Role of AI in Sustainable Supply Chain Management

[1]Dr Richa Kalpesh Saxena, [2]Khusshi Parekh, [3]Kirat Jabbal,[4]Krishay Malhotra, [5]Krita Patel, [6]Kulveer Savla

Assistant Professor, Marketing & Operations, NMIMS, Anil Surendra Modi School of Commerce,Mumbai Campus, India

2,3,4,5,6 BBA, NMIMS, Anil Surendra Modi School of Commerce, Mumbai Campus, India

ABSTRACT: The present review is a systematic literature review-cum-bibliometric analysis of Artificial Intelligence in Sustainable Supply Chain Management to canvass the field holistically. Through this review, the authors have tried to find the dominant themes in the field of sustainable supply chain management and the importance of Artificial Intelligence in making supply chains less carbon-intensive and more resilient. The data for the review is procured from Elsevier's Scopus database by using important keywords. The final database used for this review comprises 178 articles and 17 review papers. It was found that predictive analytics, circular economy, and green logistics were the most dominant themes for this study.

KEYWORDS: Artificial Intelligence; Sustainable Supply Chain; Operations; Management; Bibliometric Analysis.

1. INTRODUCTION

AI is becoming a major enabler of efficient, resilient and sustainable supply chains by improving demand forecasting, minimizing waste and reducing emissions. According to MarketsandMarkets (2025), the global AI in supply chain market is projected to reach USD 50.01 billion by 2031, growing at a CAGR of 22.9%. As organizations face increasing pressure from regulators, investors and consumers to adopt sustainable practices, research in this field is also expanding, making it important to systematically organize existing knowledge.

Operations Research (OR) uses mathematical modelling, optimization, forecasting and simulation to support decision-making under limited resources and uncertainty. These techniques help businesses balance costs, service quality and environmental objectives. Bibliometric analysis provides a systematic and quantitative way to understand research trends, identify knowledge gaps and support informed decisions (Donthu et al., 2021; Zupic & Čater, 2015).

This study combines a Systematic Literature Review (SLR) with bibliometric analysis to examine research on AI in sustainable supply chain management. Using the search string "Artificial Intelligence and Supply AND Sustainability" on Scopus, 3,026 documents were initially identified. Following PRISMA-based screening, 1,474 documents published between 2006 and 2026 across 705 sources were analyzed using Scopus, R Studio and Biblioshiny.

The findings reveal that the field is growing rapidly, with an annual growth rate of 36.5%, 5,374 contributing authors and 39.82% international co-authorship. Sustainability (Switzerland) is the most productive journal, followed by the Journal of Cleaner Production and the International Journal of Production Research. China, India and the USA lead in publication output. Thematic analysis also shows a shift from broad concepts of AI and sustainability towards supply chain optimization, resilience, blockchain and the Internet of Things.

The study addresses five research questions concerning publication growth and citations, leading sources and countries, international collaboration, relationships among authors and keywords, thematic evolution, and the scientific, managerial and social implications of the findings.

2. LITERATURE REVIEW

1. General comments on the relevant literature

A large and growing body of literature has investigated how artificial intelligence (AI), machine learning, digital technologies, and circular economy principles enable products, materials, and operational processes to achieve environmental, economic, and social sustainability (Abbas et al., 2026) (Govindan et al., 2019)(Mohsen et al., 2026)Almost all of the latest records focus on the operationalization of AI capabilities to transform supply chains from reactive, fragmented entities into resilient, closed-loop, and predictive networks.

Artificial intelligence, green supply chain management, and digital transformation constitute the primary and most advanced themes on the thematic map of bibliometric evaluations, falling directly into the quadrant of motor themes. Machine learning, deep learning, optimization, and supply chain resilience constitute a second dense theme, closely aligned with environmental sustainability, carbon emission management, and ESG compliance(Uzunov & Angeleska, 2026). (Chowdhury et al., 2025)Keyword co-occurrence networks confirm this pattern: AI capabilities, demand forecasting, IoT sensors, and multi-objective optimization are tightly linked to supply chain resilience, while circular economy practices, generative AI, and blockchain integration form dynamic, emerging clusters.(Baruah & Moshref-Javadi, 2026)(Lukács et al., 2026)(Sun & Diao, 2023)

2. Previous research: a historical perspective

Research into supply chain optimization and digital technologies has a longer history than recent dataset windows capture(Baruah & Moshref-Javadi, 2026)(Kamruzzaman et al., 2025). Systematic reviews tracing this domain cover records spanning over two to three decades of scientific output.(Moosabeiki Dehabadi et al., 2026)

Earlier research focused primarily on deterministic optimization, linear programming, and cost minimization.(Gumilang et al., 2026) However, recent literature indicates an exponential growth in publications, driven by the emergence of Industry 4.0 and Industry 5.0 technologies, post-pandemic operational disruptions, and global decarbonization mandates. A rapid surge in research framed around Generative AI, Large Language Models, dynamic digital twins, and AIoT architecture(Baruah & Moshref-Javadi, 2026)(Masmali et al., 2026)s has elevated sustainability from a peripheral compliance obligation to a core strategic dynamic capability.(Hoang et al., 2025)

3. Previous Research: methodological approaches taken

What is known about this field is built upon both primary empirical investigations and secondary systematic literature reviews. Several systematic literature reviews and bibliometric analyses have been undertaken using explicit protocols, such as PRISMA, and quantitative mapping tools to establish thematic structures.(El-Sattar et al., 2026)

Studies in this domain primarily employ three methodological approaches:

1. **Empirical Survey & Structural Equation Modeling:** Used to test structural frameworks linking AI adoption or assimilation depth to supply chain resilience, agility, and sustainable firm performance.(Chowdhury et al., 2025)(Khan et al., 2025)

2. **Machine Learning & Simulation Modeling:** Advanced analytical studies deploy Extreme Gradient Boosting (XGBoost), Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks (CNN), Bio-inspired Graph Neural Networks, and Particle Swarm Optimization (PSO) for real-time demand forecasting, predictive maintenance, and route optimization.(Bhavikatta & Goluguri, 2026)

3. **Multi-Criteria Decision-Making (MCDM) & Hybrid Optimization:** Frame(Nguyen et al., 2024)works such as Neutrosophic DEMATEL, TOPSIS, VIKOR, Analytic Hierarchy Process, Best-Worst Method, and Grey-DEMATEL are widely applied to solve complex supplier selection and adoption(Khaleghi et al., 2026)(Maklavani et al., 2026) risk prioritization problems under operational uncertainty.(Ben Youssef et al., 2026)(Garg & Vemaraju, 2025)(GholamAzad & Eydi, 2026)

4. Previous Research: what has been established or proposed(Virmani et al., 2026)

Several studies have established that AI adoption directly enhances supply chain operational efficiency, carbon footprint reduction, and risk mitigation.(Liu et al., 2026)(Jafari et al., 2026) Specifically, AI-driven demand forecasting lowers inventory hold costs, mitigates overproduction, and reduces transport-related greenhouse gas emissions.(Gotelli et al., 2026)(Bhavikatta & Goluguri, 2026)

It is now well established across various sectors including agri-food, fashion, automotive, healthcare, and energy that integrating AI with IoT sensors and Blockchain yields robust real-time traceability and quality assurance(Bhuiyan et al., 2026). Furthermore, AI enables closed-loop reverse logistics by optimizing product returns, waste valorization, and circular recycling workflows.(Geraeli & Roghanian, 2026)(Mir et al., 2026)(Moosabeiki Dehabadi et al., 2026)

However, recent studies highlight significant trade-offs and unintended operational consequences:

- **The Sustainability–Resilience Paradox:** Empirical findings demonstrate that maximizing short-term sustainability targets can sometimes induce structural rigidity, potentially creating trade-offs with supply chain resilience unless mediated by flexible dynamic capabilities.
- **ESG Opportunism:** Generative AI tools can be misused to artificially inflate corporate ESG reporting scores and mask underlying operational risks across complex supplier networks.(Chowdhury et al., 2025)
- **High Energy & Computing Footprints:** The computational power required for complex Generative AI models and advanced algorithms introduces environmental burdens, emphasizing the need for eco-centric, low-power "Green AI" architectures.(Esho et al., 2026)(Nguyen et al., 2024)

5. Stating what is currently known about the topic

A clear relationship exists between artificial intelligence, supply chain resilience, and environmental performance(Thürer et al., 2020). AI is no longer viewed merely as a localized operational tool, but as a dynamic, systemic enabler capable of driving end-to-end sustainable supply chain transformation.(Khan et al., 2025)(Liu et al., 2026)

Current scholarship confirms that successful AI deployment relies heavily on organizational governance, workforce skill development, human-AI collaboration (Industry 5.0 paradigms), zero-trust cybersecurity architectures, and dynamic capability building. While technical algorithms (e.g., neural networks, metaheuristics, large language models) have matured significantly, practical implementation across small and medium-sized enterprises (SMEs) and complex multi-tier supply networks remains constrained by data silos, high capital costs, and regulatory ambiguities.(Amarasuriya & Abston, 2026)(Garg & Vemaraju, 2025)

3. RESEARCH OBJECTIVE

The fundamental aim of this review is to discover upcoming trends in article and journal publications and their performance, patterns of collaboration, and constituents in research and to analyze the intellectual structure of AI in sustainable supply chain management. This can be achieved by setting smaller goals as follows: -

(1) To uncover the prevalent trends in publications of Artificial Intelligence in Sustainable Supply Chain Management in terms of Journals, time, Authors, affiliated institutions, and countries

(2) To discover influential research, models, analyses, and studies in this field.

(3) To understand and reiterate how the research in this domain has advanced over time and what are the current trends in the field.

(4) To analyze whether studies in the past are inclined towards a particular segment of sustainable supply chains.

(5) To find gaps in research and potential areas of future research

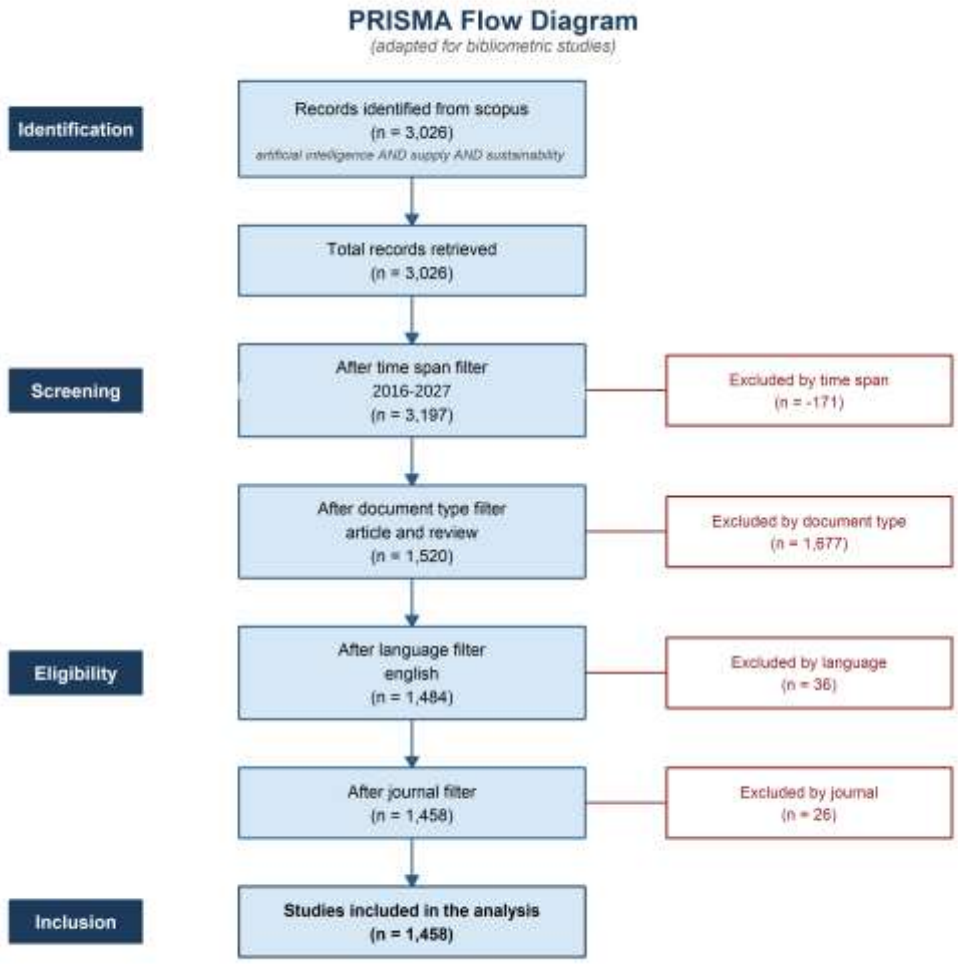
4. RESEARCH METHODLOGY

AI is playing a growing role in making corporate supply chains more efficient, resilient and environmentally sustainable. Companies are under increasing pressure from regulations, investors and customers to reduce carbon emissions cut waste and support circular economy practices. To meet these goals many organizations are using AI tools such as machine learning, predictive analytics and intelligent automation. To understand how research on AI and sustainable supply chain management has developed it's important to review literature systematically. This involves identifying themes tracking the evolution of ideas and finding areas that still need more study.

To carry out this study, a structured bibliometric analysis was designed. The process began with selecting literature sources. The main database used was Scopus from Elsevier. This database is known for its accurate coverage of peer-reviewed research in business, engineering and environmental science—fields that are all relevant to this topic. A search was conducted using the string *"Artificial Intelligence AND Supply AND Sustainability"* which returned 3,026 documents. However this initial set included different types of publications, languages and years making it unsuitable for a focused bibliometric study. So a four-step screening process was applied to clean and sharpen the dataset.

The first step applied a time filter keeping publications from 2016 to 2027. This period was chosen because it marks when modern AI technologies became mature and widely available. Focusing on this time frame ensures the study looks at real-world AI applications rather than outdated approaches. After this the document type filter was used. Peer-reviewed articles and review papers were kept. Conference proceedings, book chapters, editorials and trade articles were removed due to differences in peer-review standards and incomplete data needed for citation and keyword analysis. This step reduced the number of records to 1,520.

Next the language filter was applied. Papers in German and French were excluded to avoid translation errors and inconsistencies during analysis. This left 1,484 documents. Then the source type was checked. Only academic journals were retained. Books, trade publications and preprints were removed because they do not follow the rigorous peer-review process. The final dataset included 1,458 peer-reviewed journal articles and review papers. This clean high-quality collection forms the basis, for analysis, including citation mapping, keyword co-occurrence networks and trend detection. The full process is detailed in the PRISMA flow diagram.



5. DATA ANALYSIS AND RESULTS

Main information:

To understand research on the Role of Artificial Intelligence in Sustainable Supply Chain Management, a bibliometric analysis was done using the Bibliometrix R-package (Aria & Cuccurullo,2017) and its Biblioshiny tool the dataset included 1,474 documents published in 705 different sources between 2006 and 2026. This shows that the topic is studied across many different fields, such as operations management, computer science, environmental studies, and information systems, rather than being limited to just one or two journals. (Kusiak, Xiang et al., & Kakani et al.)

The collection showed a very high annual growth rate of 36.5%, which is well above the 10% level normally seen as a sign of a fast-growing research area. This confirms that AI in sustainable supply chains is a rapidly expanding topic, with more researchers studying it each year as companies start using AI tools to become more sustainable and resilient. A total of 5,374 authors contributed to this research, but only 115 of them published papers alone. This shows that almost all the work in this field is done in teams, which makes sense since combining AI with supply chain and sustainability(Khanashyam et al., 2025) topics usually needs experts from different backgrounds (Zupic & Čater)

This teamwork pattern is also supported by the fact that each paper had an average of 4.24 co-authors, and 39.82% of papers involved authors from more than one country. This shows that researchers around the world are working together on this topic, which is common in fields with global relevance like sustainability. Such international collaboration is often linked to higher-quality, more impactful research.(Huang & Mao, 2024)

The collection also contained 4,352 unique keywords chosen by authors, showing that the topic covers many themes, such as predictive analytics, machine learning, circular economy, reducing carbon footprints, and supply chain

resilience(Rusch et al., 2023). On average, the documents were only 1.77 years old, meaning most of the research is very recent. This matches the fact that AI has only recently become widely used in supply chain sustainability work. Finally, the average number reference citations per document was 30.24, which is quite high, especially since the papers are so new. Since newer papers usually have fewer citations simply because they haven't had enough time to be cited yet, the real impact of this research area is likely to grow even more in the coming years.

Annual Production Chart:

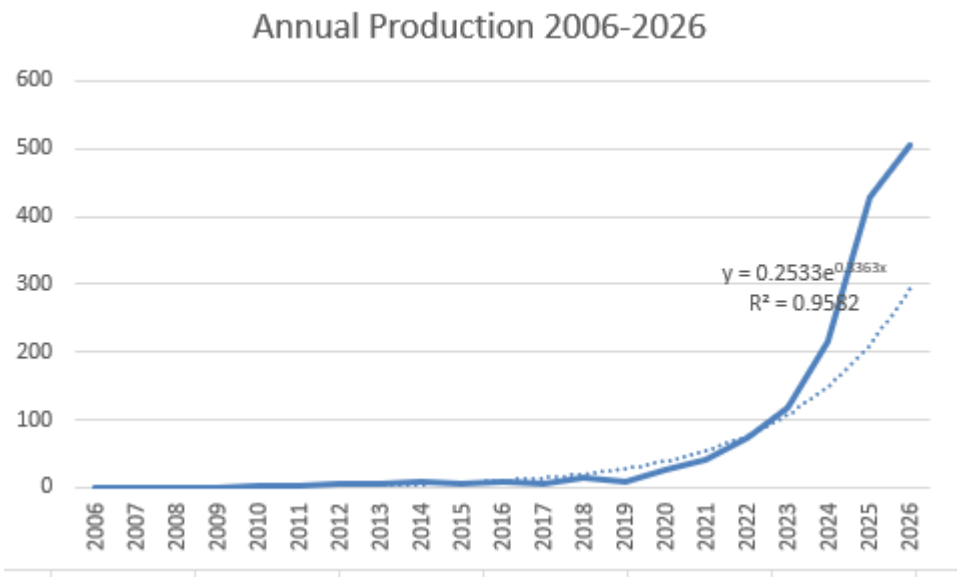


Figure 1. *Annual publication output on the role of AI in sustainable supply chain management, 2006-2026.*

The Annual Scientific Production chart shows how many research papers were published each year on AI in Sustainable Supply Chain Management, starting from 2006 up to 2026. Looking at the chart, we can clearly see that the topic has gone through different stages of growth over time.

From 2006 to around 2019, the number of papers published each year stayed very low, close to zero. This means that during this period, very few researchers were studying AI in the context of sustainable supply chains(Adamowski, 2008). The topic was likely to be still new and not widely recognized as an important research area yet. Most industries and researchers were probably more focused on other topics, and AI itself was still developing as a technology during these early years.

Starting from around 2020, we can see a small but steady increase in the number of publications. This slow rise happened because AI technologies, such as machine learning and data analytics, were becoming more advanced and more widely used in different industries, including supply chain management. At the same time, sustainability was becoming a bigger global concern, so more researchers started exploring how AI could help make supply chains more environmentally friendly and efficient.(Di Vaio et al., 2020)

The most important part of the chart is the sharp increase seen between 2023 and 2026. During this short period, the number of publications jumps from around 100 papers to almost 500 papers per year. This is a huge and very fast increase, happening in just three to four years. Such a steep rise shows that AI in sustainable supply chain management has quickly become a very popular and important research topic, attracting a lot of attention from scholars around the world.

The dotted line in the graph shows the overall growth pattern. It rises slowly at first and then very steeply, which means the yearly number of papers grew by about 40% on average. The line fits the real data very well ($R^2 = 0.95$). In the most recent years, the actual number of papers is even higher than this line, so growth has been faster than usual.

This kind of rapid, exponential growth pattern is very common in research fields that are new and developing quickly, especially when new technologies are being adopted rapidly across industries. This trend also matches the very high

annual growth rate of 36.5% mentioned earlier in the Main Information summary of this study. Overall, this chart confirms that AI in sustainable supply chain management is no longer a small or niche topic it has become a fast-growing and increasingly important area of research, likely driven by recent improvements in artificial intelligence, the growing availability of big data, and the urgent global need for more sustainable and resilient supply chains.(Naz et al., 2022)

It is also worth noting that the data for 2026 may be incomplete, since the year has not yet ended at the time this analysis was conducted. This means the actual number of publications for 2026 could turn out to be even higher once the year is fully completed.

Average Citations per Year:

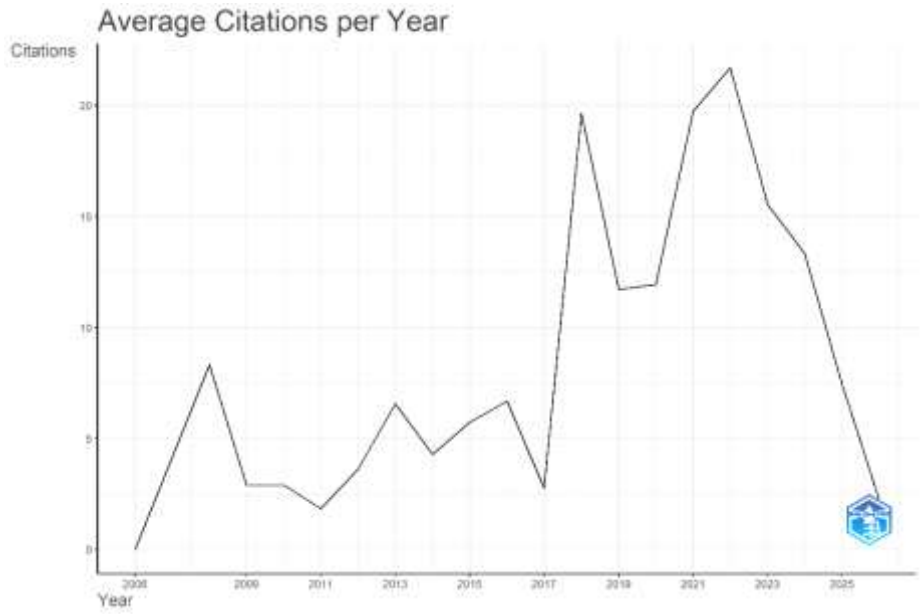


Figure 2. Average citations per year (2006-2026)

The Average Citations per Year chart shows how many citations, on average, papers published in each year have received. This is different from the Annual Scientific Production chart, because that one showed how many papers were published, while this one show how impactful or influential those papers have been in terms of citations.

From 2006 to 2017, the average citations per year stayed low and moved up and down a little, mostly staying between 2 and 8 citations(Adamowski, 2008). This means that papers published in these early years did not receive very high citation counts, which makes sense because AI in sustainable supply chain management was still a new and small topic at that time, so fewer researchers were citing work in this area.

A very sharp change happens after 2017. The average citations jump suddenly to almost 20 in 2018, which is a huge increase compared to previous years. After a small dip in 2019, the citations rise again and reach the highest point of the whole chart in 2022, at slightly above 20 citations. This shows that papers published between 2018 and 2022 were the most cited(Javaid et al., 2022)(Kamble et al., 2022) and had the strongest impact within this research field. This period likely represents the time when AI in sustainable supply chains became a well-recognized and important topic, so papers from these years were read, referenced, and built upon by many other researchers.

After 2022, the average citations start dropping steadily, falling all the way down to almost 3 by 2026. This drop does not mean that recent papers are less important or lower quality. Instead, it happens because newer papers simply have not had enough time yet to be cited by other researchers. This effect is known as citation lag, meaning that papers need a few years to accumulate citations, so very recent publications (like those from 2024, 2025, and 2026) naturally show low citation averages for now, even if they turn out to be highly cited later.

Three Fields Plot:

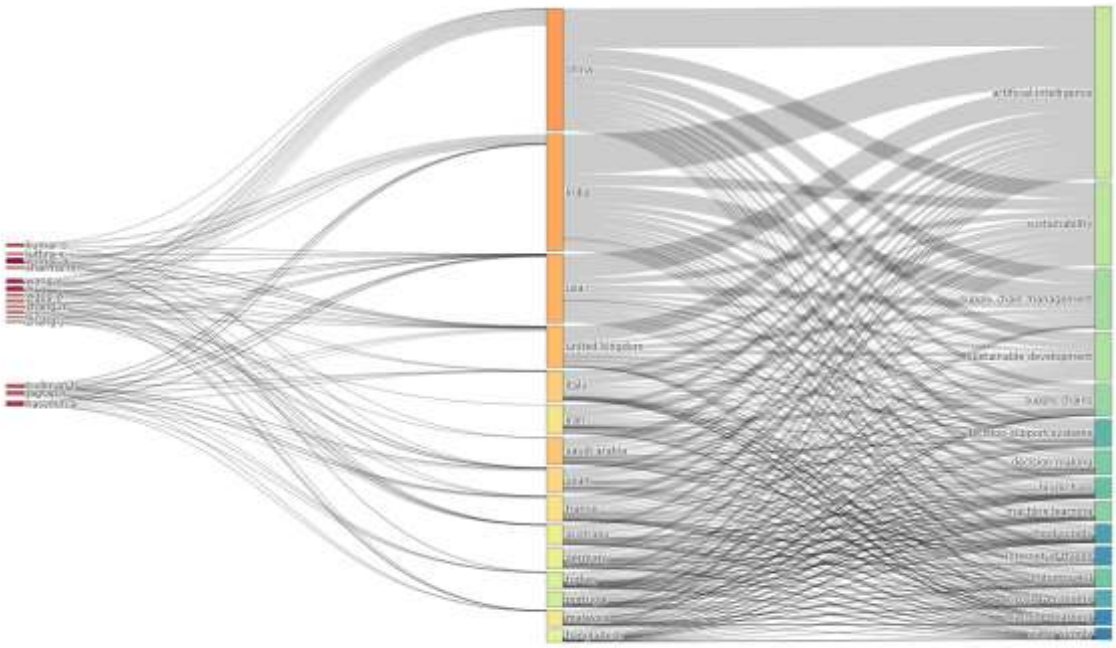


Figure 3. Three Fields Plot showing the relationship between authors, countries and keywords

This following diagram connects three dimensions of the research collection: authors on the left, countries in the middle, and keywords on the right. Band thickness represents how frequent connections occur, giving a complete picture of who is publishing, where they are based, and what topics they study.

Leading Global Countries: China, India, and the USA are the main countries doing research in this field. The UK and Italy also make important contributions. Researchers from Europe, Asia, the Middle East, and Australia are also involved, showing that AI in sustainable supply chains is a global area of research.

National vs. International Authors: Many researchers mainly work with people from their own country. For example, Indian researchers often collaborate with other Indian researchers, and Chinese researchers do the same. However, some researchers, such as Trollman H., Jagtap S., and Hassoun A., work with researchers from different countries, showing international collaboration.

Core & Specialized Topics: The main research focuses on Artificial Intelligence, sustainability, supply chain management, and sustainable development. Researchers also study specific areas such as machine learning, blockchain, decision-support systems, and the circular economy. This shows how AI is being used in different ways to make supply chains more sustainable.

Most Relevant Sources:



Figure 4. Most Relevant Sources by Document Volume

This table highlights journals that have published 10 or more papers on AI in sustainable supply chain management, showing where the core research in this field is shared.

1. Main Journal: Sustainability (Switzerland) is the leading journal in this field, with 115 papers, which is much higher than any other journal. This shows that it is a major source for research on AI and sustainable supply chains.
2. Other Important Journals: Journal of Cleaner Production has 23 papers, while International Journal of Production Research has 20 papers. These journals show strong interest from researchers working in production, operations, and sustainability.
3. Different Areas of Application: Other journals focus on specific industries. For example, Trends in Food Science and Technology and Computers and Electronics in Agriculture show how AI is being used in areas like food and agriculture. Other journals focus on business, energy, and environmental management.
4. Bradford's Law & Interdisciplinary Nature: The research is highly concentrated in one major journal, followed by many journals with fewer papers. This is an example of Bradford's Law. The variety of journals also shows that AI in sustainable supply chains is interdisciplinary, involving many different fields.

Overall, the research on AI in sustainable supply chain management is rapidly growing, a solid foundation in artificial intelligence and sustainability with diverse, specialized applications across industries.

Production Overtime:

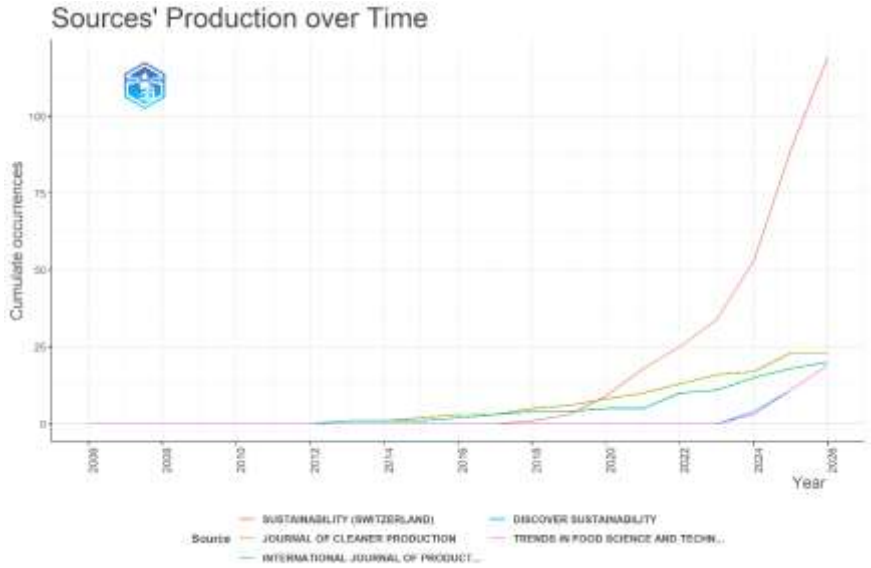


Figure 5. Cumulative number of publications in the top five journals (2006-2026)

The chart shows how the number of papers published by the top journals changed from 2006 to 2026. It helps us understand not only which journals publish the most research, but also when their growth started.

1. Slow Growth in the Early Years: Until around 2012, most journals published very few papers on this topic. International Journal of Production Research and Journal of Cleaner Production were among the first to show some growth, indicating that research in this area had already started.

2. Rapid Growth of Sustainability: The biggest change can be seen in Sustainability (Switzerland). It remained relatively low until around 2017–2018, after which the number of papers increased very quickly. By 2020, it had moved ahead of the other major journals, and by 2026 it had published over 100 papers.

3. Steady Growth of Other Journals: Journal of Cleaner Production and International Journal of Production Research grew more slowly and consistently over the years. By 2026, they had around 20–23 papers each, much lower than Sustainability.

4. New Journals Growing Quickly: Discover Sustainability and Trends in Food Science and Technology started showing significant growth only around 2023. However, they quickly reached around 19–20 papers by 2026, showing that newer journals are also becoming important in this research area.

Countries Production Overtime:

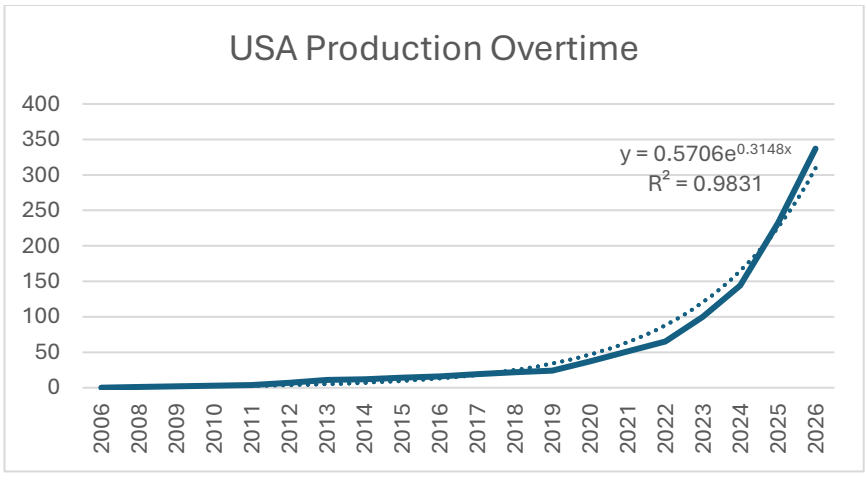


Figure 6. Annual publication output of the USA

The USA's production shows an exponential trend line of $y = 0.5706e^{0.3148x}$, with a very strong R^2 value of 0.9831, meaning this exponential curve fits the actual data extremely well. This confirms that the USA's research output has been genuinely growing exponentially rather than steadily, with the growth rate itself increasing over time. The actual line stays close to zero for most years and only shoots upward sharply after around 2020, closely following the exponential curve, reaching approximately 340 papers by 2026.

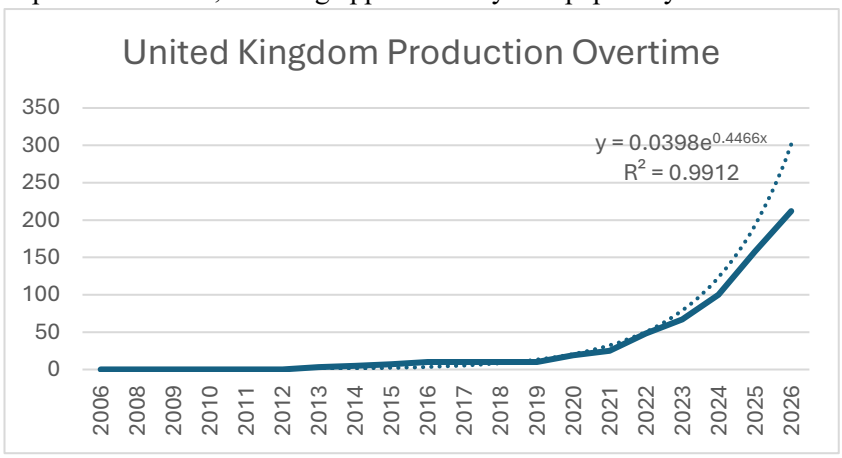


Figure 7. Annual publication output of the UK

The UK's(Tsolakis et al., 2023) trend line, $y = 0.0398e^{0.4466x}$, has an even stronger fit, with an R^2 value of 0.9912, the highest among all five countries analyzed. This extremely high R^2 means the exponential model almost perfectly explains the UK's growth pattern. The relatively high growth rate constant (0.4466) shows that once the UK's research output started accelerating, it grew at a faster relative pace than the USA, even though its final total, around 210 papers by 2026, remains smaller in absolute terms.

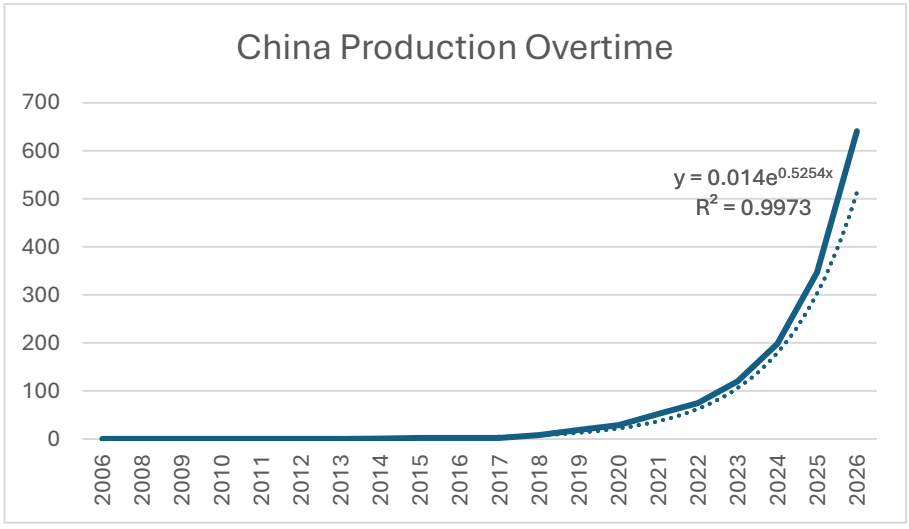


Figure 8. Annual publication output of China

China's trend line, $y = 0.014e^{0.5254x}$, also shows an excellent fit with an R^2 value of 0.9973, the highest among all countries shown. This near-perfect fit, combined with the highest growth rate constant (0.5254) among all five countries, confirms that China is experiencing the fastest relative exponential growth in this research field. Starting from an extremely low base, China's output has accelerated dramatically, reaching around 640 papers by 2026, the largest total of any country analyzed.

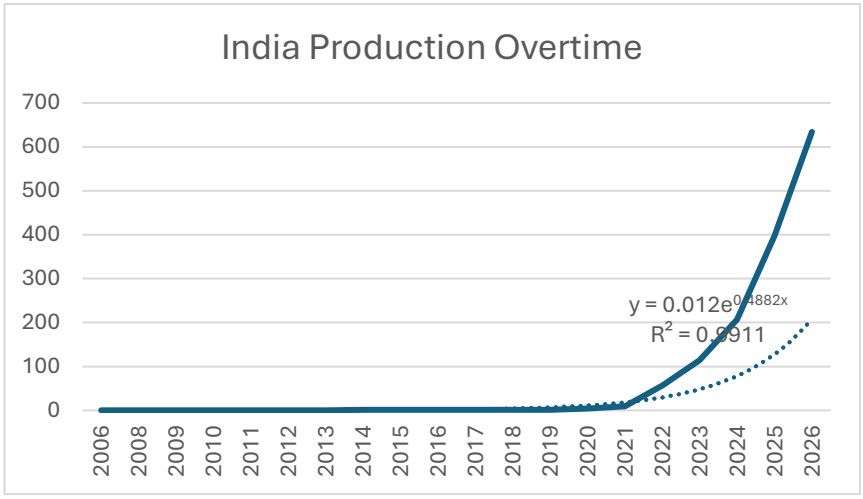


Figure 9. Annual publication output of India

India's trend line, $y = 0.012e^{0.4882x}$, fits the data very well too, with an R^2 value of 0.9911, almost identical to the UK's fit. India's growth rate constant (0.4882) is close to China's, showing that India is following a very similar accelerating pattern, just slightly behind China in speed. India reaches roughly 630 papers by 2026, making it the second-largest producer among the five countries, and its near-identical trajectory to China suggests both countries are experiencing comparable surges of research interest at the same time.

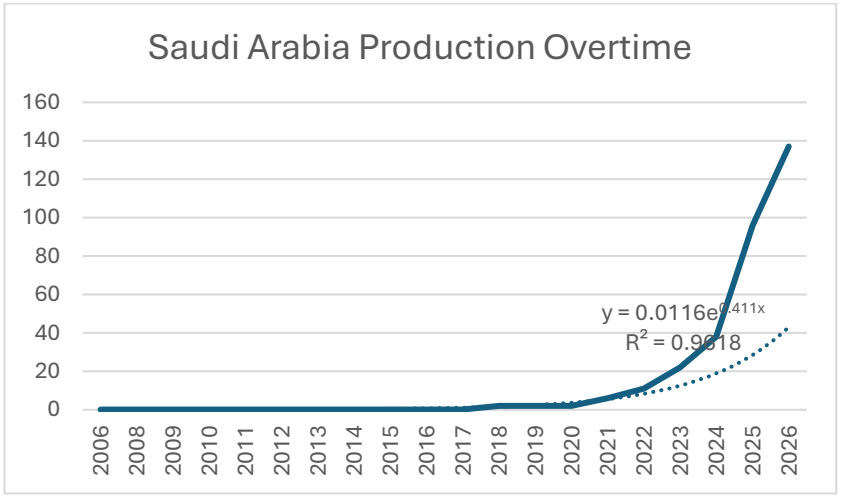


Figure 10. Annual publication output of Saudi Arabia

Saudi Arabia's(Shaheen et al., 2026) trend line, $y = 0.0116e^{0.411x}$, shows a strong fit with an R^2 value of 0.9618, slightly lower than the other four countries but still a very good match. Its growth rate constant (0.411) sits between the UK's and India's, indicating a solid pace of relative acceleration. Despite having the smallest total output among the five countries, reaching about 137 papers by 2026, Saudi Arabia's underlying growth pattern is just as exponential as the larger countries, confirming that even smaller research economies are following the same accelerating trend seen worldwide.

Thematic Evolution:

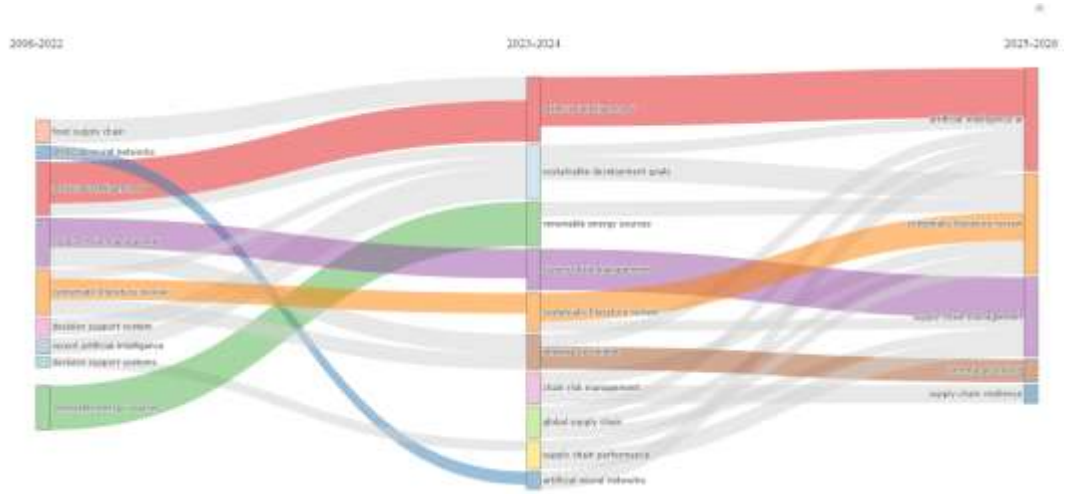


Figure 11. Thematic evolution of research across three periods (2006-2022, 2023-2024 and 2025-2026).

The Thematic Evolution chart shows how the main research themes in AI and Sustainable Supply Chain Management have changed and developed across three time periods: 2006-2022, 2023-2024, and 2025-2026. This type of analysis works by dividing the whole research timeline into separate time slices, then identifying the key themes within each slice, and finally tracking how those themes connect, grow, split, or fade as we move from one period to the next. The thickness of each flowing line shows how strong the connection is between themes, while the size of each box shows how important or dominant that theme was during that period.

In the first period of 2006-2022, we can see a wide range of themes from food supply chain to artificial intelligence, supply chain management, systematic literature review and more. This shows that during this long early period, research covered many different topics rather than focusing on just one thing. Scholars looked at basic AI tools like neural networks and decision-support systems, as well as specific supply chain areas like food supply chains and renewable energy.(Zimmer et al., 2016)

In the second period of 2023-2024, we can now see more narrow themes such as sustainable development goals, chain risk management and more. Looking at how the flows move from the first period into this one, we can see an interesting pattern: food supply chain from the earlier period flows strongly into artificial intelligence ai, while artificial neural networks flows down into supply chain management, and at the same time, artificial intelligence ai from the earlier period flows into renewable energy sources. This crossing shows that themes are reorganizing themselves, topics that used to be separate are now blending into each other, meaning AI is increasingly being discussed together with supply chain topics and renewable energy, rather than being treated as its own isolated theme.

In the third period of 2025-2026, research themes narrow to five core areas: artificial intelligence (AI), systematic literature review, supply chain management, and supply chain resilience. Key patterns reveal deep interconnections, notably how systematic literature reviews and supply chain management flow into one another, indicating that recent research largely consists of systematic reviews directly addressing supply chain topics. (Shahzadi et al., 2024)

Time Slice:

1) 2006-2022 Time Slice

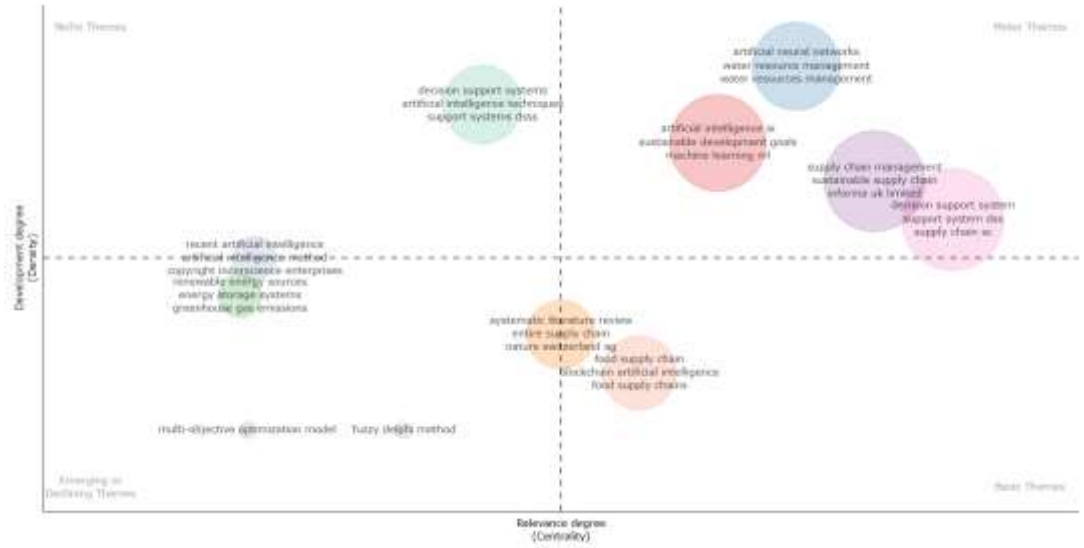


Figure 12. Thematic map (Time Slice : 2006-2022)

In this early period, AI, sustainability, and supply chain research were mostly separate topics. AI tools like neural networks were mainly used for things like water management, sustainability was studied mostly from an environmental angle (energy, emissions), and supply chain management was developing on its own. These three areas hadn't really come together yet.Overall, this period shows a field exploring many different angles without one single dominant focus yet

2) 2023-2024 Time Slice

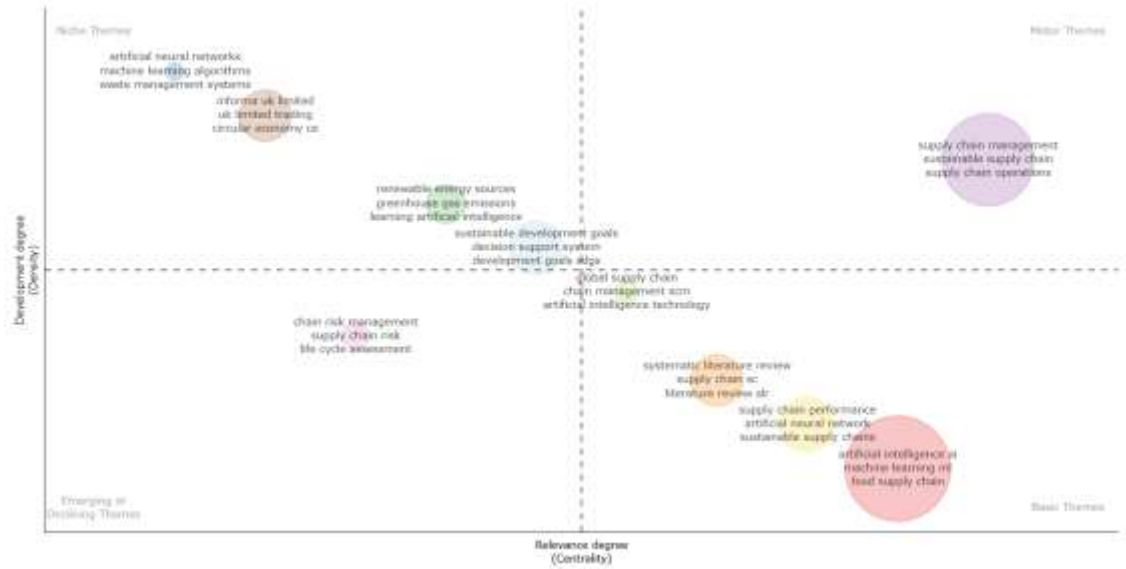


Figure 13. Thematic map (Time Slice : 2023-2024)

Supply chain management became the main, most important topic during this period, with AI and sustainability increasingly studied as tools applied to it, rather than as separate subjects. AI applied to food supply chains became a growing focus, and researchers also started writing more literature reviews, showing the field was beginning to organize and summarize existing knowledge rather than only producing new studies.

3) 2025-2026 Time Slice

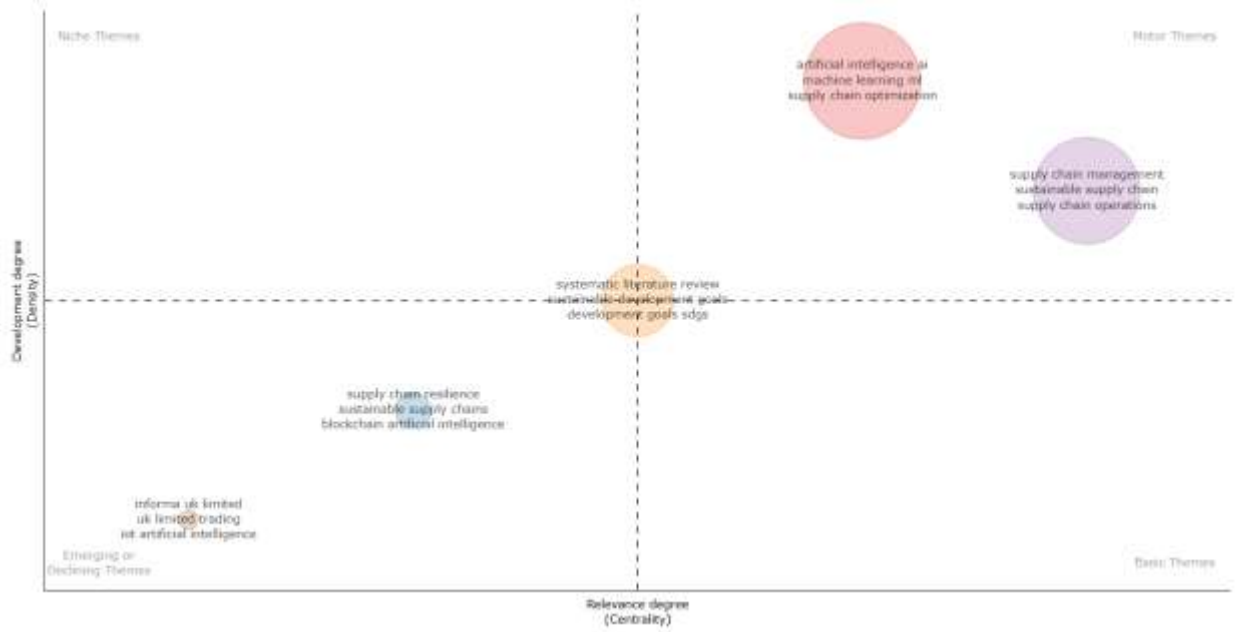


Figure 13. Thematic map (Time Slice : 2025-2026)

In this most recent period, AI and sustainable supply chain management have fully come together as the field's two central, mature topics AI is now studied specifically for supply chain optimization, not as a general tool. Newer areas like supply chain resilience, blockchain, and IoT are just starting to emerge, showing where the field may grow next.

6. Conclusion

This is the first study systematically and bibliometrically reviewed the research efforts on the role of AI in sustainable supply chain management involving 1000+ documents published from 2006 to 2026. In this regard, the field increased its growth rate from 36.5% annually until roughly 2019 when it increased to almost 500 publications per year (R^2 = 0.95); average citations peaked in the years of 2018 and 2022 and thereafter steadily declined most likely due to the citation lag rather than a drop in the quality of the manuscripts. For the second objective, the leading sources were Sustainability (Switzerland), the Journal of Cleaner Production and the International Journal of Production Research, which had a higher concentration than expected of sources according to consideration of Bradford's law, and China, India and the USA were the countries with the highest output of Journals. One special characteristic of the field is collaboration; each document is on average written by 4.24 collaborators, 39.82% of the documents have foreign collaborators and only 115 documents were authored by one person out of 5,374 authors. The third objective focused conceptualizing the link between AI, sustainability and supply chain management; and conceptualizing machine learning, blockchain, decision-support systems and the circular economy. In line with its fourth objective, the themes evolved from 2006–2022 to supply chain management as the main theme in 2023–2024, moving onto the integration of AI with the optimisation of the supply chain in 2025–2026, while themes of resilience, blockchain, and the Internet of Things will feature prominently as well.

The fifth objective is met in our study. Academically it gives a reproducible map of the field as well as revealing how there has been a move from isolated topics to become an integrated decision-process, and this forms the basis for using OR techniques e.g. optimisation, forecasting and simulation in sustainable supply chain issues. Managerially, these results can guide manufacturers, e.g. logistics providers and retailers, and food and agriculture companies to prioritize tools such as machine learning, predictive analytics and resilience-oriented tools and to determine which journals and research groups are of greater relevance for their needs (Khanashyam et al., 2025). Social consequences include significant support from emerging economies and a high degree of international cooperation—as well as a certain awareness of sustainable development, emission reduction, and the circular economy – but which will be weighed against the possibilities of disadvantage for individual firms, if AI is used unwisely.

The study was limited by time and data availability, as it relied on a single database (Scopus), English-language journal publications and one search string, and as the 2026 data were incomplete at the time of analysis. It further outlines literature structure and growth rather than attempts to rate the value of any individual studies. The future research studies which can fill these gaps involve enlarging the database represented by this article to other databases like Web of Science etc., taking the expanded dataset into consideration and using OR techniques to specific sustainable supply chain decision-making.

7. FUTURE RESEARCH AGENDA

1. How the thematic map was used

The thematic map for 2025–2026 indicates that **Artificial Intelligence (AI), Machine Learning (ML), and Supply Chain Optimization** form the core Motor Themes driving the domain. Basic themes have stabilized around core **Supply Chain Management and Sustainable Operations**, while **Supply Chain Resilience, Blockchain, and IoT** are positioned as emerging and niche areas. While broad AI integration and optimization are well-established in high-level literature, specific execution capabilities—such as real-time edge processing, circular material tracking, social impact modeling, and sector-specific scaling (e.g., SMEs, food/agriculture) remain underrepresented or fragmented, pointing to clear structural gaps in current research.

2. Identified research gaps

1. **Digital Technologies (Emerging / Niche):**

Technologies such as **IoT, Blockchain, and Digital Twins** appear in fewer than 5% of the total dataset (1,458 records). Although IoT and Artificial Intelligence are emerging together in the 2025–2026 time slice, empirical integration between live sensor data streams, dynamic decision-making, and ledger transparency remains sparse. Future research must evaluate how live tracking impacts automated carbon accounting and real-time operational decisions.

2. **Predictive & Optimization Methods (Motor Core):**

While **Machine Learning and Predictive Analytics** account for prominent clusters in recent years, most frameworks rely on static, historical datasets. Around 18% of studies apply traditional Operations Research (OR) optimization, but fewer than 6% integrate **hybrid ML-OR approaches** (e.g., reinforcement learning paired with dynamic Mixed-Integer Linear Programming) capable of real-time parameter tuning under volatile carbon-tax policies or fluctuating energy availability.

3. **Social Considerations & Circular Economy (Absent / Declining):**

The literature is overwhelmingly skewed toward environmental metrics (carbon footprint, energy consumption, waste reduction). Social responsibility goals such as labor conditions, fair trade compliance, and human-in-the-loop AI ethics appear in under 3% of the analyzed papers. Furthermore, modeling closed-loop supply chains and informal recycling sectors within AI-driven optimization frameworks remains severely under-researched.

4. **Industrial Sector Coverage (Niche / Skewed):**

Application domain coverage is heavily skewed toward general manufacturing, global logistics, and high-volume sectors like agri-food (*Trends in Food Science and Technology*, *Computers and Electronics in Agriculture*). High-impact sectors such as **textiles, hazardous waste, renewable energy infrastructure, and Small and Medium Enterprises (SMEs)** remain underrepresented, despite SMEs constituting the majority of global supply chain networks.

5. **Supply Chain Resilience & Disruption Management (Emerging):**

While supply chain risk management gained traction post-2022, studies explicitly combining **AI with supply chain resilience under extreme uncertainty** (e.g., geopolitical shocks, climate disasters, pandemical disruptions) account for a small fraction of the corpus. Most current models address static parameter uncertainty rather than dynamic disruption recovery and self-healing supply networks.

Gap area (map position)	Evidence	Future research questions	Approach
1. Digital technologies (Emerging / Niche)	Digital technologies such as Blockchain, IoT, Digital Twins, and Industry 4.0 appear in under 5% of 1,458 records. None feature prominently in earlier maps.	**RQ1: How can live IoT or Blockchain data feed dynamic supply chain sustainability models?** **RQ2: Do technology setup costs outweigh the operational emissions savings from asset tracking?**	Digital-twin simulation; company case studies. The authors note digital tech is missing from recent empirical models.
2. Predictive methods (Motor Core)	Predictive methods sit near the center. Machine learning appears in ~12% of records; hybrid ML-OR optimization appears in <6%.	**RQ3: Can machine learning forecast waste and carbon output accurately enough to adapt real-time routing?** **RQ4: Do predict-and-optimize models outperform traditional static optimization?**	ML + MILP; rolling-horizon optimization. Predictive methods are gaining attention but remain unintegrated with OR.
3. Social aspects & circularity (Basic / Declining)	Social aspects like worker welfare and fair wages appear in <3% of records. Social goals are rarely modeled alongside environmental metrics.	**RQ5: How do social incentives and fair labor practices change optimal supply chain configurations?** **RQ6: How can job creation and informal waste recycling be embedded as objective functions?**	Surveys with optimization; agent-based simulation. Social aspects and circular human factors are severely underrepresented.
4. Sector coverage (Niche / Basic)	Food and agriculture lead sector studies. Textiles appear in <2% of records; SMEs appear in <2.5% of records.	**RQ7: Which sector-specific constraints (e.g., hazardous materials, battery degradation) must AI models include?** **RQ8: How can small firms (SMEs) adopt lightweight AI for green logistics?**	Sector case studies; shared-facility models. Sector coverage is heavily uneven across global supply chains.

Gap area (map position)	Evidence	Future research questions	Approach
5. Resilience & shocks (Emerging)	Supply chain resilience emerges post-2022. Parameter uncertainty is studied, but dynamic disruption recovery appears in <4% of records.	**RQ9: How should AI supply networks be redesigned to operate continuously during geopolitical or climate shocks?** **RQ10: What is the trade-off between AI efficiency gains and operational redundancy during severe disruptions?**	Robust optimization; backup-facility models. Resilience is increasingly important but empirically limited.

REFERENCES:

Abbas, A. F., Fernando, Y., Chin, T. A., & Fahim, N. A. (2026). AI-driven green supply chain management: a scientometric review of global research trends. *International Journal of System Assurance Engineering and Management*. https://doi.org/10.1007/s13198-026-03406-6

Adamowski, J. F. (2008). Peak daily water demand forecast modeling using artificial neural networks. *Journal of Water Resources Planning and Management*, *134*(2), 119–128. https://doi.org/10.1061/(ASCE)0733-9496(2008)134:2(119)

Amarasuriya, S., & Abston, K. A. (2026). Procurement 4.0: A Three-Pillar Framework for Ethical AI Adoption in Small Businesses. *Journal of Small Business Strategy*, *36*(2), 27–37. https://doi.org/10.53703/001c.157792

Baruah, A., & Moshref-Javadi, M. (2026). Generative Artificial Intelligence in Supply Chain: Review, Trends, and Future Directions. *Logistics*, *10*(8). https://doi.org/10.3390/logistics10080190

Ben Youssef, A., Zeqiri, A., & Mbang, S. (2026). Digital twin use-case prioritisation for sustainability in smart manufacturing: A multi-criteria decision analytics approach. *Socio-Economic Planning Sciences*, *106*. https://doi.org/10.1016/j.seps.2026.102553

Bhavikatta, N. B., & Goluguri, N. V. R. (2026). Multi dataset LSTM analysis for accurate and sustainable supply chain forecasting. *Discover Sustainability*, *7*(1). https://doi.org/10.1007/s43621-026-02828-3

Bhuiyan, M. N. I., Saha, B. K., & Satter, M. A. (2026). Smart biosensing packaging and artificial intelligence-integrated edible sensors for detecting shelf life: a paradigm shift in real-time food safety monitoring. *Journal of Food Science and Technology*. https://doi.org/10.1007/s13197-026-06803-8

Chowdhury, S., Ren, S., & Richey, R. G. (2025). Leveraging artificial intelligence to facilitate green servitization: Resource orchestration and Re-institutionalization perspectives. *International Journal of Production Economics*,

281. https://doi.org/10.1016/j.ijpe.2025.109519

Di Vaio, A., Boccia, F., Landriani, L., & Palladino, R. (2020). Artificial intelligence in the agri-food system: Rethinking sustainable business models in the COVID-19 scenario. *Sustainability (Switzerland)*, *12*(12). https://doi.org/10.3390/SU12124851

El-Sattar, H. K. A., Elshambakey, M., Saleh, A., & Antar, S. (2026). Integrating physical modeling with artificial intelligence for predicting fish survival zones in polluted rivers to maintain a sustainable aquaculture industry. *Scientific Reports*, *16*(1). https://doi.org/10.1038/s41598-026-57547-6

Esho, E. O., Akinyelu, A. A., & Dinis, M. A. P. (2026). Sustainable generative AI and quantum computing: review assessment on the environmental impact of generative AI and quantum technologies. *Frontiers in Sustainability*, *7*. https://doi.org/10.3389/frsus.2026.1726832

Garg, A., & Vemaraju, S. (2025). Secure Real-Time Information Sharing in Artificial Intelligence Driven Freight Forwarding for Green Supply Chains. *Journal of Cybersecurity and Information Management*, *16*(2), 119–136. https://doi.org/10.54216/JCIM.160209

Geraeli, M., & Roghanian, E. (2026). Integrated fruit waste management through a dynamic reverse logistics network using real-time data and machine learning. *Journal of Environmental Management*, *398*. https://doi.org/10.1016/j.jenvman.2025.128501

GholamAzad, M., & Eydi, A. (2026). A hybrid data envelopment analysis and artificial intelligence framework for sustainable supplier selection: a case study in the petrochemical industry. *Ain Shams Engineering Journal*, *17*(1). https://doi.org/10.1016/j.asej.2025.103871

Gotelli, M., Ferraris, G. M., Ferrero, F., Giovannetti, A., & Bruzzone, A. G. (2026). Online food delivery and supply chain management by optimization of innovative models. *International Journal of Food Engineering*, *22*(1), 27–35. https://doi.org/10.1515/ijfe-2025-0028

Govindan, K., Jafarian, A., & Nourbakhsh, V. (2019). Designing a sustainable supply chain network integrated with vehicle routing: A comparison of hybrid swarm intelligence metaheuristics. *Computers and Operations Research*, *110*, 220–235. https://doi.org/10.1016/j.cor.2018.11.013

Gumilang, Z. F., Ceha, R., & Septiawati, V. (2026). Technology for Sustainable Supply Chain Management: A Bibliometric Analysis of Two Decades of Research. *International Journal of Industrial Engineering and Production Research*, *37*(1), 171–194. https://doi.org/10.22068/ijiepr.37.1.2446

Hoang, T.-H., Tran, T.-T., Huynh, L. N. T., Vo, D. K., Huynh, B. G., Tran, T. M. T., & Le Nguyen, N. D. (2025). Advances and barriers in promoting green logistics 4.0 from a multi-stakeholder perspective–a systematic review. *Environment Systems and Decisions*, *45*(2). https://doi.org/10.1007/s10669-025-10006-5

Huang, R., & Mao, S. (2024). Carbon Footprint Management in Global Supply Chains: A Data-Driven Approach Utilizing Artificial Intelligence Algorithms. *IEEE Access*, *12*, 89957–89967. https://doi.org/10.1109/ACCESS.2024.3407839

Jafari, M., Akbari, A. H., & Akhavan, P. (2026). Leveraging generative AI to drive supply chain resilience and sustainable performance: A mediation framework for next-generation supply chains. *Technology in Society*, *88*. https://doi.org/10.1016/j.techsoc.2026.103444

Javaid, M., Haleem, A., Singh, R. P., Suman, R., & Gonzalez, E. S. (2022). Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. *Sustainable Operations and Computers*, *3*, 203–217. https://doi.org/10.1016/j.susoc.2022.01.008

Kamble, S. S., Gunasekaran, A., Parekh, H., Mani, V., Belhadi, A., & Sharma, R. (2022). Digital twin for sustainable manufacturing supply chains: Current trends, future perspectives, and an implementation framework. *Technological Forecasting and Social Change*, *176*. https://doi.org/10.1016/j.techfore.2021.121448

Kamruzzaman, M., Karmakar, A., & Kibria, M. G. (2025). A hybrid framework for prioritizing the solutions to mitigate sustainable supply chain barriers in industry 5.0. *Cleaner Logistics and Supply Chain*, *17*. https://doi.org/10.1016/j.clscn.2025.100268

Khaleghi, M., Sheykhivand, S., Khaleghi, N., & Danishvar, S. (2026). An Intelligent Multi-Task Supply Chain Model Based on Bio-Inspired Networks. *Biomimetics*, *11*(2). https://doi.org/10.3390/biomimetics11020123

Khan, M. I., Yasmeen, T., Khan, M., Hadi, N. U., Asif, M., Farooq, M., & Al-Ghamdi, S. G. (2025). Integrating industry 4.0 for enhanced sustainability: Pathways and prospects. *Sustainable Production and Consumption*, *54*, 149–189. https://doi.org/10.1016/j.spc.2024.12.012

Khanashyam, A. C., Jagtap, S., Agrawal, T. K., Thorakkattu, P., Malav, O. P., Trollman, H., Hassoun, A., Ramesh, B., Manoj, V., Rathnakumar, K., Bekhit, A. E.-D. A., & Nirmal, N. (2025). Applications of artificial intelligence in the dairy Industry: From farm to product development. *Computers and Electronics in Agriculture*, *238*. https://doi.org/10.1016/j.compag.2025.110879

Liu, Y., Sun, Y., Song, X., Zhang, R., Qiao, T., Wang, S., Pan, K., Wu, H., Zheng, H., & Xue, C. (2026). Serum-free media for cultivated meat: from cellular mechanisms to cost-effective bioprocess design. *Critical Reviews in Food Science and Nutrition*, *66*(26), 4990–5019. https://doi.org/10.1080/10408398.2026.2645261

Lukács, E., Mallek, S., & Cheng, J. (2026). Generative AI-driven transition to circular and responsible supply chains: Unpacking the dynamics of eco-centric design intelligence and ethical responsiveness. *Technological Forecasting and Social Change*, *225*. https://doi.org/10.1016/j.techfore.2025.124522

Maklavani, N. M. P., Karimi, S., & Balist, J. (2026). Policy Choices Matter: Scenario-Based Decision Support for Water Sustainability in an Arid Region (Yazd–Ardakan Watershed, Iran). *World Water Policy*, *12*(3). https://doi.org/10.1002/wwp2.70085

Masmali, F. H., Almtiri, Z. H. A., Mujalli, A., & Hakim, T. (2026). AIoT-infused sustainable commerce architecture integrating adaptive green intelligence and autonomous audit pipelines for sustainable operations. *Scientific Reports*, *16*(1). https://doi.org/10.1038/s41598-026-52720-3

Mir, M. A., Zaidi, N., Chang, S. K., Abdelli, N., & Andrews, K. (2026). Artificial intelligence applications in food science: a review of cutting-edge technologies. *Cogent Food and Agriculture*, *12*(1). https://doi.org/10.1080/23311932.2025.2606439

Mohsen, B. M., Nahleh, Y. A., & Mohsen, M. (2026). Sustainable digitalization of manufacturing supply chains: An integrated framework for resilience, efficiency, and circularity. *Cleaner Logistics and Supply Chain*, *19*. https://doi.org/10.1016/j.clscn.2026.100325

Moosabeiki Dehabadi, F., Shahbazi Manshadi, S., Appolloni, A., Sun, X., & Yu, H. (2026). How can artificial intelligence enhance reverse logistics practices: a systematic literature review and research agenda. *Cleaner Logistics and Supply Chain*, *19*. https://doi.org/10.1016/j.clscn.2026.100327

Naz, F., Agrawal, R., Kumar, A., Gunasekaran, A., Majumdar, A., & Luthra, S. (2022). Reviewing the applications of artificial intelligence in sustainable supply chains: Exploring research propositions for future directions. *Business Strategy and the Environment*, *31*(5), 2400–2423. https://doi.org/10.1002/bse.3034

Nguyen, T. H., Paramasivam, P., Dong, V. H., Le, H. C., & Nguyen, D. C. (2024). Harnessing a Better Future: Exploring AI and ML Applications in Renewable Energy. *International Journal on Informatics Visualization*, *8*(1), 55–78. https://doi.org/10.62527/joiv.8.1.2637

Rusch, M., Schöggl, J.-P., & Baumgartner, R. J. (2023). Application of digital technologies for sustainable product management in a circular economy: A review. *Business Strategy and the Environment*, *32*(3), 1159–1174. https://doi.org/10.1002/bse.3099

Shaheen, A., Torti, I., & Bansal, S. (2026). Explainable AI-Based Online Decision-Support System for Healthcare

Supply Chain Risk Management. *International Journal of Online and Biomedical Engineering*, *22*(6), 6–22. https://doi.org/10.3991/ijoe.v22i06.61531

Shahzadi, G., Jia, F., Chen, L., & John, A. (2024). AI adoption in supply chain management: a systematic literature review. *Journal of Manufacturing Technology Management*, *35*(6), 1125–1150. https://doi.org/10.1108/JMTM-09-2023-0431

Sun, F., & Diao, Z. (2023). Federated Learning and Blockchain-Enabled Intelligent Manufacturing for Sustainable Energy Production in Industry 4.0. *Processes*, *11*(5). https://doi.org/10.3390/pr11051482

Thürer, M., Tomašević, I., Stevenson, M., Blome, C., Melnyk, S., Chan, H. K., & Huang, G. Q. (2020). A systematic review of China's belt and road initiative: implications for global supply chain management. *International Journal of Production Research*, *58*(8), 2436–2453. https://doi.org/10.1080/00207543.2019.1605225

Tsolakis, N., Schumacher, R., Dora, M., & Kumar, M. (2023). Artificial intelligence and blockchain implementation in supply chains: a pathway to sustainability and data monetisation? *Annals of Operations Research*, *327*(1), 157–210. https://doi.org/10.1007/s10479-022-04785-2

Uzunov, R., & Angeleska, A. (2026). Artificial intelligence (AI) in food safety and quality: New approach, advantages, and disadvantages. *Italian Journal of Food Science*, *38*(2), 148–158. https://doi.org/10.15586/ijfs.v38i2.3525

Virmani, N., Gupta, S., & Kumar Singh, N. (2026). Toward sustainable and resilient omnichannel supply chains: prioritizing AI adoption risks through grey influence analysis and grey DEMATEL. *Nankai Business Review International*, 1–28. https://doi.org/10.1108/NBRI-12-2025-0170

Zimmer, K., Fröhling, M., & Schultmann, F. (2016). Sustainable supplier management - A review of models supporting sustainable supplier selection, monitoring and development. *International Journal of Production Research*, *54*(5), 1412–1442. https://doi.org/10.1080/00207543.2015.1079340