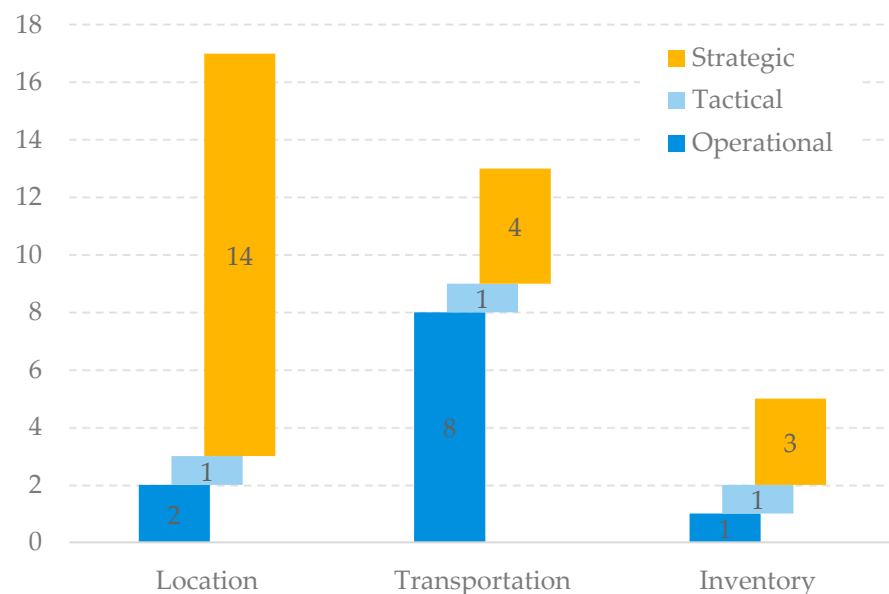
Figure 7. Number of articles by type of problem and decision-making level.

Facility location problems involve deciding where to locate one or more facilities to serve a set of demand points (e.g., [42]). Most articles address shelter locations (e.g., [43]). Additionally, problems related to locating depots for positioning humanitarian aid supplies (e.g., [31]) are studied. Articles on the location of emergency operations centers (e.g., [44]), hotspots for disaster mitigation (e.g., [29]), and Emergency Meeting Areas (e.g., [27]) were also found. In this type of problem, the most common objective is to minimize the total cost of operations, which includes establishing facilities and meeting demand (e.g., [38]).

Humanitarian organizations transport large quantities of aid for distribution after disasters. These activities include various, often conflicting, performance criteria such as time deprivation, cost, coverage, and asset ownership. Articles related to the distribution of humanitarian aid supplies, especially last-mile transportation within the first 72 h after the disaster, are mainly analyzed (e.g., [35]). This also includes the use of unmanned aerial vehicles (e.g., [40]). Evacuation problems (e.g., [45]) and search for the injured problems (e.g., [26]) are also studied. Additionally, an article on road networks and the identification of strategic highways in humanitarian operations (e.g., [33]) was found.

Inventory management in humanitarian logistics involves deciding which supplies, and in what quantities, to keep in warehouses and distribution centers [22]. It is crucial to balance the need to maintain sufficient stocks to meet immediate demand with cost efficiency and waste minimization. In this regard, the authors of ref. [46] propose lateral transshipment as a solution for dealing with surpluses at demand points. Furthermore, proper inventory control plays a key role in ensuring the continuous availability of essential supplies. Therefore, the authors of ref. [12] propose a model for partner selection that considers criteria such as humanitarian chain efficiency, legal issues, sustainability, and transparency, among others.

In everyday life, we face problems analyzing indicators that may conflict with each other, generating trade-offs. In this context, prioritization models as multi-criteria models have been developed to achieve effective and satisfactory decisions for decision-makers [47]. In the context of disaster management, these models gain greater importance due to the presence of multiple stakeholders with diverse objectives in an extremely complex, dynamic situation with a lack of information.

3.6. Prioritization Models

In this section, the results related to prioritization models are presented, including an appraisal of the prioritization object, method, and criteria, which extend the classification of [23]. Table 4 displays a classification based on these considerations.

Table 4. Prioritization classification of articles.

Art.	Prioritization Object	Method	OM	NC	Criteria			
					Ef	Ev	Eq	S
[34]	Humanitarian aid distribution	Goal programming	x	6	x	x	x	
[32]	Shelter location	Genetic algorithm	x	3		x		
[25]	Recovery operations and distribution	Lexicographic goal programming	x	5		x	x	
[11]	Humanitarian aid distribution	GRASP metaheuristic	x	6	x	x	x	
[48]	Selection of the supplier, warehouse, and vehicles	AHP/TOPSIS		4	x	x		x
[44]	Emergency operations center's location	AHP/ELECTRE		5	x	x		
[49]	Aerial delivery operations	Goal programming/stochastic optimization	x	3	x		x	
[28]	Investment in humanitarian supply chains	Swing weighting		10	x	x		
[50]	Temporary disaster debris management location	ANP/fuzzy TOPSIS	x	7	x			
[36]	Damaged areas	TOPSIS	x	4		x	x	
[51]	Shelter location	AHP		4		x		
[35]	Humanitarian aid distribution	Goal programming	x	6	x	x	x	
[30]	Shelter location	GIS/AHP		6		x		
[12]	Partner selection for supply	AHP/TOPSIS		24	x	x	x	
[26]	Search operations	TOPSIS/COBRAS/stochastic dynamic programming	x	3	x	x	x	
[33]	Road transport network	AHP		4		x		
[42]	Shelter location	Vectorial optimization/goal programming	x	3		x	x	
[31]	Distribution center's location	Stochastic programming/swing weighting	x	6	x	x		
[52]	Distribution of supplies	Goal programming	x	3		x	x	
[38]	Humanitarian network design	AHP/network optimization/dynamic simulation	x	3	x	x		
[53]	Distribution center's location	AHP/TOPSIS		16	x	x		
[45]	Evacuation	Goal programming	x	4	x		x	
[40]	Distribution routing	Differential evolution algorithm	x	4	x	x	x	
[29]	Sand and dust storms hotspots for remediation	Multi criteria evaluation		6		x	x	
[43]	Shelter location	Goal programming	x	3	x	x		
[54]	Disaster relief chains	AHP	x	5	x	x		
[39]	Food distribution	Preference elicitation algorithm	x	3	x	x	x	
[55]	Emergency facility location	VIKOR		5	x	x	x	
[56]	Shelter location	AHP		27	x		x	
[37]	Reconstruction projects	TOPSIS/VIKOR/PROMETHEE/ELECTRE		10	x			x
[41]	Hospital location	VIKOR		8	x	x		
[46]	Demand point	OPA/VIKOR	x	8		x		
[27]	Emergency assembly area's location	AHP/TOPSIS/COPRAS/BORDA		14		x		
[57]	Relief center's location	PROMETHEE		6		x		x
[58]	Disaster logistic hub location	Fuzzy AHP/BWM		20	x	x		
[59]	Sustainable humanitarian logistics network	Stochastic programming model	x	3	x		x	x
[60]	Emergency shelter's location	Metaheuristics NSGA-II/MOVDO	x	2	x	x		
[61]	Distribution center's location	Adaptive large neighborhood search	x	3	x	x	x	
[62]	Urban emergency supplies distribution paths	Multi-verse optimizer algorithm/AHP	x	7		x	x	
[63]	Relief goods distribution	Lexicographic Tchebycheff method	x	2		x	x	
	Total				26	34	20	4

"x" indicates that prioritization models present the mentioned class. OM: optimization model, NC: number of criteria, Ef: efficiency, Ev: effectiveness, Eq: equity, S: sustainability.

3.6.1. Prioritization Object

Regarding the prioritization object, it is evident that they find utility in various areas. This demonstrates the complexity and diversity of the challenges encountered in humanitarian operations. For instance, they are used in humanitarian aid distribution (e.g., [11]), distribution centers location (e.g., [53]), shelter location (e.g., [43]), and hospital location (e.g., [41]).

After a disaster, planning routes for vehicles delivering humanitarian aid, such as food, water, medicines, and clothing, to affected populations is essential. Refs. [11,34,35] tackled this challenge by prioritizing the selection of optimal routes for humanitarian aid distribution. They considered conflicting criteria such as security, time, cost, equity, coverage, and reliability.

To enhance the speed of response to a population's needs, warehouses are strategically placed to store humanitarian aid. This aid becomes accessible to assist people in need following a disaster. In this context, ref. [31] prioritizes the establishment of distribution centers for pre-positioning disaster relief supplies. The authors utilize an optimization model followed by a multi-criteria approach, considering factors such as operational cost, proximity to the Civil Defense Regional Director, the availability of human resources, safety, hygiene, and accessibility.

To evacuate people to safe locations, gyms or stadiums are frequently designated as temporary shelters for those whose homes are no longer inhabitable. For instance, ref. [32] developed an optimization model that prioritizes evacuation planning. This model integrates various decisions at this stage, considering factors such as the selection of shelter locations and routing for both public and individual transport, and taking into account both evacuation time and evacuation risk.

Some innovative research addresses transport infrastructure recovery (e.g., [25]) and waste management (e.g., [50]), in addition to partner selection (e.g., [12]) and the selection of investment in projects (e.g., [37]). A comprehensive analysis encompasses humanitarian chain design (e.g., [38]).

3.6.2. Method

Regarding the methods employed, the most commonly used ones involve some form of multi-criteria approach. Articles were also found that utilize an optimization approach, and finally, to a lesser extent, the use of heuristics.

MCDA enables the assessment and comparison of various alternatives by considering multiple criteria, aiding in the identification of the optimal choice. MCDA methodologies employed in humanitarian logistics encompass a range of techniques, as outlined in the subsequent paragraphs.

The Analytic Hierarchy Process (AHP) is a decision analysis technique that breaks down problems into hierarchical structures of criteria and alternatives, facilitating their evaluation and prioritization based on relative importance [64]. AHP has been utilized in humanitarian logistics for various purposes, including the determination of emergency assembly areas (e.g., [27]), shelter locations (e.g., [51,65]), distribution centers (e.g., [53]), and decision-making regarding road transport networks (e.g., [33]), among others.

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a method used to select the best alternative from a set of options, based on the proximity of each alternative to the ideal solution and its remoteness from the negative ideal solution [66]. TOPSIS has been utilized in humanitarian logistics for various purposes, including the selection of suppliers, warehouses, and vehicles (e.g., [48]), the prioritization of damaged areas (e.g., [36]), and partner selection (e.g., [12]), among other applications.

The Multi-criteria Optimization and Compromise Solution (VIKOR) aims to find a compromise solution closest to the ideal, considering conflicting criteria [67]. VIKOR has been utilized in various contexts, including prioritizing emergency facility locations (e.g., [55]), selecting reconstruction projects (e.g., [37]), determining hospital locations (e.g., [41]), and identifying demand points (e.g., [46]).

Elimination and Choice Expressing Reality (ELECTRE) is an approach used for decision-making based on comparing alternatives according to multiple criteria, using dominance and preference relationships to classify the alternatives [68]. ELECTRE has been utilized in humanitarian logistics for an emergency operations center's location (e.g., [44]) and the selection of reconstruction projects (e.g., [37]).

Preference-Ranking Organization Method for Enrichment Evaluations (PROMETHEE) is a method used for decision-making based on the comparison and ranking of alternatives according to multiple criteria, using predefined preference functions [69]. This method was used to select reconstruction projects (e.g., [37]) and relief centers locations (e.g., [57]).

Combined Objective Reconnaissance by Sequential Actions (COBRAS) is a method that combines the construction of an objective model with the selection of sequential actions to achieve those objectives, used in strategic decision-making [26]. This method was used to prioritize search operations (e.g., [26]).

Complex Proportional Assessment (COPRAS) assesses and ranks alternatives based on various criteria; then, by comparing alternatives against each criterion, it provides an aggregated ranking [47]. This method was used to prioritize emergency assembly area's location (e.g., [27]).

The Analytic Network Process (ANP) is a technique that enables decision-making in complex situations involving interactions between different elements, through the construction and analysis of networks of criteria and alternatives [64]. This method was used to prioritize temporary disaster debris management locations (e.g., [50]).

Outranking Process Analysis (OPA) is an approach used for decision-making that is based on identifying dominance relationships between alternatives, allowing the establishment of a preference order without requiring a precise numerical evaluation [46]. This method was used by [46] to prioritize demand points after a disaster.

The Borda Count (BORDA) is a voting method used to calculate the ranking of alternatives based on voters' preferences, assigning points to each alternative according to its position in each preference list [27]. This method was used by [27] to prioritize location of emergency assembly areas.

The Best Worst Method (BWM) is an approach used for decision-making that focuses on identifying the best and worst alternatives in relation to each criterion, allowing the evaluation of the relative importance of the criteria. This method was used to prioritize disaster logistic hub locations [58].

Swing Weighting is a weighting method used in decision analysis, where criterion weights are adjusted based on the decision's sensitivity to those criteria. This method was used to prioritize investment in humanitarian supply chains [28] and to select distribution center locations [31].

Other methods used include the development of optimization models. As depicted in Figure 8, 69% of articles include optimization models, whereas 31% do not. Among the optimization models employed are goal programming, stochastic models, dynamic models, and vectorial optimization.

Goal programming is an optimization technique used to solve decision-making problems with multiple objectives, aiming to minimize or maximize a set of objective functions subject to a series of constraints [70]. Goal programming has been utilized to prioritize humanitarian aid distribution (e.g., [34]), recovery operations and distribution (e.g., [25]) aerial delivery operations (e.g., [49]), humanitarian aid distribution (e.g., [35]), the distribution of supplies (e.g., [52]), evacuations (e.g., [45]), and shelter locations (e.g., [43]).

Stochastic models in operations research are used to address problems where at least part of the problem is subject to uncertainty or random variability. In humanitarian logistics, this is crucial due to uncertainties surrounding factors such as demand, supply availability, and transportation conditions. Stochastic optimization has been employed to prioritize aerial delivery operations (e.g., [49]), search operations (e.g., [26]), and distribution center locations (e.g., [31]).
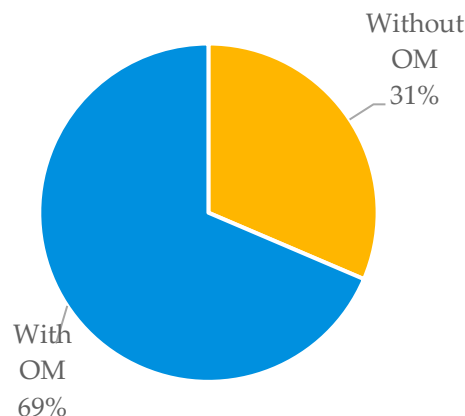
Figure 8. Articles with and without optimization model.

Dynamic models in operations research are utilized to model and solve problems involving temporal changes. In humanitarian logistics, it is important, because they allow for modeling processes that involve time-varying factors such as demand fluctuations and resource availability. For instance, stochastic dynamic programming was employed to prioritize decisions in search operations (e.g., [26]), while dynamic simulation was utilized for humanitarian network design (e.g., [38]).

Vectorial optimization is a branch of optimization dealing with the optimization of vectors of objective functions subject to constraints. It is used to find optimal solutions in problems with multiple objectives. This method is used by ref. [42] to prioritize decisions about shelter locations.

Finally, there are authors who devise algorithms to tackle complex issues, mostly related to transportation problems. These utilized algorithms include the GRASP metaheuristic, Evolution algorithm, and Preference Elicitation Algorithm.

Greedy Randomized Adaptive Search Procedure (GRASP) is a metaheuristic for combinatorial optimization, blending a greedy solution construction with random neighborhood exploration. It is used by ref. [11] to prioritize decisions about routing in humanitarian aid distribution.

Evolution algorithms, inspired by evolutionary theory, optimize by generating and manipulating a population of potential solutions. Through selection, crossover, and mutation operators, they evolve improved solutions over generations. This algorithm was used by [40] for unmanned aerial vehicle path planning in disaster management.

The Elicitation Algorithm figures out what users or agents prefer in interactive systems by analyzing their choices and feedback. It was used by [39] to prioritize decisions about food distribution by food banks.

3.6.3. Criteria

Regarding the criteria, it is observed that 85% of the articles consider criteria related to effectiveness, followed by 65% of the articles that consider criteria related to efficiency. In a smaller quantity, only 50% of the articles consider criteria related to equity. Finally, only four articles considered criteria related to sustainability.

The efficiency criteria, as highlighted by [71], generally aim to minimize costs. For example, the authors of ref. [11] study the problem of distributing humanitarian aid supplies and consider operational cost as one of the criteria to be optimized. On the other hand, ref. [41] analyzes the problem of locating field hospitals, considering criteria such as land cost, investment cost, and installation cost.

In contrast, effectiveness criteria aim to maximize a service measure, often the amount of demand met and the speed at which the demand is fulfilled [71]. For example, ref. [27] analyzes the problem of locating emergency assembly areas, considering the coverage area as one of the criteria, which includes accessibility, population density, and expansion potential. Additionally, ref. [35] addresses the issue of distributing humanitarian aid

supplies, considering security as a criterion, such as the probability of truck theft, which can obstruct the success of operations. These studies exemplify how effectiveness criteria are related to maximizing the service provided, taking into account not only the quantity served but also the quality and safety of operations. Finally, the authors of ref. [53] include in their model for the location of aid distribution centers the criterion of accessibility, considered not only as the quality of routes to the distribution center but also as alternative routes that allow access in case of road disruptions, which is vital to increase the speed of assistance to affected areas. This approach highlights the importance of considering not only the efficiency of main routes but also the resilience of the system in the face of unforeseen events, ensuring that aid reaches needy areas quickly, even in adverse situations.

Equity criteria refer to fairness in the distribution of services among beneficiaries. However, it is important to note that the definitions of "justice" and "service" can vary significantly among different authors [71]. Ref. [34] considers equity optimization by contemplating a maximum deviation proportional to the demands met. In turn, ref. [39], in analyzing food distribution by food banks, considers equity as the supply of food to each municipality in proportion to the demand they meet. Ref. [29] evaluates how sand and dust storms can impact different areas, prioritizing assistance to locations with the greatest impact.

Sustainability criteria are those that consider some objective regarding the reduction of environmental impact. It is worth noting that this category is not part of the categorization proposed by [23], but it is proposed due to its importance today, since an operation that does not consider the environment and its remediation can generate negative impacts on the community in the medium and long term. The authors of ref. [37] evaluate reconstruction projects and consider environmental criteria, such as the use of renewable energy, the assessment of carbon emission rates caused by construction activities, and the use of reusable and recyclable materials. Ref. [53] analyzes the location of relief centers, considering waste control capacity among the criteria for possible alternatives. Finally, ref. [57] considers the reduction of carbon emissions from humanitarian operations as a criterion.

Finally, Figure 9 shows that 2 articles consider two criteria and 10 articles adopted only three criteria, while another 6 articles used four criteria. Additionally, four articles considered models with five criteria, and another seven articles opted to incorporate six criteria. In summary, it was found that 31 out of the 40 studies that were analyzed for prioritization models in humanitarian logistics involved seven categories or fewer, representing 77.5% of the total. On the other hand, the use of seven or more criteria was less frequent among the analyzed articles.
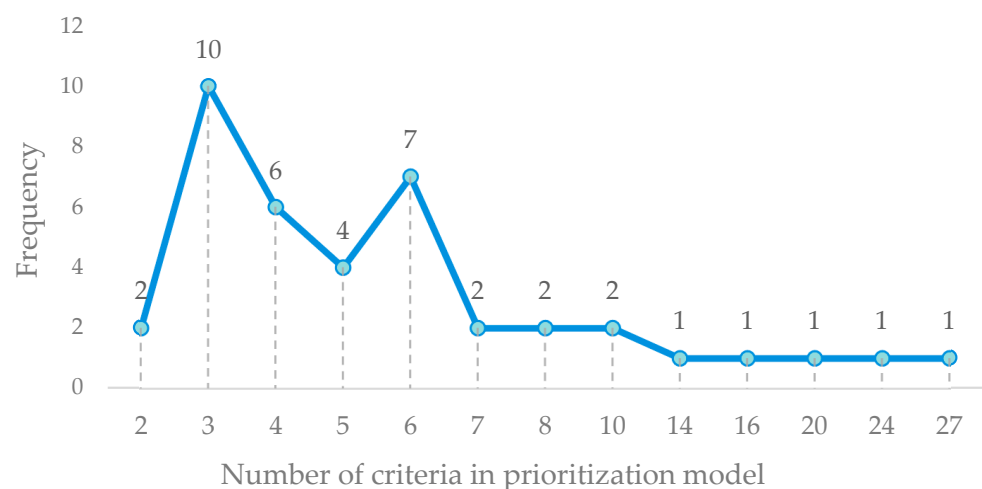

Figure 9. Number of criteria per article.

4. Discussion

In humanitarian logistics, decision-makers encounter a complex scenario fraught with numerous challenges. They must weigh various criteria, often in conflict, crucial for the efficacy of relief efforts [23]. Consequently, the necessity for prioritization models becomes apparent, aiding in the selection of optimal strategies for the myriad activities within humanitarian logistics. Following a systematic literature review on prioritization models in humanitarian logistics, discernible trends and research gaps emerge, which will be delineated in the subsequent paragraphs.

However, it is worth noting that the volume of studies addressing the application of prioritization models to humanitarian logistics is still limited, with less than seven articles published per year. Given the number of stakeholders involved in humanitarian operations and their importance, it is crucial to ensure that the objectives of each party are met. In this context, prioritization models play a significant role.

Research on prioritization models in humanitarian logistics predominantly focuses on applications to nature-induced disasters, particularly earthquakes and floods, given that two out of every three disasters are of natural origin [72]. However, there remains a gap in the study of other nature-induced disasters currently affecting the world, such as volcanic eruptions (e.g., the Mount Merapi eruption 2024), landslides (e.g., Brazil mudslides), hurricanes (e.g., the Mexico hurricane 2024), climatological disasters (e.g., Chile wildfires 2024), and biological disasters (e.g., COVID-19 pandemic).

Adapting prioritization models from extensively studied disasters like earthquakes and inundations can serve as an initial step to enhance the performance of models for other types of disasters. For instance, earthquake models, typically focused on shelter location [60], can be expanded to integrate evacuation strategies suitable for volcanic eruptions. Inundation models, which emphasize flood responses, can be tailored for landslides by incorporating effective route-planning measures. Similarly, biological disaster models can adapt location–allocation prioritization models to account for disease spread dynamics [56].

Additionally, there is evidence of a smaller number of articles related to human-induced disasters. The infrequent exploration of human-induced disasters in the literature could be attributed to their high complexity [20], because these disasters involve studies related to human actions, delving into political, social, and economic debates, thereby adding complexity to the research. Another contributing factor is the challenge of accessing areas affected by man-made disasters, which may pose complications for research in the field [73]. Currently, refugee crises, such as the exodus of Venezuelans, and armed conflicts like the Israeli–Palestinian conflict and the Russo–Ukrainian War, require further investigation regarding humanitarian logistics activities that necessitate prioritization.

Regarding the speed of start, the majority of the prioritization models study a sudden-onset disaster. However, slow-onset disasters, while allowing more time to react, can have more severe consequences due to their large scale [73]. This discrepancy may be attributed to the higher media coverage of sudden-onset disasters, resulting in less attention to slow-onset events.

Furthermore, it was observed that the majority of research on humanitarian logistics models focused on two stages of the disaster management cycle: preparedness and response. The lack of articles on multi-criteria models in the disaster recovery phase is evident, despite its significance as the final stage. Additionally, it is important to highlight that the shortage of articles focused on the reconstruction phase was also emphasized by [20]. The challenge of rebuilding and restoring both economic and emotional aspects after a disaster warrants a more thorough analysis [21]. Regarding the scarcity of articles on mitigation, it is attributed to the consideration of articles solely related to logistical activities. However, it should be emphasized that criteria aimed at disaster risk reduction need to be incorporated into the models of other phases.

In relation to the decision level classification of [22], there is a tendency to focus research on strategic and operational decisions. However, there is a limited amount

of research related to the tactical decision-making level, which involves medium-term decisions. Hence, there is an urgent need to develop prioritization models for tactical activities, particularly those related to inventory management problems.

In relation to the problem type classification of [22], location and transportation problems are the most addressed. There is a notable absence of articles addressing issues related to inventory management, such as demand forecasting, supply allocation, and supplier evaluation. An additional area of research of great interest is the integration of correlated activities, aiming to improve the overall efficiency of both operations [25].

In terms of criteria, the criteria most commonly used in prioritization models are related to effectiveness, followed by efficiency. There is a highlighted need to consider prioritization models that also include equity criteria, which ensure a fair and equitable distribution of resources among the affected, ensuring that everyone's needs are addressed impartially [71]. Likewise, the use of sustainability criteria would allow for minimizing the environmental impact of humanitarian operations, promoting responsible practices. A recommendation for selecting criteria is to consider at least one criterion from each presented category.

Regarding the selection of method, it should align with the prioritization object under study. It was observed that a variety of approaches are used, including a multi-criteria approach, optimization approach, and heuristic approach.

Optimization models allow for obtaining optimal results, while also incorporating the stochastic and dynamic approaches inherent to post-disaster situations (e.g., [26]). However, due to limitations in computational memory, modelers may be hindered from adding a greater number of criteria.

The use of multi-criteria heuristics is an excellent option for problems with a high computational complexity in humanitarian operations [32], such as humanitarian aid distribution problems. However, similar to optimization models, the number of criteria that can be used may be limited by computational memory.

On the other hand, multi-criteria models allow for considering the expertise of decision-makers and can also take into account a greater number of criteria (e.g., [31]). However, the selection of alternatives to prioritize may be subjective.

In response to this, it is proposed as future research to integrate different approaches, where optimization models or heuristics can select high-quality alternatives that can serve as input for multi-criteria models. These multi-criteria models can then incorporate criteria that could not be added in the previous stage and take into account the decision-makers' expertise.

Regarding the number of criteria, approximately 70% of articles address only four or fewer criteria. Therefore, the question arises whether there is a necessity to include more criteria in prioritization models of humanitarian operations. The response to this question is dependent on various factors. The selection of the number of criteria is related to the prioritization object being analyzed. However, as mentioned earlier, it is encouraged to use at least four criteria: one efficiency criterion, one effectiveness criterion, one equity criterion, and one sustainability criterion.

5. Conclusions

Prioritization models are powerful tools for managing the trade-offs inherent in humanitarian operations, where resources are limited and needs are urgent. These models enable decision-makers to systematically evaluate and balance different criteria, enhancing the immediate response to crises and improving the overall performance of humanitarian operations.

This systematic literature review conducted a descriptive analysis of predefined categories and proposed areas of future research in the context of applying prioritization models in humanitarian logistics. By selecting 40 articles from keywords searched in relevant databases, it was found that the quantity of articles has been slightly increasing in recent years.

Our analysis and synthesis have yielded several insights for future research opportunities and guidance for enhancing humanitarian logistics. Primarily, articles are focused on applications related to sudden-onset natural disasters, suggesting an opportunity to explore slow-onset disasters and human-induced disasters further. We identified research gaps, particularly the lack of studies addressing inventory problems, tactical-level decisions, and the reconstruction phase. It is crucial for the number of criteria used in prioritization models to align with the specific prioritization object studied. However, we recommend incorporating at least one criterion each for effectiveness, efficiency, equity, and sustainability.

Regarding solution methods, there are opportunities to explore integrated prioritization model methods that use optimization models or heuristics as inputs for multi-criteria decision analysis (MCDA) approaches. For researchers, this could pave the way for creating robust models tailored to the specific activities and types of disasters analyzed. For practitioners, these insights underscore the importance of using models to generate a limited list of high-quality alternatives and then conducting a second step to select a solution based on preferences and expertise.

Indeed, another opportunity arises in the adaptation of prioritization models to address emerging challenges across diverse contexts. This adaptability not only strengthens the resilience and effectiveness of decision-making in humanitarian logistics but also offers a dynamic approach to navigating complex scenarios. Such adaptations can encompass not only addressing various types of disasters, but also integrating different activities throughout the disaster lifecycle, further enhancing operational efficiency and preparedness.

We believe that these opportunities will enhance the utilization of prioritization models in humanitarian logistics research, encouraging the need for collaboration between academic and practitioner research to find better solutions to real situations.

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