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Green supply chain drivers and their implementation on LEED-certified projects in India

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Abstract: This study aims to identify the most critical green supply chain drivers and to explore the most prevalent drivers in the real estate industry in India. Through literature review, we identified 13 green drivers in the real estate sector in India. A structured questionnaire was administered to 280 potential participants, out of whom 150 responded by filling out the questionnaire. The respondents were working in reputed real estate companies comprising owners, contractors, consultants, architects, and project management companies in Delhi National capital region (NCR). The relative relevance index was used to rank the various green drivers in the real estate industry in India. Multiple regression analysis was used to establish the degree of linear connection between the variables. T-tests examine the differences between 13 decision factors and dependent variables. The cost–benefit of green supply chain drivers in a LEED-certified real estate project in India established the efficacy of green supply chain drivers in the real estate industry in India. The study's findings indicate that senior management, developers, and the government are the most crucial drivers for implementing the green supply chain in the real estate sector. The study's findings further confirm that green building approaches, i.e., green procurement, green transportation, building information modelling (BIM), building energy modelling (BEM), and prefabrication procedures, are underutilised in the real estate sector in India.

Keywords: green supply chain management, building energy modelling, recycling, green transportation, building information modelling, Prefabrication, green procurement

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1 Introduction

India has a population of 1.42 billion as of 2022, and the UN predicts that India will be the world's most populous country by 2030 (India Population [2022] – Worldometer n.d.). The major contributor to climate change is carbon dioxide. India is the third largest contributor of carbon dioxide emissions, trailing only China and the United States (The 5 Countries that Produce the Most Carbon Dioxide [CO_2] n.d.). Carbon emission from construction activities is 10.36 metric tonnes, and the construction industry is also a substantial absorber of emissions from other blocks (Tackling Embodied Carbon from India's Building Sector 2022). The green building concept is lacking in India. According to Sajid et al. (2020), several actions are needed to increase the efficiency of the construction industry in India. There is a severe scarcity of qualified building performance evaluators. Furthermore, workforce training is required for various energy-saving alternatives in the construction industry.

According to a study conducted by the Indian Green Building Council, the construction industry in India is growing at a rate of 9.5% on average, compared with the global average of 5% (IGBC 2013). Green concepts and techniques can help address national issues, such as energy efficiency, water efficiency, fossil fuel reduction, consumer waste management, and natural resource conservation. Many Indian states are water-stressed, and using green buildings aids in reducing, reusing, and recycling resources.

The green building rating system promotes the separation of construction waste. Buildings are also among the largest electricity consumers. Energy consumption can be reduced by utilising energy-efficient air-conditioning and lighting systems. Building energy consumption can be reduced by using energy-efficient building envelopes, lighting, and air-conditioning systems. The green building system also promotes the use of alternative modes of transportation. Green building concepts have several social advantages. The top social reasons for green buildings are improved workers' productivity and sustainable practices in business. Green buildings have lower operating costs,

improved occupant health and well-being, higher point-of-sale value, increased rental rates, design flexibility, and higher occupancy rates.

A study investigating green supply chain management in the construction industry (Setyaning et al. 2020) reported that only 5% of buildings could be called as green buildings. The study also revealed that if green buildings are not urgently implemented, conventional buildings will generate 70% of emissions by 2050. The lower cost of operations and meeting the client demand by constructing healthier buildings are the top triggers driving future green building activities in India. The study also concluded that many green practices are relevant for implementation in the construction sector but are not being used to their full potential (Petrullo et al. 2018). Furthermore, green building costs are still poorly understood by building owners. There is a misunderstanding that conventional buildings demand lower cost than green buildings. The study offers the most comprehensive empirical analysis for predicting the initial construction cost of midrise green office buildings based on different input variables. The study suggested using the multilinear regression method to develop, test, and predict the initial construction cost of midrise green office buildings (Alshamrani 2020).

The study's primary purpose is to identify and examine the effect of green supply chain drivers on project outcomes. The importance and originality of this study are that it explores the drivers that impact the implementation of the green supply chain in the real estate industry in India, where prior studies focus on developed markets. The efficacy of the identified green supply chain drivers has been verified using a case study on LEED-certified malls in Delhi/NCR region, India. This combination of findings supports the efficacy of green supply chain drivers in promoting green building practices and overcoming the misconception of the higher initial cost of implementing green practices.

The article is structured as follows. The studies conducted in India and other regions of the world were reviewed to understand the various green supply chain drivers in real estate projects. A questionnaire was prepared to understand the drivers that are more prevalent in implementing the green supply chain in this sector and the drivers that impact more in implementing the green supply chain management in India. Finally, a case study on implementing these drivers in a LEED-certified mall project has been discussed. The case study discusses how much additional cost the developer incurred and how much time the cost was recovered in terms of energy and water savings. The builder also got an additional floor area ratio and valuation of the green building. It is always more than a non-green-certified building and has attracted various international brands to lease out space in the mall.

2 Literature review

The literature review showed that the number of studies conducted in India is scarce, so the existing literature from other parts of the world was also studied to understand the various drivers of green buildings. Although the study has been carried out in various countries across the globe, these green supply chain drivers are equally crucial for the construction sector in India. Green practices reduce the environmental impact. Environmental and economic benefits drive the importance of a green supply chain. The green supply chain management process is followed more in developed than in developing economies. There is more focus on manufacturing sectors. It has been found that top-level commitment is essential for implementing Green Supply Chain Management (GSCM) in construction. The globalisation of the companies leads to higher environmental awareness and the adoption of GSCM (Al-Ma'aitah 2018). The green building market of Vietnam was also studied. They found the role of contractors for green building projects extremely important. There is a need for the government to the development of rules and regulations for the implementation of green building projects (Tran 2021). Singapore gives financial incentives to architects and engineers for additional efforts and time spent on green buildings. The US gives additional bonuses to developers by increasing the allowable height for LEED-certified buildings. As per the study, hidden benefits include improved health and productivity and reduced water, electricity, and infrastructure demand. Although there are additional costs in terms of construction, consultancy fees, and financial costs, there are benefits in terms of gross floor area, enhanced property value, and reduced maintenance costs (Qian et al. 2016). Green bonds help shift the capital to a more sustainable economic activity. Green bonds help as low-risk instrument that allows investors and issuers to contribute to sustainability at a relatively low cost. The green bond market helps in infrastructure within capital markets consisting of green guidelines (Maltias and Nykvist 2021).

The developer initiates the real estate projects and plays a pivotal role in implementing the GSCM in the real estate sector. The steps in the construction of real estate are shown in Figure 1.

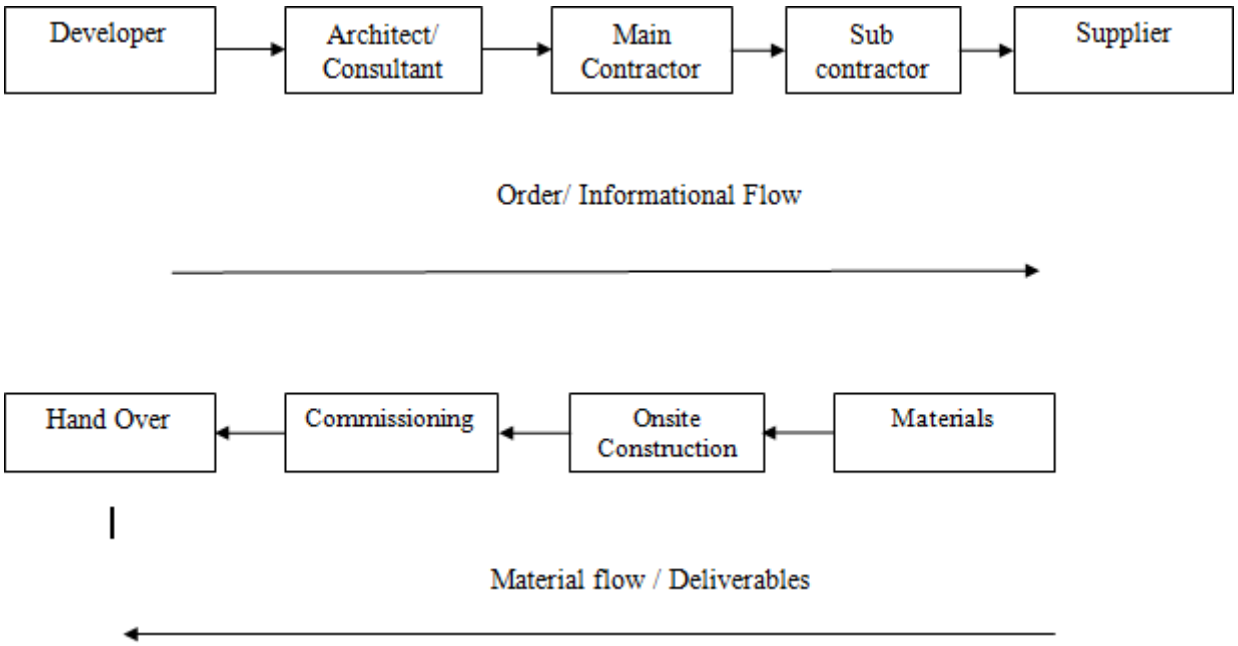

Fig. 1: Process flow of activities in the real estate project. *Source:* GSCM, an empirical investigation of the construction sector (Balasubramanian and Shukla 2017).

The developer appoints an architect to provide the blueprint of the project. The architect releases the drawings, based on which the consultants prepare the bill of quantities and technical specifications. The tenders are released, and the main contractor is appointed. The main contractor further appoints a subcontractor specialising in a particular work. The subcontractor further orders material per the bill of quantities in the contract. The ordered material is brought to the site, installed by various contractors, and finally commissioned and handed over to the developer.

Green design should be essential in GSCM in the real estate sector. The building should be designed by keeping in mind its impact on the environment. The second is green purchasing, which includes environmental considerations in the purchasing policies. The next is green transportation, which stresses using fuel-efficient vehicles and getting total truck quantities. Green manufacturing uses practices to reduce the environmental impact. The factors that can help in GSCM are environmental training and auditing, regulations regarding green development by the government, stakeholder pressure, competitor pressure, and end-consumer pressure (Balasubramanian and Shukla 2017).

It was studied that there is a strong correlation between building information modelling (BIM) and green buildings. The BIM model has been used as an organisational strategy for green projects. BIM can be used advantageously to execute green buildings' concepts and features (Mohammed 2021). The buildings and their complex process from design to occupation were also studied (Rogage et al. 2019). The growing benefits of BIM enhanced with building energy modelling (BEM) have been studied with the help of several case studies (Gerrish et al. 2017). Figure 2 depicts the process flow of BIM.

The process of designing a university building using both BIM and BEM is shown in Figure 3.

In the future, there will be intelligent construction sites with workers wearing smart safety glasses to visualise data. The future procurement and construction sites will have the availability of real-time data with tools and components at the site fitted with Radio frequency identification (RFID) tags. The crane operation should also be based on BIM. From the literature, we can understand the drivers for implementing the green supply chain in construction (Edirisinghe 2018). The BIM can be used to reduce the energy and water demands of construction projects needed for blue-collar training workers, engineers at organisational levels, designers, and contractors. In the case of developed economies, BIM is applied in their projects (Alhamami et al. 2020).

The creation of value is essential for implementing innovation in the construction sector. The study shows prefabrication helps in benefitting construction projects. There is an improvement of around 25% from the effective use of BIM. Prefabrication, preassembly, modularisation,

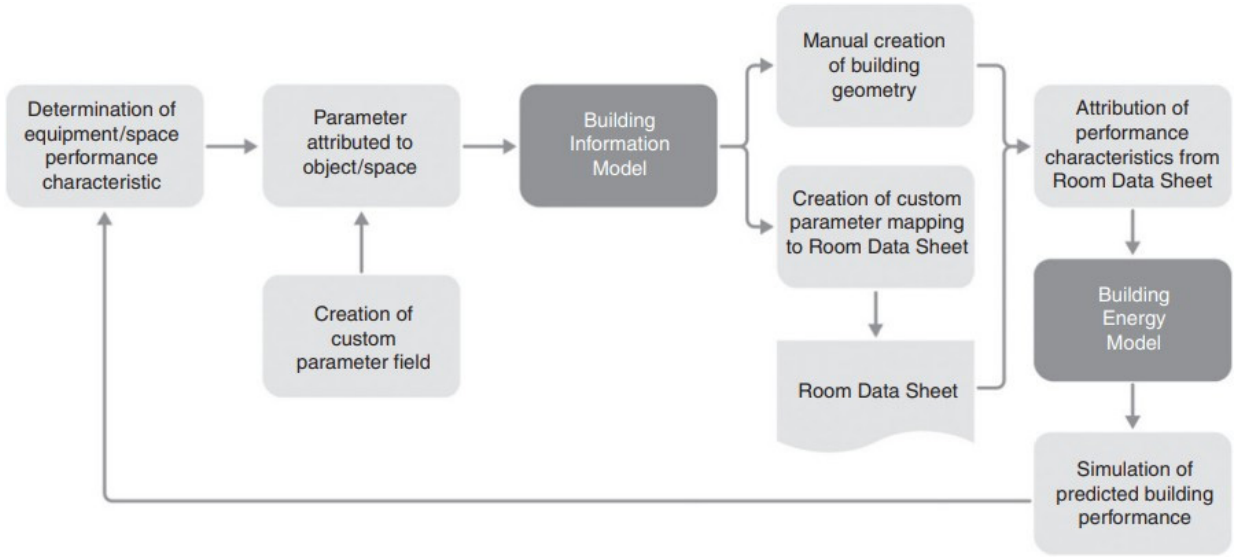

Fig. 2: BIM process flow diagram. *Source:* Using BIM capabilities to improve existing BEM practices (Gerrish et al. 2017). BEM, building energy modelling; BIM, building information modelling.

and offsite fabrication (PPMOF) can further boost the construction performance. Furthermore, it was found that prefabrication prevented quality issues and rework. Moreover, the direct cost is higher than prefabrication cost (Lavikka et al. 2021). There are three pillars to sustainability, i.e., economy, society, and environment. The carbon footprint is the amount of carbon dioxide emitted into the environment. The study also concluded that reducing carbon footprint leads to developing sustainable supply chains (Ghosh et al. 2020).

Green building certification helps in the design, improvement, and operation of buildings. Indoor environmental quality has become necessary with the impact of air pollution on all the metro cities in the world. Organisations face daunting challenges in tackling and promoting indoor environmental qualities for well-being and health (Altomonte et al. 2019). A study by Lee and Kim (2008) in the USA to evaluate the indoor air quality of LEED-certified buildings found a higher level of satisfaction among the occupant on quality of construction, indoor air quality, cleanliness, and quality of maintenance. The study used seven parameters for evaluation, namely, qualities of office layout, office furnishings, thermal comfort, indoor air quality, lighting, acoustics, and cleanliness.

Intelligent buildings focus on building energy efficiency with the help of Heating, ventilation and Airconditioning (HVAC), lighting, and air quality, as well as indoor air quality monitoring. Intelligent buildings can respond to the ever-increasing requirements of society and reduce the environmental impact. Furthermore, Ghaffarianhoseini et al. (2016) outlined prospects for a green financing system to foster energy sustainability. Green financing institutions can be utilised for redirecting investment into sustainable infrastructures to mitigate climate change. Additionally, there is a need for the timely transfer of clean energy from developed to developing countries (Ng et al. 2021). There is a need to get green technologies for sustainability. Green ICT helps enhance environmental performance, which impacts climate policy (Cecere et al. 2019).

Sustainable practices need to be increased for the execution of infrastructure projects. A study by Willar et al. (2020) in Indonesia indicated severe obstacles from the government and contractors to implementing sustainable procurement. Hoseini et al. (2021) found that the economic aspect has the highest weight than the construction industry's environmental and social aspects of supplier selection. The results also show that the criteria related to cost, quality, pollution control, and hazardous waste are of primary importance compared with other criteria in this study. Furthermore, Albuquerque et al. (2020) found low adherence to lean product development and agile project management in the construction industry.

The supply and movement of materials impact the construction industry. According to a study by O'Sullivan and Adan (2021), to improve logistical performance, small vehicle deliveries would help improve logistics movement at the site, leading to the decongestion of the city's traffic and improving the construction industry's image. Reverse logistics needs to be brought up in practice to reduce the environmental impact. Construction waste management

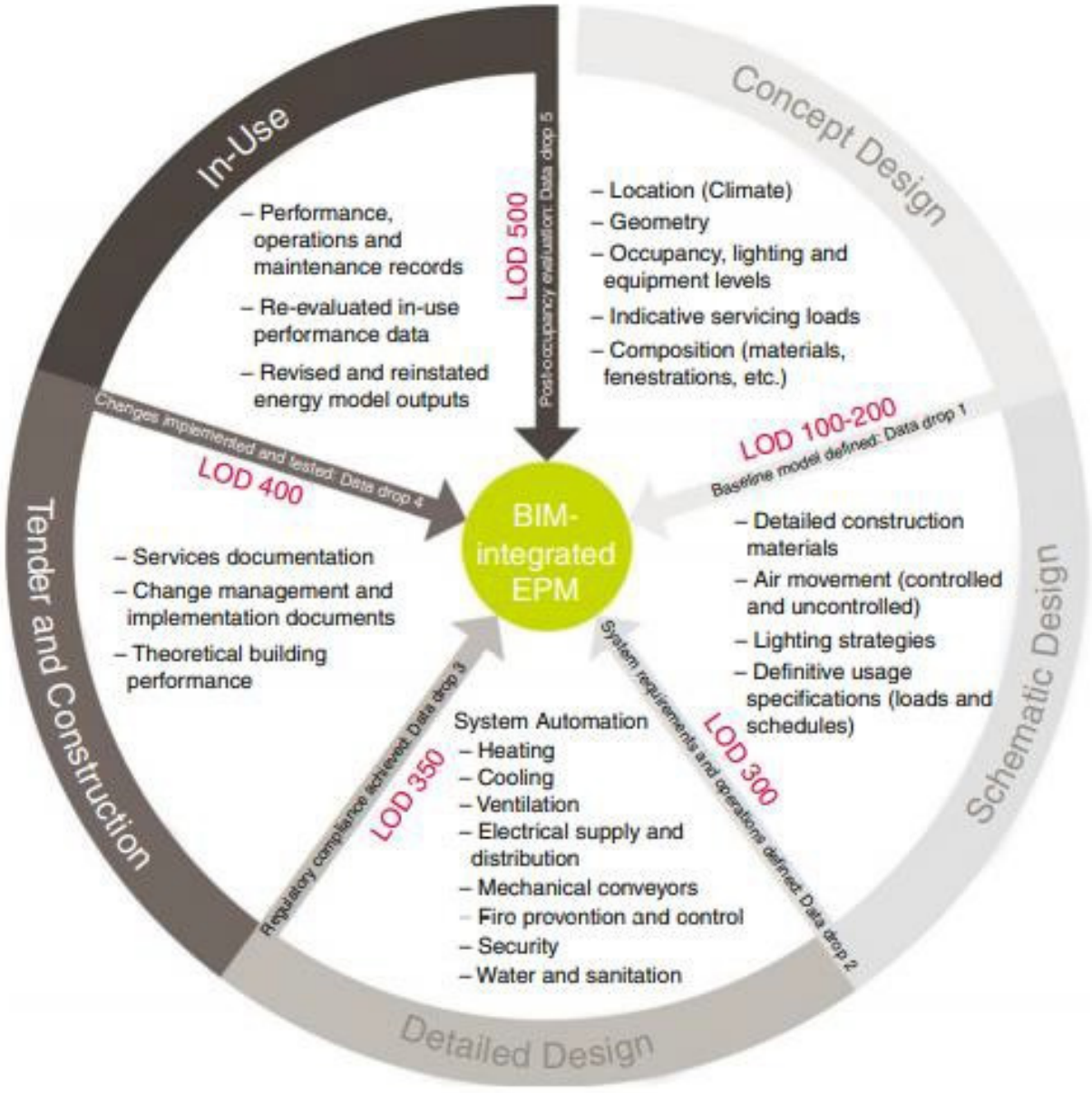

Fig. 3: Framework for BEM based on BIM capabilities for designing real estate projects. *Source:* Using BIM capabilities to improve existing building energy modelling practices (Gerrish et al. 2017). BEM, building energy modelling; BIM, building information modelling.

is a critical element of demolition and repair projects. It requires the implementation of the reverse supply chain with selective waste collection. The recovery of construction waste requires higher quality control and advanced processing methods (Vargas et al. 2021). Green recycling substantially benefits firms (Ali et al. 2019).

Green warehousing has a low cost of implementation, and there is a substantial environmental benefit in implementing green transportation. The most crucial benefit of implementing green transportation is its benefit to society. Logistics performance has a direct relationship with carbon emissions. A study by Karaduman et al. (2020) in Balkan countries about carbon dioxide emissions and the role of logistics found a direct relationship between logistics performance and carbon dioxide emissions. Further, there is a need to incorporate green culture in the construction industry. Green culture encompasses green values, beliefs, and behaviours.

Based on the literature review, the green supply drivers in real estate are tabulated in Table 1.

Green construction is related to energy conservation and reduces the impact on the environment by using hollow fly ash bricks, double glazing systems, energy-efficient systems, and water conservation by using

Tab. 1: Green supply chain drivers.

S. no.	Clubbed driver	Principal drivers	Reference
1	D1 top management	Top management commitment Green human resource Green culture Green values	Al-Ma'aitah (2018) and Karaduman et al. (2020)
2	D2 developer	Role of contractor Role of architect Role of subcontractor	Balasubramanian and Shukla (2017)
3	D3 government regulations	Green financing Additional floor area ratio	Qian et al. (2016)
		Green bonds	Maltais and Nykvist (2021)
4	D4 green professionals	Managing environment Managing sustainable use of resources	Karaduman et al. (2020), Ahmad (2015) and Shafaei et al. (2020)
5	D5 BIM	Integration of building services	Mohammed (2021), Edirisinghe (2018) and Alhamami et al. (2020).
6	D6 BEM	Cost reduction Energy modelling	Gerrish et al. (2017)
7	D7 PPMOF	Prefabrication Preassembly Modularisation Offsite fabrication	Lavikka et al. (2021)
8	D8 architect	Green design	Lee and Kim (2008), Mohammed (2021) and Ghaffarianhoseini et al. (2016)
9	D9 orientation	Building plan Orientation of windows	Hammad et al. (2018)
10	D10 building design	HVAC Lighting Air quality	Cecere et al. (2019) and Ghaffarianhoseini et al. (2016)
		Green ICT	
11	D11 material procurement	Green supplier Green warehousing Green logistics	Willar et al. (2020), Ali et al. (2019) and Karaduman et al. (2020)
12	D12 reverse logistics	Recovery of construction waste	Vargas et al. (2021)
13	D13 transportation	Fuel efficient vehicles Truck full loads Green transportation	Ying et al. (2021)

BEM, building energy modelling; BIM, building information modelling; ICT, Information and communications technology; HVAC, Heating, ventilation and Airconditioning; PPMOF, prefabrication, preassembly, modularisation and offsite fabrication.

wastewater treatment techniques (Ahuja 2021). In total, 70% of buildings will be constructed in India by 2030. There is a push by the government of India for "Housing for All" by 2022. Buildings contribute 40% of energy consumption. Similarly, 22% of greenhouse gas is from buildings, and 300 million people will move towards cities by 2035 in India (International Finance Corporation 2017). Therefore, we hypothesise the following:

> H1: The perception of companies doing risk management, and those not doing risk management, perceive green drivers differently.

The barriers to green construction include external barriers like a lack of green professionals and green vendors, internal barriers like the high initial cost of implementation, and a lack of understanding (Balasubramanian and Shukla 2017). Green HRM practices help improve an organisation's environmental performance (Shafaei et al. 2020). There is a need for green human resource management, which plays an essential role in going green at the office. Green HRM uses HRM policies to promote the sustainable use of resources. Human resources are essential in recruiting new employees more responsible for green business practices (Ahmad 2015).

Therefore, we present the following hypothesis:

H2: The perception of companies whose people are involved in decision-making and whose people are not involved in decision-making perceive green drivers differently.

The performance of construction leads to poor project planning and control. The designers need to identify the sustainable design strategy parameters. There should be a clear vision of designers directed towards employing green design concepts and thoughts (Mohammed 2021). The design and planning of projects are crucial. Construction is ranked second, followed by procurement with the third rank. High-rise building projects are impacted by the quality of construction materials and detailed design (Kabirifar and Mojtahedi 2019). The orientation and elevation of windows on building facades increase the environmental carbon. The approach used in this study can enable architects to realise the location of windows, which ultimately results in increasing carbon in the environment (Hammad et al. 2018). The completion of the project in the stipulated time, within budget, and of optimum quality is essential for every real estate project. Therefore, we present the following hypotheses H3, H4, and H5:

H3: In real estate construction projects, project completion times are positively related to the green supply chain drivers.

H4: In real estate construction projects, project completion cost is positively related to green supply chain drivers.

H5: In real estate construction projects, project quality is positively related to green supply chain drivers.

3 Research methodology

The research has been conducted in two phases. The initial phase employed an exploratory research design that incorporated quantitative research methodology, wherein a questionnaire was administered to the respondents. The subsequent phase of the study employed a qualitative research design, specifically a functional case study approach. In the first phase, the present study administered the questionnaire to a sample of stakeholders involved in the development and management of real estate projects in India. A total of 280 questionnaires were initially distributed to potential participants via email. The survey was specifically targeted towards individuals with relevant experience and expertise in green supply chain management practices in the real estate industry. The sample was selected using purposive sampling techniques to ensure that the respondents possessed the requisite knowledge and expertise to provide valuable insights into the research topic. Ultimately, 150 completed questionnaires were returned, yielding a response rate of 53.5%. The survey instrument utilised in the present study was designed to assess the utilisation and effectiveness of key drivers that facilitate the implementation of green supply chain management practices in real estate projects in India. The instrument was developed based on a thorough review of the literature and consultation with experts in the field. The questionnaire consisted of two main sections: a core section and a demographic section. The core section comprised a series of questions designed to assess the utilisation and impact of various drivers, such as environmental regulations, stakeholder pressure, and organisational culture. These questions were designed to capture both quantitative and qualitative data, allowing for a more nuanced and comprehensive understanding of the drivers of green supply chain management practices in the real estate industry. The demographic section of the survey collected information on the respondents' background and experience in the industry, the turnover of companies, the use of green supply chain drivers, participation, and techniques used in green building practices in their organisation. The survey also queried whether the respondents believed that the adoption of green supply chain practices could contribute towards the realisation of carbon-neutral buildings. The survey instrument was pretested and refined to ensure that it was valid, reliable, and relevant to the research objectives. The demographic characteristics of the respondents are presented in Table 2. The utilisation and comprehension of drivers by the respondents are displayed in Table 3.

Tab. 2: Demographic profile of respondents.

Profession (%)		Position in project (%)		Educational background (%)		Association with real estate industry (%)	
Electrical engineer	21	Director	19	Higher than a master's degree	8	0–5 years	0.4
Mechanical engineer	36	Project manager	73	Master's degree	16	5–10 years	0.6
Civil engineer	19	Manager	4	Bachelor's degree	72	10–15 years	8
Architect	19	Engineer	4	HSC	2	15–20 years	3
Quantity surveyor	5			SSC	2	>20 years	88

Tab. 3: Drivers and their use and impact using the Likert scale.

Drivers	Use of drivers	Impact of drivers
Top management developer Government regulations green professionals BIM BEM PPMOF Architect orientation building design Material procurement Reverse logistics transportation	1 – not considering, 2 – planning to consider, 3 – consider it currently, 4 – initiating implementation and 5 – implemented successfully	1 – not at all, 2 – insignificant, 3 – slightly significant, 4 – significant and 5 – highly significant

BEM, building energy modelling; BIM, building information modelling; PPMOF, prefabrication, preassembly, modularisation and offsite fabrication.

The relative importance index method was used to find the drivers that are used more in the real estate industry in India and the drivers that impact the implementation of the green supply chain in the real estate industry. The impact of the green supply chain drivers was also found on overall project completion, quality, and cost with the help of multiple regression analyses. The *T*-test was used to determine if there was a significant difference between the means of the two groups. The drivers were also tested with the help of a case study for a LEED-certified mall project in India.

3.1 Data analysis

3.1.1 Reliability analysis

The reliability test on identified decision variables revealed that the estimated 'α' for all 13 elements falls within the range of 0.887–0.891. The impact of green supply drivers indicated values from 0.951. The researchers have recommended that the values of α between $0.8 > \alpha \geq 0.7$ are acceptable, and the values of α between $0.9 > \alpha \geq 0.8$ are good (Kothari 2007).

Reliability statistics for the use of green supply chain drivers.

Cronbach's alpha	Cronbach's alpha based on standardised items	No. of items
0.887	0.891	13

Reliability statistics for the impact of green supply chain drivers.

Cronbach's alpha	Cronbach's alpha based on standardised items	No. of items
0.951	0.951	13

3.1.2 Ranking of green supply chain drivers using the relative importance index method

The relative importance index can be calculated by using the following formula:

$$\text{RII} = \sum \frac{\text{Attribute weight}}{\text{Highest weight} \times \text{Sample size}}$$

Table 4 shows the top five factors for green supply chain drivers by respondents for GSCM in the real estate sector in India. According to the respondents, the most important driver is management support in implementing the green supply chain in construction.

Table 5 shows that the top five factors significantly impact the implementation of GSCM in India. According to the respondents, the most important driver that

Tab. 4: RII of use of green supply drivers in construction.

Use of green drivers	RII	Mean
Support top management	0.795	3.952
Support of developer	0.749	3.725
Support of government	0.74	3.678
Use of green design	0.737	3.665
Use of green procurement	0.696	3.458

Tab. 5: RII of the impact of green supply drivers on construction.

Impact of green drivers	RII	Mean
Impact of top management	0.787	3.912
Impact of sourcing	0.780	3.879
Impact of recycling material	0.772	3.838
Impact of developer	0.769	3.825
Impact of fuel-efficient trucks	0.767	3.824

impacts the implementation of GSCM is the impact of top management in India.

3.1.3 Hypothesis testing

A *T*-test was applied using (IBM manufacturer, SPSS 23) to compare the perception of companies using GSCM practices and those not using GSCM regarding green supply chain practices, as well as the perception of companies whose people are involved in decision-making and non-decision-makers regarding green supply chain practices. Table 1 shows 13 dependent variables. The groups of four independent variables (called group), e.g., companies using green building practices and not using green building practices, as well as participation and non-participation of the respondent in green building, practices have been taken from the questionnaire.

3.1.3.1 Hypothesis 1

The perception of companies that use green supply chain practices and those that do not use green supply chain practices perceive green supply chain practices differently. The *T*-test was conducted with the impact of all 13 risks as test variables. Do companies that use GSCM and those not using GSCM perceive GSCM practices differently? It was found from the data analysis, as shown in Table 6, that the following variables are not significant, the impact of green supplier $t = 0.148$ and the rest of the other variables are significant. We failed to reject the null hypothesis. Thus, we can conclude that there is not enough evidence to say that companies that use green supply chain practices and do not use green supply practices perceive green practices differently; hence, the null hypothesis is accepted.

3.1.3.2 Hypothesis 2

> H2: The perception of companies whose people are involved in decision-making regarding green supply chain practices and non-decision-makers perceive green supply chain practices differently.

The *T*-test was carried out to test the hypothesis. It was found from the data analysis in Table 6 that the impact of top management, developer, government regulations, green professionals, architects, green design, and recycling of material is significant. We failed to reject null hypotheses. Thus, we can conclude that there is not enough evidence to say that people whose people are involved in decision-making regarding the use of GSCM and non-decision-makers perceive GSCM differently.

3.2 Regression analysis

Multiple regression analysis was used to check the hypothesis that there is a statistically significant

Tab. 6: *T*-test results.

S. no.	Driver	Companies using green supply chain practices and companies not using green supply chain practices		Perception of companies whose people are involved in decision- making regarding the use of green supply chain practices and whose people are not involved in decision-making	
		T	Sig (2 Tailed)	*T*	Sig (2 Tailed)
1	Impact of Top Management	3.62	0	2.332	0.021
2	Impact of Developer	5.88	0	3.161	0.002
3	Impact of Government Regulations	5.63	0	2.961	0.004
4	Impact of Green Professionals	5.37	0	2.293	0.023
5	Impact of BIM	4.16	0	1.547	0.124
6	Impact of BEM	4.16	0	1.547	0.124
7	Impact of PPMOF	4.02	0	1.72	0.088
8	Impact of Architect	4.05	0	2.141	0.034
9	Impact of Orientation	2.51	0	1.784	0.076
10	Impact of Green Design	5.87	0	2.901	0.004
11	Impact of Green Supplier	0.15	0.88	0.922	0.358
12	Impact of Recycling of material	3.28	0	1.894	0.06
13	Impact of Green Transportation	2.78	0.01	2.117	0.036

BEM, building energy modelling; BIM, building information modelling; PPMOF, prefabrication, preassembly, modularisation and offsite fabrication.

relationship among the driving factors. Three hypotheses were drawn to check the relationship among the driver variables. The first hypothesis, H3, was used to check the relationship between green supply chain drivers and project completion time. Similarly, H4 was used to check the relationship between green supply chain drivers and the project cost. H5 was used to check the relationship between green supply chain drivers and the project quality. Table 7 shows a significant linear relationship between the independent and dependent variables ($p < 0.05$).

4 Case study

A case study on the execution of the LEED-certified mall project in India was studied. The mall is located in Delhi (the national capital region) with a length of 295 m and a width of 192 m and five shopping levels, a food court at one level and entertainment at two levels. The mall developer, one of India's most prominent developers, has a track record of 75 years of satisfied customers, sustained growth, and innovation. It is the preferred choice of fortune 500 companies with 40.4 million square feet of LEED platinum-certified portfolio in office spaces, 3.45 million square feet of LEED-certified retail space, and 2.3 million square feet of upcoming projects. The thirteen green supply chain drivers found through the literature review were checked concerning similarity with the variables required for LEED certification and mainly were similar as described in Table 8.

As a part of this study, we estimated the cost of implementation for getting 42 points for LEED certification for India's first LEED-certified mall project in the Delhi/NCR region. Table 9 shows the credits taken by the developer, which were incorporated in the execution of the project, and the cost incurred was 13.6 million US dollars.

Although this is an initial expenditure, this cost was recovered 5 years after the mall became operational and had a positive impact on the environment and reduced the carbon impact, which is now essential to reduce global warming and other issues impacting humanity in the long run.

Tab. 7: Multiple regression analysis.

Hypothesis	Response variable	Predictor variable	*R*-square	Coefficient of regression	*F* value	*P* value	Decision
H3	Overall impact on project completion	13 variables	0.836	0.914	58.14	0.00	Supported
H4	Overall impact on project cost overrun	13 variables	0.849	0.922	64.2	0.01	Supported
H5	Overall impact on the project quality	13 variables	0.87	0.933	76.52	0.00	Supported

Tab. 8: Green drivers as per literature review concerning LEED credit points.

S. no.	Drivers	LEED credit points
1	Top management	Site selection, community development
2	Developer	Site selection, community development
3	Government regulations	Site selection, community
4	Green professionals	Green professionals
5	BIM	Green building design
6	BEM	Green building design
7	PPMOF	Green building design
8	Architect	Green building design
9	Orientation	Site selection
10	Building design	Green building design
11	Material procurement	Proper use of materials and resources
12	Reverse logistics	Improving energy efficiency and atmosphere
13	Transportation	Improving energy efficiency and atmosphere

BEM, building energy modelling; BIM, building information modelling; PPMOF, prefabrication, preassembly, modularisation and offsite fabrication.

Tab. 9: Credits availed by the developer for the green building mall project.

Credit no	Credit name	Points available	Budget cost (in lakhs INR)	Comments
Orientation of building				
1.0	Site selection and development density and community connectivity	2	0	An inherent feature of project
Green transportation				
2.0	Green transportation, refuelling and alternative transportation	3	3	Cost of additional 15 amp plug points for an electric charging station in the parking
Building design				
3.0	Management of stormwater, heat effect and roof effect	5	60	The additional cost of the sand pit to be incorporated in the building design, reflective paint and China mosaic tiles add to the roof effect
A. Water efficiency				
3.1	Landscaping and irrigation, Air conditioning system, wastewater management	6	0	STP water is used for irrigation as per design guidelines
B. Energy and atmosphere				
3.2	Commissioning and energy performance optimisation	12	797	Commission agent fees and using energy performance techniques
Waste management and recycling				
3.3	Waste management and recycling	6	0	PMC will sell the waste generated on the project site
Indoor environmental quality				
3.4	Indoor and outdoor air quality and increased ventilation as well as smoke control	3	100	Incorporation of CO_2 sensors in building design. Increasing ventilation by 30% above ASHRAE standards
Green sourcing				
4.1	Low-emission materials, paints, carpet and Agri fibre	3	5	Architect and PMC to assure compliance for this credit and the associated additional cost
Green professionals				
4.2	LEED accredited professionals	2	10	Additional cost for demonstration of green features
Additional cost		42	955	
Consultancy fees for LEED certification			45	
Total cost including consultancy fees (in INR lakh)			1,000	

Source: Internal Company Document.
ASHRAE, Amercian society of Heating Refrigerating and Air-conditioning Engineers; LEED, Leadership in Energy and environmental Design; PMC, Project management consultancy; STP, Sewage treatment plant.

5 Discussion

LEED has made the most significant contribution to sustainable buildings. The US Green building council developed leadership in energy and environmental design. LEED's five key areas include the right selection of materials, saving energy and water, sustainable development of sites and improving the quality of the environment (Lee and Kim 2008). Green buildings are globally recommended to improve natural resource efficiency, decrease operational costs and improve the built environment. LEED is a well-known rating system globally. Going through the study, we found the ranking of various drivers using the relative importance method required for this implementation of green supply chain management in the real estate sector in India. The results showed that drivers that support implementation are top management support, which is the most critical factor for driving green supply chain management in the real estate sector in India, followed by the developer's support. The developer is the owner of the project, and it always depends on the owner of the project to install green building practices in their projects. Using the government's support is also crucial in giving benefits to the developers showing interest in using green building practices in their projects. The government is also supporting the green initiatives with an increase in the floor area ratio for development. Top management, sourcing of materials from green suppliers and recycling materials are the top three drivers that significantly impact implementing green supply chain drivers in India. The study also found that the use of green building practices like green procurement, green transportation, BIM, BEM and prefabrication techniques is lacking in the real estate sector in India. There is also a lack of green building professionals in the country. From the responses, we found that only 44% of the respondents participated in green building practices. As we are aware that 70% of the buildings required by 2030 are still to be constructed, developing a culture of green buildings can help reduce the energy requirement and achieve the goal of a carbon-neutral economy by 2050.

6 Conclusion

The study's findings suggest that implementing GSCM in real estate projects in India is scarce. The results suggest that there is a lack of information on the construction companies as they are not using BIM, BEM, prefabrication or preassembly for fabrication, which, in the long run, can reduce the project costs. Fewer green-certified professionals in the industry can guide real estate companies. There is also a lack of awareness of using recycled material and recycling the waste of construction, increasing the carbon footprint and impacting the environment. We all know that construction is also one of the sources of the increase in carbon content. There is a need to reduce the impact on the environment with the help of implementing these green supply chain practices in the real estate industry. Additionally, the prefabrication and preassembly can lead to a reduction in rework and speed up the project. Going through the case study, we can find that although the cost of 13.6 million US$ was an additional cost spent for developing a green-certified building, and this cost recovered in 5 years of operation and further led to saving on electricity and water bills. It also helped in the reduction of carbon emissions and had a positive impact on the environment. So, it can be concluded that the implementation of green supply drivers is essential to be incorporated in all upcoming buildings by construction companies and developers to reduce the energy consumption of buildings and the impact on the environment. The study findings would help managers understand the positive impact of implementing green building drivers.

7 Limitations

The study was limited to the real estate professionals working in Delhi (the national capital region) who primarily work in the private sector. The study can be done with respondents from government organisations, public limited companies and other regions of the country.

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