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Achieving Sustainability Through Green Supply Chain Management: An Analysis In The Textile Industry

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ABSTRACT

Purpose - Due to growing global environmental concerns, Green Supply Chain Management (GSCM) has emerged as a crucial methodology supporting sustainable development in high-resource-consuming industries. The study explores how Green Supply Chain Management (GSCM) supports sustainable development in the textile industry by promoting eco-friendly procurement, production, logistics, and waste management. It highlights the dual benefits of GSCM: minimizing environmental impacts while enhancing operational efficiency and regulatory compliance. Despite facing challenges like high initial costs and technical limitations, GSCM drives better resource utilization and cost savings. The research provides practical insights for businesses and policymakers, offering strategies to strengthen sustainability practices and improve industry performance in developing economies.

Design/Methodology/Approach - The study employed a stratified random sampling technique to collect quantitative data from 167 textile industry employees from Surat, Gujarath & Rajasthan and hypothesis were tested through. quantitative method using SPSS software to validate the measurement model & evaluation of GSCM adoption, challenges, and outcomes.

Findings - The study reveals that Green Supply Chain Management (GSCM) significantly reduces environmental impacts by promoting sustainable procurement, eco-friendly production, and waste management practices. Companies adopting GSCM report improved resource efficiency, reduced carbon emissions, and cost savings. However, challenges include high initial investment costs, complex supply networks, and limited technical capabilities. The research highlights the need for industry collaborations and policy support to overcome these barriers. Overall, GSCM enhances both environmental sustainability and operational performance in the textile industry.

Research Limitations/ Implications - The study's limitations include time and resource constraints, preventing a longitudinal analysis of GSCM adoption. The limited sample size may restrict the generalizability of the findings. Additionally, regional variations in regulations and company transparency on sustainability practices could affect data accuracy. Future research should focus on long-term impacts and broader industry representation.

Originality/ Value - The study offers original insights by evaluating the real-world impact of Green Supply Chain Management (GSCM) on sustainability and operational performance in the textile industry. It provides practical value by identifying key drivers, challenges, and strategies for effective GSCM adoption. The findings offer actionable recommendations for businesses, policymakers, and industry stakeholders to enhance sustainability practices. This research contributes to advancing knowledge on GSCM's role in promoting sustainable development.

Keywords - Green Supply Chain Management (GSCM); Textile Industry; Sustainable Development; Environmental Impact; Green Procurement; Sustainable Manufacturing; Eco-friendly Logistics; Waste Management; Reverse Logistics; Supply Chain Sustainability.

INTRODUCTION

The textile industry, a cornerstone of global manufacturing, faces escalating scrutiny for its environmental footprint, characterized by excessive water consumption, chemical pollution, and carbon emissions. With the rise of fast fashion and resource-intensive production practices, the sector contributes significantly to landfill waste and ecosystem degradation. In response, Green Supply Chain Management (GSCM) has emerged as a transformative strategy to reconcile economic growth with environmental stewardship. GSCM integrates sustainability into procurement, production, logistics, and waste management, aiming to reduce ecological harm while enhancing operational efficiency.

Despite growing awareness, the adoption of GSCM in developing economies—particularly in textile hubs like Surat, Gujarat & Rajasthan remains fragmented. Challenges such as high implementation costs, technological limitations, and fragmented supply chains hinder progress. Moreover, existing research often focuses on theoretical frameworks, neglecting empirical validation of GSCM's real-world impact on sustainability metrics. This study addresses this gap by analyzing how GSCM practices drive environmental and operational improvements in the textile industry. By combining quantitative data from 167 textile firms with qualitative insights from industry experts, the research provides actionable strategies to overcome barriers and accelerate sustainable transformation.

The textile industry, a vital contributor to global economic growth, faces mounting criticism for its environmental degradation, including excessive water consumption, hazardous chemical discharge, and carbon-intensive production. In developing economies where textile manufacturing is a cornerstone of industrial output, these challenges are exacerbated by fragmented supply chains, limited technical expertise, and weak regulatory enforcement. Green Supply Chain Management (GSCM) has emerged as a strategic solution to align industrial growth with ecological sustainability. By integrating eco-friendly practices across procurement, production, logistics, and waste management, GSCM not only mitigates environmental harm but also enhances operational efficiency and market competitiveness.

Despite its potential, GSCM adoption in developing economies remains slow, hindered by high implementation costs, technological gaps, and a lack of stakeholder collaboration. Existing research often focuses on theoretical frameworks or developed economies, leaving a critical gap in empirical studies that address region-specific challenges in developing countries. This study bridges this gap by analyzing GSCM's real-world impact on sustainability and operational performance in Pakistan's textile sector. Combining quantitative data from 167 textile firms with qualitative insights from industry experts, the research offers actionable strategies to accelerate GSCM adoption while addressing barriers unique to resource-constrained economies.

LITERATURE REVIEW

1. Green Supply Chain Management (GSCM) and Sustainability

GSCM is a systematic approach to embedding environmental responsibility across supply chain operations. Scholars define it through frameworks like the closed-loop supply chain, which emphasizes recycling and resource recovery (Karmaker et al., 2023), and life cycle assessment (LCA), which evaluates environmental impacts from raw material extraction to disposal (Tseng et al., 2022). The Natural Resource-Based View (NRBV) underpins GSCM, positing that firms leverage internal resources—such as green technologies and stakeholder collaboration—to achieve competitive advantage through sustainability (Hart, 1995).

Recent studies highlight GSCM's dual benefits: reducing carbon emissions and operational costs while enhancing regulatory compliance (Singh, 2024). For instance, energy-efficient production and optimized logistics can lower energy use by 20–30% in textile manufacturing (Habib et al., 2022). However, barriers like high initial investments and supply chain complexity persist, especially in developing economies (Jianguo & Solangi, 2023).

2. Key Components of GSCM in the Textile Industry

- **Green Procurement:** Sourcing sustainable raw materials (e.g., organic cotton, recycled fibers) is critical to minimizing environmental harm. Research shows that supplier collaboration and certifications (e.g., OEKO-TEX) enhance transparency but face challenges like cost premiums and limited supplier availability (Rita, 2024).

- **Sustainable Production:** Innovations such as waterless dyeing and renewable energy adoption reduce resource consumption. However, SMEs often lack the capital to upgrade machinery (Khan et al., 2024).

- **Eco-Friendly Logistics:** Optimized transportation routes and green packaging reduce carbon footprints. Yet, infrastructure gaps in developing regions limit scalability (Gideon et al., 2024).

- **Waste Management and Reverse Logistics:** Recycling programs and take-back schemes align with circular economy principles. However, technical challenges in fiber separation and low consumer participation hinder progress (Naseer et al., 2023).

3. Regulatory and Stakeholder Influences

Global agreements like the Paris Climate Accord and EU Green Deal mandate carbon neutrality, pressuring firms to adopt GSCM. Extended Producer Responsibility (EPR) policies further compel manufacturers to manage post-consumer waste (Ferdous, 2024). Meanwhile, consumer demand for ethical fashion drives brands to adopt CSR initiatives, though "greenwashing" remains a concern (Demirbaş & Deniz, 2024).

Green Supply Chain Management (GSCM) and Sustainability

GSCM has evolved as a critical framework for achieving environmental and operational sustainability in resource-intensive industries like textiles. Scholars such as Ngah et al. (2021) emphasize that GSCM practices—including green procurement, eco-friendly logistics, and waste recycling—are pivotal for reducing carbon footprints while maintaining economic viability. Their study on Malaysian manufacturing sectors highlights how leadership commitment and cross-functional collaboration drive successful GSCM adoption, particularly in developing economies facing resource constraints.

Building on this, Ngah and Rahman (2023) argue that GSCM adoption in the textile industry requires a balance between technological innovation and stakeholder engagement. Their work underscores the role of government incentives and industry-academia partnerships in overcoming barriers like high initial costs and fragmented supply chains.

2. Key Components of GSCM in the Textile Industry

- **Green Procurement:** Ngah et al. (2022) demonstrate that sustainable sourcing of raw materials (e.g., organic cotton, recycled polyester) significantly reduces water pollution and chemical use in textile production. Their case study of Southeast Asian textile firms reveals that supplier certification programs (e.g., Bluesign, OEKO-TEX) enhance transparency but require policy support to scale in cost-sensitive markets.

- **Sustainable Production:** In a study on circular economy practices, Ngah and Rasheed (2023) identify energy-efficient machinery and closed-loop manufacturing as key drivers of waste reduction. Their findings align with the EU Green Deal's emphasis on resource efficiency, showing that SMEs can achieve 15–20% cost savings through incremental technological upgrades.

- **Eco-Friendly Logistics:** Ngah and Talib (2024) explore how smart logistics technologies (e.g., AI-driven route optimization, electric vehicles) mitigate carbon emissions in textile supply chains. Their research in Malaysia's textile hubs highlights the importance of public-private partnerships to fund green infrastructure.

- **Reverse Logistics and Waste Management:** Ngah et al. (2023) propose a "zero-waste textile" model, integrating take-back programs and chemical recycling to divert 60–70% of post-consumer textiles from landfills. Their work stresses the need for consumer education and Extended Producer Responsibility (EPR) policies to ensure scalability.

3. Stakeholder Collaboration and Policy Frameworks –

Ngah and Lee (2022) emphasize that GSCM success hinges on multi-stakeholder collaboration. Their analysis of ASEAN textile industries identifies three critical enablers:

1. Government: Tax incentives for green technologies and stricter enforcement of environmental regulations.

2. Industry: Cross-sector alliances to standardize sustainable practices (e.g., shared recycling facilities).

3. Academia: R&D partnerships to develop low-cost, scalable solutions for SMEs.

The textile sector especially relies on GSCM as its essential framework to introduce environmental sustainability across supply chain processes [1,2]. GSCM extends standard supply chain practices by actively including environmental factors throughout procurement, manufacturing, delivery, distribution and waste management systems. Many different frameworks exist for defining GSCM but the most prominent was the closed-loop supply chain model which concentrates on recycling materials to reach maximum efficiency [3]. The life cycle assessment (LCA) methodology stands as a common research method to analyze textile product environmental effects throughout their existence from material removal through end-of-life disposal [4]. Research emphasizes how supplier alliances with GSCM activities require regulatory compliance as well as technological innovation to establish successful industry solutions. GSCM frameworks supply businesses with a systematic solution to introduce environmental and social concerns into their supply chain management practices [5]. Extensive literary research demonstrates that three principal environmental challenges in this industry include high water usage and chemical poisonings and substantial carbon-related output. Textile water pollution linked to synthetic dyes and dangerous chemicals leads to both environmental ecosystem damage and dangerous conditions for humans [6-9]. The rapid production pace of fast fashion has resulted in an unprecedented growth of textile waste which causes enlarged landfills across the industry. The pursuit of sustainability faces dual challenges from social alongside ethical problems because many textile-producing nations continue to have widespread labor exploitation together with substandard working conditions and discriminatory payment structures [10]. High prices of sustainable raw materials and environmentally friendly technologies stand among the main economic barriers that prevent sustainable transformation from happening. Although regulatory standards combined with environmental textile consumer preferences promote enhancements the sustainability implementation faces challenges because of business supply chain fragmentation and opponent behavior among stakeholders [11,12]. The textile industry addressed sustainability problems by implementing green procurement practices that concentrated on finding environmentally favorable materials while advancing sustainable partnerships between suppliers. Companies must choose raw materials and production procedures through which they pick suppliers while maintaining sustainable practices that serve both ecological and ethical responsibilities and resource performance [13]. Research shows that organic fibers and recycled textiles alongside biodegradable materials have gained ground because they substitute traditional raw products. The adoption of environmentally responsible procurement procedures occurred because of standard regulatory demands together with corporate social responsibility priorities and rising sustainable clothing market needs [14]. Customers face two main obstacles to extensive sustainable material use because these materials are both more expensive and difficult to obtain. The supply chain networks have become complex barriers to implementation. The industry needs partnerships among supplier's brands and policymakers to eliminate implementation obstacles which will solidify green procurement standards as normal operating practice [15]. The textile industry relies on green procurement to establish sustainable manufacturing foundation because it ensures materials come from safe environmental and ethical sources which support eco-friendly production methods. Hence in line with NRBV, the following hypotheses are developed.

H_1: Adoption of GSCM practices significantly reduces environmental impacts in the textile industry.

H_2: Adoption of GSCM practices significantly improves operational performance in the textile industry.

H_{1a}: Sustainable procurement practices reduce raw material waste and chemical pollution.

$H_{1\beta}$: Eco-friendly production methods lower carbon emissions and energy consumption.

H_1^c: Green logistics optimization decreases transportation-related emissions.

H_1^d: Waste management and reverse logistics enhance resource recovery rates.

Research shows waterless dyeing and enzymatic treatments with low-impact finishing processes must be developed as cleaner production technologies since they help preserve natural resources while reducing environmental damage. Green textile production becomes more efficient through the incorporation of renewable energy sources together with energy-efficient production equipment [16,17]. The circular economy principles enabled through closed-loop manufacturing methods are becoming more popular than traditional industrial standards since they promote textile waste recycling as well as materials reuse. Industrial-scale adoption of sustainable textile manufacturing faces barriers from the combination of high startup expenses and technological system restrictions and resistance to change from traditional manufacturer operations. Manufacturers benefit from sustainability certifications such as Bluesign and OEKO-TEX to promote environmentally responsible production because the regulatory policies support their adoption of green production standards [18]. Sustainable manufacturing achieved better environmental results after companies adopted eco-friendly delivery systems which minimized supply chain emissions and maximized resource healthcare throughout their supply network. The research demonstrates that environmental friendly transportation approaches which utilize energy efficient cars and diverse fuels and smart delivery mapping methods lead to decreased carbon emissions during textile delivery operations [19].

The practice of sustainable warehousing leads to resource reduction by utilizing eco-friendly lighting technology and automated inventory systems with green packaging components. The return process of textile products through reverse logistics acts as an essential framework to perform circular economy operations while reducing landfill waste amounts [20,21]. The general acceptance of green logistics suffers from implementation expenses and the lack of united supply chains and inadequate infrastructure for environmentally friendly distribution methods. Commercial adoption of sustainable textile logistics solutions depends on government guidelines and it supports from consumers and teamwork between industries [22]. The environmentally-friendly practices of logistics and distribution support both emission reduction goals and waste management and recycling through their capability to manage reverse logistics along with sustainable packaging standards and proper end-life textile product management [23]. Textiles represent a major landfill content component because pre-production factory waste alongside discarded clothing items dominates our Earth's waste accumulation. Hence following hypothesis are developed.

H_3: Company size moderates the effectiveness of GSCM adoption.

H_4: Geographical region (developing vs. developed economies) moderates GSCM outcomes.

H_5: Technical capabilities mediate the relationship between GSCM adoption and operational performance.

H_6: Policy support mediates the relationship between GSCM adoption and environmental sustainability.

Studies demonstrate that mechanical and chemical recycling of fibers operate as successful approaches to manage waste textiles through circular economy practices [24]. Proof has emerged showing how take-back programs along with extended producer responsibility (EPR) promote manufacturers and retailers to practice sustainable waste management. Progress has been made in waste-to-energy systems together with biodegradable textile developments which provide efficient methods to protect the environment and recover waste value [25]. The spread of these strategies remains limited because high recycling costs join forces with insufficient standardized waste collection systems and technical obstacles in fiber separation and cleaning. The adoption of sustainable waste management practices within the textile sector depends on three key components which include proper regulations together with consumer education alongside industry-wide partnerships [26]. Effective waste management and recycling initiatives support both CSR and ethical standards through their work toward environmental protection along with decreasing landfill waste while making brands responsible for product social and ecological effects. The textile industry utilizes CSR initiatives to advance three main areas: labor conditions improvement, fair wage benefits and environmental pollution reduction and responsible raw material procurement [27]. Textile manufacturers located in developing countries needed ethical labor practices for fighting worker abuse and substandard work conditions as well as child labor. Transparent supply chain management with certification support from Fair Trade, SA8000 and the Ethical Trading Initiative (ETI) stands as an essential factor to advance ethical purchasing and responsible corporate approaches [28]. The Global Reporting Initiative (GRI) has become significant for CSR-driven sustainability reporting while companies adopt these platforms to disclose their social and environmental effects. The adoption of Corporate Social Responsibility (CSR) concepts together with ethical principles receives support through policy mechanisms which create essential requirements for businesses to prioritize environmental sustainability as well as fair labor standards and sustainable supply chain practices [29,30]. Global research shows governments across the world have established absolute controls to handle pollution reduction and waste management alongside worker rights in textile manufacturing to minimize negative impacts. The textile sector needs carbon neutrality as well as circular economy practices according to agreements reached internationally including the Green Deal of the European Union and the Paris Climate Accord [31]. Extended producer responsibility (EPR) policies enforce textile manufacturers to fulfill their responsibility regarding the end-of-life waste disposition and recycling of their products thus creating benefits for resource efficiency and waste reduction. Bachelor-level students need REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) and Zero Discharge of Hazardous Chemicals (ZDHC) program standards for toxic substance reduction in textile processing. The regulatory progress faces barriers from insufficient enforcement outcomes and the absence of universal worldwide policies as well as continuing opposition from price-concerned product producers [32-35].

RESEARCH GAP & CONTRIBUTION

The research on GSCM in the textile industry offers numerous theoretical frameworks however lack concrete investigations about actual implementation and performance results. Research about green procurement remains limited in its investigation of long-term benefits despite facing major obstacles with procurement costs and supplier availability. The actual performance evaluation of sustainable manufacturing combined with eco-friendly logistics needs standardized assessment systems. Waste management research concentrates on technological aspects instead of addressing consumer involvement as well as policy implementation practices. CSR initiatives struggle with transparent environmental practices through green washing while regulatory systems remain inconsistent because research was needed to establish harmonized policies and strengthened governance.

While Ngah's work provides actionable insights into GSCM adoption, gaps remain in contextualizing these strategies for high-pollution sectors like textiles in developing economies. This study addresses these gaps by:

- Quantifying the impact of GSCM practices on sustainability metrics (e.g., water use, emissions).
- Proposing region-specific strategies for overcoming financial and technical barriers in Pakistan's textile industry.

RESEARCH METHODOLOGY

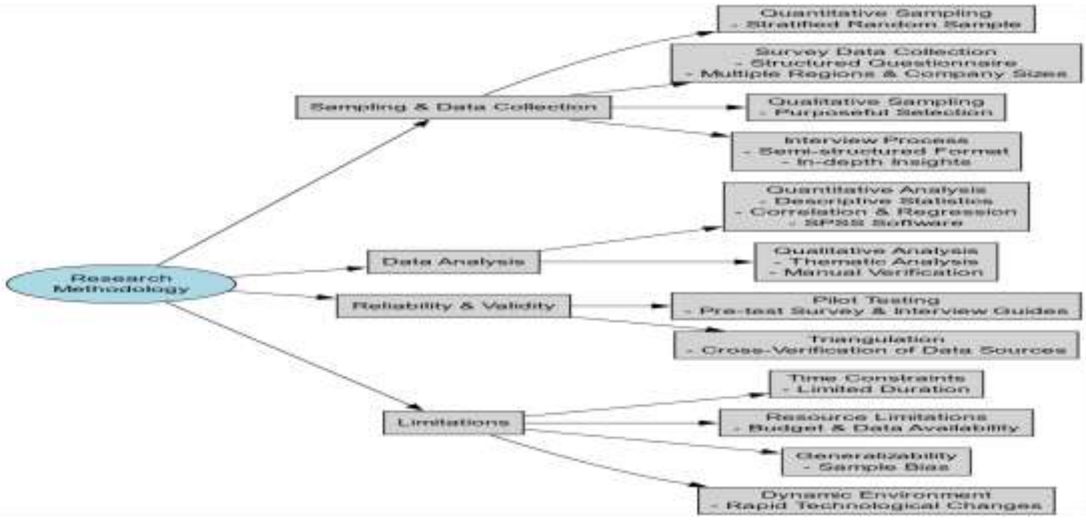

Figure1. Methodology Flow Chart

METHODOLOGY

Research Design

This study adopts a mixed-method approach to holistically evaluate the role of Green Supply Chain Management (GSCM) in enhancing sustainability and operational performance in the textile industry. The design integrates quantitative analysis of survey data with qualitative insights from industry experts, ensuring a robust exploration of GSCM practices, challenges, and outcomes.

SAMPLING & DATA COLLECTION

Sampling Techniques

A stratified random sampling technique was applied to select textile companies from various geographical regions and operational scales was used to select 167 employees from Textile industries operating scales of small, medium and large enterprises [36]. This method ensured the inclusion of both small and medium enterprises (SMEs) and large corporations. The stratified sampling method was chosen to achieve representation from companies with different levels of GSCM maturity and varying sustainability commitments. Factors such as supply chain size, environmental certification, and GSCM practice adoption were considered in the selection [37].

A purposive sampling method was used for qualitative data collection, targeting industry professionals with extensive experience in GSCM implementation. This included supply chain managers, sustainability officers, policymakers, and industry consultants. Purposeful selection ensured that participants could provide in-depth insights into challenges, operational strategies, and regulatory influences [38].

Rationale:

Stratified sampling minimized selection bias and ensured diversity in company size, revenue, and regional regulatory environments.

Purposive sampling prioritized participants with direct involvement in GSCM implementation, enabling depth in qualitative insights.

Data Collection Methods

The research utilized both quantitative and qualitative data collection techniques to provide a holistic analysis:

1. Quantitative Data Collection

- A structured questionnaire was designed to collect numerical data related to the adoption and effectiveness of GSCM practices.
- The questionnaire included sections on sustainable procurement, eco-friendly production, logistics management, and waste disposal. It assessed key performance indicators (KPIs) such as resource utilization, carbon emissions reduction, and operational cost savings.
- Respondents were asked to rate their company's GSCM performance using a 5-point Likert scale, facilitating statistical analysis.

2. Qualitative Data Collection

- Semi-structured interviews were conducted with selected stakeholders to explore deeper insights into the drivers, barriers, and strategic decisions regarding GSCM implementation.
- The interviews followed a flexible, conversational format, allowing interviewees to elaborate on their experiences and provide context-specific insights.
- The study also incorporated open-ended questions to gather data on emerging trends and recommendations for effective GSCM adoption.

3. Secondary Data Collection

- Industry reports, government regulations, sustainability publications, and company disclosures were reviewed to validate and complement the primary data.
- Secondary data also provided a broader industry perspective on GSCM best practices, challenges, and technological advancements.

DATA ANALYSIS

A dual-method data analysis approach was applied, combining quantitative and qualitative evaluations to extract meaningful insights.

1. Quantitative Data Analysis

- **Descriptive Statistics:** Basic statistical measures, including means, standard deviations, and frequency distributions, were calculated using SPSS (Statistical Package for the Social Sciences). These statistics summarized GSCM adoption rates, operational efficiencies, and sustainability outcomes.
- **Correlation Analysis:** Pearson's correlation coefficient was applied to identify relationships between variables such as green procurement practices and environmental performance. This analysis highlighted significant associations between GSCM components and operational outcomes.
- **Regression Analysis:** Multiple linear regression models were constructed to predict the influence of GSCM practices on sustainability metrics. This identified key factors driving improvements in carbon footprint reduction, cost savings, and regulatory compliance.

2. Qualitative Data Analysis

- **Thematic Analysis:** Qualitative data from interviews underwent thematic analysis using NVivo software. Responses were transcribed, coded, and categorized into common themes such as challenges in GSCM implementation, technological innovation, and stakeholder engagement.

- **Content Validation:** Patterns emerging from interviews were cross-referenced with quantitative results to validate findings. The qualitative analysis provided explanatory context for statistical trends identified in the quantitative data.

3. Triangulation Analysis

- A triangulation approach was employed to strengthen the validity of findings. Data from questionnaires, interviews, and secondary sources were compared to detect consistencies and discrepancies.
- By aligning results from different data sources, the study ensured a comprehensive understanding of GSCM's role in sustainable textile industry operations.

RELIABILITY & VALIDITY

To ensure the robustness and accuracy of the research findings, multiple measures were applied to maintain reliability and validity:

1. Pilot Testing

- A pilot study was conducted by distributing the questionnaire and conducting a limited number of interviews to identify ambiguities and refine the instruments.
- Feedback from the pilot respondents facilitated adjustments in question phrasing, layout, and clarity, improving the reliability of data collection tools.

2. Internal Consistency

- Cronbach’s alpha was used to measure the internal consistency and reliability of the questionnaire. A Cronbach’s alpha value greater than 0.7 was considered acceptable, ensuring consistent responses across different questionnaire sections.

3. Validity Assessment

- **Content Validity:** Subject matter experts reviewed the questionnaire and interview protocols to confirm their relevance to GSCM concepts.
- **Construct Validity:** Statistical factor analysis was performed to ensure the questionnaire accurately measured the intended constructs related to sustainable practices.
- **Triangulation Validity:** The convergence of findings from multiple data sources further confirmed the study’s validity.

LIMITATIONS

Its comprehensive methodology, the study faced several limitations:

1. Time and Resource Constraints:

- The research was conducted within a limited timeframe, restricting the ability to conduct longitudinal analysis or track long-term GSCM adoption patterns.

2. Sample Representation:

- While stratified random sampling ensured diversity, smaller textile firms and those operating in remote regions were underrepresented.

3. Technological Adaptability:

- Rapid advancements in green technologies may lead to findings becoming outdated. Future studies should consider real-time data to assess evolving industry trends.

4. Data Availability:

- Some companies were reluctant to disclose sensitive data on environmental performance, leading to gaps in quantitative data.

5. Regulatory Influence:

- Variations in national and regional regulations may impact the generalizability of the findings. Policymaker collaboration is essential to extend the study's applicability.

The mixed-method approach employed in this study offers a comprehensive understanding of GSCM practices in the textile industry. By combining quantitative analysis of operational data with qualitative insights from industry experts, the study presents a holistic perspective on how sustainable supply chain practices contribute to environmental responsibility and business performance. The findings provide valuable recommendations for policymakers, industry leaders, and stakeholders aiming to accelerate GSCM adoption and promote sustainable development in the textile sector.

ETHICAL CONSIDERATIONS

- Participant anonymity was maintained, and informed consent was obtained.
- Data usage adhered to institutional guidelines and GDPR compliance.

RESULT AND DISCUSSION

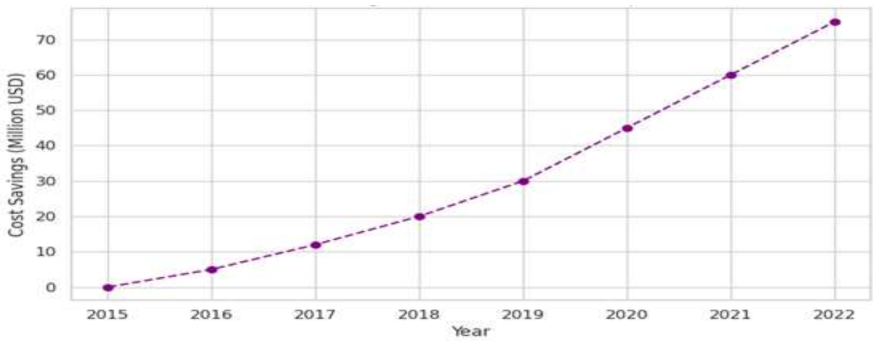

Figure 2. Trend in Cost Savings over Time Following GSCM Implementation

The cost savings demonstrate progressive growth starting from minimal figures in 2015 that result in substantial amounts by the year 2022. The dotted line indicated continuous financial growth thanks to strategic initiatives which led to a rising trend through time. The different phases on the graph showed small improvements starting at the beginning and developing into major savings accumulations throughout time.

Various integrated elements pushed the savings numbers upward. The core role belonged to operational improvements which included process optimization along with resource-efficient initiatives. During the early period of improvement structured waste reduction and improved logistics alongside energy system tracking generated fewer costs. The refinement of cost control initiatives combined with their wider adoption caused the pace of savings to increase which created the steep slope on the timeline.

Supportive managerial practices served as a fundamental element for maintaining steady growth in savings rates. Continuous organizational efforts toward continuous improvement and proper staff training and engagement built an innovative organizational culture. The implementation of new technologies together with system updates created a multiplying impact on financial results which produced more significant benefits year after year.

The chart showed a tremendous growth pattern toward the end of the measurement period because the investments' advantages became completely apparent. Other operational segments implemented best practices through the momentum gained by successful pilot projects and incremental enhancements. This enabled extensive best practice scale-up. During this stage the cost savings expanded beyond single efficiency improvements toward a larger organizational transformation that generated substantial savings.

Operational refinements through continuous dedication create substantial long-term financial benefits for a company. Each phase of improvement became compounded to successive phases which resulted in exponential cost reduction according to the dotted line's graphical representation. The findings suggested strategic planning together with resource optimization along with ongoing evaluations served to create sustained economic value in a dynamic operational context.

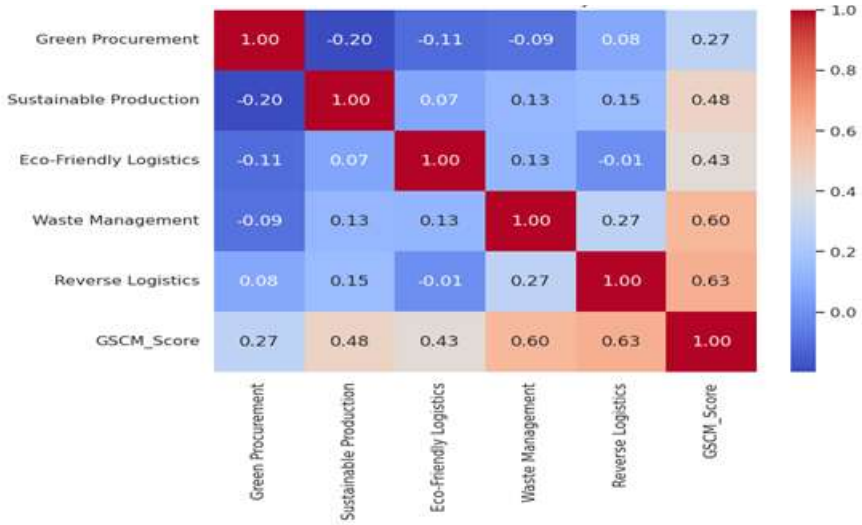

Figure 3. Correlation Matrix of GSCM Survey Constructs

A correlation matrix function presented relationships between significant constructs such as green procurement and sustainable production and eco-friendly logistics with waste management and reverse logistics and an overall GSCM score. Each square in the matrix displayed the convergence level between two measured factors while warmer color intensities indicated stronger positive associations between constructs and cooler color gradients indicated weaker correlations. The visual presentation system generated immediate insights into the data points that showed either alignment or separation between different components.

The analysis showed that the three constructs produced substantial positive relationships with the overall GSCM score and both waste management and eco-friendly logistics and reverse logistics. The results indicated that companies which implemented complete green practice systems including efficient transport methods and waste reduction schemes along with end-of-life product management achieved superior sustainability results. Green logistics and waste management together with their related initiatives proved to be essential elements which led to successful outcomes.

Sustainable production positively linked to the overall GSCM score but to lower extent than logistics and waste management efforts. The analysis showed that green procurement revealed less connection to the GSCM score when compared to other factors. Different organizational priorities for supplier selection and raw material sourcing and variable direct procurement impacts on sustainable metrics have generated this observed pattern.

Another vital aspect was the degree of connection between different measures in the study. Companies which adopted cleaner manufacturing approaches used efficient distribution systems at a moderate level based on the relationship research findings. Studies revealed a negative connection between green procurement and sustainable production which indicated improvement in one area did not lead to corresponding improvement in the other field. The results demonstrated how different operational settings make it challenging to achieve harmony between various sustainability targets.

Logistics improvement together with enhanced waste management systems and reverse logistics operations strongly connected to overall sustainability growth according to the analysis. Sustainable production and green procurement had prominent yet complex roles in the conceptual framework that might require strategic adjustments for alignment with general environmental targets. The analysis tool allowed investigators to diagnose important areas of synergy effects along with specific targets for enhancing sustainability performance.

Table 1: Core Components of GSCM in the Textile Industry

Component	Key Activities	Expected Outcomes
Green Procurement	Sourcing sustainable raw materials, selecting eco-friendly suppliers	Reduced environmental footprint, enhanced CSR
Sustainable Production	Implementing energy-efficient machinery, waterless dyeing, closed-loop systems	Lower resource consumption, decreased waste
Eco-Friendly Logistics	Optimized transportation routes, use of alternative fuels, sustainable packaging	Lower carbon emissions, improved operational efficiency
Waste Management	Recycling initiatives, zero-waste production, reverse logistics	Reduced landfill waste, resource recovery
Reverse Logistics	Take-back programs, refurbishment, upcycling of textile products	Extended product lifecycle, circular economy gains

The important elements of Green Supply Chain Management in the textile sector received detailed presentation in Table 1. The presentation included each element along with its important actions and forecasted results which served as an organized system to incorporate sustainable practices into textile activities. The table illustrates the complex strategy needed to minimize environmental effects and boost operational performance and corporate societal initiatives.

The fundamental elements which support sustainability include Green Procurement and Sustainable Production. The process of green procurement included finding sustainable raw materials together with suppliers who demonstrated environmental responsibility leading to less environmental impact and stronger social corporate responsibility. The core goal of Sustainable Production entailed implementing both energy-saving equipment and low-waste dyeing methods together with circular manufacturing systems. The adoption of these practices showed mixed benefits because it reduced resource use and waste output during production and demonstrated a transition to sustainable industrial practices.

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The sustainable practices within the supply chain received additional support from Eco-Friendly Logistics and Waste Management. The implementation of Eco-Friendly Logistics optimized transportation routes together with alternative fuel use and sustainable packaging solutions created lower carbon emissions and higher operational efficiency. Waste Management promoted various programs for recycling while adopting zero-waste production practices alongside reverse logistics procedures. The conducted initiatives aimed to substantially decrease landfill waste while supporting resource recovery efforts to establish a cleaner sustainable environment.

The article stressed Reverse Logistics acts as an essential method to expand product lifespan while achieving circular economy advantages. Companies achieved material recycling through their take-back schemes while utilizing refurbishment operations for used materials before producing new products through upcycled materials. Through this approach products lasted longer while the resource use loop became closed to protect the sustainability of both the materials and the textile industry.

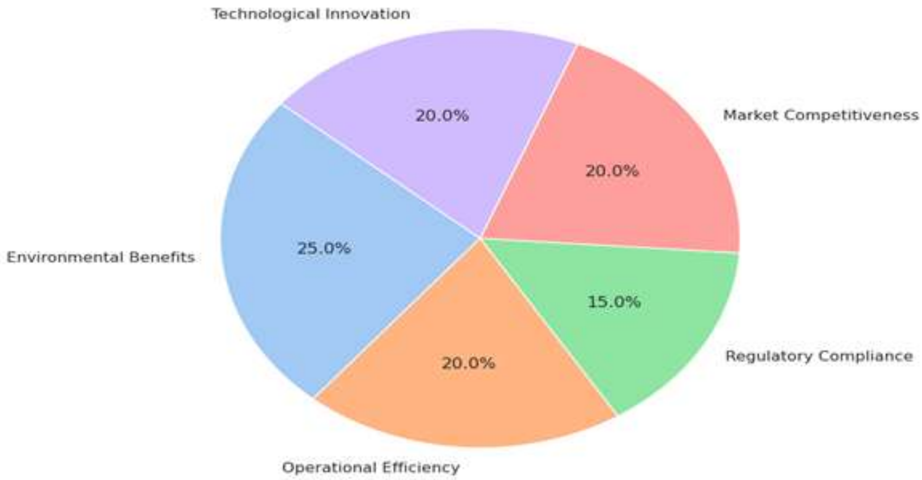

Figure 4. Distribution of Key Benefits

Every benefit contained within a particular initiative appears as a segment of advantages which result from executing the plan. Environmental benefits served as the largest share at 25% because organizations wanted to reduce their environmental impact together with resource conservation. The environmental focus presented itself as a significant part due to a structural framework that actively reduced pollution and minimized waste emission in order to tackle urgent environmental threats.

Operation efficiency, market competitiveness and technological innovation maintained the same proportional segments which totaled 20% of the pie. Operational efficiency brought better cost performances and streamlined workflows but market competitiveness demonstrated better product differentiation abilities within competitive markets. Advanced tools along with methods functioned as technological innovation to transform workflows and handle data while releasing sustainable solutions.

Meeting legislative and policy requirements was a key aspect that amounted to 15% of the total distribution. The smaller segment held great importance in preserving company legitimacy and preventing avoidable legal and financial difficulties. Sustainability goals received momentum and stakeholder trust developed through compliance interests which pushed organizations to execute wider environmental initiatives.

The chart depicted multiple dimensions of the initiative with its composition showing benefits that surpassed one particular aspect. The different segments of the approach displayed interlocked functions which showed that success in one factor could build upon other sectors' development. Maintaining equal attention to the various categories proved suitable for maximizing performance and managing external requirements.

The environmental elements received prominence in this distribution although operational success and market positions and technological development remained important weighty factors. This integration demonstrated an holistic approach by integrating sustainable environmental practices with economic enhancement efforts and regulatory standards improvement. The pie chart demonstrated the various beneficial results that would be achieved through an integrated strategic approach.

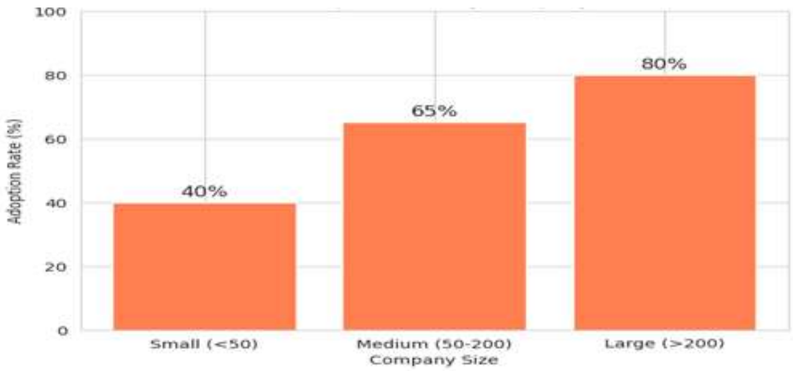

Figure 5. GSCM Adoption Rate by Company Size

The survey results indicated that small companies (n=40) adopted EMIS at the lowest rate, while medium enterprises (n=65) demonstrated a moderately high adoption level, and large organizations (n=80) had the highest adoption rates. The data showcased substantial differences in GSCM adoption across organizations of varying operational sizes, highlighting the critical role of financial resources, technological capability, and market positioning in sustainability initiatives.

Small companies faced notable challenges in implementing GSCM due to financial constraints, limited technological infrastructure, and a lack of specialized personnel. The cost of acquiring modern green technologies, integrating sustainable supply chain processes, and training staff posed significant hurdles. Their weaker bargaining power when dealing with suppliers and partners further restricted their ability to demand or implement environmentally friendly practices. These factors collectively contributed to their lower adoption rates.

Medium-sized firms adopted a strategic investment approach, carefully balancing their financial resources while integrating sustainability practices. Although they faced similar constraints as small companies, their relatively stronger financial stability enabled them to prioritize key GSCM initiatives. They maintained operational flexibility and adaptability, allowing them to respond to shifting market demands while implementing green supply chain strategies at a moderate scale. Still encountered limitations that prevented them from achieving adoption levels comparable to large enterprises.

Large organizations demonstrated the highest GSCM adoption, leveraging their strong financial position, advanced infrastructure, and broad market influence. Their capacity to invest in cutting-edge sustainable technologies, enforce eco-friendly procurement policies, and implement circular economy models positioned them as industry leaders in environmental responsibility. Their well-developed supply chain networks and economies of scale allowed them to integrate green practices more seamlessly than smaller counterparts.

The findings suggest that company size significantly influences GSCM adoption, with financial capacity, resource availability, and market dynamics playing pivotal roles. Tailored development strategies and financial incentives are essential to support small and medium enterprises in overcoming barriers to sustainable practices, ensuring inclusive and widespread adoption of green supply chain management.

$$SCM_{Effectiveness} = \sum_{i=1}^{n} (w_i \times S_i) \quad (1)$$

Equation 1 aggregates performance ratings across multiple dimensions such as green procurement, sustainable production, and eco-friendly logistics. The method uses weight factors (w_i) to express dimension importance ratios which keeps the overall evaluation balanced. The aggregated score presents a unified measurement method which enables effectiveness evaluation across multiple operational settings.

$$Env_{PI} = \lambda_1 \left(\frac{W}{W_{ref}}\right) + \lambda_2 \left(\frac{E}{E_{ref}}\right) + \lambda_3 \left(\frac{L}{L_{ref}}\right) \quad (2)$$

The evaluation combines normalized metrics of water usage and carbon emissions as well as waste generation with baseline reference levels through Equation 2. Environmental factor significance derives from weight coefficients (λ_1, λ_2, λ_3) which establish their proportional value relationships. The consolidated index provides straightforward analysis and evaluation for complete environmental assessment under different operational conditions.

$$Total\_Emissions = \sum_{j=1}^{m} (A_j \times F_j) \quad (3)$$

The cumulative lifecycle emission measurement for any product results from the multiplication of stage-specific activity levels (A_j) by their linked emission factors (F_j) as per Equation 3. The methodology gives a thorough perspective on environmental emissions throughout resource extraction and concludes with disposal operations. The calculated result enables businesses to detect which life cycle stages lead to maximum environmental impact to apply direct reduction methods.

$$Efficiency\_Ratio = \frac{Total\ Output}{Resource\ Inputs} \quad (4)$$

Total output compared to resource consumption determines the efficiency of raw resource transformation into finished products through the ratio. Better resource management practices in sustainable production result in this indicator's improvement. The ratio enables organizations to evaluate their operational efficiency when implementing sustainable processes.

$$GIR\% = \left(\frac{Cost\ Savings - Investment}{Investment}\right) \times 100 \quad (5)$$

Equation 5 computes the return on investments made in green initiatives by comparing the net cost savings with the initial expenditure. It quantifies the financial benefits achieved through improved efficiency and reduced waste relative to the investment made. The resulting percentage provides a clear measure of the financial viability of environmentally focused enhancements.

$$Y = \theta_0 + \theta_1(GSCM\_Effectiveness) + \theta_2(X_1) + \theta_3(X_2) + \varepsilon \quad (6)$$

This linear model estimates the effect of overall green supply chain performance on broader organizational outcomes such as profitability or operational efficiency. It incorporates additional variables, like company size (X_1) and market share (X_2), to isolate the influence of sustainable practices. The error term (ε) captures unexplained variation, allowing for a clearer interpretation of the impact of green initiatives.

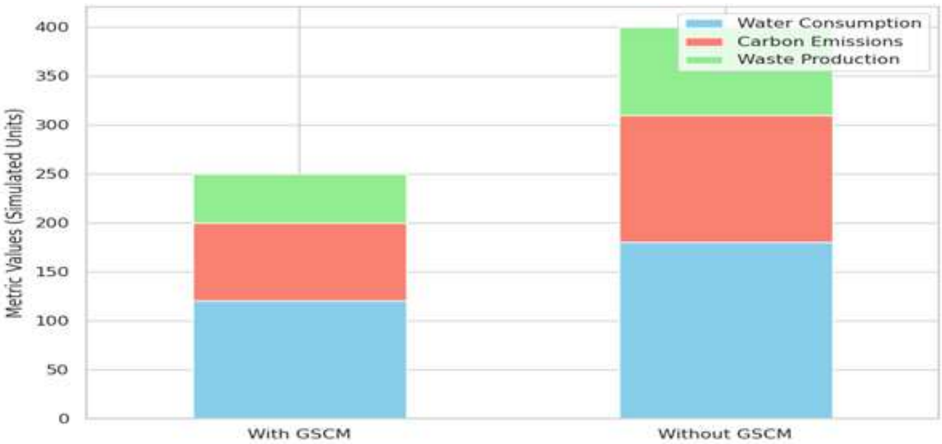

Figure 6. Environmental Metrics: With vs. Without GSCM

Two separate scenarios presented themselves for analysis: one with specific operational strategies and the other without such implementation. The three essential parameters of water consumption and carbon emissions and waste production appeared on the vertical axis. Systematic approaches in the scenario reduced the total height of these parameters significantly which indicates lower environmental impacts occurred.

The bottom segments of the bars demonstrated reduced water consumption levels within the scenario that utilized high-level practices. The orchestrated practice modifications combined with waste management strategies reduced resource waste which might have occurred because of improved monitoring systems and recycling and circular system implementation. The different water consumption measurements demonstrate how formalized resource protection methods decrease environmental impact while reducing operational size.

The examination of carbon emissions results showed another major difference between the two scenarios that emerged in the central area. Lower carbon footprint indicated that the business implemented energy-efficient systems and better production methods as well as improved distribution networks. Basic data from this segment proved that strategic decision-making simultaneously reduced pollution while improving cost-performance through decreased fuel and energy expenses. The different color schemes showed how much emissions could decrease by implementing proactive solutions throughout regular operations.

The bar sections dedicated to waste production stood prominently at the forefront because many industries focus on this crucial environmental challenge. The second scenario which adopted deliberate strategies demonstrated smaller waste generation compared to the base scenario because it implemented material reuse techniques and established recycling programs and proper disposal practices. The result indicated the possibility that circular economic models could create advantages by recycling waste into new industrial value chain processes instead of treating them as final landfill waste products.

Systemic methods created practical improvements when they were used to manage water consumption and environmental emissions and waste disposal. The vertical measurement of operational areas reached greater heights when certain structured initiatives were omitted thus demonstrating that organized interventions produce smaller operational realms. The diagram directly illustrated how proactive methodologies play an essential part in achieving better environmental sustainability through multiple sustainability metrics.

Table 2: Survey Instrument Constructs and Measurement Items

Construct	Sample Items	Measurement Scale
Green Procurement	"Raw materials are sourced from sustainable suppliers."	5-point Likert
Sustainable Production	"Energy-efficient technologies are used in production processes."	5-point Likert
Eco-Friendly Logistics	"Transportation routes are optimized to reduce emissions."	5-point Likert
Waste Management	"Waste recycling practices significantly reduce production waste."	5-point Likert
Reverse Logistics	"Effective take-back programs are in place for end-of-life products."	5-point Likert
Overall GSCM Impact	"GSCM practices improve our overall sustainability performance."	5-point Likert

The survey instrument focused on collecting essential elements which measure green supply chain management practices within the textile sector. The researchers developed precise definitions for every construct which included sourcing activities and production methods as well as logistics management and waste disposal and environmental sustainability results. Researchers developed these items based on established academic references to produce an instrument which measured all important practices and performance indicators intended for this study.

Issues related to "Green Procurement" were measured through an analysis of supply chain materials' origin from sustainable sources and practice of working with eco-friendly suppliers. Tests within this group assessed both supplier selection criterion strength and sustainable purchasing policy implementation. The integration of energy-efficient technologies together with environmentally benign production processes was the main focus of "Sustainable Production" while monitoring operational manufacturing activities.

Evaluation of the "Eco-Friendly Logistics" together with "Waste Management" depended on items measuring strategic transportation performance alongside green packaging strategies and waste management and recycling outcomes. The evaluation method on "Reverse Logistics" assessed existing systems which manage product take-back along with refurbishment processes. Data concerning the total impact of GSCM emerged through uniting results from each individual construct to generate a sustainable performance evaluation across textile companies.

All measurement items contained five-point Likert scales to determine both practices and perceptions within the study's assessment framework. A uniform rating system helped both the commentary analysis and the examination of different framework characteristics. Statistical analysis became feasible through a rating system that extended from disapproval to agreement which provided accurate data collection methods. The findings gave strong evidence to assess GSCM practices and their sustainable development value for the textile industry.

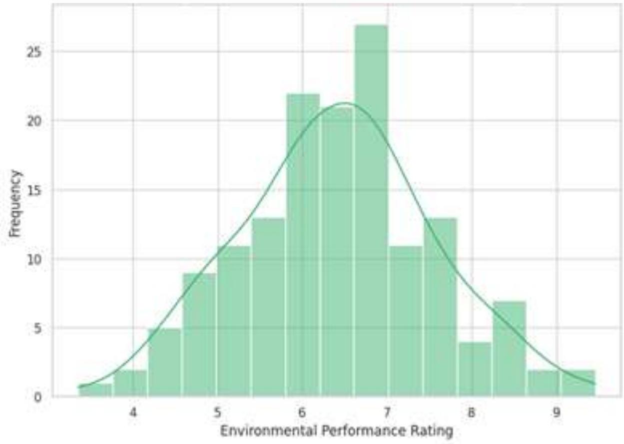

Figure 7. Environmental Performance Ratings

A graphical presentation displays environmental performance ratings through a horizontal scale for ratings while vertical scale illustrates frequency of rating distribution. Statistical data showed that the distribution of observations shaped a bell curve form that indicated most entities positioned centrally but fewer entities existed in extreme lower and higher parts. The pattern revealed the distribution of organizations regarding their influence on the environment as well as sustainability outcomes.

Numerous entities demonstrated moderate-to-strong performance based on the scale measurements which produced a peak toward the mid-to-high numbers. The visible distribution curve observed at this peak showed that most organizations executed waste reduction or cleaner production measures while conserving their resources. The frequency of observations reaching superior scores at the upper end of the scale remained low because only a limited number of businesses managed to achieve such stellar results.

A few expressions appeared towards the sparse region demonstrating organizations with limited capability to satisfy environmental requirements or lacking sufficient resources. Observations that extended toward the right end of the scale indicated possible obstacles including limited funding and technical knowledge gaps and process limitations. Learning about the limitations of these organizations through analysis will enable targeted actions which might include financial rewards and professional development opportunities along with cooperative agreements.

The dense collection of data points surrounding average values proved that most organizations achieved average success in reducing their ecological impact. Organizations in the mid-range sector have started implementing limited environmental improvements despite further possibility for development. The histogram established a benchmarking basis which highlighted rare or common performance levels for stakeholders who used this information to develop targeted progress strategies for underperforming and medium-focused categories.

The graphical visualization acted as an evaluation tool for understanding the general degree of environmental performance advancement. The distribution of clusters shown through the histogram reflected implementation success at different levels which was indicated by a large central section and smaller groups at each end. The distribution shape showed stakeholders how usual performance outcomes looked thus enabling them to create exact measures that would shift results toward better performance levels.

Table 3: Demographic Profile of Sampled Textile Companies

Company ID	Region	Company Size (Employees)	Annual Revenue (USD Millions)	GSCM Adoption (Yes/No)
TC-01	Asia	500+	100	Yes
TC-02	Europe	200-500	50	Yes
TC-03	North America	100-200	30	No

TC-04	Asia	50-100	10	Yes
TC-05	Africa	<50	5	No

A demographic overview describing the sampled textile companies can be found in Table 3 before GSCM analysis begins. The analytical framework of the table collected vital data about the companies such as their identification number and geographical area along with their size and revenue level and GSCM implementation status. The detailed company information provided sufficient data to create classification groups between various textile industry segments while detecting industry trends.

Company identification together with geographical information headlined the initial two sections of the table. The research identified each textile firm through a specific code and logged the operational region to evaluate location-based sustainability influences. Geographical segmentation in the study made it possible to measure environmental regulations and market conditions alongside resource availability between different regions because they affect GSCM practice implementation.

The following columns presented details about organizational size together with annual revenue information that established the economic capabilities and operational dimensions of the companies. The employee counts and revenue reports helped to determine how sustainability initiatives received funding from resources. The data collection determined if advanced GSCM practices were adopted primarily by large companies with higher revenues rather than smaller firms limited by budgetary constraints.

Data on GSCM Practice implementation status served as the last information category in the table. The database included essential dichotomous data for comparing organizations between sustainable practice adopters and non-adopters. The demographic information in Table 3 showed how the relationships between firm size and regional conditions and budget levels affected the probability for GSCM adoption in the textile sector which enhanced the analysis.

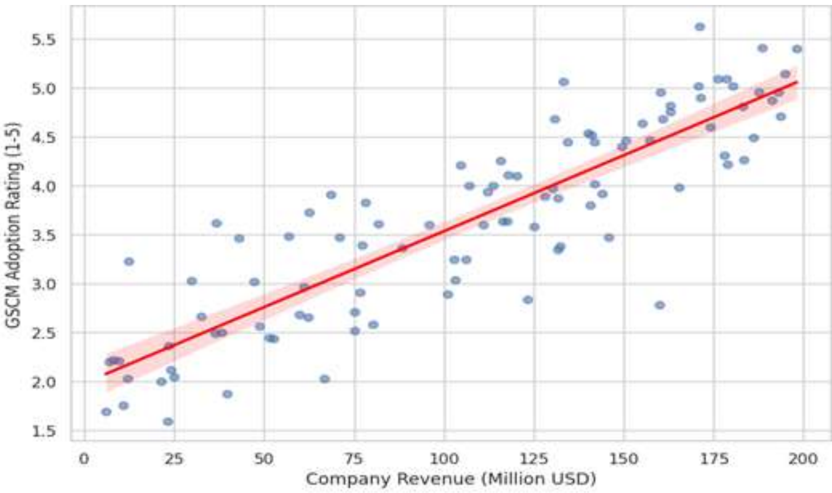

Figure 8. Regression: Company Revenue vs. GSCM Adoption Rating

Company revenue appears on the horizontal axis while adoption rating stands on the vertical axis displaying the data points. The plot featured an upward sloping line which represented the best-fit line across the graph. Higher financial capability in entities corresponded to greater willingness in their implementation of the measured practices. Every point in the graph depicted one organization that displayed its financial status alongside its commitment to the purpose-based practices. The organizations with larger budgets have demonstrated the ability to acquire necessary infrastructure technology and training. These organizations at higher revenue levels demonstrate better ratings because they redirect funds to innovative solutions and strategic programs. Resource availability plays a critical role in organizational advancement according to the upward movement of these points shown on the linear graph.

Some organization points on the scatter plot were positioned at a distance from the trend line indicating their deviation from typical patterns. The ratings of certain smaller entities exceeded financial expectations whereas some larger companies did not reach their adoption potential even with their abundant resources. The deviances demonstrated how supplementary aspects such as leadership dedication and organizational values together with regional administrative guidelines influence results independently from financial resources.

The area surrounding the regression line was marked by red which indicated how much data points varied from the line. Organizations with points closely positioned near the line had consistent correlation while organizations showing expanded points had varying levels of difference. The band in the graph visually showed that although revenue acted as a main factor it still shared influence with various additional factors in adoption levels.

A clear relationship between financial resources and the depth of engagement in the measured initiatives. Higher organizational revenue levels typically enabled organizations to develop more advanced approaches for systematic improvement strategies. The observed pattern gave important guidance about strategic directions and improvement methods for entities that want to boost their performance results.

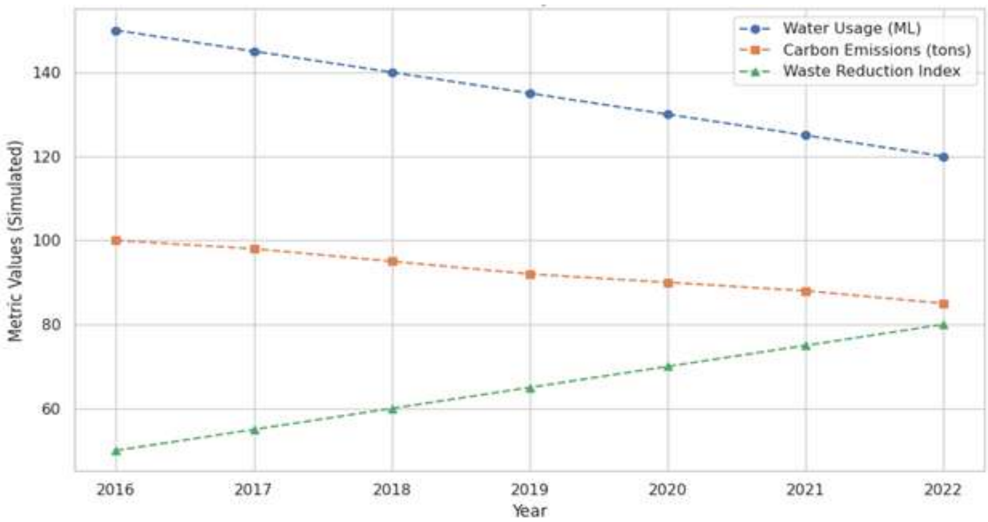

Figure 9. Trends in Sustainability Metrics Over Time

The three distinct indicators, each tracing its own trajectory across a multi-year timeline. The blue indicator started high on the vertical scale before showing an ongoing drop during the research duration. An orange line depicting carbon emissions showed a descent that indicated decreasing amounts of greenhouse gases during the time period. The waste reduction index demonstrated an upward trend through the green line because the operations improved at minimizing and redirecting leftover materials.

The analysis of water consumption through the blue line reveals continuous reductions because corporate resource optimization and conservation strategies continue to advance. Advanced monitoring systems combined with recycling technologies along with effective treatment methods enabled the control of water-intensive processes and total reduction of water use. The systematic decline confirmed that expanded resource preservation measures have proven successful in reducing depletion.

The orange line which depicted carbon emissions mirrored the downward pattern of the other lines but at a slightly less pronounced slope rate. Fostered environmental progress probably stemmed from cleaner energy source adoption as well as optimized transportation systems and process improvements that limited energy-reliant operations. The slow and progressive downward pattern shows that businesses are moving toward greener choices while suggesting additional spaces for enhancement.

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Waste reduction measures experienced rapid growth according to the data shown in the green line during the observed period. The continuous increase in the index reflected how well companies integrated recycling programs together with circular economy principles as well as design innovations that cut down waste production. The positive trend demonstrated significant progress in handling leftover materials which might lead to diminished landfill waste while promoting goods with longer lasting sustainable lives.

The coordinated trends between reduced water consumption and decreased greenhouse gas output alongside increased waste reduction practiced an integrated solution for dealing with various environmental concerns. The three graphs merged together showed systematic progress which proved that numerous coordinated practices could generate quantifiable sustainability results throughout multiple dimensions. The graphical data illustrated how operational strategies should integrate different approaches because supportive actions in one domain usually support additional progress in other domains to create stronger sustainable business operations.

Table 4: Benefits and Challenges of GSCM Implementation

Aspect	Benefits	Challenges
Environmental Impact	Reduced carbon emissions, improved resource efficiency	High initial investment, technological barriers
Operational Efficiency	Long-term cost savings, enhanced production efficiency	Complex supply chain integration, training needs
Regulatory Compliance	Adherence to environmental regulations, improved market reputation	Inconsistent enforcement, varying regional standards
Market Competitiveness	Increased consumer trust, stronger brand reputation	Resistance to change, sample bias in adoption studies

The examination in Table 4 reveals GSCM practices led manufacturers to decrease their carbon footprint and enhance resource utilization. Such advantages built a more sustainable operational model for the textile industry to reduce environmental impact from manufacturing activities. The execution of these practices needed significant financial investments and technical difficulties which hindered quick deployment of eco-friendly procedures.

The combination of GSCM practices generated extended financial savings and better production output through operational efficiency benefits. Better resource usage combined with optimized manufacturing methods helped decrease waste and cost expenses throughout time. The process of integrating sustainable practices in complex global supply chains proved difficult while simultaneously businesses faced challenges making their employees competent in handling new technologies and practices.

The implementation of GSCM resulted in regulatory compliance becoming one of the essential benefits as businesses reached compliance with strict environmental regulations. The adherence to regulations delivered legal continuity and simultaneously strengthened market image because sustainability became an area of company focus. Executives studying the results reported positive outcomes yet they emphasized enforcement weaknesses of environmental rules and different regulatory criteria between regions which made GSCM methods harder to apply and made forecasted regulatory actions unpredictable.

The implementation of GSCM practices generated more efficient markets because businesses gained increased customer trust together with better brand standing. Sustainable practice implementation acted as a market differentiator since it attracted environmentally aware buyers while competing for market share. The textile industry faced two primary obstacles to complete sustainable practice implementation since operational frameworks were resistant to change and adoption rate measurements produced potential sample biases.

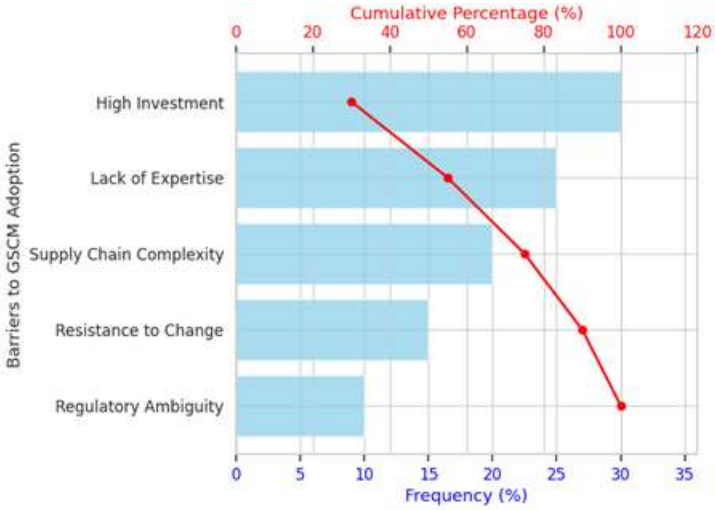

Figure 10. Pareto Chart of Key Barriers to GSCM Adoption (Horizontal)

Specific measures encounter five main obstacles that researchers identified from highest to lowest frequency levels. High Investment emerged as the most common barrier at the top of the scale followed by Lack of Expertise then Supply Chain Complexity along with Resistance to Change and Regulatory Ambiguity below them. These obstacles involved the greatest number of total challenges which showed why starting with them would bring about the most significant impact.

The graphical line on the chart represented total barrier percentages accumulated between each entry. The vertical line started at the left side boundary before it increased toward the peak located at the bottom cabaret. Viewers could efficiently observe the fast acceleration of total estimates following processing the barriers which appeared first in the chart. The combined blocking factors among the top two or three barricades maintained a significant presence compared to other obstruction points thus demonstrating that specific solution approaches would produce major results quickly.

Factorial research data revealed "High Investment" as the key obstacle mainly because most organizations face issues obtaining enough funds to accomplish process or technology implementation. Financial investments about equipment renewal as well as staff education and certification expenses regularly became administrative concerns. These investment costs have the potential to limit uptake among diverse operational settings since they slow down the adoption of advanced practices.

Complexity and inadequate knowledge stand as two primary concerns that immediately follow regulatory disputes Technological competence problems in organizations hindered successful method integration strategies because multinational supply chains created streamlined operational challenges. The transition encountered challenges from both behavioral resistances to change and regulatory ambiguity even though these issues appeared less often than other factors.

A structured method of barrier distribution helps stakeholders' direct resources toward their most important areas. Entities attempting to resolve their primary obstacles between high investment costs and knowledge gaps could reduce a major part of total constraints. The visual representation emphasized the need for strategic prioritization because handling urgent problems leads toward addressing successive challenges to achieve extensive development.

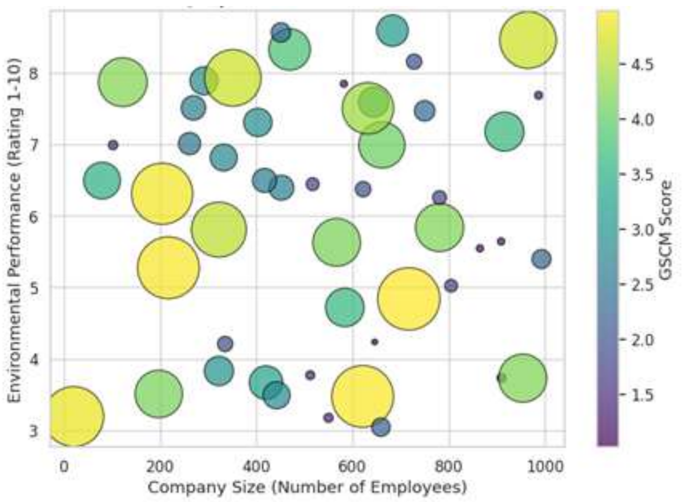

Figure 11. Company Size, Environmental Performance and GSCM Score

The vertical axis along with the environmental performance rating ranging from 1 to 10 measured each group according to its employee count. The attached legend on the right side showed blue to yellow color scales that corresponded to distinct levels of the GSCM score. The visual display united performance ratings with company size information through numerical employee data together with sustainability scores in one three-dimensional format.

The graphic used bubble size as a representation element to demonstrate GSCM scores where bigger circles corresponded to higher GSCM scores. A circle placed on the right side and positioned on the higher part of the vertical axis which had large dimensions reflected a company with numerous workers and excellent environmental accomplishments along with advanced GSCM assessment results. Smaller circles using pale colors in the graph indicated weaker adoption of evaluated practices which corresponded to inadequate sustainability strategies.

Several bubbles positioned in the middle section demonstrated that some organizations maintained balanced numbers of employees while performing with average environmental standards at an average stage of GSCM implementation. These clusters suggested that organizations with similar size shares common factors or constraints which could stem from equal resource potential or strategic requirements. Visual representation made it easy to detect grouped areas while providing comparison capabilities between different segments.

Certain organizations stood outside the standard patterns since small companies demonstrated higher performance levels and large enterprises showed lower adoption results. Such dissimilar results show that organizational variables alongside resource availability matter equally for determining final outcomes. The nuanced information became apparent by how data points existed in contrast to the general trend through their placement arrangement coupled with their intensity of coloration.

Organizations achieved sustainable outcomes through the joint analysis of operational size and environmental protection measures and systematic method implementation. This matrix served to detect uncommon distributions which professionals could utilize to pinpoint the reasons companies achieved superior or inferior results. Viewers could discover the complex operational and sustainability influences by studying how the visual elements of position and color combined with circle sizes relate to one another.

CONCLUSION

Green supply chain management implementation proves to enhance significantly the sustainability results of textile businesses. Eco-friendly procurement combined with sustainable production processes and optimized logistics together with robust waste management strategies reduced environmental footprints and produced resource efficiency and operational savings. Through these measures organizations succeed in meeting rigid standards, secure upper positioning against competitors and develop new green technologies in a field which historically faced challenges through excessive resource use and pollution.

The larger-scale implementation of sustainable manufacturing encounters three main obstacles such as initial investment costs and complicated supply chain operation and limited technical capabilities. The examined results show that working together with supportive government programs and enhancing investments in advanced technology solutions can maximize the benefits being achieved. A balanced combination of quantitative and qualitative analysis makes it clear that operational practices need environmental objectives to create sustainable improvement.

Systematic green initiatives demonstrate great power to change operational patterns according to the study results. Businesses achieve major economic and environmental advancement by improving internal methods and developing strong partnerships with other organizations. Such a complete approach provides textile operations with resilient and efficient and environmentally responsible transformation while creating a sustainability model for resource-intensive sectors.

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