

ARTIFICIAL INTELLIGENCE IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT ETHICAL IMPLICATIONS IN AUTOMATION, TRANSPARENCY & SUSTAINABILITY

Volume - II

Editors in Chief

Dr. D. Divya | Dr. G. Vignesh

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NIRF Ranking 101 -150

Pollachi, Coimbatore - 642001 Tamil Nadu

Artificial Intelligence in Logistics and Supply Chain Management Ethical Implications in Automation, Transparency & Sustainability

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First Edition: 2025

Volume: II

ISBN : 978-93-94004-44-3

Price: Rs. 650

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Printed at

SHANLAX PUBLICATIONS
61, 66 T.P.K. Main Road
Vasantha Nagar
Madurai – 625003
Tamil Nadu, India

Ph: 0452-4208765,
Mobile: 7639303383
[email:publisher@shanlaxpublications.com](mailto:publisher@shanlaxpublications.com)
[web: www.shanlaxpublications.com](http://www.shanlaxpublications.com)

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LEVERAGING AI FOR SUSTAINABLE LOGISTICS: OPTIMIZING EFFICIENCY AND REDUCING ENVIRONMENTAL IMPACT

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Abstract

Big data analytics (BDA) has revolutionized Supply Chain Management (SCM) by enabling real-time decision-making, improving operational efficiency, and enhancing demand forecasting. This research explores the role of big data analytics in optimizing supply chain processes, the key technologies involved, and the challenges faced in its implementation. The study provides insights into how BDA transforms traditional supply chain models into data-driven frameworks, ensuring agility, resilience, and competitiveness in the global market.

Keywords: *Big Data Analytics (BDA), Supply Chain Management Artificial Intelligence (AI), Logistics, Sustainable*

1. Introduction

Supply chains generate vast amounts of data from various sources, including IoT sensors, transactional records, and customer interactions [1]. The integration of big data analytics into SCM enables organizations to harness these datasets for strategic decision-making. Traditional supply chain models rely on historical data and linear decision-making processes, leading to inefficiencies, delays, and increased operational costs. The application of big data analytics can mitigate these challenges by providing real-time insights and predictive capabilities [2].

2. Literature Review

Chen et al [3] examines how different types of BDA usage influence organizational decision-making in supply chain management. It conceptualizes two patterns of BDA usage optimization and learning and reports on their impact on a firm's decision-making capabilities. Martijn et al [4] explores how the integration of IoT and BDA supports decision-making in supply chains, identifying key themes and future research directions. Zamani et al [5] conducts a systematic literature review on the role of AI and BDA in enhancing supply chain resilience, providing insights into current research trends and future opportunities. Lee et al [6] analyzes the current state of BDA in supply chain management, discussing its impact on performance and identifying gaps for future research.

3. Objectives

To analyze the role of big data analytics in enhancing supply chain efficiency. The modern supply chain has evolved into a complex, data-driven network requiring real-time insights for effective decision-making. Big Data Analytics (BDA) plays a crucial role in enhancing supply chain efficiency by enabling predictive analytics, optimizing inventory management, improving demand forecasting, and mitigating risks [6]. This paper explores the impact of BDA on supply chain operations, highlights key technologies involved, and discusses challenges and future prospects.

4. Research Methodology

Machine learning automates decision-making by analyzing large datasets, identifying patterns, and making real-time predictions. This research employs a qualitative and quantitative approach, analyzing case studies, industry reports, and statistical data to assess the impact of BDA in SCM. Big Data Analytics (BDA) in Supply Chain Management (SCM) relies on key technologies such as machine learning, artificial intelligence, cloud computing, and the Internet of Things (IoT) to enhance efficiency and decision-making[7]. AI-powered automation streamlines logistics, reducing costs and improving accuracy. Figure 1 describes the various areas of Artificial Intelligence(AI) in Sustainable Logistics

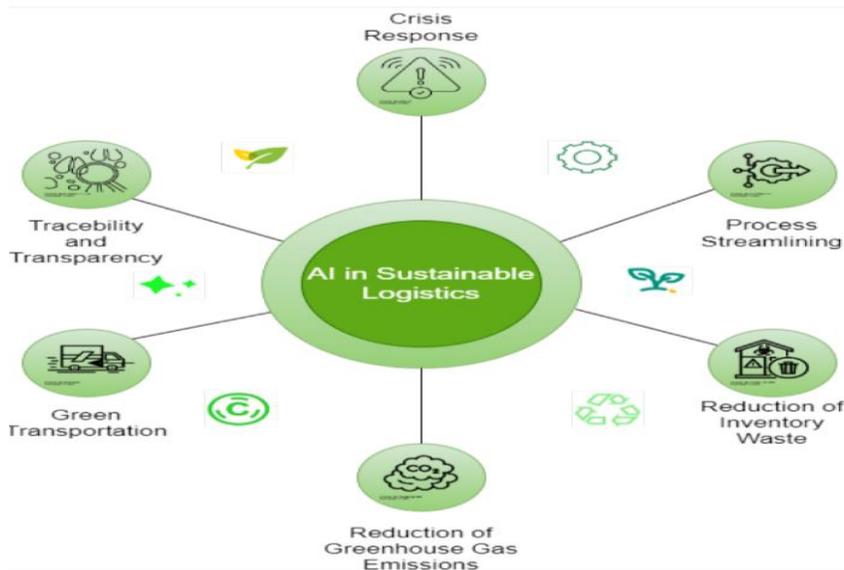


Figure 1: AI in Sustainable Logistics

Machine learning algorithms analyze vast datasets to optimize demand forecasting, inventory management, and supplier performance. Cloud computing enables real-time data access and collaboration across supply chain networks, enhancing visibility and agility. IoT devices, such as RFID tags and smart sensors, provide real-time tracking of goods, improving logistics and reducing delays. Additionally, blockchain technology enhances transparency and security in SCM by ensuring tamper-proof transaction records[8]. By integrating these technologies, BDA transforms supply chain operations, making them more resilient, data-driven, and efficient.

Key methodologies in Big Data Analytics (BDA) for Supply Chain Management (SCM) focus on leveraging data-driven techniques to enhance efficiency, decision-making, and operational resilience[9]. Descriptive analytics helps organizations understand past trends by analyzing historical supply chain data, enabling better planning and optimization. Predictive analytics utilizes machine learning and statistical models to forecast demand, optimize inventory levels, and mitigate risks such as disruptions or delays. Prescriptive analytics goes a step further by providing actionable recommendations and automated decision-making using AI-driven algorithms. Real-time analytics, enabled by IoT and cloud computing, ensures continuous monitoring of supply chain operations, improving responsiveness and agility. Additionally, data

mining techniques extract valuable insights from vast datasets, enhancing supplier selection, route optimization, and fraud detection. By integrating these methodologies, businesses can achieve a more data-driven, efficient, and resilient supply chain.

4.1 Green Transportation

AI enhances battery life, charging efficiency, and performance. It predicts optimal charging times based on grid load and renewable energy availability. It balances energy use between electric and fuel-powered systems in hybrid vehicles. An AI-powered route planning mechanism minimizes fuel consumption by finding the most efficient routes. It reduces carbon emissions by avoiding traffic congestion and optimizing delivery schedules. It predicts when vehicles or equipment need maintenance, preventing breakdowns and reducing waste [10]. Prolongs vehicle life and reduces resource consumption. IoT sensors in fleet vehicles analyze engine performance and suggest maintenance. AI predicts demand patterns to prevent overstocking and understocking, reducing waste. Enhances Just-in-Time (JIT) inventory excess production and storage costs. AI-powered robots optimize warehouse operations, reducing energy use. Automated picking, sorting, and packing lower waste and increase efficiency. AI-powered autonomous trucks and drones reduce fuel consumption and optimize last-mile delivery. AI streamlines product returns, recycling, and refurbishing, promoting a circular economy. AI-driven return management systems help minimize waste in e-commerce.

4.2 Traceability and Transparency

AI enhances traceability and transparency across various industries by leveraging advanced data analytics, machine learning, and block chain integration. In supply chain management, AI-driven systems track products from origin to destination, ensuring authenticity and reducing fraud. Machine learning algorithms analyze vast amounts of data to detect anomalies, predict risks, and improve decision-making [11]. AI-powered block chain solutions provide immutable records, enhancing trust and accountability. In financial sectors, AI ensures regulatory compliance by monitoring transactions for suspicious activities. In healthcare, AI aids in tracking medical supplies and patient records securely. By automating data collection and analysis, AI minimizes human error, promotes real-time monitoring, and fosters greater transparency in operations.

4.3 Crisis Response

AI plays a crucial role in crisis response by enabling rapid data analysis, predictive modeling, and real-time decision-making. During natural disasters, AI-powered systems analyze satellite imagery, social media data, and sensor inputs to assess damage, predict impact, and optimize resource allocation [12]. Machine learning models help in early warning systems by forecasting hurricanes, earthquakes, and pandemics, allowing authorities to take proactive measures. AI-driven chatbots and virtual assistants provide instant communication and support to affected individuals, improving emergency response coordination. In healthcare crises, AI aids in disease detection, outbreak prediction, and medical supply chain management. By enhancing situational awareness and automating critical tasks, AI improves the speed and efficiency of crisis management efforts, ultimately saving lives and reducing damage.

4.4 Process streamlining

AI enhances process streamlining by automating repetitive tasks, optimizing workflows, and improving efficiency across various industries. Machine learning algorithms analyze vast datasets to identify inefficiencies and suggest improvements, reducing manual effort and operational costs. AI-powered robotic process automation (RPA) accelerates tasks like data entry, document processing, and customer support, minimizing human errors and increasing productivity [13]. In manufacturing, AI-driven predictive maintenance ensures smooth operations by detecting equipment failures before they occur. AI also enhances decision-making through real-time insights, helping businesses optimize resource allocation and workflow automation. By integrating AI into operations, organizations can achieve higher efficiency, improved accuracy, and faster turnaround times, ultimately leading to increased productivity and profitability.

4.5 Reduction of Inventory waste

AI helps in reducing inventory waste by optimizing demand forecasting, automating stock management, and minimizing overproduction. Machine learning algorithms analyze historical sales data, market trends, and customer behavior to accurately predict demand, preventing excess stock accumulation [14]. AI-powered inventory management systems track real-time stock levels, identify slow-moving items, and suggest optimal reorder points, reducing the risk of spoilage or obsolescence. In manufacturing and retail, AI-driven predictive analytics optimize supply chain operations, ensuring just-in-time inventory replenishment. Additionally, AI-powered automation helps in detecting defects and managing returns efficiently, minimizing product waste. By improving inventory accuracy and reducing unnecessary stockpiling, AI enhances cost efficiency and sustainability in businesses.

4.6 Reduction of Greenhouse Gas Emissions

AI plays a significant role in reducing greenhouse gas (GHG) emissions by optimizing energy use, enhancing efficiency in industries, and supporting sustainable practices. AI-driven predictive analytics help businesses and power grids optimize energy consumption, reducing waste and reliance on fossil fuels. In transportation, AI improves route planning, optimizes fuel usage, and enables smart traffic management to cut emissions. AI-powered industrial automation enhances manufacturing efficiency, reducing energy-intensive processes and material waste. Additionally, AI aids in monitoring deforestation, tracking carbon emissions, and developing climate models to support informed policymaking. By leveraging AI for cleaner energy solutions, such as smart grids and carbon capture technologies, industries can significantly lower their environmental impact and contribute to global sustainability efforts.

5 Conclusions and Future Work

AI is transforming logistics into a more sustainable, cost-effective, and environmentally friendly system. Companies adopting AI-driven logistics strategies can reduce their carbon footprint, optimize resources, and meet sustainability goals efficiently.

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