

# Sustainable Logistics: A Bibliometric Mapping of Green Practices, Challenges, and Innovations

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## ABSTRACT

This study aims to map the intellectual structure, thematic evolution, and emerging research directions in sustainable logistics through a bibliometric analysis of green practices, key challenges, and innovation trends. Data were collected from the Scopus database and analyzed using VOSviewer and Bibliometrix to examine keyword co-occurrence, thematic clusters, and temporal developments. The findings reveal that sustainable development, sustainability, and logistics constitute the central foundation of the field, with strong emphasis on green supply chain management and environmental impact mitigation. Early research predominantly focused on emission control and environmental measurement, while recent studies show a shift toward innovation-driven approaches, including digital technologies, circular practices, and data-based decision-making. Despite this progression, emerging themes such as machine learning and information management remain less integrated into the core discourse. This study contributes by providing a comprehensive and structured understanding of sustainable logistics research, highlighting the interconnected roles of green practices, operational challenges, and innovation. The results offer insights for academics and practitioners in identifying future research opportunities and developing more integrated and forward-looking sustainable logistics strategies.

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## 1. INTRODUCTION

Sustainable logistics has emerged as a critical area of study in response to the rapid expansion of global trade, industrialization, and supply chain complexity. Logistics systems play a fundamental role in enabling the efficient movement of goods, yet they are also significant contributors to environmental degradation, including greenhouse gas emissions, air pollution, and resource

depletion. Freight transportation alone generates substantial negative externalities such as congestion, noise, and infrastructure strain, which increasingly threaten ecological balance and societal well-being. As global logistics demand continues to grow, these environmental impacts intensify, making sustainability an urgent priority for both policymakers and practitioners [1], [2].

In response to these challenges, the concept of sustainable or green logistics has

gained traction as a strategic approach to minimizing environmental harm while maintaining economic efficiency. Green logistics encompasses the integration of environmentally friendly practices into logistics operations, including energy-efficient transportation, reverse logistics, waste reduction, and the adoption of low-emission technologies. These practices aim to balance the triple bottom line of economic, environmental, and social performance, aligning logistics systems with broader sustainable development goals. Moreover, sustainable logistics is not limited to operational improvements but extends to the entire lifecycle of supply chain activities, from sourcing to final delivery [3], [4].

The increasing urgency of climate change and global sustainability targets has further accelerated interest in green logistics practices. The logistics sector is heavily reliant on carbon-intensive transportation modes such as trucks, ships, and airplanes, making it a significant contributor to global CO<sub>2</sub> emissions. Recent studies indicate that transportation emissions continue to rise, highlighting the need for systemic transformation within logistics systems. Governments and organizations worldwide are therefore implementing regulations, incentives, and technological innovations to promote cleaner and more efficient logistics practices. In this context, sustainable logistics is no longer a voluntary initiative but a strategic necessity for achieving long-term competitiveness and regulatory compliance [5], [6].

Alongside practical developments, academic research on sustainable logistics has grown rapidly over the past two decades. Bibliometric evidence shows a significant increase in publications, reflecting the expanding scholarly interest in this field. Research themes have evolved from basic environmental concerns to more complex topics such as digitalization, circular economy integration, smart logistics, and artificial intelligence applications. Furthermore, studies have identified multiple thematic clusters, including policy and management,

technological innovation, operational optimization, and sustainability performance measurement. This diversification highlights the interdisciplinary nature of sustainable logistics and its relevance across various sectors, including manufacturing, e-commerce, and urban distribution.

Despite the growing body of literature, the field of sustainable logistics remains fragmented and characterized by conceptual ambiguities. Existing studies often present inconsistent findings regarding the relationships between green logistics practices, organizational performance, and sustainability outcomes. Moreover, the diversity of theoretical frameworks and methodological approaches has led to partial and sometimes contradictory understandings of key concepts. For instance, while some studies emphasize the economic benefits of green logistics, others highlight potential trade-offs and implementation challenges. These inconsistencies underscore the need for a comprehensive synthesis of existing research to identify dominant trends, knowledge gaps, and future research directions.

Although research on sustainable logistics has expanded significantly, the literature remains dispersed across various disciplines, lacking a unified framework that systematically maps green practices, challenges, and innovations. The absence of an integrated bibliometric perspective limits the ability to understand the intellectual structure, thematic evolution, and emerging research frontiers in this field. Furthermore, inconsistencies in theoretical and methodological approaches create confusion regarding the effectiveness and implementation of sustainable logistics practices. Therefore, there is a critical need for a comprehensive bibliometric mapping study that consolidates existing knowledge, identifies key research clusters, and provides a clearer direction for future investigations. This study aims to conduct a comprehensive bibliometric mapping of sustainable logistics research to analyze the development of green practices, identify major challenges, and



performance” and “industry 4.0,” indicating that operational improvements and technological advancements are frequently discussed as mechanisms to enhance environmental outcomes. This cluster highlights a strong managerial and operational orientation, where firms attempt to align logistics activities with environmental standards through process optimization and digital transformation.

The visualization also identifies a distinct environmental impact and carbon-related cluster, characterized by keywords such as “carbon,” “carbon dioxide,” “emission control,” and “energy utilization.” The density and connectivity of these nodes suggest that emission reduction remains a critical concern within sustainable logistics research. The linkage between these terms and “decision making” and “regression

analysis” indicates that this stream of research is highly quantitative, focusing on measurement, modeling, and optimization of environmental impacts rather than purely conceptual discussions.

Another important cluster revolves around innovation and technological integration, where terms such as “machine learning,” “information management,” and “life cycle” appear connected to sustainability themes. Although these nodes are relatively smaller compared to core sustainability terms, their presence signals an emerging research direction. This suggests that the field is gradually moving toward data-driven and technology-enabled logistics solutions, where advanced analytics and digital tools are leveraged to improve sustainability outcomes across the supply chain.

### 3.2 Overlay Visualization

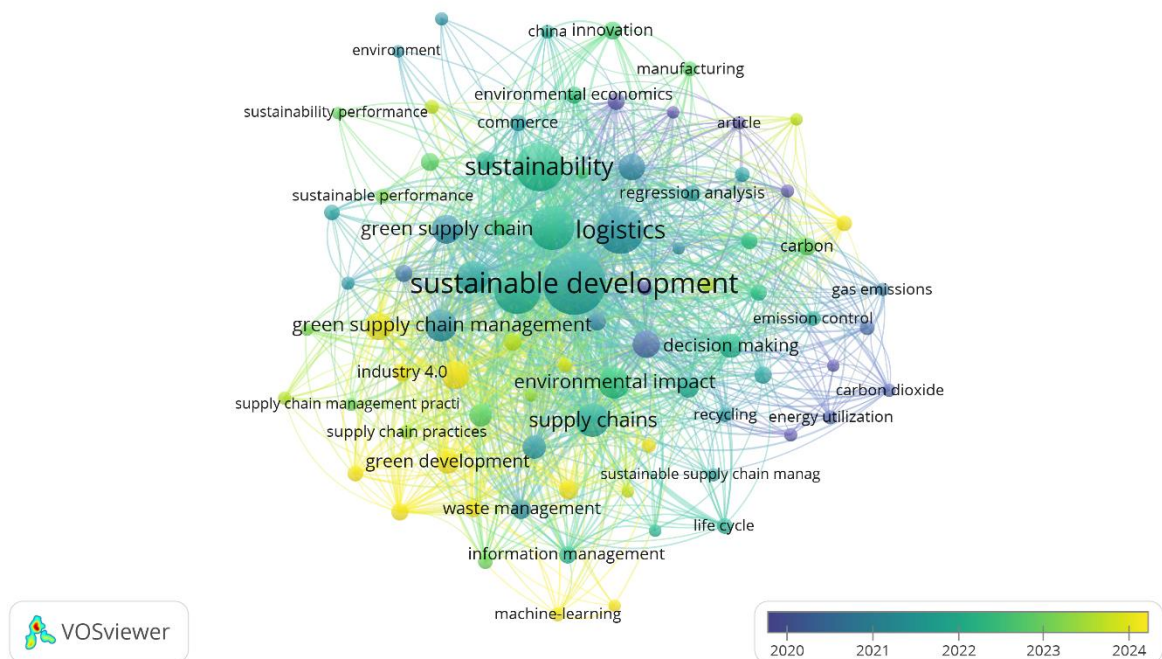


Figure 2. Overlay Visualization

Source: Data Analysis Result, 2026

Figure 2 highlights the temporal evolution of sustainable logistics research, where color gradients indicate the average publication year of each keyword. Core terms

such as “sustainable development,” “logistics,” and “sustainability” appear in green tones, suggesting that they have remained consistently central over time,

particularly around the mid-phase of the research period. This indicates that the field has been anchored by these foundational concepts, which continue to serve as the backbone for subsequent thematic developments.

Earlier research themes, represented by darker blue tones, are concentrated around topics such as “carbon,” “carbon dioxide,” “emission control,” and “energy utilization.” This pattern suggests that initial studies in sustainable logistics were heavily focused on environmental impact measurement and emission reduction, often employing quantitative and analytical approaches such as regression analysis. These early efforts laid the groundwork by identifying environmental challenges and establishing

metrics for assessing sustainability performance within logistics systems.

More recent themes, shown in yellow hues, indicate a shift toward innovation-driven and system-oriented approaches. Keywords such as “green development,” “supply chain practices,” “waste management,” “machine learning,” and “industry 4.0” reflect a growing emphasis on integrating digital technologies and advanced practices into sustainable logistics. This evolution suggests that the field is moving beyond problem identification toward solution-oriented research, where technological innovation, circular practices, and data-driven decision-making play a central role in shaping the future of sustainable logistics.

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
822	[7]	Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal
408	[8]	An empirical study of green supply chain management practices amongst UK manufacturers
385	[9]	Adoption of green supply chain management practices and their impact on performance: An exploratory study of Indian manufacturing firms
342	[10]	In search of a circular supply chain archetype—a content-analysis-based literature review
341	[11]	Stakeholder pressure in sustainable supply chain management: A systematic review
301	[12]	Impact of supply chain management practices on sustainability
282	[13]	Green supply chain management, economic growth and environment: A GMM based evidence
281	[14]	Fuzzy AHP-TOPSIS approaches to prioritizing solutions for reverse logistics barriers
255	[15]	Lean, green practices and process innovation: A model for green supply chain performance
247	[16]	Exploring financial performance and green logistics management practices: Examining the mediating influences of market, environmental and social performances

Source: Scopus, 2026



environmental and social objectives can be operationalized within supply chains. At the same time, the close interconnection among these core concepts indicates that the field has moved toward a more integrated perspective, where sustainability is embedded within logistics decision-making rather than treated as an external constraint.

The network structure further highlights the importance of green supply chain management as one of the most established research streams. Terms such as green supply chain, supply chain practices, and sustainability performance appear tightly clustered, showing that many studies focus on how firms can redesign their operations to align with environmental objectives. This stream emphasizes process improvements, resource efficiency, and the adoption of environmentally friendly practices across the supply chain. The linkage with industry 4.0 also suggests that digital transformation is increasingly seen as an enabler of greener logistics operations, particularly in enhancing transparency, coordination, and performance monitoring.

Another important insight emerges from the strong presence of environmental impact and emission-related themes, particularly in earlier stages of the literature. Keywords related to carbon emissions, energy utilization, and emission control indicate that initial research was heavily oriented toward measuring and mitigating environmental damage. These studies often relied on quantitative approaches to assess the environmental footprint of logistics activities, providing a foundation for understanding the scale and nature of sustainability challenges. Over time, however, the focus appears to have shifted from measurement toward more

strategic and solution-oriented perspectives, reflecting a gradual maturation of the field.

The temporal and density analyses reveal a noticeable transition toward innovation-driven research in more recent years. Emerging topics such as machine learning, information management, waste management, and circular practices indicate that the field is beginning to explore new pathways for achieving sustainability. This shift suggests that researchers are increasingly interested in how technological advancements and data-driven approaches can support more efficient and sustainable logistics systems. Despite this progress, these themes remain less dense compared to the core topics, indicating that their integration into the mainstream literature is still evolving and requires further development.

#### 4. CONCLUSION

This study provides a comprehensive mapping of sustainable logistics research by revealing its intellectual structure, thematic evolution, and emerging directions through a bibliometric approach. The findings show that the field is anchored by core concepts such as sustainable development, sustainability, and logistics, with strong emphasis on green supply chain management and environmental impact mitigation. Over time, the focus has shifted from measuring environmental challenges toward exploring innovation-driven solutions, including digital technologies and circular practices. Despite this progress, emerging themes such as machine learning and information management remain underdeveloped compared to established topics, indicating opportunities for further exploration.

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