"GSCM AND CONSTRUCTION SECTOR: STRATEGIES FOR GREENING THE BUSINESS IN INDIAN CONTEXT"

Research Paper

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Abstract

Greening the Indian construction sector (CS) through green supply chain management (GSCM) has been extensively explored through an appropriate methodology through study of players in the sector in India. Examination of the opportunities for greening India's CS by ensuring sustainability through GE practises and effective regularly interactions has been adopted. The contributors 40 SDG indicators (22 direct & 18 indirect) has also been verified. The contemporary SCM practices has been scrutinised in order to identify pressures and barriers. The six identified pressures have been contemplated for a conceptual framework. The six barriers have been analysed to study the legislative opportunities to green the business. The contemporary SCM practices are found to be strictly profit-centric, through there are regulatory effects supporting the scenario. The sustainable practices have been well endorsed in GSCM, and the adopted hypothesis proves that legislation has enormous openings to lighten the target. The other two independent variables (customer demand and performance) have insignificant effects on GSCM.

Key words: *CS, GSCM, SDG, conceptual framework, legislation*

1. Introduction

Construction sector (CS) has been detected to be the leading polluter from the development side (Tan *et al*., 2011) an accused releaser of CO_2eq, major GHG contributor to global warming, heat islands, beach erosion, saltwater intrusion, seasonal change, and so forth (Zhang *et al.*, 2022). The Indian construction industry is the country's second largest contributor to GDP and employment (Dixit *et al*., 2019). However, it is a significant factor in the nation's technological and technical progression, frequently controlling the expansion of the nation's infrastructure development (Hussain *et al*., 2022). UNEP (2021) has identified that globally; CS has accounted for 36% of energy use and 37% of carbon emissions (27% from building operations). CS contributes 22% to the Global Warming Potential (GWP) of India (CDKN, 2013). Indian buildings are high energy users (280-400 $kWhm^{-2}$) that vary with the climate and kind of building (Kumar *et al*., 2012). The production of building materials causes 74% of the total emissions (Tirth *et al*., 2019); utilisation claims a major part of the rest. India ranks at the bottom of all countries with an overall score of 18.9 in the EPI-2022.

Climate change is a phenomenal term, coined by the experts for such effects that are detrimental to life's existence, and nowadays it is more vigorous than at any time before. It evokes the urgency of a transition to a low-carbon economy. The construction industry is responsible for about half of the world's natural resource use. The heating, cooling, and lighting of buildings and infrastructure are behind these emissions. In comparison to walls in older buildings, the GWP of walls in modern buildings is five times higher (Bhochhibhoya *et al*., 2017). Unfortunately, the building industry is also one of the largest waste producers (Hussain *et al*., 2022). The International Energy Agency (IEA, 2021) estimates that the construction industry as a whole accounts for nearly 15% of direct CO_2 emissions and almost one-

third of the world's total final energy consumption. In order to achieve net-zero direct building CO_2 emissions by 2030, there must be a 50% reduction in these emissions.

Some efforts have been progressing to green the industry, globally. By that way, in 2016, the adopted policy changes helped India cut its yearly CO_2 emissions by over 23 $MtCO_2$ (Ali *et al*., 2020). Greening the supply chains in the construction sector, a sustainable plan, has considerably reduced carbon emissions by 28% in Hong Kong (Hossain *et al*., 2019). Business-specific GSCM implementation is critical and requires collaborative workforce participation from all levels (Mathiyazhagan *et al*. 2014). Thus, GSCM can be recognized as one of the best solutions to resolve the above-mentioned issues (Benny and Joy, 2018). 47% of respondents from a global poll in the sector said sustainability is top-of-mind or a major issue for them when it comes to business decisions (Forbes, 2021).

GSCM encourages organisations to adopt the right automation solutions to improve productivity with more accurate demand predictions (INNOVECS, 2020) and ensures a consistent cash flow and fair warehouse fulfilment charges (Chopra and Meindl, 2007). GSCM is an end-to-end circular approach that considers the environmental effects of all supply chain processes, from resource extraction to final disposal of goods (Wang and Liu, 2013). It is also essential to check whether more legislative opportunities exist to prioritise the actions outlined in the Paris Agreement. This study aims to check the openings for greening the Indian CS by solving some research questions (Fig.1) and validating a hypothesis.

In the recent past, numerous authors have emphasised the importance of a strong and prosperous, green and sustainable construction sector (Agyekum-Mensah *et al*., 2012). Koranda *et al*. (2012) discussed the urgency for strategic approaches rather than just a few initiatives. Opoku *et al*. (2015) emphasise the need for intra-organizational leadership in promoting sustainable construction practises within the firm. Waidyasekara *et al*. (2017) researched water conservation strategies for CS. Sustainable waste management strategies and reverse logistics practises were analysed by Yates (2013) and Djokoto *et al.* (2014). Sfakianaki (2015) evaluated the resource-efficient construction techniques and employee skill development programmes to protect the company's "green" strategy.

Ghosh *et al*. (2020) provided a theoretical perspective on how Carbon Foot Print (CFP) affects SCM, assisting firms and academics in developing novel strategies to deal with CFP and other sustainability concerns. Wieland (2021) has made an effort to develop SCM using panarchy theory. He replaced the modernist idea of SCM with a more up-to-date concept of "dancing the supply chain," reinterpreting it as a social-ecological system. Shurrab *et al*. (2019) made an effort to distinguish between sustainable and green construction, make a significant contribution to empirical research on the influence of green construction factors on sustainable performance, test the theory of planned behaviour in the context of construction, and empirically evaluate the performance model and green construction factors.

The need for translation and integration of fundamental sustainable components into new environments to increase stakeholders' performance was discussed by Schropfer *et al*. (2017). Using circular economy theory, Kazancoglu *et al*. (2018) created a thorough methodology for GSCM performance assessment that considers environmental, economic, logistical, operational, organisational, and marketing performance. Mallikarathna and Silva (2019) evaluated the direct effects of GSCM practises on various operational performance dimensions (flexibility, delivery, quality, and cost), as well as the indirect effects on customer satisfaction that these practises had on these dimensions.

In order to prioritise the most significant pressures, Mathiyazhagan *et al.* (2014) divided the 65 various pressures for GSCM adoption into six groups, similar to how Govindan *et al.* (2014) investigated

various neighbourhoods for the application of GSCM in CS. From the implementation perspective, GSCM calls for innovation and technology advancement, which would be one of the major obstacles the sector would have to overcome (Abd Jamil and Fathi, 2016). The relationships between the supply chain, the systems of governance, and the innovations that can support long-term GSCM were examined by Govindan *et al.* (2016). In order to design and validate the multidimensional GSCM framework for the CS, Balasubramanian and Shukla (2017) conceived the roles of all stakeholders involved at each key stage. Wyawahare and Udawatta (2017) divided the main recovered obstacles into five categories and proposed a conceptual framework to advance GSCM practises in the CS.

2. Methodology

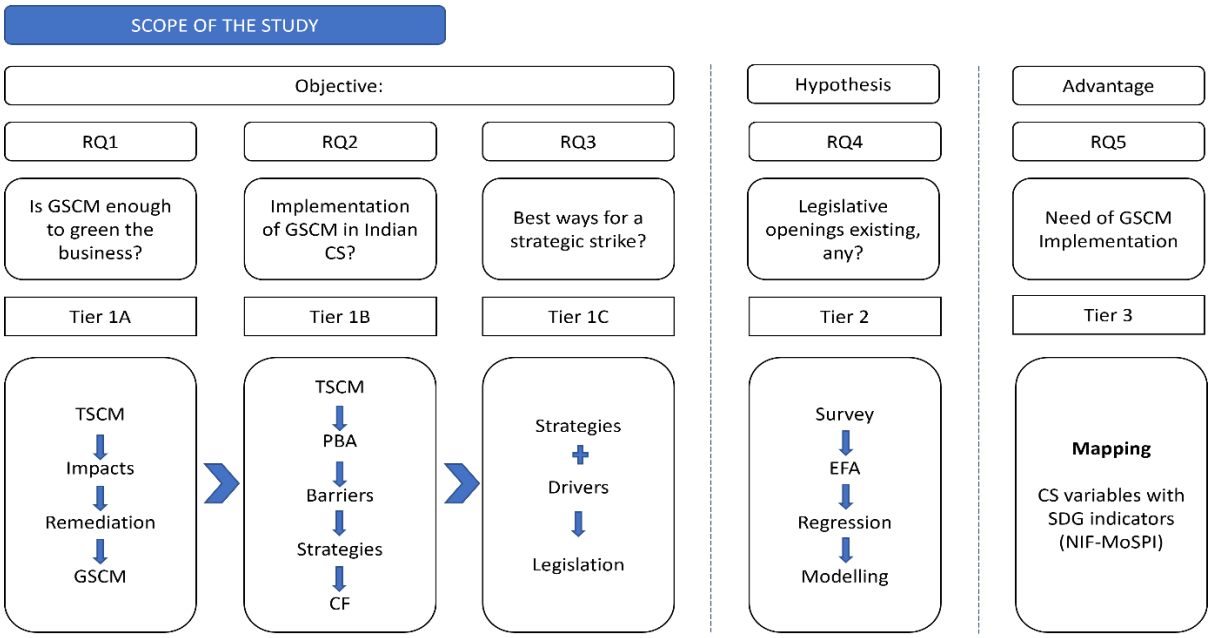

Figure 1: Flowchart delineating the extent of the study

A multi-tiered approach has been adopted to map the perspective for GSCM implementation in the Indian CS and its benefits over SDGs are examined as portraited in Figure 1. The existing SCM was analysed for impact identification with field experts *via* interviews and face-to-face conversations. The recognized impacts were plotted against global GSCM practices to check remediation. The major effort includes mapping of TSCM, impact assessment, and remediation (discussing in 4.1), validation of remedial measures via a conceptual framework (discussing in 4.3) and chances for legislative openings under tier 1 (discussing in 4.5). The hypothesis validation (discussing in 4.4), and SCM mapping over SDGs (discussing in 4.6) are treated as distinct entities, tier 4 &5 respectively.

2.1. Survey: A questionnaire survey targeting various construction sectors confined to Southern part of India in order to evaluate GSCM adoption and practises at each level of the supply chain was carried out between August 15 and September 10, 2022. Arranged appointments with potential survey respondents, followed by a personal visit from a group of surveyors, to enhance the response rate. 30 genuine responses from experts and leaders in the construction business who have international collaborations have been achieved. The ecological consequences of the "PFR-DPR-Construction-Utilization" flow and pressure barrier analysis (qualitative methodology-questionnaire) were compared to global GSCM procedures. The measured gap was used to develop the same's drivers, and the identified barriers had a significant impact on the framework's conceptualization. The pressures were integrated with strategies to check the legislative openings, which were confirmed via hypothesis testing.

2.2. Hypothesis checking: Multiple regression analysis was employed to prove the hypothesis using SPSS 26 platform. After establishing the reliability of variables using Cronbach's alpha, I performed exploratory factor analysis (EFA) to segregate them. The EFA is followed by multiple regression analysis (modelling) to check the level of adoption of GSCM in CS, India.

2.3. SDG linkage: The CS variables are mapped to each of the 14 filtered SDGs (National Indicator Framework (NIF)-2022) that have defined targets with coercive indicators that are directly aligned to the construction priorities of India.

3. Results and discussion

3.1. Scope of GSCM in Indian CS

India mostly relies on the CS for development activities, such as resilient buildings and institutions, improved transit infrastructure, industrial parks, *etc*. (Rani, 2021), and this might be true for all countries, regardless of their status as developed or developing (Ofori, 2015). The PFS-DPS-Construction-Utilization chain is the most often identified linear supply chain in the Indian CS. In India, the pre-feasibility study (PFS) stage is followed by the detailed project study (DPS) stage, where procurement and design are finalised. The next phase is the action phase, during which all designs are put into use. This is when all the work is done and lasts until the end of the building - utilization phase.

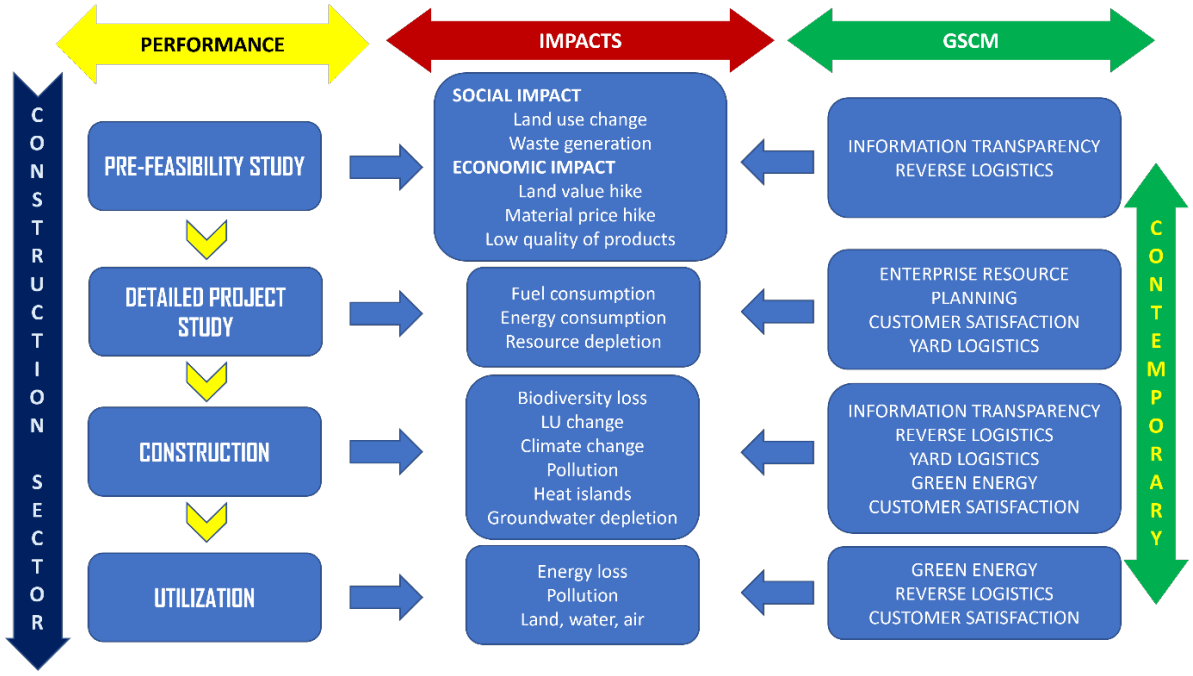

Figure 2: Impact assessment and GSCM practices over construction industry

The main issue recorded in the CS with India is resource depletion (CSE, 2012) and waste generation leads to pollution (Schoer *et al*., 2012). Unhealthy ecosystems made out of above issues and LU changes will challenge social security (UNEP, 2019) and biodiversity, and the extended pollution abatement cost will wither economic stability (Frakt, 2018). Emissions from the CS reached their highest level ever in 2019 (UNEP, 2020). Indian construction and demolition (C&D) waste production is anticipated to be 150 million tonnes per year, according to the Building Material Promotion Council (CSE, 2020). All of the denials begin with poor urban planning. Repetitive construction, demanded by unscientific planning, thrives in resource depletion, and generates indiscriminate waste, all these account for the

potential for global warming. As the supply chain advances linearly, Figure 2 shows the predicted impacts at various stages and, at the very end, the suggested green remediation.

As it finds more of a linear prototype, the economic outlook will undoubtedly gain more priority. In GSCM, supply chain managers are compelled to adopt appropriate novel sustainable technologies to address all the economic and environmental issues they face, and to communicate this to all chain stakeholders. It concentrates on creating high-quality, cost-effective goods that exceed client expectations. It saves space, energy, and inventory, making it the greatest practise to use. Hence, lean manufacturing is beneficial in terms of ecology and the environment. The global GSCM metrices wide in action are discussed below and same are adopted as variables for survey and analysis.

i. **Enterprise resource planning (ERP):** The significance of 'process mapping' and the organisational trait of how to learn from mistakes were also given and addressed in relation to how they affected the implementation's success. ERP adoption, however, necessitates a significant amount of organisational work, and many businesses fail or fail to realise the benefits anticipated before the implementation (Kripaa, 2012).

ii. **Information transparency (IT):** True transparency means reporting clear and meaningful information, not an obscure set of numbers with no frame of reference. It brings out trust between suppliers, companies, and customers. A functionally info-transparent business should prioritise disclosure (delivering the information both internally and externally at the level of specificity that is required or requested) in addition to visibility (accurately identifying and gathering data from all supply chain links) (Harbert, 2020).

iii. **Reverse logistics (RL):** Retrieving goods or products for repair, resale, recycling, or proper disposal is referred to as reverse logistics (Hsu *et al*., 2013). In addition to ensuring an effective flow of goods, reverse logistics that is well-designed with better warehouse management system can provide cost reduction, waste reduction, and loss reduction with increased sustainability. 33% of the waste generation can be avoided if architects design for waste mitigation during the pre-construction stage (CSE, 2020). If RL principles were applied throughout construction, buildings could reuse or recycle up to 85% of their whole weight (Hosseini *et al*., 2014).

iv. **Customer satisfaction (CS):** Valuing CS will activate the supply chain for innovative partners to provide consumers with the best products and services. Customers are crucial in the development of supply chains. More green demands from the customer side will make GSCM run smoother. This makes the buyers' demand supply chain resilient to disruption and ethically sound.

v. **Yard logistics (YL):** Customers nowadays choose automated yards that integrate GPS, sensors, and the Internet of Things. All warehouse and transportation arrangements put in place by management will be affected by a late cargo or a trailer that is lost in the yard, which will lead to subpar customer service. This will considerably account more fuel dependency, demurrage or detention charges, inability to win insurances and compliances and difficulty in reducing carbon footprint without negatively impacting operations (Granato, 2020).

vi. **Green energy (GE):** Access to clean, dependable, and consistent power is a creative and non-disruptive force in the operations and supply chain of a company. The first universal, legally binding global climate agreement on greenhouse gas emissions was approved by 195 nations at the United Nations Conference on Climate Change (COP21), underscoring the growing importance of policy in determining the expansion of renewable energy. Globally, 81 businesses have declared their intent to pursue only renewable energy as part of the RE100 project (Deloitte, 2016).

3.2. Drivers and barriers of GSCM in Indian CS

Many of the construction companies have now switched to GSCM (Forbes, 2021) and are required to apply environmental practises to improve their green image. The constant and varied pressures on the environment necessitate higher standards of responsibility. However, the Indian sector finds it difficult to pinpoint the crucial GSCM drivers (Mathiyazhagan *et al*., 2014). A total of 28 obstacles were discovered under 6 different classes, all of which were focused on efficient procurement and identifying

Drivers / Pressuring factor	Barriers
I. Legislative pressure (LP)	**I. Logistics barriers (LB)**
1. Central green regulation	1. Green materials
2. Regional green regulations	2. Green suppliers
3. Waste management (Electrical and Electronic)	3. Green technologies
4. Emission standards	4. Green legislation
5. High penalty for environmental pollution	5. Green awareness
6. LB initiative to sustainable urban planning	
II. Corporate Matters (CM)	**II. Technical barriers (TB)**
7. Enterprise Resource Planning	6. Technology failure
8. Corporate Greening	7. Lack of technical expertise
9. Resource capitalization	8. Lack of effective environmental measures
10. Corporate environmental performance	9. Lack of new technology
11. Carbon pricing policy	10. Flexibility of design
12. Rising transportation costs	
III. Global Market (GM)	**III. Social barriers (SB)**
13. Competitors' green strategy	11. Lack of awareness
14. WTO entry	12. Lack of Environmental Knowledge
15. New market opportunities for current (green/recycled) product	13. Finding opportunities
16. Green FDI	14. Info-transparent organizations
17. Export potential of the green product	15. Low demand GSCM
IV. Financial Factors (FF)	**IV. Economic barriers (EB)**
18. Green tax	16. High initial investments
19. Profit from Waste to energy / other means	17. Uncertainty in return-on-Investments
20. Carbon tax (global)	18. Unsupportive financial institutions
21. Green promotion	19. Competition
	20. Profit orientated supply chain
V. Customer demand (CD)	**V. Regulatory barriers (RB)**
22. Resilience of climate change and natural hazards	21. Restrictive company policies
23. Efficient cost structure	
24. Green identity and carbon footprint	22. Lack of support
25. Heritage Fantasy	
VI. Operational Performance (OP)	**VI. Administrative barriers (AB)**
26. E-logistics	23. Lack of training courses
27. Carbon Audit	24. Lack of Corporate Social Responsibility
28. Non-linear supply chains	25. Logistics invisibility
29. Competitive advantage	26. Poor supplier commitment
30. Reverse logistics	27. Top management negotiation
	28. Inadequate management capacity

Table 1: Drivers and barriers of GSCM in Indian Construction Sector

obstacles to the GSCM implementation in the CS through appropriate research methods. Similar efforts were conducted to determine the strategic pressures or openings for the adoption of GSCM. The

following table (1) contains all this information. Pressure-Barrier Analysis is essential to fix remediation and to arrive an effective conceptual framework.

Drivers identified for GSCM implementation as follows: The existing laws and regulations (EPA, 1986, CRZ, 2019, etc.) insist to be green. To what extent it is monitored and reframed according to the validation is the main RQ. The legislative chances to build strong foundation lies there - (**Legislative**). The corporate policies establishing company's green image, through better CSR they can contribute much to NRC. Carbon emission audits for Environmental protection will cover in CER -(**Corporate**). Global green market and more profit will drive you greener. FDI in Environmental Goods and Services (EGS) sectors, and FDI in environmental-damage mitigation processes are found to be other promoters -(**Global**). Special tax exemption for ISO 14001 certified firms, carbon tax etc will drive them towards greener -(**Financial**). Cost efficient products and intelligent approach to local environment will demand for green product in market and make customers in environmental protection requirements -(**Customer**). Adaptation of new materials via integration with green product suppliers and technical overhands offer advantage over competitors' advantage in either cost or differentiation will prove more confidence in investment recovery -(**Operational**).

Barriers identified are the unavailability of green materials, economic-centric linear supply chains, difficulties in identifying and auditing supplier performance, issues with novel technologies, and other legal sides of adoption and Disagreements with clients are **logistics** barriers. Fear of technology transfer and inefficiency to update to GSCM, uncertainty in return on investment and complexity of new ideas and inefficiency in handling IoT challenges to that extent are **technical** barriers. Lack of understanding of environmental legislation and the environmental impact of the organization's activities, as well as the benefits of adopting a green supply chain (**social**). The extra cost for Eco-friendly packaging, Adoption of new system and non-availability of bank loans to encourage green products/ processes -(**Economic**). **Regulatory** barriers lie with authorities who fail to extend proper support and guidance to maintain GSCM. Administratively, the resistance of top management to change existing investments, information systems, and habits makes switchover to a new supply chain system challenging -(**Administrative**).

3.3. Strategies for successful implementation of GSCM in construction industry

Long-term planning for controlled emissions and legislative backups is the best strategy for the successful implementation of GSCM (Mudgal *et al*., 2009). Coercive pressures, primarily from the government (Rivera, 2004), competitions in the global market (Park and Ghauri 2015), and customer demands (Hsu and Hu, 2008), are the major external pressures for adopting environmentally conscious policies (Balasubramanian, 2012), the company's awareness of corporate social responsibility (CSR) is an internal driver. The successful deployment of GSCM in construction organisations is also aided by the knowledge of professionals, suppliers, and end users about it (Ibrahim *et al*., 2010). Effective management of reverse logistics can help to overcome obstacles including ignorance of reverse logistics and inefficient reuse or recycling designs (Govindan *et al*., 2014). Higher initial costs, uncertainties, and potential liabilities associated with employing recovered items, operational difficulties, and lack of awareness have been noted as internal barriers to reverse logistics in the construction sector (Hosseini *et al*., 2014). The convoluted and disorganised nature of the materials flow and supply chain in the construction environment, however, is what causes the major problems with RL implementation in the industry (Tingley and Davison, 2012). However, taking into account the overall advantages of tackling

the main environmental drivers, *i.e.*, reducing consumption, using energy sensibly, reducing waste, and adhering to environmental regulations with little pollution (Sassi, 2008).

A suitable strategy derived from the above-identified barriers has been discussing in the CF. Here I have identified, in the session 4.1 of this study, six components to mitigate the impacts of traditional SC. The listed barriers are plotted under these components in the CF, and it explains how it going to overcome by GSCM practices. The effective implementation of GSCM is quite challenging; how can it be simplified vide effective strategies that all can be get knew from the CF

3.3.1. Conceptual framework

Figure 3: Conceptual framework for GSCM implementation in CS

The accurate assessment of impediments to GSCM implementation might be beneficial for advancing with appropriate GSCM practises in construction organisations. As indicated in the driver-barrier analysis, GSCM assists organisations at all levels in improving their socioeconomic and environmental performance (Gandhi *et al*., 2015). The discovery of the prospect for reverse logistics will help to manage resource depletion (Sarkis, 2003). However, there exist multitudinal challenges, *viz*., logistics, technical, social, economic, regulatory, and administrative barriers under six different components. Better strategies, *viz*., government subsidies; top management commitment; effective reverse logistics management; efficient financial management; increasing public awareness about environmental concerns; the need for IoTs; efficient reverse logistics technologies; the benefits of yard logistics; and transparent companies, have to be adopted. Figure 3 depicts a flow chart with three primary sections that lists the six basic components of GSCM, the difficulties associated with each component, and solutions to overcome those barriers. The proposed framework will aid in the implementation of GSCM.

3.4. Hypothesis checking

A response rate of more than 20% is required for a favourable evaluation of questionnaire survey results (Malhotra and Grover, 1998). This study's respondents are middle-level managers and professionals.

The sample was drawn randomly from a large group of firms involved in largescale construction projects such as roads, buildings, housing, and construction. Primary data were collected through a standard questionnaire based on a five-point Likert-type scale. Face-to-face interviews were also conducted. All items were measured on several scales based on their importance, some of which are about degree of agreement, while others include multiple alternatives to mark the priority, which is necessary to obtain meaningful information about the pressures and barriers and to substantially prove the hypothesis. Based on the scope of study (Fig.1), the following hypothesis was formulated and evaluated for the construction sector.

H1: There are strategic opportunities for the implementation of GSCM in the Indian construction industry.

Constructs	Items	Key Phrases	Mean	SD
Policy oriented	STR1	We attempted to comply government environmental regulations	3.8667	1.13664
	STR2	We actively charted out green procurement	4.2000	1.27035
	STR3	Our competitive business strategies are based on government environmental standards	3.0667	1.41259
	STR4	Our business strategy is inclusive and transparent	3.6333	1.03335
Profit oriented	BEN1	Our stakeholders realised the benefits of doing 'Green'	2.2667	1. 43679
	BEN2	Our marketing rivals has declined	2.1000	1.24152
	BEN3	Our brand value has increased through open communication across all business levels	1.8667	1.22428
	BEN4	We systematically succeeded in resolving procurement issues	3.9333	1.22990
	BEN5	We met global managerial standards	3.0333	1.24522
Customer oriented	CDEM1	We are fully committed to satisfy customers anxieties	4.4000	.89443
	CDEM2	Less effort to manage extra green cost	2.7000	1.08755
	CDEM3	Our customers encourage new green products inclusion	3.0667	1.38796
	CDEM4	Our customers have green demands	2.2000	1.27035
	CDEM5	Our production cost has declined via RL	4.1333	.81931
Performance oriented	BP1	Our ERP has enhanced the speed of the project	3.6333	.71840

Table 2: Summary of EFA- questionnaire items

Coefficients[a]

Model		Unstandardized coefficients		Standardized coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	8.300	.268		30.913	.000
	Policy oriented	.735	.273	.380	2.692	.012
	Profit oriented	1.108	.273	.573	4.056	.000
	Customer oriented	.277	.273	.143	1.015	.320
	Performance oriented	.162	.273	.084	.593	.559

Note: KMO Fit = .645, Bartlett's Test of Sphericity: χ^2 value = 342.611 (0.000). Dependent variable: SCM

Table 3: Results of multiple regression analysis (modelling)

Cronbach Alpha values for each construct considered have shown high reliability with a value of 0.750. To get a more meaningful representation, fifteen variables were considered. Concerns over operational performance over supplier selection, customer treatment, and internal work force participation belong to the construction industry and were also considered for the analysis. The exploratory factor analysis (Table 2) has performed a random pooling of all the available fifteen variables (made out of green practises like RL, IT, GE, YL, CS, and ERP) under four distinct constructs, namely, policy-oriented, profit-oriented, customer-oriented, and performance-oriented. The collinearity available for the above-mentioned four independent variables is 1.000. As a result, it is a perfect pooling with no interdependence between variables. The result **[F (4,25) = 6.269, P<.005]** indicates that current practises in the Indian CS revealed by the survey indicate a significant reliance on policy adoption and

profit-based performance (Fernando and Aruppala, 2017); thus, that becomes the most influential point of the analysis. The result (Table 3) assures a consistency in the GSCM practises in the Indian construction industry. The R value of 0.708 assures a good quality of prediction of the dependent variable, *i.e.*, GSCM. The R square values show only 50% acceptance, meaning that among the four, only two are leveraging the hypothesis. The outliers are customer demands and business performance. A perceivable reduction in customer demands and satisfaction happened because the majority of the customers were unaware of GSCM's essentiality. They seem hazy towards the recycled product inclusion (reverse logistics) and the majority are not ready to afford the extra green cost associated with GSCM. Lowering of company performance (GSCM practices) might be due to the inadequacy of newer green technology, the scarcity of technically skilled laborers, the unavailability of green suppliers, and so on. This underscores many persisting gaps and recalls a lot of opportunities for going green.

3.5. SDG accomplishment: an advantage of GSCM

SDGs have been constructed in three dimensions: social, economic, and environmental, all of which have recorded immense impacts by construction and allied industries, as they are interlinked (Ogunmakinde *et al.*, 2022). Here, the construction variable in the Indian environment has been mapped to the indicator framework developed by MoSPI (2022) for the ongoing evaluation and monitoring of SDG implementation in India. The CS variables are mapped to each of the 14 filtered SDGs targets. This approach explores the direct and indirect connections between the building-manufacturing sector, and the achievement of the SDGs. Three of the 17 SDGs have no specific connection to the construction industry. The remaining 14 SDGs have been broken down into direct and indirect connections with the construction sector (CS), which is outlined in Figure 4.

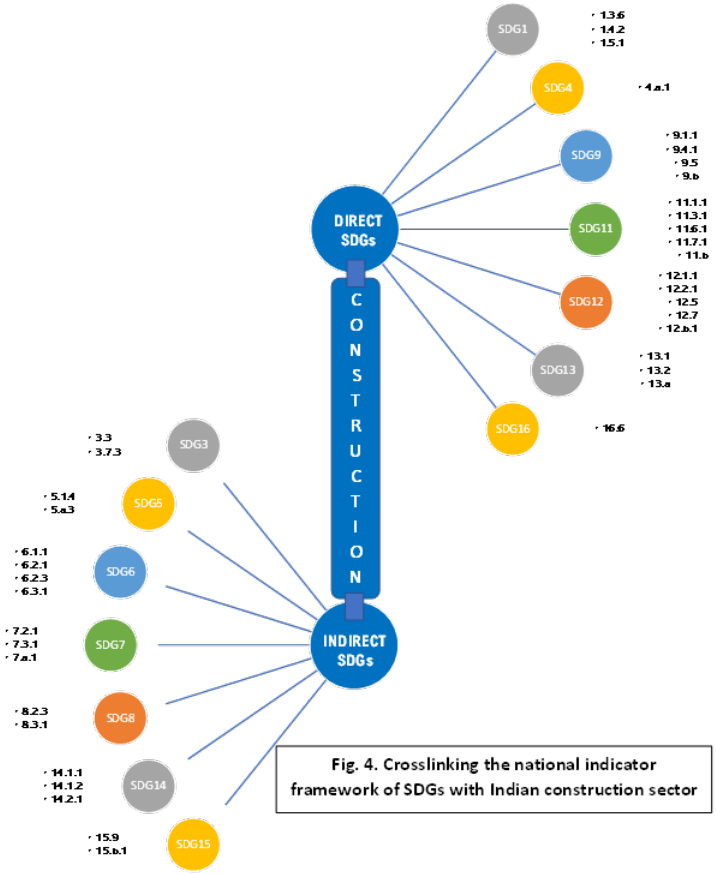

Fig. 4. Crosslinking the national indicator framework of SDGs with Indian construction sector

3.5.1. **Direct SDGs:** SDG 9 aims at innovation competency (9.1.1), CEQ emission (9.4.1), R&D share (9.5), and domestic technology development (9b); SDG 11.1.1 provides an incomparable opening to track non-resilient houses, sustainable cities with integrated plans (11.3.1), cities with proper waste management systems (11.6.1), green spaces (11.7.1), and green policies (11.b); SDG 12 facilitates the formulation of SCP (12.1), natural resource management (12.2), per capita waste generation (12.5), green public procurement policies (12.7), and cultural shift and product flow (12 b); SDG 13 addresses adaptive capacity to climatic hazards (13.1), policies and planning (13.2), and green education (13.3); SDG indicator 1.3.6, which targets SDG 4a and 16.6, validates the institutional facility and assistance provided. SDG 1.4 checks the new technologies provided, and 1.5.a accounts for the vulnerability to climatic hazards.

3.5.2. **Indirect SDGs:** SDG 3 checks the epidemic and communicable disease probabilities (3.3) and promotes institutional birth facilities (3.7.3); The construction industry can help achieve gender equality by providing equal wages (5.a3) to encourage more women to join the industry (5.1.4); Indicators 6.1.1 checks the safe drinking water facility, 6.2.1 and 6.2.3 (toilet facility), and 6.3.1 (STP); Indicators 7.2.1 offers renewable energy share, 7.3.1 (energy efficiency) and 7.a1 (ODA for clean energy); Indicators 8.23 validate the annual productivity and 8.3.1 employment rate; Construction waste that enters the water world will eventually alter biodiversity and threaten human existence through a series of climatic changes. Indicators 14.1.1 & 14.1.2 check the health index, and 14.2.1 checks the LU change (mangrove); The target 5.9 checks the biodiversity loss and 15.b1 fund utilisation for environmental conservation.

3.6. Legislative opportunities

The most frequent research question pertaining to greening the Indian CS is how the construction industry might become more sustainable (Yılmaz and Bakış, 2015; Mukherjee, 2019). The referendum after the survey conducted on the aforementioned issues discloses that no serious scientific approach to the issues concerning pollution from the construction side has been retrieved for any analysis in India thus far, which may be the main challenge faced by the Indian CS for going green. The corporate management has to be effectively supported through more research findings, international partnerships, ABS, systematic budget complementary towards ODA/MDA, green curriculum, etc. The CF derived from the pressure-barrier analysis and the results of the PFR-DPR-Construction-Utilization flow necessitates some form of pushing in order to effectively green the SC. The barriers identified can be overwhelmed by reinforcing the components that would be speedier when the strategies go legislatively (Chen-Lung and Chwen, 2011). Many of the six categories of drivers are legally binding, particularly the legislative pressures. Corporate policies reflect corporate matters, just as global, financial, and operational customers all work under agreement. Effective conditions can help to accelerate the transformation. As a result, a legislative approach was discovered to be an effective path to GSCM in India. Furthermore, hypothetical validation confirms the breadth of legislative options.

The following uncertainties must be considered while developing a legal structure that addresses the common drives and impediments:

1) Create a long-term strategy that incorporates sustainability into every process, from PFS to utilisation.
2) Mandate ethically sourced materials prior to a strict carbon audit.
3) Make all subcontractors and suppliers green experts or talents and adhere to labour regulations and fair humanitarian practises.
4) Visibility and transparency should be a corporate motto to track, measure, and eliminate emissions and waste throughout the project lifecycle, beginning with the DPS phase.
5) Implement ERP for all medium-sized construction firms and up.
6) Resolve logistics invisibility to optimise green deliveries.
7) A sustainability audit must be performed to reset emission targets to achieve carbon neutrality.
8) Guarantee that the government is represented at all GSC levels

4. Conclusion

GSCM is identified and recommended as the global environmental management strategy which is highly relevant for the Indian CS, as it is already on the green path. Uncertainty in predicted profits and losses contributes to its non-recognition among stakeholders and is found to be the primary constraint

for the 40 SDG-indicators accomplishments. The traditional SCM in India has significant ramifications for the socioeconomic and environmental systems. The identified global GSCM variables, including ERP, IT, RL, CS, YL, and GE, are deemed to be sufficient to address the issue, once the GSCM is accepted. Pressure-Barrier Analysis has laid the concrete foundation for the conceptual framework for GSCM implementation. The Indian CS survey identified six primary hurdles (logistics, technical, social, economic, regulatory, and administrative) and pressures to move with GSCM have been discussed at six levels: legislative, corporate, global, financial, customer, and operational. Furthermore, the hypothesis proposed has been found to be accepted, and it is concurred that there are numerous strategic opportunities for legislative confirmation of the same. The scope of green legislation has shown high significance, as the regression analysis proved the system is more profit- and regulation-oriented. It corroborates all the suggestions to legislative side.

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