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SYSTEMATIC LITERATURE REVIEW ON HUMANITARIAN OPERATIONS: RESOURCE OPTIMIZATION AND LOGISTICS IN FORCED DISPLACEMENT SCENARIOS

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SYSTEMATIC LITERATURE REVIEW ON HUMANITARIAN OPERATIONS: RESOURCE OPTIMIZATION AND LOGISTICS IN FORCED DISPLACEMENT SCENARIOS

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Abstract

This study conducts a systematic literature review focusing on humanitarian operations, particularly the optimization of resources and logistics in forced displacement scenarios. Guided by a rigorous review protocol to ensure scientific robustness, transparency, and replicability, the study incorporates bibliometric analysis to explore the application of operational research techniques, examining scientific contributions, methodologies, and research gaps in resource optimization, facility location, and humanitarian logistics. The review identifies significant contributions from recent studies, revealing how mathematical models and decision-making tools are used to address challenges in forced displacement, with a focus on the effective use of facility location strategies and optimization algorithms to improve resource allocation and emergency response efficiency. The review is limited to articles published between 2020 and 2024, primarily in English and in open-access databases, which may exclude other relevant contributions. Future research should expand on the integration of innovative technologies and cross-disciplinary approaches to address evolving humanitarian challenges. This research highlights the intersection of operational research and humanitarian logistics, offering a comprehensive overview of existing knowledge and practical insights, and serving as a valuable resource for academics and practitioners seeking to develop solutions to enhance the well-being of displaced populations.

Keywords: Refugee. Facility Location. Migrant. Humanitarian cause. Operational research.

1 - Introduction

Human mobility from the perspective of forced displacement is one of the most concerning phenomena of recent times. This displacement is considered one of the many coping mechanisms for economic challenges, violence, and climate impacts (Higuera Florez and Madurga Lopez, 2024). Year after year, thousands of people find themselves in this condition, forcibly, around the

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world (Ruiz and Vargas-Silva, 2013; Gökalp *et al.*, 2022). This forced displacement gave rise to the term "refugee", which has been discussed in political, economic, social, environmental, and scientific contexts.

First and foremost, it's important to understand that the notion of "refugee" at the international level was not very clear until the 1951 UN Convention and its 1967 Protocol, when the terminology began to be defined with pillars of protection. (United Nations, 1951). According to the International Organization for Migration, the reasons for human-caused displacement can arise from various types of conflict or persecution, as well as from natural disasters. Among the aforementioned reasons, political persecution, political crises, economic challenges, and environmental issues stand out (Myers *et al.*, 2024). Armed conflict is one of the most significant types of conflicts when it comes to groups of refugees. In contrast, the term "migrant" is attributed to individuals who choose to move in search of work and education, meaning they are seeking better living conditions. (UNHCR, 2012).

According to published data in the year 2021, the number of forcibly displaced people worldwide was 89.3 million (UNHCR, 2022). This number represented a growth of 21.39% in the data for the year 2022, raising the figure of forcibly displaced people to 108.4 million (UNHCR, 2023). During the development of this research, a new survey was published with data from 2023, highlighting the concern about the issue. The number of displaced people rose to 117.3 million worldwide (UNHCR, 2024). An increase of 8.21% compared to 2022 and 31.3% compared to the previous year.

In addition to the numerous challenges that forced displacement imposes, there are still many other humanitarian situations that affect the population in this context of transit. Various situations have been investigated over the years, such as proposals for networks of administrative support facilities for refugees (Kian, 2022) and models that aim to address the crisis in a way that improves the provision of support services (Jafarzadeh-Ghoushchi, 2023; Tanti, 2022).

Among the causes of forced migration, the most common found in the literature are mentioned in studies of natural disasters, whose typology includes various risks, such as hurricanes (Yang, 2024; Zhang and Cui, 2021; Shehadeh and Tucker, 2022; Shu *et al.*, 2021; Rodríguez-Espíndola, 2023), earthquakes (Shehadeh and Tucker, 2022; Gulesan *et al.*, 2021; Che *et al.*, 2024; Pochan *et al.*, 2020; Görmez *et al.*, 2011), storms (Rodríguez-Espíndola *et al.*, 2023) and floods (Shu *et al.*, 2021; Boromrit and Jamrus, 2023; Seranilla and Löhdorf, 2024; Starita *et al.*, 2017). There are also those related to conflicts (Ruiz and Vargas-Silva, 2013), which grant displaced individuals the status of international refugees or even internally displaced persons.

Fortunately, many authors have been discussing these issues from the perspective of operations research, which is considered a scientific approach focused on decision-making, aiming to determine how to design and operate systems optimally under conditions that require the allocation of scarce resources (Carter *et al.*, 2018; Arenales *et al.*, 2011). Operations research has significantly contributed to understanding the complex situations surrounding this topic and proposing tools to address them. One such theme, humanitarian logistics, has been investigated by authors (Alsoussi, 2024; Kim *et al.*, 2022; Munyaka and Yadavalli, 2021; Liu *et al.*, 2021; Stienen *et al.*, 2021; Rodríguez-Espíndola *et al.*, 2023b) and is the central subject of many studies.

However, there are other topics related to forced displacement that have received attention from operations research scholars. Some of these include disaster management, facility location, disaster prevention, humanitarian aid, supply chain management, and many others. Facility location problems, in particular, are a significant part of the mentioned study area. Many of these studies propose solutions based on mathematical models developed to assist in choosing support locations for people in transit situations (Ongoo, 2021; Kian, 2022; Boromrit and Jamrus, 2023). Some discussions have been raised about this movement, which causes various impacts, such as on the economy itself (Myers *et al.*, 2024). Among the many issues with economic implications is the consumption pattern of families in transit, which becomes dependent on temporary income sources, directly impacting the well-being of these families. Another important aspect is the

burden on host communities, which manifests in various ways, such as increased unemployment rates (Ruiz and Vargas-Silva, 2013).

It was in response to these issues that the "Economy of Francesco" movement was launched by Pope Francis in 2019, attracting people from all over the world. Among them are economists and entrepreneurs who believe that environmental, social, spiritual, and, no less important, managerial sustainability should be considered to minimize the numerous harms caused by irresponsible human actions (Economy of Francesco, 2024).

To better understand how these challenges have been investigated, this article proposes the development of a systematic literature review aimed at collecting and categorizing scientific knowledge from the perspective of operational research, focusing on the practices and conduct adopted to support people in situations of forced displacement.

The systematic review conducted in this research provides an in-depth analysis of existing knowledge on humanitarian logistics and resource optimization in forced displacement contexts. By employing a rigorous methodology, this study identifies critical research gaps and emerging trends, offering valuable insights for future research and practical applications. This review serves as a comprehensive resource for researchers and practitioners aiming to enhance the effectiveness of humanitarian operations in the face of forced displacement.

The expectation is that this article will inspire readers and researchers to explore studies aimed at addressing the causes of forced displacement. Ultimately, it aims to provide a holistic view of what has been done to tackle the issues arising from this type of displacement. To facilitate reading, the remainder of the article is organized as follows: Section 2 details the methodology used in the research. Section 3 presents an in-depth analysis of the research findings, including statistical and bibliometric analysis. Finally, the conclusions, along with suggestions for potential future studies, are discussed in Section 4.

2 - Research methodology

A systematic literature review allows for the establishment of scientific and academic knowledge around a specific topic. The state of the art of a subject to be investigated is conceived through research that, through a synthesis of published literature, provides readers with an up-to-date understanding of the topic (Palmatier *et al.*, 2018). The steps in the systematic review process include: formulation of the topic, study design, sampling, data collection and analysis, and reporting (Littell *et al.*, 2008).

The construction of this article follows established and consolidated guidelines to ensure the scientific rigor and quality of the collected material, as well as its analysis and results (Kitchenham *et al.*, 2009). The authors provide clear guidelines for conducting a systematic review, aiming to ensure its integrity and replicability.

The review followed a previously developed protocol that is available online and was conducted using a systematic literature review methodology. The protocol can be accessed at bit.ly/slr-operational-research. This review is noted for its rigor compared to traditional reviews, as it allows for the synthesis of studies related to the investigated topic in an organized, transparent, and replicable manner at each stage of the process (Mohamed *et al.*, 2021).

2.1 - Research formulation

After consulting publications on operational research (Arenales, 2011) and its application to emergency humanitarian logistics (Boonmee and Kasemset, 2020), it became clear that there is a need to understand certain aspects of the use of operational research applied to humanitarian issues. For the purpose of this systematic review, the questions presented in Table I were formulated:

Tabela I: Research Questions

ID	Research Question	Purpose
RQ1	What is the optimization task (e.g. facility location, designation, etc.)?	Identify the proposed optimization task.
RQ2	What are the variables (e.g. demographic data)?	List the variables related to the problem.
RQ3	What is the mathematical modeling approach?	Understand the proposed mathematical model.
RQ4	What are the optimization algorithms?	Highlight the algorithms proposed for optimization.
RQ5	What are the future research directions and gaps?	Verify the conduct of the studies.

To answer the research questions, this study employed rigorous criteria in the consultation and retrieval of studies from reliable data sources, which will be presented in the next section. The search string that was developed, tested, and refined is defined as follows:

(facility location) AND (refugee OR refugees OR migrant OR migrants OR humanitarian)*

Note that, to ensure the topic was thoroughly explored, Boolean operators were used to combine keywords in an advanced search process (Mohamed *et al.*, 2021).

2.2 - Inclusion and exclusion criteria

Table II presents the inclusion and exclusion criteria defined for conducting this systematic literature review:

Tabela II: Inclusion and exclusion criteria

Inclusion	Exclusion
IC1 - Articles published between 2020 and 2024.	EC1 - Articles published before 2020.
IC2 - Articles published in open-access databases, or for which the author has access.	EC2 - Duplicate articles.
IC3 - Articles that contain the words "facility location" and "refugee," or "migrant," or "refugees," or "migrants," or "humanitarian" in their title.	EC3 - Articles published in a language other than English.
IC4 - Articles that contain the words "facility location" and "refugee," or "migrant," or "refugees," or "migrants," or "humanitarian" in their abstract.	EC3 - Books, Chapters, Reference Works, Conference Proceedings, Conference Papers. EC3.1 - Any publication that is not an article.

IC5 - Articles published in English.

EC4 - Articles that contain only words such as "refugee", "migrant", "refugees", "migrants" or "humanitarian" in their title or abstract, without the string "facility location" in the title or abstract.

IC6 - Must address facility location or designation issues applied to humanitarian causes of refugees and stateless persons.

EC5 - Studies that do not provide datasets or mathematical models.

EC6 - Studies that do not address facility location from the perspective of refugees and stateless persons.

Three databases were selected for consultation and from which the data will be retrieved. The following Table III presents the chosen databases and the number of articles obtained from each, based on the defined search string:

Tabela III: Scientific databases

N.º	Journal Database	Articles
1	IEEE Xplore	10
2	ACM Digital Library	12
3	Scopus (Elsevier)	62
	TOTAL	84

After a thorough review that was conducted and refined to assess and improve the search, the articles were organized and categorized. The organization was supported by the Mendeley tool, which can be used from an installed desktop version, cross-platform (Reiswig, 2010), as well as a version available online. The tool ensures synchronization between these versions (Hicks, 2011), guaranteeing that any changes made in the desktop version will also appear in the web version, and vice versa. It assists in managing citations and storing articles in PDF format. Databases and citations can be imported from EndNote, BibTeX, Zotero, and other tools that support the RIS format (Reiswig, 2010). This choice was made due to the integration of formats between Mendeley and VOSviewer, the latter being the tool used for the bibliometric analysis of the selected articles.

2.3 - Data Collection

This section addresses the organization and categorization of the articles collected to identify which studies met the requirements established in the research protocol. It also highlights the objectives, constraints, and proposed solution methods within the selected articles.

To facilitate bibliometric analysis, the search results from the databases were adapted to the format used by Scopus, as this format is compatible with VOSviewer, the software utilized in this study. The collection focused on articles published between 2020 and July 2024.

The analysis of the collected data adheres to the research protocol, particularly concerning Inclusion Criterion 6, which states that selected studies must address facility location or designation problems applied to humanitarian causes concerning refugees and stateless persons.

Furthermore, the analysis also complied with Exclusion Criterion 5, which necessitated examining articles that included mathematical models and datasets.

Table IV presents all the collected and categorized articles, which will be referenced in the subsequent section on the analysis of research results. This structured approach ensures a thorough understanding of the literature on operational research applications in humanitarian contexts, providing a solid foundation for further discussion and insights.

Table IV - Objectives, constraints, and solution methods

Authors	Objective	Constraints			Solution Method
		Capacity	Requirements and bounds	Other	
(Maharjan and Hanaoka, 2020)	location-allocation, relief supply, distribution, temporary logistics hubs.	Facility, supply	Number of facility	Transportation network design, linkage between TLH and POD	Exact algorithm
(Taymaz <i>et al.</i> , 2020)	Location-allocation in healthcare services	Facility	Number of mobile workers	Different diseases	Exact algorithm
(Monzón <i>et al.</i> , 2020)	Aid distribution centers, humanitarian logistics	Facility	Inventory location	Road section to fortify	Exact algorithm
(Pochan <i>et al.</i> , 2020)	Framework for locating earthquake disaster relief centers	Facility	-	Three sequential steps of analysis	Spaghetti and meatballs method, Four-step transportation model
(Junior <i>et al.</i> , 2020)	Relief supply, location	Facility	Number of facility	-	Stochastic optimization
(Erbeyoğlu and Bilge, 2020)	Location, Distribution centers	Facility	Number of storage and distribution centers	Inventory level	Exact algorithm (LBBD Approach)
(Mohammadi <i>et al.</i> , 2020)	Location-allocation	relief network	Number of facilities location, routing of vehicle and victim evacuation	Transportation network	Multi-objective optimization model
(Oksuz and Satoglu, 2020)	Facility	Location-allo	Number of temporary	-	Stochastic programming

		location	medical center, medical center capacity,		model
*(Rossetti and Bright, 2019)	-	-	-	-	-
*(Kong <i>et al.</i> , 2021)	-	-	-	-	-
(Ouyang <i>et al.</i> , 2020)	Facility	Location	number of regional center points	-	Genetic Algorithm
*(Harada and Alba, 2020)	-	-	-	-	Parallel genetic algorithms
(Heyns, 2020)	Location	Facility	Number of demand points.	-	Integer-linear programming
(Baharmand <i>et al.</i> , 2020)	Location-allocation	Total logistics cost	Number of mobile storage units (MSUs) to be erected,	Response time, total unsatisfied demands	Augmented ε -constraint method
(Boonmee and Kasemset, 2020).	Location	Facility	Number of warehouses	Inventory and distribution	Equivalent Auxiliary Crisp Model, epsilon-constraint method
(Gulzari and Tarakci, 2021)	Location-allocation	Facility	Number and location of temporary health facilities	Total weighted unsatisfied healthcare demand.	Deterministic variables, integer linear program
(Cilali <i>et al.</i> , 2021)	Location-allocation	Facility	Number of individuals resettled	-	Pareto-optimal solutions
(Turkeš <i>et al.</i> , 2021)	Location	Facility	-	Transportation networks	Matheuristic algorithm
(Praneetpholkrang <i>et al.</i> , 2021)	location-allocation, cost minimization	Facility, shelters	Number of shelters	Total time for evacuating victims	Epsilon Constraint method (EC), Goal Programming (GP)
(Fakhrzad and Hasanzadeh, 2020)	-	-	-	-	-
(Tordecilla <i>et al.</i> , 2020)	Location routing	Facility	Number of routes whose aggregated customers' demand, number of	allocation of customers to open depot	Iterated Local Search - ILS - metaheuristic with Monte Carlo Simulation

(Cherkesly and Maïzi, 2020)	supply chain network	Facility	facilities to open, number of vehicles to be used and their capacity number of days out of stock	Continuum networks	Distrete Event Simulation
(Munyaka and Yadavalli, 2021)	Relief supply chain	Facility	Transportation time, cost and quantity	Cost of transportation	Linear programming (LP)
(Boostani <i>et al.</i> , 2021)	Relief logistics network, location-allocation	Facility	Number of relief distribution centers	Resource allocation, CO ₂ emissions in transportation	Compromise Programing (CP) technique and Lexicographic Optimization Method (LOM)
(Kuttler <i>et al.</i> , 2021)	Location	Facility	-	Ranked list of destinations	Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Method
(Wang and Zhang, 2021)	Location-allocation	Facility	-	Assigned customers	Exact algorithm
*(Sirbiladze <i>et al.</i> , 2021)	-	-	-	-	-
(Shu <i>et al.</i> , 2021)	Relief supply network	Facility	Facility location and relief supply pre-positioning costs.	-	Cutting-plane method
(Karuppiah <i>et al.</i> , 2021)	Sustainable humanitarian supply chain management	-	-	Facility Location problem, short lead time for emergency supplies	Neutrosophic analytic hierarchical process (AHP) method, neutrosophic TODIM method
(Stienen <i>et al.</i> , 2021)	Location	Facility	-	Minimal cost of transportation, maximum response time	Nominal optimization model
(Ashlagi <i>et al.</i> , 2021)				Summary	
(Zhang and Cui, 2021)	Location-allocation	facility	-	Transportation and	Exact algorithm

	n			deprivation costs	
(Garzón-Garnica <i>et al.</i> , 2021)	Location	facility	Number of centers	Types of vehicles	Simulated Annealing algorithm
(Yang <i>et al.</i> , 2024)	Location	facility	-	-	Scenario-robust programming method
(Gulesan <i>et al.</i> , 2021)	Earthquake detection	Facility	-	Emergency management system	K-means algorithm, mean shift clustering, density-based spatial clustering, hierarchical density-based spatial clustering
(Saatchi <i>et al.</i> , 2021)	Location-allocation, Relief supply chain	Facility	Number of facilities and their location	Transportation system	Hybrid Non-dominated Sorting Genetic Algorithm (NSGA-II), Simulated Annealing (SA) and Variable Neighborhood Search (VNS) algorithms. Exact algorithm
(Liu <i>et al.</i> , 2021)	Location	Facility	Number of facilities	Types of storage facilities	Greedy algorithm, Outer approximation and branch-and-cut algorithms (OABC)
(Munyaka and Yadavalli, 2021b)	Location	Facility	Number of demand points and number of supply points	Transportation, response time	Linear programming model
(Umar, 2022)	Hub	Smart Global Village	Number of hubs	-	Strategic Planning, Architecture, Controls and Education - SPACE
(Geng <i>et al.</i> , 2022)	Location, relief distribution	facility	Number of emergency service facilities	-	fuzzy AHP, fuzzy TOPSIS, and multi-objective optimization methods
(Sun <i>et al.</i> , 2022)	Location, allocation, transportation	facility	-	Temporary medical centers	ϵ -constraint method
*(Kin <i>et al.</i> , 2022)	SLR	-	-	-	-

(Saha <i>et al.</i> , 2022)	Allocation	shelters	number of homeless, number of shelters, number of beds	-	Exact algorithm, Two-stage based algorithm, Greedy approach
(Nazemi <i>et al.</i> , 2022)	Relief network, Last-mile operations	facility	-	Location cost, uncovered demand	ε -constraint method, balanced box methods
** (Gopalakrishnan and Mohan, 2022)	-	-	-	-	-
(Akwafuo <i>et al.</i> , 2022)	Location	Facility	Number of depots	location of depots and emergency operation centers	Route construction algorithm, Tabu search, Google Linear Optimization (GLOP) and OR-tools libraries, K-means ++ algorithm
(TANTI <i>et. al.</i> , 2022)	Location	Facility	Number of emergency facilities, number of distribution centers	Location of facilities and location of emergency facilities	Clustering algorithm, deep learning algorithm, mixed integer non linear programming
*(Saldanha-Da-Gama, 2022)	-	-	-	-	-
(Sirbiladze <i>et al.</i> , 2022)	Location	Facility	-	-	nonlinear integer model
(Sirbiladze <i>et al.</i> , 2022b)	Location	Facility	Number of open shelters	Emergency shelters' location, victims' evacuation	-
(Agarwal <i>et al.</i> , 2022)	Location-allocation, evacuation	Facility	-	minimizes total relief items supply chain cost and evacuation chain cost	Mixed integer linear programming (MILP), pattern search algorithm (PSA) and Genetic Algorithm (GA)
(Bozorgi and Najafi, 2020)	Blood bank inventory management	Optimization	-	wastage cost and shortage cost	Threshold Accepting, Tabu Search
(Diehlmann <i>et al.</i> , 2022)	Location	Facility	-	humanitarian logistics, distribution network	weighted sum approach

*(Nunes and Pereira, 2022)	-	-	-	-	-
(Kian <i>et al.</i> , 2022)	Location	Facility	Number of eligible beneficiaries	Mobile facility, demand points and vehicle conducting house-to-house	Mixed integer programming model, Sequential heuristic algorithm, CPLEX
(Rodriguez-Espindola, 2022)	Location, Allocation	Facility	-	Supplier selection, stock prepositioning, relief distribution, postdisaster procurement, inventory management	ϵ -constraint method
(Diehlmann <i>et al.</i> , 2022)	location, allocation	facility	number of schools	value of information	CPLEX
(Boromrit and Jamrus, 2023)	Location-allocation	facility	Number of victims, level of victimhood	candidate shelter capacity, travel distance, transportation costs	Nearest neighbor algorithm (NNA)
(Vahdani <i>et al.</i> , 2022)	location-allocation, sharing and routing	Facility, vehicle	-	land and air routing, redistribution disasterand service sharing	Intuitionistic fuzzy set and Robust Optimization,
(Bayraktar <i>et al.</i> , 2022)	location	facility	Number and routes of mobile facilities	Network associated with the paths of refugees	Mixed integer linear programming (MILP), Adaptive large neighborhood search algorithm
(Onggo <i>et al.</i> , 2021)	location	facility	-	food relief supply network	Exact Algorithm
(Garrido <i>et al.</i> , 2022)	location	facility	-	healthcare network's responsiveness	Non-linear programming (NLP) model
(Shehadeh and Tucker, 2022)	location	facility	number of warehouses to open at strategic locations	Inventory prepositioning, different types of relief items	DRO Decomposition algorithm
(Mashiat <i>et al.</i> , 2022)	allocation	housing needs	-	fairness trade-offs stem from heterogeneity across groups in intervention responses, distributions of	-

				utilities from different services	
(Mishra <i>et al.</i> , 2024)	location	facility	number of relief distribution centres	relief transportation,	Genetic Algorithm (GA), Pattern Search
(Zhu <i>et al.</i> , 2022)	location-allocation	Facility, drones	number of sites where disruption occurs	fixed cost, transportation cost, and penalty cost.	column-and-constraint generation (C&CG) method, Benders decomposition method
(Tanti <i>et al.</i> , 2023)	Location	facility	-	demand point prediction, prohibited route mapping, and efficient relief goods distribution	k-means clustering machine learning algorithm, artificial neural network (ANN) algorithm
(Anvari <i>et al.</i> , 2023)	Location	facility	-	inventory prepositioning, road vulnerability, quantity of lateral transshipment	VIKOR method, OPA method
(Nunes, <i>et al.</i> , 2023)	Location	facility	number of wells to be drilled	-	CPLEX
(Jafarzadeh-Ghouschi <i>et al.</i> , 2023)	Disaster management, supply chain management, Facility location and allocation	humanitarian Supply Chain	Maximum vehicle capacity, Warehouse capacity, Number of vehicles, Vehicle type limitations, Minimum supply requirements	Supply chain disruptions	-
(Yin <i>et al.</i> , 2024)	Humanitarian Logistics, Earthquake Case Study, Location Allocation	Facility, disaster, optimization	affected areas requiring the emergency resources available capacity levels of the basic resource, capacity of the emergency resources in relief facility	Uncertain emergency demand	Branch-and-Benders-Cut
(Kube <i>et al.</i> , 2023)	Homeless Services, Resource	Facility, homeless	Service Capacity, Data Limitations	Data Quality, Support Network	BART (Bayesian Additive Regression Trees)

	Allocation, Allocation of Services for Homeless People			Resources	
(Freund <i>et al.</i> , 2023)	Dynamic Refugee Allocation	Facility	Group Size Requirements, Location Capacity, Reserve Capacity, Number of Refugees	-	bid-price algorithms
(Shu <i>et al.</i> , 2023)	Optimization, Volunteer Allocation, Disaster Situations	Facility, Disaster	Number and Capacity of Emergency Department, Time for Travel, supply capacity	Budget Limitations, Demand Uncertainty	Exact Algorithm
(Rabiei <i>et al.</i> , 2023)	assign tasks	-	Number of Emergency Department; Number of volunteers, number of vacancies	-	NSGA-II (Non-dominated Sorting Genetic Algorithm II); NRGAs (Non-dominated Ranked Genetic Algorithm)
(Qi <i>et al.</i> , 2023)	minimize cost, Location and Pre-Positioning of Installations, inventory; logistics	Facility location	storage and supply capacity	-	C&CG Algorithm; ImpRG Algorithm
(Seranilla and Löhndorf, 2024)	Optimize vaccine distribution disasters	vaccines	Facilities Capacity, Allocation Limit, Number of vaccination facilities (depots)	Operational Costs	Shadow Price Approximation (SPA)
(Onggo <i>et al.</i> , 2022)	Disaster management, Demand Uncertain, Stochastic Optimization	Location	Number of facilities, Stochastic Travel Time	-	Multi-Start (MS)

(Rodríguez-Espíndola <i>et al.</i> , 2023)	Humanitarian logistics, Carbon Reduction, Resource Allocation	Sustainability	Capacity of Transshipment Points and Distribution Centres (DCs), Number of Shelters	Employee Availability, Transportation Links	ϵ -constraint method
(Koca, 2023)	Capacitated facility location problem, Uncertainty analysis	Facility	capacity constraints, facility capacity	natural disasters, intangible costs	L-shaped method
(Rodríguez-Espíndola, 2023)	Simultaneous disaster, Humanitarian logistics	Location	available vehicles, location and capacity of Distribution Centers	supplier capacity, budget	-
(Goentzel <i>et al.</i> , 2023)	Humanitarian healthcare supply chains	Facility location	Number of locations (outreach), Number of fixed health centers, Vehicle availability and capacity	demand for vaccination, budget	-
(Jin <i>et al.</i> , 2024)	humanitarian logistics, relief network, optimization	drones	number of drones, number of drone-supported relief facilities	travel time, stock capacity	Distributionally robust optimization (DRO)
(Li <i>et al.</i> , 2023)	relief network, humanitarian logistics, disasters	facility, relief network, vehicle	number of depots, number of trucks, evacuation distances, deposit capacity	fixed facility locations pre-disaster	EPH (Equivalent Penalty Heuristic)
(Wang and Jones, 2023)	Optimize drone delivery systems,	delivery, drones	number of drones, drone capacity depot capacity, flight range, travel time	uncertainty customer demands, travel time calculation, subtour problem	Sample Average Approximation (SAA); Genetic Algorithm (GA)
(Chen, 2024)	unmet demand,	Facility,	number of depots, truck	destruction risks, demand	-

	cost minimization, compative metohds	supply	capacity, capacity restrictions for depots	variability	
(Wang, 2024)	supply chain, disaster relief operations	Facility, supply	number of depots, trucks available	demand uncertainty, demand fluctuations, limited processing capacity, inventory management	Exact Algorithm
(Che <i>et al.</i> , 2024)	cost minimization, facility location, emergency supplies	Facility, supply	number of warehouses, capacity of roads and depots, available supplies, demand requirements	inventory levels, travel time, market purchase costs	Exact C&CG (E-C&CG); Approximation C&CG (A-C&CG); Non-Convex C&CG (NC-C&CG)
(Sarid <i>et al.</i> , 2024)	Infrastructure planning for electrical grid	Resource allocation	single tier assignment, upgrade restrictions	interdependencies, equity weighting	LNS (Large Neighborhood Search)
(Kim and Moon, 2024)	Humanitarian logistics, use of drones in humanitarian logistics operations	Facility, drones	number of drones, facility, shipping range, demand coverage	customer demand, travel time and cost factors	Restricted master heuristic (RMH)
(Alsoussi <i>et al.</i> , 2024)	Ethical standards in humanitarian logistics	systematic review	-	-	-

* Systematic Review/Survey articles, ** No access

Among the publications listed in Table IV, there are studies categorized as literature reviews or surveys, which are identified in the table. During the analysis, access to some articles was blocked, preventing their inclusion in this stage. For the sake of record-keeping, these documents have been retained in the table for tracking purposes. However, since this characteristic violates Inclusion Criterion 2, which pertains to access to the document, the mentioned articles were not analyzed.

3 - Research Results

This section presents an in-depth statistical and bibliometric analysis of the identified studies, highlighting the research gaps and future research directions.

3.1 - Statistical Analysis

This section presents the statistical analysis of the selected articles from the period of 2020 to 2024. In Fig. 1, there is a noticeable predominance of publications from the Elsevier database (Scopus) and their distribution by year and publication source.

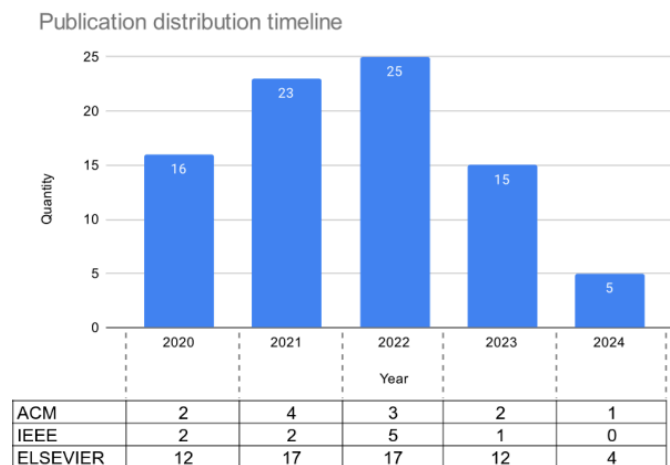


Fig. 1 - Publication distribution timeline.

To ensure the search in a location with the highest number of articles, the databases were defined based on the number of publications available in each. Among them, the database with the most publications is Scopus (Elsevier) (Stahlschmidt and Stephen, 2020; Visser *et al.*, 2021), which is considered the largest existing database for multidisciplinary scientific literature (Chadegani, 2013). Presenting an exact number of articles can be problematic since this number is variable. One observation during the survey and collection of publications was the existence of duplicate articles in the analyzed databases. This fact required an effort to organize these publications to ensure the publication source of the original version of each article.

3.2 - Bibliometric Analysis

Among the selected articles, we have the cooperation network among authors, who are the primary contributors to the evolution of the research field investigated in this study. With bibliometric analysis, research produced by leading scholars can be identified and examined to gain a better understanding of the frontier of this research area. To determine the number of cited authors, a minimum threshold of

3 documents per author and a minimum of 2 citations per author were established. From this cross-referencing, Table V presents the ranking of the top 5 most cited authors:

Table V - Top 5 Authors

Authors	Documents	Citations
Vahdani, Behnam	2	62
Munyaka, Jean-Claude Baraka	2	17
Yadavalli, Venkata Seshachala Sarma	2	17
Shu, Jia	2	16
Rodríguez-Espindola, Oscar	2	5

In Fig. 2, we see the map created in VOSviewer that shows the researchers mapped by the tool. This map complements the previous table, presenting all the authors included in this study.

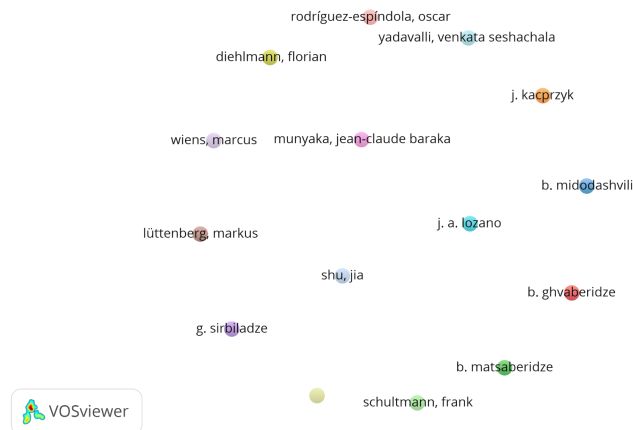


Fig. 2 - Citation of authors.

The clusters (grouping of authors) represent those involved in the project, with the size of the nodes being proportional to the number of authors and the number of connections reflecting the cooperative relationships among them. The color scheme used to identify the clusters follows the tool's standard: red for Cluster 1, green for Cluster 2, blue for Cluster 3, and yellow for Cluster 4. The bibliometric analysis conducted shows, based on the total count of sources cited in the studies analyzed, the relationship among co-cited authors, as illustrated in Fig. 3.

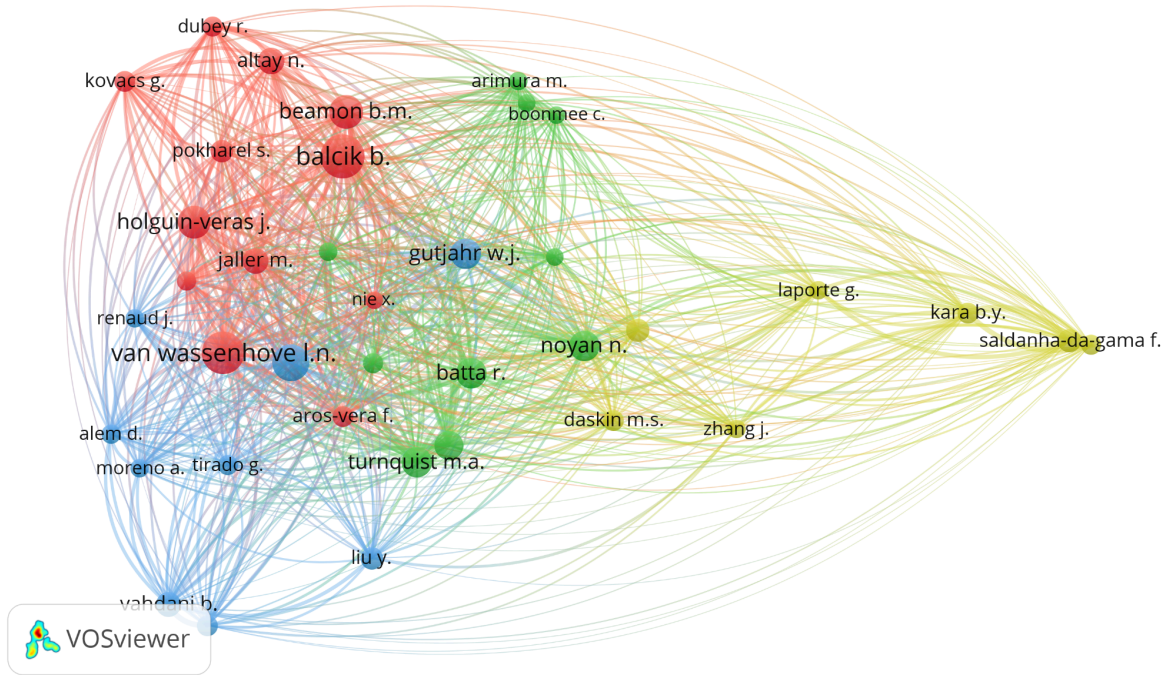
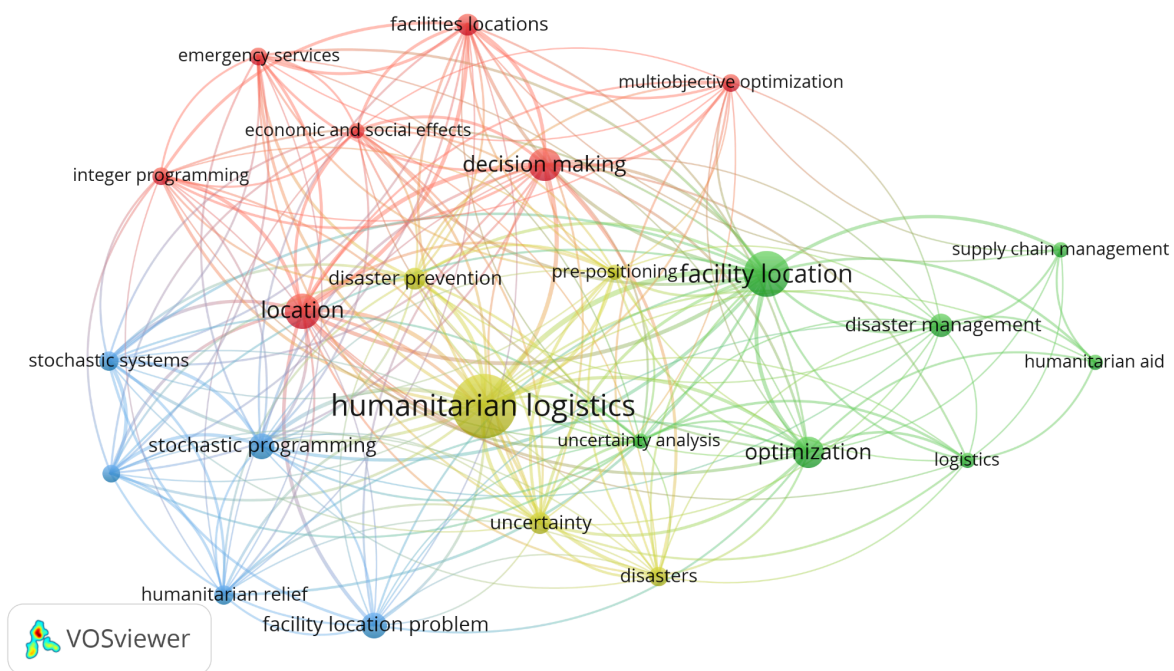


Fig. 3 - Co-citation of authors.

As observed, the distribution of authors is close, and the level of cooperation among them is high, allowing us to assert that the quality of the studies is strong.

Another point noted in the bibliometric analysis is the keywords present in the studies found, which highlight the areas of interest of the conducted research. Through the keyword analysis generated by VOSViewer, this assertion can be made. The keywords in a research paper directly reflect the scope of the study developed and represent its main content (Van Eck and Waltman, 2010). Considering the relevance of studies related to operational research, numerous efforts have been made to propose solutions to various problems associated with humanitarian logistics. The map presented in Fig. 4 clearly displays all the keywords that frequently appear in the collected publications, highlighting the relationship between operational research and humanitarian logistics.



Occupying the second place is the journal *Annals of Operations Research*. Below, in Table VII, you can see the top five most cited journals in the research included in this study. Additionally, this ranking includes the total link strength index of co-authorship between the journals.

Table VII - Top five co-citation of sources cited

Journal	Citations	Total Link Strength
European Journal of Operational Research	132	3860
Annals of Operations Research	94	3495
Social-economic Planning Sciences	59	1962
International Journal of Production Economics	50	1733
Transportation Research part. e. Logistics and transportation Review	47	1599

In terms of publication volume, the ranking shows a strong connection between the citations, allowing us to assert that the quality of the articles published in these journals is high. To establish a reliable relationship, Table VIII presents the same journals along with their respective impact factors and CiteScore².

Table VIII - The five sources with CiteScore and Impact Factor

Journal	CiteScore	Impact Factor
European Journal of Operational Research	11.9	6.0
Annals of Operations Research	-	4.4
Social-economic Planning Sciences	9.4	6.2
International Journal of Production Economics	21.4	9.8
Transportation Research Part E: Logistics and transportation Review	16.2	8.3

The impact factor, for instance, is considered an important indicator as it demonstrates the relative importance of a journal within its field of knowledge (Sabbaghtorkan *et al.*, 2020). Over time, it has been established that the impact factor is regarded as a measure of credibility, associating a higher impact factor with a prestigious journal (Garfield, 2006).

3.3 - Research gaps

After analyzing the collected data and the research found, significant and important advances in the field of operations research focused on humanitarian logistics were identified. However, there are still significant gaps that are pointed out below:

- There is a notable absence of integration between emerging technologies such as artificial intelligence and big data, and the mathematical models presented in the reviewed studies. This integration could enhance the search and location of facilities and the allocation of resources.

² The CiteScore and Impact Factor numbers were gathered during the period from July to September 2024.

- There is a scarcity of interdisciplinary approaches that combine environmental sustainability and social impact with the logistical solutions found in the literature.
- Lastly, there is limited exploration of approaches incorporating real-time data from social networks to support logistical planning.

4 - Conclusions

The presented systematic review provides a comprehensive overview of recent advancements in operations research applied to humanitarian logistics, with a central focus on facility location and resource allocation. It identified critical gaps that highlight relevant trends on the combination of models integrating the principles of the Economy of Francis, such as environmental and social sustainability, with operational efficiency and the integration of real-time data and the use of artificial intelligence. Furthermore, it serves as a replicable methodological reference that can be adapted for exploring other dimensions of humanitarian operations.

After an extensive, rigorous, and thorough systematic literature review that utilized bibliometric analysis of articles published between 2020 and July 2024, the present research yields the following contributions.

Based on the systematic literature review and bibliometric analysis conducted, it is concluded that forced displacement, whether caused by natural disasters or conflicts, has sparked intense academic and scientific debate, particularly regarding the efficient management of humanitarian operations. Forced displacement continues to rise at an alarming rate, as recent figures indicate a 31.3% increase in the number of displaced individuals between 2021 and 2023. This phenomenon has profound implications not only for the populations directly affected but also for host communities and the global economy. The relevance of this issue is evident in the number of studies dedicated to creating optimized solutions, particularly in the field of operations research, which has significantly contributed to the development of tools and models aimed at optimizing humanitarian logistics, facility location, and the allocation of scarce resources.

The use of robust methodologies, such as operations research, enables decision-makers to address the complexity of the phenomenon more effectively, developing solutions based on mathematical models that consider demographic variables, capacity constraints, and service needs. The analysis of the selected studies reveals that humanitarian logistics and facility location are the primary focuses of investigation, with innovative proposals addressing everything from disaster prevention to supply chain management in crisis scenarios. These studies not only enhance the understanding of the dynamics of forced displacement but also provide valuable insights for improving emergency response.

Additionally, the economic implications, such as the impact on unemployment rates and the consumption patterns of displaced families, indicate that the challenges extend beyond humanitarian concerns, affecting the sustainability of communities that host these populations. The inclusion of topics like the "Economy of Francesco," which advocates for a more sustainable and ethical approach to the global economy, underscores the importance of a holistic approach to addressing these issues, taking into account social, environmental, and spiritual aspects.

With a keen focus on the gaps identified in the reviewed literature, the following recommendations are proposed:

- Integrate Artificial Intelligence and emerging technologies to enhance efficiency and accuracy in facility location.
- Explore the Economy of Francis to apply its ethical principles in humanitarian logistics models, aiming to make solutions more sustainable and inclusive.
- Expand the use of integration with real-time data sources to improve the decision-making process in rapid logistics, which is common in natural disaster scenarios.

Ultimately, it is hoped that this systematic literature review will inspire new studies and practical interventions that help mitigate the impacts of forced displacement, providing researchers with a comprehensive overview of the practices adopted thus far and the existing gaps in the field. By compiling and categorizing the current knowledge on the application of operations research to

humanitarian issues, this study contributes to the evolution of the field and highlights directions for future research that could further enhance solutions supporting vulnerable populations.

Data Availability Statement

All data analyzed during this study are included in this published article and its references. No new data were generated.

Authorship Contribution

Leonardo Santiago Sidon da Rocha

Investigation
Methodology
Formal analysis
Software
Writing - original draft
Visualization

Alan Cesar de Oliveira Mathias

Data curation
Investigation
Writing - original draft

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Funding acquisition
Resources
Writing - review & editing

Rodrigo Calvo

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Project administration
Writing - review & editing

Rodrigo Clemente Thom de Souza

Conceptualization
Methodology
Supervision
Validation
Writing - review & editing

Conflict of interests

The authors declare that there are no conflicts of interest related to the publication of this manuscript.

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