Artificial Intelligence-Driven Optimization of Humanitarian Supply Chains for Effective Disaster Management: A Systematic Literature Review

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Abstract

Humanitarian supply chain management (HSCM) has been enhanced by Artificial Intelligence (AI) to improve disaster management, disaster prediction, transportation planning, demand forecasting, inventory management and resource allocation. Earlier studies on HSCM using AI techniques, including Machine Learning, Deep Learning, Reinforcement Learning, and Natural Language Processing, are analysed in this study as part of a systematic literature review. This study shows that AI improves decision-making, reduces response time, and enhances operational efficiency in the humanitarian supply chain. It also highlights significant hitches such as limited data availability, inappropriate infrastructure, and ethics-related challenges. It also identifies future research directions, including modern technologies such as Explainable AI, blockchain incorporation, and autonomous systems to build more intelligent and resilient humanitarian logistics systems for effective management of disasters.

Keywords: Humanitarian supply chain management, Disaster Management, Artificial Intelligence, Digital Technologies, Humanitarian logistics.

1. Introduction

Humanitarian Supply Chain Management (HSCM) plays a significant role in different phases of disaster management: preparedness, response, recovery, and mitigation to ensure suitable procurement, appropriate transportation, efficient warehousing, timely distribution, and well-defined coordination among relief resources. The increase in the frequency and intensity of disasters such as earthquakes, landslides, floods, cyclones, wildfires, pandemics, and geopolitical disputes has exaggerated the requirement for resilient and efficient humanitarian supply chains. Though various challenges such as uncertainty in information, demand unpredictability, infrastructure collapses, resource limitation, and poor coordination among stakeholders have been faced by earlier humanitarian supply chains, regular postponement in response and relief operations results in reduced effectiveness[7].

In this context, Artificial Intelligence (AI) has emerged as a transformative technology capable of addressing these challenges through intelligent, data-driven decision-making. AI techniques, including Machine Learning (ML), Deep Learning (DL), Reinforcement Learning (RL), and optimization algorithms, enable accurate disaster prediction, demand forecasting, inventory optimization, route planning, resource allocation, and real-time decision support, thereby enhancing the efficiency, resilience, and sustainability of humanitarian operations. Recent past studies show that the emerging implementation of AI and other digitally enabled technologies is used to improve the operations of humanitarian logistics and enhance the response operation in disaster management. Hence, this study examines recent progress in humanitarian supply of disaster management. It also highlights the existing research gaps and future research directions to build more intelligent and resilient humanitarian logistics systems for effective management of disasters.

2. Literature Review

Artificial intelligence has various applications for different operations of the humanitarian supply chain such as demand forecasting, procurement, inventory management, transportation, and logistics [1]. Toorajipour et al. [1] examined prior peer-reviewed studies to categorise the most commonly used AI methods and their impact on humanitarian supply chain performance. The authors highlighted that the most widely adopted AI method is machine learning due to its capability for prediction; after that, Deep learning and expert systems are also used. Predictions by AI techniques significantly improve demand forecasting, inventory management, warehousing, transportation, and decision support systems, used to enhance humanitarian supply chain efficiency and reduce operational costs of supply chain. The review also found some research gaps associated with real-time implementation, explainability, and integration with emerging technologies. This study also focuses on commercial supply chains, and concludes that valued perceptions are used in humanitarian supply chains and related challenges happen to optimize in larger uncertainty.

Marić et al. [2] investigated the integration of digital technologies like AI, Big Data Analytics, Blockchain, Internet of Things (IoT), Geographic Information System (GIS), and cloud computing with humanitarian supply chain operations. The review highlighted that disaster preparedness is improved through AI techniques, including forecasts for exact disaster assessment and real-time observations, resource distribution, and smart planning of humanitarian logistics. The authors report that disaster response is enhanced in terms of real-time disaster scenarios and empowers fast decision-making capabilities by the integration of AI techniques with IoT and GIS technologies [2]. However, the review also highlighted challenges such as data availability, data quality, limited infrastructure, interoperability, ethical concerns, and the lack of field testing of AI applications. The study emphasized future research directions for the adoption of emerging technologies like Explainable AI, Digital Twins, blockchain integration, and shared humanitarian information systems to enhance disaster resilience.

Bastidas et al. [3] emphasized on optimization methods involved in emergency management and humanitarian logistics. The authors focused on disaster response operations organized by different mathematical optimization models, metaheuristics algorithms, and decision-support techniques. This study categorises the primary optimisation objectives like minimize response time, resource allocation, facility location, inventory optimization, and vehicle routing to optimize humanitarian supply chains. It additionally focuses on the barriers (uncertainty, damaged infrastructure, and limited data availability) of disaster management which complicate operations of disaster logistics. The review highlighted that AI-driven optimization methods, primarily machine learning and metaheuristics algorithms, have significant capability to enhance operational efficiency of humanitarian supply chains. This study stated that the development of intelligent and resilient solution with the integration of predictive analytics with optimization models to enhance humanitarian supply chains proficient with response system during dynamic disaster scenarios.

The innovation in AI-driven humanitarian logistics is still an emerging research area [4]. Altay et al. [4] recommended that the operation of humanitarian logistics and supply chain performances can be enhanced significantly by involving digital technologies such as AI, IoT, blockchain and big data analytics. While this study highlights significant gaps like, limited beneficiary involvement, insufficient past study on innovations for the reconstruction phase, lack of usage of digital technologies in real-world implementation, limited consideration to place invention, and poor emphasis on knowledge management. The review suggested more focus on the integration of digital technologies on practical deployment with collaboration of stakeholders to build more resilient humanitarian supply chain [4].

The AI-enabled Decision Support Systems (DSS) significantly enhanced humanitarian logistics operations in all aspects of the humanitarian supply chain [5]. The study also emphasised the use of

RFID, IoT, and Digital Twin technologies for operational efficiency and supply chain performance. This study also highlighted the challenges in implementing practical deployment of digital technologies, such as major barriers to interoperability, data integration, and algorithm reliability. Christhia et al. [5] suggested the development of transparent AI-enabled DSS, robust data integration frameworks and hybrid simulation models to reinforce resilient and sustainable humanitarian supply chains.

The review investigated major research areas including emerging technologies enabled humanitarian supply chain management such as big data, IoT, blockchain, cloud computing, and Digital Twin [6]. This study highlighted significant improvements in disaster predictions and real-time decision-making by AI, Machine learning, Deep learning, big data analytics and digital technologies, resulting in appropriate resource allocation, logistics planning and stakeholder collaborations. However, the review also recommends that various challenges occur in implementing emerging technologies in HSCM, including lack of adequate data, insufficient infrastructure, inadequate technical capability, and poor coordination, which remain major barriers, primarily in developing economies. The study suggests the integration of digital technologies and increased investment in digital infrastructure, including AI expertise, adequate data availability to build more intelligent and resilient humanitarian supply chains.

Authors & Year	Research Focus	AI/Digital Technologies	Key Findings	Research Gap
Toorajipour et al. (2021)	AI applications in supply chain management	Machine Learning, Deep Learning, Expert Systems	AI improves demand forecasting, inventory management, logistics planning, transportation, and decision-making while reducing operational costs and improving supply chain efficiency.	Limited explainability of AI models, lack of real-time implementation, and insufficient integration with emerging technologies.
Marić et al. (2022)	Digital technologies in humanitarian supply chains	AI, Big Data Analytics, IoT, Blockchain, GIS, Cloud Computing	AI enhances disaster prediction, resource allocation, logistics planning, and situational awareness. Integration with IoT and GIS enables faster disaster response and better coordination.	Data quality issues, infrastructure limitations, interoperability, privacy concerns, and lack of field-tested AI applications.
Bastidas et al. (2021)	Optimization approaches in humanitarian logistics	Machine Learning, Metaheuristics, Mathematical Optimization	AI-based optimization improves response time, vehicle routing, facility location, inventory management, and resource allocation under uncertain disaster conditions.	Limited real-time adaptive optimization and insufficient integration of predictive analytics with optimization models.

Altay et al. (2024)	Innovation in humanitarian logistics	AI, IoT, Blockchain, Big Data Analytics	Digital technologies enhance disaster response, stakeholder coordination, supply chain performance, and operational resilience.	Limited beneficiary involvement, insufficient research on reconstruction-phase innovation, and lack of practical implementation.
Christhia et al. (2025)	AI and Decision Support Systems (DSS) in humanitarian logistics	AI, DSS, RFID, IoT, Digital Twins	AI improves disaster preparedness, emergency vehicle routing, resource allocation, stakeholder collaboration, and relief distribution.	Data integration challenges, algorithm reliability, interoperability issues, and limited deployment of AI-based DSS.
Bamel (2025)	Big data-driven humanitarian supply chain management	Big Data Analytics, AI, Machine Learning, Blockchain	AI and big data improve disaster prediction, real-time decision-making, supply chain resilience, resource allocation, and stakeholder collaboration.	Poor data quality, inadequate digital infrastructure, limited technical expertise, and weak coordination, particularly in emerging economies.

The investigated literature jointly elaborates that Artificial Intelligence (AI) plays a significant role in transformative technology in renovating humanitarian supply chains for optimising and improving disaster management. Digital technologies significantly enhance different phases of disaster management such as disaster prediction, demand forecasting, inventory management, resource allocation, vehicle routing, logistics planning, and stakeholder coordination by the use of AI, ML, DL, Big Data Analytics, Blockchain, IoT, GIS, DSS, and optimisation algorithms. The resilient, intelligent and sustainable disaster management system can be built by applying digital technologies which helps in real-time decision-making, improve operational efficiency, and humanitarian supply chain performance. However, the reviewed studies persistently highlight numerous challenges such as inadequate data availability, inappropriate infrastructure, interoperability complications, algorithm reliability, ethical concerns, inadequate stakeholder collaboration, and lack of real-world deployment that constrain the practical development of digital technologies-enabled HSCM. Moreover, various research gaps are identified to build a better humanitarian logistics system like, such as blockchain integration, hybrid simulation models, and adaptive real-time decision-support systems, Explainable AI (XAI), Digital Twins. Broadly, the significant potential of integrating AI with advanced digital technologies to develop intelligent, resilient, and sustainable humanitarian supply chains capable of responding effectively to increasingly complex disaster scenarios is highlighted by the reviewed studies.

4. Research Gap

It has been persistently demonstrated by the analysed studies that AI possesses substantial potential to enhance humanitarian supply chains. However, numerous challenges continue to exist. Most existing AI-based models have been evaluated through simulation environments rather than real-world disaster response operations. The effective implementation of AI is persistently constrained by

the limited availability of reliable humanitarian datasets, inadequate integration of AI with blockchain technologies, the absence of Explainable AI (XAI), and the scarcity of multi-disaster investigations. Furthermore, real-time environmental variations and dynamic decision-making processes are seldom incorporated into existing optimization frameworks, thereby emphasizing the necessity for adaptive and intelligent humanitarian logistics systems capable of operating effectively under evolving disaster conditions.

5. Conclusion

It has been revealed by the examined literature that Artificial Intelligence has emerged as a fundamental enabler of humanitarian supply chain optimization. Significant improvements in disaster prediction, demand forecasting, transportation planning, inventory management, and resource allocation have been achieved through the application of Machine Learning, Deep Learning, and optimization algorithms. Humanitarian operations have been further reinforced by advanced digital technologies through enhanced situational awareness and the facilitation of collaborative decision-making. Nevertheless, the widespread implementation of these technologies continues to be restricted by data scarcity, infrastructural limitations, and ethical considerations. Future research is recommended to be directed toward Explainable AI (XAI), Digital Twins, blockchain-enabled humanitarian logistics, federated learning, and real-time adaptive optimization so that resilient, transparent, and intelligent humanitarian supply chains capable of addressing increasingly complex disaster scenarios can be developed.

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