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A Literature Review on AI and DSS for Resilient and Sustainable Humanitarian Logistics

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Abstract—*Disaster response is a critical component of disaster management, requiring effective strategies to reduce exposure and vulnerability to hazards. Rising global temperatures and extreme weather events have intensified the need for adaptive disaster relief systems. Humanitarian logistics, a vital subset of the supply chain, plays a central role in disaster preparedness, response, and recovery phases but often faces challenges such as resource constraints, inefficient communication, and unpredictable crises. This study employs a systematic literature review (SLR) using the PRISMA methodology to explore the application of Artificial Intelligence (AI) and Decision Support Systems (DSS) in humanitarian logistics from 2019 to 2024. SCOPUS served as the primary database, identifying 1,171 documents, with 52 studies selected for in-depth analysis. These studies highlight the potential of AI techniques, including machine learning and clustering algorithms, and DSS implementations for resource allocation, stakeholder coordination, and real-time decision- making. Findings demonstrate that integrating AI and DSS can optimize emergency vehicle routing, improve relief distribution, and enhance stakeholder collaboration. Advanced technologies such as Radio Frequency Identification (RFID), the Internet of Things (IoT), and Digital Twins improve logistics efficiency and scalability. Despite these advancements, challenges like data integration and algorithmic reliability persist. The study recommends prioritizing transparent systems, hybrid simulations, and addressing algorithmic constraints to advance disaster management practices.*

Keywords: *Artificial Intelligence, Decision Support Systems, Disaster Response, Humanitarian Logistics.*

I. Introduction

The World Meteorological Organization (WMO) announced, global temperatures will rise for at least the next five years. By 2030, the International Disaster Database and the Center for Research on the Epidemiology of Disasters (EM-DAT CRED) predict a 40% increase in disaster risk due to extreme weather [1] influenced by the greenhouse effect and the El Nino phenomenon [2]. Unbeknownst to us, human actions in climate change also contribute to increasing the risk of disaster as it changes the geographic distribution of weather-related hazards, creating new patterns of risk at unprecedented levels [3]. Although affecting billions of human lives, climate change and disasters are not considered natural [4]. There are only natural hazards that could be interpreted as a risk of a disaster because of increased exposure coupled with vulnerability. Resilience is commonly defined as the ability or capacity of a system to resist effectively, absorb, buffering, and recover from the effects of hazards in a timely manner [5]. In such a catastrophe, resilience reflects on the depth of impacts in a community and the time for recovery. Thus, disaster management plays a key role in strengthening resilience based on risk prevention, and faster emergency response needs to save more lives through enabling risk governance integrated systems that can assist the decision-making process [6]. Based on the Sendai Framework for Disaster Risk Reduction 2015-2030, there are seven strategic targets for reducing disaster risk and losses by coordinating efforts with the United Nations Sustainable Development Goals (UN SDG) and the Paris Climate Agreement [7]. Two of its targets are substantially reducing global disaster mortality and the number of affected people, which drives the Humanitarian action system. Effective coordination among involved stakeholders is crucial in solving the complex nature of disaster management. Thus, to streamline the decision- making process, integrating several technology advancements, such as AI and DSS, are seen as promising tools to enhance real-time data analysis and optimize resource distribution. Supply chain is one of the study domains, especially during disasters involving complex management systems, to increase efficiency and effectiveness in terms of information and relief aids distribution flow [8]. One of the specific branches in the supply chain is humanitarian logistics, which deals with the preparedness and response phases of a disaster management system [9]. To ensure timely response in distributing relief aid, humanitarian logistics plays a pivotal role. However, several studies indicated that traditional logistics operations often struggle with unpredictability, constrained resources, and inefficient communication during crises, as reported by the Learning from Mega Disasters: Lessons from the Great East Japan Earthquake [10]. These documents highlight the need for an adaptive, technology-driven approach to secure logistic distributions due to debris-blocked roads and unplanned contingency planning specifically for logistics distributions. One effective strategy for planning logistic distribution is to adopt technological advancements, such as an artificial intelligence (AI) integrated risk governance system, to help accommodate the complexities of decision-making involving several stakeholders. Implementing mitigation planning through integrated systems, AI, and DSS could enhance proactive strategies for optimizing resource distribution decisions, enabling more effective decision-making in real- time and better coordination, forecasting resource needs, and improving response coordination [11]. Nevertheless, effective disaster relief efforts rely heavily on well-structured logistics systems, public-private partnerships, reliable infrastructure, and empowered logistics service providers and humanitarian organizations [10]. Despite technological advancements in today's era, there remains a critical gap in understanding how AI and DSS can be developed to aid disaster management services, particularly in humanitarian logistics, to optimize resource allocation and improve crisis response times. To this day, no comprehensive literature review focuses on AI and DSS implementation specifically to address unique challenges of humanitarian logistics, such as real-time resource allocation, stakeholder coordination, and operational efficiency during emergencies. Hence, this paper aims to address the issues of Artificial Intelligence (AI) integrated Decision Support Systems (DSS) implementation to mitigate humanitarian logistics and disaster relief operations. Through a systematic literature review approach, we analyze previous studies regarding AI and DSS in different disaster case study scenarios in the past five years. Thus, the allocation of resources during emergencies could be predicted, and better coordination among stakeholders explicitly engaged in humanitarian logistics efforts. Moreover, the study will provide a better understanding of how these technologies can effectively enhance mitigation and response, as well as the future research agenda.

II. Research Methods

A systematic literature review is a rigorous method used to synthesize scientific evidence transparently and reproducibly, aiming to include all relevant published studies on a specific research question while evaluating their quality [12]. Due to the importance of humanitarian lo- gistics during disasters, extraction and research analysis are focused on designing decision sup- port systems (DSS), which are integrated with artificial intelligence (AI). Specific keyword re- search in an article database is crucial for pa- pers with specific outcomes aligned with the research question. Therefore, the systematic lit- erature review conducted in this paper follows the checklist item in the PRISMA 2020 method. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method is a reporting guideline used in systematic litera- ture reviews (SLR) to ensure transparency and quality in research synthesis [13]. The use of the PRISMA method for systematic literature review is highly recommended due to simpler sorting paper techniques acquired from several trusted and reliable databases [14]. SCOPUS indexing database is one of the most comprehensive and high-quality sources databases for bibliometric research, allowing for a broader knowledge in the systematic analysis across various fields [15]. Moreover, Scopus allows researchers to analyze publication activity based on countries, cities, universities, and individual authors, providing valuable insights into trends and influential contributors in specific research areas [16]. Hence, this research focuses on the systematic literature review using a single comprehensive database SCOPUS. The PRISMA method was selected due to its robustness in ensuring a comprehensive and unbiased review, thereby enhancing the reliability and transparency of this study's findings in the context of AI and DSS in humanitarian logistics. The literature review is conducted to answer the research question: "How does Artificial Intelligence (AI) integrate Decision Support Systems (DSS) to mitigate humanitarian logistics and disaster relief operations?" Thus, this research implemented the PRISMA method and several search strategies to extract data based on our preferences. The PRISMA flowchart depicted in Figure 1 below summarizes the steps acquired in the paper synthesis.

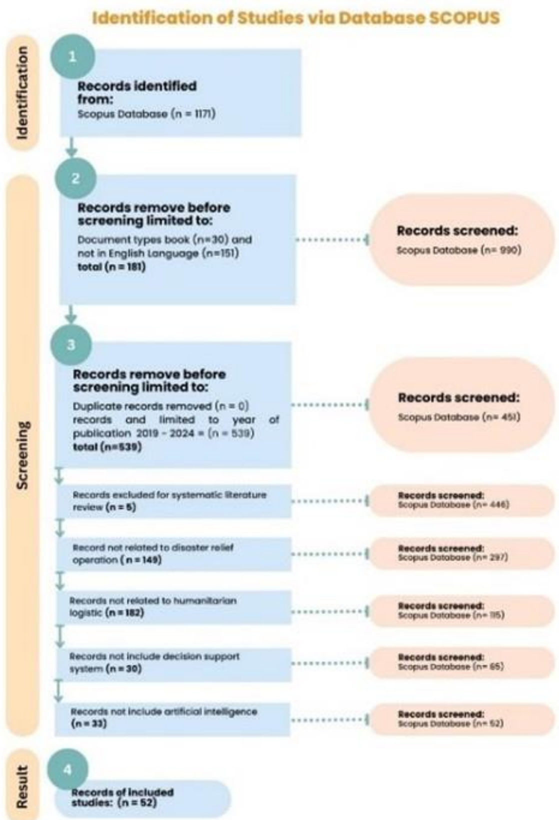

Fig. 1. Result of Systematic Literature Review

The most effective keyword search strategy for accessing academic literature on SCOPUS involves constructing a comprehensive set of relevant terms and validating them for accuracy and relevance. This strategy is crucial for ensuring the precision and comprehensiveness of the extracted literature, especially in systematic reviews and science metrics studies. Therefore, to gather a holistic view in the scope of this research, the SCOPUS search strategy is de- fined as the following queries: (TITLE-ABS- KEY (artificial intelligen* OR decision support AND disaster) AND PUBYEAR > 2018 AND PUBYEAR < 2025) AND (LIMIT-TO (DOC- TYPE,"ar") OR LIMIT-TO (DOCTYPE,"cp") OR LIMIT-TO (DOCTYPE,"ch")) AND (LIMIT-TO(LANGUAGE, "English")). Based on the advanced search queries, 1,171 documents were found with the keywords artificial intelligen*, decision support, and disaster. However, only

selected document types were chosen as our preference database for more reliable results and deep analysis reviews, such as conference pa- pers, articles, and journals that are written in English. In total, the identification of papers showed 1,020 articles in SCOPUS as . Due to technological advancements in the past few years,
451 documents were identified during publication year 2019–2024 (see the data: 10.5281/zenodo.13931530).

III. Results and Discussion

Based on our findings, 52 papers match specific criteria for implementing artificial intelligence in the humanitarian logistics decision support system case study. The Asia region, especially China and followed by India, has the highest occurrence of case study disasters with the development of DSS and AI research topics in the field of humanitarian logistics, as shown in Figure 2.

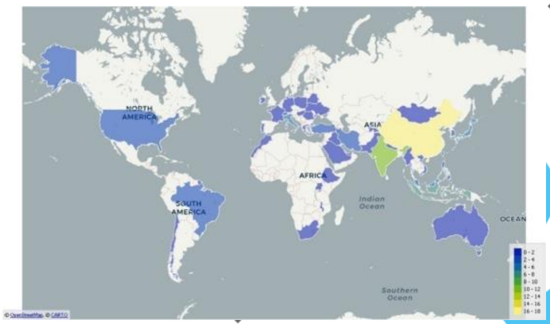

Fig. 2. Mapping of the research in several continents.

Although there have been five papers identified as literature reviews, there has been no literature review that focuses specifically on humanitarian logistics. amongst the papers identified, there are two papers focus on infrastructure [17] and decision support for urban design planning during catastrophe events such as pandemic events [18]. Whereas, the other 3 are decision support for social sensors [19]; meteorological power grid [20]; and general usage of AI implementation to assist data-driven decision-makers during disaster evacuation [21].

A. Humanitarian Logistics

Disasters can occur due to natural hazards or factors, such as hydro-meteorological (hydrological, meteorological, and climatological), geophysical, biological, and extraterrestrial hazards [22]. However, there are also other forms of hazards, such as crises due to conflict and violence, which are mostly triggered by human actions [23]. An area's potential hazards can be calculated based on the value of its vulnerability and capacity, resulting in a risk, which can be measured by the value of losses, including the number of fatali- ties, injuries, building damage, and others. Risk is a combination of potential hazards, exposure, and vulnerability [24]. Therefore, to strengthen community resilience, the government or organizations must conduct needs assessments, supply planning, and distribution planning [8] during the prevention, mitigation, and preparedness phases before a disaster occurs. In addition, organizations will focus more on their response, recovery, and reconstruction phases during and after the disaster. Due to the nature of the sudden onset of a disaster, the response phase was done based on spontaneous acts. Consequently, previous studies focused on relief distribution and victim evacuation route planning based on a case study as studied by [25–29]. Ultimately, humanitarian logistics plays a crucial role in planning, implementing, and coordinating logistics operations efforts during all phases of the disaster. According to [30], humanitarian logistics focuses on five key components: human resource deployment, knowledge management, financial resources, and collaboration, especially the coordination of several parties involved, such as governments, military, local and international non-profit organizations, and several private donors, sectors, or volunteers. There are six fuzzy boundaries which should be built upon for a successful humanitarian action, which are security, stabilization, development, sustainabil- ity, governance, and rights [9]. Therefore, supply chain in a humanitarian system, a network of interconnected institutional and operational en- tities [31], needs to act upon in every phase of disasters through short, medium, and long-term assistance [32].

B. Decision Support System (DSS) in Humanitarian Logistics

Decision Support System (DSS) is a computer-based interactive system designed to assist in decision-making by processing data into help- ful information for addressing specific semi-structured problems within an organization or company [33]. In the context of humanitarian logistics, DSS are vital for high accuracy and data integration of several stakeholders to solve dynamic and complex systems while maintaining data consistency and reliability. Previous studies have shown that DSS are leveraged to manage four different phases in disaster management, such as during mitigation, preparedness, response, and recovery [34–36].

Several approaches to addressing such challenges, as stated explicitly in the taxonomy of DSS implementation to support disaster man- agement, are mainly data-oriented and model- oriented DSS [34]. For instance, research [33] relies heavily on a Disaster Management Knowl- edge Framework, also known as DM KAF, to create customized Agent-Based Modeling (ABM) templates to generate specific disaster manage- ment plan (DISPLAN) methods through the in- tegration of six different models as the basis of ABM templates [36]. If there are no previous data, then the decision maker cannot analyze and DSS is unable to perform recommendations. Other studies suggested a hierarchical allocation of resources and tasks approach based on their location; thus, a meticulous outline of a top-down approach could define specific supply and demand points [35].

Additionally, other research in DSS facilitates the simulation and optimization-based transportation problems, such as the assimilation of agent-based modeling simulation with a mixed-integer problem formulation, a heuristic-based scheduling and routing procedure, and a tabu search meta-heuristic problem [37]. Another optimization approach is utilizing vehicle routing problems in the development of expert decision support systems [38]. As a result, the system could accommodate efficient resource allocation based on real-time data and needs and minimize the wastage of supplies and efforts. Notwithstanding its benefit, there are several limitations worth noticing in research, specifically in the DSS implementation, which is limited data analyzing performances, also known as algorithm constraints, hence leading to an inaccurate real-time decision-making process.

C. Artificial Intelligence (AI) in Humanitarian Logistics

Artificial Intelligence (AI) algorithms allow users to make data-driven decisions. AI techniques, such as machine learning, deep learning, and natural language processing, make it possible to learn from large data sets provided in any form of data and offer solutions just like what humans do to enable faster response times done by several stakeholders [39]. By providing appropriate advanced tools and techniques, AI can help the data analysis process, identify patterns, and propose effective courses of action [40, 41]. In previous studies, machine learning models are leveraged to find relationships in vast datasets, ensuring more efficient problem-solving processes and aiding human decision-makers in complex tasks without replacing them [42, 43]. Additionally, AI alignment paradigms guide the selection of suitable techniques for industrial risk management, integrating causal and anticipatory networks, multi-criteria analysis, and knowledge engineering to optimize risk mitigation strategies and improve response actions in real-time scenarios [44]. Furthermore, the concept of Intelligent Decision Assistance (IDA) within DSSs, utilizing Explainable AI (XAI) techniques, supports knowledge workers by providing insights and recommendations without imposing automated decisions, thus addressing concerns of automation bias and deskilling in decision-making processes [42].

There are several algorithms used in the implementation of AI in humanitarian logistics; for example, in the machine learning category, there are classifications [45, 46], clustering [47, 48], neural networks [49, 50], reinforcement learn- ing [51, 52], and natural language processing (NLP) [53, 54]. In addition, several studies also used deep learning techniques to predict and facilitate humanitarian routings [55–57]. There- fore, Artificial Intelligence implementation mostly concentrates on digital twin design and chatbot development. The specific algorithms used in AI are Ontology, Artificial General Intelligence algorithms, 3D printing, Blockchain protocols, Augmented Reality, Mixed Reality, haptics, and robotics algorithms [53, 58, 59]. In the design of AI implementation in humanitarian logistics, future research must consider the advantages and disadvantages of each method or algorithm.

D. Integration of DSS and AI in Humanitarian Logistics

Artificial Intelligence (AI) and Decision Support Systems (DSS) are essential in improving humanitarian logistics operations. AI technologies, including deep learning and natural language processing [60], can extract pertinent informa- tion from social media posts to offer real-time awareness during crises. Moreover, AI-based logistics tools can enhance relief distribution strategies following disasters [61], leading to increased efficiency and effectiveness. The integration of AI and DSS in humanitarian logistics not only streamlines operations but also contributes to saving more lives during disasters while promoting sustainability principles [62]. Through the use of advanced algorithms and faster computational capabilities, AI has the potential to transform decision-making processes in humanitarian logistics, ensuring prompt and effective responses to crises [63]. Additionally, hybrid simulation models that combine agent-based and discrete-event simulation techniques can assist in studying and improving coordination mechanisms among humanitarian logistics actors for better long-term outcomes [64].

Previous studies have shown that several technologies have been utilized to support the integration of DSS and AI. Among popular technologies are RFID, Digital Twins, the Internet of Things (IoT), and Blockchain. Radio-frequency identification (RFID) is an electronic tag attached to an object that can emit electromagnetic waves to exchange data with a terminal [65], facilitating identification and tracking over distances, even beyond the reader's line of sight, usually used in warehousing and relief aid stocks. Whilst tracking the aids, digital twins are employed as a virtual mimicry device of the physical objects, systems, or processes, enabling real-time simulation, monitoring, and analysis of real-world behavior [66]. One of the challenges in implementing digital twins is managing the seamless amalgamation of data from various sources, which can be complex and time-consuming. Besides data integration, one aspect that is worth noticing is that every data exchange should pass reliable and trusted database transactions to reduce fraud and errors [67], thus ensuring a secure, transparent, and traceable record-keeping and automated execution across the stakeholders involved [68].

IV. Conclusion

Advanced technology is essential for better resource allocation and decision-making in humanitarian logistics. This study explores the important role of Artificial Intelligence (AI) and Decision-Support Systems (DSS) in this context, especially in disaster management scenarios. A systematic literature review addresses a significant research gap by specifically focusing on the application of AI and DSS in humanitarian logistics. Through this review, we highlight the untapped opportunities of these technologies to improve response strategies and reduce the impact of disasters. Research trends from 2019 to 2024 reveal a real surge in interest in integrating AI and DSS in disaster management. However, amidst increasing enthusiasm, we cannot ignore the challenges that lie ahead. These include a dearth of research on certain applications and the urgent need to ensure transparency and reliability in AI-powered systems. This paper describes several promising areas of research for the future. This includes studying AI-based solutions to optimize emergency vehicle routes, facilitate collaborative decision-making, improve resource allocation strategies in humanitarian logistics, and increase the transparency and reliability of AI-based DSS. In conclusion, this research emphasizes the importance of AI and DSS in humanitarian logistics. It lays the foundation for continued research to fully exploit these technical capabilities to save lives and reduce the impact of disasters. As the global risk of disaster increases, one must prepare to decrease the chance of vulnerability and exposure due to the uncertainty of catastrophe. Therefore, technological advancement can be utilized to decrease the impact of such catastrophic events. Artifi- cial intelligence in the decision support system can support stakeholders' data-driven decision-making. There are several methods and algorithms to predict humanitarian logistics routings and logistics needs based on the location of the data and traffic model. Future studies could focus on AI models for optimizing resource deployment and logistics management systems. Increasing the human factor of cognitive function can enhance the transparency of decision-making. Thus, operators can be notified if things go wrong and adjust or act based on the necessary response.

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