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Transforming Bangladesh's Traditional Textile and Apparel Industry: A Sustainable Future with Green Supply Chain Management

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Abstract: Bangladesh's Apparel industry, a global leader in apparel exports, faces significant environmental challenges. Amid rising global competition, stricter environmental regulations, and growing sustainability demands, there is a pressing need for the industry to adopt more sustainable practices. This research explores the potential transformation of the traditional textile and apparel industry in Bangladesh through the implementation of Green Supply Chain Management (GSCM). GSCM presents a strategic approach to enhance environmental performance while maintaining economic growth by integrating sustainable practices throughout the supply chain. The paper examines current practices within the industry, highlighting both the successes and shortcomings in adopting green initiatives. It identifies key barriers to GSCM implementation, such as high initial costs, lack of awareness and expertise, resistance to change, and insufficient infrastructure by considering chi square analysis. Additionally, the paper explores the drivers that can facilitate this transformation, including regulatory pressure, market demand for sustainable products, corporate social responsibility initiatives, and technological advancements. Actionable strategies for integrating GSCM in Bangladesh's textile and apparel sector are proposed. These strategies encompass the adoption of sustainable raw materials, investment in green innovation, development of eco-friendly infrastructure, and implementation of comprehensive waste management systems. By focusing on these areas, the RMG sector can mitigate its environmental impact, enhance resource

efficiency, and improve its economic and social outcomes. This research underscores the necessity of a collaborative approach involving policy support, capacity building, technological innovation, and market incentives to achieve a sustainable future for Bangladesh's textile and apparel industry.

Keywords: Sustainability, Supply Chain, GSCM, Bangladesh, Textile and Apparel Industry

1. Introduction

The Apparel sector is pivotal to Bangladesh's economy, accounting for 84% of the country's export earnings and providing employment to approximately 4.1 million people, predominantly women (Mordor Intelligence, n.d.; Islam & Halim, 2022). Despite its economic significance, the industry is a major environmental polluter, contributing to water contamination, air pollution, and extensive resource consumption (World Bank, 2022; Smieee, 2022). Traditional practices within the textile and apparel industry lead to significant environmental challenges, including water pollution, high energy consumption, and waste generation. As global awareness of environmental sustainability grows and regulatory pressures intensify, it is imperative for Bangladesh's textile and apparel industry to adopt more sustainable practices (Smieee, 2022; Marcus Insights, n.d.; Islam, 2023; Khan, 2023). Green Supply Chain Management (GSCM) offers a strategic approach to mitigate the environmental footprint of the RMG sector. By integrating sustainable practices throughout the supply chain, GSCM can help reduce pollution, enhance resource efficiency, and promote sustainable growth. This paper explores the potential of GSCM to transform Bangladesh's textile and apparel industry. It examines current practices, identifies key barriers and drivers, and proposes actionable strategies for implementing GSCM. The goal is to demonstrate how GSCM can secure a sustainable future for the industry, ensuring it remains a cornerstone of the economy while significantly reducing its environmental impact (Islam, 2023; Khan, 2023; Tazneen, Kanan, Sharif, & Chanda, 2020; Holy, Mohammed, & Revu, 2022; Sikder, Saif, Nadim, Tarik, & Islam, 2023; Muhtadi, Mumtaj, Karmaker, Barua, & Deena, 2023; Rahman, Sakib, Mim, & Sarker, 2020).

As a result of substantial expansion and modernization, Bangladesh now ranks among the top exporters of clothing worldwide in the ready-made garment (RMG) sector. But there were difficulties along the way. Major issues with working conditions were made clear by workplace catastrophes including the 2013 Rana Plaza factory collapse and the 2012 Tazreen factory fire. Value-chain accountability and manufacturing safety have improved as a result of programs like the RMG Sustainability Council and the Accord on Fire and Building Safety in Bangladesh (Huda,

2024). Considering its remarkable expansion, the industry still has to contend with issues like reduced demand, privileged trade access, and the requirement for sustainable operations. In order to ensure a sustainable future, the sector needs to be innovative, expand its focus beyond cotton, give green supply chain management top priority, and encourage cooperation between stakeholders.

2. Literature Review

The literature on Green Supply Chain Management (GSCM) in Bangladesh's textile and apparel industry underscores the significant potential of GSCM to mitigate environmental impacts while simultaneously boosting operational efficiency and economic performance (Smieee, 2022). Essential components of GSCM include sustainable procurement practices, eco-friendly manufacturing processes, efficient logistics, and comprehensive waste management strategies. The literature suggests that successful GSCM implementation in Bangladesh is contingent on several critical factors: strong management commitment to sustainability goals, technological innovations that enable cleaner production techniques, robust regulatory frameworks that enforce environmental standards, and increasing market demand for sustainably produced goods. Studies reveal that GSCM can lead to cost savings through waste reduction and energy efficiency, improved brand reputation, and compliance with international environmental standards, which collectively enhance global competitiveness (Tazneen, Kanan, Sharif, & Chanda, 2020; Alauddin & Arif, 2022; Chowdhury, 2013; Hasan et al., 2023; Holy, Mohammed, & Revu, 2022; Muhtadi, Mumtaj, Karmaker, Barua, & Deena, 2023; Nekmahmud, 2020; Rahman, Sakib, Mim, & Sarker, 2020; Sarkar, Qian, & Peau, 2020; Sikder, Saif, Nadim, Tarik, & Islam, 2023).

Furthermore, Green Supply Chain (GSC) integrates environmental considerations throughout the supply chain, from product design to end-of-life, aiming to minimize environmental impact and enhance resource efficiency (Chowdhury, Mohammad, Tasif, & Tasnim, 2023; Frank & Mohamed, 2024; Santos, Donato, Vianna, & De Freitas Gomes, 2024; Sarin & Srivastava, 2024; Zhang, Li, & Ding, 2024). However, its implementation faces several challenges, including regulatory compliance issues, policy uncertainties, expertise, financial barriers, lack of awareness, and technological limitations (Frank & Mohamed, 2024; Sarin & Srivastava, 2024). The success of GSCM relies on overcoming these hurdles through strategies like eco-friendly packaging, reverse logistics, and strong top management support. Companies adopting GSC practices, such as Johnson & Johnson and Tesla, benefit from cost savings, improved brand image, and increased customer loyalty (Sarin & Srivastava, 2024). The literature calls for concerted efforts from the government, industry stakeholders, and international partners to overcome these hurdles

through policy support, capacity building, financial incentives, and collaborative initiatives aimed at fostering a sustainable future for Bangladesh's textile and apparel sector.

3. Problem Statement & Research Gap

Despite the recognized benefits of GSCM, the adoption rate in Bangladesh's textile industry remains low (Ahmed, Akter, & Ma, 2018; Sarker, Hasan, & Bartók, 2023). Major barriers include high initial investment costs, lack of skilled workforce, inadequate infrastructure, and limited government incentives. Addressing these challenges is crucial for the industry to achieve sustainable growth (Uddin, 2019; Uddin, 2022).

While previous studies have explored GSCM practices globally, there is limited research focused on the specific context of Bangladesh's textile industry. This paper aims to fill this gap by providing a comprehensive analysis of the current state of GSCM in Bangladesh, identifying key barriers and drivers, and proposing tailored strategies for effective implementation.

Despite notable advancements in transparency, manufacturing safety, and value-chain accountability, there is still a lack of knowledge regarding how to restructure the RMG sector in a sustainable manner. Research is specifically required to investigate innovative methodologies, diversification beyond cotton, and efficient green supply chain management techniques. In the upcoming ten years, closing these gaps will be essential to preserving and reviving the sector's economic vitality (Islam et al., 2022).

4. Research Methodology

The research employs a quantitative data analysis approach. Data is collected through surveys, interviews with industry stakeholders, and analysis of secondary sources. The strategies/recommendations for implementing GSCM are developed based on best practices identified in successful case studies and adapted to the local context .Here, all relevant stakeholders in Bangladesh's textile and apparel industry were considered as population of our study. Masco Group, Envoy Group, Bitopi Group, Team Group, DBL Group, Super Star Group and other textile and apparel industry which are focusing or going to focus on GSCM, were considered as our purposive sample for this research investigation. Although we collect data through both offline and online processes, still there were some limitations such as not being able to collect vast data due to confidentiality, limited industry approach, lack of GSCM practice in Bangladesh etc. Here in terms of research procedure, we try to find out necessary data. The processes are given below:

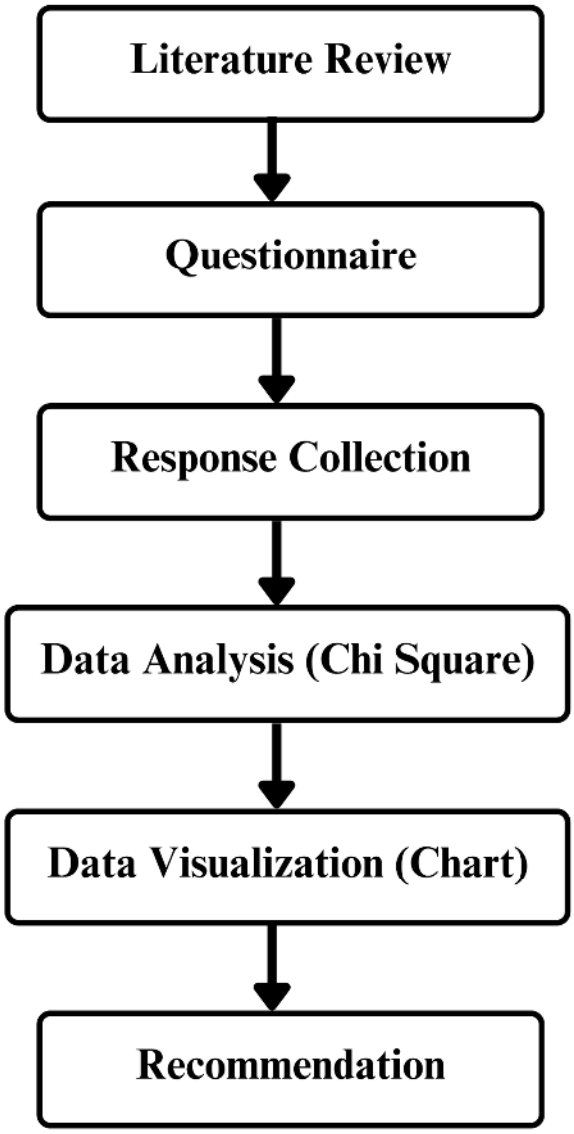

Figure 01a: Research Methodology Flow Chart

4.1 Online data collection process

Here, we can go through online survey and collect data from different industry experts to gather their opinion in different media. By utilizing their expertise in supply chain management process, we can make and identify the key differences between traditional factory process and green industry production process. In addition, we collect some necessary feasible statistical data as bangladeshi perspective.

4.2 Offline data collection process

In offline data collection process, we physically visited some green industry including Masco Concept knitting Ltd, BITOPI Group Ltd etc. We met industry expert to collect their thought about green industry production process.

4.3 Approachable Process to transform bangladesh's traditional textile and apparel industry

A number of crucial steps must be taken in order to transform the conventional clothing business into a green, eco-friendly one that improves social responsibility, sustainability, and the environment. The following are some of the primary process kinds that can be used:

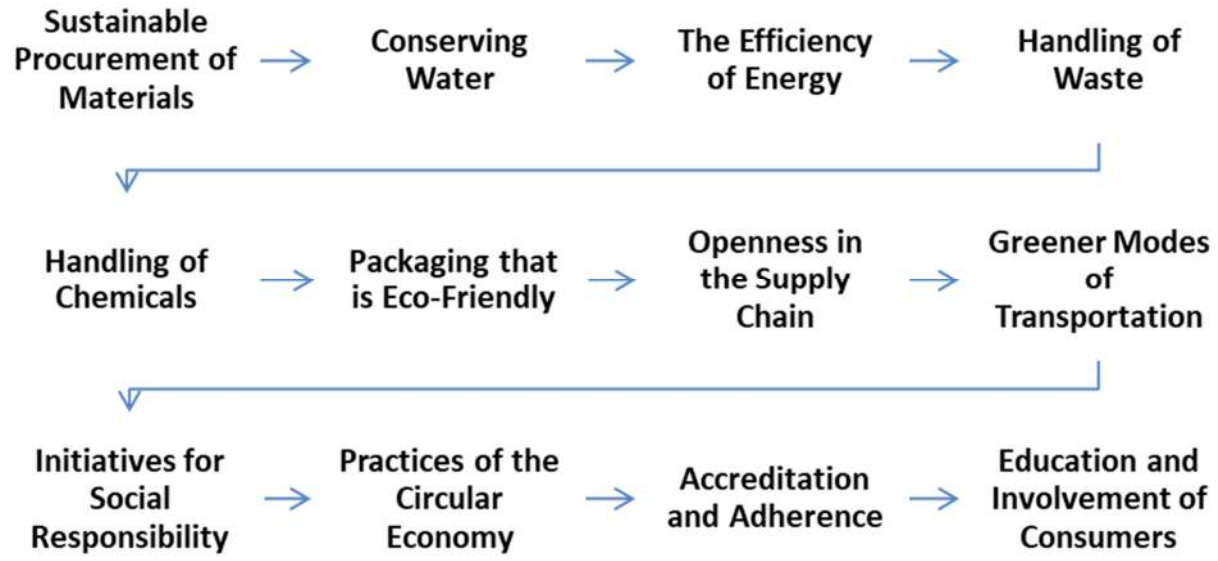

Figure 01b: Probable green sustainable industry process type - 1

1. Sustainable Procurement of Materials

- Organic Fibers: utilizing natural fibers cultivated without the use of hazardous chemicals or pesticides, such as hemp, bamboo, or organic cotton.
- Recycled Materials: Using textiles created from recovered fibers or polyester made from recycled plastic bottles as examples of recycled fabrics.
- Eco-Friendly Dyes: Using low-impact or natural dyes that consume less water and emit fewer dangerous chemicals.

2. Conserving Water

- Water Recycling Systems: Reusing water in the industrial process through the installation of water recycling and treatment facilities.
- Effective Dyeing Methods: Using dyeing methods that drastically cut down on water usage, such as digital printing or waterless dyeing.
- Rainwater Harvesting: Reducing dependency on outside water sources by gathering and utilizing rainwater.

3. The Efficiency of Energy

- Renewable Energy Sources: Changing the way that manufacturing processes are powered by solar, wind, or other renewable energy sources.
- Energy-Efficient Machinery: Changing to machinery and equipment that uses less energy and consumes less power.
- Heat Recovery Systems: Putting in place mechanisms to collect and recycle heat produced during manufacturing operations.

4. Handling of Waste

- Zero-Waste Design: Creating clothing with as little waste as possible using methods like effective fabric usage during pattern-cutting.
- Recycling and Upcycling: Putting in place procedures to turn waste textiles into new goods or repurpose clothing to increase its useful life.
- Composting: To lessen the impact on landfills, compost biodegradable waste from production.

5. Handling of Chemicals

- Non-Toxic Chemicals: Using non-toxic substitutes for hazardous chemicals across the whole production process, including printing, finishing, and dyeing.
- Chemical Recycling: Setting up mechanisms to collect, reuse, and get rid of chemicals used in manufacturing safely.

6. Packaging that is Eco-Friendly

- Biodegradable Packaging: Utilizing recyclable or biodegradable materials for packaging.
- Minimal Packaging: Choosing reusable or returnable packaging options and cutting back on the quantity of packaging utilized.

7. Openness in the Supply Chain

- Ethical Sourcing: Making certain that suppliers of materials follow sustainable and ethical methods.

- Trackability Systems: Putting in place tracking systems to guarantee complete transparency from the source of raw materials to the final product.
- Fair Trade Practices: Following fair trade guidelines will guarantee that all workers in the supply chain receive fair pay and working conditions.

8. Greener Modes of Transportation

- Local Sourcing: To lessen the carbon footprint caused by transportation, source resources locally.
- Green logistics: transporting goods by low-emission, energy-efficient means of transportation.
- Carbon Offsetting: Investing in environmental projects to offset transportation-related carbon emissions.

9. Initiatives for Social Responsibility

- Fair Labor Practices: Making sure there is no child labor involved in the production process, safe working conditions, and fair wages.
- Community Engagement: Assisting local communities with efforts for economic development, education, and social programs.
- Worker Training: Offering employees courses on sustainable business practices.

10. Practices of the Circular Economy

- Product Take-Back Programs: Putting in place initiatives that let consumers return worn clothing for recycling or other uses.
- Design for Longevity: Creating clothing that is robust and simple to fix will cut down on the amount of times it needs to be replaced.
- Garment Leasing: To encourage reuse and cut waste, clothing leasing or rental services are provided.

11. Accreditation and Adherence

- Eco-Labels and Certifications: To attest to eco-friendly methods, obtain certifications such as OEKO-TEX, Fair Trade, GOTS (Global Organic Textile Standard), or Bluesign.
- Regulatory Compliance: Ensuring local and global adherence to environmental norms and laws.

12. Education and Involvement of Consumers

- Awareness campaigns: instructing customers on the value of sustainability and how to choose environmentally friendly products.

- Sustainable Fashion Initiatives: Starting programs like clothes exchanges or repair workshops that promote sustainable fashion practices.

By putting these procedures into place, the apparel sector may greatly lessen its environmental impact while simultaneously encouraging moral behavior and fostering a more sustainable future.

Here are some alternate approaches and methods for converting the conventional clothing business into a green, eco-friendly sector:

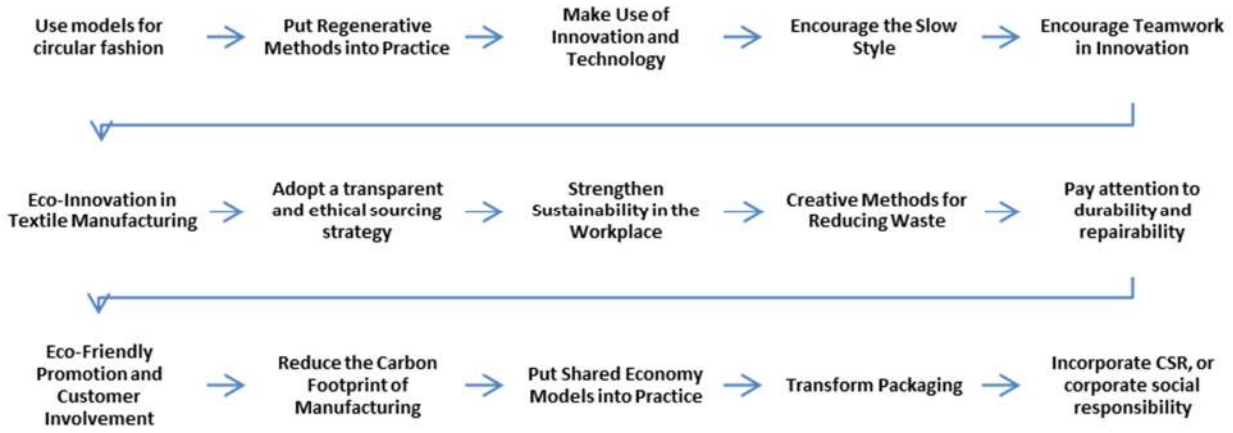

Figure 01c: Probable green sustainable industry process type - 2

1. Use models for circular fashion

- Product as a Service (PaaS): Instead of selling things, start providing clothes as a service, allowing clients to rent or lease apparel, therefore cutting down on the requirement for fresh manufacturing.
- Closed-Loop Systems: Put in place a program for the collection, disassembly, and remanufacturing of used clothing into new products.

2. Put Regenerative Methods into Practice

- Regenerative Agriculture: Purchase products from farms that use this method, which lowers carbon emissions while restoring biodiversity and soil health.

- Biodiverse Cotton Farming: To improve ecosystem health and lower the demand for chemical inputs, farmers should be encouraged and supported to plant biodiverse crops alongside cotton.

3. Make Use of Innovation and Technology

- 3D Printing and Knitting: Produce clothing with fewer waste and energy consumption by utilizing 3D printing or seamless knitting technology.
- AI-Powered Supply Chain Management: Make better use of big data and AI to streamline supply chains, cut down on surplus inventory, and forecast demand.

4. Encourage the Slow Style

- Timeless Design: Encourage customers to buy fewer items and wear them longer by concentrating on producing classic, adaptable pieces that last longer in fashion.
- Made-to-Order: To cut down on waste and overproduction, adopt a made-to-order approach in which clothing is only made once a consumer placed an order.

5. Encourage Teamwork in Innovation

- Industry Collaborations: Join forces with other companies and industry participants to exchange resources, studies, and sustainable innovation.
- Co-Creation with Customers: Include customers in the design process and let them personalize clothing to create more treasured and less likely to be thrown away products.

6. Eco-Innovation in Textile Manufacturing

- Lab-Grown Fabrics: Invest in the study and creation of bioengineered or lab-grown textiles, such as those derived from mycelium from mushrooms, algae, or spider silk.
- Waterless Fabric Finishing: To achieve fabric finishes without the use of water or chemicals, employ technologies like ozone treatment or laser finishing.

7. Adopt a transparent and ethical sourcing strategy

- Blockchain for Traceability: Make use of blockchain technology to ensure ethical sourcing and manufacturing by transparently tracing materials from point of origin to final product.
- Artisanal and Local Craftsmanship: Purchase from regional craftsmen and artisans to support customary methods and lessen the carbon footprint of long-distance travel.

8. Strengthen Sustainability in the Workplace

- Green Building Certification: Modernize buildings to fulfill LEED and other green building requirements, enhancing indoor air quality, energy efficiency, and environmental effect overall.
- Employee Sustainability Programs: Encourage staff members to adopt eco-friendly behaviors at work and at home by providing them with training and incentives.

9. Creative Methods for Reducing Waste

- On-Demand Manufacturing: Make use of on-demand manufacturing techniques to reduce waste by using resources and materials only when needed.
- Waste-to-Wealth Programs: Repurpose production waste by creating new items out of it, including home goods or accessories made from leftover cloth.

10. Pay attention to durability and repairability

- Design for Disassembly: Make clothing that is simple to disassemble for upcycling, repair, or modernization to increase longevity and cut down on waste.
- Repair and Maintenance Services: To encourage clients to fix and maintain their clothing rather than throw it away, offer repair services or sell repair kits.

11. Eco-Friendly Promotion and Customer Involvement

- Sustainable Brand Storytelling: Create and share a compelling brand narrative that emphasizes ethics, sustainability, and openness.
- Eco-Engagement Platforms: Provide web resources or mobile applications that inform users about eco-friendly clothing, provide advice, and monitor their carbon footprint reductions.

12. Reduce the Carbon Footprint of Manufacturing

- Carbon-Neutral Production: Invest in renewable energy, increase energy efficiency, and use carbon credits or forestry initiatives to offset emissions in order to achieve carbon neutrality.
- Low-Impact Manufacturing: Rethink production procedures to cut down on greenhouse gas emissions; for example, convert to electric machinery or employ cold-water dyeing methods.

13. Put Shared Economy Models into Practice

- Clothes Swaps and Resale: To prolong the life of clothing and lower the demand for new manufacture, organize clothes swap events or establish platforms for resale.

- Collaborative Consumption: Encourage shared ownership models so that people can co-own or share clothing, which will lessen the demand for new manufacture and individual ownership.

14. Transform Packaging

- Smart Packaging: Make use of creative, resource-efficient packaging that is entirely recyclable or compostable and may even include seeds that, when thrown away, can sprout into plants.
- Reusable Packaging Systems: Implement a system where clients return packaging to be cleaned and used again for shipments in the future.

15. Incorporate CSR, or corporate social responsibility

- Sustainable Development Goals (SDGs): Align the business's activities with the Sustainable Development Goals (SDGs) of the United Nations, emphasizing issues like ethical consumption, combating climate change, and decent work.
- Community Sustainability Projects: Fund neighborhood recycling campaigns or environmental education initiatives as examples of community projects that support sustainability.

These creative approaches have the potential to make a big difference in the transition of the conventional apparel business into one that is resilient, sustainable, and socially responsible.

5. Green Supply Chain Management in Bangladesh's Textile & Apparel Sector

5.1 Green Manufacturing Practices: Green manufacturing in the Apparel sector encompasses a series of practices aimed at reducing environmental impact through efficient resource use and minimizing waste. The industry has seen significant progress with the adoption of organic raw materials, eco-friendly building designs, and renewable energy sources. LEED certification has become a benchmark, with numerous factories achieving platinum and gold standards, ensuring reduced water and energy consumption (Khan, 2020).

5.2 Sustainable Raw Materials: The use of organic materials, such as Global Organic Textile Standard (GOTS)-certified cotton, is a cornerstone of green manufacturing. These materials are renewable and have a lower environmental impact compared to conventional options. The shift to organic raw materials aligns with global consumer demand for sustainable products, enhancing Bangladesh's competitiveness in the global market (Khan, 2020; Ali, Masud, Hossain, Islam, & Alam, 2024).

5.3 Green Innovation: Innovation is crucial for integrating sustainability into the Apparel sector. Green innovation includes the development of environmentally friendly products and processes. Technological advancements and organizational changes that reduce harmful environmental impacts are pivotal. For instance, many Bangladeshi Textile & Apparel firms are now employing green technologies and practices to decrease greenhouse gas emissions and improve energy efficiency (Khan, 2020).

5.4 Green Buildings: The construction and operation of green buildings are integral to sustainable manufacturing. These buildings utilize eco-friendly and resource-efficient methods throughout their lifecycle, significantly reducing energy and water usage. In Bangladesh, numerous factories have received LEED certification, reflecting their commitment to sustainable practices (Khan, 2020).

5.5 Waste Management: Effective waste management systems are vital for minimizing the environmental impact of the textile sector. This includes the implementation of efficient effluent treatment plants (ETPs), recycling programs, and the adoption of waste-to-energy technologies. Many factories have improved their waste management practices, resulting in better water and energy efficiency (Khan, 2020; Ali, Masud, Hossain, Islam, & Alam, 2024).

5.6 Green Sourcing & Distribution: Green sourcing and distribution refer to the practice of procuring and managing products in an environmentally responsible manner throughout the supply chain. This approach involves selecting suppliers and materials based on their sustainability practices, minimizing the environmental impact of production and transportation, and optimizing the use of resources. The goal is to reduce carbon footprints, minimize waste, and promote the use of eco-friendly materials and processes. By integrating these practices, companies aim to enhance environmental performance and support broader sustainability objectives (Khan, 2020).

6. Differentiation Between Traditional and Green Supply Chain

Green procurement differs from traditional procurement by integrating environmental, social, and economic factors into purchasing decisions. While traditional procurement focuses on cost, quality, and efficiency, green procurement prioritizes sustainability, ethical labor practices, and long-term benefits such as enhanced brand reputation and risk mitigation.

Key differences include the selection of suppliers based on their sustainability practices and the emphasis on ethical sourcing. Green procurement aligns business practices with broader sustainability objectives, driving innovation, improving stakeholder trust, and ensuring regulatory

compliance. Despite challenges like higher initial costs, green procurement offers strategic advantages, making it essential for businesses aiming for long-term success and resilience in a sustainability-driven market (CloudOpex, n.d.).

7. Challenges and Opportunities

The apparel sector in Bangladesh has made notable progress toward sustainability by integrating green technologies and practices. However, several challenges persist that hinder widespread adoption. High initial costs of implementing green technologies are a significant barrier, particularly for smaller factories. Additionally, there is a general lack of awareness about the long-term benefits of sustainable practices, and the existing regulatory frameworks are not robust enough to enforce or encourage green initiatives effectively. These factors collectively slow down the transition toward a more sustainable apparel industry (Hossain, 2020).

Despite these challenges, there are substantial opportunities for improvement in the sector. Enhanced regulatory support, such as stricter environmental standards and enforcement, could push more companies toward adopting sustainable practices. Financial incentives, including subsidies or tax breaks for companies that invest in green technologies, would help offset the high initial costs. Furthermore, international collaboration, such as partnerships with global brands and NGOs, can bring in the necessary expertise and resources to accelerate the adoption of Green Supply Chain Management (GSCM) practices in Bangladesh's apparel sector (Hossain, 2020).

8. Result and Discussions

8.1 Chi-Square Analysis

Pearson chi-square test has been conducted to test hypotheses. The null hypothesis and the alternative hypothesis are the two sub-hypotheses that are put forth for each hypothesis. The null hypothesis assumes that GSCM Practices have no impact on Textile & Apparel Industry. The alternative Hypothesis assumes that GSCM practices have a significant impact on the Textile & Apparel Industry. If the calculated value is greater than tabular value so null hypothesis is rejected and alternative hypothesis is accepted.
Calculation of Chi-Square (X^2) Test:

Table 1: Table of Observation Value

Title	Agree	Strongly Agree	Disagree	None	Total
Benefit of Green practice in RMG	35	15	0	5	**55**
Ensurement Sustainability	32	27	0	0	**59**
Financial benefits	35	20	3	2	**60**
Reduce of carbon footprints	32	25	0	3	**60**
Total	**134**	**87**	**3**	**10**	**234**

Table 2: Table of Expected value

Green Supply Chain/Traditional Supply Chain	Agree	Strongly Agree	Disagree	None
Benefit of Green practice in RMG	$\frac{55 \times 134}{234}$ = 31.49	20.44	0.7	2.34
Ensurement Sustainability	$\frac{59 \times 134}{234}$ = 33.78	21.93	0.75	2.52
Financial benefits	$\frac{60 \times 134}{234}$ = 34.35	22.3	0.76	2.56
Reduce of carbon footprints	$\frac{60 \times 134}{234}$ = 34.35	22.3	0.76	2.56

Table 3: Calculation of Chi – Square (X^2)

Formula= $\frac{(Observed\ Value - Expected\ Value)^2}{Expected\ Value}$

Observed Values (O)	Expected Values (E)	(O - E)	$(O - E)^2$	$(O - E)^2 / E$

35	31.49	3.51	12.3201	0.391
15	20.44	-5.44	29.5936	1.448
0	0.7	-0.7	0.49	0.700
5	2.34	2.66	7.0756	3.024
32	33.78	-1.78	3.1684	0.094
27	21.93	5.07	25.7049	1.172
0	0.75	-0.75	0.5625	0.750
0	2.52	-2.52	6.3504	2.520
35	34.35	0.65	0.4225	0.012
20	22.30	-2.3	5.29	0.237
3	0.76	2.24	5.0176	6.602
2	2.56	-0.56	0.3136	0.123
32	34.35	-2.35	5.5225	0.161
25	22.30	2.7	7.29	0.327
0	0.76	-0.76	0.5776	0.760
3	2.56	0.44	0.1936	0.076
Total				**18.3962**

Degree of Freedom= (Columns – 1) (Rows - 1)

= (4 – 1) (4 – 1)

= (3 x 3)

= 9

Level of Significance(α)= 0.05

$X^2_{tabular}$= 16.919

$X^2_{calculated}$= 18.3962

$X^2_{calculated}$= 18.3962 > $X^2_{tabular}$ = 16.919

Since calculated value is greater than tabular value so null hypothesis is rejected and alternative hypothesis is accepted. So, we reject Null hypothesis and accept alternative hypothesis. The

alternative Hypothesis assumes that GSCM practices have a significant impact on Textile & Apparel Industry.

8.2 Data Visualization and Analysis

Now, the following chart indicates that responses were collected from various companies, with each company having nearly equal percentage of representation. This diverse participation provides a broad perspective on the industry's views on green supply chain management.

Figure 02: Green supply chain management will help to ensure sustainability

The chart in **Figure 02** depicts the respondents' agreement with the statement that green supply chain management will help ensure sustainability. Where majority of respondents either agreed or strongly agreed with the statement, suggesting a strong consensus on the positive impact of green supply chain practices on sustainability.

Traditional production systems focus on maximizing output and efficiency, often at the cost of environmental degradation, high resource consumption, and waste generation. They typically rely on non-renewable resources, adhere to minimal regulatory compliance, and prioritize profitability over sustainability and ethical practices. In contrast, green production systems emphasize reducing environmental impact through the use of renewable resources, energy efficiency, waste reduction, and eco-friendly product design. They proactively comply with and often exceed environmental standards, integrating corporate social responsibility and ethical

practices into their core business strategies to promote long-term sustainability and ecological responsibility.

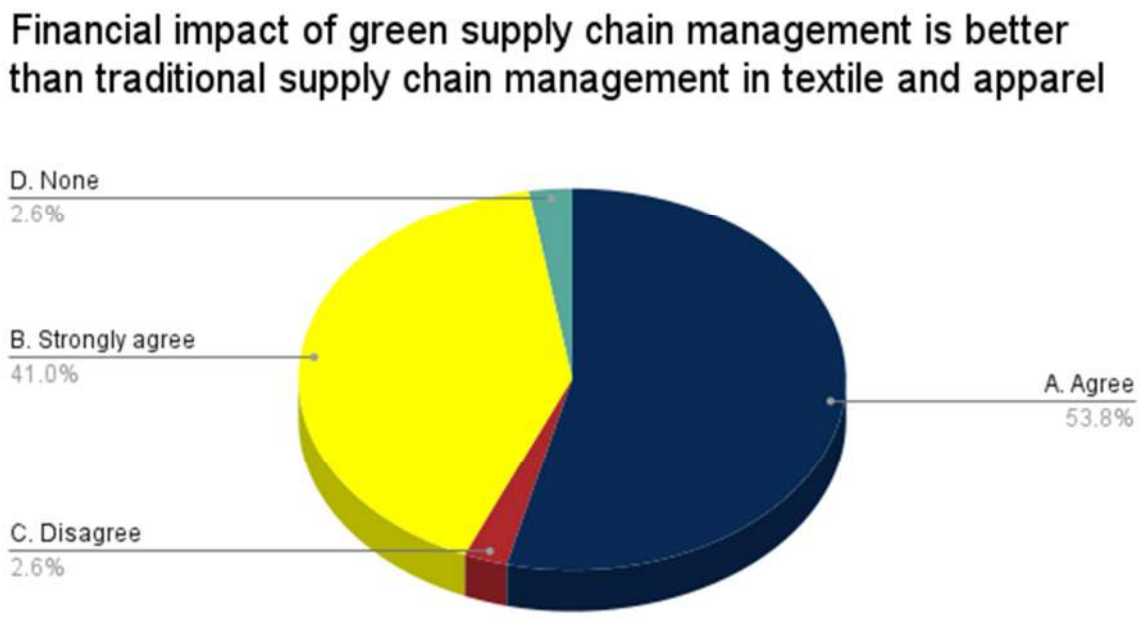

Figure 03: Financial impact of green supply chain management is better than traditional supply chain management in the textile and apparel industry

The chart in **Figure 03** shows respondents' opinions on whether the financial impact of green supply chain management is better than traditional supply chain management in the textile and apparel industry. Most respondents agreed or strongly agreed, indicating that green supply chain management is perceived to have a better financial impact.

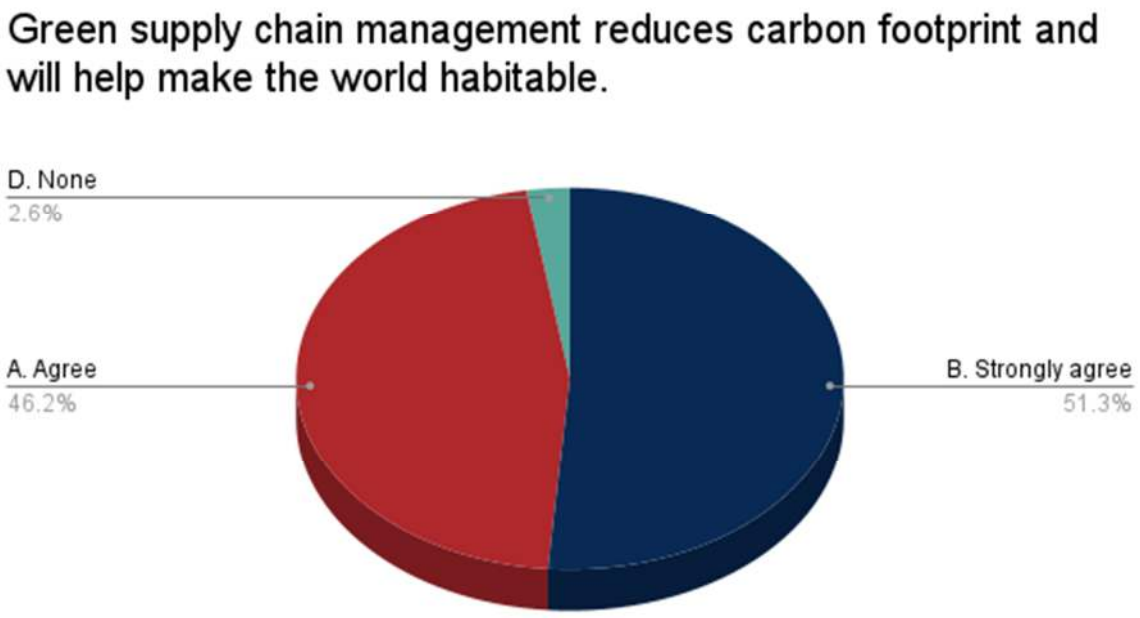

Figure 04: Green supply chain management reduces the carbon footprint and contributes to a more habitable world.

The chart in **Figure 04** shows the respondents' belief that green supply chain management reduces the carbon footprint and contributes to a more habitable world. A significant portion of respondents agreed, underscoring the environmental benefits of adopting green supply chain practices.

The Green Supply Chain (GSC) effectively reduces carbon footprints by implementing practices that lower greenhouse gas emissions across various stages of production and distribution. These practices include optimizing resource use through energy-efficient technologies, sourcing sustainable raw materials, and enhancing transportation efficiency to minimize fuel consumption. Additionally, waste reduction, recycling, and energy-efficient processes are prioritized, along with designing products for longevity and recyclability. Collaboration with partners to adopt innovative, low-carbon technologies also plays a crucial role. Through these strategies, the GSC significantly lowers the carbon footprint of products throughout their lifecycle, contributing to overall sustainability.

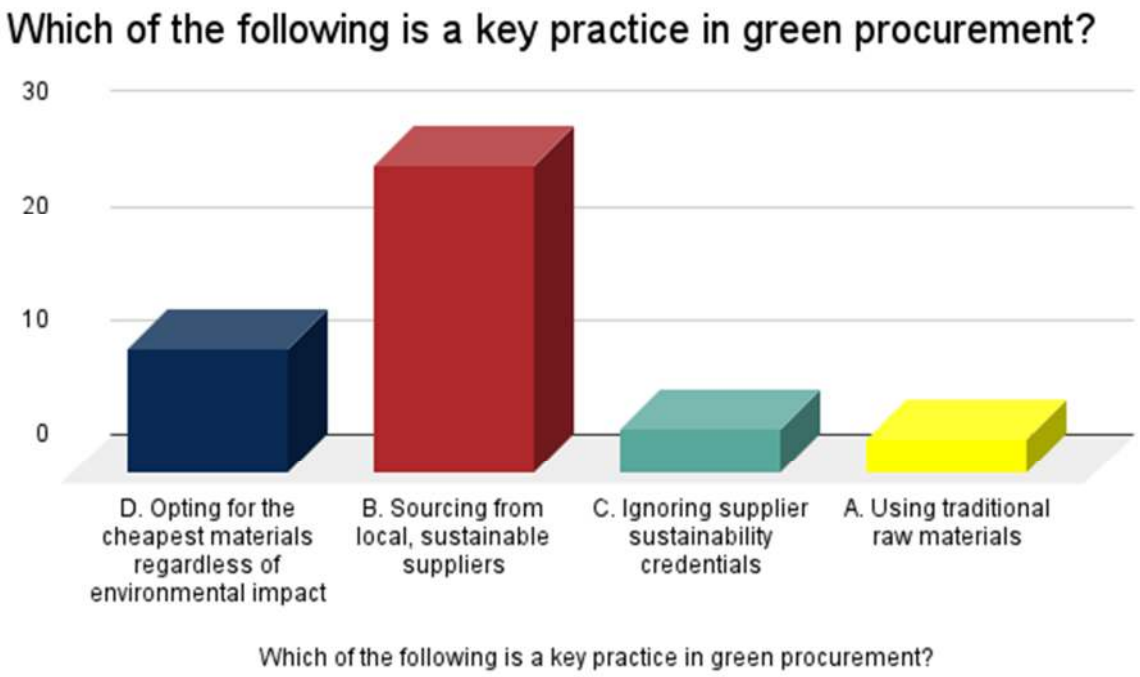

Figure 05: Key practices identified by respondents in green procurement

The bar chart in **Figure 05** shows key practices identified by respondents in green procurement. Here, we saw that sourcing from local, sustainable suppliers was the most chosen practice, highlighting its importance in green procurement strategies.

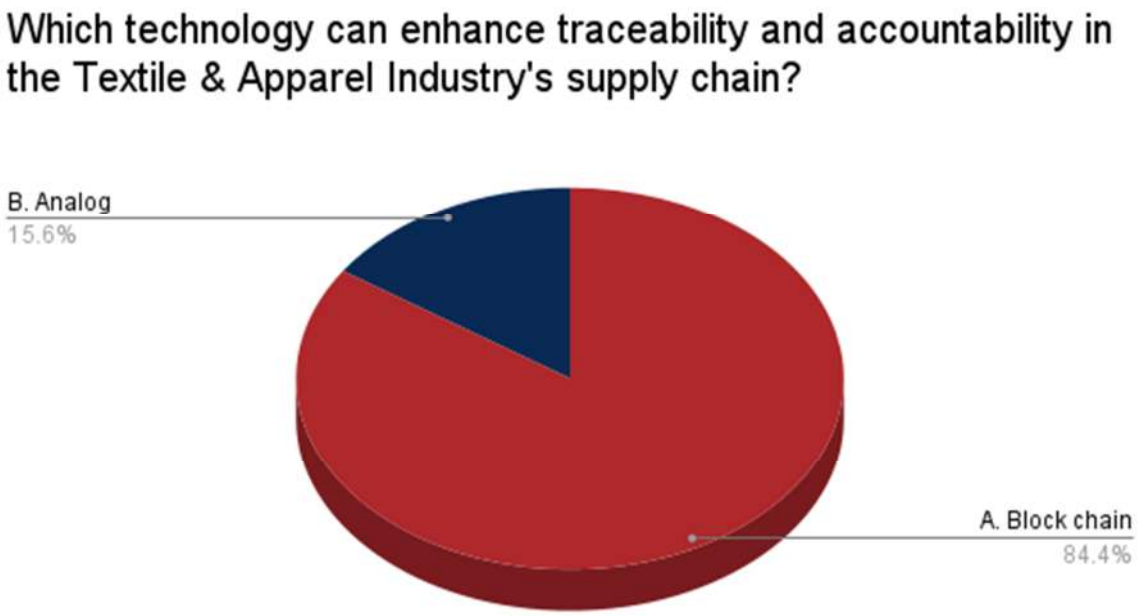

Figure 06: Which technology can enhance traceability and accountability in the Textile & Apparel Industry's supply chain

Figure 06 depicts the technology respondents believe can enhance traceability and accountability in the supply chain. Where Blockchain technology was overwhelmingly favored, indicating its potential in improving transparency in the textile and apparel industry's supply chain.

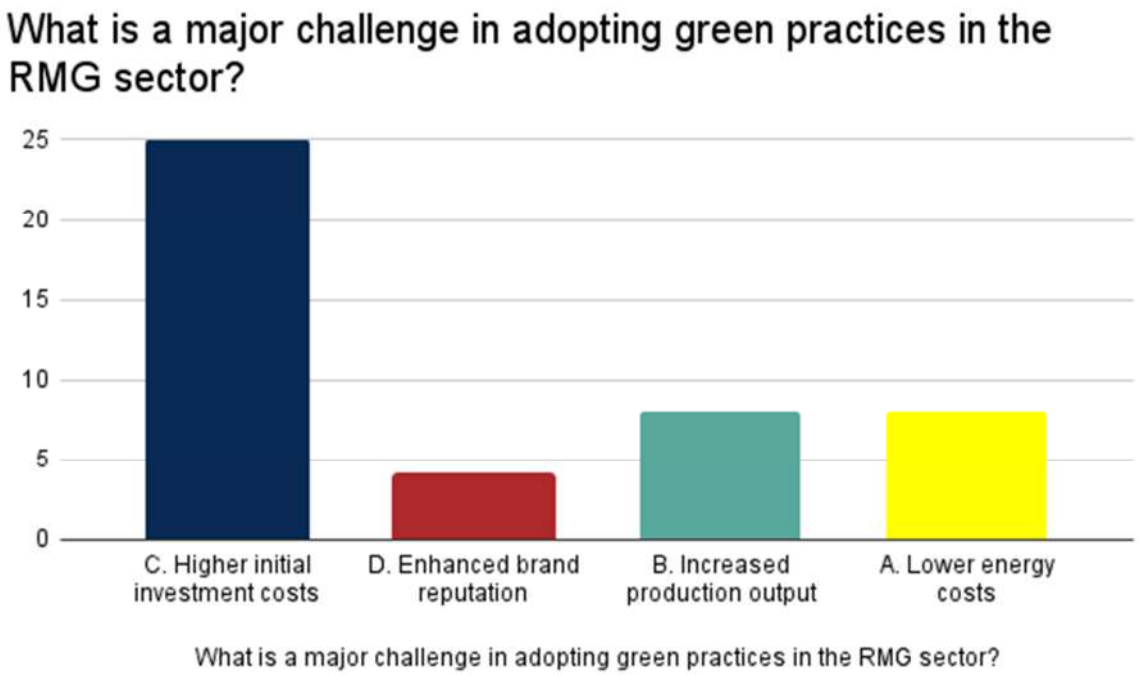

Figure 07: Major challenges identified in adopting green practices in the RMG sector.

The bar chart in **Figure 07** shows the major challenges identified in adopting green practices in the RMG sector. Here, higher initial investment costs were identified as the most significant challenge, reflecting the financial barriers to implementing green practices.

Response of one of the questions in the questionnaire illustrating methods to increase supply chain transparency in the textile and apparel industry. Blockchain technology was again highlighted as a crucial tool for enhancing transparency, reinforcing its importance in supply chain management. Another response of one of the questions in the questionnaire showing key indicators for measuring sustainability performance in the supply chain. Life Cycle assessment (LCA) was the most chosen indicator, emphasizing its relevance in evaluating sustainability.

Traditional procurement often focuses on minimizing costs and optimizing operations without giving sufficient attention to environmental impacts. This approach typically relies on established supplier networks and practices that may not prioritize sustainability, leading to increased waste, higher carbon emissions, and the use of non-environmentally friendly materials. The traditional method tends to be less transparent and adaptable to changes in environmental standards, often overlooking the broader implications of supply chain activities on the environment.

In contrast, modern procurement integrates green supply chain management principles, placing a strong emphasis on sustainability throughout the procurement process. This includes selecting suppliers based on their environmental performance, using eco-friendly materials, and incorporating practices that minimize waste and reduce carbon footprints. Modern procurement

involves a comprehensive lifecycle assessment of products to evaluate their environmental impact from production to disposal and employs advanced technologies for real-time monitoring and data-driven decision-making. By adopting these modern practices, Bangladesh's textile and apparel industry can effectively align with global sustainability standards, significantly reduce its environmental footprint, and foster a more transparent and responsible supply chain.

Another response of one of the questions in the questionnaire showing the benefits of green supply chain management. Where every participant came into agreement that improved long-term cost savings and environmental impact are the key benefits, indicating a strong belief in the long-term advantages of green supply chain practices.

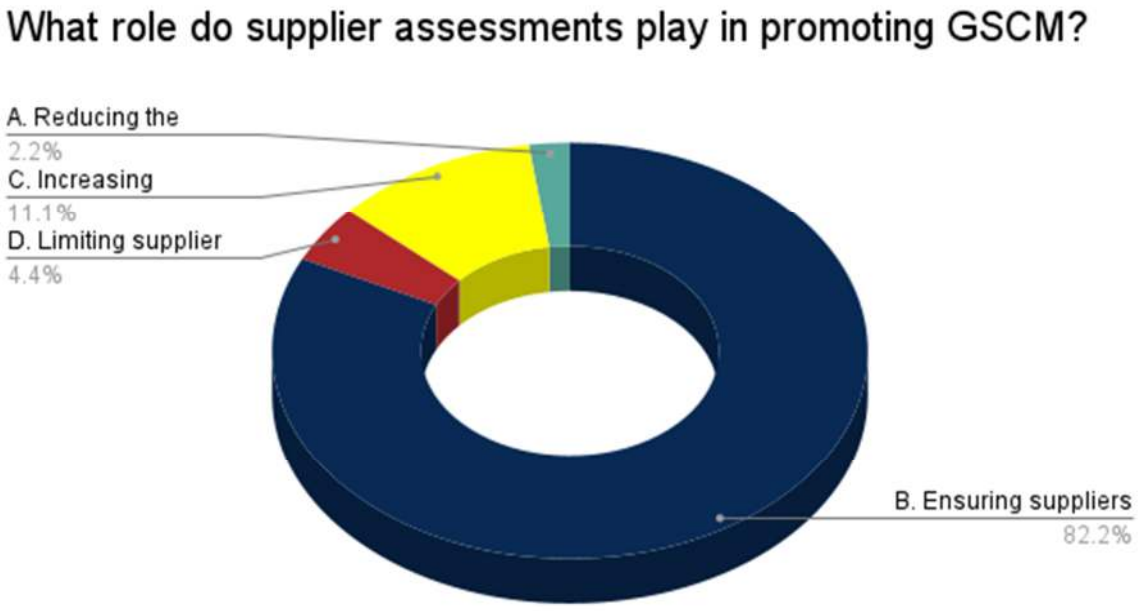

Figure 08: The role of supplier assessments in promoting green supply chain management

The graph chart in **Figure 08** illustrates the role of supplier assessments in promoting green supply chain management. Ensuring suppliers meet sustainability criteria was the most recognized role, highlighting the importance of supplier compliance in achieving GSCM goals.

Further, a response to one of the questions in the questionnaire showing how digital tools can support GSCM initiatives. Real-time monitoring and reporting were identified as the most important functions of digital tools, emphasizing their role in enhancing GSCM processes.

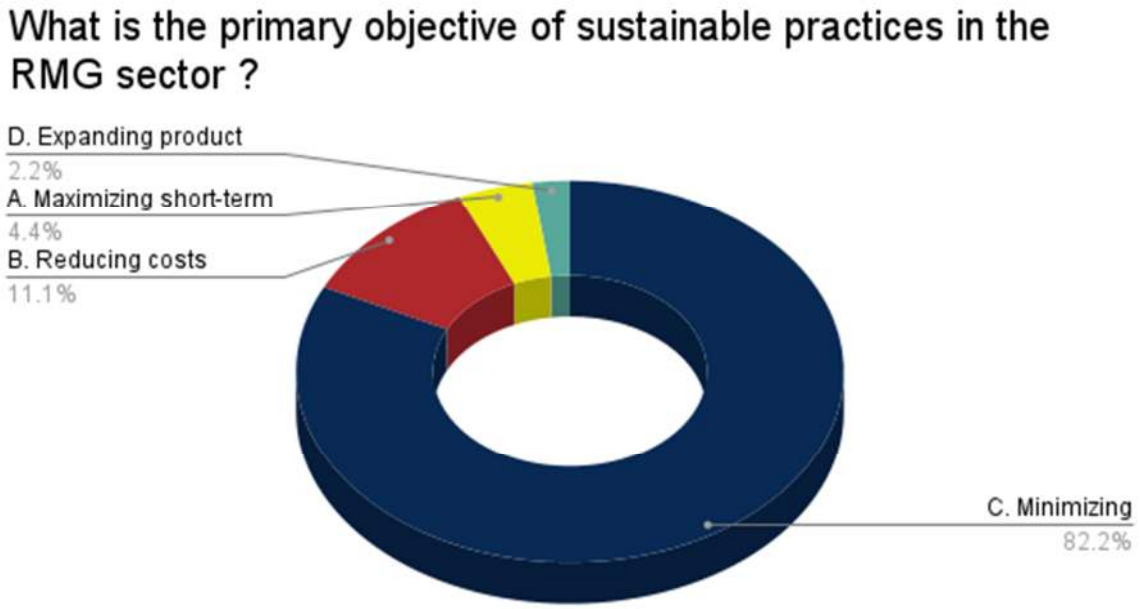

Figure 09: Primary objectives of sustainable practices in the RMG sector

Figure 09 depicts the primary objectives of sustainable practices in the RMG sector. Minimizing environmental impact and ensuring social responsibility were the most important objectives, highlighting the sector's focus on sustainability.

Triple Bottom Line (TBL) framework, which emphasizes on People, Planet and Profit for social, environmental, and economic sustainability. Green supply chains prioritize people by ensuring fair labor practices, supporting community development, and maintaining health and safety standards. They focus on the planet by enhancing resource efficiency, reducing pollution, and sourcing sustainably. Economically, they seek to reduce costs, ensure long-term viability, and boost market competitiveness through eco-friendly practices. By balancing these objectives and fostering innovation and collaboration, green supply chains contribute to achieving the TBL, ensuring that businesses are sustainable and responsible in the long term.

Another response showing the respondents' preferences for sustainable raw materials in garment production. Organic cotton was the most favored, reflecting the industry's shift towards more sustainable raw materials. Moreover, respondents' understanding of a closed-loop supply chain were asked through another question. Recycling and reusing products and materials were most identified, demonstrating the importance of circular economy practices in the supply chain.

The difference in wastage between traditional and green factories is significant, with traditional factories generating high volumes of hazardous waste, inefficiently managing resources, and relying on non-recyclable packaging and excessive energy use. In contrast, green factories focus

on minimizing waste generation, employing extensive recycling, optimizing material utilization, and using minimal, recyclable packaging. They also implement energy and water-efficient technologies, aiming for a circular economy model that reduces their environmental footprint. In the Ready-Made Garments (RMG) sector, green factories reduce textile waste, recycle materials, and conserve water and energy, significantly enhancing sustainability compared to traditional practices.

Green supply chains emphasize closed-loop manufacturing, a sustainable approach where materials and products are continuously recycled and reused, significantly reducing waste and the need for new raw materials. Key aspects include recycling and reusing materials, designing products for easy disassembly and modularity, and minimizing waste through zero-waste production and industrial symbiosis. Closed-loop systems integrate circular economy principles like extended producer responsibility and product-as-a-service models while requiring strong collaboration across the supply chain and efficient reverse logistics. The benefits include reduced environmental impact, cost savings, regulatory compliance, and enhanced brand reputation for sustainability.

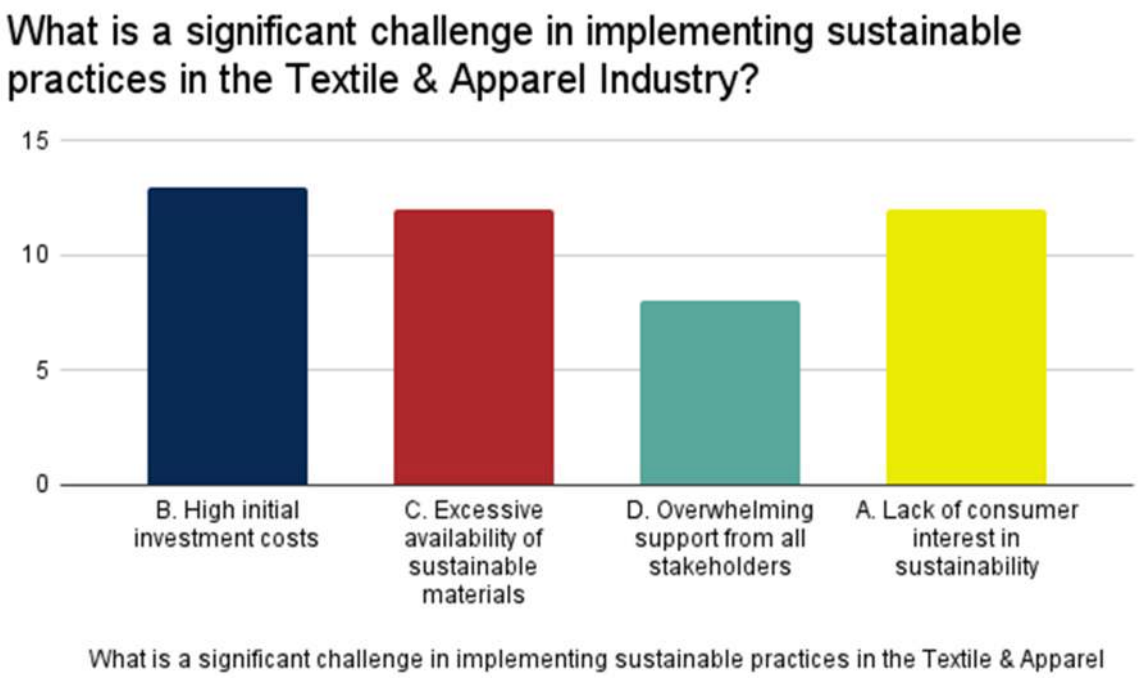

Figure 10: Significant challenges in implementing sustainable practices in the textile and apparel industry

The bar chart in **Figure 10** shows significant challenges in implementing sustainable practices in the textile and apparel industry. High initial investment costs were identified as a major challenge, echoing earlier concerns about the financial barriers to sustainability.
These charts collectively highlight the perspectives of industry professionals on the importance, challenges, and benefits of implementing green supply chain management in Bangladesh's textile and apparel industry.

9. Recommendation

9.1 Management Commitment: Strong leadership and commitment from top management are crucial for the successful implementation of green supply chain practices. Management should prioritize sustainability as a core business strategy, incorporating it into the company's vision and objectives. This commitment will help in fostering a culture of sustainability throughout the organization, ensuring that green initiatives are taken seriously and integrated into all levels of operations.

The research findings suggest that a majority of respondents agree that GSCM is beneficial for sustainability and financial performance. However, without strong managerial support, these initiatives may lack the necessary direction and resources to be fully realized.

9.2 Financial Support: Financial investment is essential to overcome the initial high costs associated with implementing green practices. Companies should allocate budgets specifically for green initiatives, including investments in eco-friendly technologies, sustainable raw materials, and waste reduction processes. Additionally, financial incentives or subsidies from the government could encourage more companies to adopt green practices.

The challenge of high initial investment costs was identified as a significant barrier. Providing financial support or incentives can help mitigate this barrier and make it easier for companies to transition to green supply chains.

9.3 Technological Integration: Embrace and invest in advanced technologies such as blockchain for traceability, real-time monitoring systems, and lifecycle assessment tools to enhance the efficiency and transparency of the supply chain. The integration of these technologies can help companies track their environmental impact, ensure compliance with sustainability standards, and optimize resource use.

Respondents highlighted blockchain technology as a key tool for enhancing transparency and traceability in the supply chain. The adoption of such technologies will not only improve

operational efficiency but also build trust with consumers and stakeholders by ensuring the traceability of sustainable practices.

9.4 Training and Development: Implement comprehensive training programs for employees at all levels to build awareness and skills related to green supply chain management. This includes educating staff on the importance of sustainability, best practices in green procurement, waste management, and the use of new technologies. Continuous professional development in these areas will empower employees to contribute effectively to the company's sustainability goals.

The success of GSCM depends on the knowledge and engagement of the workforce. Training ensures that employees are not only aware of the company's sustainability goals but also equipped to implement and innovate within these frameworks.

9.5 Collaborative Efforts: Foster collaboration across the supply chain, including partnerships with suppliers, customers, and industry peers. Collaborative efforts can help in sharing best practices, pooling resources for green initiatives, and creating a collective impact on sustainability. Industry-wide collaborations can also lead to the development of standardized practices and benchmarks for green supply chain management.

Collaboration is key to overcoming the challenges of implementing green practices. By working together, companies can share knowledge, reduce costs, and create a stronger, more unified approach to sustainability.

9.6 Regulatory Framework: Advocate for and support the development of a strong regulatory framework that enforces sustainability standards within the textile and apparel industry. This includes regulations that promote the use of sustainable materials, reduce waste, and minimize environmental impact. Additionally, the government should consider implementing policies that incentivize green practices, such as tax breaks or subsidies for companies that adopt GSCM.

A robust regulatory framework can provide the necessary external pressure to ensure that all companies in the industry adhere to sustainability practices. It also creates a level playing field where all players are required to meet the same standards, thus driving the industry as a whole toward sustainability.

By focusing on these recommendations - management commitment, financial support, technological integration, training and development, collaborative efforts, and a strong regulatory framework, the textile and apparel industry in Bangladesh can make significant strides toward a more sustainable future. Implementing green supply chain management not only improves environmental outcomes but also enhances the industry's competitiveness in the global market, ensuring long-term success and sustainability.

10. Conclusion

Transforming Bangladesh's traditional textile and apparel industry through Green Supply Chain Management (GSCM) is imperative for achieving sustainable development and growth. Embracing green manufacturing practices, utilizing sustainable raw materials, fostering green innovation, constructing eco-friendly buildings, and implementing robust waste management systems can significantly reduce the industry's environmental impact. Despite notable barriers, the potential benefits in terms of environmental sustainability, operational efficiency, economic performance, and social well-being make GSCM a viable and essential strategy. By addressing these challenges and leveraging the drivers of GSCM, Bangladesh can enhance its economic resilience and position itself as a leader in sustainable apparel manufacturing, setting a benchmark for emerging economies. The RMG industry needs to embrace innovation, diversify beyond cotton, give green supply chain management first priority, and encourage stakeholder engagement if it is to preserve and regain its economic vibrancy in the coming ten years.

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