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Literature Review on Location Routing Problem Distribution of Humanitarian Aid

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ABSTRACT

Disasters are events that disrupt and threaten the lives of communities caused by natural and/or non-natural factors, as well as human-induced factors, resulting in loss of life and economic damages. Natural disasters globally experience an increase each year across almost all continents. Based on data, Indonesia is one of the countries with the highest intensity of natural disasters in Asia. The objective of this article is to analyze the Location Routing Problem (LRP) for humanitarian aid distribution. The method used for literature review is Systematic Literature Review (SLR), which is one of the methods used to review literature by analyzing the availability of research related to the topic, determining, evaluating, and interpreting previous studies. The total number of articles or papers reviewed is 20 journals or papers from Google Scholar during the period 2019-2023. The method that can be used to solve the LRP is multi-objective optimization with objective functions applicable to single or multiple objectives. The research findings indicate that studies related to the Location Routing Problem (LRP) have been extensively conducted and can be applied in various fields of manufacturing and service industries to address problems related to locating distribution centers and determining vehicle routes. The optimization method that is commonly used and yields good research results is the Non-Dominated Sorting Genetic Algorithm II (NSGA II), while one of the methods that is rarely used to solve the LRP is Ant Colony Optimization (ACO).

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1. Introduction

Disasters are events that disturb and threaten the lives of communities caused by natural and/or non-natural factors, as well as human-induced factors, resulting in loss of life and economic damages. According to the Emergency Event Database (CRED, 2022), in the year 2022, there were 387 recorded natural disaster events worldwide, causing 30,704 deaths, affecting 185 million people, and resulting in approximately US $223.8 billion in economic losses. Based on data from the Emergency Event Database (CRED, 2022), Asia is the continent with the highest occurrence of natural disasters. Indonesia is one of the countries in Asia with the highest intensity of disasters. In the year 2022, Indonesia experienced around 2,392 natural disasters, including floods, landslides, floods, and landslides, abrasions, tornadoes, droughts, forest and land fires, earthquakes, and volcanic eruptions (DIBI, 2023).

Considering the condition of Indonesia, which is one of the countries with high disaster potential, the government enacted Law No. 24 of 2007 on Disaster Management. This law represents the government's accountability to the entire Indonesian society. The government is expected to ensure the assessment of damages and loss of lives during a disaster and prepare concrete strategic measures for disaster management. Uneven distribution of aid and delays during natural disasters are the most common issues faced. According to Jiang and Yuan (2019), in large-scale disasters, challenges in humanitarian aid distribution include the complexity of distribution, severe infrastructure damage, time pressure, and urgency. Similarly, as stated by Hamzani et al. (2022), one of the challenges in distributing aid during large-scale disasters is the need to make quick decisions and minimize delays. Some disasters like earthquakes, hurricanes, and floods are large-scale disasters that cause many casualties and significant economic losses. A quick and efficient response immediately after a disaster is necessary to minimize the damages and destruction caused by the disaster. In this regard, disaster aid distribution is a crucial component of the entire disaster response process. Disaster aid is supplied from both within the country and internationally to meet the simultaneous high demands from various affected regions. Here, the important role of distribution centers is highly needed to distribute and transport relief goods (Zhu, 2017). The problem of delays in humanitarian aid distribution during natural disasters is a common issue frequently encountered in various places. This is mainly due to the damage caused by the natural disaster, making it difficult to access the affected areas, and the lack of information about accessible distribution centers for the community. Therefore, research is needed to address this problem. The topic of the location routing problem is one study that can be used as a reference to solve humanitarian aid distribution issues.

The Location Routing Problem (LRP) is an extension of the classical routing problem that integrates strategic and operational decisions with facility location problems (FLP) and vehicle routing problems (VRP) (Tirkolaee et al., 2021). LRP combines facility location and vehicle routing problems, making it applicable for humanitarian aid distribution. The method used for implementing LRP is multi-objective optimization, which is a decision-making method involving multiple criteria in mathematical optimization problems with more than one objective to be simultaneously optimized (Chang, 2014). Non-Dominated Sorting Genetic Algorithm II is a powerful decision space exploration tool based on Genetic Algorithms (GA) used to solve Multi-Objective Optimization Problems (Verma et al., 2021). Multi-Objective Optimization (also known as multi-objective programming, vector optimization, multi-criteria optimization, multi-attribute optimization, or Pareto optimization) is a field of multi-criteria decision-making concerning mathematical optimization problems involving more than one objective function to be optimized simultaneously (Chang, 2014).

Research on the Location Routing Problem (LRP) in the distribution of natural disaster relief has been conducted by several researchers (Hamzani et al., 2022; Long et al., 2021;Beiki et al., 2021; Shen et al., 2019; Liu et al., 2019). The study by Hamzani et al. (2022) investigates the optimization of natural disaster relief considering limited funds, time constraints, and simultaneous surges in demand, leading to the complexity of humanitarian aid distribution. Long et al. (2021) conducted research on effective distribution of aid in emergency logistics systems, considering the stochastic characteristics of aid demand. This study investigates robust optimization of multi-objective, multi-period location-route problems for epidemiological logistics, a specific type of emergency logistics, under uncertain scenarios. Beiki et al. (2021) conducted research on designing an integrated aid chain to simultaneously optimize the preparedness and response phases in disaster management. This includes the location of aid distribution centers, the quantity of inventory stored in pre-disaster facilities, the location of temporary care centers, transportation points for the injured, allocation of aid services to affected areas, and vehicle routes used for aid distribution and evacuation of the injured. Shen et al. (2019) conducted research on the optimization problem of emergency logistics systems, considering environmental protection aspects and integrating them with the concept of overall emergency logistics system optimization, considering uncertainty in disaster area needs. This article explains the use of a fuzzy triangular function to capture fuzzy requirements. Liu et al. (2019) examined a multi-objective model for fair LRP developed with a lexicographic order-based optimal method, considering emergency window constraints, partial road damage, multimodal aid delivery, disaster severity levels, and the vulnerability of each demand node when its demand is unmet.

While the research conducted has made significant progress in the context of LRP (Location Routing Problem) in emergency logistics systems, there are still several research shortcomings that need to be addressed. These include: (1) Most of the existing literature assumes that the availability of aid is sufficient to meet all demands, and the scarcity of aid after earthquakes is rarely considered; (2) Although the speed and economic efficiency of post-earthquake aid distribution have been extensively researched, the fairness aspect of aid distribution still receives limited attention; and (3) Most of the existing literature assumes that the importance of emergency supplies reaching each demand node is equal; the severity of the disaster at each demand node and the extent of demand dissatisfaction at each demand node are still underexplored. During the early stages after an earthquake, distributing emergency supplies from outside the disaster area to demand nodes in a short period of time remains a challenging task. Wang et al. (2013) states usually, pre-positioned relief supplies in disaster-affected areas are insufficient to meet the needs of all impacted areas. People affected by disasters are vulnerable both physically and mentally. Therefore, when aid is distributed unevenly, it can trigger anger among the victims and even potentially lead to mass incidents with serious consequences (Yu et al., 2018; Cao et al., 2018). That is why, in the early stages following a natural disaster, it is important to prioritize the well-being of the community in emergency relief efforts and distribute emergency supplies fairly when supplies are limited in the disaster-stricken area.

The core elements of decision-making in relief material distribution involve determining the locations of emergency distribution centers (DCs) before disasters and planning vehicle routes after disasters. These are referred to as location allocation problems (LAP) and vehicle routing problems (VRP) respectively. LAP deals with establishing suitable emergency DCs to store and allocate relief materials nationwide, while VRP focuses on dispatching the right vehicles to choose efficient routes for distributing these materials from DCs to demand points. In practice, LAP and VRP are closely interconnected, forming what is known as location routing problems (LRP)

Regarding the topic of LRP, the author will conduct a literature review using the systematic literature review (SLR) method, aim to (1) identify the trends in the research approaches to the Location Routing Problem; (2) analyze the distribution topics related to the location routing problem (LRP); and (3) identify the methods commonly used to solve location routing problem (LRP) for humanitarian aid distribution.

2. Theoretical Background

2.1 Location Routing Problem (LRP)

The Location Routing Problem (LRP) is a routing problem where the optimization involves simultaneously determining the locations and number of warehouses, vehicle schedules, and delivery routes to minimize the overall system cost. Yaghoubi and Akrami (2019) investigated supply chain planning with multiple suppliers, multiple distribution centers, multiple customers, and one perishable material by developing a mathematical model considering the perishability constraint of the raw material. Navazi et al. (2019) designed a network for a location routing problem with two-compartment vehicles responsible for collecting expired products to a recycling center in dual-target routes with simultaneous pickup and delivery.

2.2 Logistics Aid Distribution

Logistics aid distribution is a method of delivering and providing logistic aid for disaster management from the source location to the intended destination. The logistic aid for disaster victims during emergency situations must be delivered to the affected individuals with timeliness, accuracy in location, targeting, quantity, and quality (BNPB, 2020).

Humanitarian logistics is one of the operations involved in the three phases of disaster management: preparedness, response, and recovery. It involves the evacuation of communities from disaster areas to safe and planned locations, implementing and controlling the direction and storage of goods and materials efficiently and cost-effectively from the source point to collection points, and gathering information from the disaster source (Harsono & Setiabudi, 2018). Humanitarian logistics involves the evacuation of people from disaster areas to safe locations, planning and managing the flow and storage of goods and materials to be efficient and cost-effective, while gathering information from disaster sources. It also includes the placement of evacuation centers to alleviate the suffering of the affected communities (Syakina & Nurdiati, 2021).

3. Methodology

The method used in this paper is Systematic Literature Review (SLR). SLR is a method for analyzing the availability of research relevant to the area or topic being studied (Calderon & Ruiz, 2015). Systematic Literature Review (SLR) is defined as a process to identify, assess, and interpret all research evidence that aims to provide specific answers to research questions (Kitchenham et al., 2009). The purpose of conducting a Systematic Literature Review (SLR) is to find approaches that can help address the challenges faced and identify diverse perspectives on the researched issue. Additionally, this research aims to uncover relevant theories related to the investigated case.

The research object is specifically the Location Routing Problem (LRP) for humanitarian aid distribution. The time span used for the research is the last 5 years, from 2019 to 2023. The journal sources to be analyzed will be gathered from Google Scholar, utilizing the "publish or perish" feature. From these objects found 514 articles or papers regarding LRP but there are 20 papers are full open access.

The stages of this SLR research consist of 5 stages, namely.
(1) Formulating the problem. In this stage, the researcher formulates the problem that will be discussed in-depth. This question is created based on the topic chosen by the researcher. The Quesntions are:

- What are the trends in the research approaches to the Location Routing Problem (LRP)?
- What are the distribution topics related to the location routing problem (LRP)?
- What are the commonly used methods for solving Location Routing Problem (LRP) issues in humanitarian aid distribution?

(2) Literature search (identification)
(3) Selecting relevant literature search results
(4) Analysing the literature findings from articles that pass the quality assessment
(5) Drawing research conclusions

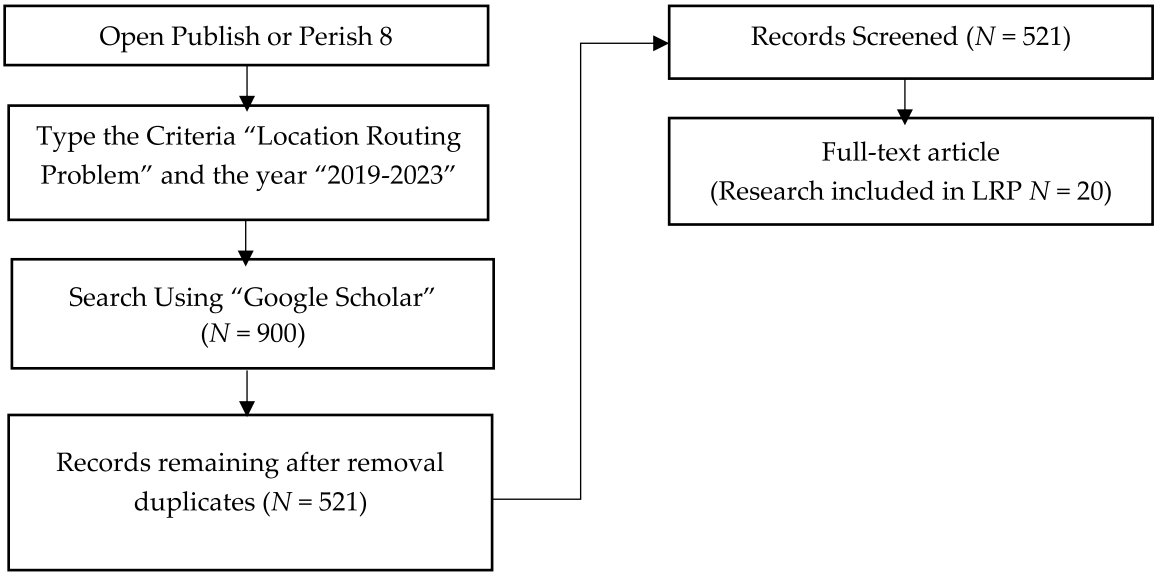

Figure 1. The flow of Systematic Literature Review

4. Results

The results of the research using SLR yielded 20 journals or articles related to LRP that are accessible. These journals examine LRP applied in various industries, including manufacturing and services. The analysis of the journals was carried out by reading the titles, abstracts, and the entire content of the journals. The review of the journals involved identifying the authors and the year of publication, the research object, objective functions, algorithm methods, and the research outcomes.

Out of the 20 journals, 17 are regular journals, two are from proceedings/conferences, and one is a book (dissertation). All these journals were analyzed by reading their abstracts and the entire content of the articles. Below are the results of the review of twenty journals or articles related to Location Routing Problem (LRP) obtained from national and international journal publications over the past five years (2019-2023).

Table 1. Summary of the Analysis Results of Journals or Articles Related to LRP

No	Authors and Publication Year	Journal Name	Objective Function	Algorithm Methods	Research outcome
1	Shen et al. (2019)	International Journal of Environmental Research and Public Health	Minimization of delivery time, minimization total cost and minimization	Particle Swarm optimization (PSO) & Tabu Search	The PSO-TS algorithm presented in this paper is efficient and demonstrates

			carbon emission (CO2)		strong performance in addressing LRP.
2	Liu et al. (2019)	MDPI Journal sustainability	Minimization maximum loss of demand node, minimization total loss of demand node and maximum time required	Hybrid heuristic algorithm (HHA & NSGA II)	HHA Provides better result
3	Zafari & Shishebori (2019)	Advances in Industrial Engineering Journal	Mimimization the unsatisfied demands, minimization the arriving times and minimization the relief operation cost	Modified of AUGMECON2 and NSGA II	NSGA II provides more satisfying results
4	Yaghoubi & Akrami (2019)	Heliyon	Minimization total transportasi cost and minimization total transportation time	Ant Colony Optimation and PSO	ACO provides more optimal results
5	Navazi et al. (2019)	Elseiver	Minimization network implementation, minimization environmental side effects and Maximization satisfaction of society.	NSGA II and MOPSO	MOPSO provides solutions faster, but NSGA II yields better results.
6	Leng et al. (2019)	International Journal of Environmental Research and Public Health	Minimization total costs, minimization service time and minimization corresponding to the social interest	MOHH and MOEAs	MOEAs are more effective and stronger in all performances
7	Salehi & Jabarpour (2020)	Control and Optimization in Applied Mathematics (COAM)	Minimization total cost, minimization missed estimation and minimization of total cargo and relief vehicle	NSGA II and MOPSO	NSGA II has a better utility level than MOPSO
8	Almouhanna et al. (2020)	Disertasi University of Portsmouth	Minimization total cost	Multi-Start Biased-Randomized Heuristic (MSBRH) dan Metaheuristic VNS	VNS bias-randomized provides higher-quality solutions using more computational time

9	Delfani et al. (2020)	International Journal of Engineering	Minimization total cost, minimization transportation risk, minimization total risk and minimization total carbon emission	MODM: Lap-metric, goal attainment method (GA), Max-Min method, the goal programming method (GP) and the weighted sum method (WSM)	LP Metric, WSM, GP, GA and Max-Min.
10	Parayoga et al. (2021)	Proceedings of the Second Asia Pacific International Conference on Industrial Engineering and Operations Management Surakarta, Indonesia,	Minimization total cos and Maximization service level	NSGA II and MOPSO	NSGA II has better performance than MOPSO
11	Hashemi et al. (2021)	Emerald	Minimization the set of costs	NSGA II and MOPSO	NSGA II is superior to MOPSO.
12	Y. Wang et al. (2022)	Elseiver	Minimization of total cost and maximization number of shared delivery vehicles.	3D K-means clustering and MOIPSO	MOIPSO provides better results
13	Safari et al. (2020)	Journal of Optimization in Industrial Engineering	Minimization total cost and maximize the minimum reliability routes.	Multi-Objective Grey Wolf Optimizer (MOGWO), Multi-Objective Water Cycle Algorithm (MOWCA), Multi-objective Particle Swarm Optimization (MOPSO) and Non-Dominated Sorting Genetic Algorithm II are developed	MOGWO is the best algorithm for solving the proposed tri-objective mathematical model
14	Tirkolaee et al. (2021)	Elseiver	Minimization total travelling time, minimization total violation and minimization the disposal sites risk.	MILP dan fuzzy chance-constrained programming	The paper introduced an innovative MOMILP formulation for the MTLRP-TW, considering practical

					considerations for waste management application, including multiple planning periods and distinct locations for disposal sites and parking. Additionally, fuzzy chance-constrained programming was employed to explore the substantial uncertainty related to the demand parameter, representing the amount of COVID-19-related medical waste generated at hospitals and infirmaries.
15	Pourghader Chobar et al. (2021)	Journal of Applied Research on Industrial Engineering	Minimization the maximum number of unserved injured people and minimization of total costs.	NSGA-II meta-heuristic	The findings suggest that with an increase in capacity, the number of distribution centers required to fulfill the demand decreases. However, the constructed distribution center may be situated far from certain shelters, resulting in higher transportation expenses.
16	Suksee & Sindhuchao (2021)	International Journal of Industrial Engineering Computations	Minimization total costs	Greedy Randomized Adaptive Large Neighborhood Search Procedure (GRALNSP)and applies the principles of the	GRALNSP provided better results

				Greedy Randomized Adaptive Search Procedure (GRASP) and Adaptive Large Neighborhood Search (ALNS) in the local search	
17	Ma et al. (2021)	Springer	Minimization total daily cost	GAMS and GA	GA has better performance
18	Hamzani et al. (2022)	Sinkron	Minimization waiting time and minimization total cost	Multi Objective Optimation	-
19	Wang et al. (2022)	Journal of Physics: Conference Series	Maximization precooling delay time	Bi-level programming	The validation of the multi-type precooling facility model and its associated algorithms is demonstrated through numerical examples.
20	Roosta et al. (2023)	Growing science	Minimization the cost of the entire system and maximization realiability routes	MILP and NSGA II	NSGA II has better result

Based on the summary of journals in Table 1, it is evident that publications related to the Location Routing Problem (LRP) in the last 5 years are found in various journals, both national and international. The analysed journal publications come in diverse forms, ranging from proceedings, dissertations, to reputable journals and articles. Below is the distribution of LRP journals over the last 5 years:

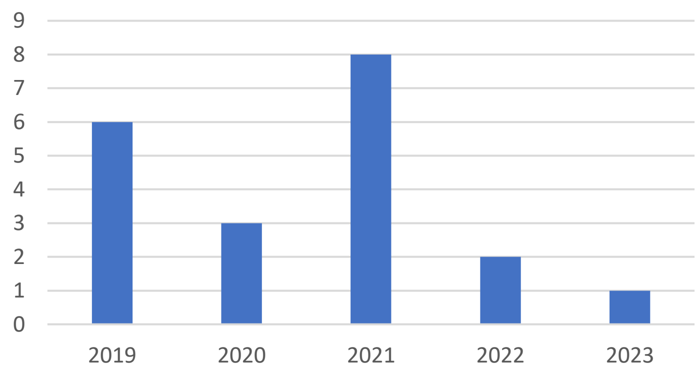

Figure 2. Number of paper in the period of 2019 - 2023

From Figure 1, it illustrates the distribution of LRP journals from 2019 to 2023. From the graph, it can be observed that in 2021, the highest number of journals, 8 in total, was published, while in 2023, the number decreased to only 1 journal. This distribution indicates that the LRP topic is a widely researched subject. The distribution of articles related to LRP based on publications can be seen in the following table:

Table 2. Distribution of LRP Publications

Publication	Number
Journal	17
Book/Disertasi	1
Proceedings	2

In Table 2, it can be observed that the distribution of publications related to LRP out of the 20 analyzed articles indicates that the most common form of publication is through journals, both national and international, with a total of 17 articles. There are two articles published in proceedings or conferences, and one article is in the form of a book/dissertation. This indicates that LRP publications have been disseminated through various media. Next is the distribution of articles related to LRP based on the number of objective functions, shown in the following graph:

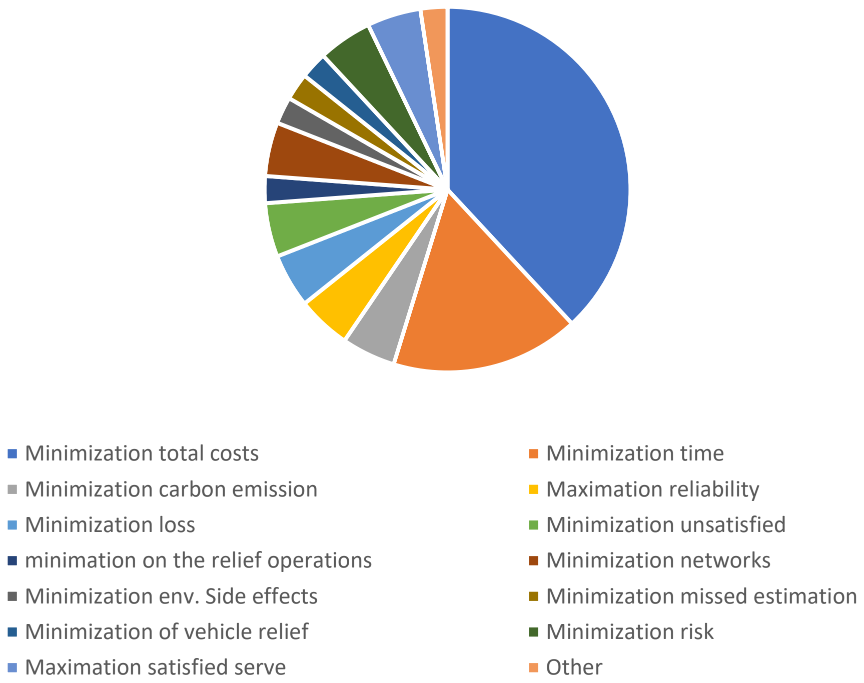

Figure 3. Objective functions used in the literature

Figure 2 shows the distribution of LRP topic articles based on objective functions varies depending on the specific goals pursued by the authors. Minimization of total cost is the most common objective function, followed by minimization of time. On the other hand, other objective functions were only used once or twice. The following is the result of the analysis related to the algorithm methods used in solving LRP-related problems, as shown in the following graph:

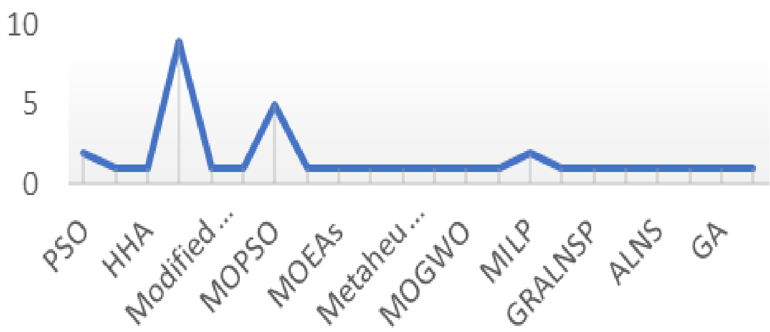

Figure 4. Algorithm used in the literatures

Figure 3 shows that the distribution of algorithm methods used to solve LRP problems is as follows. The most used method is NSGA II, with 9 occurrences, followed by MOPSO, which appears 5 times. Other methods were only used once or twice out of the 20 analyzed articles. Furthermore, the analysis based on the performance of the methods revealed several algorithms that provided better results compared to others, namely HHA, NSGA II, MOEAs, ACO, VNS Metaheuristic, MOGWO, GRALNSP, and GA.

The key to solving the location routing problem lies in the development and design of the algorithmic model. The model development involves determining variables and optimization criteria, as well as establishing assumptions. Both indicators of model development play a crucial role in shaping the algorithmic model design. The design of the algorithmic model must consider the existing assumptions to ensure that it yields an accurate and appropriate model.

5. Discussions

Based on the research results related to the LRP topic, it is evident that this research has been widely conducted in various industries, both in services and manufacturing. The following are some important aspects that are part of the discussion.

- Research Area of LRP

Table 3. Research area LRP

Research Areas	Authors
Natural Disasters	Shen et al. (2019); Liu et al. (2019); Zafari & Shishebori (2019); Pourghader Chobar et al. (2021); Hamzani et al. (2022); Salehi & Jabarpour (2020); Almouhanna et al. (2020)
Distribution Goods/Company	Yaghoubi &Akrami (2019); Navazi et al. (2019); Leng et al. (2019); Parayoga et al. (2021); Hashemi et al. (2021); Wang et al. (2022); Roosta et al. (2023)
Environment Transportation Covid-19	Delfani et al. (2020); Suksee & Sindhuchao (2021); Y. Wang et al. (2022); Safari et al. (2020); Ma et al. (2021); Tirkolaee et al. (2021)

From table 3, it is easy to see that research related to LRP can be conducted in several areas such us natural disasters, distribution goods, environment, transportation, and COVID-19. The area with the most research conducted is natural disasters, while the least is the COVID-19 pandemic. The topic of LRP in natural disasters is one of the interesting areas of current research, mainly because natural disasters can occur anytime and anywhere.

- Topic of Location Routing Problem (LRP)

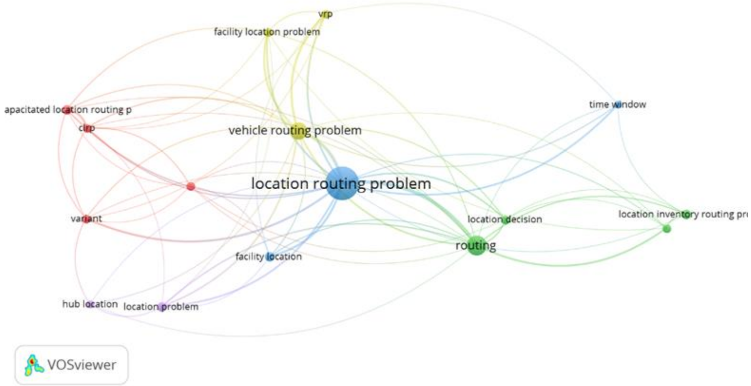

Figure 5. Topic related LRP

Based on Figure 5, it shows the interconnections between LRP and other topics. It is evident that LRP is a topic with a total network strength of 132, and it occurs 212 times in conjunction with other topics. Inventory location routing problemis a related topic to LRP with a total network strength of 11 and occurs 19 times. The other topics have weak network strength with location routing problem.

- Objective Functions for LRP

The objective functions used in LRP topics vary depending on the goals of each author. Upon analyzing 20 articles, it can be observed that approximately 25 objective functions were utilized. Each article employed either single or multiple objective functions. Out of the 20 articles, four of them used a single objective function (Almouhanna et al., 2020; Hashemi et al., 2021; Ma et al., 2021; Wang et al., 2022) while the other 16 articles used multiple objective functions (Shen et al., 2019; Liu et al., 2019; Zafari & Shishebori, 2019; Yaghoubi & Akrami, 2019; Navasi et al., 2019; Leng et al., 2019; Salehi & Jabarpour, 2020; Delfani et al., 2020; Parayoga et al., 2021; Y. Wang et al., 2022; Safari et al. ,2020; Tirkolae et al. 2021; Pourghader Chobar et al., 2021; Hamzani et al., 2022; Roosta et al., 2023)

- Algorithm Methods

The methods used to solve the Location Routing Problem (LRP) consist of several multi-objective optimization algorithms. From the analysis of 20 articles, it is evident that researchers utilized 23 algorithm methods in their studies. Each article employed one or more algorithm methods. The most widely used and superior method compared to others is NSGA II (Zafari & Shishebori, 2019; Salehi & Jabarpour, 2020; Parayoga et al., 2021; Hashemi et al., 2021; Roosta et al., 2023).

NSGA II is a suitable method for solving complex problems and multi-objective optimization tasks (Deb et al., 2000). When compared to NSGA, NSGA II has three main improvements: (1) The computational complexity of NSGA is O(MN^3), and the sorting speed is very slow for large population sizes. NSGA-II proposed the concept of fast non-dominated sorting, which reduces the computational complexity to O(MN^2) and significantly improves algorithm performance. (2) Elitism strategy is used to ensure that the optimal solutions are not lost and improve search performance. (3) NSGA-II adopts a crowding distance measurement operator to overcome the artificial determination of shared parameters in NSGA.

- Publications

The analysis of 20 articles related to the Location Routing Problem (LRP) indicates that the publications used include three types: journals, books, and proceedings. Journals are the most used publication medium, accounting for 17 articles. There are two articles from proceedings or conferences, and one article from a book or dissertation. These journals come from various reputable sources, both national and international.

The discussion above shows that the topic of Location Routing Problem (LRP) has been frequently researched. There is also a variety of methods used in these studies. Two proven algorithm methods for solving LRP problems are NSGA II and Ant Colony Optimization (ACO). NSGA II has demonstrated superior results compared to other methods and has been widely utilized. The NSGA II algorithm comprises the following stages:

- Population Initialization: The initial population is randomly generated to determine various parameters such as candidate distribution centers (D.C.), retailer visiting routes, vehicle types, and departure times. The number of populations initialized depends on specified parameters.
- Objective Function Calculation: After population initialization, the fitness of each population is calculated. In this study, fitness is determined based on total cost and service level.
- Non-Dominated Sorting and Crowding Distance Calculation: Dominance is determined for all populations, and populations with smaller front values are less dominated by others. The formed front values serve as a basis for decision-making, with priority given to solutions in the first front. Additionally, populations on the same front are sorted based on crowding distance.
- Parent Selection: Tournament selection is employed for the parent selection process. Parents are selected based on their fitness value, rank front, and crowding distance.
- Crossover: Parent populations undergo crossover to create offspring. The crossover mechanism used in this study is the crossover cycle.
- Mutation: Some populations undergo modifications to potentially form better populations. The mutation method used is swap mutation.
- Replacement: At this stage, a new population is formed by combining the initial population with populations resulting from crossover and mutation. The objective function of the new population is then calculated, and dominance is determined to obtain the next generation. The process continues until the stopping criteria are met

Ant colony optimation is a method that is still less commonly employed for addressing LRP problems. Swarm intelligence is a novel approach in problem-solving, drawing inspiration from the social behavior of insects and other animals. Specifically, various methods have been developed based on the behavior of ants, and there have been extensive research efforts in this area. One particularly successful method is the versatile optimization approach known as ant colony optimization (ACO).

Ant colony optimization is modeled after the foraging behavior of ants in search of food. These ants leave pheromones, which guide other members of their group towards the appropriate direction. In a test called the bridge experiment, an ant nest is connected to a food source by two bridges of equal length. In this scenario, the ants explore around the nest to find the food source and eventually discover it by depositing a substance called pheromone. Initially, each ant randomly chooses one of the paths. Over time, due to the random events and the accumulation of pheromones, certain points experience increased pheromone density, attracting more ants and leading to a higher number of ants selecting that direction.

Furthermore, the use of both NSGA II and ACO methods has not been explored by other researchers based on the analysis of the 20 articles. Non-Dominated Sorting Genetic Algorithm II (NSGA-II) is a powerful decision space exploration tool based on Genetic Algorithms (GA) used to solve Multi-Objective Optimization Problems (MOOPs) (Verma et al., 2021). NSGA-II has advantages in terms of its lower computational complexity, and the use of elitism can enhance the convergence of the algorithm. This method employs three strategies in its implementation. Firstly, the design process includes initialization and genetic operators to ensure proximity to the feasible area, searching for feasible solutions, and suitable chromosome structures. Secondly, a hybrid two-point crossover strategy and a two-point crossover for single points are used to aid in solution development and accelerate convergence. Thirdly, the utilization of the Pareto optimal strategy (Syakina & Nurdiati, 2021).

Ant Colony Optimization is modeled based on the behavior of various types of ants searching for food. These ants emit pheromones and determine the appropriate direction for other group members through these substances. In an experiment called the bridge experiment, ant nests are connected to a food source through two bridges of equal length (Yaghoubi & Akrami, 2019). Ant Colony Optimization (ACO) is a group of optimization algorithms that draws inspiration from the coordinated and collaborative behavior of ants. Ants, as creatures in nature with limited intelligence, roam around their nests in search of food (Dharmendra Sutariya, 2013).

6. Conclusion

Based on the data processing results, there are 521 articles related to the case study of Location Routing Problem for humanitarian aid distribution. These journals were obtained from "Google Scholar." However, when specifically related to LRP, only 20 relevant journals were accessible to the authors within the period of 2019-2023. The trends in the research approaches to the Location Routing Problem (LRP) in several areas namely natural disasters, distribution goods, environmental, transportation and covid-19. The most research conducted is natural disasters with seven authors. Topic LRP has interconnection with other topics such us inventory location problem, vehicle routing problem, capacitated location problem, etc. The most common media of publication related to the Location Routing Problem (LRP) topic are reputable journals, books/dissertations, and proceedings. The methods used to address the Location Routing Problem (LRP) consist of several approaches, namely HHA, NSGA II, MOEAs, ACO, VNS Metaheuristic, MOGWO, GRALNSP, and GA. Among these methods, NSGA II was frequently used and provided superior results compared to other methods. The benefits that researchers can derive from the findings of the conducted literature review are It can be used as a topic for further research by comparing the methods used, exploring other research areas, and connecting LRP with other topics. Based on the literature review conducted, it is recommended to conduct further studies with a larger number of journals/articles to gain a more comprehensive understanding and explore novel aspects of this topic.

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