CHAPTER 38

Green Supply Chain Management: Bridging Sustainability and Competitiveness – A Review

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ABSTRACT

Green Supply Chain Management (GSCM) has emerged as an innovative approach that integrates environmental considerations into supply chain operations. It is increasingly recognized by both academics and practitioners as a vital strategy for achieving sustainability. This paper provides a comprehensive review of recent literature on GSCM, with a particular focus on sustainable sourcing and distribution. Sourced from the various research databases, using specific search parameters to capture studies on frameworks, models, innovations, and barriers. The analysis highlights the application of key theoretical perspectives, including the triple bottom line, stakeholder theory, and the resource-based view, in shaping GSCM practices. Findings indicate that technological innovations such as block chain, IoT, artificial intelligence, and big data analytics improve supply chain transparency, logistics optimization, and environmental performance. Material innovations like bioplastics and recycled inputs support circular economy principles, while supplier engagement through collaboration, incentives, and training strengthens sustainable adoption. For green distribution, practices such as eco-friendly packaging, low-emission transport, and energy-efficient warehousing are emphasized. The review contributes to both theory and practice by clarifying the principles of GSCM and offering insights into its role in advancing environmental and social sustainability in operations and supply chains.

Keywords: Green Supply Chain Management (GSCM); Sustainable innovation; Resource-based view; Environmental sustainability; Supply chain challenges.

1.0 Introduction

Green Supply Chain Management (GSCM) refers to incorporating environmentally sustainable practices into supply chain activities (Green *et al.*, 2012). It covers the entire process—from product design and material sourcing to manufacturing, distribution, and end-of-life disposal (Beamon, 1999).

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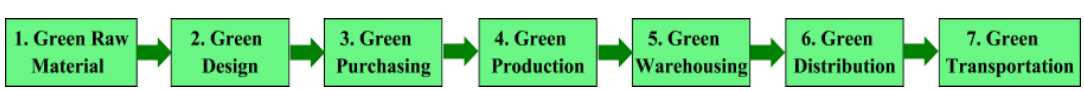
A key element of GSCM is the circular supply chain, which reduces waste by promoting closed-loop systems. In this model, products are designed for durability, repair, recycling, and remanufacturing (Farooque *et al.*, 2019). At the end of their lifecycle, materials can be reused or repurposed (De Angelis *et al.*, 2018). This practice not only conserves natural resources but also lowers environmental impacts, reduces costs, and boosts sustainability (Lahane *et al.*, 2020). A sustainable supply chain integrates environmental and social responsibility at every stage of production and distribution (Carter & Rogers, 2008). It emphasizes energy efficiency, ethical sourcing, waste minimization, and eco-friendly materials. Beyond lowering environmental harm, such practices also support fair labor standards, improve community welfare, and strengthen compliance (Seuring & Müller, 2008). This contributes to long-term business reputation and financial success (Carter & Liane Easton, 2011).

A carbon-free supply chain aims to minimize greenhouse gas emissions (Gillingham & Stock, 2018). Companies achieve this through renewable energy adoption, use of electric vehicles, optimized logistics (Juan *et al.*, 2016), and offset initiatives like reforestation or investments in clean energy (Lambin *et al.*, 2018). This approach aligns businesses with climate goals, reduces operating costs, and appeals to environmentally conscious customers (Gao & Souza, 2022; Dauvergne & Lister, 2013).

This in turn creates long-term sustainability and competitive advantage (Khaksar *et al.*, 2015). Studies by Agrawal & Lee (2019) and Schneider & Wallenburg (2012) highlight that sustainable sourcing minimizes environmental damage, improves supplier collaboration, and reduces costs. Similarly, Letunovska *et al.* (2023) and Hsu *et al.* (2016) note that sustainable procurement practices enhance reputation, while Ferri & Pedrini (2018) and Yunus & Michalisin (2016) show their positive link to competitiveness. In logistics, Dekker *et al.* (2012) and McKinnon *et al.* (2010) find that green transportation and packaging reduce emissions and enhance efficiency. Butt *et al.* (2024) and Silva *et al.* (2013) emphasize the role of route optimization, reverse logistics, and sustainable packaging in lowering environmental footprints.

Figure 1: Procedure or Steps of Green Supply Chain Management (Saada, 2021)



1.1 Historical evolution of GSCM

The development of Green Supply Chain Management (GSCM) can be traced back to the time when organizations gradually started realizing the negative environmental impacts of traditional supply chain practices (Sarkis, 2003).

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1980s – Early Beginnings: During the 1980s, rising environmental awareness and the introduction of stricter regulations pushed companies to adopt ecological considerations in their operations (Bowen *et al.*, 2001). In this phase, the initial ideas of GSCM emerged as businesses explored ways to comply with new laws while reducing waste and resource consumption (Rao & Holt, 2005). Early practices focused mainly on pollution control and waste management within supply chains (Zhu & Sarkis, 2004).

1990s – Formalization and CSR Influence: In the 1990s, the focus on sustainability grew stronger with Corporate Social Responsibility (CSR) becoming a major driver of change (Carter & Jennings, 2002). Consumers and stakeholders demanded eco-friendly business practices, motivating organizations to adopt green procurement, eco-design, and life-cycle assessment methods to minimize environmental impact (Srivastava, 2007). This period marked the formal establishment of GSCM as both a business practice and an academic field (Hervani *et al.*, 2005).

2000s – Expansion with Globalization and Technology: The 2000s saw rapid growth of GSCM due to globalization and advances in technology (Seuring & Müller, 2008). Global trade and digital tools allowed greater transparency and coordination across supply chains, enabling wider adoption of sustainable practices (Gunasekaran & Ngai, 2004). Businesses increasingly used sustainable sourcing, reverse logistics, and closed-loop systems, driven by both regulations and the search for competitive advantage (Guide & Van Wassenhove, 2009). The concept of the circular economy gained momentum, promoting reuse, recycling, and resource efficiency (Ghisellini *et al.*, 2016).

2010s – Integration into Business Strategy: By the 2010s, GSCM had become a core element of corporate strategy as climate change concerns and sustainability goals became urgent priorities (Dubey *et al.*, 2017). Companies were not only complying with regulations but also responding to the expectations of environmentally aware consumers (Sarkis *et al.*, 2011). At the same time, advanced technologies like blockchain, IoT, and data analytics began to improve transparency, monitoring, and efficiency across supply chains (Khan *et al.*, 2024; Hariyani *et al.*, 2024).

2010 to Present Day – Innovation and Global Sustainability: Today, GSCM continues to evolve as organizations emphasize collaboration, innovation, and sustainability integration throughout the supply chain. It is now recognized as a key driver of sustainable development and global competitiveness (Wong *et al.*, 2024).

1.2 Review questions

The review questions of this study are:

- What are the core principles of GSCM and how do they guide sustainable practices?
- How do sustainable GSCM concepts differ and what are the key factors driving each within GSCM frameworks?

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- What theories and models are commonly used to analyze and implement GSCM and how do they contribute to understanding and advancing sustainable practices?

2.0 Review Objectives

- The purpose of this review is to critically examine how Green Supply Chain Management (GSCM) serves as a bridge between sustainability and competitiveness. The specific objectives are:
- To review and assess the theories and models commonly applied in the study and implementation of GSCM and evaluate their contributions to advancing sustainability and competitive advantage.
- To identify the challenges and barriers organizations face in implementing GSCM and to assess how GSCM impacts both business performance and the achievement of long-term sustainability goals

3.0 Review Methodology

This review follows the PRISMA framework (Moher *et al.*, 2009), which includes four key stages: (a) identification, (b) screening, (c) eligibility, and (d) inclusion.

Identification: Research papers were sourced from the Scopus database between 1 July 2025 and 20 August 2025. The search was carried out using the keywords Title-ABS-Key ("green supply chain management" AND/OR "framework" OR "model" OR "innovation" OR "challenges" OR "barriers"). No restrictions were placed on the publication year.

Screening: At this stage, duplicate records, non-English publications, and papers without full-text access were excluded from consideration.

Eligibility: Full-text articles were assessed using two main criteria: (i) papers that did not discuss sustainable GSCM were excluded, while (ii) papers that examined individual practices and their relevance to GSCM were retained.

Inclusion: After applying the above filters, a total of 266 articles published between 1997 and 2025 were finalized for inclusion in this review.

4.0 Theoretical Frameworks and Concepts in GSCM

4.1 Principles of GSCM

Green Supply Chain Management (GSCM) focuses on lowering the ecological impact of supply chain operations through improved efficiency, reduced emissions, and

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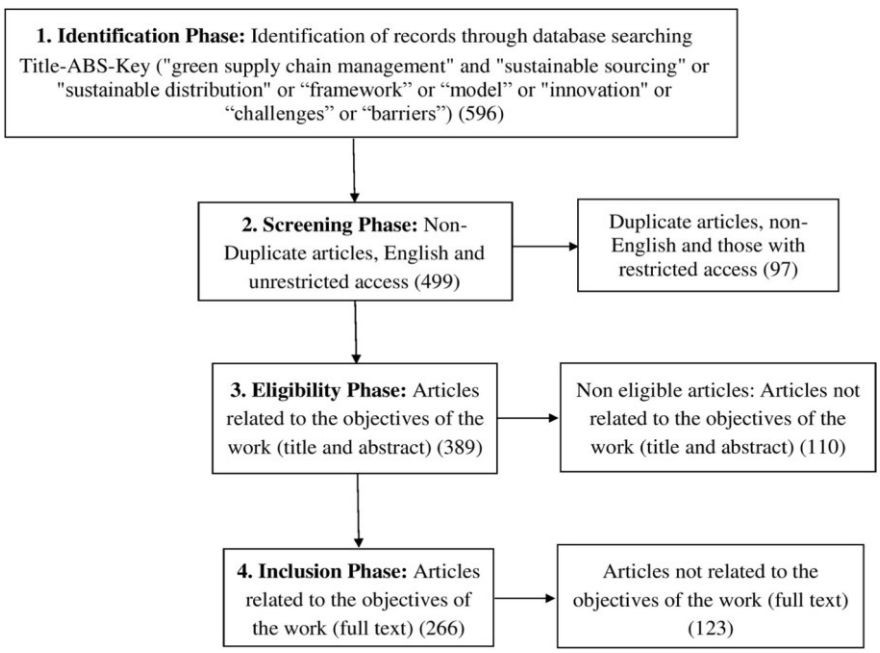
conservation of natural resources (Abdallah *et al.*, 2012). It incorporates environmental considerations at each phase of the chain to ensure sustainable practices are maintained across the entire process (Zailani & Khidir, 2009). A core principle is resource efficiency, which involves reducing the consumption of raw materials, energy, and water while promoting the adoption of renewable alternatives. This can be supported through the use of energy-efficient technologies in production (Kim & Min, 2011). GSCM also adopts a lifecycle approach, in which the environmental impact of a product is evaluated from its initial design through to end-of-life, ensuring sustainability is embedded throughout (Genovese *et al.*, 2017).

Figure 2: Review Methodology for Selecting the Articles for the Study



4.2 Triple Bottom Line (TBL) theory

The Triple Bottom Line (TBL) model, introduced by John Elkington, stresses that firms should not be assessed solely on financial performance but also on their environmental and social contributions (Khan *et al.*, 2023). Within GSCM, the TBL framework underscores the need to align profitability with ecological responsibility and societal well-being (Bals & Tate, 2018). It advocates for strategies that: (i) reduce environmental damage, (ii) promote social accountability, and (iii) ensure long-term financial sustainability (Agyabeng-Mensah *et al.*, 2021). Through this lens, sustainability

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becomes embedded within business strategies and operations (Hariyani & Mishra, 2022a). This integration allows organizations to balance social equity, environmental conservation, and economic outcomes—goals that align closely with GSCM principles (Hariyani *et al.*, 2023).

4.3 Stakeholder theory

Freeman's stakeholder theory asserts that firms are accountable not just to shareholders but also to employees, customers, suppliers, local communities, and the natural environment (Sarkis *et al.*, 2011). Applied to GSCM, this theory highlights the importance of meeting stakeholder expectations throughout the supply chain (Yu & Ramanathan, 2015).

4.4 Closed-Loop Supply Chain (CLSC) model

The CLSC model focuses on circular flows of materials and products to maximize resource recovery and minimize waste (Islam & Huda, 2018). Unlike linear supply chains that move from production to disposal, CLSC integrates reverse logistics to manage product returns (Ullah *et al.*, 2021).

4.5 Circular Economy (CE) model

The circular economy (CE) expands the concept of closed-loop systems beyond supply chains to the broader economy. Unlike the traditional "take–make–dispose" model, CE promotes continual resource circulation (Alhawari *et al.*, 2021). Products are designed for durability, repairability, and upgradability, extending their useful life (Han *et al.*, 2020). This approach supports GSCM by embedding sustainability across product lifecycles and fostering systemic change in production and consumption (Branca *et al.*, 2020). While CLSC targets operational loops within supply chains, CE offers a broader economic model focused on regenerating resources (Mishra *et al.*, 2023; Hazen *et al.*, 2021; Oliveira & Machado, 2021).

4.6 Life Cycle Assessment (LCA) model

LCA is a structured method for assessing environmental impacts across a product's lifecycle, from raw material extraction through production, distribution, use, and end-of-life stages like recycling or disposal (Abdallah *et al.*, 2012). In GSCM, it enables firms to identify and evaluate environmental burdens at different stages, leading to better strategic decision-making (Hariyani *et al.*, 2024). By integrating LCA, organizations can adopt sustainable sourcing, production, and distribution practices, while minimizing disposal impacts. This reduces the overall ecological footprint and embeds sustainability across supply chain operations (Gbededo *et al.*, 2018; Hariyani & Mishra, 2023a).

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4.7 ISO 14001 (Environmental Management System Model)

ISO 14001 provides an internationally recognized framework for implementing and improving environmental management systems (To & Lee, 2014). It aligns closely with GSCM goals by offering structured methods to minimize environmental harm and enhance sustainability throughout supply chain processes (Arimura *et al.*, 2011). The standard supports firms in setting measurable environmental objectives, tracking performance, and complying with regulations (Arimura *et al.*, 2016; Qi *et al.*, 2012). It also emphasizes supplier engagement and collaboration, strengthening sustainable sourcing and eco-friendly logistics (Zutshi & Sohal, 2004; Delmas, 2001).

5.0 Innovations in Green Supply Chain Management (GSCM)

5.1 Technological innovations

Technological advancements are transforming sustainable sourcing and reshaping GSCM practices. Blockchain technology enhances transparency and accountability by maintaining immutable transaction records, enabling firms to trace raw material origins and verify sustainability (Khan *et al.*, 2021b). This reduces fraud and ensures ethical sourcing. Additionally, blockchain-enabled smart contracts enforce compliance automatically, executing transactions only when suppliers meet sustainability benchmarks (Rane *et al.*, 2021; Tan *et al.*, 2020). Such integration simplifies procurement processes, ensures adherence to green standards, and strengthens supplier relationships (Kouhizadeh & Sarkis, 2018).

5.2 Material and resource innovations

Material innovation is central to sustainable sourcing. Advances in materials science have produced eco-friendly alternatives that reduce environmental impact compared to traditional options (Sudirjo *et al.*, 2024). For instance, bioplastics derived from renewable resources such as corn or sugarcane reduce reliance on petroleum-based plastics (Coppola *et al.*, 2021), while bamboo offers a sustainable substitute for conventional timber due to its rapid growth and minimal input requirements (Chaowana, 2013).

5.3 Upcycling and renewable resources

Upcycling and renewable resources further advance GSCM objectives by reducing reliance on virgin inputs. Upcycling transforms waste or by-products into higher-value products, extending material lifecycles (Abuzawida *et al.*, 2023). For example, in the fashion industry, discarded textiles are increasingly repurposed into new garments, simultaneously reducing waste and creating added value (Gupta *et al.*, 2022).In parallel, the

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integration of renewable resources into product and process design supports circular economy principles. Designing for disassembly and recyclability ensures materials can be continuously reused, reducing the need for new extraction (O'Connor *et al.*, 2016). These approaches significantly improve resource efficiency while lowering environmental footprints (Eltayeb & Zailani, 2014; Guang Shi *et al.*, 2012).

6.0 Supplier Engagement and Collaboration

6.1 Methods for engaging suppliers

Supplier engagement is essential to sustainable sourcing success. Organizations often use education and training programs—such as workshops, webinars, and on-site sessions—to build supplier capacity for sustainable practices (Roehrich *et al.*, 2017; Lo *et al.*, 2018). Incentives including financial rewards, long-term contracts, preferred supplier status, and recognition programs further motivate supplier compliance (Patil *et al.*, 2022). Embedding sustainability criteria in supplier contracts (Uygun & Dede, 2016) and using sustainability scorecards for ongoing evaluation ensure alignment with organizational goals (Bhattacharya *et al.*, 2014; Kim & Rhee, 2012). Additionally, collaborative goal-setting fosters shared responsibility and enables co-creation of practical, mutually beneficial sustainability strategies (Vachon & Klassen, 2008; Lee, 2015).

6.2 Partnership models and frameworks

Partnership models and collaborative frameworks reinforce sustainable sourcing by strengthening supplier relationships. Strategic partnerships with key suppliers foster trust and mutual benefit, enabling joint development of sustainable products and processes (Youn *et al.*, 2013; Zhou *et al.*, 2020). Supplier development programs—covering joint innovation projects, sustainability audits, and resource-sharing initiatives—enhance supplier capabilities (Dou *et al.*, 2018; Neutzling *et al.*, 2018). Collaborative networks, such as industry coalitions and multi-stakeholder initiatives, promote knowledge-sharing and collective action on sustainability challenges (Choi & Hwang, 2015). Organizations may also engage in joint ventures or co-innovation partnerships to develop new sustainable technologies (Wong & Ngai, 2019; Matopoulos *et al.*, 2015).

6.3 Reverse logistics and the circular economy

Sustainable distribution innovations are increasingly shaped by reverse logistics and circular economy principles. Reverse logistics involves moving products from their point of consumption back to manufacturers or designated facilities for return, reuse, recycling, or disposal (Mishra *et al.*, 2012). By closing material loops, reverse logistics reduces waste, lowers resource demand, and improves supply chain resilience.

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6.4 Developments in sustainable packaging

Sustainable packaging innovations focus on eco-friendly materials and designs that minimize environmental impact. Biodegradable and compostable packaging made from plant-based materials such as cornstarch, bamboo, and seaweed naturally decompose and reduce landfill waste (Teixeira-Costa & Andrade, 2021). Recycled materials, such as post-consumer plastics and paper, further reduce reliance on virgin resources while supporting circular economy models (Oloyede & Lignou, 2021).

6.5 Balancing functionality with sustainability in packaging

A central challenge in sustainable packaging lies in balancing functionality with environmental performance. Packaging must protect products during transport, extend shelf life, and communicate essential information, while minimizing ecological impact (Lee & Rahman, 2014).Recent innovations address this balance by using lighter materials to reduce transportation emissions (Kutz, 2007) and advanced barrier technologies—such as multilayer films, coatings, and laminates—that preserve product quality with thinner materials (Tyagi *et al.*, 2021). Recyclable and compostable packaging designs further mitigate waste without compromising functionality (Morris, 2017).

7.0 Challenges and barriers to implementing GSCM

7.1 Financial and economic barriers

The adoption of GSCM often requires overcoming substantial financial and economic constraints. Initial investments in eco-friendly materials, energy-efficient technologies, or certifications can be significant, particularly for organizations with limited capital (Gawusu *et al.*, 2022; Tumpa *et al.*, 2019). For example, retrofitting facilities with energy-efficient systems or sourcing sustainable raw materials may increase production costs. Nevertheless, the long-term return on investment (ROI) can be positive. Organizations benefit from reduced operating costs through energy efficiency, waste minimization, and resource optimization (Jaggernath & Khan, 2015; Chandrakar & Kumar, 2012). Moreover, sustainable practices enhance brand reputation, customer loyalty, and regulatory compliance, providing competitive advantages and market opportunities (Famiyeh *et al.*, 2018; Ho *et al.*, 2009).

To mitigate financial barriers, organizations should strategically allocate resources, pursue government incentives and green financing mechanisms (e.g., sustainability-linked loans), and adopt phased implementation strategies (Kirchoff *et al.*, 2016; Hariyani & Mishra, 2022a). Collaboration with stakeholders can also share costs and create joint value, improving economic feasibility (Kumar & Goswami, 2019). Effective financial planning

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and a clear understanding of ROI are critical for balancing upfront costs with long-term benefits (Fang & Xu, 2020).

7.2 Technological and infrastructure challenges

The lack of suitable technologies and infrastructure often hinders GSCM adoption. Many organizations struggle to implement systems such as IoT sensors, blockchain for traceability, renewable energy solutions, and advanced analytics due to high costs, limited expertise, or scalability issues (Hu *et al.*, 2021; Hariyani *et al.*, 2024). Smaller firms, in particular, face difficulties in accessing these innovations (Rahman *et al.*, 2020). Infrastructure poses another challenge. Outdated facilities and logistics networks are often not aligned with green practices, making retrofitting costly and complex (Li *et al.*, 2015; Plaza-Úbeda *et al.*, 2020). Inadequate recycling and waste management systems further hinder circular economy practices (Rahman *et al.*, 2020). Additionally, fragmented supply chains without standardization impede the adoption of uniform sustainable practices (Mathiyazhagan *et al.*, 2013; Dhull & Narwal, 2016). Addressing these barriers requires capital investment, strategic partnerships, and industry-wide standards to enhance coordination (Wu *et al.*, 2022; Esmaeilian *et al.*, 2020). Organizations can advance sustainable practices by modernizing infrastructure, leveraging digital technologies for transparency, and committing to long-term innovation (Hastig & Sodhi, 2020).

7.3 Regulatory and policy constraints

Regulations and policies play a dual role in shaping GSCM adoption. On the one hand, they provide guidelines and incentives (e.g., emissions standards, subsidies, tax credits, and grants) that encourage sustainable practices (Tuffour *et al.*, 2024; Kayikci *et al.*, 2021). On the other hand, they can create barriers. Fragmented or inconsistent regulations across regions increase compliance costs for multinationals, while overly stringent policies may discourage innovation (Geng *et al.*, 2019; Dhull & Narwal, 2016).

The absence of comprehensive and updated policies also limits progress—for instance, weak guidelines on plastic waste management or sustainable packaging (Kannan *et al.*, 2022; Singh *et al.*, 2016).To overcome these challenges, organizations should engage with policymakers, advocate for consistent and forward-looking policies, and develop flexible compliance strategies (Ilyas *et al.*, 2020; Zhu *et al.*, 2011). Collaboration with stakeholders to push for updated regulations ensures policies evolve to address emerging sustainability challenges (Lee, 2023; Fontoura & Coelho, 2022).

7.4 Cultural and organizational resistance

Beyond financial and policy issues, cultural and organizational resistance often hinders GSCM implementation. Long-standing operational routines, entrenched supplier

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relationships, and existing infrastructure may be perceived as too costly or disruptive to change (Govindan *et al.*, 2014; Orji, 2019). Employees or departments may also resist due to fear of uncertainty, preference for the status quo, or doubts about the benefits of sustainability (Al Zaabi *et al.*, 2013).Resistance is further intensified when top management commitment is weak, leading to a lack of clear direction, resources, or accountability for sustainability initiatives (Sajjad *et al.*, 2020; Tumpa *et al.*, 2019).Overcoming resistance requires building awareness, education, and engagement at all organizational levels. Training programs and open communication can align employees with sustainability goals and highlight how these efforts contribute to profitability and efficiency (Mudgal *et al.*, 2009; Dou *et al.*, 2018). Strong leadership support and the gradual integration of sustainable practices into existing operations can reduce disruption, foster innovation, and make the transition smoother Yang (& Lin, 2020; Khan *et al.*, 2021a).

8.0 Conclusion

This review highlights how Green Supply Chain Management (GSCM) integrates sustainability across sourcing, production, packaging, and distribution. By embedding principles such as resource efficiency, circular economy practices, and stakeholder collaboration, GSCM enables firms to reduce environmental impact, improve supply chain resilience, and enhance financial and social performance. Sustainable sourcing ensures ethical procurement and resource conservation, while green distribution—through innovations in logistics, packaging, and reverse flows—supports waste reduction and efficiency. Theories and models like the Triple Bottom Line, stakeholder theory, CLSC, CE, LCA, and ISO 14001 provide structured frameworks that guide organizations toward responsible practices and long-term competitiveness. Despite challenges such as high costs, regulatory inconsistencies, and cultural resistance, GSCM offers significant benefits, including risk reduction, regulatory agility, innovation, and stronger stakeholder trust.

Overall, adopting GSCM equips organizations with the tools to balance economic growth with environmental stewardship and social responsibility, positioning them as leaders in sustainable business practices

9.0 Future Research Directions

Future research in Green Supply Chain Management (GSCM) should explore the role of advanced technologies such as AI, machine learning, blockchain, IoT, cloud computing, and big data analytics. These tools can improve transparency, efficiency, and sustainability. AI and machine learning may help predict disruptions and optimize logistics,

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while blockchain can ensure traceability and secure transactions. IoT supports real-time monitoring of resources, cloud computing enables smooth data sharing, and big data offers insights into consumer behavior and performance. Studies can focus on how these technologies strengthen predictive analytics, resource management, and supply chain security. Another area of research is the circular economy and closed-loop supply chains. Attention should be given to product design for durability, reverse logistics, and models that promote reuse and waste reduction. Such work will support the shift from linear systems to sustainable, resource-efficient models, thereby reducing environmental impact and enhancing resilience.

Researchers should also examine the effect of evolving policies, international agreements, and sustainability initiatives on supply chain practices. This includes integrating policy frameworks into strategies, responding to new regulations, and developing reliable sustainability metrics. Future studies can also address risk management, cross-sector collaboration, consumer engagement, and the role of green innovation in products and processes

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