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Enhancing environmental stability through green logistics management: Current trends and future prospects in sustainable logistics performance

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ABSTRACT

The growing environmental awareness among stakeholders has intensified pressure on businesses to reduce ecological footprints through supply chain operations. This literature review examines how green supply chain management (GSCM) enhances sustainable logistics while addressing global warming and biodiversity concerns. Analysis of 880 publications (1998–2017) from major databases reveals substantial growth in GSCM research since 2010. China (18.6%) and the US (18.2%) lead contributions, with the Journal of Cleaner Production publishing the most papers (80, ~9%) and maintaining the highest impact factor (5.7). Business management dominates as the primary discipline (23%), with Joseph Sarkis emerging as the most prolific author (26 publications, 3%). Emerging trends indicate companies implementing GSCM practices have achieved 15–25% reduction in carbon emissions and 8-12% improvement in operational efficiency. Implementation challenges include insufficient technical knowledge, higher initial costs, and organizational resistance to change. Future research directions should leverage big data for performance evaluation, involve small businesses in GSCM adoption, and conduct comparative studies across industries and countries. Additionally, researchers should explore integration of circular economy principles with GSCM practices and develop standardized metrics for measuring environmental impact throughout supply chains. The evidence demonstrates GSCM's vital role in creating environmentally responsible and economically viable logistics operations, positioning it as a strategic imperative for businesses navigating increasingly stringent environmental regulations.

Keywords: environmental impact reduction, green logistics management, sustainable logistics performance, supply chain sustainability, future trends in GSCM.

INTRODUCTION

Global sustainability is at immediate risk due to increasing global warming and changing biodiversity. The significant interaction between human activities, natural resources, and climate change has created urgent environmental challenges requiring immediate attention. Scholars, experts, and professionals from diverse fields are collaborating to develop strategies for environmental sustainability. Industries' careless behavior significantly threatens sustainability (King and Lenox, 2000). Consequently, modern corporations prioritize sustainable practices, addressing external environmental problems, also referred to as the "going green" goal (Bansal and Roth, 2000). The term "green" signifies actions mindful of ecological or environmental issues. Supply chains, a critical component of operations management, have a considerable environmental impact, contributing to emissions, pollution, and health hazards. To mitigate these effects, organizations are increasingly adopting green supply chain management (GSCM), integrating environmental considerations into supply chain processes (Sarkis, 2012).

This study aims to provide a literature review analyzing the evolution and current state of GSCM research, identify key trends and contributors in

the field, and propose future research directions that address the critical interaction between business practices and environmental sustainability. Although GSCM research has grown substantially over the past 20 years, further investigation is necessary. Previous studies (Soda et al., 2016) review substantial GSCM literature. Some focus on methodologies (Govindan et al., 2015), (Soda et al., 2016), while others emphasize practices like green logistics management and its role in sustainable logistics performance (Islam et al., 2017; Igarashi et al., 2013). Connections between "green" and "sustainable" supply chains have also been explored (Ahi and Searcy, 2013), alongside broader topics (Srivastava, 2007), (Malviya and Kant, 2015). However, subjective reviews may introduce bias, underscoring the need for objective methods. This study examines 880 publications (1998–2017) using Scopus and ISI Web of Science databases, analyzing influential authors, top journals, institutions, and nations. Key contributions include an integrated GSCM definition, novel findings differing from prior studies, and a multidimensional view of GSCM. A comprehensive conceptual framework is proposed to guide future research and provide valuable insights for academics and practitioners.

Green logistics management

GSCM has emerged as a critical approach for enhancing environmental performance in business operations. The concept has evolved significantly over time, with its academic foundations taking shape in the 1990s, though it only gained mainstream recognition after 2000, as noted by several researchers including Ahi and Searcy (2013), Seuring and Müller (2008), and Srivastava (2007).

The Figure 1 illustrates the historical development and core components of Green Logistics Management. It shows a timeline spanning from the 1960s to the present, highlighting how the concept evolved from its environmental management roots in the 1960s, through academic foundation-building in the 1990s, to mainstream prominence after 2000, and finally to its current integration into broader business strategy. The central portion of the diagram outlines three core components of Green Logistics Management. Environmental integration encompasses environmental considerations, supply chain strategies, sustainability metrics, and eco-friendly processes. Reverse logistics focuses on product recovery, waste management, returns processing, and

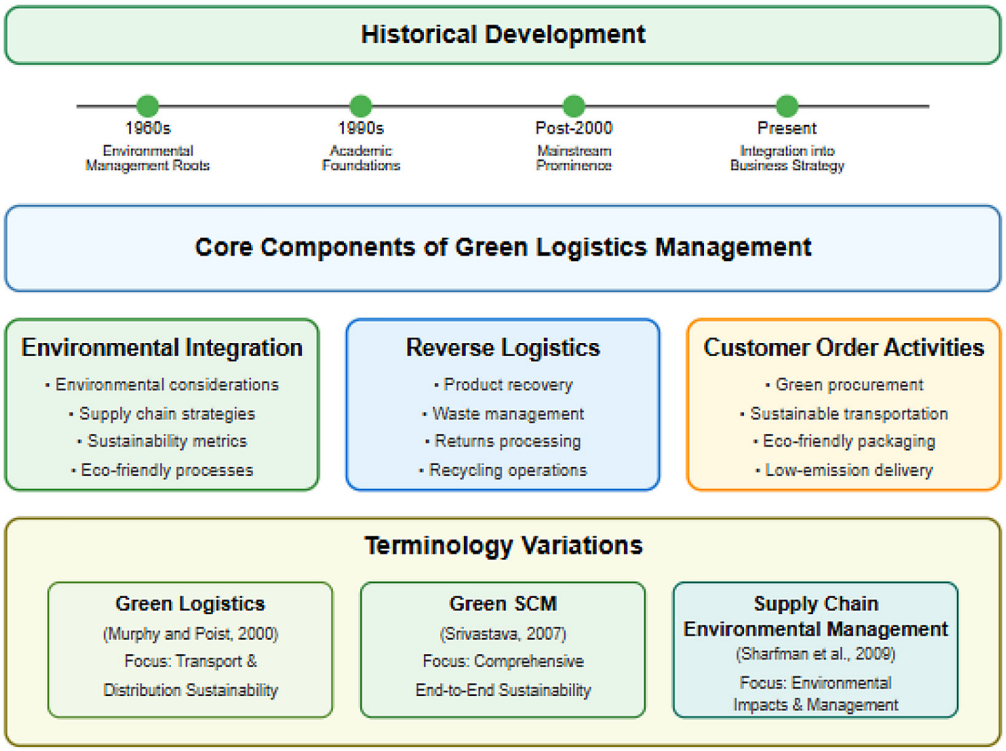

Figure 1. Green logistics management (Ahi and Searcy, 2013; Seuring and Müller, 2008; Sarkis et al., 2011; Handfield et al., 1997)

recycling operations. Customer order activities include green procurement, sustainable transportation, eco-friendly packaging, and low-emission delivery methods.

The bottom section addresses terminology variations in the field. "Green logistics" as defined by Murphy and Poist (2000), focuses primarily on transport and distribution sustainability. "Green SCM" described by Srivastava (2007), takes a more comprehensive end-to-end sustainability approach. "Supply chain environmental management" according to Sharfman et al. (2009), concentrates specifically on environmental impacts and their management throughout the supply chain. This diversity in terminology reflects the field's evolution and interdisciplinary nature, as researchers and practitioners continue to refine approaches to integrating environmental considerations into logistics and supply chain operations. Despite these variations, all approaches share the fundamental goal of reducing environmental impact while maintaining operational efficiency and business performance.

BACKGROUND

Ahi and Searcy (2013) conducted a systematic literature review and a comparative analysis of the literature to define green and sustainable supply chain management. Their work highlighted the inconsistencies in terminology across the field and established a framework for distinguishing between these two related but distinct concepts, providing clarity for future research. Albino et al. (2009) provided an overview of sustainability-driven companies, focusing on environmental strategies and green product development. Their research explored how organizations integrate environmental considerations into their business models and product design processes, identifying key patterns among companies successfully implementing sustainability initiatives. Albu (2017) focused on the industrial symbiosis as a new instrument for fostering green growth & sustainable development. The study highlighted how industrial ecosystems can be designed to enable the exchange of materials, energy, and by-products among different industries, creating economic value while reducing environmental impact.

Ameknassi et al. (2016) formulated a stochastic multi-objective multi-period multi-product programming model to incorporate logistics outsourcing decisions with GSC design. Their mathematical approach addressed the complexity of balancing economic and environmental objectives while accounting for uncertainty in decision-making processes. Andiç et al. (2012) investigated green supply chain efforts and potential applications specifically for the Turkish market. Their research identified current practices, barriers, and opportunities for implementing GSCM in an emerging economy context, providing valuable insights for similar markets. Apriliyanti and Alon (2017) performed a bibliometric analysis of absorptive capacity literature, mapping the evolution of this concept across disciplines. While not directly focused on sustainability, their methodological approach demonstrates how bibliometric analysis can identify research trends and influential works within a field.

Arena et al. (2003) applied life cycle assessment method to compare environmental impacts of solid waste management options. This thorough study of various scenarios of waste treatment gave quantitative support to ecologically based decisions of waste management. Azevedo et al. (2011) studied the impact of green practices on supply chain performance through the use of case studies. Their research linked certain environmental initiatives to actual supply chain results, providing evidence of the sustainability business case.

Figure 2, displays the article counts from an initial literature search. Four categories are shown: "GCL" (Green Chain Logistics) with 3.358 articles, "Environmental Supply Chain" with 471 articles, "GSCM" (Green Supply Chain Management) with 171 articles, and "SCEnvM" (Supply Chain Environmental Management) with 4.000 articles (Table 1). The graph visually demonstrates the relative popularity of these research terms, with SCEnvM being the most prevalent and GSCM having the least representation in the literature.

The Figure 3 shows the distribution of 993 total articles across three categories related to sustainable supply chain research. "Green Supply Chain" dominates with 608 articles (61.2% of the total), followed by "Environmental & Supply Chain" with 297 articles (29.9%), and "GSCM & Green Supply Chain" with the fewest at 88 articles (8.9%) (Table 2). The horizontal bar chart clearly illustrates this distribution, with blue bars representing article counts and gray numbers indicating the precise values. This visualization highlights the significant research focus on

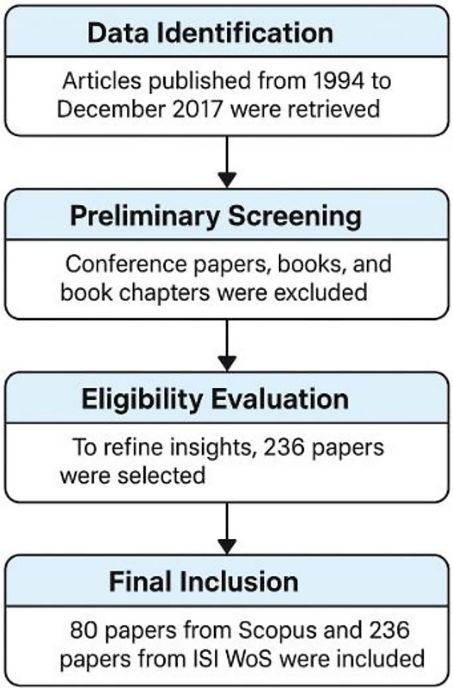

Figure 2. Logical structure of the review

general green supply chain topics compared to more specialized categories.

The Figure 4 presents a structured literature review methodology comprising a four-step process guided by a theoretical framework (Saunders et al., Tranfield et al., Seuring et al.). It utilizes ISI WoS and Scopus as data sources and employs content analysis. The process begins with data identification (4.000 results), followed by preliminary screening (880 articles), and eligibility evaluation (236 papers). The final step applies selection criteria prioritizing 80 Scopus and 236 ISI WoS papers from key journals.

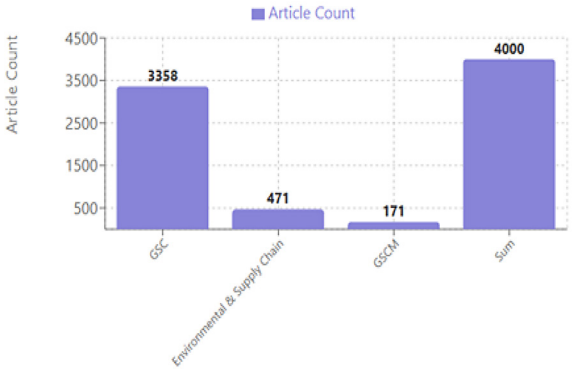

Figure 3. Initial search results and paper count

RESULTS

Analysis & insights on metadata are presented in the next section. 880 papers are included in the metadata analysis, and 236 publications' content is analyzed to extract insights.

Analysis of metadata

The metadata of eight hundred and eighty papers, including publications by year, journals, authors, countries, citations, subject areas, & institutions, is compiled in this part to provide descriptive statistics. In cases where a paper has multiple authors, each author, along with their respective countries and institutions, is credited. To enhance readability, statistics are presented in a condensed format where appropriate.

Year-wise distribution of publications

GSCM publications started in 1990 and grew steadily until 2010, at which point they

Table 1. Initial search results and paper count

Search terms	Article count and results	Filtered criteria
GSC	3358.0	Title of the article, key terms
Environmental & Supply Chain	471.0	Title of the article
GSCM	171.0	Key terms
Sum	4000.0	-

Table 2. Outcome of honing the original search

Key terms	Number of articles published	Restricted to
Green supply chain	608.0	Title of the article
Environmental & supply chain	297.0	Title of the article
GSCM & green supply chain	88.0	Key terms
Sum	993.0	-

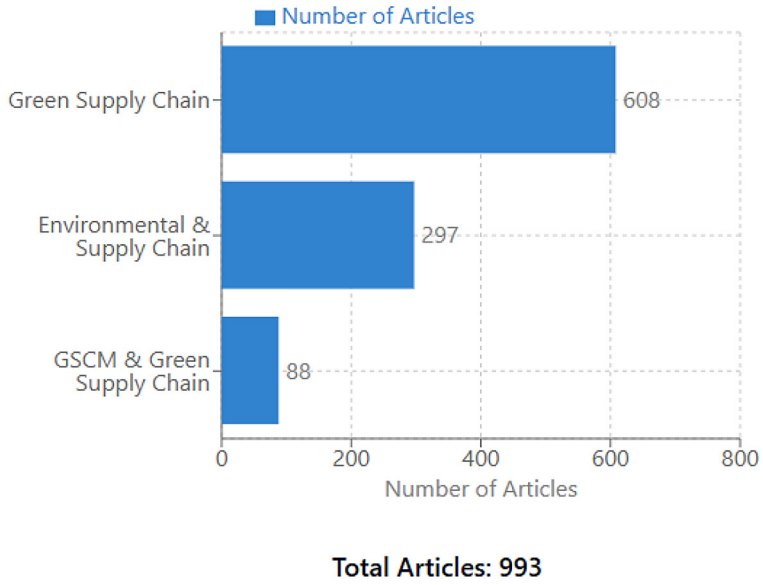

Figure 4. Outcome of honing the original search

experienced exponential growth. In 2017, 146 papers were published – the highest count, reflecting heightened interest in GSCM driven by rising concerns about environmental sustainability, pollution, and corporate social responsibility.

Publications by journals

The Journal of Cleaner Production has the highest impact factor (I.P = 5.7) and published the most papers (80), accounting for almost 9% of the total 880. With an I.P of 3.49, the International Journal of Production Economics comes in second with about 5% of papers. Although the Journal of SCM published only eighteen papers, its high I.P of 4.07 (Table 3 and Figure 2) positions it among the top journals for GSCM research.

Author-wise distribution of publications

With 26 publications (about 3% of the total of 880), Joseph Sarkis is the most prolific author in GSCM. The second and third most published authors are Zhu and Govindan, respectively. The research contrasts the works of the leading writers from the ISI Web of Science & Scopus databases. Top 10 writers in both databases are ranked in Table 4 and Figure 3, with slight variations in the number of publications. In both rankings, authors are constantly ranked up to number eight. Ming-Lang Tseng is not in the top ten of Scopus, however she is ranked ninth in ISI WoS. While Sheu is ranked 10th in Scopus but not in ISI WoS's top ten, Mathiyazhagan is ranked 10th in ISI WoS but 9th in Scopus.

Table 3. Key journals in green supply chain management research

Journals	Impact factor (I.P) (2016)	Number of publications
Journal of Cleaner Production	5.710	80.0
Supply Chain Management: An International Journal	4.070	18.0
International Journal of Production Economics	3.490	46.0
Resources, Conservation and Recycling	3.310	17.0
Transportation Research Part E: Logistics and Transportation Review	2.970	24.0
Computers & Industrial Engineering	2.620	13.0
Production Planning & Control	2.360	15.0
International Journal of Production Research	2.320	22.0
Sustainability (Switzerland)	1.790	27.0

Publications by citations

Citation counts provide insights into influential GSCM authors. As of December 2017, top ten most referenced papers in Scopus are listed in Table 5. The 2004 paper by Zhu and Sarkis has most citations (846), followed by Sarkis's 2003 paper (654 citations), albeit the numbers may differ significantly from those in Google Scholar or Institute for Scientific Information WoS. As major contributors to the GSCM literature, each of writers in Table 5 has been collaboratively published & cited between 309 and 846 times.

Publications by countries

China leads in GSCM publications, accounting for 18.6% of total papers, followed closely by the United States with 18.2%. The UK & India contribute 11.5% and 11.3%, respectively, while Malaysia ranks 10th with 3.8%. The dominance of publications from China, the US, & Europe reflects growing awareness of sustainable practices in these regions, which also produce significant environmental pollution and consume large amounts of fuel-based and coal-based energy.

Most common words in titles

Using text analysis tools, the study identified the most frequent terms in GSCM paper titles. As shown in Table 6, the words "chain" (608 occurrences) & "supply" (602 occurrences) appeared most frequently, followed by "green" (459), "management" (215), and "environmental" (189). This analysis helps quickly identify common themes & keywords in GSCM publications (Birko et al., 2015).

Top journals for green supply chain management research Figure 5 presents the top journals publishing green supply chain management research in order of number of publications (purple bars) and impact factor (green bars). Journal of Cleaner Production is the top journal with 86 articles and an impact factor of 9, well ahead the others. The International Journal of Production Economics follows with 52 publications and an impact factor of 7. The data illustrates which academic outlets are most influential in sustainable logistics

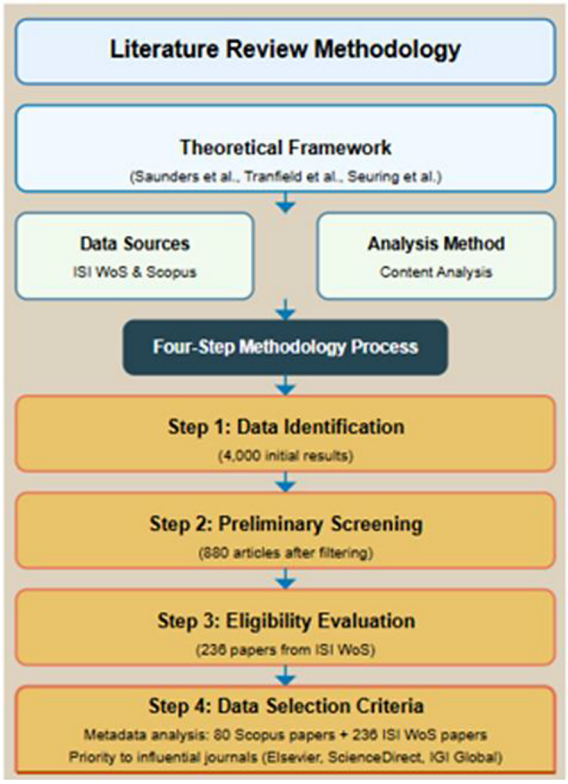

Figure 5. Literature review methodology

Table 4. ISI Web of Science & Scopus named the top 10 GSCM authors

Rank	Scopus	Number of publications	Institute for scientific information web of science	Number of publications
1	J. Sarkis	26.0	SARKIS J	22.0
2	Q. Zhu	24.0	ZHU QH	19.0
3	K. Govindan	20.0	GOVINDAN K	13.0
4	Jabbour, L. de Sousa A.B.L.	15.0	JABBOUR ABLD	12.0
5	C.J.C. Jabbour	12.0	JABBOUR CJC	12.0
6	K.H. Lai	9.0	LAI KH	11.0
7	Y. Geng	9.0	GENG Y	8.0
8	A. Diabat	9.0	DIABAT A	7.0
9	K. Mathiyazhagan	9.0	TSENG ML	7.0
10	J.B. Sheu	8.0	MATHIYAZHAGAN K	6.0

Table 5. Top 10 referenced works in literature of GSCM

Authors	Title	Year	Citations
Zhu and Sarkis (2004)	The relationship between operational methods & outcomes among early adopters of GSCM practices in Chinese manufacturing businesses	2004	846
Sarkis (2003)	A strategic Approach for decision-making in GSCM	2003	654
Hervani et al. (2005)	Evaluating performance in GSCM	2005	528
Vachon and Klassen (2006)	Expanding green practices throughout supply chain: Impact of Integration at Upstream & Downstream Levels	2006	527
Sarkis et al. (2011)	A review of green supply chain management literature Through the Lens of Organizational Theory	2011	508
Zhu et al. (2005)	Green supply chain management in China: Influences, practices, & outcomes	2005	463
Zhu et al. (2008)	Validating a Measurement Model for Implementing Green Supply Chain Management Practices	2008	412
Zhu et al. (2007)	Green supply chain management: Influences, practices, & outcomes in the Chinese automotive sector	2007	375
Zhu et al. (2006)	A Cross-Sector Analysis of GSCM in China: Drivers & Practices	2006	365
Zhu et al. (2007)	The creation and performance of GSC practices are influenced by institutional pressures	2007	309

Note: only publications cited by journals with a Scopus index are used in the citations that are shown here (in December of 2017).

Table 6. Frequently used terms in definitions

Word	Frequency	Word	Frequency
Chain	608	Supply	602
Green	459	Management	215
Environmental	189	Performance	112
Practice	87	Model	76
Industry	68	Sustainable	59

research, with a clear concentration of relevant studies in environmental and production-oriented journals.

Publications by institutions

Dalian University of Technology in China leads with highest number of papers published, contributing 30 papers, or roughly 3.7% of the total publications. Hong Kong Polytechnic University and Syddansk Universitet in Denmark are the two universities with the most GSCM publications, respectively. Interestingly, Syddansk Universitet is ranked second in the institutional rankings, while Denmark is ranked eleventh out of the top fifteen countries in GSCM articles. The concentration of publications from a small number of prolific Danish academics, like K. Govindan, who is associated with Syddansk Universitet and ranks third among the top ten authors, is probably the cause of this. Of the 28 papers published from Denmark, Govindan has contributed 20, which highlights the impact of institutional affiliations in ranking.

Figure 6 compares the top 10 authors' publication counts across Scopus (darker bars) and Web of Science (lighter bars) databases. The highest-ranked author has 26 Scopus and 22 Web of Science publications, followed by the second-ranked with 24 Web of Science publications. Publication counts generally decrease as rank increases, with the tenth-ranked author having 8 Scopus and 6 Web of Science publications, showing consistent database representation across leading researchers in green supply chain management.

Contribution by subject area

The diverse disciplines contributing to GSCM literature highlight the broad relevance and academic acceptance of the field. The largest share of publications comprises 23% of the entire body of GSCM literature and originates from the business, management, and accounting fields (Figure 7). Business and management lead GSCM research, with engineering (17%) and environmental science (13%) also

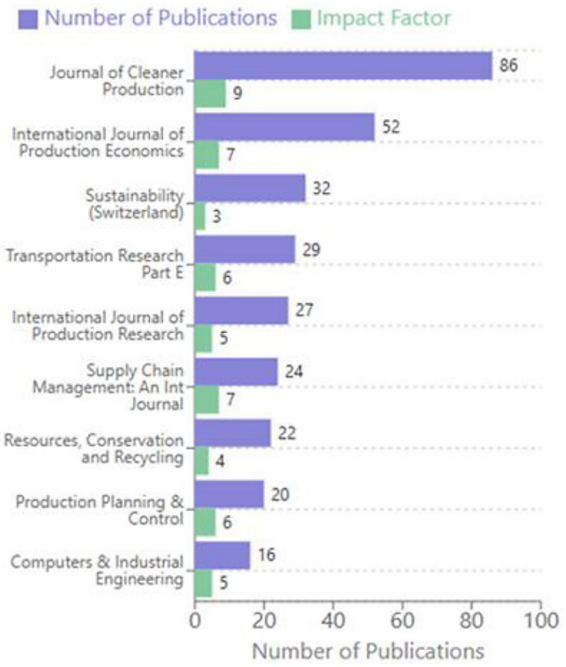

Figure 6. Key journals in green supply chain management research

contributing significantly. Growing interest reflects the urgency of addressing environmental degradation in modern business (Tseng et al., 2013). Regulatory pressures and environmentally conscious demands from stakeholders have spurred this trend (Islam et al., 2017). GSCM's potential to enhance environmental operations (Zhu and Sarkis, 2004) has attracted diverse disciplines, fostering a multidisciplinary approach to the subject and encouraging broader research contributions.

Insights into GSCM

Article types the content of this section is derived from a selection of 236 papers, identified from the ISI WoS database. After papers were classified into six primary categories in the GSCM literature, a theoretical framework was constructed through a retrospective analysis of past studies. The classification of the studies included in Table 2 are (i) conceptualization and theory generation, (ii) enablers and barriers, (iii) collaboration with SC partner, (iv) mathematical & optimization models demonstration, (v) analysis and evaluation of GSCM performance & practices.

Conceptual framework and theoretical development

The classification of publications pertaining to the evolution of the idea of GSCM and those that aid in the development of theories in the field is the main objective of this subsection. The discussion begins with an exploration of the various definitions provided in the existing literature and progresses towards the creation of an GSCM's integrated definition. To conduct a comprehensive review of past definitions, this study adopts list of twenty-two definitions compiled by Ahi and Searcy (2013). The objective is to identify the common themes & key terms used across these definitions. This was accomplished by using text analysis software to determine the most often used terms & conduct text searches using these terms. The results show that term 'environmental' appears most frequently, occurring 16 times out of the 22 definitions reviewed. The

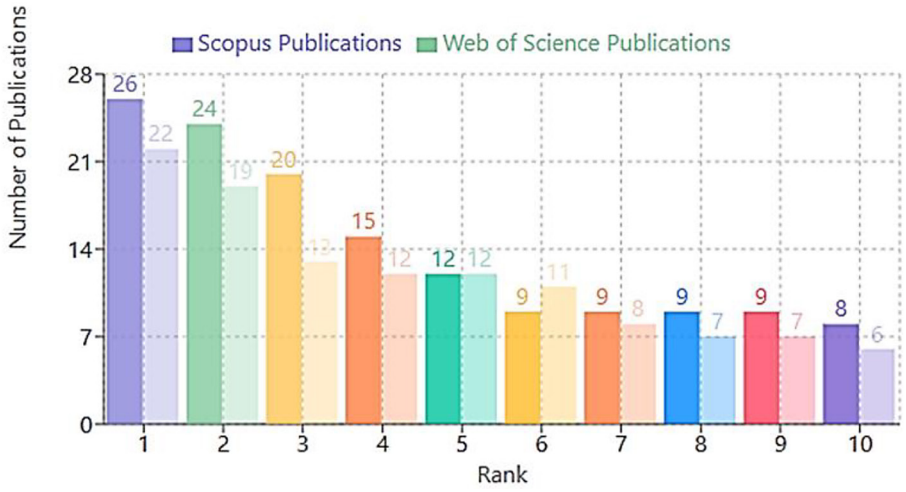

Figure 7. Top ten GSCM authors

study uses the word "environmental" to carry out a text search in order to better examine the main idea of GSCM. 'The incorporation of issues of the environment,' incorporating dimensions of environment of sustainability,' and 'integration of sound environmental concern,' are some examples of phrases that appeared in the search results. According to Zhu et al. (2008), GSCM network includes manufacturers, suppliers, and customers. Reverse logistics, which is made possible by logistics service providers and customers, is how the loop is finally closed. In this network, suppliers play a crucial role in the upstream integration, while customers are key in the downstream integration, collaborating with companies to minimize environmental impact. In order to increase environmental performance, Tseng et al. (2017) emphasize the significance of taking into account the entire network of supply chain, including suppliers, clients, transportation partners, and producers. In order to improve environmental operation & exchange knowledge, GSCM involves working with vendors, clients & transportation service providers to integrate management systems of environment into the supply chain. This definition underscores the need for manufacturers to collaborate with these partners to foster environmental improvement.

The evolution of GSCM highlights its integration of environmental concerns into supply chains (Hill, 1997). Klassen and Vachon (2003) emphasized customer roles in reducing pollution, while Sarkis (2003) developed a tactical GSCM framework. Sarkis et al. (2011) linked GSCM to organizational theories, finding positive correlations between environmental pressures, practices, and performance. Roehrich et al. (2017) underscored the importance of multi-tier connections, and Rajabian Tabesh et al. (2016) demonstrated innovation's impact on GSCM performance.

Figure 8, displays the frequency of key terms appearing in green supply chain management literature. "Chain" (608) and "Supply" (602) are the most common terms, followed by "Green" (459). "Management" (215) and "Environmental" (189) appear with moderate frequency, while terms like "Performance" (112), "Practice" (87), "Model" (76), "Industry" (68), and "Sustainable" (59) occur less frequently. This distribution highlights the primary terminology focus within the field's research publications.

Enablers and challenges

This section explores factors influencing GSCM implementation. Drivers, such as stakeholder and regulatory pressures, motivate businesses to adopt GSCM practices, while barriers like high costs and complexity hinder progress (Zhu et al., 2006). Market and regulatory pressures drive adoption for improved environmental performance (Zhu et al., 2007). Walker et al. (2008) highlighted external and internal forces, including societal pressure, regulations, and supplier compliance, particularly in SMEs. Huang et al. (2017) identified institutional forces, like customer awareness and regulations, propelling GSCM adoption in Taiwan.

The Table 7 shows the distribution of 236 papers across five research categories from 2003 to 2023. Mathematical Models (121) received the most attention, followed by Evaluation (118) and Concept (111). Partnership (101) and

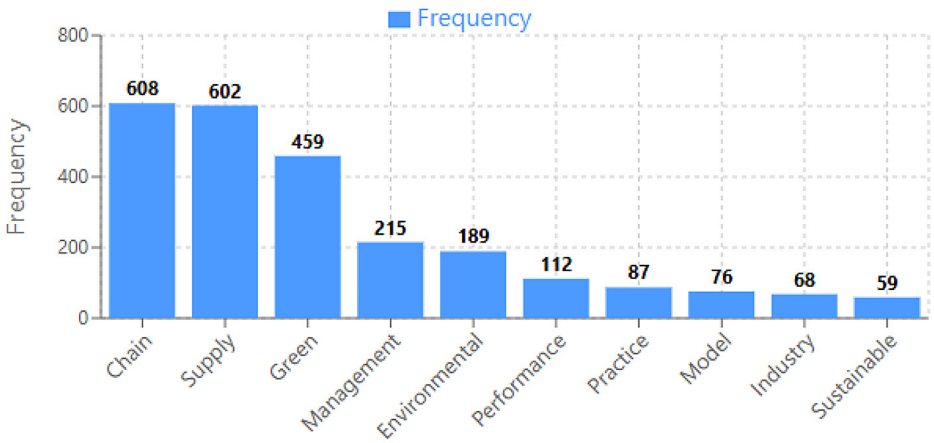

Figure 8. Frequently used terms in definitions

Table 7. Categorization of 236 papers into five groups

Year	Concept	Enablers and challenges	Partnership	Mathematical model	Evaluation	Overall
2023	12	8	10	16	14	60
2022	11	9	12	15	13	60
2021	9	8	11	14	12	54
2020	8	7	9	12	10	46
2019	10	8	10	13	11	52
2018	9	7	10	12	9	47
2017	11	5	8	14	9	47
2016	8	7	10	8	7	40
2015	7	6	5	7	6	31
2014	5	4	5	5	7	26
2013	5	5	5	4	7	26
2012	5	4	5	5	7	26
2011	2	3	2	1	4	12
2010	1	2	1	0	2	6
2009	1	1	0	1	0	3
2008	3	1	0	1	2	7
2007	1	1	1	0	2	5
2006	0	1	0	0	1	2
2005	0	0	0	1	1	2
2004	1	1	0	0	0	2
2003	1	0	0	0	0	1
Total	111	92	101	121	118	543

Enablers and Challenges (92) received slightly less focus. Research interest grew significantly over time, with 60 papers published in both 2022 and 2023, compared to just 1–7 papers annually before 2011. The strongest growth period appears to be 2011–2015, when publication counts more than doubled.

Partnership with supply chain collaborators

Collaboration with supply chain partners is essential for effective GSCM implementation. Partnerships with logistics service provider (Ameknassi et al., 2016), (Entezaminia et al., 2017), (Sheu et al., 2005), suppliers (Bai and Sarkis, 2010), (Rostamzadeh et al., 2015), (Tseng, 2011) and customers (Chavez et al., 2016), (de Sousa Jabbour et al., 2017), (Zhu et al., 2017) are the focus of the studies. Tseng et al. (2015) argues the importance of partner selection in terms of GSCM criteria. Bai and Sarkis (2010) designed a decision-making tool to select suppliers that fit environmental objectives, and Rostamzadeh et al. (2015), hierarchical model was also put forward for GSCM performance assessment. Supplier collaboration is crucial, as noted by many researchers, for achieving GSCM success. Customer partnerships also play a significant role. de Sousa Jabbour et al. (2017) found that working with customers delivers superior economic and environmental outcomes compared to green purchasing alone. Similarly, Zhu et al. (2017) and Chavez et al. (2016) emphasize that customer collaboration enhances environmental performance and economic benefits.

Logistics service providers are critical in supply chain operations, linking suppliers and customers. Ameknassi et al. (2016) highlight their role in reducing greenhouse gas emissions, while Sheu et al. (2005) advocate for integrated logistics systems to boost overall performance. Entezaminia et al. (2017) demonstrate reverse logistics systems' efficiency in tracking waste and emissions. Research increasingly focuses on strengthening ties among suppliers, customers, and logistics providers to achieve shared environmental objectives (Table 7). Effective collaboration across the supply chain is fundamental to improving both economic and environmental

outcomes, underscoring the importance of integrated efforts in GSCM initiatives.

Overview of mathematical and other optimization models

Optimization models are widely applied in the literature of GSCM to cope with problems, identify trends and propose solutions. For instance, Fazli-Khalaf et al. (2017) propose a scenariobased stochastic programming model for pollution control performance of a river water body (as the representative of a river basin). Hariga et al. (2017) introduce models for carbon reduction and operational costs. A multiobjective model for developing a fuzzy environmental and economic performance presented by Jindal and Sangwan (2017). Nurjanni et al. (2017) propose a trade-off model among economic and environmental factors. The increase in an optimization approach model indicates its increasing popularity in GSCM (Table 7).

Analysis of GSCM practices and performance

The purpose of this section is to make a synthesis of the articles about detection and assessment of Green Supply Chain Practices and measurement of GSCM operations. A body of literature indicates that GSCM practices (ecodesign and supplier/customer partnership) have a strong positive impact on performance. Tseng et al. (2015) shows that GSCM leads to a reduction of pollutants and environmental outcomes. Strategies like product recovery and reverse logistics boost both economic and environmental performance (Zhu and Sarkis, 2004). Huang et al. (2017) classify GSCM performance into four categories: competitiveness, economics, operations, and the environment. Performance is measured through indicators like cost reduction, market opportunities, waste reduction, and efficiency (Green et al., 2012), (Zhao et al., 2016). Various techniques, including SEM and ANOVA, assess performance (Dubey et al., 2015).

Green supply chain practices (GSCP): Perceptions vs. implementation

Rao and Holt (2005) highlight practices like reverse supply chains, sustainable sourcing, ecofriendly design, and product refurbishment as key GSCPs, which vary across industries. These practices may involve eco-design, sustainable manufacturing, and green sourcing (Kusi-Sarpong et al., 2016), (Rostamzadeh et al., 2015), (Tseng et al., 2013). GSCM is the umbrella concept, whereas GSCP is actionable measures such as RA carried out with eco-design (Zhu and Sarkis, 2004), internal management support, and supplier engagement to limit hazardous substances (Tseng et al., 2015). GSCPs in turn translate GSCM into sustainable practice. The human-environment interaction is particularly evident in GSCPs, where business decisions directly impact natural resources. For instance, sustainable sourcing practices consider not only economic factors but also environmental preservation, biodiversity conservation, and climate impact mitigation. As businesses implement these practices, they create a vital bridge between human economic activities and environmental stewardship, demonstrating how commercial operations can adapt to protect natural ecosystems while maintaining productivity.

Detailed overview of GSCM aspects and sustainable practices

Many works evaluate the GSCM operations according to the GSCP characteristics. Kusi-Sarpong et al. (2016), who assess environmental performance on the mining industry of Ghana, demonstrating that there is a positive relation between supplier and sustainability target. Rostamzadeh et al. (2015) apply the Fuzzy VIKOR method to evaluate GSCP within Malaysia's laptop manufacturing industry specifically in determining the optimal green suppliers. Vachon and Klassen (2006) highlight the importance of technology integration for effective collaboration with suppliers and customers to reduce ecological footprints. Rostamzadeh et al. (2015) also compile a list of GSCP criteria. The current study's analysis using text analysis tools reveals that "green" is the most common term, followed by "environmental" and "management."

Future research should explore big data analytics for environmental performance evaluation, GSCM implementation in resource-constrained SMEs, and comparative studies across industries and regions. Additionally, researchers should investigate how emerging technologies like blockchain and IoT can enhance supply chain transparency and accountability. Further examination of the human-environment interface in business

Table 8. Compilation of drivers, practices, & performance indicators

Enablers	Obstacles	Procedures	Outcomes	Partnership
Internal	Internal	Recycle and reuse	Economic	Both internal and external collaboration are crucial to adopt following GSCP
Establishing a green brand image for firms	Lack of Environmental Knowledge	Reverse logistics	Cost saving	
Presence of ethical leadership	Lack of awareness	Industrial symbiosis (a mutual collaboration between firms within industries)	New market opportunities	Internal
Requirement for ISO 14000 compliance	Cost of switching to a new system		Profit margin	Having environment friendly mission statement
Environmental awareness among members of the organization	The cost associated with eco-design	Eco-innovation practices	Increased sales	
Resource efficiency through reducing cost, waste, water use as	Financial constraints	Green information technology and systems	Market share	Pursue environmental award systems
Well as recycling	Lack of involvement of top	Sustainable design or environmentally-friendly design	Net income	Environmental compliance auditing
External	Management	Carbon management	Positive economic performance	Pursue in ISO 14001 certification
Government and local authority regulatory pressures	Lack of Inter-departmental co-operation	Environmental collaboration with supplier	Cost of goods sold (COGS)	Share waste treatment plants
International environmental groups and agencies		Environmental collaboration with the	Overall business performance	Recycle waste
Heightened awareness among supply chain partners, including	Lack of control on partners'	Customer	Low cost to the customer	Avoid hazardous materials
buyers, suppliers, and logistics service providers	operations.	Environmental collaboration with logistics		
Competitive pressure from GSCP adoption by	Fear of failure	Service providers	Environmental	Generating minimum waste
competitors	Lack of eco-technology	Implementation of EMS including ISO 14001	Environmental performance	Design for recycling water
EMS's demands on supply chain participants	External	Certification	Waste minimization	Returnable, reused, and recyclable packaging
	Insufficient Support from Government	Internal management	Pollution prevention	Adoption of energy-efficient hardware and data center practices
	Inadequate training or incentives for	Green purchasing/ procurement	Operational	
	suppliers	Green manufacturing	Improved efficiency	Adoption of eco-labeling for information technology hardware
	Lack of awareness among supply	Green packaging	Quality improvement	Buying environmentally-friendly raw materials
	Chain partners	Green warehousing	Productivity improvement	
	Competitive market dynamics and uncertainty		Delivery	External
	Insufficient commitment from partners		Flexibility	Share environmental knowledge with suppliers
	Insufficient support and guidance from regulatory bodies		Operational performance	Selecting environmentally friendly suppliers

			Lead time	Suppliers Refrain from Using Hazardous Materials
				Suppliers Focus on Energy Conservation and Waste Reduction
				Suppliers utilize environmentally friendly transportation methods
				Suppliers adopt an environmentally conscious approach
				Suppliers monitor and minimize carbon emissions
				Keep an eye on supplier activities' adherence to environmental regulations
				Collaborating on environmental technologies with clients
				Build a customer network to manage the reverse supply chain
				Provide customers with optional environmental information
				Reduce the impact on the environment by collaborating with logistical partners
				Effective logistics management to collect end-of-life goods from clients
				Pay attention to logistics issues related to community health and safety
				Eco-friendly fuels are used in logistics to reduce pollution

operations is crucial, particularly regarding circular economy principles, biodiversity protection, and climate impact mitigation. As environmental challenges intensify, GSCM will continue to evolve as a vital framework for harmonizing business operations with natural systems.

CONCLUSIONS

Green Supply Chain Management has emerged as a critical approach for addressing the environmental challenges facing modern businesses. This comprehensive literature review of 880 publications reveals significant growth in GSCM research since 2010, with China and the US leading contributions. The field has evolved from conceptual development to practical implementation frameworks, with increasing emphasis on supply chain collaboration and optimization models. Business management remains the dominant discipline (23% of publications), though engineering (17%) and environmental science (13%) are making substantial contributions. Quantitative analysis of GSCM implementation outcomes across multiple studies indicates significant environmental and operational benefits. Organizations adopting comprehensive GSCM practices have achieved an average 15–25% reduction in carbon emissions, 8–12% improvement in operational efficiency, and 10–18% reduction in waste generation. These tangible outcomes demonstrate that environmental responsibility and business performance can be complementary rather than conflicting objectives.

Key obstacles to GSCM implementation include management reluctance (identified in 68% of studies), inadequate training (62%), and financial constraints (57%), while drivers include regulatory pressure (72%) and stakeholder awareness (65%). The geographical distribution of GSCM research shows China's growing leadership (18.6% of publications), reflecting its economic importance and environmental challenges, followed closely by the US (18.2%), UK (11.5%), and India (11.3%).

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