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Leveraging Artificial Intelligence to Advance Sustainability and Resource Management in Supply Chains

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Abstract

This research investigation examines ways artificial intelligence (AI) could enhance supply chain sustainability with a focus on resource efficiency and values of the circular economy. For the purpose of exploring AI applications in waste mitigation, logistics optimization, and handling product lifecycle, the study employs a systematic literature review of scientific documents from the Scopus database. AI's contribution to decision-making processes, such as resource preservation systems, and closed-loop manufacturing processes, is emphasized. The paper presents an accurate assessment of AI's benefits and drawbacks in sustainable supply chains by tackling issues including data quality, ethical concerns, and potential rebound outcomes. The results reveal that AI can serve as a catalyst towards encouraging environmentally conscious industrial practices, supporting evidence-based business strategies and shaping laws and regulations to promote the shift. By highlighting AI's ability to effectively use resources while supporting responsible production and consumption, the current research further contributes to the current topic over AI's value as an important enabler of sustainability instead of solely a technological solution.

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Introduction

Worldwide supply chains are rapidly encountering major challenges due to the rising demands for sustainability from globally accepted standards , lack of resources, and degradation of the environment . businesses are no longer expected to consolidate their actions solely on competitiveness and financial efficiency, besides they are now required to behave responsibly by cutting waste, lowering carbon footprint , and assuring ongoing sustainability. In this respect, the emergence of Artificial Intelligence (AI) served as a distruptive enabler to improve optimizing sustainability throughout all stages of supply chain lifecycle as well as opmtize resource usage.

AI-powered technologies including machine learning, predictive analytics, computer vision, and intelligent automation hold the promise to enhance decision-making processes, improve the accuracy of demand prediction , streamline logistics paths, and detect defects in production and shipping. Thanks to these capabilities, AI can promote more sustainable supply chain activities through lowering carbon emissions along with boosting resilience nd operational efficiency . Therefore, AI is becoming more recognised as a significant weapon to assist the accomplishment of the Sustainable Development Goals, specifically the ones associated with tackling climate chnage, responsible consumption and production, and technological advancement.

Even though studies on AI-driven sustainable supply chains, existing research continues to grow and to become prevalent, it is still fragmented among many academic domains, revolves around isolated sustainability applications . There is a lack of a structured and complete overview regarding the way AI technologies promote sustainable resource management across supply chains along with the way these benefits fit into the overall SDG paradigm. This seperation restricts conceptual and insightful assistance for businesses aiming to employ AI for sustainable supply chain improvements.

To address this gap, the current research is going to explore how artificial intelligence can be applied for bettering resource efficiency and sustainability in supply chains. to determine the key AI uses and constraints relating to sustainable supply chain management, the research applies a systematic literature review along with a theoretical synthesis of scientific and pertinent studies. the aim of this endeavour is to provide an improved understanding of AI's contribution in promoting sustainability-related goals by gathering and analysing current literature.

Thus this study aims to respond the research questions as follows:

RQ1: What are the key artificial intelligence tools employed d in sustainable supply chain management?

RQ2: How do applications powered by AI enhance supply chain efficiency and resource optimization ?

RQ3: What barriers are connected with the adoption of AI for sustainable supply chain processes ?

1. Literature Review

1.1 Sustainable Supply Chains

Sustainability of the supply chain management (SSCM) entails integrating the environmental problems with the societal issues to the traditional procedures of supply chain. It is also interested in minimizing waste, using resources and ethical behavior in the procurement, manufacturing, and distribution ((Tuni et al., 2025). Circular supply channels are used to substitute the linear supply channels and this adds the advantage of promoting reuse, recycling, and waste reduction (Nowicka, 2025). This can enable an extension of products' life cycle to eventually minimize wastes and environmental impacts.

1.2 Artificial Intelligence and Supply Chain Optimization

Artificial intelligence tools contribute to the sustainability of supply chains through delivering factual data considered us real-time insights to improve operational efficiency and make informed decisions. The applications of AI can be categorized as the following:

- **Predictive analytics:** is known as demand and inventory forecasting. It highly relies on historical data and analyzes different market trends while adopting machine learning for an accurate inventory optimization and demand forecast which helps business to stay ahead from competition and maintain proactiveness over other competitors (Anumula, 2025).
- **Program of traffic and logistics optimization:** AI ensures efficiency in the overall movements of goods when the material turns to a finished good (Abyaneh et al., 2025). Sensors, demand prediction and real-time data from GPS are used to come up with the most suitable delivery route to reduce operational costs and prevent delays.
- **Computer vision:** considered as a field of AI using image processing with an aim of an efficient quality control on production lines (Patel, 2022). It allows the detection of defects, labelling issues or even recyclable products to encourage the achievement of a closed-loop production contribution to sustainable supply chain.

- **The learning of scheduling and managing the energy dependent on time:** AI also contributes to supply chain sustainability by improving energy use by recognizing repetitive patterns of consumers anticipate the quantities to be manufactured at the right time (Abyaneh et al., 2025). Leveraging machine learning configurations for processes or equipment to be running at most efficient times only. AI helps improve energy use by learning patterns of consumption and anticipating when demand will increase or decrease.

According to research (ISMAEIL & Lalla, 2024), AI will save the operation cost, increase the agile, and minimize the environmental footprint. However, the implementation of AI in sustainable supply chains still continues to grapple with the challenge of data access, IT infrastructure and employee readiness.

1.3 Theoretical Framework

The study will rely on the Triple Bottom Line (TBL) and the view of Resource-Based (RBV).

By combining the internal strategic significance of artificial intelligence features with the more universal sustainability standards that existing supply chains have to fulfill, these two different viewpoints complement one another. The RBV explains that the AI capabilities are strategic resources that enhance competitive advantage through optimization of the utilized resources (Moderno et al., 2023). This implies that businesses can strengthen operational accuracy, reduce bottlenecks, and arrive at more informed choices all throughout the supply chain with the use of AI-driven statistical analysis, modeling for prediction, automation, and dynamic algorithms. It can be facilitated with the help of the TBL emphasis on the economic, environmental, and social performances-AI balance, which will enable efficient, ethical, and low-impact operation (Meena et al., 2025). By employing the TBL perspective, artificial intelligence programs are examined not merely for optimizing profitability but also for the way they minimize environmental impacts including waste and emissions.

2. Methodology

2.1 Data Search and Selection Criteria:

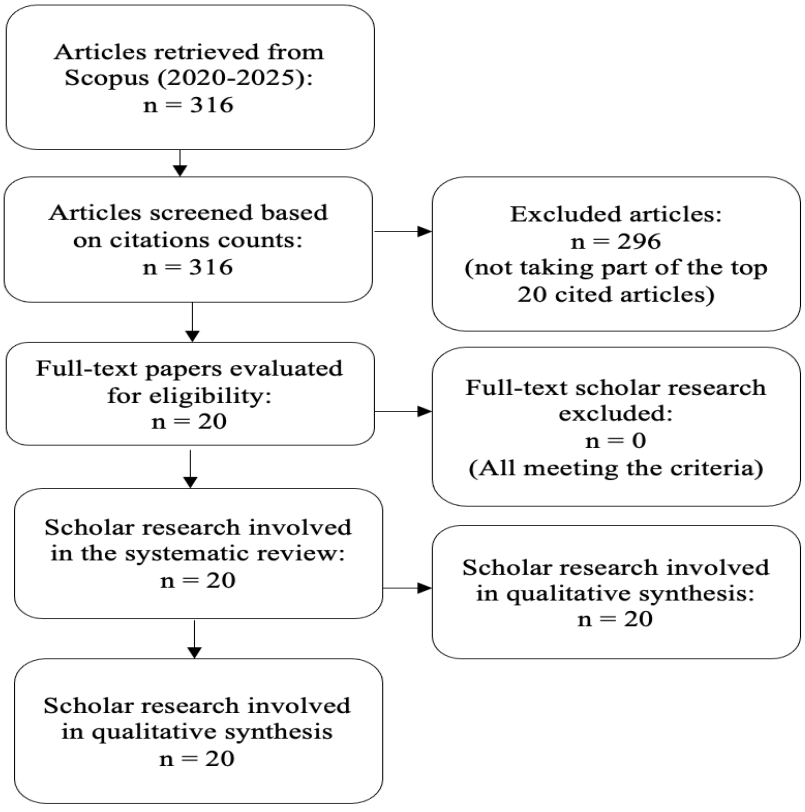
For our methodology we conducted a systematic investigation through the widely-used Scopus database to determine the most pertinent review. The query used for searching involved the following combination of terms: “Artificial Intelligence” AND “Sustainable Supply Chain” OR “Resource

Optimization". In order to ensure that all retrieved articles are addressing Artificial intelligence technologies used in supply chains to achieve sustainability and to optimize resources. The search was also strictly limited to English written publications and open access documents to guarantee accessibility. The selected year range was from 2021 to 2025. Initially the search results found was a total of 316 articles, then we ranked them based on the highest citation counts from which we selected the top 20 articles for in-depth examination.

This method will allow us to build a pertinent review highlighting the relevant studies and identifying the patterns in implementing AI into supply chains to guarantee sustainability. The main objective of this methodology is to synthesize fundamental themes, approaches, and results from highly cited academic works.

2.2 Research Design

Figure 1: PRISMA Flow Diagram



Source : Authors' own elaboration

We classified the following 20 selected articles from Scopus database by author, article title, source, year and number of citations:

Table 1: The top 20 highest cited articles:

Author(s)	Article Title	Source	Year	Citations
Liu, L.; Song, W.; Liu, Y.	Leveraging digital capabilities toward a circular economy: Reinforcing sustainable supply chain management with Industry 4.0 technologies	Computers and Industrial Engineering	2023	222
Kour, V.P.; Arora, S.	Recent Developments of the Internet of Things in Agriculture: A Survey	IEEE Access	2020	218
Dwivedi, Y.K.; Sharma, A.; Rana, N.P.; Goel, P.; Dutot, V.	Evolution of artificial intelligence research in Technological Forecasting and Social Change: Research topics, trends, and future directions	Technological Forecasting and Social Change	2023	208
Ebinger, F.; Omondi, B.	Leveraging digital approaches for transparency in sustainable supply chains: A conceptual paper	Sustainability Switzerland	2020	120
Olawade, D.B.; Fapohunda, O.; Wada, O.Z.; Ajisafe, O.; Oladapo, B.I.	Smart waste management: A paradigm shift enabled by artificial intelligence	Waste Management Bulletin	2024	117
Alhayani, B.; Kwekha-Rashid, A.S.; Mahajan, H.B.; Alkhayyat, A.; Mohammed, H.J.	5G standards for the industry 4.0 enabled communication systems using artificial intelligence: perspective of smart healthcare system	Applied Nanoscience Switzerland	2023	113
Olan, F.; Liu, S.; Suklan, J.; Jayawickrama, U.; Arakpogun, E.O.	The role of Artificial Intelligence networks in sustainable supply chain finance for food and drink industry	International Journal of Production Research	2022	81

Kunkel, S.; Matthess, M.; Xue, B.; Beier, G.	Industry 4.0 in sustainable supply chain collaboration	Resources Conservation and Recycling	2022	80
Kazancoglu, I.; Ozbiltekin-Pala, M.; Mangla, S.K.; Kumar, A.; Kazancoglu, Y.	Using emerging technologies to improve the sustainability and resilience of supply chains in a fuzzy environment in the context of COVID-19	Annals of Operations Research	2023	74
Tavana, M.; Shaabani, A.; Vanani, I.R.; Gangadhari, R.K.	A Review of Digital Transformation on Supply Chain Process Management Using Text Mining	Processes	2022	71
Khan, A.A.; Laghari, A.A.; Baqasah, A.M.; Alsafyani, M.; Alsayaydeh, J.A.J.	BDLT-IoMT—a novel architecture	Journal of Supercomputing	2025	67
Xia, L.; Huang, C.; Xu, Y.; Zhang, X.; Chen, T.	Spatial-Temporal Sequential Hypergraph Network for Crime Prediction	IJCAI	2021	66
Dumitrascu, O.; Dumitrascu, M.; Dobrotă, D.	Performance evaluation for a sustainable supply chain management system in the automotive industry using artificial intelligence	Processes	2020	64
Narayan, V.; Mall, P.K.; Alkhayyat, A.; Kumar, S.; Pandey, P.	Enhance-Net: An Approach to Boost the Performance of Deep Learning Model Based on Real-Time Medical Images	Journal of Sensors	2023	62
Jankovic, S.D.; Curovic, D.M.	Strategic Integration of Artificial Intelligence for Sustainable Businesses	Sustainability Switzerland	2023	59
Panigrahi, R.R.; Shrivastava, A.K.; Qureshi, K.M.; Almuflih, A.S.;	AI Chatbot Adoption in SMEs for Sustainable Manufacturing Supply Chain Performance	Sustainability Switzerland	2023	57

Qureshi, M.R.N.				
Amani, M.A.; Sarkodie, S.A.	Mitigating spread of contamination in meat supply chain management using deep learning	Scientific Reports	2022	55
Lee, Y.K.	Transformation of the innovative and sustainable supply chain with upcoming real-time fashion systems	Sustainability Switzerland	2021	54
Da Rio, L.; Spadaccini, M.; Parigi, T.L.; Repici, A.; Armuzzi, A.	Artificial intelligence and inflammatory bowel disease: Where are we going?	World Journal of Gastroenterology	2023	49
Tang, Y.M.; Chau, K.Y.; Lau, Y.-Y.; Zheng, Z.	Data-Intensive Inventory Forecasting with Artificial Intelligence Models for Cross-Border E-Commerce	Applied Sciences Switzerland	2023	47

Source: by authors' elaboration

2.3 Data Extraction and Analysis

Table 2: The systematic analysis of extracted papers

ID	Purpose of Study	Methodology	AI Tools applied	Key Findings	Role in SSCM or Resource Optimization
1	Investigate Industry 4.0 for circular economy	Conceptual + case insights	IoT, automation, data analytics	Digital tools improve waste reduction & resource loops	Supports circular supply chains & resource efficiency
2	Evaluate IoT in agriculture	Systematic survey	IoT, sensors	IoT improves monitoring & efficiency	Enhances SSCM in agriculture industry
3	Record AI research trends	Bibliometric	ML, NLP	AI growth areas identified	Displays AI relevance to sustainability domains
4	Transparency in SSC	Conceptual	Blockchain, IoT	Digitalization increases traceability	Supports ethical & sustainable supply chains
5	Enhance waste disposal by AI	Review	ML, CV	AI optimizes waste sorting	Reduces waste, boosts circularity
6	AI-enabled communication	Conceptual	AI+5G	Smart communication improves industrial efficiency	Indirectly supports sustainable operations

7	AI for financing decisions	Empirical	Neural networks	Boosts financing efficiency for suppliers	Improves supplier sustainability
8	Collaboration practices	Interview study	IoT, automation	Digital tools improve coordination	Supports sustainable purchasing
9	Improve resilience in COVID	Fuzzy methods	AI, IoT	Enhances decision-making	Boosts resilience & sustainability
10	Review digital transformation in supply chain	Text mining	ML, text analytics	Key digital transformation themes extracted	Shows AI role in optimizing processes
11	Secure IoMT model	Architecture	ML (SVM)	Progresses healthcare data security	Supports efficient health supply systems
12	Predict crime patterns	Hypergraph networks	DL	High accuracy prediction	Indirect sustainability via safer logistics
13	Assess AI in automotive SSCM	Modelling	ML forecasts	AI improves production efficiency	Supports automotive sustainability
14	Boost DL model performance	DL architecture	CNN	Better medical image accuracy	Supports health supply chain quality
15	Investigate AI incorporation	Conceptual	AI, data analytics	AI enhances decision-making	Helps digital sustainability transitions
16	Chatbots in SMEs	Survey + modelling	NLP	AI adoption boosts performance	Helps SME supply chain sustainability
17	Forecast contamination	DL	CNN	AI detects contamination	Diminishes waste & food risk
18	Fashion supply chain innovation	Conceptual	AI, automation	Real-time data improves efficiency	Supports fast & sustainable fashion
19	Clinical AI analysis	Review	ML, DL	AI improves diagnosis	Indirect supply chain optimization in healthcare
20	Develop inventory predictions	ML modelling	ANN, RF	AI enhances forecast accuracy	Optimizes inventory & reduces waste

3. Results

The systematic review of the 20 studied articles reveals an increasing number of scholars who are highly engaged in leveraging different AI-driven technologies to boost and strengthen the resilience and ensure transparency throughout supply chains. The following are the three main identified subject areas:

Subject area 1: Supply Chains Sustainability with Industry 4.0 and Digitalization

Several articles emphasize the importance of digital capabilities such as internet of things. The crucial role of digital features such as data mining, automation, internet of things and increased connectivity in advancing a circular economy, aligning supply chain and handling resources is highlighted in a selection of documents. According to research conducted by Liu et al. (2023) and Kunkel et al. (2022), the digital growth contributes to the acceleration of circularity practices and improves the level of traceability with the operations of supply chain.

Subject area 2: Operational Efficiency and Resource Optimization with AI & ML

several articles tackled the use of deep learning, machine learning, and models of neural network to support decisions regarding operations. Such applications consist of automating the disposal of waste (Olawade et al., 2024), as well as the dependent planning of energy and projections of inventories (Tang et al., 2023). Additionally, they serve in detecting any kind of food spoilage across the supply chain (Amani & Sarkodie, 2022). The findings frequently argue that artificial intelligence enhances predictions, mitigates waste and strengthens accuracy.

Subject area 3: Risk Management, Sustainability and Supply Chain Resilience

Another consideration percentage of studies point out the way emerging innovations foster the resilience of supply chains. AI powered decision platforms assist with minimising risks and evaluating scenarios (Kazancoglu et al. 2023) . In a similar comparable way, literature on the adoption of AI from a financial perspective shows that AI is an enabler of equity (Olan et al., 2022).

All in all, the results reveal that AI adoption is not only related to automation but highly serves as a significant catalyst for circularity, sustainaability as well as transparency in overall supply chains.

3. Discussion

This review emphasis on numerous significant insights into the role of AI in contributing to sustainable supply chain management. In accordance with the prevailing standards for sustainability and global agreements such as SDG 12 (Responsible Consumption and Production), the examined studies continually demonstrate AI 's contribution in promoting improved resource utilisation and automated operations. Also, real time information assisting businesses in tracking their products evaluate environmental outcomes and guarantee compliance with standards are all attained when AI is paired with internet of things. Additionally, the accuracy in predictions, the assurance of quality, the scheduling of production and the optimization of logistics, all are enabled by the use of predictive analytics.

The different publications on our review that employed deep learning algorithms alongside with artificial neural networks demonstrate considerable improvements in reactivity and reliability. The following indicates that AI allows businesses to perform a change strategy toward a more proactive decision-making based on real-data. In addition, it was showed that AI contributes to SDG 13 (Climate Action) and SDG 9 (Industry, Innovation and Infrastructure) through its proactiveness capabilities in detecting of anomalies on supply chain and handling crisis, especially when taking consideration of the ongoing global warming issues and resource shortage.

Conclusion

This study answers the need for a deep understanding of how artificial intelligence promotes sustainability across supply chain operations and eventually contributes to resource optimization within a context where all businesses trying to act sustainably to face environmental challenges.

Although AI contributions in supply chains highly grow, yet existing research remains fragmented, since only uncomplete knowledge tackling directly the way AI-powered tools assist initiatives towards sustainability. To cover this gap, our research implemented a systematic literature review of the highest 20 cited publications from Scopus database between 2020 and 2025. This method allowed a clear determination of main AI solutions, sustainability results , and adoption barriers across supply chains.

The findings highlight that artificial intelligence has a crucial impact in improving supply chain transparency and durability while keeping it sustained. Technologies including IoT-enabled systems, machine learning, digital platforms, and Industry 4.0 tools highly enhancing resource optimization, waste reduction and assist in providing an accurate inventory. Additionally, they promote resilience to disruptions and activate circularity.

However, the study identifies significant challenges, among them ethical concerns, the inadequate adoption of AI among some types of firms, and the lack of scientific support in this field of research. Through assembing different body of literatures, we created a complete corpus providing a clear understanding of the way AI supports sustainability across supply chain operations. In terms of use, it delivers knowledge for managers and legislators who seek to align supply chain objectives with sustainability goals.

Future investigations need to broaden empirical research in the developing and emerging economies while according emphasis to full assessment paradigms which incorporate economic, social, and environmental aspects.

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