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Exploring Green Supply Chain Management's Obstacles in the Textile Sector Using Interpretive Structural Modeling

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ABSTRACT

Bangladesh has a rich history and is the second-largest exporter of textile manufacturing. Every day, many textile products are produced by companies with a very high product capacity. They often unconsciously damage the environment in their hope of extra production and profit. As a result, a good, eco-friendly system should be designed to reduce harmful manufacturing and efficient production. It is crucial to integrate sustainable practices for GSCM in the textile industry. Additionally, it highlights specific challenges in Bangladesh's textile industry and emphasizes the need for a comprehensive approach that balances economic, environmental, and social sustainability. The studies were carried out by collecting and analyzing data from different sources, such as reviewing papers and expert opinions. This research paper, Review of Literature, emphasizes that we found 10 barriers to stockholder opinion from 29 barriers through setting questionnaires, where expert people give points for those barriers, and the data is ranked by the ISM method. The ISM method is incorporated here to rank the obstacles created in the textile industry by collecting data through research papers, setting questions, and obtaining expert opinions for shorting. Sustainability analysis is done through MICMAC analysis. Barriers during production were trying to be found, and the most hazardous problem for textile production was ranked at the top.

Keywords: ISM, Barriers, GSCM, MICMAC.

1. Introduction

Green supply chain management (GSCM) in the textile industry involves integrating environmentally friendly tasks into the sourcing, production, distribution, and disposal of textile products [10]. Many contaminated wastes and by-products come out during manufacturing. The textile supply chain is complicated by several factors, including low profit margin, high product diversity, the minimum life cycle of a product, seasonal demand that can be satisfied in various ways, lack of product standardization, and environmental issues. According to the World Bank, the contribution to Bangladesh's GDP is about $46 billion, generated by exports, 82% of which was in the textile industry. Bangladesh became the 2nd largest textile producer after China in 2016. To produce one kilogram of textiles, 200 gallons of water are needed on average. By identifying and structuring these barriers, we can unravel the intricate web of factors constraining the transition to green supply chain practices. A GSCM strategy addresses economic, social, and environmental concerns.

2. Review of Literature

Many scholars have done tasks to identify obstacles and create linkages in GSCM. The following unit recaps the implementation tool of ISM for ranking barriers concerning GSCM. GSCM involves environmentally friendly phenomena with the SCM, including designing products, sourcing materials and shorting, manufacturing methods, and delivery lead times of the final product after its life span [2]. ISM the methodology was employed to comprehend the stimuli among these barriers so that those driving hindrances, which can intensify a few more impediments, and those independent and dependent barricades, which are influenced mainly by driving barricades, are identified [3]. Some researchers have applied the Analytic Hierarchical Process (AHP) to rank strategies inclined with (GSCM). GSCM's objectives are to diminish the ecological destructiveness of fabric production, optimize source consumption (liquid, dynamism, materials) through the supply chain application practices that lessen waste creation, and manifest recycling; organization may decrease costs related to waste dumping, energy consumption, underscoring safe working, and social amenability, strengthen dealings with suppliers to improve overall supply chain bounciness [4]. Textiles are one of the most momentous industries for emerging countries and also the second-most contaminating trade after petrochemicals. So, the manufacturing process creates a large amount of solid and liquid waste [5]. Barriers to greenness in the Indian textile and apparel segment consuming the Delphi-DEMATEL method originate from the deficiency of operative governmental strategies and deprived infrastructure [6]. A recent study has claimed that some barriers to electronic waste management practices in India, such as the dearth of public consciousness for electronic waste recycling and the lack of strategies and principles, contribute to the e-waste problem [7]. In Bangladesh, there is a massive chance of reducing the barriers to growing in the textile sector.

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Table 1 Drivers and barriers of green supply chain management. [5]

SL No.	No of Elements	Important Elements	Description of Elements
1	10 barriers	Lack of public awareness	Consumer awareness implies that if anyone wants sustainable goods, the company needs to adapt its technology and organization to provide cutting-edge green items.
2	15 barriers	financial constraints	The high expanse of waste disposal is also a barrier to the organization's adoption of GSCM
3	8 drivers	Green practices, Standards of safety, safety and health issues	Safety standards for Green Supply Chain Management (GSCM) aim to integrate environmentally friendly practices without compromising worker, community, or environmental safety. These standards cover handling and disposal of hazardous materials, use of renewable energy, greenhouse gas reduction, and sustainable practices across the supply chain.
4	14 barriers	Absence of governmental regulations and inadequate infrastructure	The government can either promote or inhibit the implementation of innovation, as it establishes the environmental standard for industry. The 1979 industry may be discouraged from using GSCM by tax arrangements that skew incentives.
5	14 barriers	High maintenance and implementation expense	High investment, High initial capital cost of environmentally friendly packaging and low return is the biggest setback for the implementation of green supply chain.
6	12 barriers	Limitation of resources and green specialists	The goal of GSCM is to reduce the chain's overall environmental effect. For the purpose of seeing possibilities, putting plans into action, and tracking results, proficiency with sustainable practices and laws is essential.
7	12 barriers	Lack of commitment by the higher management	One major obstacle is the upper management's lackluster dedication. Any strategic initiative must have the support of top management to be successful. For (GSCM), top management commitment is crucial because it may impact, facilitate, and promote the creation and execution of green initiatives throughout the firm.
8	9 barriers	Insufficient use of sustainable techniques in the organization's vision and mission	Reusing and recycling materials, energy, solid waste recycling, and unsafe substances are all part of innovative green methods. The initial cost of implementing GSCM techniques is significant.

Table 2 This table represents Barrier's classification [5]

No	Category	Specific barriers
1	**Strategic Management**	Inadequate management capacity
2		Inadequate higher management commitment
3		Insufficient planning for strategy
4		No specific environmental goals
5	**Supplier**	Insufficient green suppliers
6		Insufficient environmental cooperation and trust between supply chain participants
7		Inadequate incentive program for suppliers
8	**Technology**	Absence of a supplier incentive system
9		Insufficient scope to develop new system
10		Complexity in designing green system and process
11		Absence of innovative materials, processes, and technology
12	**Information**	Fear of failure
13		Lack of green knowledge
14		Insufficient knowledge about environmental effect on business
15		Market uncertainty and competition
16		Insufficient understanding of reverse logistics
17	**External Stakeholder**	Insufficient awareness of external stakeholders
18		Lack of customer support and motivation
19		Absence of legislation and laws
20		Lack of direction and assistance from regulatory organizations.
21	**Human Resources**	Inadequate work environment
22		Insufficient technical knowledge
23		Lack of proper training and eco-literacy
24		Absence of reverse logistics training
25	**Economic**	High-cost disposal of hazardous wastes
26		Lower return from investments
27		High installation and maintenance expense
28		Insufficient economic benefits
29		Cost of environmentally friendly packaging

3. Research Methodologies

3.1 Identification of barriers

The barriers to GSCM in Bangladesh's apparel and textile sector are examined in this paper. In Fig. 1, the research technique is identified. As indicated in Table 1, 29 barriers were found following through literature research in GSCM. Strategic management, technology, human resources, external stakeholders, economics, information, and suppliers were the seven groups into which the barriers were categorized. Questionnaires and surveys are utilized to gather the majority of the data. The supply chain managers from top textile companies in Bangladesh received 32 questionnaires asking them to rate the barriers, they found using a Likert scale (maximum score: 5 and minimum score: 1). These managers are experts in the field of production, quality, and procurement within the textile supply chain. 15 responses were collected from those supply chain managers in reputed textile companies. A focus group discussion was conducted to understand the contextual relationship among the GSCM barriers. A team of five supply chain managers of leading textile and garment organizations in Bangladesh participated in the focus group discussion. Table 2 displays the average score for the top ten barriers. It should be mentioned that each barrier has two, from the external stakeholder and supplier categories, two from the technology and economic categories, and one from each of the human resources and strategic management categories. The list of the top 10 barriers does not include any information-related barriers.

Fig. 1 shows a flow chart of research methodology. After reviewing the literature, we identified 29 barriers by examining various papers. Then, the expert identified the top 10 important barriers through a questionnaire survey. Those 10 barriers can be analyzed by developing interpretive structural modelling (ISM).

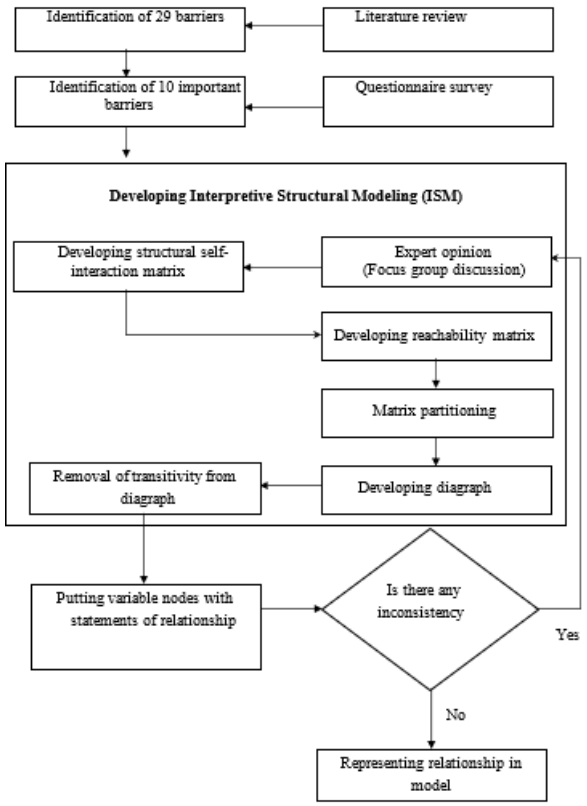

Fig.1 Flowchart of research methodology Examples of heading are as follows.[8]

Table 3 displays the top 10 obstacles in the green textile supply chain based on expert opinions. The experts have rated each barrier on a Likert scale, and we have averaged those values to determine the average score scores (According to the expert opinion, they have given different types of scores in several barriers. We have averaged those values and determined the average score). The highest average score of 4.3 out of 5 was given to the Inadequate incentive program for suppliers (IP). The other 9 barriers are also identified using the same process.

Table 3 Top 10 barriers to GSCM

No	Significant obstacles for both the organized and unorganized sectors	Average Score
1	Inadequate incentive program for suppliers (IP)	4.3
2	Lack of proper training and eco-literacy (TEL)	4.2
3	Complexity in designing green systems and process (CGS)	4.2
4	Inadequate higher management commitment (HMC)	4.0
5	Insufficient green suppliers (IGS)	3.9
6	Lack of direction and assistance from regulatory organizations (DAR)	3.8
7	High installation and maintenance expense (IME)	3.8
8	Insufficient economic benefits (IEB)	3.8
9	Lack of customer support and motivation (CSM)	3.7
10	Insufficient environmental cooperation and trust between supply chain participants (ETP)	3.7

3.2 Developing structural self-interaction matrix (SSIM)

An SSIM captures pairwise relationships among variables relevant to a specific problem. It forms the initial step in ISM, a technique for exploring and mapping out the hierarchy and interconnections among these variables. Based on expert insights and contextual understanding, SSIM is transformed into a Reachability Matrix (RM) by binary coding and transitivity checks based on contextual knowledge and expert observations.

From RM, a directed graph or structural model is developed to show the levels and influence directions of the variables. The experts questioned the contextual relationship established between any two obstacles (l and t) and the corresponding direction of the association during the focus group discussion. In this case, "t" stands for the table's row and "l" for its column.

The relationship between any two barriers is indicated by using 4 symbols:

B: The influence of Barrier “t” on Barrier l

U: Barrier l is influencing t

Y: Barriers l and t are influencing one another

Q: There is no connection between Barriers l and t

Those relations are used to build an SSIM of GSCM barriers, as shown in Table 4.

Table 4 SSI matrix of GSCM barriers

Barriers		10 ETP	9 CSM	8 IEB	7 IME	6 DAR	5 IGS	4 HMC	3 CGS	2 TEL	1 IP
1	IP	Y	B	B	Q	Q	B	U	Q	B	-
2	TEL	Y	B	B	Q	B	B	B	Q	-	
3	CGS	Q	Q	U	U	Q	Q	B	-		
4	HMC	U	B	B	B	B	Q	-			
5	IGS	B	B	B	Q	Q	-				
6	DAR	B	Q	Q	Q	-					
7	IME	B	Q	B	-						
8	IEB	B	U	-							
9	CSM	B	-								
10	ETP	-									

Table 5 RM of GSCM barriers

Barriers	ETP	CSM	IEB	IME	DAR	IGS	HMC	CGS	TEL	IP	Driving power
ETP	1	0	0	0	0	1	0	0	1	1	4
CSM	1	1	1	0	0	1	1	0	1	1	7
IEB	1	0	1	0	0	1	1	0	1	1	6
IME	1	0	1	1	0	1*	1	0	1*	1*	7
DAR	1*	0	0	0	1	1*	1	0	1	1*	6
IGS	0	0	0	0	0	1	0	0	0	0	1
HMC	1	0	0	0	0	1*	1	0	1	1	5
CGS	1*	0	1	1	0	1*	1	1	1*	1*	8
TEL	1	0	0	0	0	1	0	0	1	1	4
IP	1	0	0	0	0	1	0	0	1*	1	4
Dependence	9	1	4	2	1	10	6	1	9	9	

1* indicate transitivity links

3.3 Developing reachability matrix (RM)

The RM is a square matrix where rows and columns indicate the elements that we have selected from the survey. Binary data is converted into assumed data in this step.

In this step, the SSIM was resolved into a binary matrix called the reachability matrix, which substitutes B, U, Y, and Q by 1 and 0 as per the case. The following are the guidelines for replacing 1s and 0s.

If the (l, t) entry in the SSIM is U, then (l, t) and (l, t) entries turn 1 and 0, respectively. If the (l, t) entry in the SSIM is B, then (l, t) and (l, t) entries become 0 and 1, Accordingly. If the (l, t) entry in the SSIM is Y, then the (l, t) and (l, t) entries both turn to 1. If the (l, t) entry in the SSIM is Q, then the (l, t) and (l, t) entries both become 0.[9]

3.4 RM partitioning

The RM in ISM is essential for comprehending the connections between elements within a certain domain. The RM can be divided into different levels in this stage. The set of variables influenced by this variable itself constitutes the Reachability set. On the other hand, the element itself and the additional items that could affect or motivate the element constitute the antecedent set. The shared variable of reachability and antecedent sets for each component may then be used to calculate the intersection set. The aspects with the same intersection and reachability sets are at the top of the ISM hierarchy. In Table 5, the levels are arranged according to the driving power or the highest dependence power. Table 6 to Table 11 shows the iteration.

Table 6 1st Iteration of partitioning of matrix

SL. No	Barrier	Reachability set	Antecedent set	Intersection	Level
1	ETP	1,6,9,10	1,2,3,4,5,7,8,9,10	1,9,10	
2	CSM	1,2,3,6,7,9,10	2	2	
3	IEB	1,3,6,7,9,10	2,3,4,8	3	
4	IME	1,3,4,6,7,9,10	4,8	4	
5	DAR	1,5,6,7,9,10	5	5	
6	IGS	6	1,2,3,4,5,6,7,8,9,10	6	I
7	HMC	1,6,7,9,10	2,3,4,5,7,8	7	
8	CGS	1,3,4,6,7,8,9,10	8	8	
9	TEL	1,6,9,10	1,2,3,4,5,7,8,9,10	1,9,10	
10	IP	1,6,9,10	1,2,3,4,5,7,8,9,10	1,9,10	

Table 7 2nd Iteration of matrix separation

SL. No	Barrier	Reachability set	Antecedent set	Intersection	Level
1	ETP	1,9,10	1,2,3,4,5,7,8,9,10	1,9,10	II
2	CSM	1,2,3,7,9,10	2	2	
3	IEB	1,3,7,9,10	2,3,4,8	3	
4	IME	1,3,4,7,9,10	4,8	4	
5	DAR	1,5,7,9,10	5	5	
7	HMC	1,7,9,10	2,3,4,5,7,8	7	
8	CGS	1,3,4,7,8,9,10	8	8	
9	TEL	1,9,10	1,2,3,4,5,7,8,9,10	1,9,10	II
10	IP	1,9,10	1,2,3,4,5,7,8,9,10	1,9,10	II

Table 8 3rd Iteration of matrix separation

SL. No	Barrier	Reachability set	Antecedent set	Intersection	Level
2	CSM	2,3,7	2	2	
3	IEB	3,7	2,3,4,8	3	
4	IME	3,4,7	4,8	4	
5	DAR	5,7	5	5	
7	HMC	7	2,3,4,5,7,8	7	III
8	CGS	3,4,7,8	8	8	

Table 9 4th Iteration of matrix separation

SL. No	Barrier	Reachability set	Antecedent set	Intersection	Level
2	CSM	2,3	2	2	
3	IEB	3	2,3,4,8	3	IV
4	IME	3,4	4,8	4	
5	DAR	5	5	5	IV
8	CGS	3,4,8	8	8	

Table 10 5th Iteration of matrix separation

SL. No	Barrier	Reachability set	Antecedent set	Intersection	Level
2	CSM	2	2	2	V
4	IME	4	4,8	4	V
8	CGS	4,8	8	8	
8	CGS	8	8	8	VI

4. Result analysis

The relationship among the many barriers to GSCM is illustrated in the diagram in Figure 2. Seven levels of barriers are organized in a hierarchical system. Here, the barriers of GSCM at the top of the hierarchical system are driven by those at the bottom. In this case, Insufficient green suppliers (IGS) are placed at the top of the hierarchy, and Complexity in designing green systems and processes (CGS) is placed at the bottom.

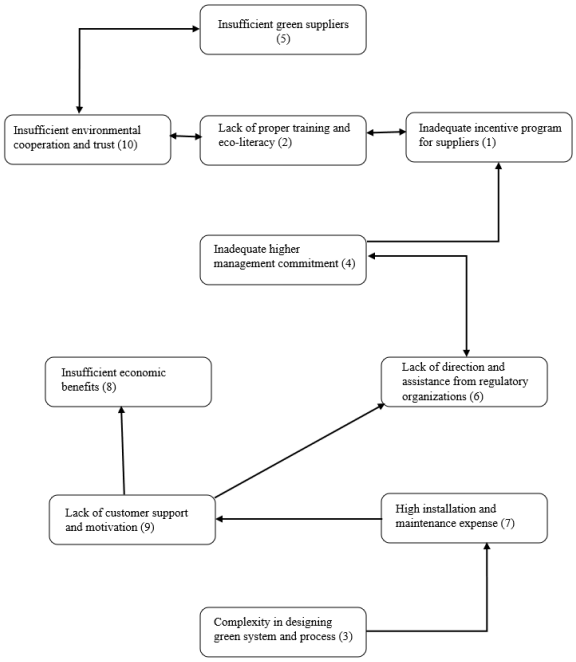

Fig. 2 Barriers of green supply chain management in textile industry by using ISM model.

4.1 MICMAC analysis

MICMAC analysis is a tool used in ISM. 4 variables in MICMAC analysis can be categorized as autonomous, driving, linkage, and dependent variables. The driving variables have strong influences in the system but weak influences in themselves.[10] The dependence and driving power of GECM barriers are already identified in Table 5 RM. The driving power of an element is determined by adding all the entities in the relevant row of the RM. The dependence power of a component is determined by adding all the entities in the relevant column of the RM. The elements with low driving and high dependence power are dependent variables. So, the graph plots IGS, ETP, TEL, and IP in a dependent quadrant.

Table 12 Driving and Dependence power of 10 barriers

Barriers	Dependence power	Driving power
ETP	9	4
CSM	1	7
IEB	4	6
IME	2	7
DAR	1	6
IGS	10	1
HMC	6	5
CGS	1	8
TEL	9	4
IP	9	4

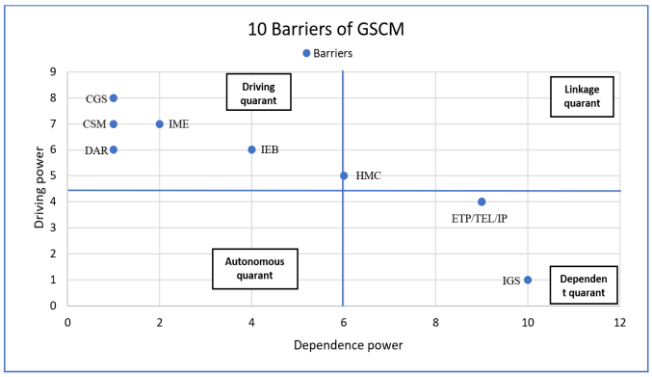

Fig. 3 10 barriers are illustrated in driving vs dependence power graph

5. Discussion

ISM is used to identify and establish relationships among barriers. The top 10 barriers are identified through expert opinion. The complexity of designing a green system and process is the first driven barrier to be removed and placed at the bottom of the hierarchy. Insufficient green suppliers are the final barrier that is influenced by other barriers and placed at the highest level of the hierarchy.

6. Conclusion

This paper identifies important barriers to GSCM and establishes relationships among them. Future work must focus on integrating the informal sector, which plays an important role in collecting and sorting post-production textile waste, into the formal economy. Also, a mitigating strategy can be applied to reduce these barriers. This integration will ensure better working.

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NOMENCLATURE

GSCM:	Green Supply Chain Management
ISM:	Interpretive Structural Modeling
IP:	Inadequate incentive program for suppliers
TEL:	Lack of proper training and eco-literacy
CGS:	Complexity in designing green system and process
HMC:	Inadequate higher management commitment
IGS:	Insufficient green suppliers
DAR:	Lack of direction and assistance from regulatory organizations
IME:	High installation and maintenance expense
IEB:	Insufficient economic benefits
CSM:	Lack of customer support and motivation
ETP:	Insufficient environmental cooperation and trust between supply chain participants