GREEN TRANSFORMATION OF SUPPLY CHAIN OF INDIAN CONSTRUCTION SECTOR VIA POLICY LEVEL INTERVENTIONS

By

S J VIJAYADAS

DISSERTATION

Presented to the Swiss School of Business and Management Geneva

In Partial Fulfilment
Of The Requirements
For The Degree

DOCTOR OF BUSINESS ADMINISTRATION

SWISS SCHOOL OF BUSINESS AND MANAGEMENT GENEVA
JUNE 2024

GREEN TRANSFORMATION OF SUPPLY CHAINS OF INDIAN CONSTRUCTION SECTOR VIA POLICY LEVEL INTERVENTIONS

by

S J VIJAYADAS

Supervised by

Dr. MINJA BOLESNIKOV,

Approved by:
dr. Jaka Vadnjal

Dissertation Chair

RECEIVED/APPROVED BY:

Admissions Director

DEDICATION

This thesis is dedicated to those who have supported and encouraged me throughout this journey.

First and foremost, to God, for providing me with the strength, wisdom, and perseverance to complete this work.

To my wife, Reena, for her patience and understanding, especially during times when my focus was unwavering.

To my parents, for their unwavering support, faith in my potential, and boundless love and dedication.

To my children, for their continued academic pursuits in their respective fields and for following my example.

To all my colleagues who generously contributed their time to complete the survey; without your participation, this study would not have been possible.

And finally, to my mentor and advisor, Prof. Dr. Minja Bolesnikov, for his invaluable guidance and support throughout this project.

This work stands as a testament to your inspiration and influence.

ABSTRACT

GREEN TRANSFORMATION OF SUPPLY CHAIN OF INDIAN CONSTRUCTION SECTOR VIA POLICY LEVEL INTERVENTIONS

S J Vijayadas
2024

Dissertation Chair: <Chair's Name>
Co-Chair: <If applicable. Co-Chair's Name>

This research study explores the green transformation of the Indian construction sector's supply chain through policy-level interventions. The objectives include assessing key processes that can encompass green supply chain principles, identifying challenges in the Indian context (supply chain management), scrutinizing policy elements influencing green construction via circular or sustainable supply chains, and proposing a conceptual framework to guide policymakers towards achieving carbon-neutrality in the construction industry.

The study addresses critical aspects of sustainability (theoretical framework), green supply chain mechanisms (GSCM), barriers to circular economy adoption, experts-driven consensus building (Delphi Analysis), integration of theoretical concepts, enforcement of sustainability criteria by authorities, and the alignment of local-level authorities with sustainability policies. It aims to provide insights into developing comprehensive strategies for greening the Indian construction sector, emphasizing stakeholder collaboration and policy framework development to overcome existing barriers and achieve sustainable development goals. The regulatory tactics employed and their successful strategic implementation mechanisms were thoroughly analyzed during the study of modern construction practices and exceptional scenarios, such as pandemic crises, in order to reach a conclusion for Construction Frameworks (CFW).

The construction industry is progressively embracing sustainable practices across all stages, emphasizing eco-friendly design, material procurement (low carbon emissions and minimal embodied energy), transportation (sustainable logistics), energy efficiency (strategic energy

management, SEM), waste management (circular economy), and post-construction O&M measures. However, the Indian construction sector faces numerous obstacles in implementing Green Supply Chain Management (GSCM) practices, due to regulatory, logistical, technical, economic, and social barriers. Policy-level interventions are observed to be essential to overcome these challenges and facilitating green transformation in the sector.

The study identifies 45 critical environmental sustainability criteria for the Indian construction sector's green transformation of supply chain elements, proposing a conceptual framework (CFW) for policy interventions. Stakeholder consultations and expert reviews validate the framework, underscoring its significance in guiding policymakers towards sustainable construction practices. Policy mapping reveals various regulations influencing sustainability in the construction sector, such as the National Building Code, Environmental Impact Assessment Notification, and Smart Cities Mission.

A comprehensive strategy for green supply chain management necessitates capacity building, collaboration, and regulatory strengthening. Educational programs and certification initiatives enhance stakeholder expertise, while collaborative partnerships promote knowledge exchange and resource sharing. Effective policy change models incorporate stakeholder engagement, strategic incentives, and monitoring mechanisms to drive sustainability.

The study concludes by emphasizing the need for a unified approach to sustainable construction, combining policy reformulation, stakeholder engagement, and strategic interventions to foster a culture of sustainability within the construction supply chain rather than policy development.

ACKNOWLEDGEMENT

I am immensely grateful to all those who have contributed to the completion of my thesis on the "Green Transformation of Supply Chain of Indian Construction Sector via Policy Level Interventions" at the University of SSBM Geneva, Switzerland.

First and foremost, I extend my deepest appreciation to Dr. Minja Bolesnikov, Head of Research (DBA) and Vice President of International Affairs at SSBM Geneva, for his invaluable guidance, support, and mentorship throughout this research journey. His expertise and encouragement have been pivotal in shaping the direction and quality of this study.

I would like to express my heartfelt thanks to the thirty Delphi experts and participants of interviews whose valuable insights and expertise have enriched the depth and breadth of the research findings. Their willingness to share their knowledge and experiences has been instrumental in advancing the understanding of sustainable practices in the construction sector.

I am deeply grateful to Dr. KM Abraham, CEO of KIIFB, for his unwavering support and encouragement. Additionally, I extend my sincere appreciation to the senior officials at KIIFB for their steadfast support and encouragement.

I am grateful to my friends and colleagues from TERI (The Energy and Resources Institute), NIUA (National Institute of Urban Affairs), and KIIFB for their encouragement, feedback, and assistance at various stages of the research. I am indebted to the Kerala Building Contractors Association located in Kerala (an Indian State) for their cooperation, support, and valuable contributions to this research endeavor.

Lastly, I would like to acknowledge the unwavering support of my family, friends, and colleagues, whose encouragement and understanding have been my pillar of strength throughout this journey. Their support has been invaluable and deeply cherished.

I offer my heartfelt gratitude to the Almighty for His blessings and guidance throughout this endeavor.

Thank you all for your invaluable contributions and support.

S.J. VIJAYADAS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

3D	Three Dimensional
3R's	Reduce, Reuse and Recycle
A4	Alternative 4
AAC	Autoclaved Aerated Concrete
AB	Administrative Barriers
AE	Association of Engineers
AEC	Architecture, Engineering and Construction
AECOM	AECOM Asia Company Limited
AI	Artificial Intelligence
AMA	Amsterdam Metropolitan Area
ANOVA	Analysis of Variance
BGRE	Belhar Gardens Rental Estate
BIM	Building information modeling
BPE	Building Performance Evaluation
BREEAM	Building Research Establishment Environmental Assessment Method
BSAM	Building Sustainability Assessment Method
C&D WM	construction and demolition waste management
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CB	Corporate Barriers
CCI	Chinese construction industry
CD	Customer demand
CDKN	Climate and Development Knowledge Network
CDW	Construction Demolition Waste
CEf	Carbon Efficiency
CE	Circular Economy
CEBs	Compressed earth blocks
CEECI	Carbon Emission Efficiency of Chinese Construction Industry
CEM	construction engineering and management
CEMM	carbon emission measurement model
CER	Certified Emission Reduction
CER	corporate environment responsibility
CFW	Conceptual framework
CI	Construction Industrialization
CM	Corporate Matters
CNA	Citation Network Analysis
CO2	Carbon dioxide
COP	Conference on Climate Change
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPM	Critical Path Method
CRZ	Coastal Regulation Zone
CS	Customer satisfaction
CSE	Centre for Science and Environment
CSF	Critical success factors

CSR	Corporate Social Responsibility
CuS	Customer Satisfaction
DDPA	Driver and Dependence Power Analysis
DEA	Data Envelopment Analysis
DGNB	German Sustainable Building Council method
DPP	Defense Procurement Procedure
DPR	Detailed project report
e.g.,	For example
EB	Economic barriers
ECBC	Energy Conservation Building Code
EGS	Environmental Goods and Services
EIA	Environmental Impact Assessment
EMS	Environmental management systems
EoL	End-of-Life
EoT	Extension of Time
EPA	Environmental Protection Act
EPI	Environmental Performance Index
EPR	Extended Producer Responsibility
ERP	Enterprise resource planning
et al.	and others
EU	European Union
EUI	Energy Use Intensity
e-waste	Electronic waste
FB	Fiscal Barriers
FDI	Foreign Direct Investment
FF	Financial Factors
FS	Feasibility Study
GB	green building
GBTs	Green Building Technologies
GCA	Grand Challenges Approach
GCPs	Green Construction Practices
GDP	Gross domestic product
GE	Green Energy
GHG	Greenhouse gases
GM	Global Market
GPI	green performance index
GPS	Global positioning system
GRIHA	Green Rating for Integrated Habitat Assessment
GrSCC	green supply chain collaboration
GSCM	Global Supply Chain Management
GSI	Greenlandic Sustainable Index
GSR	Global Status Report
GST	Goods and Services Tax
GtCO2	Gigatonnes of Carbon Dioxide
GWP	Global Warming Potential

HK-BEAM	Hong Kong Building Environmental Assessment Method
HVAC	Heating, Ventilation, and Air Conditioning
I-BPE	Indian building performance evaluation
ICT	information and communications technology
IEA,	International Energy Agency
IGBC	Indian Green Building Council
ILO	International Labour Organization
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPD,	Integrated Project Delivery
IPDP	Integrated Product Development Process
IPP	integrated product policy
IPS	implementation strategy
IRB	industrialized residential building
IRB	Institutional Review Board
ISM	interpretative structural model
ISO	International Organization for Standardization
ISSB	International Sustainability Standards Board
IT	Information Technology
IT	information transparency
KM	knowledge management
KMO	Kaiser–Meyer–Olkin test
KPI	key performance indicators
LB	Logistic Barriers
LCA	life cycle assessment
LCCA	Life-cycle Cost Analysis
LEED	Leadership in Energy and Environmental Design
LP	Legislative pressure
LTIFR	Lost Time Injury Frequency Rate
M&E	monitoring and evaluation
MCDM	multiple criteria decision-making
MiC	modular integrated construction
MJ	Megajoule
MRV	Monitoring, Reporting, and Verification
MS	Member state
MSMEs	Micro, Small & Medium Enterprises
MSWM	municipal solid waste management
NBC	National Building Code
NDRF	National Disaster Response Fund
NGOs	Non-Governmental Organization
NPV	Net-Present-Value
NRC	National Register of Citizen
OB	Operational Barriers
OECD	Organization for Economic Co-operation and Development
OP	Operational Performance

OPEC	Organization of the Petroleum Exporting Countries
OSC	Off-site construction
PBA	Pressure Barrier Analysis
PCA	Principal component analysis
PCEE	pure carbon emission efficiency
PCR	potential carbon reductions
PDFs	policy driving forces
PFS	project feasibility studies
PLS-SEM	partial least squares-structural equation modeling
PMS	performance management system
POFA	palm oil fuel ash
PPPs	Public-Private-partnerships
PQR	Project Quarterback Rating
R&D	Research and Development
R.	Open-source programming language
RAND	Research and Development
RAP	Reclaimed Asphalt Pavement
RB	Regulatory Barriers
RCA	recycled Concrete Aggregate
RCPD	Resource-constrained product development
RE/CE	Resource Efficient Circular Economy
RE100	100% renewable electricity
RERA	Real Estate Regulatory Authorities
RESC	Renewable Energy Supply Chain
RFID	Radio Frequency Identification
RHA	rice husk ash
RIA	regulatory impact assessment
RL	Reverse Logistics
RoI	Return-on-Investment
RQ	Research Questions
SB	Social barriers
SBTs	smart building technologies
SC	Supply chain
SCM	Supply Chain Management
SCPs	sustainable construction practices
SDGs.	Sustainable Development Goals
SE	Scale Efficiency
SLR	Systematic Literature Review
SMEs	Small and Medium Enterprises
SPCB	State Pollution Control Board
SPSS	Statistical Package for the Social Sciences
ST	Sustainable technologies
SWM	solid waste management
SWOT	strengths, weaknesses, opportunities, and threats
TB	Technical Barriers

TCO	Total Cost of Ownership
TERI	The Energy and Resources Institute
TESM	Total Energy Security Mission
TRIR	Total Recordable Incident Rate
TSCM	Traditional supply Chain Management
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNSDG	United Nations Sustainable Development Goals
USA	United States of America
USD	United States Dollar
viz.,	namely
VM	value management
VOC	Volatile organic compounds
WBCSD	World Business Council For Sustainable Development
WFP	Workforce Plan
WMA	Warm Mix Asphalt
WRP	Workflow and Resource Planning
WtE	Waste to Energy
WTO	World Trade Organization
YL	Yard Logistics

CHAPTER 1

INTRODUCTION

1.1 Background

The close associative term found with the centurion-phrase "development" (advancement through progressive stages) is "construction." Even two centuries after the word was first used in the year 1756, it was found to be exceedingly virulent in the 1950s and 1960s (Rabie, 2016). Wherever fundamental infrastructure is required around the world, most notably in emerging nations like India, the construction sector—more accurately, an industry—has expanded quickly in recent decades (Doloi, *et al.*, 2012). The construction business is significant because it is one of the modern cannonading industries that resulting in substantial ramifications for the economy of any country (Meng and Fenn, 2019). When the construction industry fosters employment and skill, add on to health and safety sectors, fuels better transportation surroundings, and creates fiscal opportunities for MSMEs across various related industries, its significance becomes clearer (Sui Pheng *et al.*, 2019). It is a basic fact that the construction business is not just in charge of building things that increase productivity and quality of life (Agenda, 2016). One may argue that the building industry is essential to a country's socioeconomic success (Kniivila, 2007). The construction business generates employment for close to 7% of the world's total employed workforce, with a contribution to the global GDP that is typically around one-tenth of the overall amount (HHI, 2018). With almost 220 million jobs, the sector significantly contributes to the level of employment across all nations in the world (ILO, 2019). The building industry is crucial to any country's economy. Construction is second only to agriculture as the greatest economic industry in emerging countries. Currently, 21% of all non-agricultural jobs in India are employed within the realm of the building sector. It's significant to indicate that the construction industry employs the biggest percentage of temporary workers—roughly 84%. Therefore, putting social protection measures into place should be a top concern (Lewis, 2021).

Any construction project will inevitably have constraints that frequently include technical, political, legal, and economic restrictions. While preparation and working within constraints, rather than against them, is advantageous to the team and the construction

project, awareness does not imply that every demand or constraint can be avoided (Kashkol and Talib, 2019). It covers all primary constraints impacting construction project performance included inadequate project scheduling and coordination by stakeholders, as well as factors related to organizational and governmental policies the South African construction sector (Masoetsa et al., 2022). Economic limitations stem from budget allocation and financial restrictions. Legal impediments hinder construction progress, causing delays that disrupt schedules and undermine project and organizational dependability. Familiarity with legal restrictions empowers project managers to anticipate and mitigate obstacles, ensuring timely and budget-compliant project completion. During the planning and design phase, the project management team must engage with the Environmental Division to secure approval or validation for the project. If not obtained, the project could be delayed or cancelled altogether. Political Constrain is a broad concept that denotes the risks that political instability or change poses to investments and contracts from both governmental (project area security) and non-governmental (societal and environmental variables) vantage points (Fitzpatrick, 1983; Howell, 2014).

Performance management is the process of organizing, putting into action, evaluating, and enhancing an organization's, an agency's, internal unit's, and individual staff members' efficiency and effectiveness (Srinivasan, 2013). Setting expectations, developing targets, receiving feedback (including 360-degree input), establishing goals, and evaluating the progress made toward those goals are all parts of the performance management procedure within the construction sector (Kaviya and Hema, 2015). It gained popularity in recent years, even among small-scale industries, when clients demonstrated significant managerial interests; soon after, the much profit-oriented segment radically switched to a performance-oriented approach to bagged business. Construction management is well-known for its traditional approach to measuring the performance of the construction industry, which includes performance measures such as cost, quality, and delivery, financial measures (profits and net turnover), technical measures (insurance, skilled resources), technological measures (design and planning), and so on.

This industry utilizes over 50% of the Earth's natural resources, contributes to over 30% of worldwide final energy usage, and generates nearly 40% of the global greenhouse gas (GHG) emissions (WBCSD 2018). The materials utilized, as well as the heating, cooling, and lighting of buildings and infrastructure, are the primary sources of these emissions.

Unfortunately, one of the biggest sources of garbage today is the building industry (Hussain et al., 2022). The Global Warming Potential (GWP) of walls in modern constructions is five times greater than that of walls in older structures (Bhochhibhoya et al., 2017). As per the International Energy Agency (IEA, 2021), the construction industry worldwide accounts for approximately 15% of direct CO2 emissions and nearly one-third of global final energy consumption. By 2030, direct building CO2 emissions must be cut by 50% if net-zero building CO2 emissions are to be achieved. CS makes for 22% of India's GWP (CDKN, 2013). Buildings in India consume a lot of energy (280–400 kWhm–2), depending on the temperature and kind of construction (Kumar et al., 2012). According to Tirth et al. (2019), building material manufacturing is responsible for 74% of all emissions, with usage accounting for the majority of the remaining emissions. India had the lowest total score of any nation, coming in at 18.9 on the EPI-2022, and contributed Δ0.6%. Global warming is the most widely recognized consequence of climate change, and CS has represented 36% of worldwide energy consumption and 37% of carbon emissions. Recent global polling indicates that executives within the engineering and construction sectors have shown the most advancements in sustainability during the design phase. According to UNEP (2021), globally, the construction sector has contributed to 36% of energy consumption and 37% of carbon emissions, with 27% originating from building operations. Despite substantial investments and worldwide efforts to decrease the energy intensity of buildings, the industry's overall energy usage and CO2 emissions increased in 2021 compared to pre-pandemic levels, as reported in the 2022 Buildings-GSR. Building energy demand surged by nearly 4% from 2020 to reach 135 EJ, marking the highest increase in the past decade. CO2 emissions from building activities reached a new peak of over 10 GtCO2, representing a rise of approximately 5% from 2020 and 2% from the previous peak in 2019 (UNEP, 2022).

To manage effectively the anticipated business rivalry, each construction firm has created individual conceptual models to measure efficacy and efficiency, which aid in managing its organizational performance. Organizations are resorting to the adoption of new technologies and engaging in continuous innovation for a systematic approach to developing a performance management system (PMS) and formulating strategic performance objectives (Rai et al., 2013). Construction firms are currently being compelled by stakeholder competition to demonstrate improved supply chain management

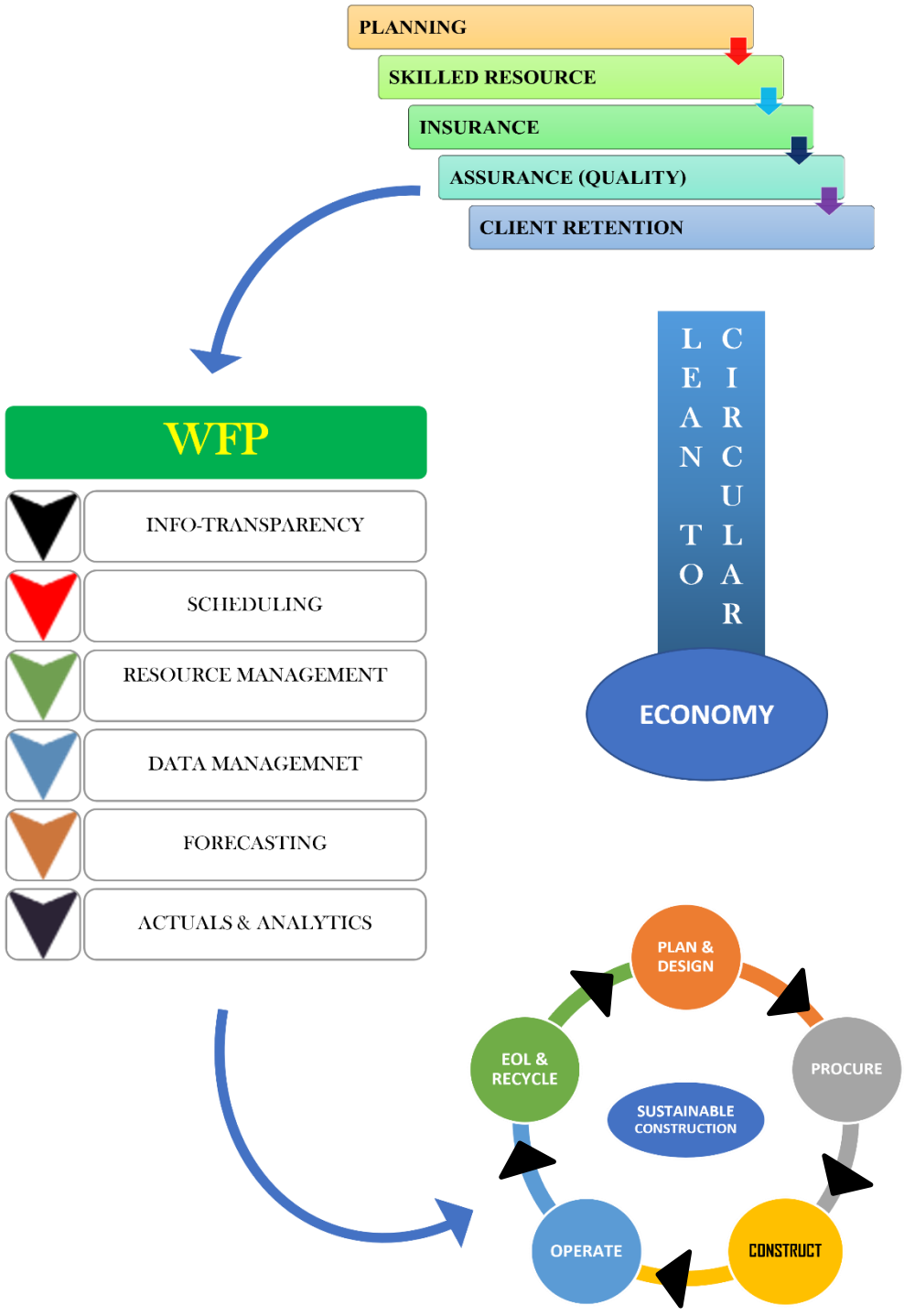


Figure 1.1: Performance management: Workforce plan (WFP) integration

(SCM) that visualises the overall performance of the company, encompassing both financial and non-financial aspects, and therefore they are forced to own and validate a cutting-edge PMS model.

1.1.1. Supply Chain Management (SCM)

Supply chain management (SCM) has become a popular concept in management since its introduction in the early 1980s. Harland (1996) asserts that it involves overseeing a network of interconnected enterprises engaged in delivering the necessary product and service packages to the end customer. The primary attention of supply chain management

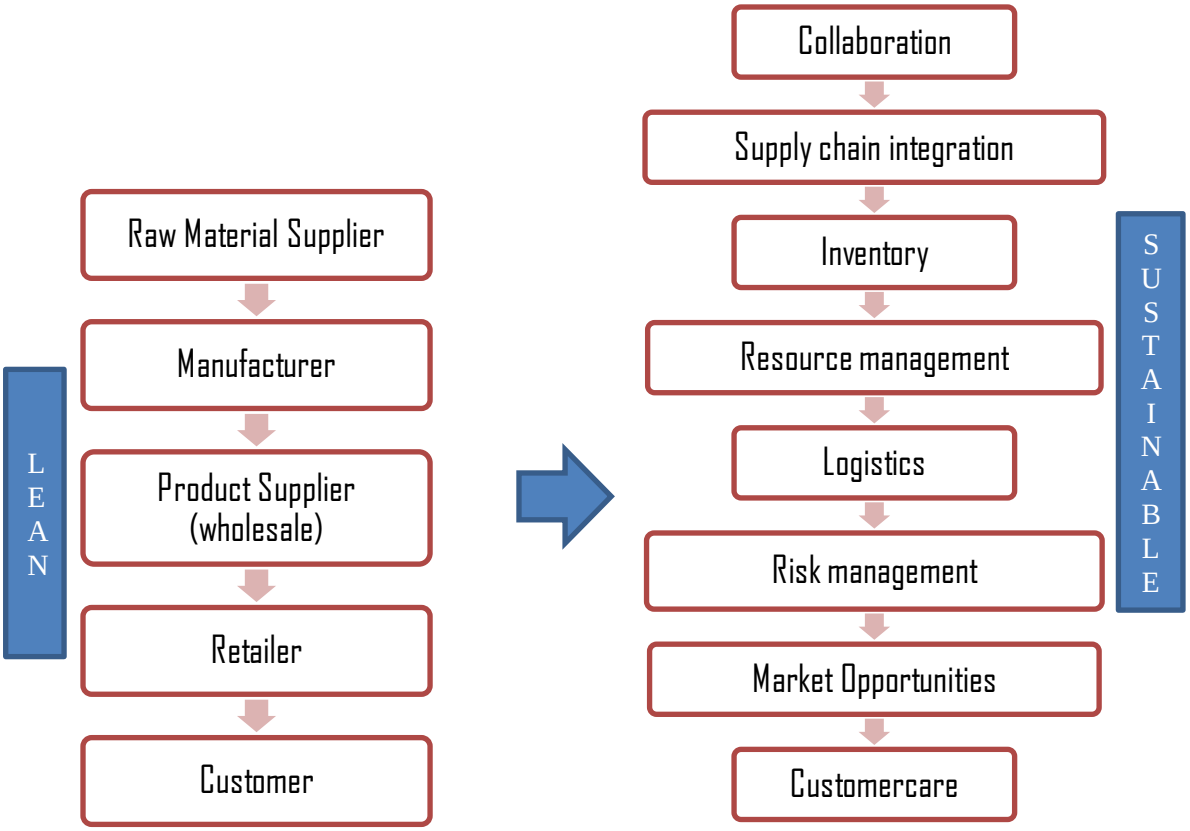


Figure 1. 2: Functional Diagram for SCM (Traditional and Sustainable)

has transitioned to guaranteeing customer contentment by ensuring the desired quality product with timely delivery at the most economical prices. This can be achieved through the selection of multiple partners, partner assessments grounded in purchase price, strict negotiations, and short-term contracts under centralised management of supply chains. Spekman et al. (1994) assert that success is no longer determined solely by individual transactions but by competitiveness, gauged through competitive pricing, punctual delivery, and innovative sourcing aimed at achieving end-customer satisfaction. This approach fosters intense competition among supply chain partners to fulfill desired requirements. Supply chain management is now viewed as a network of companies collaborating with others while simultaneously competing across the entire supply chain.

Quinn and Hilmer (1994) elaborates that top-tier companies are accelerating efforts to align processes and information flows throughout their value-added network to meet the escalating expectations of a dynamic marketplace. Sustainable competitive advantage is linked to an organization's endeavors in establishing and maintaining long-term advantages, influenced by three factors: the size and extent of the target market, expanded access to resources and customers, and constraints on competitors' capabilities.

Construction supply chain management (CSCM) is an initiative that effectively manages the new types of linkages among construction project participants. It represents a more recent advancement compared to partnering and is defined by O'Brien et al. (1995) as the framework involving vendors, suppliers, and contractors responsible for producing, delivering, and installing materials for construction projects. Construction Supply Chain Management (CSCM) encompasses the establishment, coordination, and upkeep of an improved supply chain that operates efficiently, meeting requirements and objectives optimally, and linking all stakeholders involved in construction projects. It entails a consortium of entities and individuals collaborating within a network of interconnected and organized construction processes to best fulfill the client's needs while ensuring satisfaction across all participants in the chain (Vrijhoef, 1998).

SCM is the backbone of the construction business and aims to meet a need while providing better underlying value to stakeholders. It integrates the entire process through digitization and digitalization rather than manual methods, offering outcomes such as improved harmonization, control, and monitoring of costs. SCM has been successful in the construction business due to its ability to customize and restructure itself to fulfill the requirements of the end user. It has the advantages of on-time project completion within the parameters of the contract, the degree to which the implementation complies with the standards and requirements outlined in the contract terms, and the fact that there must be enough money left aside for implementation costs and no budget overruns. The formulation of SCM strategy needs to be integrated into an organization's planning procedures to address objectives such as establishing and sustaining global information systems, addressing strategic aspects of make-or-buy decisions, and identifying and managing innovation to support and improve core technologies. The aim of SCM should not be only reducing costs but also highlighting the skills, knowledge, and competencies of organizations.

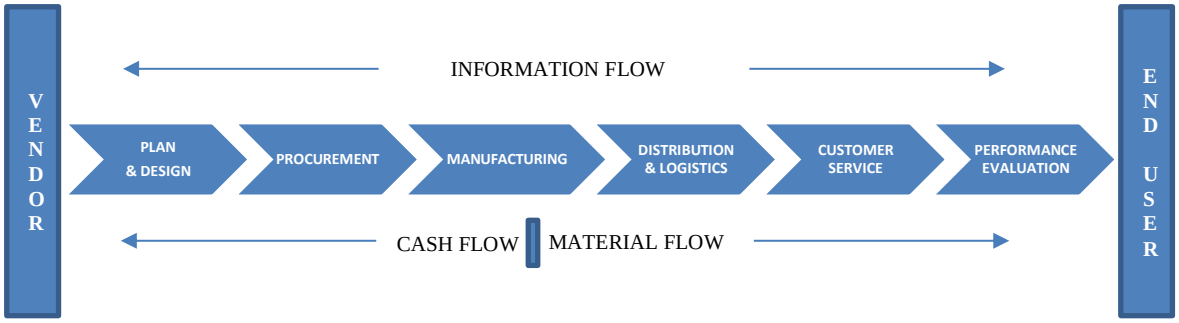


Figure 1. 3: An illustration of Supply Chain (Adopted from Robert et al., 1998)

1.1.2. Problems in the Construction Supply Chain

As it is developed to meet user demand, it is modified every day by the developer side to meet the competition mentioned earlier. Even though it has detected several issues and has rectified them over time with much experience and professional tactics, some issues still pertain to this sector.

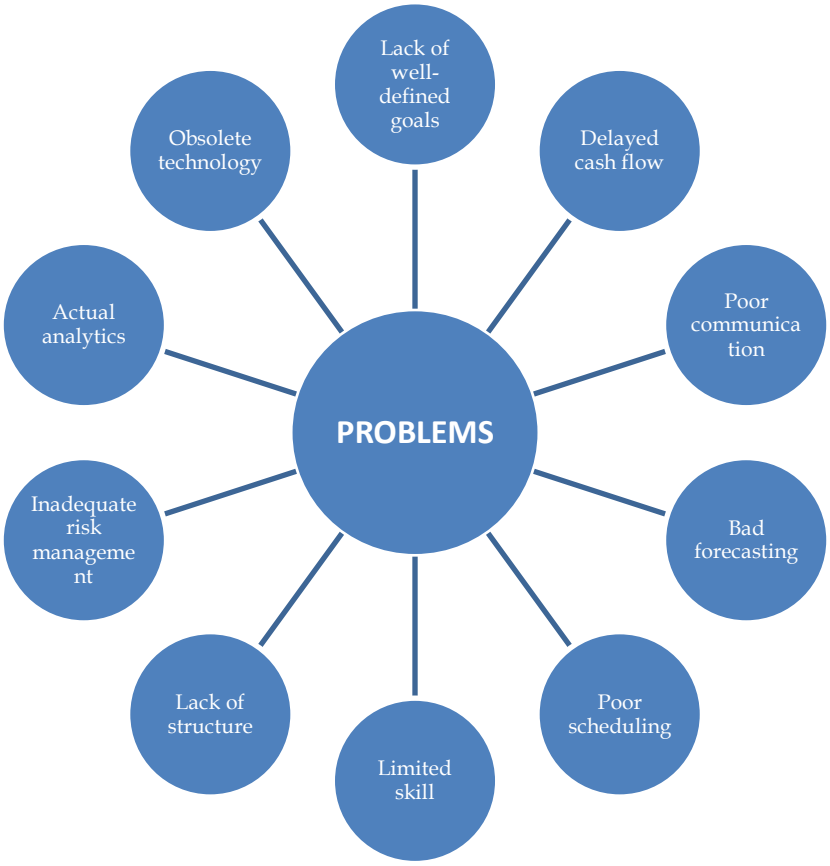


Figure 1.4: Issues pertain to construction industry supply chain management

1. At times, stakeholders are unable to accomplish their objectives because they lack clarity

or because of disagreements. Goals that are unclear will waste time and resources and cause timetable delays (**Lack of Well-Defined Goals**).

2. Identifying project deliverables should come first. The expectations of stakeholders and the project's requirements are the primary factors used to set the budget. The project could fail due to an error in judgement, inadequate supervision, or a poor decision. It is the responsibility of construction project managers to make reconciliations to ease and control cost overruns and to set appropriate expectations for them (**Actual analytics**).

3. The team misses out on the crucial task because of inadequate communication (visibility), and they remain ignorant of the problem until it is too late to fix it. Less transparency also has some or much worser impacts as it holds a bigger horizon (**Poor Communication**).

4. Some clients and stakeholders may make unrealistic demands, such as for projects to be finished quickly or with a less budget. The biggest detriments to morale and productivity are these irrational expectations and unreasonable requests (**Bad forecasting**).

5. Time restrictions, according to many stakeholders, are the largest problem, leading to subpar designs, high accident rates, and a decline in revenue. To make up for missed deadlines and prevent more delays and increased expenses, contractors may take short cuts (**poor scheduling**).

6. The skill difference in those teams will undoubtedly result in some delays. Project managers must address many factors that contribute to delays and create workflows that satisfy the criteria (**Limited Skills**).

7. Absence of clear objectives may lead to cost overruns or delays in construction projects (lack of organization). Performing tasks efficiently becomes difficult in the absence of well-defined objectives or job roles. (**Lack of Structure**).

8. Managing risk is a typical difficulty in project management, which necessitates the use of suitable skills. The project will overspend its budget or be delayed if there is no previous risk management and project analysis. Project managers need to be able to spot possible issues and figure out how to fix them (**Inadequate Risk Management**).

9. The invoicing mechanism used by the construction industry causes payment delays.

Additionally, late payments have a detrimental effect on a company's financial flow. Construction organisations may make sure that cash flow does not adversely affect other projects by using hybrid software technology and auto follow-through. Budget factors that a project manager cannot control include environmental considerations, resource and labour constraints, currency exchange, and numerous other factors (**Abrupted Cash Flow**).

10. A significant problem within the construction industry is worker safety. The protection of employees and their safeguards from accidents and injuries must be a business owner's first priority (**Obsolete technology**).

1.1.3. Green supply chain management

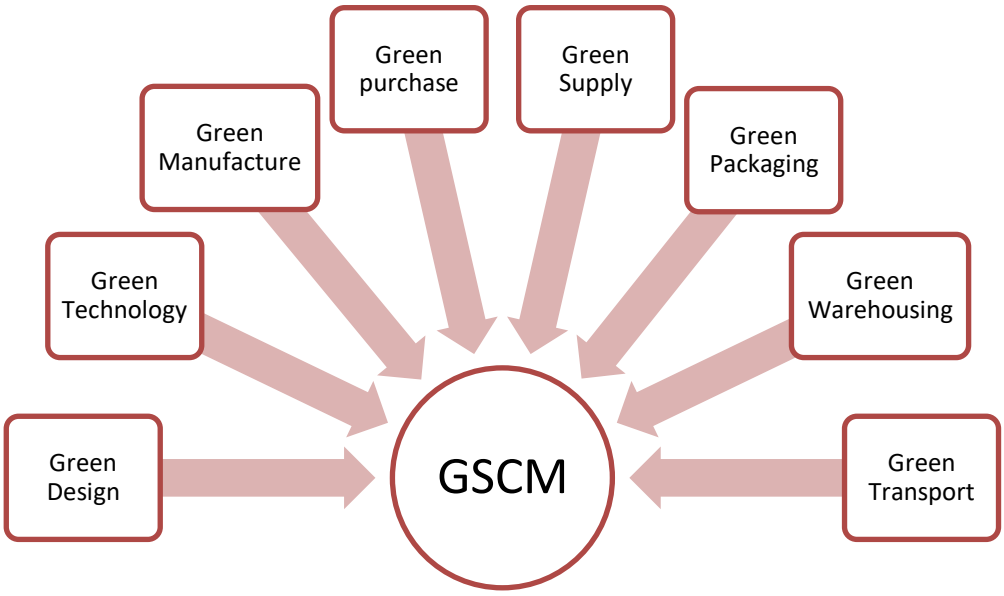


Figure 1.5: Business flow in GSCM in habitation industry

There is little collaboration and visibility outside of the conventional supply chain, where materials and information flow linearly from one end to the other. Each partner in the supply chain has a limited understanding of the upstream and downstream supply chains. For a worldwide, multi-centered aim, this convergent strategy will not be worthwhile, and because of restrictions on information sharing, the costs are frequently far from optimal. With more precise demand forecasts, GSCM will push customers to adopt the appropriate automation solutions. It guarantees a steady cash flow and reasonable warehouse fulfilment costs. The green supply chain is a comprehensive circular approach that

considers environmental impacts across all supply chain activities, from raw material extraction to final product disposal. Only with appropriate tactics would the overall financial advantages of selecting GSCM be obvious. Hong Kong's carbon emissions have been significantly decreased by 28% due to implementation of a sustainable plan that involves greening the supply chains in the building industry (Hossain et al., 2019). Executing industry-specific Green Supply Chain Management (GSCM) is a vital endeavor that requires collaboration from all levels of the workforce, ranging from entry-level staff to senior management. Mathiyazhagan et al. (2014) argue that not all factors exert an equal influence on the adoption of GSCM in India. In contrast to alternative supply chain managing approaches, green supply chain managing (GSCM) has demonstrated greater comprehensiveness, practical, and rigorous. There are associated legislative chances to give the Paris Agreement's activities top priority. Green building is primarily presented as a business opportunity, despite the environmental and social benefits of "going green in contracting" being emphasized as potential competitive advantages for a green entrepreneur (ILO, 2014).

1.2 Problem Statement

Despite numerous efforts to analyze previous literature concerning the significant challenges and intricacies of implementing Green Supply Chain Management (GSCM) in construction projects (Liberatore et al., 2000; Behera et al., 2015), understanding of GSCM is still deemed to be at an early stage in India. Consequently, there remain numerous unanswered questions or areas not comprehensively understood due to a lack of complete and clear insight into the subject matter, such as identifying the key issues and complexities involved. Industry has long before recognized the value of creating a work plan that is pollution-free, information-transparent, ecologically friendly, and sustainable. Nevertheless, numerous construction projects continue to be observed with reduced productivity, exceeding budgetary limits, exceeding time constraints, insufficient design specifications, and claims of liability that might be linked to insufficient recognition and management of restrictions. Consequently, additional conflicts in the field are unavoidable when a restriction is improperly identified during scheduling. According to Park et al. (2003), a successful construction is achieved by implementing strategies that recognize the differences between a conventional supply chain in manufacturing and one customized for the construction sector. The complexity of the construction supply chain is distinctive due

to its involvement of various stakeholders interconnected with the project, including material suppliers, material consumers, planners, contractors, and owners. The observed gap includes a long-term perspective on integrating green supply chain management (SCM) practices within the operational procedures of the construction sector, specifically addressing environmental considerations. Literatures are especially lacking in topics like government efforts and how they affect GSCM in the building industry. The relationship between environmental policy and regulation and the idea of green SCM has not yet been established, despite the fact that there are numerous published publications on the subject (Broft et al., 2016 and Cheng et al., 2020).

The enforcement of the EPA laws was lax, so contractors did not prioritize C&D WM and tended to illegally dump garbage. Adequate legislation and regulations have been widely recognized as essential elements supporting effective Construction and Demolition Waste Management (C&D WM) practices in various countries, including certain regions of India (Zhao, 2021). Thus, there is a need for an efficient policy framework that extends beyond merely managing the performance of the construction supply chain to also promote sustainability within the sector. The primary challenges in implementing Internet of Things (IoT) technology in the construction industry include concerns regarding safety and security, the absence of standardized documentation, limited awareness of potential benefits, challenges in the initial implementation of IoT, and issues related to connectivity reliability (Gamil et al., 2020). Conversely, research has indicated that projects utilizing Green Construction Practices (GCPs) often experience schedule delays more frequently than conventional construction projects, leading to adverse impacts on the sustainability of green construction initiatives (Bakchan et al., 2019). In this research, an empirically verified framework has been developed considering the three constructs viz. social, economic and environmental and can be easily implemented by the GSCM professionals for managing performance of construction SCs.

1.3 Research Objectives

This study principally focuses on the design and development of a unified policy framework that can manage the performance and implementation of GSCM. It is so complex as the industry has been found to be interlinked with allied industries such as manufacturing, transportation, energy, etc. A step-by-step approach is needed to

understand the objective of the current study, which is to provide a comprehensive review of literature and industry practices in relation to GSCM and outline a conceptual framework for constraint management and the effective use of drivers. To accomplish this, the best suitable performance measures and indicators will be established, and the validity of the measures and linkages among them will be verified with an expert panel. The framework will be developed accordingly, with the data generated from the appropriate methodology adopted and the same validated by applying statistical techniques based on the data collected through SLR, semi-structured interviews, and case studies *via* questionnaire surveys and interviews.

In light of this, the study seeks to achieve the following objectives:

1. Assessing the key processes in construction sector having the potential to introduce green supply chain principles.
2. Specific issues in Indian context, which make the integration of green supply chain concepts in the construction sector processes ranging from design, procurement, transportation, execution, and waste recycling.
3. Identification of Policy elements in India which has direct and indirect influence on the green supply chain in construction industry and exploring their integration into a unified framework.
4. Presenting a conceptual framework to the attention of policy makers at national and local level for necessary interventions to green the construction sector with the objective of achieving the ultimate goal of carbon-neutrality in the sector.

1.4 Significance of the Study

The construction sector has traditionally been characterized as a high-cost industry with limited productivity and operational efficiency. To remain profitable and competitive, construction firms must implement systematic performance management systems and process tools to improve business intelligence through Green Supply Chain Management (GSCM) practices. GSCM plays a significant role in effectively controlling costs and assessing the competitive environment to enhance overall efficiency. The fundamental objective of SCM for construction is optimizing the business process through KPI to accelerate the strategic and operational goals. These performance indicator tools contribute

in gauging the predefined targets or forecast vs actual achievements in an organization. Saad and Patel (2006) state that while there have been numerous initiatives to manage performance at the organizational level, there have been comparatively few efforts to control performance at the interorganizational level. Through this study, a unified framework that integrates the current legal systems, corroborated by all environmental international treaties, especially the Paris Agreement and UNSDG-2030, is looking ahead with a motto to "green" business. For the business community, GSCM professionals, and academics, the research is of utmost importance because the suggested model is expected to account for a number of understudied relationships between the GSCM and construction industries.

1.5 Research Questions

RQ1. What are the main sustainability criteria that stakeholders should consider when creating a green/carbon neutral infra-developmental strategy?

RQ2. What are the crucial elements/factors for green supply chain mechanism in the Indian setting and better addressing sustainable construction?

RQ3. What barriers have stakeholders found that need to be removed at an earlier stage to achieve circular economy in construction industry via GSCM in an Indian scenario?

RQ4. In their green strategies, policies, guidelines, or practices, how do well authorities in India impose sustainability criteria?

RQ5. How much do local-level authorities in India observe or plan to follow the policies, procedures, or guidelines that point out the sustainability constraints and necessitate sustainability criteria in the green strategies or contracts for infra-development projects?

RQ6. Identify the stakeholders best fit to sort out constrains that better address the scope of greening the Indian construction sector and develop a policy framework?

1.6 Scope of the Study

The IPCC (Intergovernmental Panel on Climate Change) has already emphasized the

importance of strategies to improve collaboration throughout the building supply chain. For a company in the construction industry, GSCM mandates that all of its supply chains that go into producing its final products aim for zero environmental discharge. This study examines the literatures on TSCM, LCA, circular economy and GSCM to understand the current Methods for managing the performance of construction supply chains. The integration of environmental goals with SCM principles for inter-firm cooperation, process integration, and relationship management gives a conceptual framework that can help the industry undergo the change that is necessary (Sarkis et al., 2011).

Thus, this research intends to explore various constructs, phases, issues, drivers, and updates of project management and the prospects of performance management via the GSCM strategic move via much-needed policy framing in India.

1.7 Limitations of the Research

- There is limited data on GSCM routines in the Indian CS.
- Challenges in accessing detailed policy implementation information.
- Dependence on stakeholders' willingness for participation.
- Potential biases in the interpretation of findings are due to subjective research methods.
- Limitations in predicting the long-term effectiveness of policy interventions.
- Limited ideas to green the business from respondents (interview) due to fragmented nature of industry and irregularity in expertise for sustainable construction supply chain.
- Concern regarding the insufficiently identified GSCM factors for sustainable construction strategies limits the ability to construct a conceptual framework from the expert side.
- There are limited choices to validate GSCM factors rather than Delphi exercises, interviews, or case studies, as realistic accounts are hidden.

1.8 Research Methodology Overview

This research investigates the environmentally friendly evolution of India's construction

supply chain through the utilization of the Delphi method. The study seeks to collect insights from experts, evaluate policy ramifications, and promote sustainable practices within the industry. The methodology provides a robust framework for policy assessment and expert consensus building, ensuring the collection of rich, qualitative data to inform comprehensive insights and contribute to sustainable advancements in the construction industry.

I. **Research Design:** To examine the varied viewpoints of specialists on the sustainable transformation of the building supply chains, the study employs a qualitative research design. Qualitative approaches are ideal for delving deeply into complicated phenomena, gathering a range of perspectives, and producing insightful results.

i. Data Collection Methods:

a) Primary Data: The major data collection revolves around expert opinions via various means of interviews and questionnaire reviews. The Delphi method will involve selecting a panel of renowned experts, academics, and practitioners in the domains of policy, sustainability, and construction.

b) Secondary Data: Contextualizing expert perspectives within the larger landscape will require gathering complementary secondary data from governmental documents, industry reports, and already published literature.

II. **Delphi Method Application:**

i. **Selection of Experts:** An exhaustive review will be conducted to identify and invite a diverse group of experts from design and forecasting, procurement, construction, transportation, and reverse logistics. The selection will consider individuals with a proven track record in sustainable construction, policy development, SCM, and the CE.

ii. **Delphi Rounds**:

a) Round 1: On the current status of the construction supply chain, current policies, and potential areas for development, experts will anonymously

share their thoughts.

b) Round 2: Experts will seek iterative feedback by synthesizing Round 1 responses and reevaluating their opinions based on collective insights.

c) Round 3: The focus will be on consensus building, aiming to unite opinions on key policy changes and transformative initiatives.

iii. **Data Analysis**: Patterns, themes, and consensus points from the Delphi rounds will be extracted using procedures for qualitative data analysis including 'content analysis and thematic coding'.

III. **Case Study Approach**: A case study technique may be applied in addition to the Delphi method to offer practical examples of green changes in the construction supply chain. Case studies will supplement expert viewpoints and provide useful insights.

IV. **Ethical Considerations:** The research process in Delphi involves informed consent, confidentiality, respect for autonomy, minimization of harm, and beneficence. Participants must receive comprehensive information regarding the research objectives, processes, and possible risks. Researchers should seek ethical approval from an Institutional Review Board (IRB) to ensure ethical standards and promote participant welfare.

1.9 Thesis Organization

The thesis explores India's green transformation of the construction supply chain using the Delphi Analysis for policy assessment. It follows a sequential arrangement of chapters (1-7), each contributing to advancing sustainability in the construction industry.

Chapter 1: Introduction establishes the context, significance, and research questions. Provides an overview of the construction supply chain in India and its challenges. It also introduces the Delphi method as the primary research tool.

Chapter 2: Literature Review surveys existing literature on sustainable construction practices; explores the current state of the construction supply chain in India; investigates relevant policies and frameworks influencing the industry; and examines

previous applications of the Delphi method in policy assessment.

Chapter 3: Theoretical Framework conceptualizes the green transformation of the construction supply chain, explores the role of the supply chain in fostering sustainability, the Delphi method and its applicability in policy analysis, and integrates theoretical concepts to guide the research.

Chapter 4: Research Methodology details the qualitative research design chosen for the study; describes the process of selecting experts for the Delphi method; explains the iterative rounds of the Delphi process; and outlines the case study approach and process of obtaining ethical approval.

Chapter 5: Results and Discussion reviews and interprets the qualitative results regarding the construction supply chain in India from a green perspective, provides an in-depth analysis of the current state of the construction supply chain in India, examines the challenges and opportunities for green transformation, and incorporates case studies to illustrate practical examples. This chapter details the findings from each round of the Delphi method and analyzes expert opinions on policy changes and transformative initiatives. And compares and contrasts responses to identify key consensus points. The chapter also discusses the implications of expert opinions for policy and practice and finally relates findings to existing literature and theoretical frameworks.

Chapter 6: Conclusion and Recommendations summarizes key research findings and highlights contributions to knowledge. It provides recommendations for policy changes and future research.

The thesis entitles the references and lists all sources cited throughout the thesis. Following that, the appendices include supplementary materials, such as the Delphi questionnaire, expert profiles, and additional data.

CHAPTER II

LITERATURE REVIEW

2.1. Introduction

Sustainability has been found to be a key global concern nowadays, not only in the construction sector (CS), as it is recognised as more polluting (Shuai-ping, 2018). Even while considering the unexemplary developmental performance that fosters social and economic benefits (Tunji-Olayeni *et al*., 2018), its eyes cannot be closed to the continuation of the same, i.e., irreversible shifts such as climate change, resource depletion, and so on (Estokova, 2022).

Risks and issues pertaining to the CS have been mapped since the 1990s (Cooper, 1994) to green the supply chain and bring sustainable development (Quesada *et al*., 2011). Embodied energy, construction waste management, sustainable resource management, life cycle assessment (LCA), etc. are some of the leading management options practiced in the sector (Amaral *et al.*, 2020). Mitigating the global warming potential (GWP) of each CS element has proven to be an efficient method of generating a green supply chain (Karlsson, 2020). The supply chains of CS were found to be more complex as they are very interlinked and interconnected to many related sectors of manufacture, transportation, waste, energy, etc. (Vijayadas, 2022). Dashore and Sohani (2013) and Singh and Misra (2020) have mapped the drivers and barriers of GSCM in CS and formulated frameworks that can bring green to the system. Many research studies cannot find merit in effective management of supply chain (SC) in CS (de Oliveira *et al.*, 2018) and could blame the inefficient execution and implementation of existing policies and laws (Li *et al*., 2021). For that, Milios (2018) recommends a policy mix rather than a number of policies for an effective outcome.

In order to identify the actual problems impeding GSCM, the literature that has been available for the last three decades about CS and GSCM has been analysed. Indian CS is more engaged than ever in sustainability by implementing cutting-edge methods, concepts, and technologies (Mojumder *et al*., 2022). The lack of collaborative contracts and the problems with stakeholder participation in the business, where several medium-sized companies handle the developing activities, lead researchers to conclude that the

consistency is desperate (Marinelli *et al*., 2022). Enforcing appropriate regulations strictly can promote consistency in behaviour, stakeholder involvement in knowledge management, and government involvement (Yap *et al*., 2022).

The literature evaluation for the study is set up in a way that it investigates the supply chain's present gap while progressing in the direction of sustainability. The need, benefits, and significance of related industries including transportation, construction waste, and energy are also covered for the literature review. The focus has been placed firmly on sustainability. Under GSCM practises, green practises both locally and globally are discussed, along with their contribution to sustainable development goals (SDGs) attainment. The key topics covered are managerial alternatives and factors. Following this examination of the many strategies and framework studies in the sustainability elements of the construction sector, a distinct area where some novel research has been conducted has focused on the drivers and barriers of GSCM. The analysis of the most serious part of policy interventions is complete. The analysis of the most serious part of policy interventions is complete. China, the UK, and the USA have produced the majority of studies on policy. 'Nigeria' is one of the emerging nations that has expressed a strong interest in the GSCM of CS.

2.2. INTERNATIONAL

2.2.1. Sustainability and construction sector

2.2.1.1. Performance evaluation

Ugwu and Haupt (2007) investigated the development of key performance indicators (KPIs) integrated within an analytical model and explored additional potential applications of the proposed model and methodology for automation within integrated sustainability assessments in infrastructure design and construction within developing nations. They utilized techniques such as the 'weighted sum model' in multi-criteria decision analysis and the 'additive utility model' in the analytical hierarchical process to formulate the model for computing sustainability index assessments in infrastructure projects in developing countries like South Africa.

After examining whether a significant challenge exists, Windapo and Cattell (2013) concluded that additional research is required to identify the factors contributing to the rise

in building material costs and to test the hypothesis that the exploration and development of new materials and technologies, rather than relying on existing ones, will lead to stable building material prices.

Ding (2014) highlighted the importance of Life Cycle Assessment (LCA) in assessing the environmental effects of building materials, focusing on economic, social, and environmental criteria. However, he noted that LCA has limitations in analyzing sustainable materials. Ding also highlighted the lack of research in developing countries using local data.

de Sousa Jabbour et al. (2015) conducted a study on the impact of green supply chain management (GSCM) practices on environmental and operational performance indicators. They found that "internal environmental management" has the most significant positive impact on environmental performance indicators, while "cooperation with customers" has the greatest positive effect on operational performance. To enhance environmental performance, companies should establish procedures and programs based on environmental management systems and adopt cleaner production initiatives. To improve operational performance, they should address audits, enhance information exchange between companies and clients, and establish research and development areas to foster environmental innovation.

After conducting an in-depth literature review and utilizing PLS-SEM (partial least squares-structural equation modeling) assessment, Zeng et al. (2018) developed an exploratory research model comprising eight latent constructs. The study revealed a positive correlation between the integration of the construction supply chain and the sustainable use of building materials. These findings underscore the value of integrating the construction supply chain to promote sustainability.

From the perspective of the consultants, Tayeh *et al*. (2020) looked into what influences sustainability performance during the building development stage in the Gaza Strip. In total, 55 factors were taken into account in this study, and after factor analysis, 31 remained. These elements are categorized into three groups: economic, social, and environmental. It is urged that new measures be used to promote sustainable building, such as offering green buildings building permits at a discount. The Palestinian Contractors Union and the AE (Association of Engineers) should offer lectures and

workshops to raise the level of sustainability knowledge among those involved in the construction process.

Susanti et al. (2020) developed a performance assessment framework for implementing sustainability criteria in building construction projects, serving as an initial step to enhance sustainability performance in construction endeavors in Indonesia. They identified 11 sustainability criteria that exhibit high performance and have been effectively integrated into building construction and operation. Conversely, six other sustainable construction criteria demonstrate relatively low performance or implementation levels at project sites. Among these, nine criteria are directly linked to the construction process, while three sustainable construction criteria exhibit high performance and include limitations on chemical pollutants at project sites. However, six additional sustainability criteria still exhibit low performance or implementation, such as the absence of rainwater storage from building roofs, aimed at reducing reliance on primary water sources.

Zhang and Wang's 2021 study explores green building and low-carbon campus promotion in junior high and primary schools. They aim to promote environmental protection, energy savings, and carbon reduction, while promoting eco-friendly, low-carbon campuses. The findings can help governments define policies, prioritize initiatives, and assign weights to indicators, ensuring equitable distribution of educational funding, improved green building quality, and energy- and carbon-saving measures.

Zhang et al. (2021) employed a three-stage DEA model to investigate the factors contributing to a 16% increase in carbon emissions in the Chinese construction industry (CCI). They identified several factors that negatively influenced CEECI, pure carbon emission efficiency (PCEE), and scale efficiency (SE), such as energy structure optimization, labor force size, total power of construction equipment, and construction intensity within the industry. The study aimed to enhance carbon emission efficiency within the Chinese construction sector.

2.2.1.2. Management

Marcelino-Sadaba et al. (2015) emphasize the importance of sustainable project products, processes, organizations committed to sustainability, and sustainability training for achieving sustainable projects. Their framework and research agenda aim to assist project

managers in managing projects sustainably and serve as a foundation for future research on sustainable project management tools and methods.

Silvius and Schipper's (2014) analysis of sustainability in project management identifies three transitions: a shift from focusing on time, cost, and quality to managing social, environmental, and economic effects; a paradigm shift from predictability and controllability to flexibility, complexity, and opportunity; and a shift from project managers focusing solely on achieving desired results to assuming ownership of sustainable growth for organizations and society. These transitions emphasize the importance of adapting project management strategies to ensure sustainability.

Tunji-Olayeni et al. (2018) assessed sustainability strategies in the construction industry by analyzing mission statements, identifying barriers to sustainability adoption, and recognizing the benefits of integrating sustainability into construction activities. They suggested encouraging sustainability awareness and policies to boost interest and adoption, predicting that these measures would promote Nigeria's green growth strategy.

Zavadskas et al. (2018) analyzed 27 peer-reviewed works on sustainable construction, focusing on sustainable architectural design, construction technology, environmentally friendly building materials, construction economics, sustainable infrastructure planning, and project risk evaluation. They employed a variety of methodologies and tools, ranging from fundamental decision-making models to advanced multi-criteria decision-making techniques, to examine and assess these studies..

The studies by Thomson & El-Haram (2019) highlighted the significance of allowing project stakeholders to interact with professionals who have higher levels of sustainability literacy in order to transmit their emotional and technical intelligence and enable experiential learning that can benefit subsequent projects. Similar in scope to BREEAM, the more recent German Sustainable Building Council method (DGNB) encourages a more quantitative approach that reflects lifecycle building performance with higher requirements for technical standards. This study argues that in order to encourage conversation and recognise the possibility of change, the evolution of BSAM's (Building Sustainability Assessment Method) needs to provide chances for project stakeholders to access and exchange knowledge at crucial times.

The goal of Heurkens and Dbrowski (2020) was to identify the obstacles preventing the application of the items required for controlling a circular economy (CE) transition in an urban area. By looking into the potential for transitions towards a CE in the Amsterdam Metropolitan Area (AMA), which is frequently (self-) branded as a global leader in circularity, they have addressed the aforementioned knowledge gaps.

Aghimien et al.'s 2019 study on sustainable construction in Nigeria and South Africa found that while awareness has increased, challenges remain. In Nigeria, resistance to change, clients' apprehension about SC materials, insufficient knowledge of sustainability concepts, inadequate technology, and government policies hinder SC. In contrast, in South Africa, resistance to change, clients' concerns about SC materials, client preferences, limited access to information, and historical data are the main obstacles.

Kadaei et al. (2021) conducted an extensive examination of sustainability assessment options across architectural design, construction, refurbishment, and restoration. They applied multiple criteria decision-making (MCDM) to assess hotel construction and determined that alternative A4 proves most effective in addressing sustainability concerns. Given the expansion of urban populations and urbanization, ensuring energy supply and efficiency in buildings emerges as a critical concern for both planners and residents.

Norouzi et al. (2021) conducted a quantitative scientific analysis to trace the evolution of applying circular economy (CE) principles in the building industry. The aim was to identify emerging trends and illustrate the evolution of this research topic. Their findings revealed that in the past five years, scholars have shown particular interest in terms such as "sustainability," "energy efficiency," "life cycle assessment," "renewable energy," and "recycling." The study highlights three current areas of research focus that may become prospective future research topics: (i) the advancement and utilization of alternative construction materials; (ii) the establishment of circular business models; and (iii) the intersection of smart cities, Industry 4.0, and their relationships with CE.

2.2.1.3. Energy

Karimpour et al. (2014) found that embodied energy plays a crucial role in reducing the life cycle energy of buildings. They found that various passive and active technologies can reduce operational energy in residential buildings, with operational energy accounting for

80-90% of total life cycle energy. However, low-energy buildings have less embodied energy, and the proportion can be 40-60%. They also noted that previous research has overlooked climate impact and that existing life cycle energy analysis studies do not consider carbon time value.

Irani et al. (2017) conducted a study using fuzzy cognitive mapping to examine the relationship between green supply chain collaboration (GrSCC) factors. They found that Knowledge Management plays a crucial role in facilitating GrSCC, and a futures-based perspective was proposed for implementing it. They identified 24 factors based on strategic, managerial, organizational, operational, technological, human-sociological, financial, and environmental dimensions. The authors then applied weighted relationships to each factor, creating a visual matrix of interrelationships using the fuzzy cognitive mapping technique.

Hou et al. (2018) conducted an examination of China's industrial transition towards environmental sustainability, identifying the primary factors influencing carbon intensity and their impact on its reduction. The research observed a gradual transformation of China's industry, leading to a decrease in pollution emissions. However, regional variations and fluctuations impose limitations on the extent of this transformation process. Additionally, the study revealed that inadequate environmental regulations can substantially lower carbon intensity through environmental initiatives. Nevertheless, once regulations surpass a certain threshold, the effectiveness of the transformation in reducing CO2 weakens, potentially resulting in a failure to decrease carbon intensity.

Dlamini and Yessoufou (2022) aimed to assess the sustainability initiatives implemented at the BGRE (Belhar Gardens Rental Estate) in the Western Cape Province of South Africa, based on the perceptions of residents and professionals. Their objectives included evaluating the awareness level among professionals involved in the Calgro M3 developments, addressing their perceptions regarding opportunities, obstacles, and potential solutions for integrating sustainability into South African construction practices. They also sought to gauge the awareness level among residents of the Belhar Gardens Rental Estate and obtain their feedback on the various sustainability measures adopted within the estate. Additionally, the study aimed to identify the factors influencing the effectiveness of water-saving sustainability initiatives.

2.2.1.4. Waste

To assess the performance of municipal solid waste management (MSWM) and address challenges related to the principles of Reduce, Reuse, and Recycle (3R), Chi and Long (2011) evaluated the advancements in implementing 3R initiatives, which are integral to a successful solid waste management (SWM) policy. They examined the gradual introduction and evolution of the 3R initiative within MSWM in Vietnam. Their findings underscore the necessity for implementing more effective measures in MSWM practices, emphasizing the importance of robust institutional frameworks, supportive measures, and technologies to promote 3R. Specifically, they emphasize the need to reduce the disposal of hazardous substances and enhance the management of hazardous waste as urgent priorities in this regard.

Resource-constrained product development (RCPD), according to Sharma and Iyer (2012), can strengthen competitive advantage as well as supply chain and green initiatives. One major advantage of resource-constrained product development is that it might be the best method for developing eco-friendly goods. They have mentioned in this article that RCPD, which focuses exclusively on the features of products that are the most important and use fewer but local materials, may be the way to build green products.

Samad et al. (2018) studied green concrete using construction and agricultural waste. They combined recycled Concrete Aggregate (RCA) with palm oil fuel ash (POFA) and rice husk ash (RHA) to replace cement and aggregate. The research found that using POFA and RHA increased concrete's compressive strength and tensile strength by up to 20% and 10%, respectively. Additionally, adding POF increased the material's strength and crack-resistant qualities.

AECOM (2018) proposed policy recommendations to improve construction and demolition waste management in China. These include developing technical guidelines for segregation and processing, capacity-building initiatives, and implementing policy instruments to stimulate demand for recycled CDW. The recommendations will be developed in collaboration with ministries and professional associations, and a cost-benefit analysis will assess the potential benefits of implementing these recommendations. The aim is to enhance CDW management practices and reduce waste in the construction industry.

Pushpamali et al. (2020) studied the environmental impact of reverse logistics (RL) strategies in the construction industry using LCA, highlighting the need for informed supply chain decisions for environmentally friendly practices. They hypothesized that alternative RL strategies offer greater environmental benefits than recycling and traditional landfilling. Meanwhile, Mingaleva et al. (2020) explored the role of waste management in developing modern green and smart cities. They concluded that the effectiveness of green technologies, particularly in waste management, depends on the level of citizen participation. They suggested that the introduction of green technologies can only be achieved when city residents' behavioral attitudes align with the implementation of green and smart urban technologies. Both studies highlight the importance of considering environmental impacts in supply chain decisions.

Reche et al. (2020) analyzed models related to the relationship between Green Supply Chain Management (GSCM) and Integrated Product Development Process (IPDP), focusing on green manufacturing, distribution, and procurement issues. Baranikumar et al. (2021) assessed green supply chain management activities in the Indian construction industry, focusing on waste management. They found challenges in GSCM adoption and suggested that other components should be focused on to improve GSCM. They suggested that stakeholders in the construction industry should take steps to improve GSCM in all areas for 360-degree development and inclusive growth for a healthy environment.

Zhao (2021) assembled an extensive compilation of factors influencing construction and demolition waste management (C&D WM) and conducted a systematic literature review to chart the connections between these factors and relevant stakeholders. The research identified 35 stakeholder-related variables that impact C&D WM, categorizing them into six distinct groups: the regulatory framework, governmental and public supervision, technological progress, the recycling market, stakeholder knowledge, awareness, attitude, and behavior, as well as project-specific considerations.

Yuan et al. (2022) created a system-dynamic model to assess the adoption of prefabrication during the design stage for construction waste reduction at the project level. The model reveals how interaction behaviors among factors affect the final CW reduction. Data from residential projects was analyzed to understand the effectiveness of different measures to promote the prefabrication method. The simulation results suggest that a

reasonable policy system is beneficial for promoting the prefabrication method during the design stage and CW reduction.

2.2.1.5. Transportation

Chang et al. (2013) conducted an assessment of CO2 emission reduction in China's transportation sector on a provincial basis. They employed metrics such as the total factor green performance index (GPI) for CO2 emissions, potential carbon reductions (PCR), and carbon efficiency (CEf).

Mao et al. (2020) proposed a model for green urban mobility to characterize smart mobility features within smart cities. They underscored the significance of comprehending the role of smart cities in overall urban planning.

He et al. (2022) developed a model called the carbon emission measurement model (CEMM) to assess the carbon emissions of 26 resilient high-speed railway construction projects in China. Their study revealed potential correlations and positive relationships between resilience and carbon emissions. They also offered recommendations for governments and construction enterprises to enhance the resilience and low-carbon development of transportation infrastructure in China.

2.2.1.6.SDGs

Verma et al. (2021) highlighted the importance of sustainable construction in achieving the 11th and 15th Sustainable Development Goals (SDGs). They suggested that multi-disciplinary approaches, including energy saving, material use, waste minimization, pollution control, and emission control, are needed for sustainable construction in the building industry. Iyer-Raniga and Huovila (2021) emphasized that sustainable design and construction lead to sustainable buildings and built environments. However, these buildings may not function as sustainable from a resource utility or health and well-being perspective. The study begins by understanding the links between the SDGs and sustainable buildings and construction.

2.2.2. Supply chain management and construction sector

Elbarkouky and Abdelazeem (2013) propose that the implementation of Green Supply Chain Management (GSCM) in Egypt can be realized through the coordination of various

stakeholders, including governments, owners, manufacturers, consultants, contractors, society, NGOs, and universities. They supported this assertion through two case studies examining GSCM practices in two construction companies in Egypt. Their analysis identified drivers such as ISO 14001 certification and market competitiveness, as well as barriers such as the absence of regulations, government support, and societal pressure.

The most recent trends and findings for each perspective were highlighted by Golini *et al*. (2016), who used a systematic literature review to examine the various perspectives used to analyse SCM in the construction sector and their evolution over time. This allowed them to identify the most promising potential future developments for the field. They examined the data and came to the conclusion that while ICT (information and communications technology) and sustainability are the newest and fastest-growing issues, they are still not fully integrated with the other ideas. They talked about how poorly the building supply chains perform, which shows how important this is and how more work is needed to give normative contributions that incorporate all the other disciplines.

de Oliveira et al. (2018) performed a systematic literature review of articles published between 2006 and 2016 to assess the research implications and future directions of Green Supply Chain Management (GSCM). According to the findings, around 40% of the research was devoted to GSCM implementation's advantages, and just 10% to its difficulties. It follows that studies that could help to lessen or even eliminate the obstacles to GSCM deployment would provide a direction for future study.

Wongthongchai and Saenchaiyathon (2019) developed a practical structural model using the interpretative structural model (ISM) to investigate relationships among elements in green supply chain management and the human resource department. Benachio et al. (2019) analyzed environmental sustainability in the construction sector, focusing on waste management, carbon emissions reduction, and material selection. They found that these practices should be implemented throughout the construction life cycle, particularly during the design phase. Wieland (2021) advanced supply chain management through panarchy theory, reinterpreting the supply chain as a social-ecological system and replacing a modernist view with a contemporary vision of "dancing the supply chain.”

2.2.2.1.Factors @ SCM

Jing et al. (2019) investigated the motivational factors influencing the adoption of Green Supply Chain Management (GSCM) in the construction industry, which contributes significantly to environmental pollution. Twelve factors were identified, including internal motivators, external motivators, internal demotivators, and external demotivators. Jiang et al. (2019) compared the performance of modular prefabrication and conventional construction approaches, revealing that modular prefabrication offers numerous sustainable benefits over conventional methods. They found that modular prefabrication has better performance in terms of construction waste, aesthetics, site disruption, water consumption, and pollution generation. Khan (2020) studied the multi-party green supply chain finance model and concluded that green supply chain finance can create more suitable credit products for buyers and banks, supporting more green firms. To achieve environmental and economic benefits, investment institutions should focus on environmental risks, standardize green investing behavior, and encourage green investing.

2.2.2.2. Risk @ SCM

Shen and Tam (2002) highlighted the benefits of implementing environmental management in the Hong Kong construction industry, including environmental protection, reduced risk, improved environmental image, and cost savings. Luthra et al. (2014) explored Green Supply Chain Management (GSCM) issues and suggested further research to identify gaps in literature and opportunities for future studies. Organizations aim to enhance brand image, competitiveness, resource utilization, customer service, and profitability through defensive and offensive business strategies. Andal and Juanzon (2020) identified six primary risk factors associated with implementing sustainable building materials in condominium fit-outs. These factors include the adoption of sustainable materials, appropriate material selections and specifications, availability of sustainable materials, affordability of sustainable materials, project delivery and schedule, and the life cycle scheme. These studies highlight the importance of addressing environmental management in construction to achieve various objectives.

2.2.2.3. Monitoring @ SCM

Adegbile (2012) sought to identify a sustainable design tool suitable for the Nigerian built environment, prioritizing long-term performance, innovation, and flexibility. Their study

involved a comparative analysis of seven sustainable rating systems, namely BREEAM, CASBEE, GREEN GLOBES, GREEN STAR, HK-BEAM, IGBC Green Homes, and LEED. The objective was to enhance quality, minimize environmental impact, and optimize life cycle costs. LEED, which dominates in the United States and Canada, emerged as the most suitable option for Nigeria due to its robust foundation, significant investments, and demonstrated benefits.

Zuo and Zhao (2014) reviewed common research themes and methodologies, revealing that existing studies primarily focused on the environmental aspect of green buildings, neglecting other dimensions of sustainability, particularly social sustainability. Siva et al. (2017) addressed the advantages and constraints of Singapore's sectoral innovation system in promoting energy transition in the construction sector, focusing on the institutional aspect of the system, including central government strategy, program, policy instruments, and certification systems. The study aimed to outline the network of interactions between various components of the building industry in Singapore.

The Greenlandic Sustainable Index (GSI), which was created with the intention of being straightforward to implement but ambitious in terms of performance level, was examined by Labansen and Bastien (2019) in terms of its implementation's scope. They discovered that although more intricate and thorough sustainable building certification processes do exist, they are not used in Greenland since they look like an unattainable goal in comparison to the current building standards based on the Greenlandic Building Code of 2006. They hope to use this initial iteration of the GSI in further case studies and look forward to its future improvement. Through this study, they inadvertently opened a discourse with other actors interested in sustainability in the Arctic.

Owusu-Manu et al. (2020) studied indicators for measuring greenness in developing countries' cities. They found that green cities should improve air quality, water production, sanitation management, land use, health, transportation, renewable energy, and sustainable construction. Meanwhile, Stanitsas et al. (2021) explored sustainability in project management in construction projects, identifying 82 sustainability indicators based on the triple-bottom line scenario of economic, environmental, and social dimensions. Both studies emphasize the importance of enhancing air quality, improving water production, sanitation management, and promoting sustainable construction and green buildings.

*2.2.2.4. **Operational** performance and SCM*

Azhar *et al.* (2008) highlights the advantages of BIM for the Architecture, Engineering and Construction (AEC) industry through two case studies. They understand that as the adoption of BIM grows, project team collaboration should rise, which will enhance profitability, cut costs, improve time management, and strengthen client/customer relationships. Teams utilising BIM should be extremely cautious about legal problems such data ownership and related propriety issues as well as risk sharing.

Ma *et al*. (2018) thoroughly compared the advancement of modern building techniques across various Chinese regions. The opinions of industry experts regarding the effects of BIM on other modern construction methods were also investigated. In order to successfully integrate the most recent methods locally and globally, the research findings are anticipated to be beneficial to both the construction industry and the government as a whole.

Lekan et al. (2018) developed a model to integrate the building information model and lean construction process for sustainable construction. They found that lean construction requires a conscious change in thinking and operations to overcome challenges like delays and ineffective works. The model achieved preset value by automating drawing and documentation generation, promoting flow throughout the value chain, generating design alternatives quickly, and mapping the value stream process.

Jabbour et al. (2020) observed that internal stakeholders, such as company owners/shareholders, might exert a more significant influence on adopting circular economy (CE) business models, especially in institutional voids. They noted that CE adoption could enhance sustainable performance indicators, economic and environmental efficiency, and social image. This emphasis on improving sustainable performance extends beyond merely meeting regulatory compliance requirements. The relevance of this finding is notable in Brazil, where formal frameworks and policies for disseminating CE to firms are lacking.

Assessing how different aspects of green supply chain management relate to organisational outcomes in terms of financial and environmental performance was the main goal of the study by Cahyono *et al.* (2020). They came to the conclusion that green

supply chain drivers have a favourable impact on supply chain support activities, organisational supply chain management techniques, and organisational outcomes. Furthermore, it proves that the green supply chain drivers, via the green SCM support activities, have influenced the green SCM practices. In an effort to integrate waste elimination and cost reduction tools into the supply chain to improve organisational performance, the integration of organisational SCM strategies and its impact on green SCM practices are particularly crucial.

Alshehri (2020) aimed to assess the awareness of value management (VM) in the building sector, highlighting its importance in the construction industry. However, he identified barriers such as lack of knowledge, lack of standardized problem-solving, contractor VM practices, novelty in regions, unwillingness to implement VM, and lack of qualified personnel. VM adoption can improve productivity, sustainability, and achieve targets within timeframes. Mavi et al. (2021) highlighted the need for sustainability in sustainable construction project management, highlighting the importance of incorporating sustainability from the beginning of design and feasibility studies and following it throughout the project. The study also found that BIM features and lean principles could influence project building processes.

Yap *et al*. (2022) has recognised the value of knowledge management (KM) strategies, as well as the tools and methods utilised by construction-related organisations to support them. This conclusion was reached because, within the broader context, improvements in efficiency, decision-making, quality control, error management, and information sharing were identified as the top five desired advantages. Among the knowledge management (KM) tools and techniques utilized most frequently were project meetings and reviews, training sessions, brainstorming sessions, face-to-face interactions, and post-project reviews.

2.2.3. Drivers and Barriers in GSCM

Ho et al. compared conventional and green supply chains in 2009, discussing opportunities in green supply chain management in manufacturing, bio-waste, building, and packaging. They discussed LEED, a national voluntary standard for high-performance, sustainable buildings, eco-labeling, Life Cycle Assessment, and eco-labeling. Ahn et al. (2013) identified the primary drivers and barriers of sustainable design and construction, focusing on increasing indoor environmental quality, preserving the environment and resources,

and reducing waste. However, the initial cost premium, long payback periods from sustainable techniques, the tendency to maintain current practices, and the low knowledge and abilities of subcontractors were identified as further impediments to sustainable design and construction. Both studies highlight the importance of addressing environmental and economic factors in promoting sustainable practices.

AlSanad (2015) discovered and suggested that a study of the application of the existing legislation be advised to get over the "lack of government enforcement" element, which the respondents said was one of the existing reasons why green construction technologies were not being used in Kuwait. He proposed that in order to further the idea of going green, the government could change the existing norms or enact new laws, establishing suitable criteria for the adoption of sustainable practices. This will then motivate all parties to adjust their practices in order to conform to the new laws.

Darko et al. (2017) conducted a study that identified 26 barriers, 21 drivers, and 12 promotion strategies for the adoption of green building technologies (GBTs). The primary barriers included resistance to change from traditional technologies, lack of knowledge and awareness about GBTs, and higher costs. On the other hand, the main drivers for GBT adoption were identified as greater energy-efficiency, water-efficiency, and the enhancement of company image and reputation through marketing strategies. All 12 promotion strategies were considered significant, with financial and market-based incentives being particularly notable. Other strategies included providing better information on the costs and benefits of GBTs, implementing green labeling, and disseminating information effectively.

Durdyev *et al*. (2018) looked at the level of knowledge among industry players on the variables influencing and roadblocks to the embracement of sustainable building practices in Cambodia. The findings imply that SC practices are not widely adopted in the industry, which is thought to be caused by a lack of awareness and understanding as well as a reluctance to adopt new sustainable technologies. They discovered that the drivers are potent enough to compel industry stakeholders and decision-makers to address the obstacles and make investments in their removal. The removal of these obstacles would encourage widespread SC adoption, the application of its advantages, and thereafter encourage the adoption of SC methods in Cambodia.

Darko et al. (2018) explored and modeled the effects of different types of barriers, drivers, and promotion strategies on the adoption of Green Building Technologies (GBTs) in Ghana. Drawing from the findings, they put forward an implementation strategy (IPS) to encourage the adoption of GBTs. The study underscores the importance of enhancing government involvement in promoting the adoption of GBTs.

Ahmed *et al.* (2020) looked at the significant barriers of GSCM's adoption and the opportunities that could be reaped from such an implementation in the developing world's construction sector. The study also develops plans for avoiding major implementation obstacles and seizing chances for an improvement in the building sector's overall environmental performance. Additionally, the tactics to put GSCM into effect include appropriate policies from top management to include activities like cutting-edge 'green'-design, sourcing, packaging, and distribution, and even end-of-life management, which are crucial for reducing emissions.

By contrasting their focuses and motivators, Tafazzoli *et al*. (2020) investigated the implicit links between green and lean techniques in the building business. The prospects for merging the two techniques were divided into five groups based on a thorough literature assessment. The difficulties were similarly enumerated and discussed in four groups. The findings showed that the biggest opportunity was to reduce waste, while the biggest obstacle was to lower beginning expenses. They showed that it is more useful to think of the amalgamation of 'lean' and 'green' as a tool to maximize the synergistic benefits of the two concepts rather than as a technique to combine the two approaches and create a third strategy.

Compressed earth blocks (CEBs) were examined by Lakys *et al*. (2022) as an alternative sustainable building material in their study of the factors influencing sustainable building in the Kuwaiti construction sector. They checked how well-known and well-liked sustainable building materials are across various stakeholders. The drivers were initially chosen based on their rate of citations and where they placed in previous studies that were identified in the literature. The drivers were then narrowed down based on their suitability for the Kuwaiti construction sector and their applicability to CEB.

Based on Certified Emission Reduction (CER), Lee *et al.* (2013) proposed a funding approach for assisting green construction projects with a government guarantee. As a

result, CER in real trading markets was used in this study as a return for the assurance. They asserted that the danger of project failure may directly impact the government if it offered a government guarantee for green building projects.

Du et al. (2014) conducted a study to understand the barriers to energy-saving technologies adoption in the building sector. They used a questionnaire approach and in-depth interviews to gather quantitative information. Ojo et al. (2014) identified several obstacles to Green Supply Chain Management (GSCM) in Lagos, Nigeria, including lack of demand, resources, sustainable practices, market for recyclable materials, information sharing, public awareness, environmental knowledge, and poor management commitment. They recommended focusing on energy and resources to maintain an environmentally sound supply chain. Djokoto et al. (2014) investigated sustainability in Ghana, identifying a lack of demand for green buildings, a lack of marketing strategy, higher starting costs, public awareness, and government assistance. They suggested strengthening the industry's skill set and implementing policies and rules on environmental issues, which could be achieved through government support. The importance of addressing these challenges in the construction sector is highlighted.

According to Darko and Chan (2017), the most frequently cited barriers in the literature review include a lack of knowledge, cost, incentives, interest and demand, and (green building) GB laws and regulations. They demanded that in order to promote investment in GB, the government should take into account enforcing mandatory regulations such as (1) requiring a certain level of GB certification before granting construction permission, (2) imposing financial penalties for disregarding mandatory standards, and (3) imposing mandatory minimum building energy-efficiency standards on market participants. They acknowledge that the absence of GB codes and regulations is a significant impediment to GB adoption. In order to facilitate the adoption of GB among stakeholders, the government should develop distinct national public policy packages and make these policies mandatory.

Dadzie et al. (2018) found that while new sustainable technologies (STs) are often produced to increase energy efficiency, only a few initiatives have been implemented in older buildings. In Australia, perceived benefits in demolish-and-build, building age, cost of STs, slow payback times, unreliable energy-saving projections, existing designs, hidden

renovation costs, and cost of STs are all obstacles to the adoption and use of sustainable technologies.

Daniel et al. (2018) conducted an evaluation of the obstacles to implementing sustainable construction practices (SCPs) in the Nigerian construction sector, identifying key barriers such as insufficient expertise, absence of legislation, inadequate client demand, and limited consideration for sustainability in the design phase. They suggested the formal incorporation of sustainability modules into built environment programs at the higher education level to enhance the understanding of sustainability among construction professionals. Chowdhury and Srabon (2018) identified the most significant obstacles to the adoption of sustainable practices in the construction sector of Khulna, Bangladesh, including a lack of project manager qualifications, knowledge of sustainable construction, and familiarity with sustainable technologies.

Fathalizadeh *et al*. (2019) made an effort to investigate the challenges that developing nations face when attempting to incorporate sustainability into building project management. To accomplish this goal, an extensive literature review was undertaken, and a compilation of 30 barriers was derived from existing studies to identify the most prominent obstacles to sustainability. This list provides researchers, practitioners, and policy makers with invaluable insight that will help them support the shift in project management practices toward achieving sustainability goals.

In their investigation of the major impediments hindering the adoption of green design within construction practices, Ming et al. (2019) pinpointed the challenges that prevent contractors in Malaysia's construction industry from participating in initiatives associated with green design. Results indicated that important impediments to the use of green design practices were company resources and government support. They emphasized that green initiatives could lessen the negative effects of unsustainable construction activities while also having significant positive effects, such as lowering greenhouse gas emissions, consuming less energy and natural resources, and disposing of construction site waste more sparingly.

Ghansah et al. (2020) identified various impediments to the integration of smart building technologies (SBTs) into project management processes, including prolonged approval procedures, the organizational structure of the construction sector, higher costs associated with smart

construction practices and materials, limited familiarity with smart building technology, and technical complexities. They recommended government intervention to promote SBTs through sustainable development policies, aiming to benefit the global construction community. Osuizugbo et al. (2020) conducted an assessment of the obstacles to sustainable construction practices in the Nigerian construction industry, uncovering significant barriers such as inadequate government support, absence of relevant legislation and regulations, insufficient demand from clients, low awareness regarding sustainable construction, and concerns about the expenses related to adopting sustainable construction methods. The study identified a total of 21 potential barriers present in both developed and developing nations. Toriola-Coker et al. (2021) found 58 obstacles to Nigeria's use of sustainable construction methods, including policy development, sustainable building regulations, implementation, financial grants, and increased client and stakeholder awareness. The least significant obstacle is that sustainable construction does not increase building market values. All these obstacles must be considered to effectively implement sustainable construction in Nigeria.

2.2.4. Framework for GSCM

A framework for adopting green construction standards in developed and developing nations was envisioned by Korkmaz *et al.* in 2009. The green construction movements in the chosen developed and developing nations—the United States, India, and Turkey—had been examined for that purpose. They discovered that among the nations looked at, the United States, a developed nation, appeared to be leading the pack in terms of adoption and application of green construction principles. India's progress has also been boosted by the establishment of the Indian Green Building Council. They concluded that although there are more green buildings in Turkey than ever before, more inter-development is required to allow for large-scale production.

Sarkis et al. (2011) conducted a literature review on Green Supply Chain Management (GSCM) with the aim of identifying relevant organizational theories used to enhance understanding and knowledge in this research domain. They noted that researchers in GSCM have increasingly applied various organizational theories in explicit ways, leading to a deeper comprehension of these theories. Additionally, they observed that organizational theory serves as a valuable foundation for investigating and advancing research in GSCM, highlighting numerous prospects for future research and exploration using theories that have already been employed.

Balasubramanian (2012) assessed the obstacles to GSCM adoption in the UAE construction sector using a hierarchical structure. In order to grasp their importance for

decision-making, he had identified 32 barriers across the economic, environmental, technological, and social sectors and categorized them. For their interplay, he adopted a scientific hierarchical modelling of barriers.

SCM decision-making involves at least one stakeholder at all times, according to Wittke's (2014) analysis of the role of stakeholder theory in this field. This is so because any individual or group of individuals who must be taken into account when making a decision within an organization is by definition a stakeholder. This also indicates that prior assessments of the environment (competition, market structure, opportunities and threats, government, and more) were conducted in order to comprehend the forces at play as well as the key players in the business and the decision in question. In order to determine which stakeholder interests should be addressed first, stakeholders must also be categorized.

Stakeholder theory should be examined from a range of foreign viewpoints, according to Harrison *et al*. (2015), who also noted how this will develop management theory. They emphasized that tackling some of the crucial business issues from an international viewpoint is where stakeholder theory is found to be particularly helpful. It provides a chance to reinterpret a range of ideas, models, and phenomena from several academic fields. The opportunity to reinterpret circumstances from a range of fresh viewpoints, including perspectives that engage numerous stakeholders at once, is provided by the multifarious nature of stakeholder theory in particular.

Wyawahare and Udawatta (2017) formulated a conceptual framework through an extensive literature review on Green Supply Chain Management (GSCM) practices aimed at mitigating carbon emissions and associated concerns. They classified the primary barriers to GSCM implementation into five main categories: technology, knowledge, finances, outsourcing, and management. Additionally, they devised strategies to enhance GSCM practices within construction organizations, including top management commitment, adjustments to existing policies and technologies, heightened awareness of environmental issues, training and education initiatives, and the implementation of efficient materials and waste management systems.

The crucial GSCM components were found by Balasubramanian and Shukla in 2017 and transformed into managerially useful GSCM constructs. Furthermore, they confirmed the legitimacy of each of these Green Supply Chain Management (GSCM) elements for all

stakeholders, incorporating the second-order latent construct (core green practices). A significant advancement in the research realm lies in the operationalization of essential green practices as a second-order latent concept. The GSCM constructs were successfully integrated into a useful and experimentally tractable GSCM framework in this study.

Branch (2018) has talked on the methods construction project managers do to make their projects environmentally sustainable. He advised senior project managers to make sure that stakeholders are informed of the most recent laws and fashions in order to start implementing environmental sustainability practices. In order to implement ecologically friendly methods for the construction business, there should be a shared vision, set of values, and plan. Before a project is started, stakeholders should be consulted. This will raise awareness of environmental sustainability in the construction sector.

Farida et al. (2018) proposed a framework for green material management in the construction sector, consisting of five dimensions, 16 elements, and 20 indicators. They aimed to promote sustainable construction and reduce carbon emissions through environmentally friendly practices, particularly green transportation. Wibowo et al. (2018) developed a framework for green supply chain management (GSCM) in the construction sector using the Delphi methodology. The model consists of five concepts (green initiation, green product design, green material management, green construction, and green operation and maintenance), 22 dimensions, and 86 elements. Both studies emphasize the importance of adopting environmentally friendly practices in the construction sector.

Samaraweera and Gunawardhana (2019) conducted an analysis of the difficulties to the implementation of GSCM in building construction by Sri Lankan construction organizations. The enforcement of current legal frameworks on construction [the rating of government and semi-government buildings which is compulsory for those, and also the private sector can apply] and waste disposal are found to be insufficient, according to their analysis of the barriers to developing an action plan/legal framework for Sri Lankan building construction organizations. They came to the conclusion that organizational policies, visions, and missions within the construction industry generally cover sustainable construction concepts. However, it falls short because their primary goals are profit and competitiveness.

Wiguna et al. (2021) proposed a comprehensive Green Supply Chain Management (GSCM) framework for Indonesia's construction sector, integrating seven green practices linked to each other. This study provided a platform for ranking GSCM practices and stakeholders. Alnahhal et al. (2021) created a framework for the UAE's construction industry, including green initiation, design, construction, and operation and maintenance. Results showed a strong association with all GSCM principles and dimensions, and environmentally friendly materials were used at a reasonable level, regardless of respondents' experience. Harouache et al. (2021) put forward a conceptual framework tailored to Algeria's construction sector, emphasizing the adoption of three core Green Supply Chain Management (GSCM) practices to enhance environmental sustainability and performance. These practices encompass green procurement, reverse logistics, and customer relationships, alongside research and development cooperation and supplier evaluation. The effectiveness of GSCM initiatives is underpinned by factors such as top management support, organizational environmental policy, investment recovery, and green ecological design. These findings underscore the significance of GSCM adoption within the construction industry.

2.2.5. Policy-level interventions

Labouze *et al*. (2003) overviewed the distribution of environmental impacts across the various life cycle-stages of construction product groups, included case studies on specific products and/or product-service systems, and offered a framework for prioritizing potential policy measures.

Meacham *et al*. (2005) addressed whether the current performance-based regulatory framework can change to suit society's needs for building regulation. They acknowledged that despite the fact that performance-based building regulations are implemented or being developed in many nations around the world, there are still significant difficulties in accurately defining performance, comprehending and meeting a range of societal expectations, and establishing reliable performance-based regulatory systems. Building regulatory tools must be expected to be valid across borders, not to obstruct commerce, and to satisfy local and national demands without sacrificing local cultural and societal norms. These difficulties are made more difficult by the building construction market's growing globalization.

The life-cycle effects of societal consumption as a whole and the relative weight of several final consumption categories were examined by Tukker and Jansen in 2006. They discovered that building and related housing were the main consumers of energy and advise utilizing LCA mode to examine the effects of potential policy changes, especially those that may affect consumption quantities.

The environmental pressure brought on by various product groups eaten in Sweden was measured and ranked by Palm *et al*. (2006). Utilizing data from economic and environmental statistics, this is done. With the aid of input-output analysis, about 50 product categories are examined during the year 1998. For the objectives of integrated product policy (IPP), this kind of study has several significant advantages. The most significant product categories for private consumption were determined to be transportation and construction. The potential for creating IPP indicators is also highlighted.

Varnas et al. (2009) conducted a study on green procurement in Swedish construction projects, revealing that both public and private clients consider environmental concerns when making purchases. Environmental requirements are often expressed as environmental preferences. Tykka et al. (2010) evaluated the sources of innovation in wood frame construction firms, examining whether novel EU construction policies in six European nations influenced timber-frame innovation at the firm level. The findings showed that timber-framed companies are now participating in the building sector, driven by business opportunities from demographic changes in the environment, such as environmental sustainability and affordable housing for lower income groups.

To achieve synergistic impacts on waste management, resource protection, and GHG emission reduction, Sakai *et al*. (2011) designed an integrated policy focused on the 3R. The results of the international comparative research on 3R policies demonstrated that these policies' objectives are developed not only as straightforward waste management strategies but also as a means of achieving synergistic effects with national strategies aimed at avoiding landfills, obtaining resources, and lowering greenhouse gas emissions.

According to Stahel (2013), a straightforward and compelling approach—a modification to a tax system grounded in sustainability principles—could expedite the transition to a circular economy. This approach involves transitioning from taxing renewable resources,

such as human labor (work), to taxing non-renewable resources. By imposing taxes on materials and energy, there would be an incentive for adopting low-carbon and low-resource solutions, thereby steering away from a "linear" global economy reliant on fuel-based transportation for commodity movement. This transformation would promote various "caring" activities, encompassing the preservation of cultural heritage and natural assets, provision of healthcare services, dissemination of information and expertise, alongside substantial enhancements in material and energy efficiency, regional employment opportunities, and reductions in national greenhouse gas emissions.

Ogunbiyi (2014) emphasised the importance and requirement of a building code in Nigeria to ensure the efficient functioning of experts in the construction business. The code's numerous sections and subsections are examined to demonstrate their importance and influence on the actions of the leading professionals in the sector. In his final remarks, he emphasized the thirteen (13) main sections and subsections of the code and its applicability to the many professions working in Nigeria's construction sector. It points out the fundamental topics that have an impact on and are relevant to professionals.

New empirical data on the effects of various technology policies on businesses' innovative behaviour is presented by Guerzoni and Raiteri's (2015) study. They looked into how policies affected innovative activity and how they interacted. Although research has extensively examined and experimentally analyzed supply-side policies such as R&D subsidies and tax credits, the investigation of innovative public procurement is an emerging focus in the literature but remains lacking in robust empirical evidence. It has been suggested that disregarding simultaneous public programs aiming for the same objective while evaluating the efficacy of a policy instrument in a quasi-experimental scenario may lead to procedural errors due to hidden treatments.

Dadhich et al. used a plasterboard supply chain of a top European distributor and building material contractor as a case study for hybrid lifecycle assessment (LCA) techniques. They found that the company had implemented the Low Carbon Business Policy and received ISO 14001 certification, leading to the Carbon Trust Standard. Cross-docking practices and renewable energy use were found to be significant decarbonization interventions. Beldek et al. (2016) investigated the cost-benefit and social-benefit reflections of green supply chain and reverse logistics in construction demolition waste (CDW) in Turkey

under current government-mandated legislation. They found numerical disparities between Turkish and EU legislation, as the excavation soil and CDW management regulations do not include target numbers, causing construction firms to be unaware of the waste's effects.

Agenda (2016) explores the role of national governments as regulators and policymakers in the Engineering and Construction sector, focusing on how new technologies, materials, and processes can improve project delivery and building life-cycle performance. The study found that government influence can affect technology development and diffusion. Advocacy strategies are crucial as a counterweight to the constantly changing regulatory regime. Chang et al. (2016) conducted an analysis of China's policy system aimed at facilitating the transition to sustainable construction. Their study revealed that laws and regulations play a crucial role in regulating the behaviors of various participants in the construction sector. They identified key supporting activities such as technology innovation, enhancement of standards, establishment of demonstration projects, and publicity efforts. However, the study also highlighted two emerging challenges: the inadequate consideration of the social and economic dimensions of sustainable construction and the ineffectiveness of key policies like environmental impact assessment.

Milios (2018) mapped the EU's resource policy framework, finding that materials efficiency policies are underutilized in the production and consumption stages. He identified three policy areas for improving resource efficiency: reuse, repair, remanufacturing, green public procurement, and improving secondary materials markets. He also proposed a transitional road to circular economy policy making. Li et al. (2018) investigated how construction enterprises perceive industrialized residential building (IRB) policy through literature review assessment and explored the relationship between perception and policy acceptance. Their study aimed to develop a theoretical framework for future studies on IRB perceptions, aiming to promote industrialized residential building policies.

Cui and Zhang (2018) conducted a comparative analysis of Circular Economy (CE) development influenced by China's public policy and research. They performed a selective analysis of 248 articles through bibliometric literature review to identify research trends and gaps in China. Additionally, they integrated these findings with the implementation of

circular economy practices in China's 10th, 11th, and 12th 'Five-Year Plans'. By examining the interaction between research and practice, they summarized the developmental trajectory of CE research and practice and explored potential new research directions. Their analysis revealed a decrease in the number of published articles in Chinese domestic journals post-2010, juxtaposed with an increase in publications in international journals. Notably, CE research and practice witnessed significant advancements during the 12th Five-Year Plan period (2011-2014), where circular economy development assumed a pivotal role, being positioned as a crucial component of China's ecological civilization.

Domenech and Bahn-Walkowiak (2019) examined the EU and Member States' policy frameworks for Resource Efficient Circular Economy (RE/CE) and identified three interdependent components: the policy framework, economic incentive system, and economic side policies. They found that these frameworks are fragmented and complex, with projects' success limited by conflicting objectives and viewpoints. They suggested coordinated policies from the EU and MS to improve RE, but acknowledged the challenges of creating such cooperation. Han (2019) highlighted the importance of green initiatives tailored to local conditions and governance elements in facilitating sustainable urbanization. Singapore's top-down policy-making tradition and developmental state legacy have been adapted to collaborative partnerships with multiple stakeholders, resulting in an effective mode of new green urban governance. Yu (2020) suggested the government should build a green logistics evaluation system, improve policies and regulations, and strengthen infrastructure construction.

Khan (2020) discusses the importance of promoting cooperation among stakeholders in the green building supply chain from both environmental construction and system construction perspectives. He believes that green building is the result of multi-subject cooperation and the integration of "4R+1D" technology. Xie et al. (2020) use structural equation modelling to examine causal linkages between constructs and found that environmental rules have a positive impact on the adoption of green building supply chain management (GSCM) practices. Businesses under intense market pressure are more motivated to seek government assistance and form PPPs to actively participate in GSCM practices.

Li et al. (2021) studied the success rate of environmental law implementation and policy development in wealthier countries and less-developed states. They found that in less-developed states, environmental law differs significantly from moral values, necessitating changes in moral values for successful implementation. Synchronization of policies and cultures may take generations, but successful legal adoption is more likely in well-developed regions. Raoufi and Fayek (2021) surveyed building businesses in North America to identify and evaluate mitigating measures for the Covid-19 pandemic. They identified 177 interventions, divided into 16 categories, and made tentative recommendations based on the early results.

Jin et al. (2021) investigated the regulations and policies facilitating global Construction Industrialization (CI) to provide a comprehensive insight into its interconnections and developmental patterns. They identified and scrutinized seven crucial themes in CI policy formulation—regulatory policies, standardized policies, promotional policies, urban design and planning policies, technological policies, managerial and educational policies, and sustainability policies—by conducting annual publication trend analysis, geospatial distribution, and citation analysis. Through the exploration and discussion of the internal relationships and reciprocal influences among these seven categorized policies, the researchers enhanced the understanding of current CI policy research and provided guidance for future research endeavors.

Chen and Ye (2022) studied the impact of government intervention on oligopolies, which promote collaboration in green supply chains. They found that these oligopolies enhance collaboration intentions and can guide consumers to follow leaders. They concluded that these oligopolies are crucial for green environmental improvement. Jin et al. (2022) analyzed the policy driving forces (PDFs) related to modular integrated construction (MiC) projects in Hong Kong, aiming to educate policymakers on how to launch legislation to support MiC practice in the increasingly popular city. Both studies contribute to the understanding of MiC practices in Hong Kong.

2.2.6. DELPHI METHOD

Hallowell and Gambatese (2010) suggested a standardized yet adaptable approach for research in construction engineering and management (CEM), with the goal of comprehending the advantages, application, and methodology of the conventional Delphi

process. The method is often used when traditional methods fail due to complex topics or sensitive data. However, it has seen minimal use due to variation among studies and ambiguity in literature. Hasson and Keeney (2011) discussed the importance of establishing rigor in Delphi studies, focusing on reliability, validity, and trustworthiness. They propose using both qualitative and quantitative measurements and corroborating results with relevant evidence to enhance the development and utilization of rigour in the future. Xia and Chan (2012) conducted research on project complexity in the People's Republic of China through a Delphi questionnaire survey. They identified six primary measures: building structure and function, construction method, project schedule urgency, project size/scale, geological conditions, and neighboring environment. Utilizing the Delphi method as a self-validating mechanism, they established a valuable framework for accessing expert knowledge.

Similarly, Mozaffari et al. (2012) employed the Delphi technique to recognize the most significant complexity factors in Iran's construction industry. They provided detailed recommendations for mitigating project complexity, emphasizing the necessity for integrating modern project management concepts in Iran. Agumba and Musonda (2013) examined the significance of the Delphi method in attaining consensus on intricate matters. They shared insights from their utilization of the method with seasoned health and safety professionals in two case studies within the South African construction sector. They assert that while the Delphi method is effective in reaching agreement on demanding health and safety concerns in construction, effective communication is essential for yielding meaningful results.

Sourani and Sohail (2014) conducted a review on the Delphi Method, a systematic procedure utilized to achieve consensus among experts across various fields, including construction management. While the method is widely employed to identify areas of uncertainty or lack of agreed knowledge, its application in construction research has been limited due to factors such as limited awareness, lack of clear guidance, and variations in its utilization. The main characteristics of the Delphi method include anonymity, iteration with controlled feedback, and statistical group response, which optimize committee usage and offer the opportunity for quantitative analysis of results. Employing the Delphi method in students' research projects provides several key learning benefits, including deep learning, knowledge generation, critical thinking skills development, feedback

incorporation, identity and career planning, simultaneous utilization of qualitative and quantitative research approaches, self-validation, and flexibility.

Ameyaw et al. (2014) found that the Delphi method can be enhanced by combining it with advanced modeling techniques like fuzzy sets and the analytical hierarchy process. The Delphi method is a robust tool used for purposes such as identifying, evaluating, and forecasting in various aspects of project planning, design, contracting, labor and personnel issues, as well as organizational matters. Habibi et al. (2014) presented a comprehensive theoretical framework for the application of Delphi in qualitative research, explaining its application and consensus principles. The study recommends using a group of ten experts with different specialties, snowball sampling, a nine-point Likert scale, and Kendall's coefficient of concordance to achieve consensus when developing sets of indicators.

Renzi and Freitas (2015) utilized the Delphi method to predict technological and innovation advances and interaction expectations in the next 5 to 10 years. This method, originating in the 1960s, involves inviting and filtering experts to create a consensus based on their experiences and perspectives. The process can generate various future possibilities, with experts from different parts of the world having similar ideas and expectations. The success of the method depends on the expertise involved, and careful research and filtering are recommended before sending invitations. The majority of acceptance comes from experts within the chain of contacts, but conferences can also serve as a resource for adding new contacts. Some predictions are already appearing in papers, labs, lectures, and conferences.

Tengan and Aigbavboa (2017) discussed the implementation of the Delphi technique in the Ghanaian construction industry, focusing on the importance and relevance of monitoring and evaluation (M&E) implementation in project success. The experts involved researchers from industry, research institutions, and higher learning faculties in two iterative rounds. After two rounds, consensus was reached on the need for and relevance of M&E. The study recommends clear instructions for Delphi experts and a short-structured questionnaire for high response rates. They argue that the Delphi technique is crucial for studies where consensus on the need and relevance of construction project management practices is yet to be reached. In another study, Mazzucca et al. (2018) found that the Delphi method is a useful tool for spotting, assessing, and forecasting in construction

safety research. They found that construction researchers often use a panel of 8–20 experts for consensus building, using Likert scales and techniques like standard deviation and Kendall's coefficient of concordance. Although not widely used in construction safety and health research, the Delphi method has potential for greater use in this field to assess the adoption of research findings on construction sites and influence safety and health outcomes. Emerging research using Delphi panels can use similar parameters to guide its development and implementation.

In 2019, Ametepey et al. documented the Delphi technique, developed in the 1950s by the RAND Corporation, as a widely recognized research method for predicting and understanding sustainable infrastructure development in developing countries. The technique involves a survey conducted in two or more rounds, with participants providing feedback in the second round. Despite numerous empirical studies supporting the technique, it has not been widely used to study sustainable infrastructure development due to the need to solicit experts' views on complex subjects. Hsu and Sandford (2019) underscored the significance of the Delphi technique as a widely employed approach for gathering insights from experts regarding real-world issues. They utilized questionnaires distributed multiple times to collect data from a panel of chosen participants. However, they cautioned that when designing and executing a Delphi study, considerations such as subject selection, time frames, low response rates, and inadvertent feedback should be taken into account.

Similarly, Fink-Hafner et al. (2019) investigated the efficacy of the Delphi method in achieving consensus among academics regarding definitions, particularly within social science domains. They introduced a specialized Delphi approach aimed at identifying minimal common definitions of globalization, Europeanization, and internationalization in higher education. They also discussed its strengths and weaknesses, proposed ways to adjust the Delphi method, and evaluated Delphi results through focus groups, surveys, and further analysis of 'lost' data. Yusuwan et al (2019) revealed that a good contractual claim requires factual evidence, complete documents, and competent handling. The success of an Extension of Time (EoT) claim in the ‘Malaysian Building Industry’ is closely related to the sufficiency and completeness of documents and the competency of handling claims.

Nasa et al. (2021) scrutinized the Delphi methodology in healthcare research, uncovering

inconsistencies in reporting fundamental elements such as panel member identification, consensus definition, round closing criteria, and results presentation. They propose evaluation criteria for researchers, medical journal editorial boards, and reviewers.

Belay et al. (2021) investigated success factors in Ethiopia's public and private construction sectors using a hierarchical model and Delphi-Analytic Hierarchy Process. They identified clear project goals, financial capacity of contractors, and consulting firm competency as the top three critical success factors in private construction projects. In public construction projects, adequacy of funds, political environment, clear project goals, contractor competency, and technology and innovation were deemed major critical success factors.

Ansah *et al.* (2021) employed the Delphi technique to forecast Total Quality Management constructs in the Ghanaian construction industry. Willar et al.'s (2022) research on quality management in Indonesian road construction projects uncovered challenges in implementing processes and explored countermeasures. Their study adopted a mixed quantitative and qualitative approach, focusing on Delphi questionnaire surveys and focus group interviews. They observed that quality standards and documentation pose challenges during the preconstruction stage, emphasizing the pivotal role of the project team in quality control activities. The study, the first of its kind to assess quality management processes in Indonesian road projects, advocates for detailed standard operating procedures, project checklists, and quality measurement standards.

Ali and Akkas (2023) conducted a study utilizing the Delphi Method to investigate the incorporation of data sciences and smart technologies in the construction industry, particularly in air conditioning project management. The research yielded varied outcomes, questioning the assumption that location impacts worker safety and that surpassing international safety standards results in cost savings. Nonetheless, it underscored the significance of global safety standards and the contribution of data sciences and smart technologies in bolstering human safety. Wu et al. (2023) emphasized the importance of the environmental protection industry in China for ecological civilization and economic growth, developing evaluation index systems to assess the competitiveness of environmental protection enterprises. Kazmi and Chakraborty (2023) proposed a circular economy to optimize resources and eliminate waste in the construction

industry, identifying 144 indicators through literature review and a three-round Delphi survey. Wang et al. (2023) used a hybrid multi-criteria decision-making framework to study the role of AI tools in the construction industry, finding that technological factors were the most crucial, followed by environmental factors. Al-Rawe and Naimi (2023) focused on improving risk estimation accuracy and efficiency for successful completion of construction projects and infrastructure development in Iraq and other developing countries. The methodology proposed can be adapted for similar construction industries. Accurate risk and cost estimation are crucial for the success of construction projects in Iraq, enabling project teams to develop realistic budgets and schedules, as well as effective risk management strategies.

2.3. NATIONAL

2.3.1. Sustainability and construction industry

2.3.1.1. Performance evaluation

Kumar et al. (2012) devised a quantified index focusing on energy consumption in building materials and usage, along with associated environmental emissions, to promote the preservation of finite natural resources. They conducted a comparison between two structural types: fireclay brick structures and ash block structures. Despite the ash blocks being three times more expensive than fireclay bricks, their utilization significantly reduced the size of the air conditioning system, overall energy usage, and ultimately the total building cost due to their lightweight and insulating properties. Consequently, the adoption of ash blocks has contributed to the conservation of natural resources, energy, and the environment.

Gupta et al. (2019) conducted an exploratory study to create and implement a tailored building performance evaluation (BPE) method for the Indian setting, known as the I-BPE framework, aimed at assessing the actual performance of green buildings. This involved an expert survey and an analysis of a case study building. Findings from the expert survey highlighted a significant hurdle to the widespread adoption of BPE, which is the shortage of skilled professionals capable of instructing on BPE practices. This underscores the importance of having trained individuals alongside effective frameworks.

2.3.1.2. Energy

To ensure minimal energy for building, Joshi and Kambekar (2013) evaluated the embodied energy of the materials used in the construction of a building in Kalyan, Maharashtra, and made comparisons with other alternative materials. They discovered that the college building's total embodied energy for all materials was 19,01,9008 MJ. If clay bricks are used instead of fly ash bricks, it saves around 1288825 MJ and reduces energy consumption by about 74.6%. It also lowers costs by about 14% and lowers carbon emissions by about 26.6%. AAC blocks cut energy usage by 45% but raise costs by 39%. With a 6% cost increase, using PPC instead of OPC reduces energy use by 33% and carbon emissions by 13%. When compared to Terrazo tile, which has an increase in cost of 13%, the usage of Kota stone saves energy consumption by 7% and carbon emissions by 1.6%.

2.3.1.3.Waste

Arif et al. (2012) conducted an initial investigation into waste management practices within the construction industry in India, identifying strategies for more efficient waste management. They pinpointed significant obstacles encountered in the implementation of these practices and emphasized the necessity for project management to adapt to integrate waste management effectively.

Sharma et al. (2020) examined the utilization of Reclaimed Asphalt Pavement (RAP) in Warm Mix Asphalt (WMA) technology, which exhibited favorable performance outcomes. They proposed that future advancements in RAP incorporation in WMA should aim for complete recycling, with recycled materials comprising up to 70% considered acceptable. Additionally, they recommended the adoption of WMA technology to address issues such as elevated emissions during RAP blending with virgin aggregate and premature cracking due to aging binder. Their discussion encompassed various aspects of WMA technology, including classification, mix design protocols, the era of recycling, utilization of RAP and RAS, and the significance of rejuvenators in WMA.

2.3.1.4. Transportation

The requirements and advancements for the development of transportation infrastructure were examined by Subramanian (2011). He summed up by saying that a variety of cutting-

edge materials and techniques have been developed to increase the lifespan of bridges and keep maintenance costs low. Bridge sustainability involves thorough life-cost and energy-use analysis. Similar advancements in pavement and road construction materials and methods have been made. To create green highways, pervious pavements and other environmentally friendly practices like recycling are required.

In his 2017 article, Narayanaswami covered a variety of managerial issues of creating, planning, and developing a significant amount of infrastructure-intensive public transportation service. As a result, it's crucial to research and comprehend some of the cutting-edge techniques and procedures for benchmarking in urban transportation projects. Only when the current infrastructure and urban transportation systems are unable to keep up with rising traffic demands is it determined that an urban transportation project is necessary.

Singh et al. (2018) conducted a study investigating the technologies and strategies employed to attain transportation planning credits within the IGBC Green Townships rating system. Their research aimed to comprehend the obstacles encountered in obtaining green township credits, essential for enhancing connectivity, social responsibility, and overall well-being.

Vajjarapu et al. (2020) proposed a methodological framework for assessing adaptation strategies aimed at mitigating the impact of urban flooding on the transportation sector. They recommended that cities enhance the coverage of unaffected metro and monorail systems within their networks and outlined parameters for evaluating adaptation policies.

Gupta and Garg (2020) evaluated the role of the transportation sector in realizing sustainable development and carbon neutrality in India. They advocated for a comprehensive transformation of India's transportation sector, emphasizing the importance of optimizing modal distribution, integrating intermodal transportation systems, and enhancing first and last-mile connectivity. Their analysis utilized economy-wide and techno-economic models, incorporating iterative exchanges of key drivers to develop policy-relevant pathways. While estimating a cumulative investment cost of 4.2 trillion USD from 2013 to 2050 for these transitions, they suggested that a reduction in fuel imports could offset these expenses. Moreover, they highlighted the potential for infrastructure and logistics development to generate employment opportunities and

enhance living standards.

2.3.2. SCM and construction industry

Malviya and Kant (2015) examined the current state of research on Green Supply Chain Management (GSCM) and its portrayal across various parameters. The study has looked into a number of factors, such as the journals that publish articles on GSCM research the most frequently, the authors who have published the most articles in the Analytical arena (the unit of analysis/ research design, the techniques used to analyze the data, the theories and theoretical constructs employed, and the contexts examined). They discovered that the most often written about subjects in the GSCM area included organizational practices, environmental concerns, process, performance, and sustainability.

Reshma and Laxmiprasad (2014) looked into the importance of GSCM as well as the motivations behind it and the difficulties that India's construction industry is facing in putting it into practice. To include environmental thinking into supply chain management, they experimented with the GSCM concept. They came to understand that creative, environmentally friendly concepts may help businesses make money while also benefiting the environment. Consequently, Green Supply Chain Management (GSCM) not only improves environmental performance but also contributes to cost reduction, heightened productivity, and expedited innovation.

Srivastav and Gaur (2015) undertook an evaluation of green supply chain management within the construction industry in northern India to investigate opportunities for advancing sustainable development. Their assessment included analyzing the environmental repercussions of construction materials, scrutinizing the implementation of green supply chain management practices by construction firms in northern India, and evaluating the reception of green purchasing strategies within the industry.

Singh and Trivedi conducted a comprehensive analysis in 2016 to assess the future research trends by examining the research inquiries derived from an exhaustive and systematic review of existing literature. Their findings revealed a growing interest among scholars and industry experts over the last decade in the domain of sustainable green supply chain management. Their analysis showed that there is a need to address behavioural issues such supply chain partner relationship management and human

resource management. Researchers and practitioners are beginning to pay more attention to the use of IT and information systems. Recycling, waste management, and reverse logistics are widely recognised as essential for the successful application of green techniques.

Kulkarni et al. (2017) conducted an analysis of the current state and potential of Green Supply Chain Management (GSCM) within the Indian construction sector, focusing particularly on the factors influencing its implementation. They observed that many construction firms express favorable intentions and are committed to procuring environmentally sustainable materials, including recycled ones, while emphasizing waste management as a key aspect of environmental performance.

Jayant and Tiwari (2017) undertook a comparative study of sustainability and implementation challenges across China, India, and Brazil. Their findings indicated that initiatives with a strong emphasis on green manufacturing and production, particularly those centered on raw material and component recycling, are of paramount importance. They noted that the adoption of green practices is most pronounced in areas where cost reduction and efficiency gains are directly linked, such as inventory optimization and raw material reuse.

Negi et al. (2017) delved into the intricate workings of supply chain mechanisms in the construction domain, with a specific focus on drivers like Facilities, Inventory, Transportation, Information, Sourcing, and Pricing. Their analysis underscored the significance of waste reduction, the maximization of eco-friendly and locally sourced materials, and the timely and cost-effective completion of high-quality projects as pivotal factors for achieving sustainability in construction endeavors.

Mojumder and Singh (2021) investigated the readiness of various Indian construction enterprises to embrace green supply chain practices, assessing the correlation between drivers, facilitators, and obstacles and the industry's inclination towards adopting environmentally responsible supply chain practices.

2.3.2.1. GSCM Monitoring

Yadav and Ray (2015) conducted a comparative analysis between Supply Chain Management (SCM) practices in the Indian construction sector and the seamless project

SCM model proposed by Love et al. (2004). They recommended several adjustments and enhancements to the seamless project SCM model proposed by Love et al. (2004) to better align it with the operational context of developing nations like India. Specifically, they highlighted the need for fostering long-term partnerships among stakeholders, such as clients and project managers, to extend beyond individual projects and encompass specific project categories or types (e.g., flyovers, roads, factory buildings, airports).

Subramani and Tamizhanban (2016) examined the potential and roles of SCM within the construction industry, focusing particularly on the supply chain dynamics of key contractors. They emphasized that the expansion of supply chains in construction can also be influenced by real estate developers. Additionally, they investigated the predominant use of trucks as the primary mode of transportation in the cement sector of Tamil Nadu, exploring strategies to mitigate associated risks and inefficiencies.

Tripathi and Gupta (2019) aimed to gain insights into the diverse and intricate nature of performance measurement systems across various industries by gathering key performance indicators. Their objective was to critically assess the existing literature on supply chain performance measurement, providing a comprehensive evaluation of its diversity and complexity.

2.3.3. Drivers and Barriers in GSCM

Dashore and Sohani (2013) developed a hierarchical sustainable framework to investigate the challenges faced by companies during the implementation of Green Supply Chain Management (GSCM) practices. Through an exhaustive literature review and consultation with expert academicians and professionals, they identified a total of 14 barriers to GSCM implementation. To understand the complexity and interrelation of these barriers, they utilized the interpretive structural modeling (ISM) technique to construct a structural model. Furthermore, they conducted a Driver and Dependence Power Analysis (DDPA) to categorize and identify the primary barriers.

Dube and Gawande (2016) have created an ISM-based model for the organization's effective GSCM 26 implementations for better environmental and financial performance. In order to interpret the structural model with greater sensitivity than only a binary link between the barriers, these 27 ISM-based models have been improved to a fuzzy ISM-

based model. Furthermore, when compared to traditional models, this model enhances the MICMAC analysis 22's sensitivity. The findings of the study provide top management with recommendations for how to implement the GSCM programme successfully and efficiently, which will enhance organisational performance.

Lamba and Thareja (2016) pinpointed several barriers in the Indian manufacturing sector that impede supply chain performance. They underscored the significance of mitigating these barriers to facilitate the effective implementation of Green Supply Chain Management (GSCM). Singh and Misra (2020) assessed the ranking of green supply chain practices in the Indian construction industry, examining their environmental consciousness. They found that the government's commitment to promoting green practices in organizations and society's demand for environmental sensitivity were the most promising elements for creating a strong GSCM framework. Both studies highlight the need for proper attention to overcome these barriers.

To construct a hierarchical model demonstrating the causation between the components that were identified as the main obstacles to off-site construction (OSC) implementation in India, Marinelli *et al*. (2022) examined some factors. In order to address them more effectively, they have also recorded the barriers that have a significant impact on other barriers. They discovered that the design rigidity, storage and transportation issues, supply chain inadequacies, initial capital requirements, and a lack of expertise are the constraints that specialists believe to be the most significant. However, the ISM demonstrates that issues like public procurement laws and the sector's fragmentation are what are really to blame for these impediments. Therefore, it is suggested that in accordance with the provided techniques, the later impediments should be attacked first.

2.3.4. Framework for GSCM

Excluding the unimportant drivers, Mathiyazhagan *et al*. (2018) proposed a simple benchmarking methodology that identifies the key drivers for the deployment of GSCM. 27 drivers were found to fall into 7 groups after a review of the literature and discussions with specialists. The primary categories were identified as government, market, supplier, customer, internal drivers, and environment. Through the application of the Analytic Hierarchy Process method and expert opinions, the most influential factors driving the adoption of GSCM were ranked. The primary driver for implementing GSCM has been recognised as money

and profit.

2.3.5. Policy-level interventions

Sanganal and Geetha (2014) conducted an examination of the uptake of green building and energy efficiency principles, focusing specifically on Bangalore and Mysore cities. They aimed to identify any challenges or constraints associated with the adoption of these concepts. They noted that builders are gradually adopting green building principles and that having numerous regulations and standards will only increase ambiguity and may hinder the development of green buildings. For more buildings to embrace ratings and codes, they need to have minimal requirements and documentation procedures. The requirements could be too strict for some tasks. It is necessary to work toward making ECBC a requirement. Only buildings that need the approval of the environmental ministry, such as green buildings and TERI GRIHA-rated buildings, are now required to have it. Building byelaws can be adopted to do this.

Mahant (2015) analyzed supply chain management models, their frameworks, and their relevance to the government and public-sector enterprises. They concluded that effective implementation requires trust, information, and transparency. Singh et al. (2017) highlighted the absence of regulatory bodies that address societal and ecological concerns in business growth. They assessed the development of Green Supply Chain Management (GSCM) strategies and focused on environmental and social sustainability in operations management and supply chain management. Abraham and Gundimeda (2018) highlighted the need for eco-labelling of green structures to ensure investors understand the value of their investment. The concept of "Green Leases" for green buildings can increase rent and property resale value. A strategic combination of tools, including regulation, taxes, green consumer subsidies, preferred housing loans, and information disclosures, is needed. The study reveals numerous impediments to India's transition to green construction, suggesting that a single strategy may not be sufficient. Government regulation, command and control, and market-based instruments are needed to facilitate this shift.

While the use of smart building technologies (SBTs) ensures sustainability, it has been found that adoption is hindered by hidden hurdles, particularly in project management procedures. To enable the successful and widespread use of SBTs in developing nations, like Ghana, these hidden obstacles must be removed (Ghansah *et al*., 2020). In order to

evaluate the potential for igniting a more extensive polemic debate among construction stakeholders and motivating government policymakers to invest in beneficial, long-term interventions in developing countries, they looked into the significant latent barriers hindering project management processes in those nations.

Sharma et al. (2021) highlighted the significant green initiatives within supply networks, which include the development of environmental strategies, policies, and procedures, along with performance evaluation and long-term sustainability action plans. These interventions exhibit high driving power and low dependence power, emphasizing the adoption of advanced technology, cleaner production methods, participation in industry-wide sustainability programs, green distribution practices, supplier selection criteria, reverse logistics strategies, efficient transportation management, eco-friendly design principles, and supply chain mapping.

On the other hand, Zhao (2021) examined the factors influencing construction and demolition waste management (C&D WM) and established connections between these factors and the stakeholders involved. They found that lax enforcement of environmental protection laws often leads to contractors neglecting C&D WM and resorting to illegal waste disposal methods. Effective legislation and regulations are deemed essential for promoting good C&D WM practices, particularly in countries like India, where only a mere 1% of C&D waste gets recycled.

2.3.6. Delphi Method

Sawhney et al. (2014) used the Grand Challenges Approach (GCA) to identify challenges in the construction sector in emerging economies, including India. The study involved a Delphi process and a survey of 39 professionals from various sectors. The results indicate that tackling these obstacles on a national scale has the potential to revolutionize the industry, leading to enhanced efficiency, quality focus, and overall success.

Kirun and Varghese (2015) conducted a literature review to understand factors affecting local construction projects' performance and importance in Ernakulum district. They identified major problems and used Delphi techniques and questionnaire surveys to investigate project cost control and cost overruns. Key findings highlighted the complexity of the learning process and the importance of effective cost management in construction

projects.

Akbari and Qureshi (2018) focused on methodologies to analyze delays in Indian construction projects, highlighting its significance for the nation's fortune, job growth, and substantial investment opportunities. The Delphi method, which requires fewer time and resources, is appropriate for assessing variables contributing to delays.

Ingle (2020) analyzed the Indian construction industry's challenges due to performance shortfalls and lack of well-established performance assessment models. They devised a mathematical representation for evaluating construction project performance, adapting the initial Project Quarterback Rating (PQR) model. This revised model consisted of ten performance domains and 28 performance indicators. To gather qualitative data, they employed a mixed-method research strategy, utilizing survey questionnaires and case studies.

2.4. Gap Identification: Literature Review

Even though supply chain management, circular economy, sustainable construction, and infrastructure development are hot topics for the era, the policy assertions in the scenario that help to fasten the transformation are completely lacking in a way. A crucial first step in developing a theoretical framework for green transformation is highly susceptible to the delineation of the lacuna in the existing course of survey. The subsequent gaps identified from the analysis enlighten the scope of the research in this area further to achieve a consolidate and stable concrete basis for environmentally friendly construction with minimal emissions and pollution.

The thesis aims to compensate for the limitations of existing literature on green transformation in the Indian construction supply chain. During the literature survey, it has been observed that so many gaps exist, especially in the comprehensive theoretical framework, use of the Delphi method in policy assessment, stakeholder perspectives in policy assessment, sustainable practices and policy frameworks, green transformation in the Indian construction supply chain, and related case studies. The goal of the thesis is to enrich comprehension regarding the green transformation within the Indian construction supply chain by filling in the gaps present in the current body of knowledge. It will serve as an exemplary study to demonstrate the shortcomings of Delphi technique in policy assessment for green transformation. The thesis aims to bridge the gap between

sustainable practices and policy frameworks in the Indian setting by providing a comprehensive perspective and focusing on real-world examples of successful green transformation in the Indian construction sector.

CHAPTER III

THEORETICAL FRAMEWORK

3.1. Introduction

The theoretical framework chapter is crucial for establishing the research's conceptual basis. It introduces the broader context by presenting existing knowledge, theories, and concepts relevant to the study. The chapter should conceptualize the route of research work, possible outcomes, existing gaps, expectable debates, and areas where the research will contribute, as it should define central concepts, terms, and variables and present the theoretical foundations, discussing major theories or frameworks that guide the study. Identifying research gaps is essential, as it highlights areas of ambiguity in the existing literature and suggests areas for further investigation. It will provide a rationale for the chosen approach, assess its strengths and weaknesses, and clarify why it is the most appropriate method for tackling the research inquiries (Sileyew, 2019). This will be linked to the selected research methods, illustrating how these theories shape the research framework, methods of data collection, and techniques for data analysis.

The transition toward sustainability in India's construction supply chain necessitates a multifaceted strategy (Montag, 2023), encompassing the conceptualization of green transformation, the supply chain's role in sustainable practices, utilization of the Delphi Method, policy interventions, and the establishment of legal or conceptual frameworks. This holistic approach serves as the theoretical foundation for comprehending, planning, and successfully executing eco-friendly initiatives within the construction sector. The framework amalgamates three interconnected and core theoretical concepts: the conceptualization of green transformation, the supply chain's involvement in sustainable practices, and the applicability of the Delphi Method.

3.2. Holistic Vision of Green Transformation:

The construction sector is moving towards sustainability through a holistic approach called Green Transformation. This involves environmental regulations, incorporating circular economy principles, extended producer responsibility, life cycle assessments, and a commitment to social and economic sustainability. This approach aims to minimize environmental impact while contributing positively to societal well-being and economic

growth (Jayarathna et al., 2023). This holistic approach sets the stage for a thorough cognizing of sustainability in the building and development sector.

The green transformation in solid waste management involves a comprehensive understanding of the theoretical frameworks that underpin environmentally sustainable practices. This framework serves as the foundation for understanding the complexities of adopting green initiatives in India's construction supply chain. Core principles play a vital role in driving this transformation, integrating diverse viewpoints to offer a comprehensive grasp of the factors, obstacles, and prospects linked to sustainable practices within the construction industry.

1. **Life Cycle Assessment (LCA):** Life Cycle Assessment (LCA) serves as a methodological tool for gauging the ecological ramifications of a product or process from inception to disposal. Its application in scrutinizing the environmental footprint of construction materials, procedures, and waste management strategies facilitates informed decision-making toward more sustainable alternatives (Khasreen et al., 2009).

2. **Green Supply Chain Management (GSCM):** Green Supply Chain Management (GSCM) amalgamates environmental concerns into supply chain operations to mitigate their ecological footprint. Investigating the incorporation of GSCM principles within the construction supply chain encompasses aspects like sustainable sourcing, transportation, and waste management (Lam et al., 2015).

3. **Circular Economy:** The circular economy paradigm underscores the perpetual utilization, recycling, and repurposing of materials to reduce waste and enhance resource efficiency. Examining the integration of circular economy principles into the construction supply chain aims to mitigate the environmental consequences of waste generation and disposal (Yang et al., 2023).

4. **Institutional Theory for Innovation-Decision:** Institutional theory delves into the impact of institutions, encompassing laws, regulations, and norms, on organizational behavior and the progression of individuals and organizations towards embracing new concepts, methodologies, or technologies within a given society or sector. This study will investigate how institutional pressures shape

green practices within the construction supply chain, with a specific emphasis on regulatory frameworks and policy implementations (Hanna et al., 2023). Employing the innovation-decision process framework, it aims to comprehend the stages of green practices adoption, ranging from initial awareness to widespread acceptance, while also scrutinizing the factors that influence their adoption.

5. **Extended Producer Responsibility (EPR):** Extended Producer Responsibility (EPR) mandates that product manufacturers bear responsibility for their products throughout their life cycle, including disposal and recycling. This study aims to assess the feasibility of implementing EPR programs within the construction sector to encourage sustainable product design, utilization of recyclable materials, and conscientious disposal practices (Gupt and Sahay, 2015).

3.3. Supply Chain as the Engine of Change:

The construction sector relies on its supply chain to champion eco-friendly practices, streamlining operations, reducing waste, and championing sustainability. Green Supply Chain Management (GSCM) emphasizes sustainable logistics, reverse logistics, collaborative supply chains, and corporate social responsibility to facilitate the smooth flow of materials and resources. This theoretical framework delves into the correlation between supply chain dynamics and environmentally responsible practices, laying the groundwork for empirical inquiries into the real-world implementation, hurdles, and potentials of embedding sustainability within the construction supply chain.

1. **Supply Chain Management (SCM):** Supply Chain Management (SCM) entails organizing and enhancing supply chain operations, from sourcing raw materials to delivering finished products. When geared towards environmental sustainability, SCM emphasizes green sourcing, efficient transportation, and waste minimization (Shekarian et al., 2022). Innovation Diffusion in Supply Chains involves propagating green technologies and practices across the entire supply chain.. Factors influencing the diffusion of green innovations include communication, learning mechanisms, and organizational culture. Technologies like blockchain, RFID, and data analytics can enhance transparency, traceability, and environmental performance.

2. **Green Supply Chain Management (GSCM):** GSCM is a sustainable approach that incorporates environmental considerations into traditional supply chain practices. It focuses on eco-friendly processes and product life cycle management. This approach is being explored in the building SC to promote sustainability, reduce carbon footprints, and encourage the development of greener technologies (Chowdhury et al., 2016).

3. **Reverse Logistics:** It involves the movement of resources from consumers to manufacturers for recycling, remanufacturing, or disposal. EMS frameworks like ISO 14001 help organizations manage environmental performance. Incorporating reverse logistics practices can improve construction materials recycling and reuse, reducing waste and promoting a circular economy (Hsu et al., 2016). Implementing EMS within the supply chain ensures systematic environmental management and continuous improvement.

4. **Green Procurement for Sustainable Logistics:** Green procurement and sustainable logistics are strategic approaches aimed at minimizing the environmental footprint within the supply chain. It involves selecting suppliers and products based on environmental criteria, while sustainable logistics focuses on energy-efficient transportation and optimized distribution networks (Teixeira et al., 2018). These methodologies are essential for attaining green supply chain goals within the construction sector.

5. **Corporate Social Responsibility (CSR):** It includes environmental stewardship, especially when it comes to CER (corporate environment responsibility). It all depends on the projects you come across. It stresses social and environmental responsibility in line with green building supply chain principles, while considering the paradigm shift of the construction sector towards eco-friendly plans (Hohnen and Potts, 2007). CSR for creative research, case study statements, etc. can cover the additional costs associated with greening the supply chain.

3.4. Policy/legal frame

Policy and legal frameworks are essential for promoting sustainability in the construction sector. They serve as strategic directives, shaping industry behavior towards

environmental responsibility, while legal support ensures compliance and accountability. Environmental regulations embedded in policy frameworks set benchmarks for construction activities, limiting emissions, optimizing resource use, and mitigating environmental impact. These policies, when underpinned by enforceable legal structures, provide a foundation for compliance, ensuring construction entities adhere to established standards. Policy frameworks are powerful catalysts, setting environmental standards, incentivizing eco-friendly choices, and mandating responsible practices. They also provide a framework for regulatory compliance, ensuring construction entities align with sustainability benchmarks (Ashford and Hall, 2011). They foster innovation, promote research and development, and create a supportive environment for green technology adoption. Policies can influence market dynamics by prioritizing sustainable criteria in public procurement, shaping industry behavior, and signaling a collective commitment to environmental responsibility. The strength of policies lies in their capacity to drive a systemic shift towards sustainability within the construction supply chain, shaping industry norms and fostering a culture of environmental stewardship (Bennett et al., 2018). Effective green transformation requires strategic interventions at the policy level, involving the formulation of policies that incentivize sustainable practices, regulate environmental impact, and encourage collaboration between stakeholders. Theoretical underpinnings guide the design and implementation of policies that align with the envisioned green transformation.

1. **Incentive Mechanisms:** Governments can incentivize construction firms to adopt eco-friendly technologies and practices through financial incentives or tax breaks. Legal frameworks to formalize and enforce these incentives, encouraging companies to invest in green technologies and sustainable materials. Incentive mechanisms, such as green certification programs, are crucial for recognizing and promoting sustainable practices. Legal frameworks formalize certification processes, making adherence a legal requirement for project participation or subsidy eligibility (Chen et al., 2022).

2. **Waste Management Policies:** Construction waste is a major environmental issue, and policies can be developed to promote recycling, reuse, and responsible disposal. Legislation can define waste management responsibilities, impose penalties for improper disposal, and support waste reduction initiatives. Legal

support ensures companies are legally responsible for waste management, discouraging improper disposal. Public procurement policies mandate green criteria in project selection, promoting sustainability. Research and development funding, facilitated through policies, drives innovation for sustainable construction, with legal structures governing the allocation and administration of such funds (Bon and Hutchinson, 2000).

3. **Public Procurement Policies:** Governments can implement policies promoting sustainability in public procurement (construction), formalizing the inclusion of green criteria in procurement processes, thus making sustainability a crucial factor in contractor selection (Shadrina et al., 2022).

4. **Green Certification Programs:** Governments can promote green certification programs, encouraging construction companies to adopt sustainable practices. Legislation can mandate or incentivize adherence to green certification standards, making it a requirement for certain projects or subsidy eligibility (Saka et al., 2021).

5. **Environmental Regulations:** Construction operations can be overseen by stringent environmental regulations, which govern emissions, waste management, and resource utilization, thereby encouraging the adoption of environmentally friendly practices to minimize ecological impact (Chen et al., 2023).

6. **Research & Development & Collaborative Platforms:** Policies can foster collaboration and industry partnerships to promote sustainability in construction. Governments can allocate funds for green construction technologies and materials and promote educational programs and training to enhance professionals' skills in sustainable practices. Legal frameworks can manage these funds, promoting innovation and adoption of sustainable practices. Legislation can mandate the inclusion of sustainability modules in construction education and training programs, ensuring a skilled workforce. These initiatives elevate the industry's skill set and foster a shared commitment to sustainability. The synergy between policies and legal frameworks can activate and sustain the green-shift of the construction industry, ensuring environmental consciousness is ingrained in supply chains (Geng et al., 2017).

3.5. Expert-Driven Consensus Building:

The Delphi Method serves as a structured communication tool employed to attain agreement on intricate subjects like policy interventions for the green transformation of construction supply chains in India. It involves a panel of experts who contribute their insights through iterative questioning, aligning theoretical vision with practical considerations. This method provides a nuanced understanding of challenges and opportunities in implementing green practices (Dalkey and Helmer, 1963). The Delphi method's adaptability ensures that the theoretical framework remains dynamic, responsive to emerging trends and industry shifts. Its adaptability makes it a valuable tool for achieving green transformation, as it helps generate insights, build consensus, and inform policy and strategy for sustainable development. In summary, the Delphi Method proves to be a valuable asset for facilitating green transformation across different domains.

1. **Delphi Analysis Overview:** The Delphi analysis is a systematic approach to gathering insights and opinions from a diverse panel of experts in the construction and sustainability domains through structured questionnaires or surveys, with anonymous feedback provided to reach a consensus.

2. **Expert Panel Selection:** An expert panel, comprised of experts in construction, supply chain management, environmental sustainability, and policy-making, provides comprehensive insights into the green transformation through multiple rounds of questionnaires, ensuring diverse knowledge and experience are utilized in the research.

3. **Iterative Questioning Process:** The Delphi technique is an iterative approach to question formulation that engages multiple rounds of questioning, building on previous responses and feedback. This method allows for adaptability in the face of uncertainty, allowing experts to refine their opinions based on evolving understanding of emerging themes and technologies. It can be used to navigate uncertainties related to emerging technologies, market dynamics, and regulatory changes affecting green transformation.

4. **Anonymity and Confidentiality:** The Delphi method promotes open, honest responses among participants, ensuring anonymity and fostering a collaborative environment for sharing expert insights without fear of judgment.

5. **Quantitative and Qualitative Data Integration:** Delphi is a statistical analytical approach that integrates quantitative data like rating scales with qualitative narratives to provide a comprehensive understanding of expert perspectives on green transformation strategies.

6. **Consensus Building:** Delphi procedure has a cross-disciplinary approach that aims to reach consensus among experts through multiple iterations, allowing for convergence or divergence of opinions. It facilitates the gathering of insights from experts across various disciplines, enabling exploration of scenarios and potential future developments. The method helps identify areas of consensus and divergence, providing a nuanced understanding of priorities and challenges in achieving a green transformation. It considers environmental, economic, and social dimensions, and can be used to explore scenarios related to policy changes, technological advancements, and industry trends influencing the green transformation of the Indian construction manners.

7. **Policy Recommendations and Guidance:** The Delphi method provides strategic guidance and evidence-based policy recommendations based on the collective expertise of panel members, paving the way for green transformation and guiding policymakers and stakeholders (Hung et al., 2019).

3.6. GSCM Implementation Framework:

Incorporating legal or conceptual frameworks is essential to ensure the successful execution of green initiatives within the construction industry. Legal frameworks set binding regulations, while conceptual frameworks offer flexible guidelines for consistency and accountability. A clear vision for achieving carbon neutrality in the construction sector is established, with quantifiable goals and timelines for reducing emissions throughout the supply chain. This holistic approach recognizes the multifaceted nature of the industry and emphasizes collaborative, innovative, and systematic strategies for sustainability goals.

1. **Life Cycle Assessment (LCA):** Utilizing a Life Cycle Assessment (LCA) is essential for advancing sustainability in the construction sector and working towards carbon neutrality. This methodology assesses the environmental ramifications of a product or process across its entire life span, from initial resource extraction to final disposal. LCA provides a holistic understanding of the environmental footprint associated with construction activities, identifying and quantifying carbon emissions at each stage. This data-driven insight guides the development of low-carbon alternatives by evaluating the environmental performance of various materials and technologies (Bergerson et al., 2020). LCA also acts as a benchmarking tool, establishing a baseline for current carbon emissions in construction processes. This baseline is crucial for setting achievable goals towards carbon neutrality and providing a roadmap for the industry to track progress and refine strategies over time. LCA's transparency and accountability enhance the credibility of sustainability efforts, fostering trust in the construction sector's commitment to carbon neutrality. Thus, LCA serves as an indispensable tool in the conceptual framework, offering a data-driven and systematic approach to navigate the complexities of achieving carbon neutrality in the construction industry.

   Implement carbon offsetting and sequestration strategies like afforestation and reforestation to balance emissions. Establish a Monitoring, Reporting, and Verification (MRV) system for transparency and accountability, and validate reported data for data validation (Gupta et al., 2012).

2. **Circular Economy and Capacity Building:** The CE is a sustainable approach to the construction sector, focusing on the reuse, recycling, and repurposing of materials to minimize waste and carbon emissions. It is a transformative approach to greening the sector, aiming to achieve carbon neutrality. The circular economy promotes sustainable material management, reducing the demand for new raw materials and mitigating carbon emissions associated with extraction and production. It drives the adoption of innovative construction techniques, focusing on modular and prefabricated components, enhancing resource efficiency and minimizing waste generation. The circular economy also fosters a closed-loop system, recycling materials and reintegrating them into new construction projects,

reducing reliance on finite resources and minimizing carbon emissions linked to traditional waste disposal methods. It aligns with carbon neutrality goals by promoting energy-efficient buildings, emphasizing longevity, and reducing the overall environmental impact of construction projects (Velenturf and Purnell, 2021). In essence, the circular economy is an integral part of the conceptual framework, offering a sustainable and regenerative approach that aligns with efforts to green the construction sector and achieve carbon neutrality.

3. **Industry Collaboration and Stakeholder Engagement:** Stakeholder engagement is a crucial aspect of the greening of the construction sector, aiming to achieve carbon neutrality. It involves involving diverse stakeholders, such as government bodies, industry players, and research institutions, in the conceptualization, planning, and implementation stages of interventions (Bal et al., 2013). This approach ensures a comprehensive range of insights is considered, fostering collaborative decision-making and identifying potential challenges and opportunities. Stakeholders also promote inclusivity and transparency, gaining widespread support for proposed interventions and building trust among them. Engaging stakeholders enhances the effectiveness of interventions by incorporating local knowledge and context-specific considerations, ensuring strategies align with the unique needs of the construction industry in specific regions. This creates a sense of ownership and shared responsibility, aligning diverse interests towards the common objective of carbon neutrality (Fallah Shayan et al., 2022). It empowers stakeholders to actively contribute to the development and implementation of policies, regulations, and practices that drive sustainable change in the construction sector. Thus, stakeholder engagement is pivotal in creating a collaborative and adaptive conceptual framework, leveraging the collective intelligence of diverse stakeholders, aligning interventions with local contexts, and fostering a sense of ownership necessary for the successful transition of the construction sector towards carbon neutrality.

4. **Green Certification for Sustainable and Energy Efficiency Technologies:** The construction sector is transforming towards carbon neutrality by mandating adherence to green building standards and certification programs. These programs, such as LEED and BREEAM, serve as benchmarks for sustainable construction,

providing a structured framework for evaluating and certifying environmentally friendly buildings. They encompass a spectrum of sustainability criteria, including energy efficiency, resource conservation, and emissions reduction. Integrating green certification into the conceptual framework ensures construction projects adhere to stringent environmental standards and fosters a culture of sustainability within the industry. Sustainability practices go beyond certification programs, focusing on holistic approaches to minimize environmental impact, including optimizing energy use, incorporating renewable energy sources, and promoting circular economy principles. By embedding green certification and sustainability practices in the conceptual framework, the construction sector is encouraged to prioritize eco-friendly alternatives, innovate in design and construction techniques, and actively participate in the global effort to reduce carbon emissions (Ekins et al., 2020). These initiatives endorse environmentally responsible practices, driving the industry toward a more ecological and Zero-carbon future.

5. **Regulatory policies and Financial Frameworks:** The construction sector is undergoing a significant transformation towards carbon neutrality. Regulatory policies and financial mechanisms are crucial in this process. Regulatory policies set the legal foundation for sustainable practices, penalizing carbon-intensive practices, and creating a level playing field for green technologies (Udeagha and Ngepah, 2023). Financial aid and mechanisms, such as grants, subsidies, and tax incentives, support businesses in transitioning to carbon-neutral practices. These mechanisms not only alleviate initial costs associated with eco-friendly alternatives but also stimulate innovation and research in low-carbon construction methods. The synergy between stringent regulations and supportive financial structures ensures that sustainability becomes economically viable and legally obligatory. This dual approach fosters a robust framework where legal mandates and financial incentives work in tandem, propelling the construction sector towards a more sustainable and carbon-neutral future.

3.7. Integration of Theoretical Concepts:

The theoretical framework for the green transformation of the construction supply chain in India synthesizes three core concepts: Conceptualizing Green Transformation, The Role of Supply Chain in Green Practices, and Delphi Method and Its Applicability. This integrated framework offers a holistic understanding of how these concepts interact to shape strategies and policies for promoting sustainability in the construction sector. Overall, the integration of these elements forms a robust theoretical foundation, guiding empirical research and facilitating a structured approach to comprehending, analyzing, and implementing the green transformation of the construction supply chain in India. The fundamental ideas that underpin the research are shown in **Figure** 3.1, wherein supply chain transformations occur and linear supply chains are changed to circular ones by adding green components.

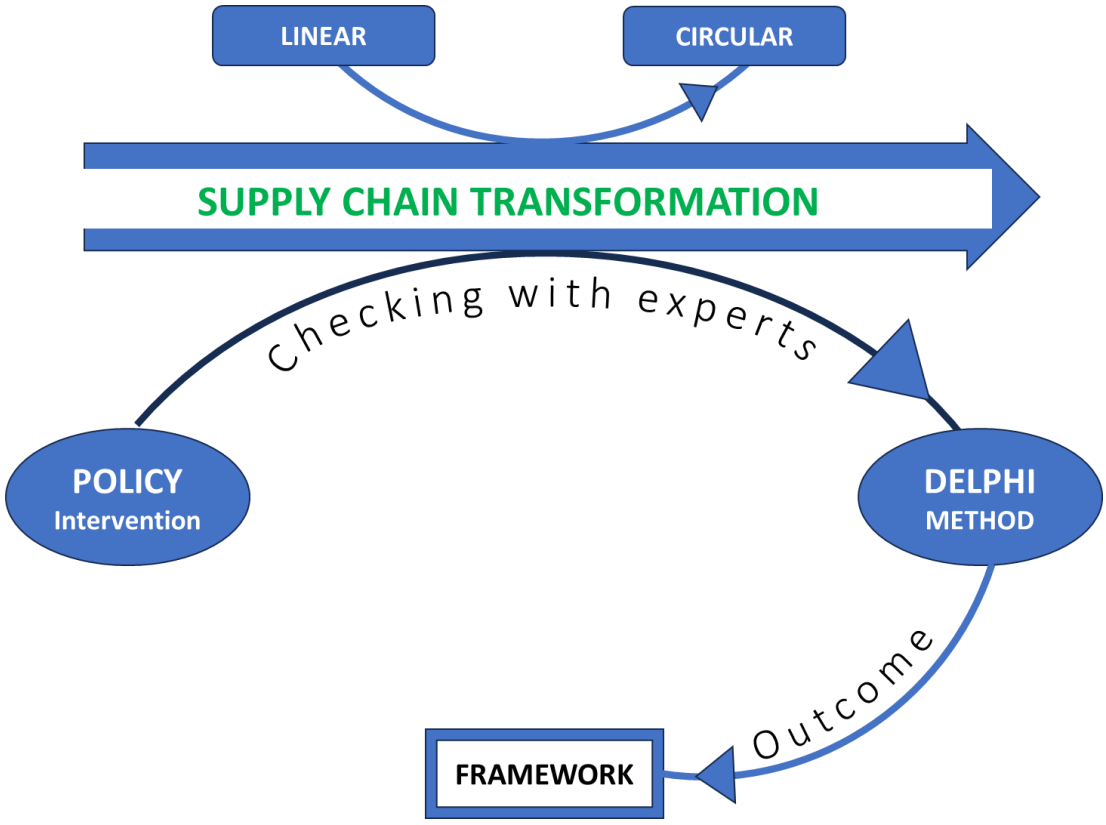


Figure 3.1: Structural Blueprint: Theoretical Framework and Research Organization

Since there are five main components to the supply chains for construction in India, all of them have been verified by experts in the field. In this context, we are employing the Delphi method to validate policy-level interventions with experts, aiming to construct a

conceptual framework for achieving carbon neutrality and facilitating green transformation within the construction industry.

1. **Integration of Conceptualizing Green Transformation:** The green transformation concept envisions a sustainable construction supply chain that integrates circular economy principles, producer responsibility, and life cycle assessments, addressing ecological, societal, and economic aspects in a holistic manner.

2. **Integration of The Role of Supply Chain in Green Practices:** The supply chain is crucial in implementing green transformation strategies, integrating Green Supply Chain Management principles to optimize sourcing, logistics, and waste management. The reverse logistics approach recycles construction materials, contributing to a circular economy. Collaborative and sustainable logistics drive this alignment with green practices.

3. **Integration of Policy Formulation and Supply Chain Principles:** The theoretical framework leads to evidence-based policy recommendations, aligned with GSCM principles and the vision of green transformation, ensuring practicality and visionary approach in supply chain operations and industry dynamics.

4. **Integration of Delphi's Iterative Nature:** The Delphi method is a key tool in green transformation, involving experts from various fields like construction, supply chain management, and environmental sustainability. It uses iterative questioning to gather expert opinions on the most effective strategies. This process fosters open communication, allowing for a robust exploration of scenarios and uncertainties. The method's adaptability allows for refinement of policy recommendations and strategic guidance. It aligns with continuous improvement, ensuring the theoretical framework remains adaptive to emerging trends and technologies. The Delphi method provides both quantitative and qualitative data, enabling a nuanced understanding of expert perspectives and facilitating evidence-based decision-making.

5. **Integration across Concepts:** The demand for a conceptual framework in decision-making and policy development for Green Supply Chain Management

(GSCM) stems from the complexity of sustainability challenges in supply chain practices. A conceptual framework offers a systematic and comprehensive understanding of the interdependencies involved in GSCM, serving as a roadmap for decision-makers. It delineates key components, relationships, and variables influencing sustainable supply chain strategies. This cross-disciplinary approach captures insights from environmental sciences, engineering, business, and policy-making, ensuring a theoretical framework enriched with diverse perspectives (Herrmann et al., 2021). In GSCM, where environmental, social, and economic factors converge, a conceptual framework facilitates informed decision-making, identifying critical success factors, trade-offs, and synergies between sustainability goals and operational efficiency. It aids in crafting effective policies that incentivize green practices, regulate environmental impact, and foster collaboration across supply chain stakeholders. The explicit demand for a conceptual framework is rooted in its ability to guide decision-makers towards strategic, evidence-based, and sustainable solutions in the complex landscape of GSCM.

The theoretical framework for facilitating green transformation within India's construction supply chain offers a holistic approach by incorporating Conceptualizing Green Transformation, The Role of Supply Chain in Green Practices, and Delphi Method and Its Applicability. By embracing interdisciplinary perspectives, evidence-based decision-making, and ongoing refinement, this framework establishes the foundation for empirical studies and real-world application. It steers research efforts towards tangible outcomes and feasible tactics for promoting sustainability, addressing the gap between theoretical concepts and practical implementation. By harmonizing aspirational goals with practical strategies, it paves the way for a sustainable and adaptable construction sector.

Chapter IV

Research Methodology

4.1. Introduction

This chapter delves into the methodological framework employed in conducting the study, elucidating the different facets of the research design and its inception. It encompasses elements such as the study's objectives, research strategy, methods employed, type of inquiry, level of researcher involvement, study environment, unit of analysis, timeframe, sampling approach, among others. The chapter scrutinizes the diverse methodologies and techniques utilized for data collection, encompassing literature review analysis, semi-structured interviews, case studies, questionnaire surveys, and Delphi exercises. Furthermore, it introduces the triangulation method and underscores its significance in this study's context.

Moreover, it's crucial to delineate between "research methodology" and "data gathering approach." A research technique refers to "a systematic, deliberate approach to data gathering with the goal of extracting information from the data" (Jankowicz, 1991). Examples of primary research techniques include experiments, surveys (utilizing both interviews and questionnaires), archival analysis, historical research, and case studies (Yin, 1994; Jankowicz, 1991). Conversely, methods entail "specific, step-by-step instructions that you can follow to collect data and analyze it for the information it includes" (Jankowicz, 1991). For instance, while a case study serves as a research method, some individuals might perceive it as a data gathering technique. When conducting a case study, it's imperative to employ specific research methods. Upon selecting a case, the optimal data gathering methods (such as surveys, document analysis, or interviews) must be determined. Without the selection of appropriate data gathering methods, no data can be collected solely by choosing a case study (Bell and Bryman, 2022). Determinations concerning the study's purpose, research methods and techniques, type of investigation, degree of researcher interference, study setting, unit of analysis, time horizon, measurement and measures, sampling, and data analysis collectively form the selection of a suitable research methodology.

According to Jankowicz (1991), the following methods are categorized:

■ Open-ended, semi-structured research methods include focus groups, one-on-one interviews, key source interviews, and conversations.

■ The questionnaire (structured), structured face-to-face interviews, and materials for postal and telephone surveys are all examples of fully structured methods.

■ Additional methods encompass the repertory grid, attitude scaling, and observational strategies such as structured observation and the field trial.

The first two have been adopted to fulfil this research. The study's nature will rely on how in-depth the subject knowledge is. As the research transitions from the exploratory phase to the descriptive phase, and then to the hypothesis testing phase, more extensive design decisions can be formulated (citing Casula et al., 2021).

Exploratory study tackles a subject about which not much is known. In such a situation, it is necessary to evaluate pertinent concepts and theories, create new theories as necessary, and determine whether it is possible to use current methodologies (Phillips and Pugh, 2000). Exploratory studies employ qualitative techniques, which result in more quantitative or organised studies (Hakim, 1987).

Finding the boundaries of previously advanced generalisations is the goal of testing out study (Phillips and Pugh, 2000). Through the processes of defining, modifying, and clarifying, such generalisations can be enhanced. Typically, hypothesis testing attempts to identify differences between groups or to explain the nature of specific relationships between variables (Sekaran, 2003). Both quantitative and qualitative statistics can be used with it.

One definition of a case study, as provided by Yin (1994), describes it as an empirical inquiry that scrutinizes a contemporary phenomenon within its real-life context, especially when the distinctions between the phenomenon and its context are not readily apparent. Case studies provide an in-depth examination of situations where similar issues arise (Sekaran, 2003). Thoughtfully selected case studies have the potential to yield valuable insights into problem causation. Various types of case studies exist, including exploratory, observational, and explanatory ones. The data gathered for a case study may be qualitative or quantifiable, according to Yin (1993).

The triangulation approach included both testing and exploration, and it was applied to various methods and techniques (see Section 4.3.6). A thorough literature survey has been adopted for data retrieval, review, and comparative analysis for all the objectives one-on-one leading to the ultimatum of objective 4 (see 4.3.1). semi-structured interviews (9) at different occasions, preferred mostly here in this research, and the data inputs were statistically verified and mapped against the other frameworks isolated via a literature survey (experts) (see 4.3.2). Case study research is an eclectic approach that uses multiple methods, perspectives, and data sources to investigate a research question or phenomenon, promoting methodological diversity and flexibility (see 4.3.3). The questionnaire survey and interviews were performed as part of case studies and represented an investigation of the elements crucial for respondents to address green supply chain practices more effectively for sustainable building through a firm policy framework (see 4.3.4). In addition, researcher validated whether these results in relation to these variables served as a test of the Delphi results (see 4.3.5). Finally, inviting feedback from respondents or interviewees about any of the items listed in the questionnaires or interview guides utilized in this project also functioned as a validation of the sustainability criteria identified in the Delphi study.

The Delphi Analysis, for instance, was used for investigation and testing. The first-round of the Delphi process was probing/exploratory in nature with the aim of identifying sustainability criteria that three-level stakeholders/ respondents should take into consideration when developing a green strategy and factors that are crucial for three-level stakeholders when developing a unified policy framework to better address sustainable/green construction. The findings from the first-round were put to the test in the second-round.

4.2. Research Analytics

Various research methods are available, as outlined by Yin (1994) and Jankowicz (1991). These encompass experiments, surveys (comprising interviews and questionnaires), archival analysis, historical research, and case studies, among others. Yin (1994) offers a helpful framework delineating suitable scenarios for different research methods. Survey research typically employs an instrument with a structured format, encompassing both

interviews (typically conducted face-to-face) and questionnaires (typically administered via mail or other indirect means) (Garson, 2009).

The research queries in this dissertation stem from its objectives follows.

4.2.1. Research Questions

RQ1. What are the main sustainability criteria that stakeholders should consider when creating a green/carbon neutral infra-developmental strategy?

RQ2. What are the crucial factors/elements for green supply chain mechanism in the Indian setting and better addressing sustainable construction?

RQ3. What barriers have stakeholders found that need to be removed at an earlier stage to achieve circular economy in construction industry via GSCM in an Indian scenario?

RQ4. In their green strategies, policies, guidelines, or practices, how do well authorities in India impose sustainability criteria?

RQ5. How much do local-level authorities in India observe or plan to follow the policies, procedures, or guidelines that point out the sustainability constraints and necessitate sustainability criteria in the green strategies or contracts for infra-development projects?

RQ6. Identify the stakeholders best fit to sort out constrains that better address the scope of greening the Indian construction sector and develop a policy framework?

Utilizing Yin's (1994) framework to address the proposed research questions revealed that the survey and case study methodologies were the most appropriate for addressing RQ1, Delphi also has to be adopted for RQ2, survey and interviews are for RQ3, and Delphi is suitable for RQ4 and can be supplemented with interviews. Again, interviews were found to be the most suitable method for answering RQ5, and case studies worked as well. Finally, surveys, interviews, and Delphi are appropriate for RQ6. Questions for the survey can be organized in interviews /questionnaires, just as questionnaires are the most important for case studies to arrive at conclusions (Fink, 2003). Both methods used in this research for data retrieval from RQ1 to RQ6 are depicted in tables 4.1 and 4.2, which are

the same as the research design. The triangulation techniques and their physiological attributes are detailed in a flow chart in Figure 4.1.

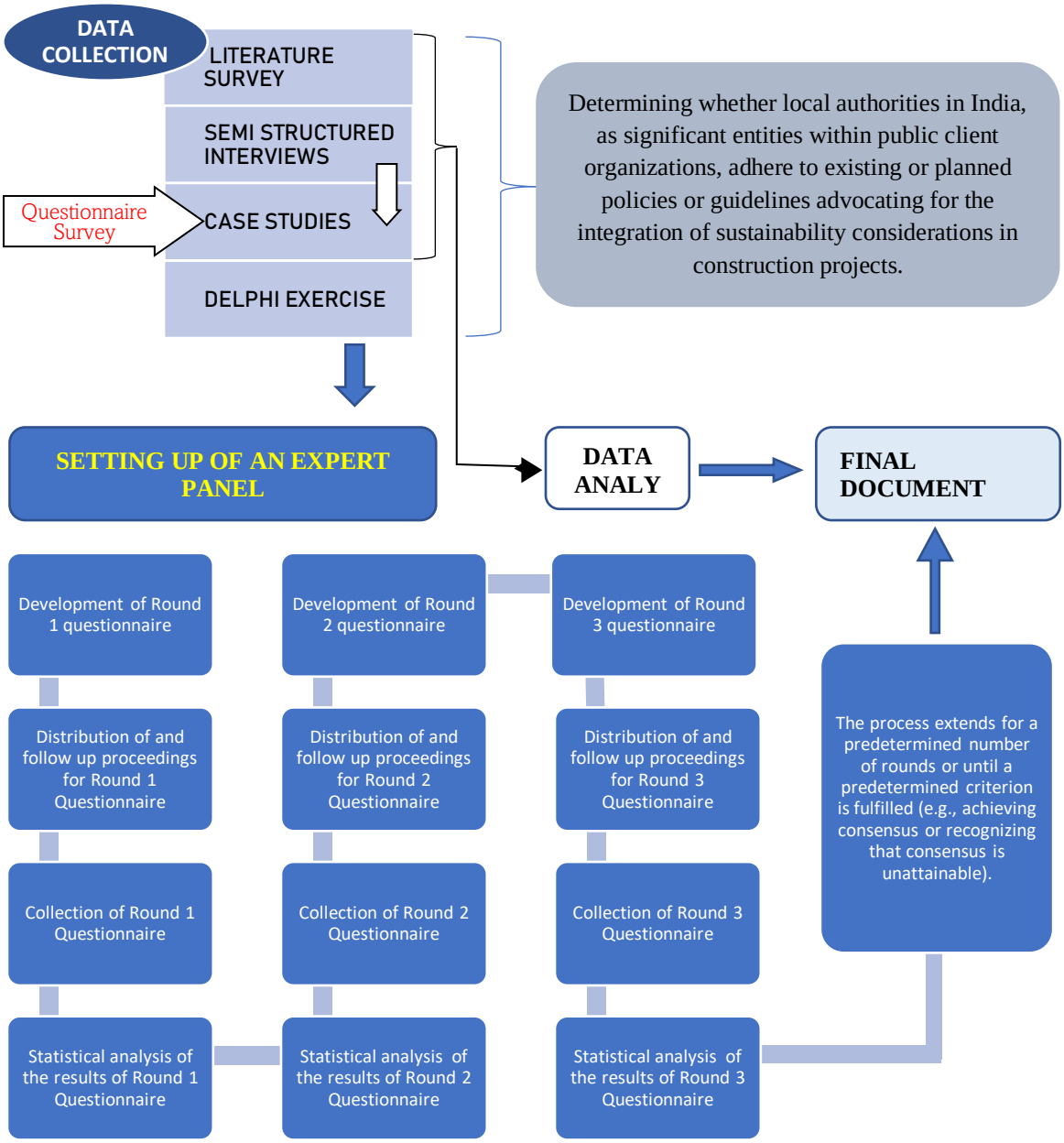


Figure 4.1: Flowchart depicts the Research Methodology to arrive at the Objectives of the Research *(modified after Linstone and Turoff, 1975)*

The research design depicted in tables 4.1 and 4.2 will discuss how effectively the methodologies adopted will achieve the aim of addressing all the research questions and finally leading the way toward all four objectives.

The research design consists of four objectives: evaluating the construction sector's potential for implementing green supply chain principles, identifying specific issues in the Indian CS that hinder the integration of green supply chain concepts, identifying policy elements in India that directly and indirectly influence the green-supply-chain, and creating a conceptual framework for policymakers to guide interventions in greening the construction sector towards carbon-neutrality.

The first objective aims to evaluate the construction sector's potential for implementing green supply chain principles. This is derived from Research Question 2 (RQ2), which focuses on identifying key elements for green-supply-chain mechanisms (GSCM) in the Indian context. Three methods are employed to achieve this objective: Literature Survey, Case Study, and Delphi Technique.

The second objective aims to identify specific issues in the Indian construction sector that hinder the integration of green-supply-chain concepts. This is derived from Research Questions 3 and 6 (RQ6), which focus on understanding barriers to achieving a circular economy in the building sector *via* Green Supply Chain Management (GSCM) and identifying stakeholders best suited for developing a policy framework for greening the sector. Two methods are employed: Literature Survey - Pressure-Barrier Analysis and Semi-Structured Interviews.

The literature survey has been useful in development of the pressure-barrier analysis framework to identify key barriers perceived by stakeholders, such as external pressures like regulatory requirements or market demands, and internal barriers like lack of awareness or resistance to change. Key stakeholders in the Indian construction industry are interviewed using a semi-structured approach, including government officials, industry leaders, environmental experts, and representatives from relevant organizations. These interviews help identify practical constraints and potential solutions tailored to the Indian context.

Figure 4.1 details the Delphi approach, which involves expert selection, three-round validation, and final output preparation. If experts agree on sustainability criteria and have not made any further modifications, the process can be ended with three rounds and forwarded for data quality checking, ensuring no dissonance in sustainability criteria.

Table 4.1: Research Design and Techniques Adopted To Manage The Research Questions

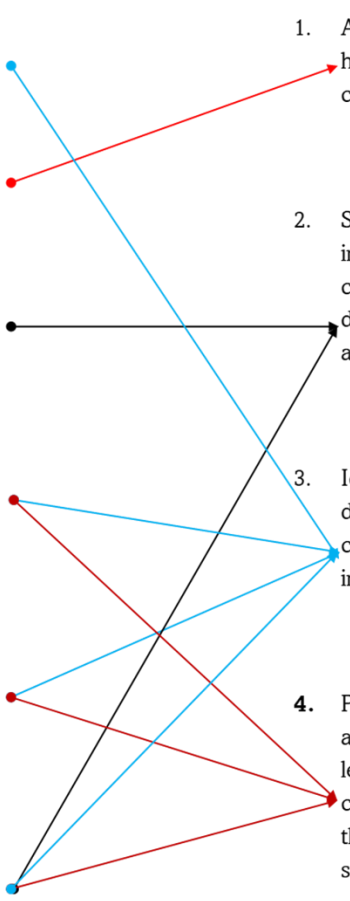
Research Questions	Mapping	Research Objectives	Research Methodology
RQ1. What are the main sustainability criteria that stakeholders should consider when creating a green/carbon neutral infra-developmental strategy?		1. Assessing the key processes in construction sector having the potential to introduce green supply chain principles.	**1.** Literature Survey **2.** Case study
RQ2. What are the crucial elements/factors for green supply chain mechanism in the Indian setting and better addressing sustainable construction?			**3.** Literature Survey **4.** Delphi
RQ3. What barriers have stakeholders found that need to be removed at an earlier stage to achieve circular economy in construction industry via GSCM in an Indian scenario?		2. Specific issues in Indian context, which make the integration of green supply chain concepts in the construction sector processes ranging from design, procurement, transportation, execution, and waste recycling.	**5.** Literature Survey **6.** Semi structured Interview
RQ4. In their green strategies, policies, guidelines, or practices, how do well authorities in India impose sustainability criteria?		3. Identification of Policy elements in India which has direct and indirect influence on the green supply chain in construction industry and exploring their integration into a unified framework.	**7.** Delphi Method **8.** Semi structured Interview
RQ5. How much do local-level authorities in India observe or plan to follow the policies, procedures, or guidelines that point out the sustainability constraints and necessitate sustainability criteria in the green strategies or contracts for infra-development projects?		**4.** Presenting a conceptual framework to the attention of policy makers at national and local level for necessary interventions to green the construction sector with the objective of achieving the ultimate goal of a carbon-neutrality in the sector.	**9.** Semi structured Interview **10.** Case study **11.** Delphi Method
RQ6. Identify the stakeholders best fit to sort out constrains that better address the scope of greening the Indian construction sector and develop a policy framework?			**12.** Semi structured Interview **13.** Literature Survey

Table 4.2: Research Design and Summary of The Analytical Approach

R. Objectives	Methodology	Reason	R. Questions
Objective #1 Assessing the key processes in construction sector having the potential to introduce green supply chain principles.	Literature Survey	Identification of GSCM elements	**RQ2** What are the crucial elements/factors for green supply chain mechanism in the Indian setting and better addressing sustainable construction?
	Case study	Real-world practices for GSCM in the Indian construction industry	
	Delphi	Confirmation from experts for the GSCM factors identified	
Objective #2 Specific issues in Indian context, which make the integration of green supply chain concepts in the construction sector processes ranging from design, procurement, transportation, execution, and waste recycling.	Literature Survey	Pressure- Barrier analysis	**RQ3** What barriers have stakeholders found that need to be removed at an earlier stage to achieve circular economy in construction industry via GSCM in an Indian scenario?
	Semi-structured Interview	Level of policy adoption, its constraints, and the targeted green strategies (all should come from stakeholders, hence interview)	**RQ6** Identify the stakeholders best fit to sort out constrains that better address the scope of greening the Indian construction sector and develop a policy framework?
Objective #3 Identification of Policy elements in India which has direct and indirect influence on the green supply chain in construction industry and exploring their integration into a unified framework.	Delphi	Confirmation of policy elements and their influences on Indian GSCM	**RQ4** In their green strategies, policies, guidelines, or practices, how do well authorities in India impose sustainability criteria?
	Semi-structured Interview	-do-	
	Case study	How well does the COVID pandemic exhibit an inclination towards GSCM analysis of feasibility and practicality in GSCM action via policy or framework?	**RQ5** How much do local-level authorities in India observe or plan to follow the policies, procedures, or guidelines that point out the sustainability constraints and necessitate sustainability criteria in the green strategies or contracts for infra-development projects?
	Literature Survey	Sustainable criteria @ stakeholder point of view	**RQ1** What are the main sustainability criteria that stakeholders should consider when creating a green/carbon neutral infra-developmental strategy?
Objective #4 Presenting a conceptual framework to the attention of policy makers at national and local level for necessary interventions to green the construction sector with the objective of achieving the ultimate goal of a carbon-neutrality in the sector.	Literature Survey	Stakeholder analysis and policy frameworks	**RQ6**
	Semi-structured Interview	How well do authorities impose sustainability criteria	**RQ4**
		-do-	**RQ5**
	Delphi	-do-	**RQ4**
		How much will it be effective via CFW	**RQ6**

Objective three seeks to ascertain the policy components in India that impact the green supply chain within the construction sector, intending to integrate them into a cohesive framework. This objective stems from Research Questions 1 (RQ1), 4 (RQ4), 5 (RQ5), and 6 (RQ6), collectively addressing sustainability criteria, policy impacts, and stakeholder engagement concerning green supply chain management (GSCM) in the Indian construction industry.

The Delphi Technique confirms and prioritizes policy elements that influence GSCM in the Indian context, as perceived by a panel of experts. Semi-structured interviews assess how effectively authorities in India enforce criteria for sustainability in their green strategies, policies/guidelines, or practices. A panel of experts in sustainability, construction management, policy analysis, and related fields gathers feedback and consensus on the proposed conceptual framework for greening the construction sector through iterative rounds of surveys or structured discussions.

By employing these methods, Objective #4 is systematically addressed, leading to the construction of a robust conceptual/strategic framework for guiding interventions in the green construction sector in India.

A strong correlation between research objectives and research questions is crucial for a study's success. Research questions should align with the objectives, covering all aspects of the research topic or problem. They should be specific and focused, reflecting the specific dimensions of the objectives, providing clear guidance on what the researcher intends to investigate (Farrugia et al., 2010). Measurable research questions should be formulated in a way that allows them to be empirically tested and are actionable, facilitating data collection and analysis. The research questions should follow a logical progression that aligns with the objectives' hierarchy, starting with broader questions and moving towards more specific inquiries. Ultimately, the research questions should lead to comprehensive findings and outcomes that address the objectives comprehensively, ensuring the study remains focused and coherent. This strong correlation ensures clarity, coherence, and effectiveness in guiding the research process and achieving meaningful outcomes.

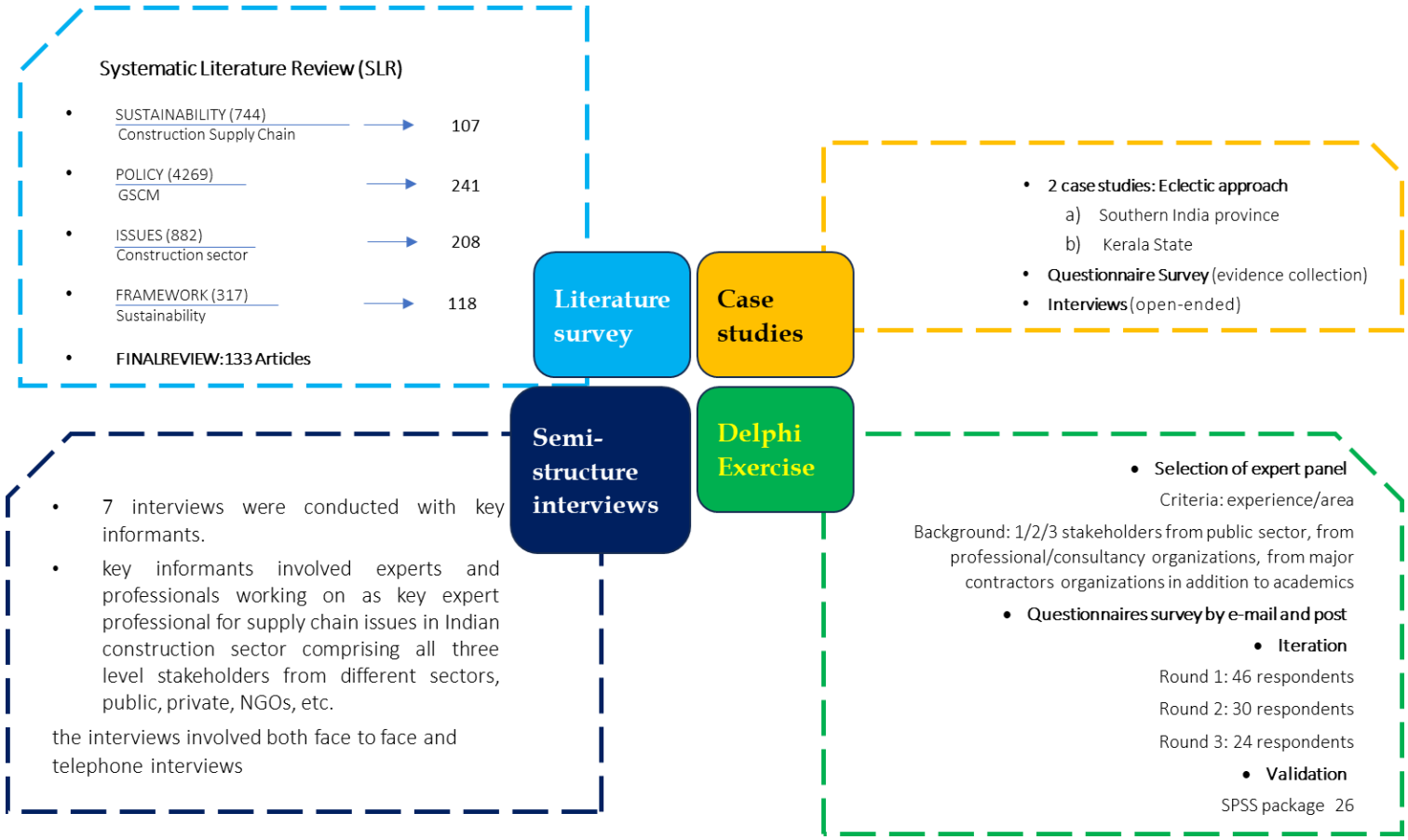


Figure 4.2: A summary of the Triangulation adopted for the research (*methods and techniques*)

4.2.2. Multiple Research Approach - Triangulation

Triangulation involves employing multiple research methods or measures to enhance objectivity and validity, encompassing data triangulation, methodological triangulation, investigator triangulation, and interdisciplinary triangulation. Figure 4.2 provides a schematic detailing and speculation of the methodological triangulation attributed to this study. This approach aids in mitigating biases and strengthening the credibility of research findings. While traditionally associated with quantitative methods, triangulation can also be applied in qualitative research, such as using observations to validate interview findings. By integrating quantitative and qualitative methods, triangulation allows for cross-validation of results, enhancing reliability and validity. Love et al. (2003) advocate for triangulation as a means to expand theoretical scope in construction management research, emphasizing its role in promoting convergence of findings and elevating research quality. However, Bell and Bryman (2022) highlight challenges in maintaining triangulation integrity, citing potential compromises to internal, external, and construct validity in management research.

4.2.3. Eclectic approach: Case study

This study employs a case-study approach utilizing an eclectic method, combining questionnaire surveys and interviews. The approach is chosen to address the multifaceted nature of the research questions, enhancing the validity of findings and capturing diverse perspectives. It details the design of questionnaire surveys, sampling strategy, data collection, and management measures. Interviews are conducted to explore participants' experiences, perceptions, and attitudes. This session also discusses the selection criteria, protocols, and procedures for conducting and transcribing interviews. The integration and analysis of data collected are discussed, including data coding, categorization, and thematic analysis.

4.2.4. Data analysis

Adoption of ‘Green’ in Supply Chain Management (GSCM) approaches in the building industry requires a deep perceptional dissection of both qualitative and quantitative data. This study attempts to collect solid data for perceptive analysis and informed decision-making in developing GSCM activities within the construction industry through

questionnaire surveys, case studies, interviews, systematic literature reviews (SLR), and Delphi methodologies. It was deemed more suitable to introduce data analysis alongside the presentation of findings obtained through the application of various methods and techniques see section 4.4 and 4.6.

4.3. Research Methodologies Adopted

4.3.1. Literature Survey

A literature survey is a fundamental aspect of research papers, involving the analysis of academic references to uncover hypotheses, methodologies, and gaps in existing knowledge. It serves as a cornerstone for comprehending established science, identifying emerging trends, refining research objectives, and situating findings within the broader academic discourse. Typically, it comprises six key steps: conducting a comprehensive search for relevant literature, reviewing cited references, discerning prevalent trends, debates, and gaps, and delineating the conceptual framework. This systematic examination plays a pivotal role in the research domain, facilitating the demonstration of knowledge, delineation of research ideas and questions, establishment of research significance, and formulation of hypotheses (Paré et al., 2015; Zorn and Campbell, 2006). However, many literature reviews suffer from shortcomings, ranging from being overly exhaustive to inadequately selective. The aim is not to regurgitate information but to critically assess existing studies, pinpoint areas of deficiency, and enrich the body of literature. Literature surveys fulfill diverse objectives, including the provision of a theoretical foundation or avenue for further exploration, comprehension of research scope, and resolution of practical queries (Torres-Carrión et al., 2018). They can be written as an introductory section of an essay or part of an analytical thesis or dissertation. In the rapidly advancing field of market analysis, literature reviews are increasingly necessary as a method for science (Feddes and Gallucci, 2015). They can help scientists improve their expertise and fill gaps by drawing on others' work.

Literature survey can be categorized into two types: the 'literature review' or 'background section', which consolidates existing literature and explores knowledge gaps in the analytical analysis (citing Sylvester et al., 2013). Additionally, the theoretical framework for the proposed analysis can be presented to elucidate the problem and provide an explanation for the analysis. A literature survey encompasses two main types: the

'literature review' or 'background section,' which consolidates existing literature and elucidates disparities in knowledge within the analytical context (Sylvester et al., 2013). Additionally, it can provide a theoretical framework for the proposed analysis to elucidate the issue, delineate the analysis as a novel contribution to knowledge, or assess suggested research methodologies (Rowe, 2014). Prior examination of relevant literature is indispensable for all studies, as it informs the thesis rationale, elucidates the research subject and hypotheses, and is often denoted as 'literature analysis,' 'theoretical framework,' or 'research history' (Snyder, 2019; Wee and Banister, 2016). Literary analysis is an iterative and ongoing process integral to research endeavors, involving six key stages: formulation of research questions, literature search, inclusion criteria assessment, evaluation of research integrity, data synthesis, and interpretation (Templier and Paré, 2015). This analysis is iterative, with tasks initiated during the preparatory phase and refined in subsequent stages (Finfgeld-Connett and Johnson, 2013).

Figure 4.3. Process of Literature Review adopted from (Leitner et al., 2017)

The review process involves several steps to ensure an accurate and holistic analysis of a specific subject (see Figure 4.3). First, the study question(s) formulation and purpose should be clearly defined, addressing the research issues they propose to investigate. This helps in guiding the review methodology and ensuring that the necessary knowledge is available. Next, the review team must search for existing literature and determine its suitability for analysis (Pare et al., 2015). Three primary coverage techniques are commonly employed in literature surveys: comprehensive coverage, which encompasses all relevant published and unpublished articles, indicative of the majority of works within a particular field or domain, and reflective of previous seminal works essential to a specific topic. The subsequent step involves inclusion examination, determining the relevance of the material and screening potential studies to ascertain their significance (Paré and Kitsiou, 2017). This necessitates substantial research resources and a rigorous selection process. Equally crucial is the evaluation of the quality of primary research, assessing the robustness of study design and methodology, as well as the analytical validity of the selected studies. This systematic assessment enables the research team to

refine studies, identify potential biases, and enhance the validity of the findings. Data processing constitutes the final step, involving the synthesis or extraction of pertinent information from each primary review. The format of data to be extracted depends on the initial research questions but may also offer insights into the nature and methodologies of the primary studies. Finally, data interpretation and synthesis culminate the process, entailing the gathering, summarization, synthesis, organization, and comparison of data from the included studies.

4.3.1.1. Guidelines for the Literature Survey

Literature reviews should adhere to clear methodological criteria, allowing for the development of critical assessments and methods. The synthesis of research necessitates decisions concerning the primary objective and the style of analysis. Scholars concur that the advancement of science hinges significantly on the suitability of tools and techniques, emphasizing the importance of carefully selecting and employing appropriate procedures and methodologies (Hart, 2018). Various research methodologies and current literature review protocols are utilized to review papers, ensuring they are suitable for the specific aim and analysis objective (Snyder, 2019).

4.3.1.2. Methods of Literature review

a) Narrative Reviews

Narrative reviews summarize previously published studies on a subject, focusing on concepts, hypotheses, methods, and findings. They provide a comprehensive summary of existing literature and recent expertise in the field (Templier and Paré, 2015). Narrative reviews Acting as an initial reference for potential research opportunities and development, allowing researchers to define and refine questions or theories. They aim to provide an exhaustive context for enhancing comprehension of current knowledge while underscoring the significance of fresh research.

b) Mapping or descriptive reviews

Descriptive reviews aim to identify discoverable patterns and trends in a subject through systematic processes like searching, evaluating, and classifying studies. They use a structured search method and quantitative findings from individual frequency analysis

samples (Paré et al., 2015). Each research is considered an analytical unit, providing a database to define interpretable patterns and draw decisions on existing understandings, ideas, approaches, and conclusions.

c) Scoping Reviews

A scoping review assesses the current and potential breadth of the literature within an emerging field (Daudt et al., 2013). It entails a thorough research strategy encompassing grey literature and a precise delineation of the field. Criteria for inclusion and exclusion are established to filter out studies not aligned with the research objectives. Abstracts are reviewed and screened by two reviewers, with synthesized evidence presented in tables organized by subject or topic (Pare et al., 2015).

d) Aggregative Reviews

Systematic reviews are a methodological approach that aggregates, assesses, and synthesizes empirical data to meet specific requirements. They follow scientific standards and rigorous examinations, ensuring consistency and reproducibility. System studies classify and assess related research, gathering and interpreting data to address specific questions or hypotheses (Witell et al., 2016). Meta-analyses serve as a powerful synthesis tool that consolidates independent research findings into a unified and objective assessment of scale effects. Employing specialized data extraction methods and computational techniques, they quantify effect size and confidence intervals. Meta-analysis offers more robust and consistent estimates of intervention outcomes compared to individual studies analyzed in isolation, as they combine multiple sources of evidence (Randolph, 2018).

e) Realist Reviews

Realistic analysis is a theoretical study that enhances traditional structural reviews by analyzing complex policy data. It emerged from critiques of positivist structural reviews. Institutional analyses classify causes, applicable in fields like medicine and education (Okoli and Schabram, 2010). However, some argue that clear causal connections cannot be identified in social policy, administration, and information systems.

f) Critical Reviews

Critical reviews play a vital role in objectively evaluating existing literature within a field. They systematically report on the accomplishments, limitations, inconsistencies, conflicts, anomalies, and other issues pertaining to ideas, assumptions, methodologies, or findings present in the literature. The primary goal of critical reviews is to educate fellow researchers about the shortcomings of prior studies and to facilitate knowledge advancement by guiding future research endeavors (Pare et al., 2015).

For this study, ii. Mapping or descriptive reviews, iii. Scoping Reviews, and vi. Critical Reviews methods of literature reviews found critical.

4.3.1.3. Analysis and discourse on methodologies

The literature survey approach entails debating different analytical questions or aims and coming up with plans to meet the review's goals. While systematic reviews are known for their strictures and the application of particular algorithms to eradicate variances in the study-synthesis process, narrative reviews provide greater flexibility in the finding and syncretization of publications. Certain reviews, like scoping/mapping reviews, are experimental in nature, whilst other reviews, like descriptive reviews, establish themes or employ the synthesis approach, which may involve critical analyses conducted prior to the review (Paré et al., 2015). Prior to starting a research analysis, it is imperative to determine the most applicable type of review, the goal of the analysis study, and the best strategies to achieve the intended goals. This method aids in standardizing the study and synthesis process, reducing discrepancies and ensuring consistency across the research. Resolving knowledge gaps and advancing the research objective can be achieved by high precision analysis. Developed themes can sometimes be used to create a conceptual framework that directs the study. Reviews must contain study effects or guidance that is practical, instructive, and up to date.

This study adopts a systematic literature review methodology, adhering to the guidelines outlined by Briner and Denyer (2012). The approach ensures that the review is conducted systematically, transparently, and with the potential for replication and updates, summarizing and synthesizing the core themes of the research area. This method facilitates the production of systematic findings that can be utilized and updated by other researchers

for further analysis. Briner and Denyer (2012) propose a protocol for conducting a systematic literature review, comprising eight sequential steps: initial scoping, problem definition, objective setting, criteria establishment, search strategy formulation, study eligibility determination, data extraction, quality assessment, and results synthesis. The visual representation of these steps is depicted in Figure 4.4, delineating how these stages are operationalized in the context of this research.

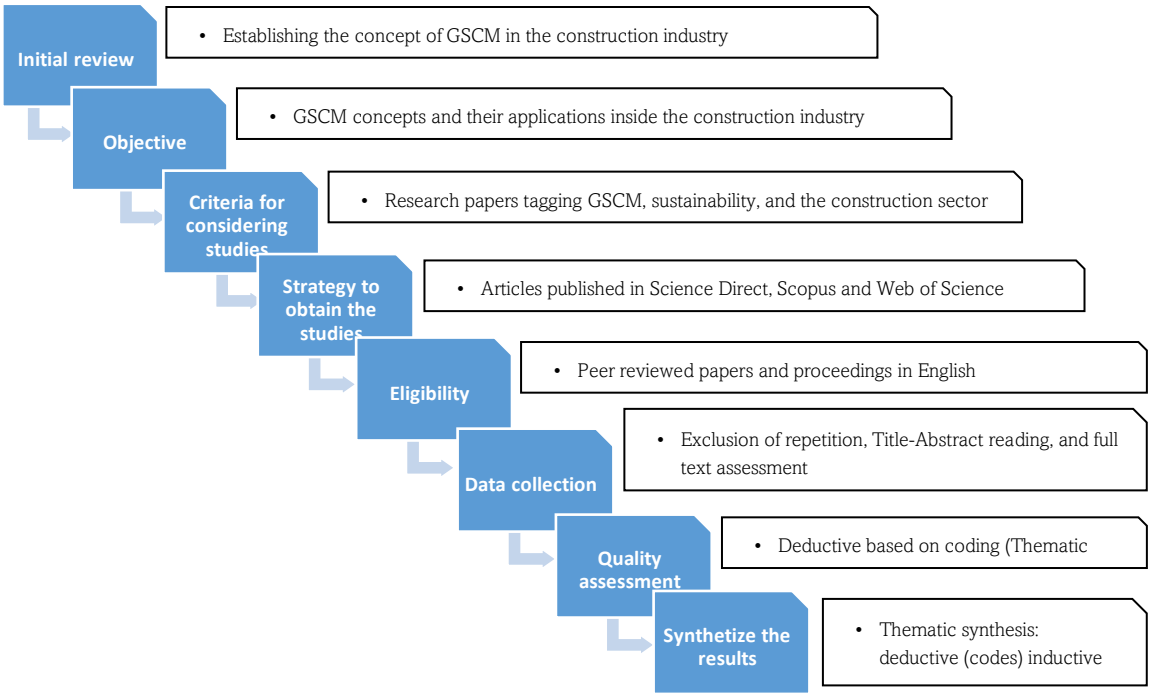


Figure 4.4: SLR: Systematic review protocol modified after Gough et al. (2012)

4.3.1.4. Systematic Literature Review (SLR)

A Systematic Literature Review (SLR) is a systematic process that involves identifying relevant sources, developing a search strategy, screening and selecting studies, extracting relevant data, assessing the quality of included studies, synthesizing findings using methods like thematic analysis, narrative synthesis, or meta-analysis, and reporting the findings. This process ensures comprehensive coverage and rigorous analysis of relevant literature, leading to reliable and actionable insights. The process begins with identifying relevant sources, such as academic databases, journals, conference proceedings, and grey literature repositories. A systematic search strategy is developed using predefined search terms and Boolean operators to retrieve relevant studies. The titles & abstracts of the

identified studies undergo screening against predefined inclusion and exclusion criteria. The full-text assessment is conducted to determine the eligibility for inclusion in the review. The findings are reported following established guidelines, including a summary of the search process, characteristics of included studies, findings from data synthesis, and implications for practice and future research.

4.3.1.5. SLR: A Comprehensive Procedure

In this context, the research tool was crafted to explore the implementation of Green Supply Chain Management (GSCM) principles within the construction industry. The aim was to assess the feasibility and applicability of these principles within this specific sector. Criteria for selecting studies were established, prioritizing those that addressed the

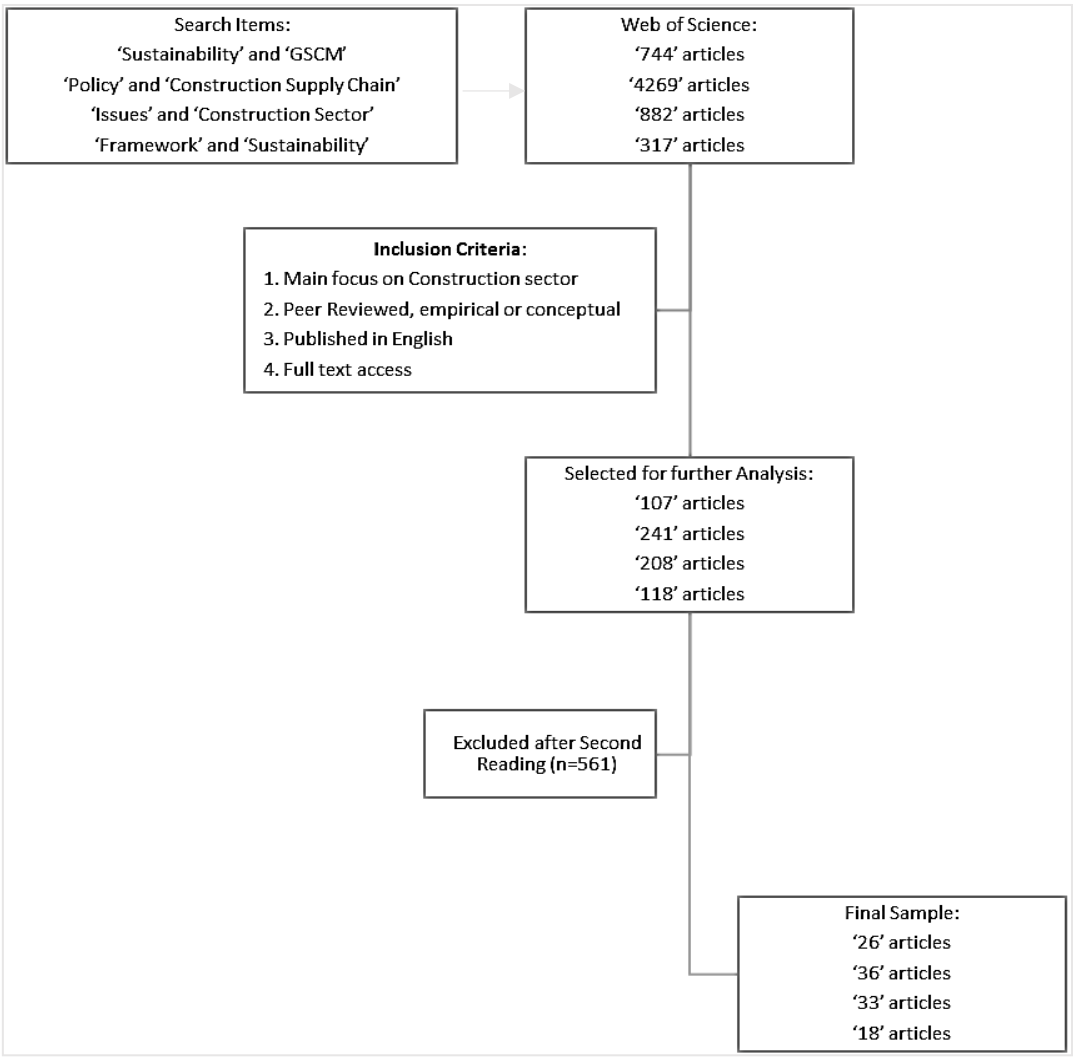


Figure 4.5. An Summary of Literature Survey assumed from (Witell *et al.*, 2016)

practical application of GSCM concepts in construction. Primary keywords included GSCM, drivers/opportunities, barriers, policies/regulations, and conceptual frameworks. Secondary keywords included circular economy, sustainability, unified strategies, and the Indian construction. To obtain studies, the strategy involved searching in Web of Science databases using key words "Green Supply Chain", "Sustainability", "Construction Sector", "Policy", "Framework", "Construction Supply Chain", and "Issues". Coding of keywords were adopted diplomatically to get better filtration and representation for all four corners of research (objectives). As it accounts for four different scenarios in construction sector need to check different ways to represent those four aspects with better results. Another issue was all keywords are important and altogether use would not produce net results, hence individuality should have been the priority came up to project reasonable outcomes.

The study examines 18,244 academic research papers focusing on Green Supply Chain Management (GSCM) within the construction industry, applying various filters to narrow down the selection criteria. These filters encompass aspects such as methodology, sample years, research design, and paper sources. The literature is segmented into different categories based on these criteria. The majority of the studies employ qualitative methodologies to explore the relationships between performance, sustainability, and GSCM, often opting for qualitative analysis techniques. Quantitative approaches are also prevalent, with studies utilizing both primary and secondary data analysis methods. More than half of the studies incorporate qualitative aspects in defining constructs and identifying variables. However, the availability of secondary data sets for analysis remains limited, resulting in fewer studies employing secondary data analysis. The study underscores the significance of GSCM in promoting sustainability within the construction industry and emphasizes the necessity for manufacturers to embrace sustainable practices related to SCM to facilitate the adoption of mandatory environmental measures. Figure 4.5 details the process of filtering and refining the data collection, retrieval, and synthesizing existing research on a specific topic, identifying gaps, trends, and patterns for further research, and understanding.

This resulted in 18244 initial articles. The eligibility of these articles was determined, excluding non-peer-reviewed or conference proceedings articles. Data collection was conducted, removing repeated articles, The articles were then analyzed for a title and abstract reading, resulting in a total of 674. A complete reading was conducted, removing

irrelevant articles, and 561 articles were eliminated, resulting in a final selection of 113 articles for the final review.

The study analyzed selected articles in the construction industry through a seven-step process, including a quality assessment of databases and peer-reviewed and conference proceedings papers. The selected articles were then categorized into four areas [GSCM, drivers and barriers, policies/regulations, and conceptual frameworks] of study for a comprehensive analysis. The research involved descriptive and bibliometric analysis, with each article categorized into specific research areas. The sequence of papers was systematically analyzed to provide a comprehensive summary of each paper, along with a review of the prevailing concepts derived from Green Supply Chain Management (GSCM) within each area under investigation.

4.3.2. Semi-structured Interviews

Qualitative interviews are a valuable tool for researchers to understand how individuals construct reality based on their personal beliefs and values. Interviews can be categorized as unstructured, semi-structured, or structured, and can be conducted face-to-face, by telephone, or online (Jamshed, 2014). Unstructured interviews aim to delve into complex behaviors without predefined categories, providing a wide range of data and aiding in the identification of key variables. Structured interviews involve asking the same set of questions to different interviewees in a consistent manner, sequence, and tone, often with a written interview guide to ensure uniformity. While structured interviews facilitate reliable comparison of responses, they offer limited flexibility in question format and response style (DeJonckheere and Vaughn, 2019). Semi-structured interviews feature questions with content and sequence that are not fully predetermined. They seek to elicit insights into events, patterns, and behaviors deemed important by the interviewee. Questions in semi-structured interviews are typically open-ended, allowing respondents to express their perspectives in their own words. However, there is flexibility in how the questions are posed and structured (Nhu, 2012).

Semi-structured interviews serve as a robust research methodology for investigating policy-level interventions aimed at green transformation within the Indian construction supply chains (Bowen, 2009). This approach offers a balance between flexibility and structure, allowing for in-depth exploration of key issues while maintaining a degree of

standardization across interviews. By engaging with stakeholders such as policymakers, industry experts, and practitioners, Semi-structured interviews offer valuable insights into the challenges, opportunities, and potential strategies for promoting sustainability in the construction sector. Additionally, the open-ended nature of semi-structured interviews allows researchers to uncover nuanced perspectives and capture diverse viewpoints, contributing to a comprehensive understanding of the policy landscape and its implications for green transformation (Ruslin et al., 2022). Overall, leveraging semi-structured interviews as a research methodology facilitates the identification of actionable recommendations and policy interventions to drive sustainable practices and innovation in the Indian construction supply chains.

Semi-structured interviews were chosen for the research due to the determined variables. The selection process involved obtaining respondents' views on the problem's importance and providing flexibility. Multiple case studies were proposed, all supporting the decision to use semi-structured interviews. The content and sequence of the interview list were not fully specified.

The quantity of participants in a research investigation is influenced by several factors, including the research objectives, scope of investigation, sampling methodology, resource limitations, saturation point, participant demographics, and ethical concerns. A larger sample size is needed for comprehensive understanding, while a smaller number is needed for focused inquiries (Andrade, 2020). Balancing these factors ensures representativeness and generalizability in the study. Nine interviews with experts and professionals from primary, secondary, and tertiary domains who were eminent on sustainability issue management in a range of specialists and all-sector organizations were done between November 2022 and October 2023.

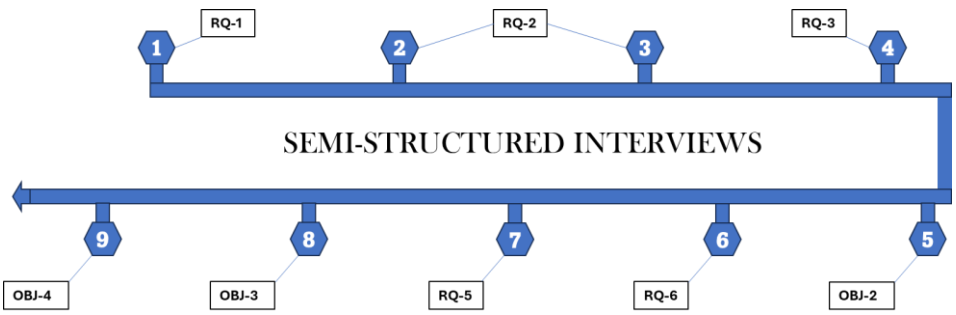


Figure 4.6: Schedule and Research Scope of Semi-structured Interviews

Three distinct types of interviews were conducted: in-person, virtual/online, and over the phone. Most of the traits found through the Delphi approach were validated by the interview results, which also allowed for the identification of several more aspects not found by Delphi. In this study, direct interviews were employed as part of case studies (eclectic) and in two different scenarios for data collection and validation. It was simpler to acquire comprehensive information regarding the challenges encountered and the factors discovered thanks to the qualitative interviewing method. A thorough overview of time intervals and appropriation is provided in **Figure** 4.6. **Appendix I** provides comprehensive information pertaining to the procedural aspects of the semi-structured interviews, including the invitation process, interview guidelines, questionnaire format, and participant profiles.

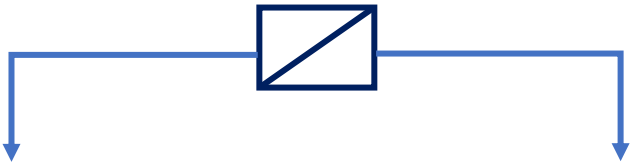
4.3.3. Case Studies

Case studies are crucial research methods for in-depth understanding, contextual analysis, theory building, practical application, and flexibility. They allow researchers to explore complex phenomena in real-life contexts, providing rich insights that may not be captured through other methods (Rashid et al., 2019). They also offer the opportunity to examine the social, cultural, and organizational dimensions surrounding a particular issue or phenomenon, which is crucial for understanding factors influencing outcomes. Case studies contribute to theory building by providing empirical evidence that helps refine existing theories or develop new ones. Discoveries derived from case studies can directly inform decision-making and issue resolution across diverse sectors such as business, healthcare, education, and public policy (Orunbon and Oluranti, 2023). These findings are versatile and adaptable to various research frameworks and methodologies, providing a comprehensive perspective on research endeavors. In this investigation, the case studies concentrate on the Indian construction domain, examining how sustainable construction practices are integrated through the adoption of green supply chain principles and the efficacy of implementing related policies, guidelines, or procedures. The examination of case studies draws from multiple data sources and benefits from the prior establishment of theoretical propositions to guide both data collection and analysis.

In case study research, the research design is a vital step that connects the data gathered with the study's initial inquiries, shaping the conclusions drawn from the analysis. It

comprises five components: research questions, case selection, data collection, data retrieval, data analysis, and trustworthiness and validity. Research questions guide the focus of the case study investigation by specifying what aspects of the phenomenon under study will be examined. Case selection determines the context and scope of the study, while data analysis involves organizing, interpreting, and synthesizing the collected data to derive meaningful insights. Trustworthiness pertains to the credibility, transferability, dependability, and confirmability of research findings, while validity addresses the accuracy and reliability of the study's conclusions. The inquiry into the study's questions focuses on the structure of the inquiries and their alignment with the suitable research strategy. The study's propositions indicate areas that warrant investigation within the study's framework. The coherence between data and propositions, as well as the criteria for interpreting findings, are established through evidence examination, scrutiny, and comparative analysis.

Table 4.3: Mapping of the case studies conducted and appropriation



Case Study #1		**Case Study #2**	
Location	South Indian Provinces	Location	Kerala State
Target	Major construction organizations	Target	Local Bodies and construction organizations/associations
Strategy	Stakeholder Analysis	Strategy	Regulatory compliance
Core	Professionals @ 1˚, 2˚, &3˚	Core	Stakeholders @ 1˚, 2˚, &3˚
Time	between August 15 and December 10, 2022	Time	between May 15 and October 30, 2023

Various types of designs can be employed based on the research questions shooting objectives and the nature of the phenomenon under investigation. Some main types include single case design, multiple case design, holistic case design, embedded case study, and multi-case design. Single case design is useful when the case is unique or when the research aims to provide detailed insights into a particular situation. **Appendix II** contains the structure of the case studies conducted for the research, including comprehensive abstracts, procedural details such as letter notifications,

guides/handbooks, and specifics of the interviews conducted to shape the survey. Multiple case design is useful when establishing broader trends or principles but requires extensive time and resources. Holistic case design is a comprehensive approach to studying a case, considering all relevant aspects and dimensions, and is useful for exploring complex phenomena that cannot be adequately understood by focusing on isolated aspects. Embedded case studies involve multiple units of analysis, such as subunits, to explore specific elements within a broader context. Nonetheless, it is crucial to refrain from concentrating solely on the subunit level and neglecting to reconnect with the broader unit of analysis. In the undertaken case studies, an embedded design was embraced, enabling the exploration to encompass additional units of analysis, such as individual departments or project programs, thereby circumventing the challenges linked with holistic design.

4.3.4. Questionnaire survey

Questionnaire surveys are a valuable research method for studying green transformation in Indian construction supply chains. They offer wide coverage, standardization, efficiency, anonymity, and confidentiality, making them suitable for studying complex issues and multiple stakeholders. Quantitative analysis allows researchers to quantify the prevalence of certain attitudes, behaviors, or opinions within the target population, enabling statistical testing of hypotheses and identifying significant relationships between variables. Longitudinal studies can track changes in attitudes, behaviors, or policy effectiveness over time, providing insights into the long-term impact of policy interventions on green transformation in the construction sector. Questionnaires are cost-effective, convenient, and minimal researcher interference, but have limitations like respondents being denied help without an investigator, low response rates, missing data, and difficulty in obtaining certain data.

4.3.4.1. Questionnaire Development

To craft a questionnaire for GSCM implementation in the Indian construction sector, attention should be directed towards three primary aspects: wording principles, measurement principles, and overall presentation. The questionnaire ought to be lucid, succinct, and accessible, steering clear of specialized terminology and technical language.

It should encompass a diverse array of pertinent subjects and concerns associated with GSCM implementation, addressing both quantitative metrics and qualitative facets. Validity and reliability should be ensured by using validated measurement scales or established indicators, and the questionnaire should be pilot-tested with a small sample of respondents to identify potential ambiguities, inconsistencies, or biases.

The questionnaire should be context sensitive, tailoring it to the specific context of the Indian construction sector, considering the unique challenges, opportunities, and cultural factors that may influence GSCM implementation. It should be logical and coherent, with clear sections or themes that guide respondents through the survey. Ethical considerations should be considered, such as respecting respondents' rights and confidentiality, obtaining informed consent, and providing anonymity or confidentiality options.

Questionnaire surveys can be administered through various channels, such as online platforms, email, postal mail, in-person interviews, or telephone interviews. Online surveys are commonly used due to their cost-effectiveness, ease of administration, and ability to reach a large and geographically diverse audience. Mail questionnaires have the advantage of reaching a broad geographic scope and allowing respondents to complete them at their convenience. However, a challenge arises in striking a balance between personalizing the interaction and preserving respondent anonymity.

Sampling entails choosing a subset of individuals from the target population to partake in the survey. Probability sampling methods guarantee equal representation of all members of the target population, while non-probability sampling methods are employed when probability sampling is impractical.

In the questionnaire survey, the organization (i.e., construction groups) acts as the unit of analysis, with only one individual from each organization receiving the questionnaire. Ethical considerations, including privacy, confidentiality, informed consent, and transparent communication of the research purpose, are imperative.

A questionnaire is a structured tool used to collect information from respondents, typically comprising various sections serving specific data-gathering purposes. While the structure may vary based on research objectives and study nature, common components include an

introduction, demographic information, main question sections, response options, additional sections, and a closing section.

The questionnaire comprised four main parts: Part 1 solicited general information about respondents and their organizations, Part 2 presented three sets of sustainability considerations from the Delphi Exercise, and Part 3 inquired whether respondents' authorities adhere to policies, strategies, guidelines, or procedures indicating the necessity of addressing these considerations in their construction procedures.

Multiple-choice surveys are commonly used for collecting information regarding practices, performances, adopted technologies, and preferences within the construction sector while still achieving the research objectives. These questions can be categorized as single response or multiple answer, and the most typical kind asks respondents to select one response from a predetermined list of choices. However, passive bias and the potential for incomplete lists of answers are two frequent drawbacks of multiple-choice questions.

Open text or remark boxes compensate for the restriction by providing feedback that whatever they enter is the right response. In rating scale questions, respondents are asked to select the numerical point on a scale from 1 to 5 that best describes their view or experience. The connection between the numbers on a scale and the ideas they measure must be made clear, either in the question or on the rating scale itself, for respondents to understand it. The research employed two survey methods, with the pattern and mode of approach clearly defined in the questionnaire, which are included in Appendix III.

Data collection indentions were met via multiple-choice questions and descriptive models. Statistically aligned with L/S and confirmed with Delphi analysis for the success of the Conceptual framework (CFW).

A Likert scale was used in Part 3 of the survey to gauge respondents' agreement or disagreement [‘1’ stands for ‘strongly disagree’ and ‘5’ stands for ‘strongly agree’] with specific statements regarding the need for sustainable building and policy development. Respondents were given the opportunity to submit any comments in Part 4.

Pilot testing is an essential stage in research because it assists in identifying ambiguities, assess clarity, test technical functionality, estimate completion time, and build confidence

in the questionnaire's validity and reliability. It helps to identify language and comprehension issues, assess the clarity of questions from respondents' perspectives, and ensure a smooth data collection process. Pilot testing also helps estimate completion time, which is essential for planning survey administration and ensuring appropriate survey length. By addressing potential sources of bias, error, or misinterpretation during the pilot phase, researchers can enhance the validity of the survey instrument and collected data' quality improvement, strengthening the reliability of the study findings and the credibility of the research outcomes.

4.3.4.2. Survey Dissemination

The distribution of a questionnaire after pilot testing involves several customs. These include sending personalized invitations to potential respondents, setting a clear deadline for completion, sending reminder emails to encourage participation, ensuring confidentiality and anonymity, Supplying explicit guidance on how to fill out the questionnaire, ensuring accessibility through online platforms, mail, or in-person distribution, following up with non-respondents after the initial invitation and reminder emails, acknowledging and thanking respondents for their participation, and ensuring data security.

The questionnaire was piloted with professionals/field-level experts working in all levels of hierarchy (1˚,2˚, &3˚) and was sent to respondents in November 2022 and October 2023. No specific timeframe was imposed for responses; however, a response within a two-week period would be appreciated. Respondents were guaranteed that their replies would remain confidential and that the data collected would solely be utilized for research objectives. Non-respondents were subsequently reminded via letter, phone call, or email, and provided with another copy of the questionnaire two weeks later. By following these customs, researchers can effectively distribute the questionnaire and maximize response rates, ensuring the success of their data collection efforts.

4.3.4.3. Questionnaire Management

i. Response Rate

To boost a questionnaire's response rate, consider strategies such as sending follow-up letters, announcing respondents beforehand, using a reputable research organization, ensuring the questionnaire's quality and presentation, providing a suitable covering letter, providing clear guidelines, starting with interesting questions, personalizing the cover-letter, reminders, and minimizing open-ended questions (Gill and Johnson, 2002). Adhering to the three dividends' guidelines can streamline the program and increase the response rate.

ii. Easy management

1. Employing clear and understandable language for the respondents.
2. Including an open-ended question at the conclusion of the questionnaire alongside closed-ended questions, allowing respondents to provide additional comments.
3. Steering away from negative questions, as they may be challenging for some respondents to comprehend or may be overlooked due to the negative wording.
4. Ensuring that questions are of suitable length to maintain respondent engagement and clarity.
5. Modifying or incorporating questions that have proven effective in previous surveys.

iii. Max accuracy

1. Providing closed-ended questions with options that are both mutually exclusive and collectively exhaustive.
2. Employing a funnel approach in question design, ensuring a logical flow from general and straightforward questions to more specific and challenging ones.
3. Subjecting the questions to review by both experts and potential respondents to ensure clarity and relevance.

iv. Advocacy

1. Steering clear of questions that prompt socially desirable responses.
2. Eliminating recall-dependent questions, which require respondents to recall vague past experiences.
3. Omitting leading questions that influence respondents to provide answers favorable to the researcher.
4. Handling personal data with sensitivity to the feelings and privacy of respondents.
5. Abstaining from using loaded questions that contain implicit assumptions or bias.

4.3.5. The Delphi method

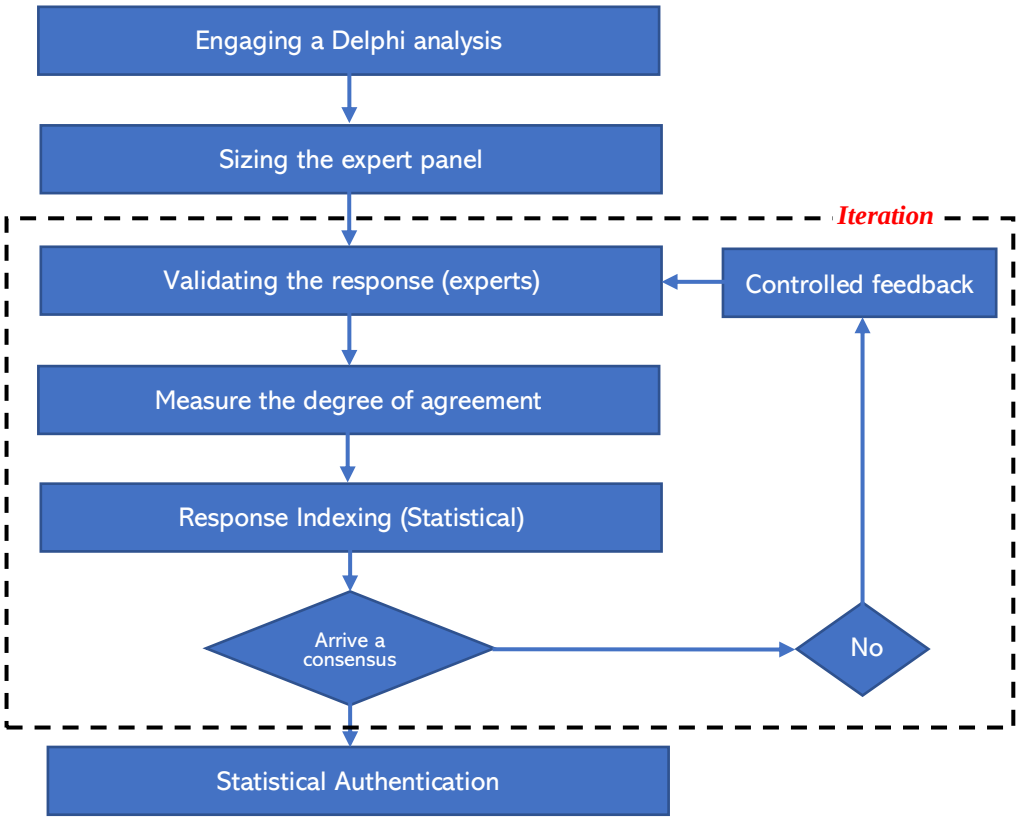


Figure 4.7: The Delphi Procedure (flowchart)

The Delphi technique is a methodical approach to obtaining professional advice through an iterative process (see Figure 4.7). It aims to bring a panel of specialists' opinions into a credible consensus through anonymous communication. The process involves setting up an expert panel, which is unique in that all communication is conducted anonymously

(Martino, 1993). Delphi is typically conducted through surveys, with a new questionnaire created and distributed to participants in the next round after each round's answers are analyzed (Procter and Hunt, 1994). This procedure persists for a set number of iterations or until meeting specific criteria, such as achieving consensus (Mullen, 2003). The Delphi method stands out from other group decision-making processes due to its four distinctive characteristics: anonymity, regulated feedback iterations, statistical group responses, and professional input (Varndell et al.,2021). It is used in various fields, including classical, policy, and decision-making, and is particularly useful for qualitative issues. The Delphi method helps researchers identify and prioritize problems, create a framework for recognizing them, and determine the nature and essential components of a phenomenon. Despite its long-standing use in academic and scientific research, Delphi remains a valuable tool for gaining insights and making informed decisions.

4.3.5.1. Scope of Delphi

Applying multi-criteria decision-making (MCDM) methods to evaluate items in operations research issues represents a key utilization of the Delphi technique (Afshari et al., 2012). In general, any purpose necessitating the use of committees can be served by Delphi (Linstone and Turoff, 1975; Martino, 1993). Delphi is particularly helpful to use when there is a need for experts to reach a more conclusive conclusion regarding a dispute, a debate, or a confusing situation but there is not enough time to do so. Managing complex issues that require more in-depth analysis or expensive, difficult-to-find knowledge is vital. The most preferred method for reaching an agreement on novel and uncharted areas of study and decision-making is considered to be Delphi. The same method can be used to encounter and elicit ground truth clarifications for a range of perspectives acting as minimal quantitative evidence or to combine disparate viewpoints into a more inclusive reservoir of knowledge.

C. Pros:

- Anonymity: The influence of dominating people is lessened by anonymity, which also lessens peer pressure to conform and enables the consideration of views without hostility.

- Iterations: multiple iterations to arrive Consensus provides sufficient space for the panelists to change or rethink their comments according to the objectives of the research.

- Statistical validation calibrates the responses and weights them equally, so no one person can shift the opinions of the group.

- A multi-tier data collection (scheduling, travel/space requirements, lengthy discussions) enables the panel to refine the outcome with fewer drawbacks.

- Controlled feedback on the group's opinion lowers noise and enables participants to revise their rankings considering those of other participants.

D. Cons:

- The number of panels is hard to maintain uniform.

- Sizing the Expert panel shall be very curious and keen, as the whole process is lied to that.

- When research has multidisciplinary goals, technique poses more difficulties for the researchers, particularly when creating round 1 surveys that ask for descriptive responses in order to create round 2 questionnaires.

- There will be no evidence of reliability if two panels receive the same query but are unable to reach a consensus.

- The Delphi study's reached agreement simply indicates that the expert panel has agreed on something based on their interests, which are more significant and related to the study's goals. It does not imply that the Delphi study's consensus represents the best solution, opinion, or judgement.

- There aren't any precise methodological rules governing the panelists and stages (Diamond et al., 2014).

- Does not enable participant discussion and does not give participants the chance to elaborate on their opinions (Yousuf, 2007).

- The sanctity of Delphi may be impacted by pressure. i.e., a group member with the ability to make a strong argument may have too much influence over the talks and ideas of the group.

- The limitations of the Delphi technique, like potential low participation rates and the need for considerable time investment from both respondents and researchers, may arise when the sample size becomes overly large (Ludwig, 1994).

4.3.5.2. Specificity of Delphi

a) ***Flexibility and Anonymity:***

The Delphi method is a flexible method that allows experts from diverse geographical locations and time zones to participate without the constraints of physical meetings. Participants remain anonymous throughout the process, promoting open and honest expression of opinions without fear of judgment or bias. This anonymity is the primary advantage of the Delphi method compared to other measurement techniques. It is mainly used for quantitative assessments and is commonly referred to as "quasi-anonymity" due to respondents' familiarity with one another but complete anonymity with their views and assessments. The Delphi technique is recommended for large sample sizes and when face-to-face interaction becomes challenging due to large sample sizes or political issues. Participants in the Delphi technique have the freedom to respond unbiasedly to the pressures and identities of other participants, and can act and share ideas in an impartial manner. A 70% answer rate is recommended to uphold the method's rigor. Anonymity is a key aspect of the Delphi method that sets it apart from other consensus and judgement methods. However, total anonymity can create long-term issues, and respondents must be aware of their anonymity, known as "quasi-anonymity," to ensure their views and assessments remain anonymous.

b) Expertise:

Delphi participants are selected based on their expertise and knowledge relevant to the subject matter. This ensures that the insights gathered through the process are informed by diverse perspectives and informed opinions, contributing to the robustness of the final outcomes.

c) Structured Communication:

Delphi exercises are characterized by structured communication protocols, often facilitated by a moderator or facilitator. This ensures that the discussions remain focused, and participants adhere to predefined guidelines for submitting responses and providing feedback.

d) Iterative Group Dynamics with Controlled Feedback:

The Delphi method is a group dynamic that involves multiple rounds of data collection and feedback, allowing participants to reconsider their opinions based on the group's collective input. This iterative process continues until consensus or convergence is reached on the topic under investigation. Participants receive controlled feedback from previous rounds, such as summaries of responses or statistical analyses, which helps them refine their opinions, clarify uncertainties, and track the evolution of group consensus over time. The Delphi method can be applied repeatedly until consensus is reached, and the results of earlier iterations can be altered or revised by individual experts (panel) in successive iterations. This approach is expected to lead to greater problem-solving orientation, more insightful views, and reduced noise effects. The feedback procedure motivates participants to reconsider their original assessments of the data presented in earlier iterations. The structured feedback mechanism involves providing a systematic recapitulation of the preceding round, enabling each participant to contribute additional insights and elucidate on the information generated from earlier iterations. The number of Delphi iterations may vary between three and five, contingent upon the desired level of consensus. Statistical analysis is employed to ensure equitable representation of each participant's opinions in the final iteration, considering the potential for significant variation in individual viewpoints by the end of the exercise.

e) Statistical delineation

The second-round results would be analyzed over statistical tools to prioritize the aroused opinions/components and the same will be shared to the participants to rearrange/reorganize the arrived decision according to the statistical indexing. The group opinion is typically discussed by a statistical clarification (such as the mean), which may also show the range of opinions within the cluster/group (e.g., the SD-standard deviation).

4.3.5.3. Delphi expert Panel

The Delphi analysis for policy interventions in Green Supply Chain Management (GSCM) in the Indian CS involved selecting experts built on various criteria. These criteria prioritized diversity, expertise, and credibility, ensuring that the process captured insights from various stakeholders. The experts were chosen based on their in-depth understanding, familiarity, know-how, and contributions to GSCM and policy development. The size of the expert sample was carefully determined to strike a balance between inclusivity and manageability, ensuring sufficient representation from diverse stakeholder groups while maintaining an efficient and focused Delphi process. This approach allowed for meaningful interactions and consensus-building among participants while avoiding logistical challenges associated with larger expert panels. **Appendix** IV of the Delphi analysis performa contains communications, information sheet, a comprehensive list of the participating specialists, and questionnaire, providing transparency and accountability regarding the selection process. Each expert's affiliation, expertise, and sector representation are documented to offer stakeholders insights into the diverse range of perspectives contributing to the policy interventions for GSCM/sustainability in the Indian construction industry.

The selection of experts for participation in the Delphi Exercise was based on specific criteria, considering both the nature and size of the sample. The chosen experts were diverse, representing various perspectives and sectors within the industry. They encompassed academics, professionals from the public sector, as well as representatives from professional/consultancy organizations and major contracting entities.

a) Sizing the experts' panel

Researchers have debated the definition of expertise, with various factors such as publications, awards, patents, peer reviews, presentations, and media coverage being considered. Years of experience as eminent professionals, such as leadership or membership in a professional society or organization, are also important. Delphi studies are well-suited for three groups: top management decision-makers, professional staff members, and Delphi questionnaire takers. Ludwig (1994) suggests soliciting nominations from esteemed and reputable individuals within the targeted expert groups. The credentials of Delphi experts must be carefully examined and considered by researchers. Principal

investigators should use a nomination procedure to identify and choose the most suitable participants, and experts should have extensive training and expertise in the specialized field of knowledge related to the problem. The credentials of Delphi experts should be carefully examined and considered by researchers.

b) Selection of Delphi expert panel: Challenges

When assessing a Delphi study, researchers should take into account factors such as the size of the panel, the complexity of the issue at hand, the level of homogeneity within the panel, and the resources available. A diverse panel can offer a broader range of perspectives and enhance the generalizability of consensus, whereas a homogeneous group may be more reliable for addressing specific study objectives. It's crucial for the methodology to outline how homogeneity is achieved, especially in multidisciplinary studies.

Selecting experts for Delphi analysis in the realm of policy interventions for Green Supply Chain Management (GSCM) within the Indian construction industry presents several challenges. These include identifying and recruiting experts with pertinent expertise in GSCM, policy formulation, and the Indian construction sector. The availability and willingness of these experts to participate in the Delphi process may pose additional hurdles. Ensuring diversity among selected experts is crucial for obtaining comprehensive and unbiased insights. However, finding experts representing various stakeholders, such as government agencies, industry associations, academia, and non-governmental organizations, can be challenging.

Expert reliability is essential for the validity and credibility of the Delphi process, but determining the reliability of experts' opinions and providing informed inputs can be challenging. Securing active participation from selected experts throughout the Delphi process requires effective communication and facilitation. Minimizing potential biases among selected experts is essential for generating unbiased and objective insights, but identifying and addressing biases without compromising their expertise or independence can be challenging.

Addressing potential turnover or attrition among selected experts during the Delphi process can pose challenges in maintaining continuity and consistency of input. Proactive

management and recruitment strategies are required to ensure a sufficient number of experts remain engaged and replace those who withdraw from the process.

Utilizing technology and eliminating the need for physical voting, the electronic Delphi survey, commonly referred to as e-Delphi, facilitates global participation of panel members, streamlines the survey rounds, and saves time. In this approach, experts are selected based on their qualifications identified through online research. Subsequently, invitations to participate in the project can be sent via email. Experts can have a low acceptance rate, and when deciding who to invite, researchers typically take this greater attrition rate into account.

4.3.5.4. Contributing potential towards this research

The Delphi method, a structured and iterative approach, proves effective in studying policy interventions for implementing Green Supply Chain Management (GSCM) in the Indian construction sector. It enables the collection of diverse perspectives and opinions from experts across academia, industry, government, and pertinent organizations, thereby ensuring a holistic grasp of the issues and challenges associated with GSCM policy interventions.

The anonymity provided by the Delphi method encourages open and honest contributions from participants, particularly in sensitive areas such as policy formulation and implementation. This fosters a more candid exchange of ideas and minimizes biases that may arise from social dynamics. The iterative process of Delphi involves compound data collection and feedback, allowing for the refinement and validation of responses over successive iterations.

The Delphi method is scalable, accommodating a wide range of participants, making it suitable for capturing diverse viewpoints on complex policy issues spanning the Indian construction sector. It offers flexibility in its application, allowing researchers to adapt the process according to the research objectives, timeframe, and resource constraints.

The Delphi method is particularly suitable for investigating dynamic and multifaceted topics like GSCM policy interventions, where stakeholder perspectives may evolve over time. The Delphi method's "hybrid" position within the qualitative/quantitative discourse

positions it favorably for application. While primarily qualitative, Delphi offers rich, context-driven insights, enhancing comprehension of intricate issues. Yet, its capacity to yield quantitative outcomes indicates the potential for consensus assessment.

This research employs the Delphi method for three objectives (**Table 4.2**), utilizing a systematic and adaptable approach to explore policy interventions in GSCM implementation in the Indian construction sector, utilizing expert consensus, anonymity, iterative feedback, scalability, and flexibility.

4.3.6. Triangulation

Triangulation, as a research methodology, employs multiple methods and measures to mitigate bias and enhance validity. It encompasses various approaches, including data triangulation, methodological triangulation, investigator triangulation, and interdisciplinary triangulation. This methodological diversity enables the integration of quantitative and qualitative research techniques, thereby enhancing research quality. Love et al. (2003) advocate for triangulation's suitability in expanding theoretical horizons within construction management research, emphasizing how convergent findings enhance result reliability and validity. Despite this, there's been a reluctance in construction management research to blend methodologies, potentially undermining overall research rigor.

In this study, an operational conceptual framework was developed to address sustainable construction in the Indian construction sector through policy-level interventions, focusing on green supply chain elements/criteria. Literature surveys, semi-structured interviews, case studies, and the Delphi Exercise were utilized to establish these elements. Barriers hindering sustainable construction were identified through semi-structured interviews and case studies, with key stakeholders capable of addressing these barriers also identified through the same methods.

Triangulation manifests in various forms, including diverse data sources, collection methods, researcher perspectives, temporal triangulation, and theory triangulation. Different sources like stakeholder interviews, policy document analysis, site observations, and literature reviews provide multifaceted insights into the research topic. Engaging

stakeholders with diverse backgrounds enriches the research process and ensures comprehensive understanding.

By examining data collected over time, researchers can evaluate policy effectiveness, sustainability, and areas necessitating improvement. Triangulation bolsters research validity and reliability by corroborating evidence across multiple dimensions. In the realm of GSCM implementation in the Indian construction sector, triangulation is indispensable for generating comprehensive insights and informing evidence-based policy interventions within supply chains.

4.4. Data Analysis

4.4.1. Data collection

The study seeks to explore the implementation of Green Supply Chain Management (GSCM) in the Indian construction sector through the analysis of six distinct sources of evidence: questionnaire surveys, documentation, interviews, direct observation, participant-observation, and tangible artifacts. Documents provide insights into formalized aspects of GSCM implementation, such as regulatory requirements, industry standards, and organizational practices related to sustainability and green initiatives. Interviews with key stakeholders offer firsthand perspectives on challenges, strategies, successes, and barriers in the Indian context. Direct observation allows researchers to witness real-time activities, interactions, and challenges faced by stakeholders involved in sustainable construction projects. Participant-observation involves actively participating in construction projects or sustainability initiatives, providing unique insights into the dynamics of GSCM implementation within the Indian construction industry. Artefacts, such as green building materials, technologies (energy-efficient), waste management systems, and ‘green’ trends construction, can offer concrete evidence of GSCM implementation efforts in the Indian construction sector. Documentation is pertinent to all case study subjects, with the exception of investigations into preliterate societies. The primary objective of conducting case studies was to ascertain how stakeholders were integrating GSCM criteria into their strategies, policies, guidelines, or procedures for sustainable construction. The methodologies and technologies utilized in the questionnaire survey are outlined in Section 4.2.4.

Case studies are a qualitative research method that aims to provide in-depth insights into a particular phenomenon, context, or problem. To ensure rigorous and comprehensive data collection, several key principles must be considered: comprehensive data retrieval, compound evident sources, contextual understanding, in-depth interviews, document analysis, data triangulation, reflexivity and transparency, data management and organization, and ethical considerations. Thorough data collection entails encompassing various sources of evidence, including documents, archival records, interviews, direct observation, participant-observation, and artifacts. Contextual understanding is crucial in case studies, as it allows researchers to capture the unique context, dynamics, and nuances of the case. In-depth interviews allow researchers to gather firsthand accounts, perspectives, and insights from key stakeholders, participants, or informants involved in the case. Effective data management and organization are essential for case study research, with clear protocols for data collection, storage, and retrieval.

Case study selection is influenced by several factors such as the research purpose, inquiries, propositions, theoretical context, accessibility, resources, and available time, need to be considered, diversity and representativeness, complexity, stakeholder perspectives, and ethical considerations. Researchers must consider these factors when selecting cases to effectively address research objectives, provide valuable insights, and contribute to scholarly knowledge. Theoretical context, accessibility, resource availability, and time constraints are essential considerations in case study selection. Researchers must consider factors such as geographic location, organizational cooperation, data availability, and participant willingness to ensure feasible access to cases. Resources, including funding, personnel, and technical support, also impact selection. Time available is another important factor, as researchers must choose cases that can be thoroughly investigated within the specified time frame. Diversity and representativeness are essential for comprehensive exploration and generalizability of findings. Complexity allows researchers to explore nuances, interactions, and underlying mechanisms within the case. Involving stakeholders in the selection process can enhance relevance and engagement. Ethical considerations are also crucial to ensure the protection of participants' rights, confidentiality, and privacy. By carefully considering these factors, researchers can select case studies that effectively address research objectives, provide valuable insights, and contribute to scholarly knowledge.

Case studies are crucial in both qualitative and quantitative research methodologies, providing valuable insights and contributing to the depth and richness of research findings. In qualitative research, case studies are used to explore complex phenomena in real-life contexts, uncovering detailed insights, patterns, and underlying meanings through methods like interviews, observations, and document analysis (Priya, 2021). They are particularly useful for theory building, hypothesis generation, and exploring new areas of inquiry. In quantitative research, case studies are used to examine specific cases within a broader context, providing empirical evidence, validating hypotheses, and identifying statistical trends. They allow for the examination of relationships between variables, testing causal mechanisms, and generalizability of findings to larger populations (Chukwudi et al., 2019). Case studies complement and triangulate quantitative data with qualitative insights, providing a more comprehensive understanding of research phenomena. Overall, case studies are essential in both qualitative and quantitative research for their ability to provide detailed, contextually rich, and nuanced insights into complex phenomena.

The case studies aimed to support substantially objectives 1 and 3 in sustainable construction. Two case studies were conducted at different time scales [1&2] on GSCM criteria in sustainable construction criteria in Indian construction. The first study introduced sustainable construction (supply chain) elements and sought to identify if these criteria were addressed in the organization's strategies, policies, guidelines, or procedures confined to south Indian provinces comprising major cities like Chennai, Bangalore, etc. If affirmative, the researcher aimed to delineate the organization's approach to addressing these criteria. In the second case, Objective 3 was tackled by scrutinizing policy components in India and their impact, both direct and indirect, on the efficient execution of Green Supply Chain Management (GSCM) and circularity aspects in Green Building Construction in India. The researcher endeavored to pinpoint any additional significant sustainability criteria perceived by the organization as imperative for their strategies and Supply Chain Management (SCM) elements, including the effectiveness of policy implementation and its success rate.

4.4.2. Data processing

According to Yin (1994), the examination of evidence in case studies poses challenges owing to the absence of clearly defined strategies and methodologies. He proposes two methods for effective analysis: converting events into numerical data and employing analytic techniques. Although the latter method is deemed preferable, caution must be

exercised during manipulation to prevent skewing the outcomes. Yin underscores the significance of adopting a comprehensive strategy for case study analysis, which may be grounded in theoretical propositions or a descriptive portrayal of the case. Data analysis for case studies can be conducted using various software tools, including SPSS (Statistical Package for the Social Sciences) and R (Open-source programming language). A general strategy for conducting data analysis for case studies using SPSS and R includes data preparation, descriptive analysis, data visualization, inferential analysis, qualitative data analysis, integration of quantitative and qualitative data, interpretation and reporting, and sensitivity analysis (see Figure 4.8). Data preparation involves importing raw data into the respective software platform, cleaning the data by identifying and handling missing values, outliers, and inconsistencies, and creating visualizations to explore relationships and patterns within the data. Inferential analysis uses SPSS's Analyze menu to conduct t-tests, ANOVAs, correlation analyses, regression analyses, chi-square tests, etc., while qualitative data analysis uses coding techniques to analyze text-based data. Integration of quantitative and qualitative data is essential for providing a comprehensive understanding of research questions. SPSS or R can merge datasets, perform joint analyses, and generate integrated reports. Interpretation and reporting involve interpreting the results in the context of research objectives and hypotheses, preparing summary tables, figures, narratives, and generating comprehensive reports and visualizations. Validation and sensitivity analysis are crucial for testing the robustness of findings and assessing the impact of potential biases or assumptions. By following this data analysis strategy,

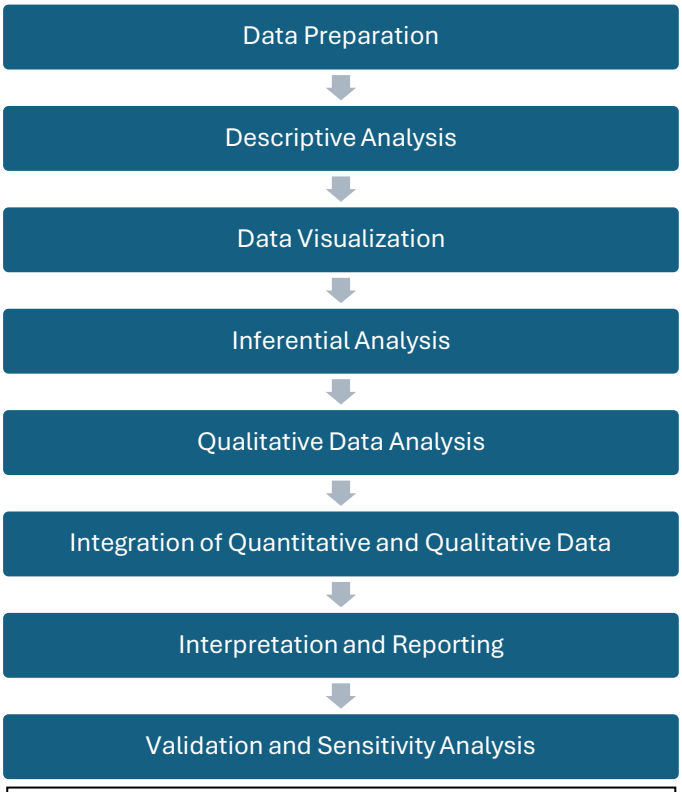


Figure 4.8: Flow chart: Analytics in a Case study research

researchers can effectively analyze case study data using SPSS and R, leveraging their capabilities to derive meaningful insights and conclusions from the study.

4.5. Assessing the Quality of Research

This section provides an overview of the criteria utilized to assess the quality of both qualitative and quantitative research. Similarly, it illustrates how each of these criteria was taken into account within the scope of this study.

4.5.1. Quantitative Research: The Quality Assessment

Assessing the quality of quantitative research involves evaluating two key aspects: Reliability and Validity.

A. Reliability

Reliability is the consistency, stability, and precision of the measurement process in quantitative research. It evaluates the repeatability and consistency of a study's findings when replicated or when different researchers measure the same phenomenon. There are various types of reliability, including internal consistency reliability, test-retest reliability, and inter-rater reliability. Stability concerns whether a measure remains consistent over time, with test-retest reliability used to assess stability. Internal consistency reliability measures the coherence of participants' responses to different aspects of a concept, indicating whether their scores on one measure correlate with others. Cronbach's coefficient alpha values indicate stronger internal consistency and a more reliable measuring instrument. Alternative form reliability involves altering the wording or sequence of questions and responses while retaining the meaning. Inter-observer reliability involves significant subjective judgment in recording observations or categorizing data. Overall, reliability plays a crucial role in quantitative research to ensure the accuracy and consistency of the study's findings (Mohajan, 2017).

B. Validity

Validity is the accuracy of a study's measurements and the precision of inferences drawn from its findings. It can be categorized into content validity, criterion validity, construct validity, and convergent and discriminant validity. Researchers use various methods and statistical analyses to assess reliability and validity, enhancing the credibility and

trustworthiness of their research results. Internal validity ensures that an independent variable is responsible for observed variation in the dependent variable. External validity assesses whether the findings can be generalized beyond the specific research context. Ecological validity examines if social scientific findings are relevant to individuals' everyday social environments. Measurement validity concerns whether a measure genuinely reflects a concept. Concurrent validity evaluates how well one instrument performs compared to another, with concurrent validity and predictive validity. Predictive validity assesses how accurately the item or scale predicts expected future observations, while convergent validity evaluates whether different methods yield similar results. Overall, validity is crucial for ensuring the credibility and trustworthiness of research results (Mohajan, 2017).

4.5.2. Qualitative Research: The Quality Assessment

Bell and Bryman (2022) suggest that assessing qualitative research quality involves credibility, transferability, dependability, and confirmability, rather than traditional reliability and validity concepts commonly used in quantitative research.

A. Credibility:

In qualitative research, credibility mirrors internal validity in quantitative research and concerns the assurance in the authenticity and precision of the findings as perceived by the participants. To enhance credibility:

i. ***Use of Multiple Techniques****:* Researchers utilize diverse methods like extended interaction, triangulation, member validation, and peer consultation. Extended interaction entails dedicating ample time to engage with participants, fostering trust and rapport, thereby augmenting the trustworthiness of the gathered data. Triangulation encompasses the utilization of various data sources or methodologies to validate findings, thereby enhancing their credibility. Member validation entails revisiting participants to authenticate the accuracy and interpretation of the data. Peer consultation involves soliciting input from colleagues or experts to ensure the integrity of the research process and outcomes.

ii. ***Thick Descriptions and Direct Quotations:*** Researchers provide thick descriptions and include direct quotations from participants in their research reports. Thick

descriptions furnish comprehensive narratives of the research environment, participants' encounters, and the data collection methodology, furnishing readers with abundant contextual details. Direct quotations allow readers to directly engage with the participants' voices, enhancing the credibility of the findings by demonstrating their alignment with participants' perspectives.

By employing these techniques and providing rich contextual information, investigators can boost the credibility of their qualitative research findings, increasing confidence in the accuracy and truthfulness of the results from the perspective of the participants.

B. Transferability:

Transferability in qualitative research mirrors the concept of external validity in quantitative research, concentrating on the degree to which the findings can be extended or applied to different contexts or environments. To enhance transferability:

i. ***Detailed Descriptions***: Researchers furnish thorough depictions of the research setting, participants, and data gathering approaches in their research papers. These descriptions enable readers to grasp the precise circumstances in which the study took place and evaluate the significance of the results to their own situations. By offering comprehensive details about the research methodology, researchers empower readers to assess the relevance of the findings to alternative settings.

ii. ***Purposive Sampling:*** Researchers employ purposive sampling methods like maximum variation sampling to guarantee the representation of a wide array of viewpoints in the research. Through deliberate selection of participants embodying diverse demographic traits, experiences, or perspectives pertinent to the research subject, researchers enhance the potential for the findings to be applicable to a broader spectrum of scenarios. This diversity in sampling enriches the extrapolation of the findings beyond the particular context of the study.

Through comprehensive depictions of the research setting and participants, along with the utilization of purposive sampling methods, researchers can augment the transferability of their qualitative research outcomes. This amplifies the assurance that the findings hold relevance and applicability beyond the immediate research environment, thereby enhancing the external validity of the study.

C. Dependability:

Dependability in qualitative research mirrors the concept of reliability in quantitative research, focusing on the consistency and stability of findings across time and researchers. To enhance dependability:

i. ***Prolonged Engagement***: Researchers spend sufficient time in the field, immersing themselves in the analytical context to foster a deep know-how of the phenomenon under study. Prolonged engagement allows researchers to capture the complexity and nuances of the subject matter and increases the reliability of the findings by minimizing the likelihood of missing important details.

ii. ***Reflexivity***: Researchers ensure reflexivity by critically examining their own biases, assumptions, and preconceptions throughout the research process. By acknowledging and addressing their subjectivity, researchers can mitigate the impact of personal biases on data gathering and analysis, thereby enhancing the dependability of the findings.

iii. ***Audit* Trails**: Researchers maintain detailed audit trails, documenting every phase of the research journey, from data collection to analysis and interpretation. These trails provide transparency and allow others to track the researcher's decision-making process, ensuring the reliability and consistency of the data collection and analysis procedures.

iv. ***Peer* Debriefing and Member Checking**: Peer debriefing involves seeking feedback from colleagues or experts in the field to validate the interpretations and conclusions drawn from the data. Member checking entails revisiting participants to validate the accuracy of the researchers' interpretations of their experiences. These techniques enhance dependability by ensuring that the findings are grounded in the data and reflect the participants' perspectives accurately.

By employing techniques such as prolonged engagement, reflexivity, audit trails, peer debriefing, and member checking, researchers can enhance the dependability of their qualitative research findings, increasing confidence in the dependability and consistency of the results.

D. Confirmability:

Confirmability in qualitative research refers to the degree to which the findings are independent of the investigator's biases or preconceptions and are solely shaped by the data collected. Here's how researchers can enhance confirmability:

Maintaining an Audit Trail: Researchers should keep detailed records documenting every of the research steps in the so-called process, data collection to interpretation. This audit-trail provides transparency and accountability, allowing others to trace the researcher's decision-making process and verify the integrity of the findings. By documenting their actions, researchers can demonstrate that their interpretations are grounded in the data rather than personal biases.

Reflexivity: Reflexivity involves the researcher's explicit acknowledgment and consideration of their own role, perspectives, and biases in the research process. Researchers should critically reflect on how their personal experiences, beliefs, and assumptions may influence their interpretations of the data. By acknowledging their subjectivity, researchers can mitigate the impact of their biases on the findings and strive for objectivity in their analysis. Reflexivity encourages researchers to remain open-minded and self-aware throughout the research process, allowing them to identify and discourse any potential biases that may arise.

In conclusion, enhancing confirmability in qualitative research requires researchers to maintain transparency through documentation and to engage in reflexivity to acknowledge and mitigate their own biases. By following these practices, researchers can ensure that their findings accurately reflect the data collected and are not unduly influenced by personal perspectives or preconceptions. Overall, the quality assessment for qualitative research involves ensuring that the study is credible, transferable, dependable, and confirmable, thus improving the trustworthiness and legitimacy of the outcomes.

4.6. Conceptualization

The objective of this study is to comprehend and promote the adoption of environmentally sustainable practices within the Indian construction supply chain via policy interventions. The research adopts a triangulation approach, primarily utilizing the Delphi method, along

with Systematic Literature Review (SLR), semi-structured interviews, and case studies, to maximize the extraction of valuable insights.

Triangulation employs various methods or data sources to strengthen the credibility and dependability of research outcomes. The Delphi method facilitates the systematic gathering of expert opinions through structured questionnaires or surveys, ensuring a thorough exploration of complex topics and consensus-building among diverse stakeholders. The Systematic Literature Review (SLR) provides a rigorous approach to reviewing and synthesizing existing literature relevant to the research objectives, establishing the foundational knowledge base, identifying gaps in current research, and informing subsequent data collection and analysis.

Semi-structured interviews offer a flexible yet focused approach to gathering qualitative data from key stakeholders involved in the Indian construction sector. Case studies provide contextualized insights into real-world applications of ‘green principles’ in supply-chains within the Indian CS, examining diverse case scenarios, ranging from design and procurement to execution and waste recycling.

The selected methodologies are meticulously aligned with the research objectives and six research questions, ensuring maximal optimization in output recovery via triangulation. Key processes will be assessed using the Delphi method and SLR, specific issues will be identified through interviews (semi-structured) and case studies, and policy elements influencing green supply chain integration will be explored through Delphi method and SLR.

Figure 4.9 illustrates the conceptualization of employing a triangulation approach, which integrates the Delphi method, SLR, semi-structured interviews, and case studies. This approach offers comprehensive insights into the green transformation of the Indian construction supply chain, delineating specific intervals, their boundaries, and areas of overlap. Additionally, the process flow validates the sequential delivery of data and the analytical criteria adopted for the research.

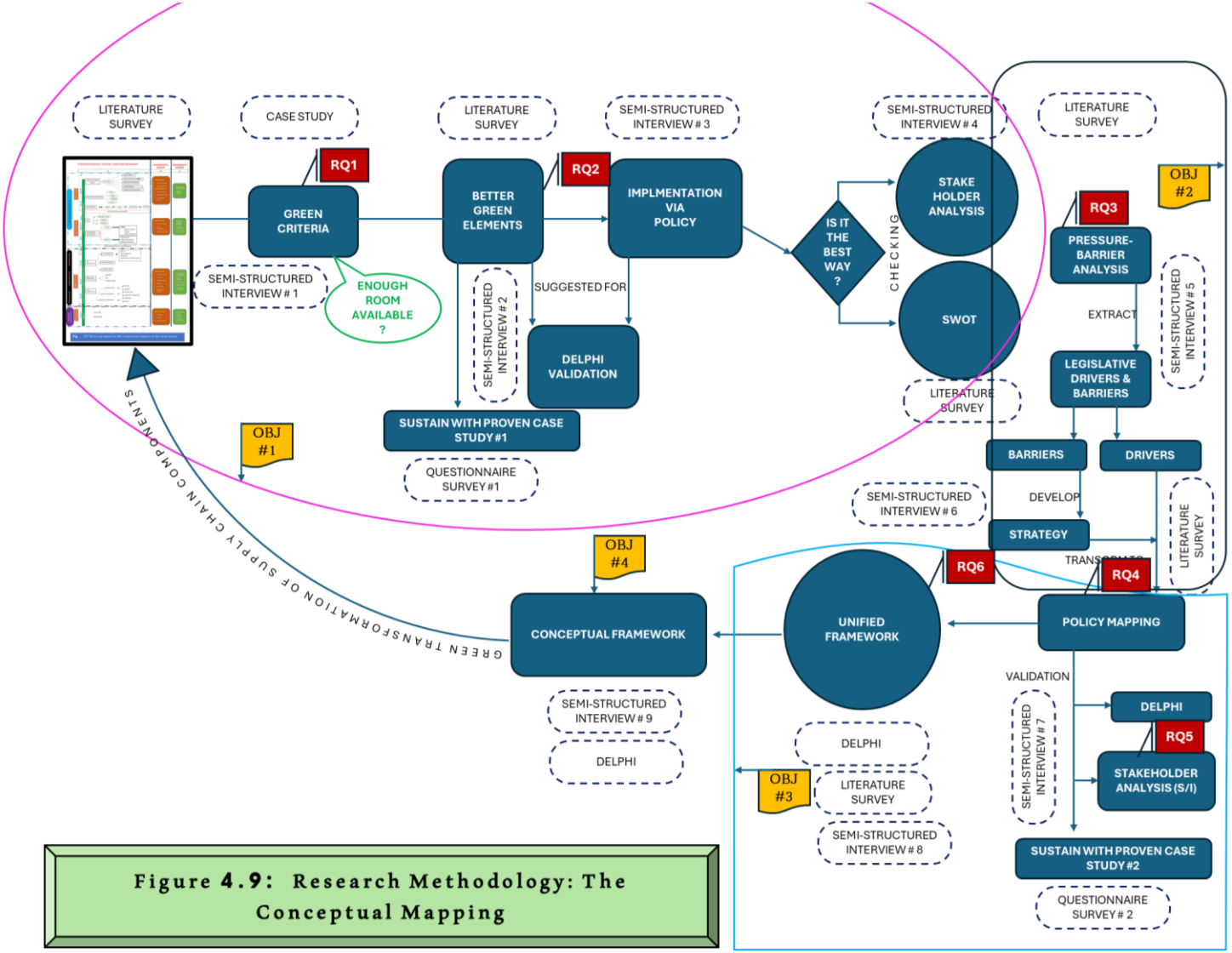


Figure 4.9: Research Methodology: The Conceptual Mapping

Chapter V

Results and Discussion

5.1. Introduction

The construction sector (CS) is a key player in global sustainability efforts, but its resource-intensive nature poses significant challenges. This chapter examines the Indian construction sector's journey towards sustainability, focusing on the integration of green supply chain principles. Key processes such as design optimization and waste recycling have the potential to usher in sustainable practices. However, specific challenges unique to the Indian context, such as regulatory complexities, infrastructure limitations, and socio-economic factors, hinder the seamless adoption of green-supply-chain concepts.

The study also explores the interplay between regulatory frameworks and green-supply-chain practices in India. By mapping existing policies and regulations, the authors identify opportunities for policy intervention and integration into a unified framework for sustainable development. This holistic approach underscores the importance of aligning regulatory measures with sustainability objectives to drive meaningful change within the construction sector.

A conceptual framework for transformative change is proposed, aiming to guide policymakers and stakeholders in fostering green transformation within the construction sector. The framework delineates strategic interventions and policy measures aimed at promoting environmental sustainability, social responsibility, and economic viability. By aligning with this framework, stakeholders can chart a course towards a more sustainable future, where construction practices align with ecological imperatives and contribute to global sustainability goals.

The findings of this study are not confined to theoretical discussions but are intended to spur action and drive tangible change in the industry. Subsequent discussions will delve deeper into these findings, proposing actionable strategies for stakeholders to embrace and implement them. By leveraging insights from the triangulation approach and statistical analyses, stakeholders can identify opportunities, address challenges, and collectively

work towards a greener and more sustainable construction sector. The road map of study development and assertions, finally towards conclusion, is depicted in Figure 5.1.

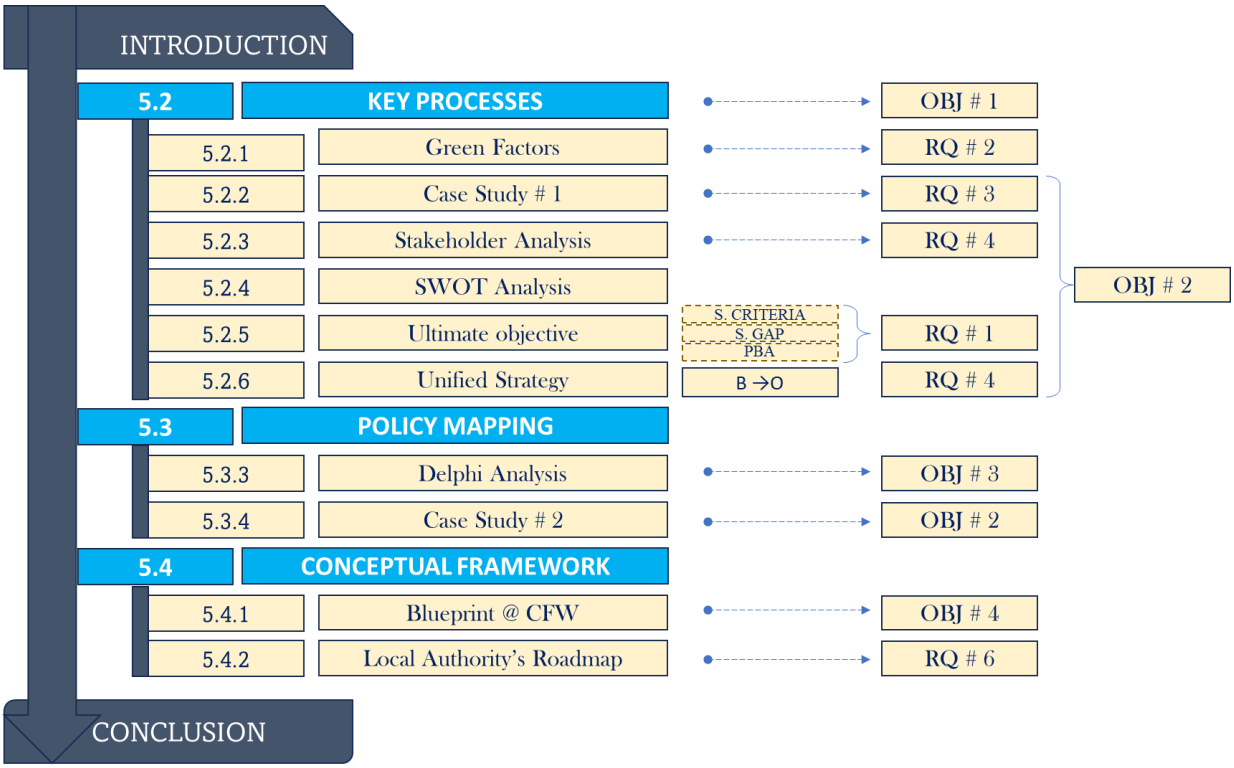


Figure 5.1: Roadmap: Green Transformation of Indian Construction Sector *via* Policy Interventions

5.2. Key processes in construction sector

The construction industry is actively promoting sustainable practices, integrating green supply chain principles at every stage of construction. This approach considers environmental impact at design, material procurement, construction practices, transportation, energy efficiency, waste management, and post-construction phases. The industry's recognition of its significant environmental footprint drives the integration of green supply chain principles. Sustainable design practices, including energy efficiency and life cycle assessments, are crucial. Material procurement strategies prioritize sustainable sourcing, including recycled content and locally available materials. **Figure** 5.2, titled "Construction Lifecycle and Supply Chain Integration," outlines the five supply chain elements and their roles throughout the construction process. Construction planning involves waste management strategies to minimize waste and optimize resource utilization. During construction, eco-friendly techniques, energy-efficient equipment, and renewable energy integration are implemented. Transportation and logistics are optimized

for efficiency and reduced emissions. Water conservation measures are integrated into construction activities. Beyond the construction phase, site management strategies preserve biodiversity and certifications like LEED, BREEAM, or GRIHA are pursued. Stakeholder engagement promotes awareness and adherence to sustainable practices. Post-construction, occupant training, commissioning, and monitoring ensure efficient building operations. Recycling and reuse of construction waste, along with legal compliance with environmental regulations, are integral components of a sustainable construction supply chain.

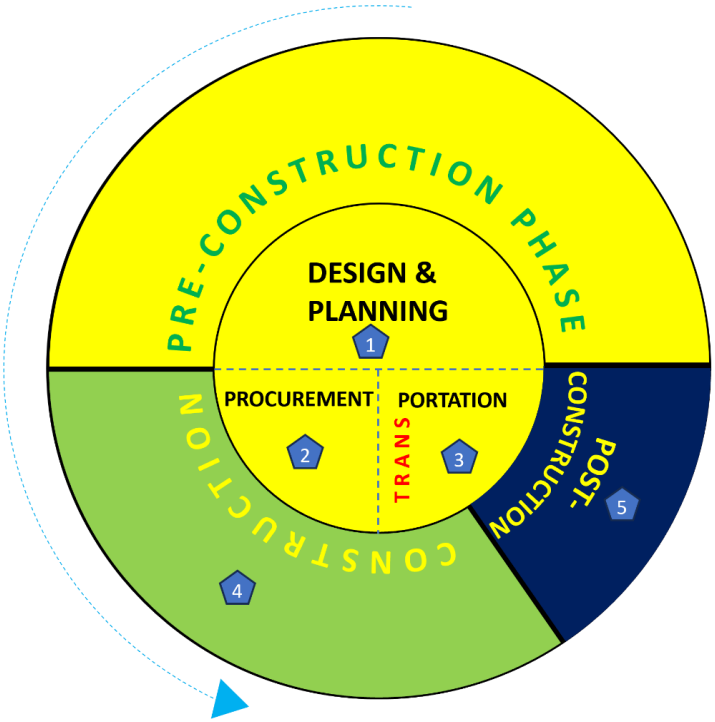


Figure 5.2: Indian Construction lifecycle And Its Supply Chain Integration (*1-5*)

A. Design Phase:

The Design Phase stands as a critical juncture in construction, marked by the integration of sustainable measures to develop environmentally-conscious structures. Core aspects entail prioritizing energy efficiency, selecting eco-friendly materials, and minimizing the ecological footprint across the building's entire lifespan. A thorough Life Cycle Assessment (LCA) is undertaken to appraise the environmental ramifications of design decisions spanning from raw material procurement to construction, operational phases, upkeep, and eventual dismantlement. This data is

used to make informed decisions about materials, construction methods, and building systems that align with sustainability goals. Regularly revisiting the LCA analysis throughout the design process helps identify opportunities for improvement and refine sustainability strategies. By integrating sustainable design practices and conducting thorough life cycle assessments, the Design Phase ensures construction projects align with environmental and sustainability objectives, resulting in buildings that are not only aesthetically pleasing but also ecologically accountable and resource-efficient throughout their entire life cycle.

Design and planning are crucial in shaping construction projects, influencing their outcomes and enduring sustainability. Green Supply Chain Management (GSCM) principles are essential for fostering environmental responsibility and resource efficiency in the construction sector. GSCM principles include design innovation, sustainable planning, resource optimization, and life cycle thinking. They ensure environmental footprint reduction, align construction projects with green objectives, and minimize environmental impact. Regulatory compliance is achieved through GSCM principles, positioning projects as sustainable and environmentally responsible. Corporate responsibility is enhanced by addressing the growing demand for corporate social responsibility. Risk mitigation is achieved through future-proofing, considering environmental impacts during planning. Resilience planning is enhanced by GSCM integration, enhancing construction projects' resilience to climate-related challenges. Collaborative design processes involve multi-stakeholder engagement, integrated design thinking, and technology integration. Building Information Modeling (BIM) technology aids in creating digital representations of projects, enabling efficient collaboration and sustainability analysis.

B. Procurement:

Material procurement is a crucial stage in construction, influencing the quality of structures and their environmental impact. Green Supply Chain Management (GSCM) principles are essential for promoting sustainability and reducing environmental impact. By choosing materials responsibly and implementing eco-friendly sourcing practices, the construction industry can significantly contribute to global environmental conservation efforts. Key aspects of sustainable material

sourcing include prioritizing recycled content, choosing eco-friendly certifications, focusing on materials with low embodied carbon, and local sourcing for transportation efficiency and reduced environmental impact.

Sustainable material choices contribute to carbon reduction, biodiversity preservation, and resilience to supply chain disruptions. Incorporating recycled materials aligns with circular economy (CE) principles, promoting pristine-source-conservation and waste balance. Diversifying material sources and relying on local suppliers enhances resilience to supply chain disruptions. Challenges and solutions include cost considerations, such as long-term savings in operational efficiency and environmental benefits, and supply chain transparency. Encouraging transparency within the supply chain ensures traceability, allowing stakeholders to verify the sustainability claims of materials. By implementing these principles, the building industry can contribute significantly to global environmental conservation efforts.

C. Construction Practices:

The construction phase is a critical stage in transforming the design of a sustainable and eco-friendly built environment into reality. Green Supply Chain Management (GSCM) principles are identified as essential means for mitigating environmental impact and fostering a more sustainable construction industry. Key features of green construction include modular construction, prefabrication, sustainable construction materials, energy-efficient equipment, and renewable energy integration. Green construction techniques reduce waste, optimize resource utilization, and reduce carbon footprint. Modular construction allows for off-site fabrication, reducing waste and enhancing efficiency. Prefabrication minimizes on-site construction activities, reducing resource consumption and disruption to local ecosystems. Energy-efficient equipment and renewable energy sources contribute to a substantial reduction in the project's overall carbon footprint. Low-embodied carbon materials further aid in mitigating greenhouse gas emissions.

Construction planning is crucial for successful project execution and fostering a more sustainable and more resource-efficient construction/development industry. It involves strategic decisions that minimize waste, optimize resource utilization, and ensure environmental responsibility. Key aspects of construction planning include

comprehensive waste management plans, recycling initiatives, energy usage optimization, water conservation strategies, and material efficiency. Effective waste management planning reduces environmental impact by diverting materials from landfills, conserving resources through recycling initiatives, and optimizing resource usage for cost-efficiency. This leads to reduced material wastage, lower energy bills, and efficient project timelines. Construction planning that prioritizes efficient resource utilization aligns with broader sustainable development goals, contributing to a more responsible and resilient built environment.

Construction planning faces challenges such as cultural shift, education, and regulatory compliance. To overcome such resistances, education and awareness programs highlighting the long-term benefits of sustainable construction planning are essential. Aligning with local and international regulations is crucial, and stakeholders should stay updated on evolving standards. Adopting green construction practices involves technological adoption, including training programs, and focusing on long-term benefits like operational efficiency and reduced environmental impact. By incorporating green techniques and energy-efficient equipment, the construction industry can transform into a more balanced and resilient sector.

A construction action plan differentiates three phases of construction, facilitating organized planning, execution, and monitoring, while aligning with sustainability goals and regulatory requirements. The pre-construction phase involves planning and design, obtaining permits and approvals, site preparation, and material procurement. It involves defining project goals, developing architectural and engineering designs, establishing budgets, and ensuring compliance with local building codes. Site preparation involves clearing the site, conducting geotechnical investigations, and preparing the site for construction activities. The construction phase involves foundation and structure work, safety measures, building systems, construction management, health and safety compliance, and resource management. It involves installing mechanical, electrical, and plumbing systems, incorporating energy-efficient technologies, and managing resources and subcontractors. The stage also includes addressing issues, managing resources, and implementing safety training for construction personnel.

i. Energy Efficiency Measures:

Green Supply Chain Management (GSCM) emphasizes the importance of energy efficiency measures during and after the construction phase. Renewable energy integration, such as wind turbines and solar panels, reduces reliance on traditional energy grids and promotes sustainable, eco-friendly energy. Energy-efficient lighting and HVAC systems are also crucial for minimizing energy consumption in construction sites. These measures contribute to environmental conservation and a more sustainable approach to resource usage. Implementing these measures is integral to GSCM, reducing environmental impact and streaming a more resilient and eco-conscious construction sector.

ii. Water Conservation:

Water conservation measures are crucial for Green Supply Chain Management (GSCM) to ensure sustainable construction. Efficient water-resource administration is essential for sustainable construction, and GSCM promotes water efficiency through the adoption of technologies. Effective stormwater management is also crucial, as it prevents pollution and protects water quality. These measures demonstrate a commitment to environmental responsibility, source-effectiveness, and the overall sustainability of building practices.

The post-construction phase involves occupancy and commissioning, educating occupants on sustainable practices and energy-efficient systems, waste management and recycling, monitoring and maintenance, and stakeholder engagement. Promoting sustainable construction involves obtaining occupancy permits, commissioning building systems, educating occupants, establishing waste management, and conducting routine maintenance, while engaging with local communities and stakeholders.

iii. Site Management:

Site management in the later construction phase is crucial for sustainability. It involves implementing measures to protect local ecosystems and biodiversity, monitoring progress, and adjusting preservation strategies based on project requirements. This ensures continuous conservation and adaptability, while

maintaining stakeholder engagement. Erosion and sediment control measures are also managed, addressing changing conditions and monitoring regularly. Water quality maintenance is also essential, and regulatory compliance is maintained throughout the construction phase. Minimizing the long-term environmental impact of construction activities is also crucial. Adaptability, ongoing monitoring, and adherence to regulations contribute to the overall sustainability of the construction and development actions.

iv. Certifications and Standards:

In the later construction phase, obtaining and maintaining certifications and standards are crucial for a project's commitment to sustainability. Green Building Certifications, such as LEED or GRIHA, provide credibility and recognition for sustainable practices, enhance market competitiveness, and assure stakeholders of the project's commitment to sustainability. Sustainable Construction Standards ensure consistent application of industry standards for sustainable construction practices, ensuring quality assurance and regulatory compliance. These actions contribute to long-term credibility, competitiveness, and compliance with industry expectations. Incorporating these certifications and standards into ongoing construction processes ensures the continued application of sustainable construction principles, maintains quality assurance, and meets regulatory requirements related to sustainability in construction.

D. Transportation and Logistics:

The construction industry's environmental footprint is significantly influenced by transportation and logistics. Sustainable practices in this phase include efficient transportation planning and the adoption of eco-friendly logistics solutions. This can lead to a greener construction ecosystem. Key aspects include strategic planning, supply chain optimization, transitioning to low-emission vehicles, and fleet management. Effective transportation planning plays a pivotal role in decreasing greenhouse gas emissions, enhancing air quality, and preserving resources. Low-emission or electric vehicles enhance air quality on construction sites and surrounding areas, promoting a healthier environment. Sustainable transportation practices also lead to fuel efficiency, conserving fossil fuels, and reducing the industry's impact on

non-renewable resources. Challenges and solutions include addressing infrastructure limitations through collaboration with local authorities and investing in sustainable technologies. Collaborating with local authorities can enhance transportation routes for construction activities and showcasing their long-term benefits can encourage investment in sustainable transportation technologies. Overall, efficient transportation and logistics practices can significantly contribute to a more environmentally conscious and resilient future in the construction industry.

E. Post-Construction stage / End-user Management:

The post-construction stage of a building is crucial for its long-term sustainability. It involves educating and involving occupants in energy-efficient practices, waste reduction, and sustainable features. This fosters a culture of environmental responsibility, ensuring the building's long-term sustainability goals are met. Commissioning and monitoring are essential for efficient operation, tracking energy consumption, water usage, and overall performance. This dynamic period shifts focus from physical construction to active engagement of occupants and ongoing performance assessment. By educating occupants and implementing rigorous commissioning and monitoring processes, the construction sector ensures green buildings meet initial sustainability standards and continue to operate efficiently over the long term. To achieve the GSCM, it includes a variety of requirements and forms, including R&D, legal compliance, and stakeholder participation (Sánchez-Flores et al., 2020).

i. Stakeholder Engagement:

Engaging stakeholders is essential for advocating sustainable practices within the construction industry. This includes community outreach, worker training, and recycling and reuse strategies. Community outreach helps build sustainable relationships and involve local residents in decision-making processes, fostering transparency and shared responsibility. Worker training enhances safety awareness and educates workers on sustainable building methods. Recycling and reuse are essential components of sustainable construction practices. Implementing robust processes for waste recycling reduces environmental impact by segregating and recycling materials like concrete, metal, and wood. Material reuse, identifying

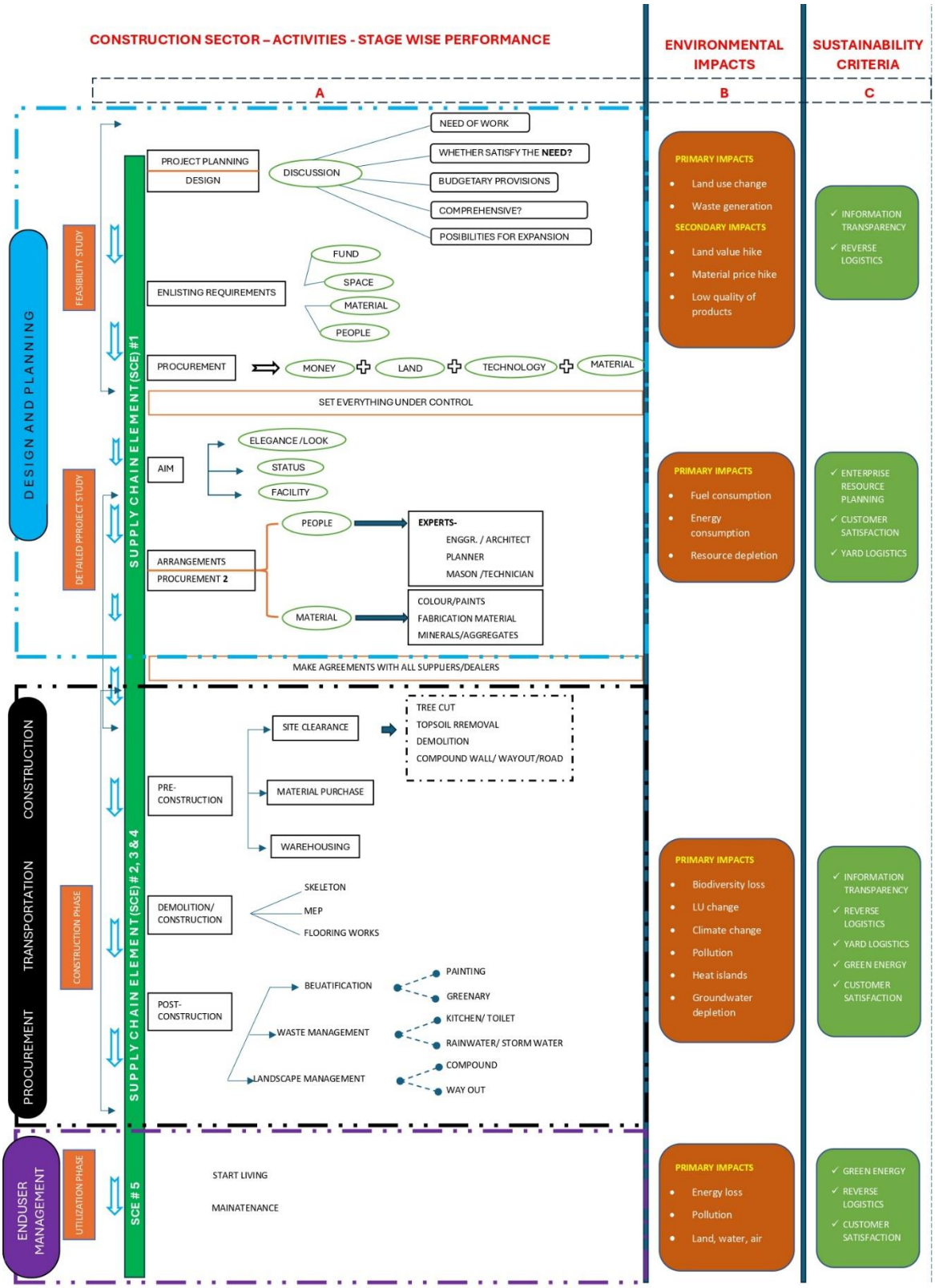


Figure 5.3: GSCM incorporation for the construction impacts on the environment

salvageable components from deconstructed buildings, aligns with the circular economy concept and promotes a more sustainable and cost-effective construction approach. In summary, stakeholder engagement practices, including community outreach and worker training, along with effective recycling and reuse strategies, are essential for advancing the sustainability agenda within the construction sector.

ii. Legal Compliance:

Legal compliance in green construction is crucial for promoting sustainable practices within the construction/developmental industry. This involves adhering to environmental regulations, green building codes, and standards to minimize pollution, protect biodiversity, and preserve natural resources. Building projects must conduct robust environmental impact assessments to identify and address potential ecological concerns. Green building codes and standards provide a framework for incorporating eco-friendly practices, energy efficiency, and resource conservation into building designs and operations. Engaging with regulatory authorities and environmental agencies is essential for staying updated on regulations and actively participating in shaping regulatory frameworks that encourage sustainable building practices. Adhering to legal compliance measures serves as a proactive risk mitigation strategy, safeguarding the construction project against potential legal challenges, delays, and fines. Choosing green building certifications like LEED or IGBC can enhance a project's marketability and reputation while satisfying legal obligations. By effectively navigating environmental regulations, the construction industry can contribute to a more sustainable and resilient built environment.

iii. Innovation and Research:

In the construction sector, the post-construction phase of green supply chain management (GSCM) necessitates the incorporation of innovation and research. This involves dedicating resources to research and development (R&D) to investigate and create innovative technologies, materials, and approaches that bolster building sustainability. Pilot projects provide a practical way to test and showcase new sustainable construction practices, assessing their feasibility, efficiency, and performance. Technology adoption, such as smart building technologies, AI and IoT

applications, and data analytics, contributes to improved energy efficiency, resource management, and overall sustainability in constructed facilities. Collaboration with research institutions fosters a dynamic exchange of knowledge and expertise, ensuring a continuous flow of innovative ideas and practices. Regulatory compliance and standards are essential, allowing the construction sector to adapt to changing requirements and align with globally recognized sustainability benchmarks. In summary, emphasizing research, development, and innovation during the post-construction phase of green supply chain management allows the construction sector to evolve continuously, diminish its environmental footprint, and play a role in fostering a more sustainable built environment. A thorough examination of the Indian building scenario is given in **Figure** 5.3, which includes information on the steps performed at each stage, the main environmental effects, and the sustainable standards that were employed to lessen those effects. It offers information on the tactics and programs used by the building industry to solve environmental issues and advance sustainability during the course of a project.

5.2.1. Factors from Indian CS for a "green shift"

Sustainable construction is a crucial aspect of the construction industry, requiring a comprehensive approach that includes enterprise resource planning, information transparency, reverse logistics, yard logistics, green energy, and customer value and satisfaction. These elements collectively contribute to environmental responsibility, operational efficiency, and stakeholder satisfaction. The multifaceted nature of sustainable construction necessitates a strategic alignment of diverse factors to meet environmental goals, enhance operational efficiency, and meet stakeholder expectations. Sustainable construction is not a singular pursuit but a collaborative endeavor, weaving together technology, communication, logistics, energy solutions, and customer-centric approaches. Prioritizing these elements can significantly contribute to environmental conservation, resource efficiency, and stakeholder well-being in the Indian construction industry. Enterprise Resource Planning (ERP) systems are essential for managing construction processes, enhancing efficiency and communication, enabling centralized data management, informed decision-making, and resource optimization. Information transparency is crucial for improving collaboration, reducing errors, and promoting accountability. Reverse logistics is essential for efficient product returns and waste

reduction, contributing to circular economy principles. Yard logistics is crucial for efficient material handling and storage, reducing delays and waste. Green energy, such as solar and wind power, reduces reliance on non-renewable resources and aligns construction processes with eco-friendly energy solutions. Presenting sustainability in the construction industry enhances brand reputation and market competitiveness, while customer satisfaction is crucial for long-term success and industry loyalty.

A. Enterprise resource planning (ERP):

Process mapping and organizational learning from mistakes are significant aspects addressed in relation to their impact on the success of ERP implementation. However, adopting ERP systems requires substantial organizational effort, and many businesses struggle to realize the anticipated benefits before and during implementation (Kripaa, 2012). Organizational learning can be facilitated through experiential learning and knowledge sharing with other enterprises. Life cycle impact assessment involves evaluating both midpoint and endpoint impacts. In essence, the effectiveness of ERP implementation hinges on thorough process mapping, identification of environmental considerations, and selecting the appropriate ERP system (Akca et al., 2013). Several factors, including demand forecasting, production planning and control, data transaction tracking, material movement, quality control, inventory management, and environmental impact assessment, are pivotal throughout the ERP implementation life cycle. Critical success factors (CSF) encompass elements like ERP team collaboration, top management support, effective communication, project management, project championing, suitable business and IT legacy systems, change management initiatives, business process reengineering, software development and testing, business planning, and performance evaluation (Papageorgiou, 2009). Process mapping serves as a valuable tool for scrutinizing business processes prior to ERP implementation, aiding in guiding the organization through the process while identifying activities relevant to environmental concerns. The "As-Is" phase involves identifying crucial processes and distinguishing between value-added and non-value-added activities. In contrast, the "To-Be" phase focuses on creating optimized processes and removing non-value-added activities (Bradford and Gerard, 2015). ERP software assumes a pivotal role in this phase, necessitating benchmarking to select the most suitable software for enterprise processes. The transition from "As-Is" to "To-Be" processes, or the "Bridging the Chasm" phase, is

imperative before ERP software implementation. Change management initiatives are vital to identifying human barriers and maintaining communication to align employees with the new processes (Kandananond, 2014). Teams responsible for customizing ERP software, conducting testing, and performing analysis are established during this phase.

B. Information transparency (IT):

Genuine transparency entails offering clear and meaningful information rather than presenting a vague array of numbers devoid of context. It cultivates trust among suppliers, companies, and customers. A truly transparent business prioritizes disclosure, which entails disseminating information both internally and externally at the appropriate level of detail, alongside visibility, accurately identifying and collecting data from all segments of the supply chain (Harbert, 2020). According to Jackley (2023), the advantages of supply chain transparency include customer confidence, brand loyalty, and stronger partnerships. Publicizing information about production practices, safety standards, and supply chain ethics empowers consumers to make informed choices, increasing the likelihood of selecting a product with provenance information over one without. Brand loyalty also results in favorable word-of-mouth advertising, bringing positive attention to your brand. Supply chain transparency comprises two elements: visibility and disclosure. Visibility entails accurately identifying and collecting data from all aspects of a business's supply chain, while disclosure involves communicating that information internally and externally at the necessary level (Budler et al., 2024). Supply chain transparency is vital for establishing trust among suppliers, companies, and customers, nurturing stronger partnerships, and ensuring product quality and safety. Supply chain visibility enables businesses to gain insights into operations across all tiers of their supply chain, facilitating the sharing of relevant information such as daily production activities, quality control reports, audits, and compliance assurance (Messina et al., 2020). Achieving supply chain visibility aligns all stakeholders for improved overall efficiency. Key tactics for achieving transparency in the supply chain include sharing data, standardizing processes, mapping the supply chain, and implementing supplier scoring. Shared data enables businesses to track products from their source to the consumer, ensuring all stakeholders have access to relevant information. Uniform processes ensure that data regarding quality, safety, and ethical compliance gathered at supplier factories remains consistent and reliable,

irrespective of the location or whether inspections are carried out by in-house teams or third-party providers (Lockhart, 2022).

C. Reverse logistics (RL):

Reverse logistics, as outlined by Hsu et al. (2013), encompasses the retrieval of goods or products for repair, resale, recycling, or appropriate disposal. The implementation of well-structured reverse logistics, in conjunction with an effective warehouse management system, has the potential to decrease costs, minimize waste, and mitigate losses, consequently fostering sustainability. According to CSE (2020), architects can prevent 33% of waste generation by incorporating waste mitigation strategies during the pre-construction stage. Furthermore, Hosseini et al. (2014) suggest that applying reverse logistics principles throughout construction could enable buildings to reuse or recycle up to 85% of their total weight. Managing reverse logistics is crucial for a company's bottom line and reputation, as consumers prefer to purchase from companies with integrity. Utilizing warehouse management software is essential for handling inbound and outbound logistics and providing real-time analytics. Enterprise Resource Planning (ERP) platforms such as NetSuite, when integrated with warehouse management systems, facilitate businesses in efficiently tracking returns, monitoring goods movement, issuing credits through the accounting system, and updating customer records. Additionally, effective inventory management is crucial for optimizing returns processes. Elevated return rates may lead to inventory accumulation, and a proficient inventory management system will notify businesses when inventory levels are rising at a pace exceeding their sales rate (Singh, 2022). In the construction industry, reverse logistics plays a crucial role in transporting and recycling recovered materials, as noted by Jenkins (2021). This process involves purchasing leftover items, managing returns, and transporting reusable materials to new locations for repair, resale, recycling, or proper disposal. Implementing reverse logistics can help minimize costs, add value, lower risk, and complete the product life cycle (Hosseini et al., 2015). However, internal barriers such as higher initial costs, uncertainties, potential liabilities, operational difficulties, and lack of awareness hinder reverse logistics implementation in the construction sector (Vijayadas, 2022). The complex and disorganized nature of materials flow and supply chain management in the construction environment exacerbates challenges with reverse logistics implementation. The five Rs of reverse logistics—returns, reselling, repairs, repackaging, and recycling—

are essential components to consider (WareIQ, 2022). To optimize reverse logistics, seven strategic ways include:

1. *Reviewing and updating relevant policies and agreements*: Assess and amend procedures related to returns and repairs by addressing the underlying causes of returns and repairs.

2. *Collaborating closely with suppliers*: Establishing strong partnerships with suppliers ensures a seamless and coordinated experience for customers.

3. *Leveraging data for process optimization*: Gather data on product returns to identify reasons for customer returns and implement adjustments in sales, product design, and forward logistics processes accordingly.

4. *Implementing product traceability*: Establishing links between raw materials, finished goods, and customer orders enables businesses to trace ingredients in the event of recalls.

5. *Centralizing return centers*: Consolidate return centers to facilitate efficient product sorting and determine the most suitable next steps for each item.

6. *Assessing logistics and transportation*: Regularly evaluate forward and reverse logistics and transportation processes to explore opportunities for integration and transit efficiency.

7. *Automating operations*: Utilize cloud-based logistics software to streamline operations, monitor asset recovery, oversee refurbishment activities, and generate business intelligence analytics.

D. Customer satisfaction (CS):

Appreciating corporate social responsibility (CSR) will stimulate collaboration within the supply chain, encouraging innovative partners to deliver superior products and services to consumers. Customers play a pivotal role in shaping supply chains, and a growing demand for environmentally friendly products will enhance the efficiency of Green Supply Chain Management (GSCM) (Yang et al., 2023). This shift toward sustainability makes the demand-supply chain more resilient to disruptions and aligns with ethical principles. The

challenges of green construction include overcoming misconceptions and lack of awareness, promoting transparent communication about the benefits and impacts of green practices, and addressing cost perceptions by demonstrating long-term savings and return on investment associated with green construction features (Liu et al., 2022). Green design is essential for improving environmental performance and ensuring compliance with regulations. It involves tailoring solutions to meet customer preferences and incorporating innovative technologies. Regulatory compliance ensures legal requirements are met, while quality assurance ensures customer satisfaction (Network, 2003). Satisfied customers are more likely to engage in future projects and become advocates, contributing to positive word-of-mouth marketing and attracting more clients interested in green construction. The construction sector is transforming towards green practices, covering the entire project lifecycle from design to post-construction. Understanding and addressing customer expectations is crucial for meeting regulatory requirements and promoting a sustainable, customer-centric approach. The transformation is driven by customer demand for sustainability, which drives market demand for environmentally conscious projects (Sheth et al., 2011). Green construction projects optimize resource efficacy, recycled-waste contemplation, and promote circular economy principles, contributing to economic viability. Green construction projects enhance resource efficiency, encourage recycling, and promote circular economy principles, thus enhancing economic viability.A community-centric approach is often used, ensuring local stakeholders are considered and heard. A satisfied customer base fosters positive social impacts, contributing to community well-being and sustainability (Moisescu and Gică, 2020).

E. Yard logistics (YL):

Modern customers increasingly prefer automated yards equipped with GPS, sensors, and Internet of Things (IoT) technology. Any delays or losses in cargo within these automated yards can significantly impact warehouse and transportation operations, resulting in poor customer service (Egalogistics, 2021). Such incidents can lead to increased fuel consumption, additional demurrage or detention charges, challenges in obtaining insurance coverage and meeting compliance requirements, and difficulties in reducing carbon emissions without disrupting operations (Granato, 2020). SAP Yard Logistics is a solution that helps businesses manage their yard processes, covering various modes of transport such as trucks, rail, ships, and aircraft (SAP, 2018). The yard plays a crucial role in loading

cargo between different modes, and to ensure security, each vehicle must be registered. The system then routes the transportation unit on the yard, performs cargo unloading or loading, and tracks all actions (Song, 2021). The yard process consists of four steps: planning, check-in, execution, and check-out. After launching the application, it is crucial to have good onsite support for users to work effectively with customers. After the go-live of the manual process, customers can start using an automated yard with integration with GPS, sensors, and the IoT world (Alsudani et al., 2023). Planning involves entering all known information into the system. Check-in involves registering the transportation unit, which can be done by employees, security staff, or drivers. Execution involves predefined yard tasks, with each task having a planned start and end time. Commands can be sent to employees via SMS, web services, or email. Check-out involves checking out the driver after returning their equipment and driving through the last checkpoint in the yard. The check-out process is essential for tracking the vehicles operating in the yard (SAP, 2018).

F. Green energy (GE):

Access to clean, reliable, and consistent energy is pivotal in improving the efficiency and stability of a company's operations and supply chain. The importance of renewable energy has been emphasized by the adoption of the inaugural universal, legally binding global climate agreement on greenhouse gas emissions during the United Nations Conference on Climate Change (COP21), which involved 195 nations. This highlights the increasing influence of policy in shaping the trajectory of renewable energy expansion. As evidenced by the RE100 project, which has garnered commitments from 81 businesses worldwide to pursue exclusively renewable energy sources, there is a growing trend towards renewable energy adoption (Deloitte, 2016).

Renewable energy offers numerous advantages to supply chains, including mitigating the risks associated with fossil fuel price fluctuations, attracting stakeholders interested in corporate responsibility, and fostering corporate growth by remaining competitive in the market (Cader et al., 2022). With renewable energy becoming more accessible and cost-effective, organizations are reevaluating their energy management strategies. It is noteworthy that 154 companies have pledged to take aggressive climate action through the American Business Act on Climate Pledge, while 81 companies have committed to achieving 100% renewable energy through the RE100 initiative (Bapna, 2015).

The Renewable Energy Supply Chain (RESC) encompasses the process of converting raw energy into usable energy, involving effective management principles from resource acquisition to consumption (Jelti et al., 2021). This supply chain comprises five phases: procurement, generation, transmission, distribution, and demand, encompassing all stages of renewable energy production and distribution. Barriers to the development of the RESC can be classified into four dimensions: political and regulatory, technical, economic and financial, and managerial. Overcoming these barriers is essential for organizations to unlock the benefits of renewable energy and drive sustainable growth.

5.2.2. Case study #1

A case study serves as a valuable research approach for gaining profound insight into a specific real-world subject. It can be utilized in various forms—single, complex, or multiple—to compare and comprehend different aspects of the research problem (Crowe et al., 2011). Particularly beneficial in theses or dissertations, case studies aid in maintaining focus and managing limited time or resources effectively. In this particular instance, the focus is on exploring sustainability standards that stakeholders should consider when formulating a green or carbon-neutral infrastructure strategy, along with identifying prominent green practices observed throughout the "FS-DPR-Construction-Utilization" process in India. This serves to clearly define Research Question 2, which is aligned with Objective 1. This process typically involves a feasibility study, detailed project report preparation, construction commencement, and subsequent utilization. The study centers on major cities in South India, including Kochi, Chennai, Hyderabad, and Bangalore, and relies on the involvement of "Sobha" builders and related developers.

The study delineates the outlook for implementing GSCM applications within the Indian Construction Sector (CS). Current Supply Chain Management (SCM) practices were scrutinized to gauge their impact, with insights from field experts garnered through interviews and face-to-face discussions. The identified impacts were then juxtaposed against global GSCM practices to pinpoint potential areas for enhancement. Key tasks involved in this endeavor encompassed mapping the Traditional Supply Chain Management (TSCM), conducting impact assessments, executing remedial actions, validating these measures via a conceptual framework, and exploring avenues for

legislative support. Hypotheses underwent validation, and a questionnaire survey was administered between August 15 and September 10, 2022, targeting various construction sectors in South India. Multiple regression analysis was conducted to validate the hypotheses using the SPSS 26 platform.

The study aimed to assess the imperative of implementing GSCM applications in India's construction sector to bolster sustainability. Primary data was procured via a standardized questionnaire and face-to-face interviews, with a hypothesis formulated and rigorously evaluated within the construction sector. The study identified six pivotal obstacles and influences impeding the adoption of GSCM, encompassing logistical, technical, social, economic, regulatory, and administrative facets.

Strategically, the study underscores opportunities for legislative endorsement of GSCM, emphasizing the significant role of green legislation in a profit-driven and regulation-oriented milieu. Construction firms are increasingly embracing GSCM to burnish their environmental image and meet environmental exigencies. Nonetheless, the Indian sector grapples with 28 impediments to GSCM implementation, including extant laws, corporate policies, carbon emission audits, the global green market, FDI, special tax exemptions, cost-efficient products, and a judicious approach to the local environment. **Table 5.1** furnishes an exhaustive analysis of Green Supply Chain Management (GSCM) in the Indian Construction Sector, delineating 30 drivers and 28 barriers. It offers insights into the assorted pressures and hurdles influencing GSCM implementation, facilitating informed decision-making and strategic planning for sustainable development endeavors. The table endeavors to furnish a comprehensive grasp of the Indian construction milieu.

Global Supply Chain Management (GSCM) metrics encompass enterprise resource planning (ERP), information transparency (IT), reverse logistics (RL), customer satisfaction (CS), yard logistics (YL), and green energy (GE). ERP centers on process mapping and learning from mistakes, while IT accentuates transparent reporting to foster trust between suppliers, companies, and customers. Reverse logistics can curtail costs, waste, and loss while enhancing sustainability. Yard logistics may be affected by late cargo or trailer loss, leading to subpar customer service, fuel dependency, demurrage charges, insurance, compliance issues, and challenges in reducing carbon footprint without adversely impacting operations.

Table 5.1: Key Pressures and Barriers in Green Supply Chain Management within the Indian Construction Sector

Pressures/Driving factor	Specification	Ref	Barriers	Specification	Ref
I. Legislative pressure (LP)			**I. Logistics barriers (LB)**		
1. Central 'green' regulation	EPA, 1986, CRZ, 2019, etc.	[1]	1. Green materials:	unavailability, economic centric linear supply chains, etc.	[26,27]
2. Regional green regulations	Total Energy Security Mission (TESM), Kerala Renewable Energy Policy 2002, etc.	[2,3,4]	2. Green suppliers:	difficulties in identifying and auditing supplier performance	[21, 28,29, 30,31,32]
3. Waste management (E-type)	e-waste Management and Handling Rules 2011	[5]	3. Green technologies:	Challenges related to emerging technologies and various legal aspects of adoption	[26]
4. Emission standards	SPCB regulations	[6]	4. Green legislation:	Policy irregularities can occasionally have a negative impact on performance since they are powerful enough to compel businesses to adopt environmentally friendly practises. At the same time, there are some worldwide disputes that impede performance.	[3,35, 37]
5. High penalty (polluting environment)	Violation of EPA, 1986	[7]			
6. Initiative of Local Body (Sustainable urban planning)	Urban Policy and Action Plan for Kerala	[8]	5. Awareness:	Disagreements with clients (a distinct group) over the use of environmentally beneficial ideas	[10, 34,35]
II. Corporate Matters (CM)			**II. Technical barriers (TB)**		

Pressures/Driving factor	Specification	Ref	Barriers	Specification	Ref
7. Enterprise Resource Planning	Establishing company's green image	[9]	6. Technology failure:	Concerns about transferring technology and reluctance to transition to GSCM due to uncertainty regarding return on investment	[36]
8. Corporate Greening	Corporate Social responsibility	[3]	7. Lack of technical expertise:	Difficulty in discovering a substitute to create an environmentally friendly product that meets environmental standards.	[26]
9. Resource capitalization	NRC,2021	[10]	8. Lack of effective environmental measures:	Organizations are not come forward to implement effective environmental measures as there is many gaps in legislative side.	[36,38]
10. Corporate environmental performance	Corporate environment responsibility	[11]	9. Want of new technology:	The absence of suitable technology, processes, or materials within organizations complicates the transition to GSCM.	[26]
11. Carbon pricing policy	Carbon emission audits for Environmental protection	[12]	10. Flexibility of design:	The intricacy of implementing new concepts aimed at reducing resource or energy consumption, coupled with inefficiencies in managing challenges related to the Internet of Things (IoT), contributes to this difficulty.	[39,40]
12. Rising transportation costs	OPEC	[13]			
III. Global Market (GM)			**III. Social barriers (SB)**		
13. Competitors' GREEN strategy	Alumasc Group Plc, Binderholz GmbH, etc.	[2]	11. Lack of awareness:	negative perception of organizations to reverse logistics adoption and eco-illiteracy among supply chain members.	[41]
14. WTO entry	Global market	[2]	12. Deprivation of Environmental Knowledge:	The situation is exacerbated by a lack of understanding of environmental regulations,	[34,42]

Pressures/Driving factor	Specification	Ref	Barriers	Specification	Ref
				disregard for the ecological impact of organizational activities, and the lack of adoption of green supply chains.	
15. Market-Zones for green/ recycled product	Green construction markets	[2]	13. Finding opportunities:	inefficiency to recognize green openings.	[26,27]
16. Green FDI (Foreign Direct Investment)	FDI in EGS sectors, as well as FDI in methods aimed at mitigating environmental damage.	[14, 15]	14. Info-transparent organizations:	Industries struggle to maintain a visible &steady information flow	[21,26,32]
17. Export potential of the green product	Sustainable exports	[2]	15. Low demand GSCM:	Low demand because of customers' ignorance to GSCM.	[35]
IV. Financial Factors (FF)			**IV. Economic barriers (EB)**		
18. Green tax	Indirect contributions to green fund	[15]	16. High initial investments:	High investment cost for green conceptualization.	[35]
19. WtE Profits	Income from Environmental Goods and Services (EGS) functions	[16]	17. Uncertainty in RoI:	Extra charges for green adoption: Eco-friendly texturing, (3R's), etc.	[35]
20. Carbon tax (global)	Increased use charge for energy and fuel	[12]	18. Unsupportive financial institutions:	Feeble bank support to incentivize the adoption of environmentally friendly products and processes.	[35]
21. Green promotion	Special tax relief granted to firms certified under ISO 14001	[17]	19. Risk &Competition:	Implementation of GSCM is time consuming and its higher cost & uncertainty in markets will affects staid industries.	[10]
			20. Profit orientated supply chain:	Linear supply chains are stick to that	[43]
V. Customer demand (CD)			**V. Regulatory barriers (RB)**		
22. Climate & Disaster	Customer demand for	[9,10]	21. Restrictive company	EPR of the company has to revised	[3,33,37]

Pressures/Driving factor	Specification	Ref	Barriers	Specification	Ref
Resilience	products that meet environmental standards		policies:	ecologically	
23. Efficient-cost structure	Customer preference for environmentally friendly products	[18]			
24. Green identity and carbon footprint	Increasing pressure to provide cost efficient products	[19]	22. Lack of support:	Regulatory authorities fail to extend proper support and guidance to maintain to follow GSCM	[26]
25. Heritage Fantasy	Taking an intelligent approach to local environment	[20]			
VI. Operational Performance (OP)			**VI. Administrative barriers (AB)**		
26. Electronic-logistics	Material footprint	[21]	23. Lack of training courses:	Professionals require training to integrate GSCM practices into their operations and to oversee progress through consultation with relevant institutions.	[44]
27. Carbon Audit	Operational strategies to reduce carbon emissions, reduce environmental accidents, and reducing business risks	[1, 22]	24. Lack of Corporate Social Responsibility:	Non environment inclusive CSR, companies lack environmental goals.	[10]
28. Non-linear supply chains	Incorporating new materials through collaboration with suppliers of green products	[23, 10]	25. Logistics invisibility:	ERP will not be sufficient for GSCM if company doesn't resolve logistics invisibility pertains.	[45]
29. Competitive advantage	Technical advantages provide a competitive	[24]	26. Poor supplier support/commitment:	Suppliers may be reluctant to share environmental information with	[21,31,32]

Pressures/Driving factor	Specification	Ref	Barriers	Specification	Ref
	edge, whether in cost or product differentiation			industries due to concerns about the impact on the end product, & no training/reward for the same	
30. Reverse logistics	Focus on pristine resource reduction to reduce waste and global awareness about investment recovery	[25]	27. Non-cooperative Top management:	Resistance from top management to change existing investments, information systems, and practices poses a significant challenge to transitioning to a new supply chain system, reflecting a lack of responsibility.	[34,46,47]
			28. Management Inadequacy:	There is reluctance or apprehension about adopting new systems or making the switch to alternative approaches.	[39]

1. Zhu and Sarkis (2006); 2. Wu et al. (2022); 3. Al Khidir and Zailani (2009); 4. Darnall et al. (2008); 5. Ninlawan et al. (2010); 6. Sundarakani et al. (2010); 7. Abdallah et al. (2013); 8. Zhu, et al. (2007); 9. Zhu et al. (2008); 10. Mudgal, et al. (2010); 11. Thipparat (2011); 12. Evangelista et al. (2010); 13. Litman (1996); 14. Zhu and Geng (2010); 15. Zhu and Cote (2004); 16. Ebert (2003); 17. Elefsiniotis and Wareham (2005); 18. Huang et al. (2012); 19. Zhu and Sarkis (2004); 20. Okba and Embaby (2013); 21. Sarkis (2003); 22. Hoejmose et al. (2012); 23. Ganeshan et al, (1999); 24. Zutshi and Sohal (2004); 25. Kumar et al. (2012); 26. Perron (2005); 27. Govindan et al. (2014); 28. Sarkar and Mohapatra (2006); 29. Calleja et al. (2018); 30. Hamner (2006); 31. Massoud et al. (2010); 32. Hong et al. (2009). 33. Revell and Rutherfoord (2003); 34. Shen and Tam (2002); 35. Chen et al. (2006); 36. Rao and Holt (2005); 37. Hillary (2004); 38. Faisal et al. (2000); 39. Beamon (1999); 40. Russel (1998); 41. Meade et al. (2007); 42. YuLin and HuiHo (2008); 43. Fan and Zhang (2016); 44. Carter and Dresner (2001); 45. Ravi and Shankar (2005); 46. Ghobadian et al. (1998); 47. Zhu et al. (2007).

Findings suggest that GSCM in the Indian CS is primarily driven by profit motives,

The findings suggest that GSCM in the Indian construction sector is primarily driven by profit motives, supported by regulatory incentives. However, there is strong endorsement for sustainable practices within GSCM, and legislative actions could further enhance this trend. The study advocates for GSCM as a global environmental management strategy for the Indian construction sector, given its existing inclination towards sustainability.

The study concludes that legislative strategies can serve as a catalyst for overcoming barriers and expediting transformation in the construction sector. Legislative interventions have proven to be an effective avenue for promoting green construction management in India, with hypothetical validation affirming the spectrum of legislative possibilities.

The ‘R’ value of 0.708 indicates a robust prediction quality of the dependent variable, GSCM. However, only two outliers were observed influencing the hypothesis. Customer demands and business performance emerged as outliers, with a decline in customer demands and satisfaction primarily attributable to widespread unawareness of GSCM's significance and reluctance to absorb the additional green costs associated with it. The decrease in company performance may be attributed to the inadequacy of newer green technologies, a shortage of technically skilled-labourers, and a dearth of green suppliers.

Table 5.2 presents the findings of Exploratory Factor Analysis (EFA), delineating questionnaire items and their respective factors, thereby buttressing the investigation's hypothesis. Table 5.3 showcases the results of Multiple Regression Analysis, affirming the hypothesis regarding strategic opportunities for implementing GSCM in the Indian building sector. Statistical analyses serve to validate the hypothesis and pinpoint significant predictors for further exploration and strategic planning.

Supply chain management (GSCM) is recognized as a crucial strategy for addressing both economic and environmental considerations within the supply chain. It focuses on producing high-quality, cost-effective goods that exceed customer expectations while also conserving space, energy, and inventory. Lean manufacturing, in particular, is beneficial for ecological conservation and environmental sustainability. In conclusion, the study highlights the need for more effective GSCM practices in the Indian construction industry, hence, **H0** rejected.

H1: Strategic openings exist for the integration of GSCM practices within the Indian construction sector.

Table 5.2: Summary of EFA- Questionnaire items

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 order fulfilment speed has improved	3.6333	.71840

Table 5.3: Results: Multiple Regression Analysis

Coefficients[a]

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
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

5.2.2.1. Legislative opportunities

When formulating a legal framework to tackle the typical motivations and obstacles, it's crucial to take into account the following uncertainties, which found motive for sections 5.3-5.5.

1. Develop a comprehensive, long-term strategy integrating sustainability across all processes, from project feasibility studies (PFS) to utilization stages.
2. Enforce the use of ethically-sourced materials as a prerequisite, followed by a rigorous carbon-audit.

3. Ensure that all subcontractors and suppliers possess expertise or proficiency in sustainable practices, while also adhering to labor regulations and maintaining equitable humanitarian standards.
4. Embrace transparency and visibility as fundamental corporate values to monitor, evaluate, and mitigate emissions and waste throughout the project lifecycle, starting from the design phase.
5. Implement Enterprise Resource Planning (ERP) systems for medium-sized construction companies and larger corporations.
6. Address logistical hurdles to improve the efficiency of eco-friendly deliveries.
7. Perform a sustainability assessment to readjust emission targets with the objective of attaining carbon neutrality.
8. Guarantee government involvement across all tiers of Green Supply Chain Management (GSCM) endeavors.

In summary, the Indian building arena acknowledges the impacts, benefits, and importance of Green Supply Chain Management (GSCM) and sustainability. However, there is a lack of diligence in implementing GSCM practices and a limited focus on sustainability. Profit-oriented business strategies are prioritized over GSCM practices, with minimal advantages perceived. GSCM practices are embraced only when they entail minimal economic burdens and are deemed affordable, regardless of the firm's size or market presence. The green factors that have been assiduously ferreted around so far in this study have also been validated by a Delphi analysis (Research Design Plate 4.2.1). Section 5.3.3 of this chapter has been extremely diligent in attempting to foster a discussion regarding their coherence, and the results have been kindly interpreted in Section 5.3.3.2.

5.2.3. Stakeholder Analysis for Sustainable Construction via GSCM in an Indian Scenario:

The results of semi-structured interviews have illuminated the effectiveness of policy interventions as a crucial mode for implementing GSCM in the construction segment. Stakeholder analysis emerged as a cornerstone, showcasing the invaluable insights and contributions of diverse stakeholders in shaping sustainable policies. Their perspectives, ranging from government agencies to industry leaders and community representatives, underscore the collaborative spirit essential for driving meaningful change. These findings underscore the significance of inclusive policymaking and stakeholder engagement,

paving the way for robust policy frameworks that prioritize environmental sustainability and foster industry-wide transformation.

Stakeholder analysis is a crucial process in understanding the interests, influence, and potential contributions of various entities involved in Green/sustainable building through GSCM. In India, stakeholders include government agencies, industry associations, environmental groups, and construction companies. Analyzing their perspectives helps identify barriers and formulate effective strategies for achieving sustainable construction goals. Stakeholder analysis is instrumental in navigating the complex landscape of sustainable construction and GSCM, fostering partnerships, and addressing challenges collectively. Benefits of stakeholder analysis include informed decision-making, conflict resolution, and enhanced collaboration for more effective sustainable construction initiatives.

Table 5.4 provides an overview of stakeholders who participated in the study, categorized into primary, secondary, and external experts. These stakeholders represent all five supply chain elements and have sectoral expertise. Their insights are crucial for implementing GSCM practices in the Indian building segment. The **table** highlights the collaborative efforts and diverse perspectives driving eco-beneficiary trends in the industry.

Stakeholder analysis involves identifying key stakeholders, prioritizing their influence on sustainable construction practices, understanding their specific interests, mapping their influence in decision-making processes, identifying effective communication channels, identifying barriers to sustainable construction and GSCM adoption, and developing collaborative strategies to overcome these barriers and promote sustainable practices. Collaborative efforts are crucial to overcome these barriers and align interests, ultimately leading to a potent sustainable building segment.

Table 5.4: Details of Stakeholders participation for the semi-structured interviews

Category	Role	Position
Primary	Local Government Officials	▪ Town Planners ▪ Environmental Officers
	Policy Makers	▪ Members of Municipal Councils

		▪ Government Representatives
	Government Departments	▪ Housing and Urban Development Department ▪ Environment and Pollution Control Boards
Secondary	Urban Planners and Architects	▪ City Planners ▪ Architects involved in local projects
	Community Representatives	▪ Local Community Leaders ▪ NGOs working on environmental and sustainable development issues
	Industry Representatives	▪ Construction Industry Associations ▪ Real Estate Developers ▪ Builders and Contractors
External	Environmental Experts	▪ Environmental Scientists ▪ Researchers in Sustainable Development
	Researchers	• R&D team
	Supervisory Bodies	▪ Environmental Impact Assessment (EIA) Authorities ▪ Real Estate Regulatory Authorities (RERA)

Government agencies, industry associations, environmental groups, and construction companies all have interests in regulatory compliance, environmental sustainability, and economic development. Government agencies shape policies and enforce environmental standards, while industry associations promote business growth and best practices. Environmental groups focus on environmental conservation and climate change mitigation, while construction companies aim for profitability, project efficiency, and regulatory compliance. They contribute to sustainable practices through green building technologies, workforce training, and innovation in construction methods.

5.2.4. SWOT Analysis

SWOT analysis serves as a valuable instrument for policymakers in the Indian construction sector to identify strengths, weaknesses, opportunities, and threats. It helps in

identifying existing strengths like governmental support, stakeholder collaboration, and technological advancements. It also helps in recognizing weaknesses like implementation challenges, resource constraints, and regulatory hurdles. Opportunities like economic incentives, knowledge exchange, and public awareness can be explored to capitalize on potential benefits. Threats like resistance to change, political instability, and external factors underscore the importance of proactive policy interventions. A comprehensive SWOT analysis can offer a thorough comprehension of the elements impacting the efficacy of policy interventions in the construction sector. This can serve as a foundation for further research, stakeholder consultations, and policy development processes to design targeted interventions that address specific issues and capitalize on opportunities for sustainable development. However, additional evidence and analysis may be needed to fully substantiate the effectiveness of policy interventions as the best solutions for issues in the Indian construction sector. The research aims to assess the green transformation of the Indian building segment through policy-level interventions, evaluating key processes for green-supply-chain integration, identifying areas for improvement, and assessing the feasibility of implementing green supply chain concepts. It will also propose a conceptual strategy for policymakers at the national and local levels to implement necessary interventions to achieve carbon-neutrality in the construction sector.

A. ***STRENGTHS***:

India's construction sector has several strengths, including existing awareness of green supply chain principles, technological advancements, regulatory support, rich cultural heritage, growing awareness among stakeholders, technological innovation, existing environmental policies, government support, and stakeholder engagement. The country's rich cultural heritage can be leveraged to promote sustainable construction practices, aligning with traditional principles of resource conservation and environmental stewardship.

India's environmental policies and regulations provide a foundation for integrating green-supply-chain principles into the construction segment. Government initiatives promoting Sustainable Development and green practices can facilitate policy integration efforts in the construction sector. Stakeholder engagement with

Figure 5.4: Policy Interventions for GSCM Implementation: A Comprehensive Accreditation Matrix

government agencies, industry associations, and environmental organizations can enhance the effectiveness of policy implementation.

India's building segment contributes extensively to the country's GDP and employment, and leveraging green transformation through policy interventions can create new economic opportunities. Access to renewable resources, such as solar and wind energy, can enhance sustainability and reduce reliance on finite resources.

India's global recognition and commitments to environmental sustainability, such as the Paris Agreement, can enhance its standing as a conscientious contributor in worldwide endeavours to address climate change and advance sustainable development. Collaboration with research and academic institutions can provide valuable expertise and technical support for policy interventions.

India's diverse ecosystems and natural landscapes present opportunities for incorporating sustainable design principles and green infrastructure solutions into construction projects. Public support and advocacy for environmental conservation and sustainability initiatives can facilitate their implementation and effectiveness in driving ‘green’ transformation in the building segment.

B. ***WEAKNESS****:’*

The construction industry in India faces several weaknesses, including resistance to change, lack of standardization, limited expertise, infrastructure challenges, regulatory complexity, and skill shortages. Traditional construction methods, materials, and attitudes towards sustainability may pose challenges to the adoption of new green technologies and practices promoted through policy interventions.

Lack of standardized processes for green supply chain integration may lead to inconsistencies and challenges in implementation. Skilled labor and expertise in sustainable construction practices may also limit the successful implementation of green supply chain initiatives. Enforcement challenges, policy fragmentation, and limited resources may also hinder the effectiveness of existing policies promoting green supply chain practices.

Implementation challenges include complexity in implementing the proposed framework, resource constraints, and regulatory hurdles. Time lag in policy implementation can impede the timely adoption of green transformation initiatives and hinder progress towards sustainability goals. Inadequate monitoring and evaluation mechanisms may limit accountability and hinder the assessment of their effectiveness.

Resistance from traditional construction practices may also pose challenges to the adoption of new green technologies and practices promoted through policy interventions. Insufficient public participation and engagement may lead to policies that do not adequately reflect the needs and priorities of all stakeholders. Lack of long-term planning and vision may hinder the formulation of comprehensive and sustainable strategies for green transformation.

The success of policy interventions for green transformation may depend on external influences viz., global economic conditions, technological advancements, and geopolitical dynamics. Cultural and behavioral barriers may also present barriers to the adoption of green transformation initiatives. Addressing these weaknesses requires strategic approaches such as streamlining policy implementation processes, strengthening monitoring and evaluation mechanisms, enhancing stakeholder engagement and public participation, fostering long-term planning and vision, diversifying dependencies, and promoting cultural shifts towards sustainability.

C. ***OPPORTUNITIES***

The assessment of the Indian construction sector presents several opportunities for innovation, collaboration, market differentiation, policy innovation, public-private partnerships, international best practices, economic incentives, knowledge exchange, and public awareness. These opportunities include the potential for green supply chain practices to enhance sustainability and efficiency, government initiatives like Smart Cities Mission and Make in India campaign, and the integration of green supply chain principles into urban development projects.

India-Government initiatives, *viz.*, Smart Cities Mission and Make in India campaign, can also promote sustainable construction practices. International partnerships can facilitate knowledge exchange, technology transfer, and access to best practices in green supply chain management. Increasing consumer demand for environmentally friendly products and services creates opportunities for construction companies to differentiate themselves by adopting green-supply-chain practices.

Policy innovation and public-private partnerships can also be leveraged to incentivize the adoption of green-supply-chain practices in the construction segment. Economic incentives, knowledge exchange, and public awareness can also be leveraged to drive sustainability initiatives.

Urbanization trends in India, advancements in sustainable materials and technologies, circular economy principles, international collaboration and funding, climate resilience and adaptation, and green finance mechanisms can all contribute to green transformation in the Indian construction sector. These opportunities underscore the potential for policy-level interventions to catalyze green transformation, contributing to environmental sustainability, economic growth, and social development.

D. ***THREATS***

Green supply chain initiatives in India face several threats, including economic constraints, supply chain disruptions, regulatory changes, cost considerations, resistance to change, environmental risks, political instability, and external factors. Economic constraints can deter SMEs from investing in green technologies and sustainable practices, while environmental risks like natural disasters, climate change, and resource scarcity can disrupt supply chains. Political instability and changes in government priorities may also disrupt policy continuity and implementation efforts.

Industry resistance, particularly from developers and contractors who prioritize cost and profitability over sustainability goals, may also hinder policy adoption. Economic pressures may lead to reduced government investment in sustainability

initiatives and limit resources available for policy implementation. External factors such as economic downturns or natural disasters may divert attention and resources away from sustainability initiatives.

Threats include weak enforcement mechanisms, inadequate public awareness, technological barriers, greenwashing and misinformation, and legal and litigation risks. Weak enforcement of environmental regulations and policies can lead to widespread disregard for environmental standards and practices. Insufficient public awareness and education about the benefits of green construction practices may also hinder public support for policy interventions. Technological barriers, such as lack of suitable green technologies, interoperability issues with existing systems, and scalability challenges, may also hinder the adoption of green transformation initiatives.

To address these threats, proactive measures must be taken, including strengthening enforcement mechanisms, providing incentives for sustainable investments, enhancing public education and awareness campaigns, fostering technological innovation, and ensuring transparent and accountable governance in policy implementation. By mitigating these threats, policymakers can enhance the effectiveness and sustainability of policy interventions aimed at transforming the Indian construction sector.

5.2.4.1. Policy Alignment: Maximizing GSCM Implementation Success

Policy intervention is a crucial tool for promoting green transformation in the Indian construction sector. It can leverage existing regulatory support, government support, stakeholder engagement, economic opportunities, access to renewable resources, and global recognition and commitments. These strengths indicate favorable conditions for policy intervention and suggest that policies can effectively leverage existing support, engagement, resources, and opportunities to drive green transformation in the sector.

However, there are weaknesses that demand policy intervention. Standardization of practices, guidelines, and regulations within the construction sector is crucial to ensure consistency, quality, and alignment with sustainability objectives. Policy intervention is needed to establish standardized frameworks that promote the adoption of green practices

across the industry. The complexity of existing regulations may hinder compliance and impede the adoption of green practices. Policy intervention is required to simplify and streamline regulatory frameworks, Facilitating stakeholders' comprehension and adhere to environmental standards.

Enforcement challenges are another challenge that policy intervention must address. Weak enforcement mechanisms for environmental regulations can lead to non-compliance and undermine sustainability efforts in the construction sector. Policy intervention is necessary to strengthen enforcement mechanisms, such as monitoring, penalties, and compliance incentives, to ensure adherence to environmental standards. Policy fragmentation can create inconsistencies and confusion among stakeholders, and policy intervention is needed to harmonize and integrate existing policies into a cohesive framework that promotes sustainability goals effectively.

Implementation challenges in the construction sector, viz., want of technological know-how and resistance from stakeholders, require policy intervention to provide support, guidance, and incentives for successful implementation. Inadequate monitoring and evaluation mechanisms hinder the assessment of progress towards sustainability goals and the effectiveness of policy interventions. Insufficient public participation and engagement in sustainability initiatives within the construction sector can hinder the adoption of green practices. Policy intervention is needed to facilitate public involvement through outreach, education, and participation mechanisms that foster collaboration and support for sustainability goals.

Long-term planning and vision for sustainability within the construction sector can result in short-term solutions that do not address underlying challenges effectively. Policy intervention is necessary to develop strategic plans and frameworks that set clear long-term goals and pathways for achieving sustainability objectives. Cultural and behavioral barriers may impede the adoption of green practices within the construction sector. Policy intervention is needed to address these barriers through education, awareness-raising, and incentives that promote sustainable behavior change.

Opportunities for policy intervention include government initiatives providing a strategic framework and support for policy interventions aimed at promoting green transformation in the construction sector. Policy interventions can drive innovation by introducing new

regulations, incentives, and frameworks that incentivize and promote sustainable practices in construction. Public-Private Partnerships have the potential to utilize resources, expertise, and capabilities to implement sustainable solutions and promote green transformation. Economic incentives, knowledge exchange, public awareness, urbanization trends, sustainable materials and technologies, circular economy principles, climate resilience and adaptation, and green finance and investment can all be facilitated by policy interventions.

To mitigate threats, policy intervention is required to provide stability and clarity through consistent policies and guidelines, establish and strengthen enforcement mechanisms, address inadequate public awareness, combat greenwashing and misinformation, and establish legal and litigation risks. By addressing these challenges, policy interventions can effectively leverage strategic initiatives, partnerships, incentives, and frameworks to promote green transformation in the Indian construction sector.

5.2.5. Ultimate objective

Pressure Barrier Analysis (PBA) is a strategic tool used to identify and address specific issues and drivers for GSCM implementation in the Indian construction sector. PBA examines both external pressures and internal obstacles that influence the adoption of GSCM practices. External pressures include environmental regulations, market demands for sustainable construction, and societal expectations for corporate responsibility. Internal barriers include organizational culture, lack of resources, and resistance to change. In the Indian construction sector, PBA helps identify challenges such as inadequate infrastructure for recycling construction waste, limited availability of eco-friendly building materials, and fragmented regulatory frameworks. It also helps identify drivers for change, such as government incentives for sustainable construction, increasing consumer awareness about environmental issues, and cost savings through energy-efficient building practices. Strategic decision-making is made by stakeholders based on PBA insights, enabling them to make informed decisions regarding the prioritization of GSCM interventions, such as investing in renewable energy sources, establishing partnerships with eco-friendly suppliers, or implementing green building certifications. PBA also helps overcome resistance by identifying and addressing internal barriers, such as organizational culture, employee attitudes, and resource constraints. By systematically assessing external and internal pressures, stakeholders can chart a path towards sustainable practices, contributing

to environmental stewardship, social responsibility, and long-term viability in construction activities.

5.2.5.1. Specific Issues in The Indian Construction Supply Chain Concepts

The Indian construction sector faces a complex challenge in integrating green supply chain concepts from the design phase to waste recycling. The sector faces challenges in procurement strategies, transportation logistics, execution methodologies, and sustainable waste management practices. Green structures require energy-efficient architecture, responsible material choices, and life cycle assessments. Procurement faces challenges in sustainable material sourcing and localization to reduce environmental impacts. Transportation faces logistics planning and eco-friendly fleet adoption issues. The execution phase requires incorporating green construction techniques like modular construction and prefabrication, along with energy-efficient equipment. Waste management planning is crucial to minimize construction waste and requires comprehensive recycling strategies. By understanding and addressing these challenges, the sector can contribute to a more sustainable and environmentally responsible future.

5.2.5.2. Socio-Economic-Environmental Sustainability criteria (SC)

The Social Supply Chain (SC) examines a range of metrics utilized to evaluate safety and health standards within construction projects. These metrics encompass Lost Time Injury Frequency Rate (LTIFR), Total Recordable Incident Rate (TRIR), Health and Safety Training Compliance, Employee Satisfaction Index, Labor Law Compliance, Diversity and Inclusion Measures, Community Engagement Initiatives, Stakeholder Satisfaction Surveys, Social License to Operate, Supplier Code of Conduct Adherence, Supply Chain Transparency, Work-Life Balance Indicators, Health and Wellness Initiatives, Local Procurement Spending, Job Creation and Training Programs, Human Rights Impact Assessments, and Anti-discrimination Policies. The summary underscores the significance of prioritizing worker safety and health, ensuring comprehensive training in safety protocols, and fostering inclusivity and equal opportunities. It emphasizes the importance of supply chain transparency to uphold accountability and traceability of materials. Additionally, the summary highlights the need to address potential human rights risks and implement anti-discrimination policies to combat bias based on various factors like race, gender, or religion.

Table 5.5: Socio-Economic-Environmental Sustainability Criteria in the Indian CS

Criteria	KPIs
SOCIAL SUSTAINABILITY CRITERIA	
1. Worker Health and Safety Performance	○ Total Recordable Incident Rate (TRIR). ○ Lost Time Injury Frequency Rate (LTIFR) ○ Health and Safety Training Compliance
2. Labor Rights and Fair Employment Practices	○ Employee Satisfaction Index ○ Compliance with Labor Laws ○ Diversity and Inclusion Metrics
3. Community Engagement and Stakeholder Relations	○ Community Outreach Activities ○ Stakeholder Satisfaction Surveys ○ Social License to Operate
4. Supply Chain Ethics and Responsible Sourcing	○ Supplier Code of Conduct ○ Transparency in Supply Chain
5. Employee Well-being and Work-Life Balance	○ Work-Life Balance Metrics ○ Health and Wellness Programs
6. Local Economic Development and Social Impact	○ Local Procurement Spend ○ Job Creation and Training
7. Human Rights and Ethical Conduct	○ Human Rights Impact Assessments ○ Anti-discrimination Policies
8. Promoting CBA & It's Equal Distribution at Local, Regional, and International Levels	○ Social Impact Assessment: ○ Community Benefits Agreements: ○ Global Supply Chain Transparency:
9. Preservation of Culture and Heritage	○ Cultural Heritage Protection: ○ Community Engagement in Design:
10. Affordable Housing (Green Materials and Green Energy)	○ Affordability Index for Housing: ○ Energy Cost Savings:
11. Inter-generational Parity (Cost-saving for Forthcoming)	○ Future Cost Mitigation: ○ Resilience Planning:
ECONOMIC SUSTAINABILITY CRITERIA	
1. Cost Savings and Efficiency	○ Cost Reduction Percentage ○ Resource Utilization Efficiency
2. Life-cycle Cost Analysis (LCCA)	○ Life-cycle Cost Reduction ○ Total Cost of Ownership (TCO)
3. Return-on-Investment (ROI)	○ GSCM Initiative ROI ○ Payback Period
4. Green Financing and Investment Opportunities	○ Access to Green Financing ○ Investment in RE
5. Supply Chain Resilience and Risk Managing	○ SC Disruption Costs ○ Risk Mitigation Savings
6. Market Differentiation and	○ Premium Pricing

Competitive Advantage	○ Market Share Growth
7. Financial Performance Indicators	○ Revenue Growth ○ Profit Margin Improvement
8. Life-time Value for Money	○ Return-on-Investment (ROI) ○ Net-Present-Value (NPV)
9. Higher Initial Investment on Green Promotion	○ Percentage of Budget Allocated to Green Initiatives
10. Enforcing a Green Tax	○ Green Tax ○ Compliance Rate
11. Carbon Tax/Carbon Pricing	○ Carbon Emission Fees ○ Carbon Intensity Reduction
12. Instability in Construction Raw Material Pricing	○ Material Cost Variability ○ Supply Chain Resilience
13. Employment Generation/GDP Improvement via Labour Force Participation	○ Job Creation Rate ○ Contribution to GDP
14. Fitness and Flexibility	○ Functional Performance ○ Flexibility Index
15. Consideration of Whole Life Costing	○ Whole Life Cost Analysis ○ Cost-Benefit Ratio
16. Waste Minimization and Management (Reusability)	○ Waste Reduction Rate ○ Material Reuse Percentage
17. Financial Affordability for Intended Beneficiaries	○ Affordability Index ○ Cost-Benefit Analysis for End Users
ENVIRONMENTAL SUSTAINABILITY CRITERIA	
1. Energy Efficiency and Consumption	○ Energy Use Intensity (EUI) ○ Renewable Energy Integration
2. Greenhouse Gas (GHG) Emissions	○ Carbon Footprint Reduction ○ GHG Intensity
3. Waste Reduction and Recycling	○ Waste Diversion Rate ○ Recycled Content Percentage
4. Water Conservation and Management	○ Water Use Efficiency ○ Rainwater Harvesting Utilization
5. Biodiversity Preservation	○ Habitat Preservation ○ Native Vegetation Restoration
6. Material Sustainability and Eco-friendly Practices	○ Embodied Carbon Reduction ○ Sustainable Material Sourcing
7. Eco-efficient Transportation and Logistics	○ Transportation Emissions Reduction ○ Efficient Transportation Management

Furthermore, it underscores the importance of social impact assessments, community benefit agreements, global supply chain transparency, cultural heritage preservation, community involvement in design processes, housing affordability indices, energy cost

savings, future cost mitigation, and resilience planning within construction projects. The summary stresses the necessity for fair labor practices, ethical sourcing, equitable distribution of benefits among socio-economic groups and communities, and community engagement to uphold cultural heritage and traditions. It also accentuates the significance of energy efficiency for occupants of environmentally friendly housing units, future cost reduction strategies, and resilience planning to ensure the sustainability and endurance of built assets for future generations.

The Economic SC discusses the benefits of Green Construction Management (GSCM) initiatives, including cost reduction percentage, resource utilization efficiency, life-cycle cost reduction, Total-cost of ownership (TCO), GSCM Initiative ROI, Payback Period, access to green financing, investment in renewable energy, supply chain disruption costs, risk mitigation savings, premium pricing, market share growth, revenue growth, and profit margin improvement. Cost reduction percentage measures the reduction in total costs over the life cycle of construction projects, while resource utilization efficiency indicates resource efficiency and optimization. Total Cost of Ownership evaluates the total costs associated with owning and operating assets. The return on investment (ROI) of GSCM initiatives represents the financial gains yielded from investments in GSCM practices, while the payback period signifies the duration required to recover the initial investment. Additionally, GSCM initiatives can help reduce supply chain disruption costs, mitigate risks, command premium prices for sustainable construction projects, and drive market share growth.

The various aspects of green construction, including green tax revenue, compliance rates, carbon emission fees, material cost variability, supply chain resilience, job creation rates, contribution to GDP, functional performance, flexibility index, whole life cost analysis, cost-benefit ratio, waste reduction rate, material reuse percentage, affordability index, cost-benefit analysis for end users, NPV, ROI, and percentage of budget allocated to green initiatives. Green tax revenue is the total revenue generated from levying taxes or fees on environmentally harmful construction activities, products, or emissions. Compliance rates indicate the percentage of construction firms or projects complying with green tax regulations and contributing to environmental conservation efforts. Carbon emission fees are paid by construction firms for their carbon emissions, with carbon intensity reduction achieved through carbon pricing incentives and emission reduction measures. The

summary also discusses the impact of material cost variability, supply chain resilience, job creation rates, contribution to GDP, functional performance, flexibility index, whole life cost analysis, waste reduction rate, material reuse percentage, affordability index, and return on investment.

The Environmental SC discusses strategies to enhance energy efficiency in construction projects, including integrating renewable energy sources, reducing carbon footprint, and promoting recycling. It also discusses waste diversion rates, recycled content percentages, water use efficiency, rainwater harvesting systems, habitat preservation, native vegetation restoration, embodied carbon reduction, sustainable material sourcing, transportation emissions reduction, and efficient transportation management. The study also emphasizes the need for route optimization, modal shift, and fleet electrification to reduce GHG emissions. The approach concludes by emphasizing a more greener construction, focusing on energy use intensity, waste diversion, recycling, water use efficiency, habitat preservation, and sustainable material sourcing.

Table 5.5 presents a set of Socio-Economic-Environmental sustainability criteria for the Indian Construction Sector. These criteria are categorized into three classes: social, economic, and environmental. The social class focuses on the social impact of construction activities, such as community engagement and labor rights. The economic class assesses the financial aspects of sustainability, such as cost-effectiveness and innovation. The environmental class emphasizes environmental conservation, resource efficiency, and mitigation of ecological impacts. The table provides 73 Key Performance Indicators (KPIs) to assess the sustainability performance initiatives in the Indian CS. These KPIs guide stakeholders towards a more sustainable and resilient future.

5.2.5.3. Sustainability Gaps

India faces several challenges in implementing sustainable practices in construction projects, including a lack of green building practices, infrastructure deficiencies, urban sprawl and congestion, resource depletion, and social equity concerns. Despite growing awareness, many construction projects still prioritize traditional methods, leading to resource inefficiencies and environmental degradation. India also faces challenges in developing sustainable infrastructure, such as inadequate waste management systems, limited access to SDG-6 (clean water and sanitation), and insufficient renewable-energy

integration (SDG-7). Rapid urbanization has led to increased pollution levels and inadequate public spaces. Additionally, construction activities often neglect social equity concerns, leading to displacement of marginalized communities and unequal access to resources.

Figure 5.5: Sustainability Gaps in Indian Construction Sector

The **Figure** 5.5. "Sustainability Gaps in the Indian Construction Sector" diagram visually highlights five key sustainability gaps in the industry: Lack of Green Building Practices, Infrastructure Deficiencies, Urban Sprawl and Congestion, Resource Depletion, and Social Equity Concerns. These gaps highlight the industry's inability to achieve sustainability objectives and call for urgent attention. The diagram serves as a catalyst for targeted interventions and strategic initiatives to bridge these gaps and advance sustainable development in the construction sector.

A. Social sustainability:

i) Addressing Health and Well-being Concerns: Importance of ensuring worker health and well-being.

ii) Formalizing Labor Practices: Importance of formalizing labor practices and promoting worker rights for social sustainability.

iii) Addressing Community Displacement: Importance of engaging with affected communities and respecting their rights.

iv) Promoting Gender Disparities: Importance of promoting gender equality and creating a safe work environment.

v) Investing in Skill Development and Training: Importance of investing in vocational training programs and capacity-building initiatives.

vi) Addressing Health and Safety: Importance of stricter enforcement of safety regulations, provision of safety training, and implementation of safety protocols.

vii) Enhancing Client Satisfaction: Importance of improving project management capabilities, fostering effective communication, and ensuring transparency in project delivery.

viii) Addressing Ethical Considerations: Strengthening regulatory oversight, promoting ethical business practices, and enforcing labor standards.

ix) Enhancing Community Engagement: Importance of community participation, conducting social impact assessments, and incorporating community feedback into project planning.

x) Strengthening Labor Rights and Welfare: Importance of strengthening labor rights enforcement, providing social security benefits, and improving access to affordable housing and healthcare.

xi) Addressing Labor Rights and Welfare: Importance of community engagement in decision-making processes.

xii) Promoting Inclusion and Equity: Challenges faced by vulnerable groups, including women, marginalized communities, and informal settlements.

B. Economic sustainability

i) Cost Overruns: Adopting green building practices can reduce operational costs and mitigate risks.

ii) Dependency on Non-renewable Resources: Transitioning to green construction practices can reduce reliance on finite resources and enhance economic viability.

iii) Low Productivity and Efficiency: Inefficient practices and outdated technologies can hinder economic growth and competitiveness.

iv) Inadequate Investment in Green Infrastructure: Despite increasing awareness, there remains a deficiency in funding for green infrastructure projects in India.

v) Market Demand for Sustainable Buildings: With increasing environmental awareness, there is a growing demand for green buildings.

vi) Return on Investment (ROI): Many construction projects struggle to achieve satisfactory ROI due to cost overruns, delays, and inadequate market demand.

vii) Employment Generation: Challenges related to job quality, skill development, and labor rights lead to issues like underemployment and informal employment.

viii) Value for Money: Inefficiencies, corruption, and lack of transparency in procurement and project management processes can lead to wastage of resources.

ix) Whole Life Costing: Inadequate maintenance planning and budget allocation can lead to premature infrastructure deterioration and higher life cycle costs.

x) Infrastructure Financing: Limited availability of long-term financing, high interest rates, and regulatory constraints hinder infrastructure development and economic growth.

xi) Housing Affordability: High property prices, land scarcity, and inadequate housing finance options contribute to housing unaffordability and exclusion.

xii) Informal Economy: Formalizing the sector and improving labor standards are crucial for promoting economic sustainability and livelihood security.

C. Environmental sustainability

i) Resource Depletion: The construction industry consumes vast amounts of natural resources, leading to environmental degradation.

• Sustainable practices like using recycled materials and minimizing resource consumption can conserve resources.

ii) Pollution and Emissions: Construction activities contribute to pollution (air, water, soil, and Noise).

• Green building techniques, pollution control measures, and cleaner construction methods can mitigate these impacts.

iii) Habitat Destruction: Urbanization and infrastructure development often result in habitat destruction and loss of biodiversity.

• Sustainable land use planning, preserving green spaces, and ecological design principles can minimize habitat loss.

iv) Climate Change: The construction sector contributes significantly to greenhouse gas emissions.

• Waste Generation: Waste management practices like recycling, reuse, and waste reduction can minimize environmental impact.

v) Renewable Energy Share: The construction sector's share of renewable energy is relatively low. Energy-efficient building designs, renewable energy sources, and reducing carbon emissions are essential strategies.

• Greater emphasis on integrating renewable energy technologies into building design and construction practices is needed.

vi) Reverse Logistics: Limited infrastructure and awareness for reverse logistics contribute to environmental pollution and resource depletion.

vii) 3R's: Strategies to minimize waste generation, maximize material reuse and recycling, and encourage sustainable construction practices are essential.

viii) Local Procurement: The construction industry often relies on imported materials and equipment, leading to higher carbon emissions.

ix) Biodiversity and Sensitive Area Conservation: Inadequate environmental assessment and enforcement of regulations exacerbate threats to biodiversity and ecological integrity.

Addressing environmental, social, and economic sustainability gaps in India's construction sector requires a multi-stakeholder approach. This includes promoting sustainable practices, enhancing resource efficiency, and safeguarding natural ecosystems. Policy interventions should focus on improving project planning, transparency, and infrastructure financing. Here is the comparative evaluation document placed side by side to highlight the advantages of transitioning to green practices (**Table** 5.6). This aligns with the findings of the triangulation study (literature survey and interviews), emphasizing its potential usefulness in various contexts corroborating section 5.2.3.

Table 5.6: A Glimpse of The Green Shift: Traditional *vs.* Sustainable Supply Chain Management

EVENTS	**TSC**	**GSC**
Background	Accelerated diversity and uncertainty on market	Env. Degradation and resources shortage
Objective and value	Economic	Economic and Ecological
Essential elements	Supplier/ manufacturer/ distributor/ retailer/ consumer/	Supplier/ manufacturer/ distributor/ retailer/ consumer/ society and environment
Procurement	prioritize cost-effectiveness over sustainability, leading to the use of conventional materials	Emphasizes recycled or locally sourced materials, as well as materials with lower embodied carbon.
Transportation and Logistics	Long-distance transportation and inefficient logistics.	Low-emission vehicles, optimizing routes to minimize fuel consumption, and integrating alternative transportation modes where feasible.
Supplier selection criteria	Price switching suppliers; short term relations	Ecological aspect; long term relations
Supplier Management	Conventional Supplier	Green suppliers

Stakeholder Engagement and Social Responsibility	Limited focus on social responsibility, legal and ethical standards.	Carry over broader sustainability goals and positive social impact.
Regulatory Compliance and Certifications	Traditional SCM: with environmental Compliance based on cost and benefit	Commitment to environmental stewardship and continuous improvement.
Primary activities	Material flow/ information flow/ capital flow	Material flow/ information flow/ capital flow/ knowledge flow
Eco sensitivity	Focuses solely on cost and speed, with less consideration for environmental consequences.	More focus on environmental consequences.
Resilience and Risk Management	Less integrated, so lower resilient to risks and disruptions	Highly integrated, resilient, and adapted
Theoretical basis	Optimal allocation of resources	SCM (Optimal allocation of resources) AND Sustainable development (equity theory)
Manufacturing model	Lean production, agile manufacturing	Cleaner production/ green manufacturing
Cost	Low	High
Economic Factors	Short-term cost-effective practices to lower upfront investment.	Long-term cost savings via energy-efficiency, waste-drop, and enhanced brand reputation
Speed and flexibility	High	Low
Strategic objectives	1. Inventory optimization or minimization is achievable. 2. Reduction of the overall supply chain costs is feasible. 3. Enhancement of product delivery time to the final consumer is attainable. 4. Flexibility can be increased within the supply chain. 5. Minimization of uncertainty and maximization of benefits are possible objectives.	1. The primary aim of GSCM is to align business practices with eco-friendliness. 2. GSCM practices are pursued to attain competitive advantage and enhance performance. 3. Integration of GSCM into corporate policies and strategies ensures seamless operations. 4. GSCM initiatives strive to introduce a significant shift in approach. 5. significance of ecological

		conservation & sustainable resource use, emphasizing the interconnectedness of business activities with the environment.

Modified after Dube et al. (2011)

Literature analysis is crucial for identifying barriers and developing strategies for transformation (see section 4.3.1.). Systematic Literature Review (SLR) and Citation Network Analysis (CNA) are two research methodologies used in academic research to analyze existing literature in a specific field. SLR gathers, assesses, and synthesizes relevant literature, identifying gaps and offering insights into the current state of knowledge. CNA, on the other hand, examines the relationships between academic publications based on their citation patterns. By integrating these methodologies, researchers can gain insights into the flow of information, the diffusion of ideas, and the evolution of research over time.

A study was conducted using Web of Science databases to search for academic research papers related to Green Supply Chain Management (GSCM) in the construction industry. The selection criteria focused on studies using both qualitative and quantitative methodologies to examine the link between performance, sustainability, and GSCM. The study excluded non-peer-reviewed articles or conference proceedings to ensure the quality and reliability of the selected studies. Data collection was conducted to remove repeated articles and enhance the dataset's integrity. The final selection resulted in 674 articles for further analysis, with 133 articles for the final review. The methodology approach involved a systematic process of data collection, filtering, and selection to ensure the inclusion of high-quality, relevant studies for the citation network analysis. The Citation Network Analysis (CNA) results are shown in **Figure** 5.6, which provides a thorough visual depiction of the linkages, relationships, and significant publications in the academic discourse on the subject of the study.

Figure 5.6: Tree map: "Insights from Citation Network Analysis: Unveiling Connections in Scholarly Discourse"

5.2.5.4. Barriers of Green supply chain management:

The construction sector faces several challenges in implementing Green Supply Chain Management (GSCM). These include customer resistance, slow supplier adaptation, significant upfront costs, and measurement challenges. Customers may be resistant to environmentally sustainable practices, and suppliers may be slow to adapt to new environmental standards. The cost of implementing green processes, such as renewable energy sources and energy-efficient technologies, can be prohibitive for construction firms. Measurement of return on investment (ROI) for GSCM initiatives can be complex, and there may be no standardized methods for evaluating the financial benefits of sustainability practices. To overcome these barriers, collaborative efforts from stakeholders across the supply chain, including customers, suppliers, regulators, and industry associations, are needed. Strategies such as raising awareness about GSCM benefits, incentivizing sustainable practices, fostering innovation in green technologies, and developing reliable measurement tools for Return on Investment (ROI) can serve as a tool to surmount these challenges and facilitate the adoption of environmentally sustainable practices within the construction sector.

Due to the transition to Green Supply Chain Management (GSCM), numerous construction enterprises are compelled to adopt environmental practices to bolster their eco-friendly reputation (Forbes, 2021). Increased levels of accountability are necessary owing to the consistent and diverse pressures on the environment. However, as noted by Mathiyazhagan et al. (2014), the Indian industry encounters difficulties in pinpointing the key drivers of GSCM. Seven distinct classes including a total of Thirty-six obstacles were found to be related to effective procurement and using the right research techniques to identify roadblocks to the GSCM implementation in the CS. Analogous endeavors were undertaken to ascertain the strategic constraints or prospects for the implementation of GSCM. All of this information is included in **Table (5.7)** that follows. In order to correct remediation and arrive at an efficient conceptual framework, pressure-barrier analysis is necessary.

The administrative challenges faced by construction projects include workforce management, supply chain disruptions, workflow inefficiencies, virtual risk assessment,

poor site management, material damage due to prolonged storage, and delays in work progress and reporting.

Table 5.7: Important Issues Addressing Sustainable Building Practices and Adoption of GSCM

Level	Issues (I)	Level	Issues (I)
Administrative	1. Workforce management [I_1,I_2] 2. Supply chain disruption [I_3,I_4] 3. Workflow [I_5,I_6] 4. Virtual risk assessment [I_7] 5. Poor site management [I_5,I_8] 6. Damage to materials due to prolonged storage [I_3] 7. Delays in work progress and reporting [I_1,I_8]	Regulatory	1. Nominal government measures/approvals [I_5] 2. Government subsidy [I_{16}] 3. Claims, disputes, and litigation [I_3,I_{11}] 4. Monopolisation of construction materials [I_3]
Fiscal	1. Cost overruns [I_2,I_4,I_6] 2. Increase in the project's cost [I_8,I_{10},I_{11},I_9] 3. Unsteady cash flow with lack of funding [I_5,I_6,I_{11}] 4. Financial flexibility for local government [I_{12}]	Corporate matters	1. Corporate Reasons [I_{17}] 2. Lack of practises in virtual training [I_2,I_8,I_{11}] 3. Ineffective transition to remote work. [I_3,I_{11}] 4. Insufficient support to adapt to new technologies [I_2,I_8,I_{11}] 5. Resource planning.[I_{14}]
Operational	1. Safety management [I_{11},I_{13}] 2. Material management [I_3,I_{11}] 3. Green transportation [I_1,I_{11}] 4. Communication flaws [I_{13}]		
Technical	1. Technological shortfalls [I_{13}] 2. Risk management [I_{14}] 3. Limited virtual platforms [I_2,I_8] 4. Lack of experts [I_3] 5. Urgency of advanced technologies [I_2,I_8,I_{11}] 6. Shortage of construction equipment [I_{11},I_{14}] 7. Engaging AI and IoT [I_{15}]	Logistic	1. Scarcity of material [I_2,I_6,I_1] 2. Finding suitable alternative materials [I_8,I_{11}] 3. Lack of communication between parties [I_{13}] 4. Local manufacturers and suppliers [I_5] 5. Poor storage on construction sites [I_{13}]
I_1 [Osuizugbo, 2020]; I_2 [Gamil and Alhagar, 2020]; I_3 [Kawmudi, et al., 2020]; I_4 [Vithana, et al., 2020]; I_5 [Ghandour, 2021]; I_6 [Ogunnusi, et al., 2020]; I_7 [Karmaker et al., 2021]; I_8 [Oey and Lim, 2021]; I_9 [Zamani, et al.,2021]; I_{10} [King, et al., 2021]; I_{11} [Alsharef, et al., 2021]; I_{12} [Rani et al., 2022]; I_{13} [Alenezi, 2020a]; I_{14} [Alenezi, 2020c]; I_{15} [Naz et al., 2022]; I_{16} [Assefa, 2023]; I_{17} [Kaushik and Guleria, 2020]			

Financial issues include cost overruns, increased project costs, unstable cash flow and revenue, and financial flexibility for local governments. Operational challenges include safety management, material management, green transportation, communication flaws, technological shortfalls, risk management, limited virtual platforms, shortage of experts, and the urgency of advanced technologies.

Technical challenges include insufficient technological capabilities, outdated systems, lack of experts, and the need for advanced technologies. Limited virtual platforms and construction equipment shortages also pose challenges. AI and IoT technologies can enhance project performance.

Regulatory challenges include nominal government measures/approvals, government subsidies, claims, disputes, and litigation. Monopolization of construction materials and the dominance of a few suppliers in the market impact pricing and availability.

Corporate matters include internal corporate policies or decisions impacting project execution and management, lack of virtual training practices, ineffective transition to remote work, and insufficient support for adopting new technologies. Resource planning challenges involve effectively planning and allocating resources, including manpower, materials, and equipment.

Logistical challenges include scarcity of material, finding suitable alternative materials, communication breakdowns among stakeholders, engagement with local manufacturers and suppliers, and poor storage on construction sites. Addressing these issues is crucial for successful construction projects.

5.2.6. Unified Strategy

The Indian construction sector must adopt a strategy to overcome various obstacles and successfully implement Green Supply Chain Management (GSCM), which is a crucial step in ensuring efficient and sustainable operations in the country. This calls for a thorough examination of these obstacles, the determination of their underlying causes, and the involvement of supply chain participants. To get beyond these obstacles, creative solutions and cutting-edge technology might be investigated, such as digital platforms, environmentally friendly building materials, and green building technologies. Investments in capacity building initiatives are necessary to improve the expertise and abilities of those involved in the execution of GSCM. To provide a supportive atmosphere for the implementation of GSCM, policy advocacy should be promoted at both the national and local levels. Establishing partnerships with academic institutions, research organizations, NGOs, and industry peers can facilitate the pooling of resources and knowledge aimed at addressing obstacles and advancing the implementation of GSCM. In order to motivate

others and develop a shared commitment to overcoming obstacles and seizing opportunities, players in the construction industry should be encouraged to share best practices and success stories. Lastly, a culture of continual improvement and learning should be promoted within the sector.

The construction sector is implementing a unified strategy to transform barriers to supply chain management (GSCM) into opportunities. This strategy includes a comprehensive analysis of these barriers, stakeholder engagement, innovation and technology adoption, capacity building, policy advocacy, collaboration with industry peers, academic institutions, and NGOs, and continuous improvement. **Figure** 5.7 explains the goal, to overcome regulatory constraints and technological limitations, explore innovative solutions, and empower stakeholders to overcome barriers. The strategy also encourages collaboration and partnerships to pool resources and expertise, and fosters a culture of continuous improvement. This will help the sector overcome barriers and seize sustainable development opportunities.

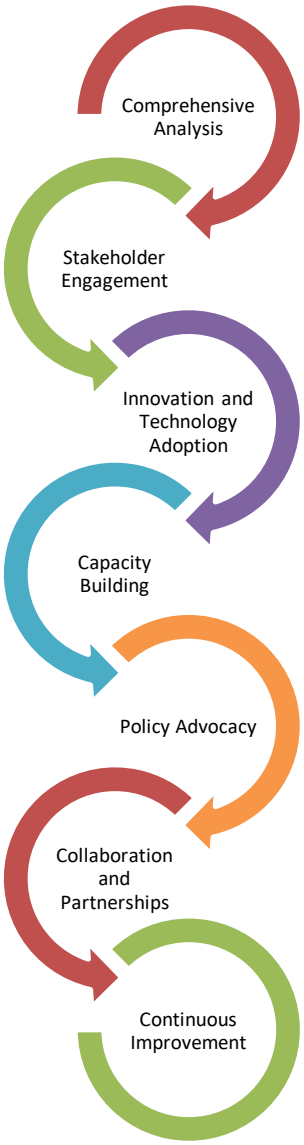


Figure 5.7: GSCM: Strategic Shift

In Green Supply Chain Management (GSCM), barriers can be transformed into opportunities through cooperative stakeholder discussions, innovation, and technology like digital platforms and sustainable procurement tools. To ensure long-term success, funding educational programs and capacity-building projects is crucial for fostering a sustainable culture among staff and suppliers, improving supply chain transparency, and streamlining procedures.

5.2.6.1. Implementation of Green supply chain management:

Green Supply Chain Management (GSCM) is crucial for promoting sustainability in the construction sector. Key strategies include integrating sustainable practices into daily operations, such as reducing energy consumption, optimizing transportation routes, and minimizing waste generation. Recycling programs are essential for managing construction waste, conserving resources, and reducing environmental impact. Product design should focus on sustainable design principles, using recycled or renewable materials for durability and recyclability. Renewable and environmentally friendly raw materials should be used in construction projects, sourcing from sustainable suppliers and avoiding deforestation or habitat destruction. Green manufacturing practices should be encouraged, reducing emissions, conserving water and energy, and minimizing pollutants. Energy-saving measures should be implemented in construction activities, such as using energy-efficient equipment and lighting, optimizing building designs for natural ventilation and lighting, and adopting renewable energy sources like solar or wind power. Participation in environmental initiatives and certification programs, such as LEED certification for green buildings, is essential for demonstrating commitment to sustainability standards. Investing in renewable energy solutions can reduce reliance on fossil fuels and lower carbon emissions. Waste reduction strategies should be implemented throughout the construction process, such as minimizing packaging waste and reusing materials on-site. Using environmentally friendly construction products and materials, such as low-VOC paints, sustainable wood products, and non-toxic building materials, can minimize environmental impact and promote health and safety.

5.2.6.2. Benefits of Green Supply Chain management:

Green Supply Chain Management (GSCM) is a sustainable approach to business operations that promotes environmental sustainability and reduces the use of toxic chemicals. It aims to minimize waste generation through efficient resource utilization, recycling programs, and waste reduction strategies, leading to cost savings and environmental conservation. GSCM also promotes the sustainable use of natural resources by sourcing responsibly, reducing resource depletion, and conserving biodiversity. Implementing sustainable practices often leads to cost savings through reduced energy consumption, waste management expenses, and operational inefficiencies, improving

profitability. GSCM fosters operational efficiency by optimizing supply chain processes, streamlining workflows, and minimizing resource waste, enhancing productivity and competitiveness. GSCM can differentiate businesses by offering sustainable products, appealing to environmentally conscious consumers, and enhancing brand reputation. Companies that prioritize sustainability build a positive brand image, attract environmentally aware customers, investors, and stakeholders, and reduce reputational risks. GSCM mitigates risks associated with environmental regulations, supply chain disruptions, and reputational damage by proactively addressing sustainability challenges and complying with industry standards. Employee morale increases when companies demonstrate environmental responsibility and ethical values, leading to higher job satisfaction and retention rates. Overall, integrating GSCM practices into business operations not only drives environmental sustainability but also yields tangible benefits in terms of cost savings, efficiency improvements, and enhanced reputation.

5.3. The Imperative of Policy Mapping for Addressing Sustainability Gaps

Policy mapping is a strategic method used to identify sustainability gaps in industries, especially in construction (Le *et al.*, 2023). It involves a systematic analysis of existing policies, regulations, and frameworks within a specific sector. This approach helps identify gaps and opportunities, informs advocacy efforts, facilitates collaboration among stakeholders, promotes compliance and enforcement, and encourages innovation and investment. Gaps in current regulatory frameworks hinder sustainable practices, while opportunities can be identified through policy interventions. Policy mapping provides insights into the strengths and weaknesses of current policies, enabling stakeholders to advocate for reforms or new regulations aligned with sustainability goals. This advocacy can influence policymakers to prioritize sustainability considerations in decision-making processes. Clear policy frameworks facilitate compliance and enforcement mechanisms, ensuring businesses adhere to sustainable practices. Policy mapping can also identify areas where incentives, subsidies, or grants can stimulate innovation and investment in sustainable technologies and practices.

5.3.1. Policy Mapping for A Unified Framework

The construction industry in India is increasingly focusing on integrating green practices into its processes to address environmental challenges. The formulation and

implementation of policies significantly influence the adoption of sustainable practices within the construction supply chain. This chapter explores the intricate web of policy elements in India that impact the green supply chain, aiming to discern key insights for a unified framework promoting sustainability and circularity.

The research methodology involved a systematic and comprehensive approach to unravel the intricate tapestry of policies shaping the sustainable construction landscape in India. Academic articles, government publications, industry reports, surveys, and interviews with government officials, industry experts, and academic professionals provided insights into key actors influencing sustainable practices in India. The cross-verification of findings from various sources facilitated a comprehensive synthesis, enabling a holistic understanding of the roles of different parties, existing and planned policies, and practical implementation strategies.

Government publications show increasing awareness and commitment to sustainability, but policy translation may vary. Industry reports provide practical insights into policy implementation, while surveys and interviews offer nuanced perspectives on stakeholder capabilities, policy alignment, and local authorities' strategies' effectiveness.

5.3.2. Policy Mapping for Environmental Sustainability, Construction, and Supply Chain Practices:

Policy mapping is a strategic process that involves identifying, analyzing, and categorizing policies related to environmental sustainability, construction, and supply chain practices. It helps create a visual representation of how different policies impact the green supply chain, providing clarity, strategic insights, and decision support. Policy mapping helps identify opportunities and challenges in the green supply chain, and informs decision-making by highlighting areas for policy improvement or alignment. It is a valuable tool for policymakers, industry professionals, and researchers to navigate the regulatory environment and enhance sustainability in construction and supply chain practices. Policies can be categorized based on direct impact, such as promoting eco-friendly materials or setting energy efficiency standards, or indirect impact, like general regulations affecting business operations or waste disposal. Analyzing interconnections between policies, identifying gaps or overlaps, and considering stakeholders involved in policy formulation and enforcement can help create a visual map or chart.

Table 5.8: Policy Mapping of Key Regulations for Sustainable Construction in India

DESIGN AND PLANNING		PROCUREMENT		CONSTRUCTION		TRANSPORTATION		CONSTRUCTION WASTE MANAGEMENT	
Direct Influence	**Indirect Influence**	**Direct Influence**	**Indirect Influence**	**Direct Influence**	**Indirect Influence**	**Direct Influence**	**Indirect Influence**	**Direct Influence**	**Indirect Influence**
National Building Code (NBC), 2016	Smart Cities Mission, 2015	The Indian Contract Act, 1872	Manual on Procurement of Goods, 2022	Real Estate (Regulation and Development) Act, 2016 (RERA)	The occupational health and working condition code 2020	National Urban Transport Policy, 2014	National Highway Act, 1956	Guidelines For Implementation of Green Building Norms	Guidelines For Managing C&D Waste in Kerala, 2022
IGBC, 2019	Heritage Conservation Policies	Warehouse Bye Laws, 1976	Arbitration And Conciliation (**Amendment**) Act, 2015	The building and other construction workers act, 1996	Make In India Initiative, 2014	The Motor Vehicles Act, 1988	Goods and Services Tax (GST) Policy	National Mission on Sustainable Habitat 2021-2030	The Swachh Survekshan 2020
ECBC, 2017	Building byelaws, 2016	Public Procurement (Preference to Make in India) Order, 2022	Assam Public Procurement Act, 2017	The contract labour act 1970	National Solar Mission, 2012	The Carriers Act, 1865	The Inland Vessels Act, 2021	Solid Waste Management Rules (2016)	Guidelines Sustainable Habitat, 2014
National Urban Housing and Habitat Policy, 2017	National Policy on Disaster Management	Manual On Procurement of Works, 2022	Goods and Services Tax (GST)	The Ozone Depleting Substances (Regulation & Control) Rules, 2000	Utilisation Of Fly Ash from Coal or Lignite Based Thermal Power Plants, 1999	The Motor Transport Workers Act, 1961	The Inland Waterways Authority of India Act, 1985	The National Environment Policy (Nep), 2006	CPCB Guidelines on Environmental Management of C & D) Wastes, 2017
Design Act, 2000	Zoning Regulations-Kottayam	Guidelines for Procurement of Goods, Works, and Services under National Disaster Response Fund (NDRF), 2020	Defence Procurement Procedure (DPP)	Environmental Impact Assessment (EIA) Notification, 2006	Coarse and Fine Aggregate for Concrete Specification_ BIS, 2016	Freight Corridor Policies	Multimodal Transportation of Goods Act, 1993	CPWD Green Rating Manual, 2019	Extended Producer Responsibility (EPR)
CPHEEO Operation & Maintenance and Part C Management, 2019				New Labour Code, 2022	National Urban Transport Policy	National Water Policy, 2023	Fast Tracking Freight in India A Roadmap for Clean and Cost-Effective Goods Transport, 2021		
				National Building Code (NBC)					

Table 5.8 lists the main policies that India is considering for successful construction demonstrations: direct contribution to sustainability for urban development as direct and more lenient as indirect. The table includes the outcomes of the first Delphi Round as well as the semi-structured interviews that followed. Because 70–90% of specialists concur about their significance for development and building, they have been listed as primary reference. As indicated in **Appendix** V, sustainability carries a high degree of accountability; those that play a supporting role or are of relatively secondary importance. **Appendix** III shows the questionnaire designed for semi-structured interviews.

5.3.3. Delphi Analysis

Delphi is a research method that combines qualitative and quantitative data collection, allowing for the synthesis of diverse viewpoints and comprehensive coverage of a subject matter (Skulmoski et al., 2007). It involves iterative rounds of surveys or interviews with a panel of experts to reach a consensus on a specific topic. The Delphi method also provides a structured framework for quantifying expert opinions and preferences, facilitating the aggregation and synthesis of data into measurable indicators. Iterative refinement of responses based on group feedback enhances the quality (reliability & validity) of the findings, leading to more robust conclusions and recommendations. This study presents insights from a Delphi analysis conducted among 30 experts from various sectors within the construction supply chain, focusing on three pivotal inquiries aimed at enhancing the implementation of GSCM practices in the Indian construction sector.

Delphi Analysis on Sustainable Supply Chain Management (GSCM) in Indian Construction is

- Aimed to identify key GSCM criteria and factors for effective adoption in the Indian building segment.
- Examined existing policies and regulations to identify policy elements influencing GSCM implementation.
- Aimed to uncover the optimal policy framework for GSCM adoption and efficacy in the Indian construction sector.

- Explored the importance of a conceptual framework for GSCM implementation through policy-level interventions.

This study, as per research design (4.2.1), conducted by Deplhi to ascertain Objectives 1, 3, and 4, targets to improve green practices in the Indian construction segment through rigorous analysis and expert consensus. It synthesizes expert perspectives and policy insights to inform stakeholders, policymakers, and industry practitioners, facilitating the development of strategies and frameworks conducive to sustainable construction practices in India.

5.3.3.1. Developing the agreed set of 'major sustainability criteria'

The Delphi Method, employed for developing and validating the established set of sustainability criteria for construction supply chain management, was thoroughly elucidated in Section 4.3.1 (RD for Delphi). This section delineates the process of identifying and validating these criteria across the first, second, and third rounds of Delphi. A detailed discussion of the results obtained from Round 3 will be provided in Section 5.3.1. Delphi was adopted in this study to arrive at consonance at three major area of research *viz*. (a) GSCM, (b) Policy interventions and (c) Conceptual frameworks, to corroborate the significance of policy interventions i.e., objective 3 of the research.

A. Round 1

The initial round of the Delphi Exercise entailed participants identifying five principal construction supply chain elements associated with sustainable construction, including design and planning, procurement, construction, transport, and waste management. Respondents were asked to pinpoint five key construction supply chain criteria with a focus on sustainable construction, aiming to establish a consensus on policy interventions. The procedure encompassed the selection of experts, formulation of a questionnaire, clarification provision, questionnaire dissemination, follow-up procedures, and distribution of respondents, as extensively discussed in Section 4.3.1. Thirty responses were received in the first round. The analysis led to the development of 45 construction sustainability criteria, covering GSCM, policy interventions, and conceptual framework factors. The results are presented in **Table** 5.9. The process

involved detailed procedures for analyzing the results.

B. Round 2

The second-round questionnaire was formulated by analyzing the expert responses obtained in the initial round, as discussed in Section 4.3.1.8. Participants were tasked with assessing the significance of the 45 construction supply chain factors using a 5-point Likert scale, where 1 denoted "strongly disagree" and 5 indicated "strongly agree." Furthermore, experts were invited to specify the importance of any additional criteria not listed and to offer any additional comments.

The procedures employed to analyze the findings of Round 2 were detailed in Section 4.3.1.8. The analysis conducted facilitated the determination of the importance level of the 45 GSCM sustainability criteria featured in the second round, which were categorized into three groups [27 GSCM, 10 Policy, and 8 CFW] to enhance the interpretation of the research objectives. No new environmental sustainability criteria emerged during this round. As delineated in Section 4.3.1.8, mean and standard deviation values for each of the 45 criteria were computed based on the scores provided by the experts.

Table 5.9: Analyzed set of GSCM sustainability criteria/factors based on responses received in Delphi Round 2

ID	CRITERIA	Mean	SD	Rank
1	GSCM improves overall cost efficiency and eliminates uneven risks.	3.33	1.15	24
2	GSCM practices are flexible and scalable compared to traditional supply chains, so they offer better customer reliability for the organization.	3.00	1.29	40
3	Experienced stakeholders are the key for effective supply chain building.	3.87	1.25	1
4	GSCM is a ‘multi-layer collaboration network’ that offers maximum-risk elements.	2.93	0.98	41
5	Environmental consideration is at the bottom of sustainability measurements.	2.63	1.43	44

6	A profit-oriented green business is hard to achieve, especially for smaller firms.	2.80	1.19	42
7	Policy change can accelerate the green transformation of traditional supply chains.	3.70	1.26	6
8	A better legal framework improves inventory visibility.	3.50	1.11	16
9	A project can be managed effectively if the activities of independent organizations are integrated using SCM principles.	3.67	1.15	7
10	SCM faces challenges due to temporary stakeholder relationships, value management, early project involvement, and information transparency gaps due to inferior relationships with suppliers and subcontractors.	3.37	1.10	23
11	A conceptual framework promotes supplier diversity, legitimizes process flaws, and can satisfy multiple clients with a well-accepted design, overcoming temporary stakeholder relationships.	3.43	1.10	22
12	RoI is the main financial concern for clients that catalyzes green transformation	3.13	1.36	35
13	The design stage calibrates improving cost-management, right stakeholder selection, and optimizing resource utilization.	3.43	1.07	20
14	Enterprise Resource Planning (ERP) is based on system internal policies.	3.27	0.94	31
15	Planning and scheduling are integral parts of GSCM.	3.60	1.30	8
16	Conceptual frameworks offer better solutions for flaws in planning and scheduling.	3.30	1.24	30
17	Risk management is easier when moving on with a legal framework.	3.47	1.31	18
18	Do you think procurement policies can have a major impact on the other four supply chain elements? [Design, transportation, operation, and waste management]	3.50	1.28	15
19	A better procurement policy needs effective software integration to attain sustainability.	3.43	1.30	21
20	Do you agree that procurement heavily depends on design but has supremacy over transportation and construction?	3.13	0.94	36
21	Do you think current procurement policies are sufficient to meet evaluation and contract requirements in	2.63	0.93	45

	procurement?			
22	Do you wish to revise existing policies to manage invoice approval and disputes in procurement?	3.13	1.17	37
23	Do you consider procurement policies to be at the top among other laws that comply with supply chain elements?	3.17	1.02	34
24	Labour-only subcontracting complicated the process because several tiers of subcontractors exist within a single project setting.	3.10	1.32	38
25	Due to bidding-based selection, main contractors can maintain transient relationships between suppliers and main contractors.	3.70	1.26	25
26	Main contractors recommend fostering teamwork, which will help with faster completion at a budgeted cost.	3.17	0.95	26
27	The transportation supply chain may be more functional when AI and IoT are integrated with field surveys.	3.50	1.20	12
28	Logistics services in construction require modifications to transportation law, as pollution is closely linked to transportation.	3.73	0.98	3
29	The better way to address supply chain interruption (transportation) in GSCM was discovered to be yard logistics.	3.50	1.25	33
30	Transportation is mostly reliant on procurement strategy and has control over waste management and reduction.	3.33	1.18	39
31	Better logistical planning and tight security characterize GSCM.	3.33	1.03	29
32	A strong and visible transit network can increase market size.	3.07	1.08	13
33	The GSCM guarantees minimum material loss during transportation.	3.53	0.97	28
34	Building code familiarization is not a hectic job.	3.70	1.32	32
35	A better conceptual framework enhances the safety and reliability of the construction process by allowing for detailed discussions with the client.	3.53	1.22	10
36	The construction process becomes safe and reliable with a better conceptual framework.	3.53	1.20	11

37	All building bylaws are tightly packed in India to safeguard the environment and workforce.	2.73	1.01	43
38	Construction industry in India works in a very fragmented format	3.33	1.27	14
39	Recycling waste for optimization of resources secures the overall project cost.	3.20	1.06	27
40	The promotion of less embodied energy for construction materials is a sustainability criterion.	3.33	1.09	9
41	India faces uncertainty in waste quantity estimation due to ineffective waste management practices and multitudinous authority.	3.33	1.03	4
42	India needs to update its green building regulations in response to the construction industry's sharp and rapid increase in air pollution.	3.83	1.39	2
43	We are lacking developed markets for green and recycled products at attractive price.	3.50	1.28	5
44	Clients may be compelled to adopt unsustainable construction practices due to higher recycling costs, which are a result of the increased costs for green products.	3.43	1.22	19
45	The absence of a post-monitoring mechanism causes a delay in the construction industry's sustainable integration cycle.	3.50	1.22	17

The Delphi study analyzed 45 criteria across three categories: Green Supply Chain Management (GSCM), Policy, and Framework. The study identified six major elements of GSCM, covering 27 criteria, including energy-efficient operations and transparent information sharing practices. The policy category consists of ten key criteria that outline the regulatory landscape and policy frameworks governing sustainability initiatives within the supply chain. These criteria provide insights into government regulations, industry standards, and compliance requirements that shape sustainability practices. The framework category delineates the structural elements necessary for developing a cohesive framework for sustainable supply chain management. By clustering the 45 criteria under these categories, the study aims to provide a holistic understanding of the interplay between GSCM practices, policy interventions, and framework development in fostering sustainability within the

supply chain (see **Figure** 5.8).

The questionnaire for the third round was formulated based on the responses gathered in the second round from experts. Participants were provided with feedback on the environmental sustainability criteria [S1-27, P1-10, and F1-8], presenting two scores indicating their significance. The initial score, termed "Your Score," reflected the expert's rating in Round 2, while the second score, termed "Mean Score," reflected the mean rating from all experts in Round 2. During the third round, experts were afforded the opportunity to reassess their scores using the same 5-point Likert Scale. Matters pertaining to the third-round questionnaire, such as clarification, distribution, follow-up procedures, and respondent allocation, were deliberated upon in Section 3.3.1.8. A total of 24 responses were received in that round.

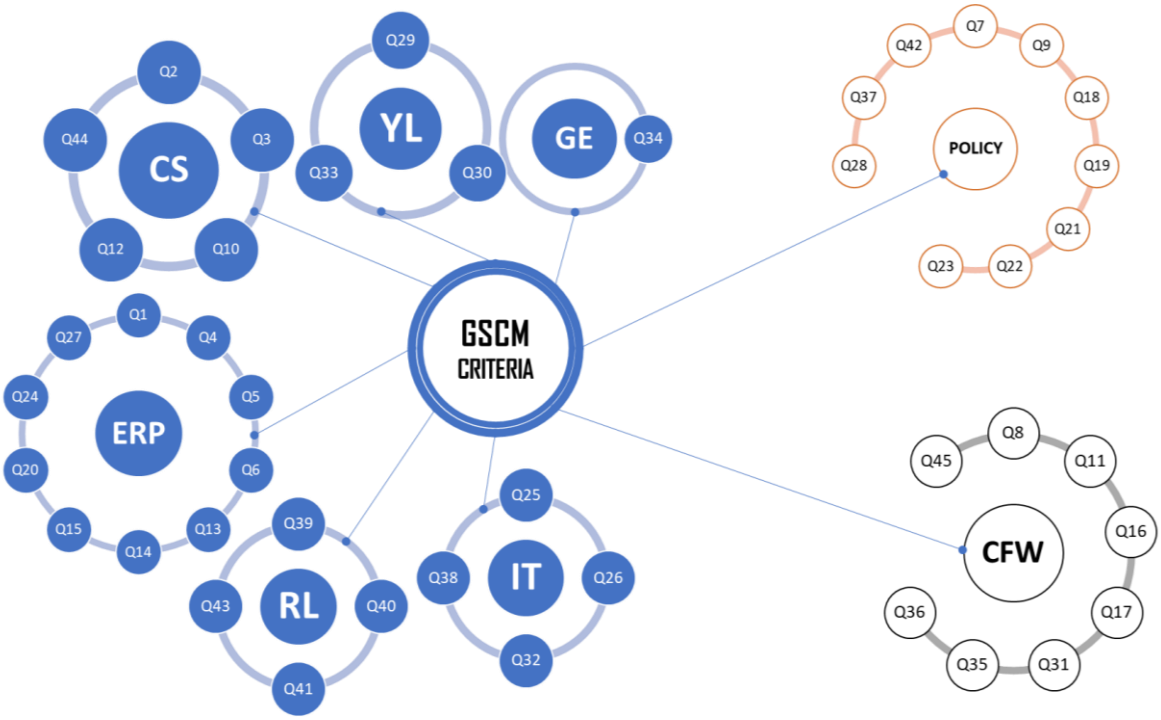


Figure 5.8: Clustering of 45 sustainability criteria for Delphi analysis

C. Round 3

Table 5.10 presents the criteria derived from Round 3 of the Delphi Exercise, outlining the mean, standard deviation, and the percentage of respondents concurring on the ranking of each criterion. Criteria with a mean value equal to or above 3 are deemed significant, with agreement among respondents established when 75% or

more concur on a ranking equal to or greater than 3. The standard deviation values depicted in Table 6.3 are relatively low, indicative of consensus. The 45 construction sustainability criteria (27+10+8) evaluated in Round 3 exhibited mean values above 3, were deemed important by 75% or more of the experts, and demonstrated relatively low standard deviation values. These criteria are essential for assessing sustainable construction factors and criteria and for further developing a framework for policy intervention.

Table 5.10: Key Factors for Developing a Sustainable Construction Strategy: Insights from Delphi Round 3

ROUND 3A: GSCM												
ID	**CRITERIA**	**Mean**	**SD**	**Rank**	**% (agreement)**					**% (voting pattern)**		**Total**
					5	**4**	**3**	**2**	**1**	**5 to 3**	**1 to 2**	
S1	GSCM practices are flexible and scalable compared to traditional supply chains, so they offer better customer reliability for the organization.	3.25	1.07	24	12.50	29.17	33.33	20.83	4.17	75.00	25.00	100
S2	Experienced stakeholders are the key for effective supply chain building.	4.17	1.05	3	50.00	29.17	8.33	12.50	0.00	87.50	12.50	100
S3	SCM faces challenges due to temporary stakeholder relationships, value management, early project involvement, and information transparency gaps due to inferior relationships with suppliers and subcontractors.	3.75	0.79	11	16.67	45.83	33.33	4.17	0.00	95.83	4.17	100
S4	RoI is the main financial concern for clients that catalyzes green transformation	3.46	1.28	20	25.00	29.17	20.83	16.67	8.33	75.00	25.00	100
S5	Clients may be compelled to adopt unsustainable construction practices due to higher recycling costs, which are a result of the increased costs for green products.	3.83	0.92	9	25.00	41.67	25.00	8.33	0.00	91.67	8.33	100
S6	GSCM improves overall cost efficiency and eliminates uneven risks.	3.54	0.93	16	12.50	41.67	37.50	4.17	4.17	91.67	8.33	100
S7	GSCM is a ‘multi-layer collaboration network’ that offers maximum-risk elements.	3.13	0.90	25	0.00	41.67	33.33	20.83	4.17	75.00	25.00	100

S8	Environmental consideration is at the bottom of sustainability measurements.	2.83	1.46	27	20.83	12.50	16.67	29.17	20.83	50.00	50.00	100
S9	A profit-oriented green business is hard to achieve, especially for smaller firms.	3.00	1.02	26	4.17	33.33	25.00	33.33	4.17	62.50	37.50	100
S10	The design stage calibrates improving cost-management, right stakeholder selection, and optimizing resource utilization.	3.83	0.64	10	12.50	58.33	29.17	0.00	0.00	100.00	0.00	100
S11	Enterprise Resource Planning (ERP) is based on system internal policies.	3.54	0.66	17	0.00	62.50	29.17	8.33	0.00	91.67	8.33	100
S12	Planning and scheduling are integral parts of GSCM.	4.13	0.74	4	29.17	58.33	8.33	4.17	0.00	95.83	4.17	100
S13	Do you agree that procurement heavily depends on design but has supremacy over transportation and construction?	3.38	0.82	21	8.33	33.33	45.83	12.50	0.00	87.50	12.50	100
S14	Labour-only subcontracting complicated the process because several tiers of subcontractors exist within a single project setting.	3.54	1.02	18	16.67	41.67	20.83	20.83	0.00	79.17	20.83	100
S15	The transportation supply chain may be more functional when AI and IoT are integrated with field surveys.	3.96	0.75	6	20.83	58.33	16.67	4.17	0.00	95.83	4.17	100
S16	Building code familiarization is not a hectic job.	3.38	0.97	22	8.33	41.67	33.33	12.50	4.17	83.33	16.67	100
S17	Due to bidding-based selection, main contractors can maintain transient relationships between suppliers and main contractors.	3.71	0.62	13	8.33	54.17	37.50	0.00	0.00	100.00	0.00	100
S18	Main contractors recommend fostering teamwork, which will help with faster completion at a budgeted cost.	3.63	0.77	15	8.33	54.17	29.17	8.33	0.00	91.67	8.33	100
S19	A strong and visible transit network can increase market size.	4.04	0.62	5	20.83	62.50	16.67	0.00	0.00	100.00	0.00	100
S20	Construction industry in India works in a very fragmented format	3.96	0.86	7	29.17	41.67	25.00	4.17	0.00	95.83	4.17	100
S21	Recycling waste for optimization of resources secures the overall project cost.	3.71	0.91	14	16.67	50.00	20.83	12.50	0.00	87.50	12.50	100
S22	The promotion of less embodied energy for construction materials is a sustainability criterion.	3.88	0.68	8	16.67	54.17	29.17	0.00	0.00	100.00	0.00	100

S23	India faces uncertainty in waste quantity estimation due to ineffective waste management practices and multitudinous authority.	4.21	0.78	1	37.50	50.00	8.33	4.17	0.00	95.83	4.17	100
S24	We are lacking developed markets for green and recycled products at attractive price.	4.21	0.72	2	37.50	45.83	16.67	0.00	0.00	100.00	0.00	100
S25	The better way to address supply chain interruption (transportation) in GSCM was discovered to be yard logistics.	3.50	0.66	19	4.17	45.83	45.83	4.17	0.00	95.83	4.17	100
S26	Transportation is mostly reliant on procurement strategy and has control over waste management and reduction.	3.29	0.95	23	4.17	45.83	29.17	16.67	4.17	79.17	20.83	100
S27	The GSCM guarantees minimum material loss during transportation.	3.75	0.99	12	25.00	33.33	37.50	0.00	4.17	95.83	4.17	100

ROUND 3B: POLICY

ID	CRITERIA	Mean	SD	Rank	% (agreement)					% (voting pattern)		Total
					5	4	3	2	1	5 to 3	1 to 2	
P1	Policy change can accelerate the green transformation of traditional supply chains.	4.13	0.68	2	29.17	54.17	16.67	0.00	0.00	100.00	0.00	100
P2	A project can be managed effectively if the activities of independent organizations are integrated using SCM principles.	4.13	0.61	3	25.00	62.50	12.50	0.00	0.00	100.00	0.00	100
P3	Do you think procurement policies can have a major impact on the other four supply chain elements? [Design, transportation, operation, and waste management]	3.92	1.02	5	29.17	45.83	16.67	4.17	4.17	91.67	8.33	100
P4	A better procurement policy needs effective software integration to attain sustainability.	3.92	0.88	6	29.17	37.50	29.17	4.17	0.00	95.83	4.17	100
P5	Do you think current procurement policies are sufficient to meet evaluation and contract requirements in procurement?	2.58	0.88	10	4.17	12.50	20.83	62.50	0.00	37.50	62.50	100
P6	Do you wish to revise existing policies to manage invoice approval and disputes in procurement?	3.58	0.72	7	4.17	58.33	29.17	8.33	0.00	91.67	8.33	100
P7	Do you consider procurement policies to be at the top among other laws that comply with supply chain elements?	3.46	0.83	8	8.33	41.67	37.50	12.50	0.00	87.50	12.50	100

P8	Logistics services in construction require modifications to transportation law, as pollution is closely linked to transportation.	4.13	0.54	4	20.83	70.83	8.33	0.00	0.00	100.00	0.00	100
P9	All building bylaws are tightly packed in India to safeguard the environment and workforce.	2.88	0.90	9	4.17	16.67	45.83	29.17	4.17	66.67	33.33	100
P10	India needs to update its green building regulations in response to the construction industry's sharp and rapid increase in air pollution.	4.42	0.72	1	54.17	33.33	12.50	0.00	0.00	100.00	0.00	100
ROUND 3C: CFW												
ID	**CRITERIA**	**Mean**	**SD**	**Rank**	**% (agreement)**					**% (voting pattern)**		**Total**
					5	**4**	**3**	**2**	**1**	**5 to 3**	**1 to 2**	
F1	A better legal framework improves inventory visibility.	3.88	0.68	5	12.50	66.67	16.67	4.17	0.00	95.83	4.17	100
F2	A conceptual framework promotes supplier diversity, legitimizes process flaws, and can satisfy multiple clients with a well-accepted design, overcoming temporary stakeholder relationships.	3.83	0.70	6	16.67	50.00	33.33	0.00	0.00	100.00	0.00	100
F3	Conceptual frameworks offer better solutions for flaws in planning and scheduling.	3.79	0.72	7	12.50	58.33	25.00	4.17	0.00	95.83	4.17	100
F4	Risk management is easier when moving on with a legal framework.	3.92	0.97	4	29.17	45.83	12.50	12.50	0.00	87.50	12.50	100
F5	Better logistical planning and tight security characterize GSCM.	3.71	0.69	8	8.33	58.33	29.17	4.17	0.00	95.83	4.17	100
F6	A better conceptual framework enhances the safety and reliability of the construction process by allowing for detailed discussions with the client.	4.04	0.62	1	20.83	62.50	16.67	0.00	0.00	100.00	0.00	100
F7	The construction process becomes safe and reliable with a better conceptual framework.	4.04	0.55	2	16.67	70.83	12.50	0.00	0.00	100.00	0.00	100
F8	The absence of a post-monitoring mechanism causes a delay in the construction industry's sustainable integration cycle.	4.00	0.66	3	20.83	58.33	20.83	0.00	0.00	100.00	0.00	100

5.3.3.2. Discussion of the results

In order to ensure sustainability in the Indian construction sector through the green

transformation of supply chain elements, as agreed upon in Section 5.2, this section of the thesis addresses 45 critical environmental sustainability criteria agreed by the expert authority for creating a conceptual framework for an effective policy intervention strategy.

A. GSCM criteria

i. GSCM practices are flexible and scalable compared to traditional supply chains, so they offer better customer reliability for the organization.

The criterion "S1" was ranked 24th by the experts with a mean of 3.25 and standard deviation of 1.07. It was considered important by 75% of the experts.

Green Supply Chain Management (GSCM) is a significant shift in the Indian construction sector, offering flexibility and scalability. Unlike traditional supply chains, GSCM prioritizes environmental sustainability and social responsibility while maintaining operational efficiency. This flexibility allows construction companies to respond more effectively to changing customer demands, regulatory requirements, and market conditions, aligning their operations with evolving sustainability standards and client preferences (Ullah et al., 2022). GSCM also allows construction organizations to adjust their supply chain processes according to project scale and scope, tailoring sustainability initiatives and resource management strategies to meet the specific needs of each project. By embracing GSCM practices, construction companies in developing countries like India can enhance customer reliability, demonstrate commitment to environmental stewardship, social responsibility, and sustainable development, fostering trust and loyalty among clients and positioning them as leaders in the transition towards more environmentally conscious and socially responsible construction practices (Nureen et al., 2023).

ii. Experienced stakeholders are the key for effective supply chain building**.**

The criterion "S2" was ranked 3rd by the experts with a mean of 4.17 and standard deviation of 1.05. It was considered important by 87% of the experts.

According to Choudhary et al (2021) Indian construction industry is a dynamic and diverse sector with complexities ranging from regulatory challenges to project requirements and environmental considerations. Experienced stakeholders, with their deep understanding of local regulations and industry best practices, play a crucial role in

managing supply chains. Their expertise helps streamline processes, optimize resource utilization, and mitigate risks, contributing to project success and timely delivery. They also leverage their industry networks to identify opportunities for innovation, cost savings, and performance improvement. Their insights into emerging technologies, sustainable practices, and market trends drive continuous improvement and foster a culture of innovation within the construction supply chain. Thus, experienced stakeholders are essential for building robust and efficient supply chains in the developing economies like Indian construction industry (Okafor et al., 2022).

iii. SCM faces challenges due to temporary stakeholder relationships, value management, early project involvement, and information transparency gaps due to inferior relationships with suppliers and subcontractors.

The criterion "S3" was ranked 11th by the experts with a mean of 3.75 and standard deviation of 0.79. It was considered important by 95% of the experts.

The Indian construction industry faces challenges in supply chain management (SCM) due to transient stakeholder relationships, limited emphasis on value management, delayed project involvement, and inadequate information transparency. These issues are exacerbated by fragmented relationships with suppliers and subcontractors, which hinder the efficiency and effectiveness of SCM practices. According to Rajhans (2018), short-term stakeholder relationships can lead to communication gaps, coordination issues, and a lack of alignment on project objectives. The traditional focus on cost reduction often overshadows value-based decision-making, resulting in suboptimal project outcomes and inefficient supply chain operations. Delayed stakeholder involvement can lead to missed opportunities for value engineering, cost optimization, and risk mitigation. Information transparency gaps arise due to inferior relationships with suppliers and subcontractors, resulting in inefficiencies, delays, and substandard decision-making. Brun et al. (2020) stated that addressing these challenges requires long-term partnerships, prioritizing value management, promoting early stakeholder involvement, and enhancing information transparency across the construction supply chain.

iv. RoI is the main financial concern for clients that catalyzes green transformation

The criterion "S4" was ranked 20th by the experts with a mean of 3.46 and standard deviation of 1.28. It was considered important by 75% of the experts.

Return on Investment (RoI) is a key financial factor for Indian construction clients, including real estate developers, commercial enterprises, and government agencies, when adopting green building solutions (Prasath, 2014). RoI refers to the anticipated financial benefits or cost savings resulting from investments in sustainable construction practices and green building technologies. The Indian construction sector faces economic and environmental challenges, such as rising energy costs and environmental concerns. Clients view green transformation as a strategic imperative to mitigate operational expenses, enhance asset value, and demonstrate corporate social responsibility (Le, 2022). By embracing sustainable practices like energy-efficient design, renewable energy integration, and resource optimization, clients can realize tangible RoI benefits like reduced energy consumption, lower operational costs, and enhanced market competitiveness. The Indian government's initiatives, such as green building certifications and tax incentives, further incentivize clients to prioritize RoI considerations.

v. Clients may be compelled to adopt unsustainable construction practices due to higher recycling costs, which are a result of the increased costs for green products.

The criterion "S5" was ranked 9th by the experts with a mean of 3.83 and standard deviation of 0.92. It was considered important by 91% of the experts.

The Indian construction industry faces challenges in adopting sustainable practices versus traditional methods due to higher recycling costs and increased expenses associated with green products. Clients may perceive the costs of recycling infrastructure as prohibitive, leading them to prioritize conventional waste management practices. Additionally, the increased costs for green products and materials, such as limited availability, specialized manufacturing processes, and certification requirements, can compound the financial burden for clients considering sustainable construction options (Nalewaik and Venters, 2010). This decision-making dynamic suggests the need for policy interventions, incentives, and awareness campaigns to address the affordability and accessibility of sustainable construction solutions. By reducing financial barriers associated with recycling and green products, policymakers and industry stakeholders can encourage wider adoption of sustainable practices and facilitate India's transition towards a more environmentally conscious built environment (Rahman et al., 2023).

vi. GSCM improves overall cost efficiency and eliminates uneven risks.

The criterion "S6" was ranked 16th by the experts with a mean of 3.54 and standard deviation of 0.93. It was considered important by 91% of the experts.

Green Supply Chain Management (GSCM) is a crucial strategy in the Indian construction industry, enhancing cost efficiency and mitigating risks. It optimizes resource utilization, minimizes waste, and streamlines processes, leading to cost savings across various project stages. GSCM practices, such as efficient material sourcing, waste reduction, and energy conservation, minimize resource wastage and costs, especially in India where resource scarcity and fluctuating prices impact project budgets. GSCM also promotes transparency and collaboration among stakeholders, facilitating better risk identification and mitigation strategies. This fosters stronger relationships between suppliers, contractors, and other stakeholders, ensuring smoother project execution and reducing disruptions or disputes (cxotoday 2023). Overall, GSCM offers significant benefits to the Indian construction industry, contributing to its long-term sustainability and competitiveness.

vii. GSCM is a 'multi-layer collaboration network' that offers maximum-risk elements.

The criterion "S7" was ranked 25th by the experts with a mean of 3.13 and standard deviation of 0.9. It was considered important by 75% of the experts.

Green Supply Chain Management (GSCM) is a strategic framework in the Indian construction industry that focuses on sustainability and environmental responsibility. It encourages collaboration among stakeholders, including suppliers, contractors, government agencies, and communities, to manage and mitigate risks associated with construction projects. GSCM aims to ensure environmental compliance by implementing sustainable practices and incorporating eco-friendly materials (Benny and Joy, 2018). It also addresses supply chain disruptions and uncertainties, enabling stakeholders to diversify their supply sources and establish contingency plans. It also addresses social and community-related risks, such as labor disputes and stakeholder conflicts, by encouraging engagement with local communities, transparent communication, and stakeholder participation in decision-making processes (Govindan et al., 2021). GSCM enhances project resilience, sustainability, and overall success in the dynamic and complex construction landscape of India (Srivastava, 2007).

viii. Environmental consideration is at the bottom of sustainability measurements

The criterion "S8" was ranked 27th by the experts with a mean of 2.83 and standard deviation of 1.46. It was considered important by 50% of the experts.

Indian construction projects often prioritize environmental considerations over other sustainability aspects due to economic and financial constraints, tight project timelines, and the competitive nature of the industry. Environmental sustainability regulations are often perceived as weak or inadequate, leading to non-compliance and overlooking of environmental concerns. Cultural and social factors, such as traditional construction practices and lack of awareness about long-term environmental impacts, also contribute to this trend. Stakeholders may perceive addressing environmental sustainability as requiring additional investment and resources, which can deter them in a cost-sensitive industry. Research literature highlights the need for greater awareness, education, and policy interventions to elevate the importance of environmental considerations in Indian construction projects (Kiani Mavi et al., 2021; Simons,2023; Vyas and Reddy, 1998). Incorporating sustainability into project planning can lead to long-term benefits like resource efficiency, reduced environmental footprint, and enhanced reputation for stakeholders.

ix. A profit-oriented green business is hard to achieve, especially for smaller firms.

The criterion "S9" was ranked 26th by the experts with a mean of 3.00 and standard deviation of 1.02. It was considered important by 62% of the experts.

According to Singh et al. (2023) the Indian construction industry faces significant challenges in achieving a profit-oriented green business, especially for smaller firms. Factors contributing to this include high upfront costs, lack of access to affordable financing, and a lack of expertise, technical knowledge, and resources. Additionally, market dynamics and consumer preferences limit smaller firms' ability to command premium prices for green building projects (Jones, 2022).

To overcome these challenges, research suggests supportive policy frameworks, financial incentives, and capacity building programs. Government initiatives promoting sustainable construction, such as green building certification programs and tax incentives, can help level the playing field and encourage broader adoption of green strategies. Collaborative

efforts between industry stakeholders, academia, and government agencies can facilitate knowledge sharing, skill development, and technology transfer, empowering smaller firms to embrace sustainable practices profitably (Ahmed and Ali, 2022).

x. The design stage calibrates improving cost-management, right stakeholder selection, and optimizing resource utilization.

The criterion "S10" was ranked 10th by the experts with a mean of 3.83 and standard deviation of 0.64. It was considered important by 100% of the experts.

The design stage is crucial in the Indian construction industry for cost-management, stakeholder engagement, and resource optimization. It sets the foundation for cost management by considering factors like material selection, building layout, and construction methods. Early cost planning and value engineering techniques help identify cost-saving measures and mitigate budget overruns. Effective stakeholder selection is essential for project success, as it fosters collaboration and aligns project goals (Hassan, 2023). Stakeholder involvement in decision-making addresses diverse perspectives and conflicts. Optimizing resource utilization is a key focus, with sustainable design principles like energy efficiency, water conservation, and waste reduction integrated into building designs (Hafez et al., 2023). Green building practices are essential for sustainability goals, operational costs, and occupant comfort. The design stage plays a pivotal role in achieving cost-effective, stakeholder-engaged, and resource-efficient construction projects (Wick, 2023).

xi. Enterprise Resource Planning (ERP) is based on system internal policies.

The criterion "S11" was ranked 17th by the experts with a mean of 3.54 and standard deviation of 0.66. It was considered important by 91% of the experts.

Enterprise Resource Planning (ERP) systems are essential in the Indian construction industry for streamlining internal processes and enhancing organizational efficiency. They serve as a centralized platform for managing construction projects, integrating various functions and data sources, facilitating seamless communication and collaboration across departments. ERP enhances project visibility, enables real-time monitoring of key performance indicators, and supports informed decision-making (Kelly and Ma, 2024). It also helps enforce internal policies and standard operating procedures, ensuring

compliance with regulatory requirements, quality standards, and contractual obligations. By aligning ERP configuration with internal policies and workflows, businesses can streamline processes, enhance data accuracy, and mitigate operational risks (Seethamraju and Sundar, 2013). ERP systems also enable construction companies to capture and analyze data related to project performance, resource utilization, and cost management, providing strategic planning insights and enhancing operational efficiency and competitiveness.

xii. Planning and scheduling are integral parts of GSCM.

The criterion "S12" was ranked 4th by the experts with a mean of 4.13 and standard deviation of 0.74. It was considered important by 95% of the experts.

Planning and scheduling are crucial in GSCM practices in the Indian construction industry. They optimize resource utilization, minimize wastage, and enhance project efficiency. By considering factors like material availability, labor productivity, and weather conditions, construction companies can streamline operations, reduce delays, and mitigate risks. Proactive planning strategies address environmental considerations, such as minimizing carbon emissions and energy consumption (Mojumder and Singh, 2021). Tools like Building Information Modelling (BIM), Critical Path Method (CPM), and Lean Construction principles facilitate GSCM implementation. Integrating sustainability criteria into planning and scheduling processes aligns GSCM practices with broader environmental goals and regulatory requirements, contributing to the built environment's sustainability. Overall, planning and scheduling are essential elements of GSCM, enabling construction companies to achieve environmental objectives, enhance project performance, and drive sustainable development (Gaur, 2022).

xiii. Do you agree that procurement heavily depends on design but has supremacy over transportation and construction?

The criterion "S13" was ranked 21st by the experts with a mean of 3.38 and standard deviation of 0.82. It was considered important by 87% of the experts.

The notion that procurement is solely dependent on design but has supremacy over transportation and construction in Indian construction projects is a controversial view. While procurement is crucial for acquiring materials, equipment, and services, it may not

always be the primary focus (Luong, 2023). Transportation and construction activities are equally important in construction projects, as they ensure timely delivery of materials, minimize delays, and meet quality standards. However, the importance of each aspect may vary depending on project specifics, such as size, complexity, location, and contractual arrangements (San Cristóbal *et al*., 2019). In projects with intricate designs or specialized materials, procurement decisions may have a greater impact on project outcomes, while in projects with strict timelines or challenging site conditions, efficient transportation and construction methodologies may take precedence (NITI Aayog, 2019).

xiv. Labour-only subcontracting complicated the process because several tiers of subcontractors exist within a single project setting.

The criterion "S14" was ranked 18th by the experts with a mean of 3.54 and standard deviation of 1.02. It was considered important by 79% of the experts.

According to Loganathan and Kalidindi (2017), labour-only subcontracting, a common practice in the Indian construction industry, involves subcontractors providing labour services without providing materials or equipment. This can lead to multiple tiers of subcontractors handling specific aspects of the project, increasing the risk of delays, cost overruns, and quality issues. The fragmentation of responsibilities among subcontractors can also lead to coordination difficulties and accountability gaps. Research literature emphasizes the need for effective subcontractor management strategies, such as clear contractual agreements, robust project management practices, and communication protocols (Ahuja and Yang, 2006). Informal subcontractors, often lacking formal contracts or regulatory oversight, can introduce uncertainties regarding labour rights, safety standards, and project compliance, further complicating project management and risk mitigation efforts. According to Bal et al. (2013), a holistic approach integrating effective subcontractor management practices, regulatory compliance, and stakeholder engagement is needed to enhance project efficiency, transparency, and sustainability.

xv. The transportation supply chain may be more functional when AI and IoT are integrated with field surveys.

The criterion "S15" was ranked 6th by the experts with a mean of 3.96 and standard deviation of 0.75. It was considered important by 95% of the experts.

The Indian construction sector is exploring the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) with field surveys to enhance the transportation supply chain. Traditional transportation management systems encounter issues such as route inefficiencies, delays, and insufficient resource allocation, resulting in heightened costs and project delays. AI algorithms have the capability to analyze real-time data from IoT sensors, thereby optimizing route planning, scheduling, and resource allocation. IoT-enabled sensors offer insights into vehicle performance, fuel consumption, and driver behavior, facilitating preventive maintenance measures and enhancing fleet management (Sanghavi, 2024). Real-time monitoring of vehicle location, cargo status, and environmental conditions can facilitate better stakeholder coordination, minimize transportation risks, and ensure regulatory compliance. According to Rai et al. (2023), the integration of AI and IoT technologies with field surveys offers benefits such as reduced transportation costs, improved asset utilization, enhanced safety and security, and faster project delivery.

xvi. Building code familiarization is not a hectic job.

The criterion "S16" was ranked 22nd by the experts with a mean of 3.38 and standard deviation of 0.97. It was considered important by 83% of the experts.

Research suggests that building code familiarization in the Indian construction industry may not be a significant barrier to project execution. Indian building codes are simpler and easier to understand, reducing the perceived difficulty of familiarization. Indian construction professionals often have experience working within the regulatory framework established by building codes, which may contribute to a more streamlined process for code compliance (Sapatnekar et al., 2018). Advancements in technology and increased accessibility to information resources have made it easier for stakeholders to access and interpret building codes. However, compliance with building codes remains crucial for ensuring safety, quality, and sustainability of construction projects. Therefore, continued efforts to educate and train construction professionals on building code compliance are essential for maintaining high standards of construction quality and safety (RREN, 2023).

xvii. Due to bidding-based selection, main contractors can maintain transient relationships between suppliers and main contractors.

The criterion "S17" was ranked 13th by the experts with a mean of 3.71 and standard deviation of 0.62. It was considered important by 100% of the experts.

The Indian construction industry often experiences transient relationships between suppliers and main contractors due to bidding-based selection processes. The competitive nature of bidding often results in frequent changes in supplier contracts, as main contractors seek favourable terms for each project. This results in limited collaboration and loyalty between parties, leading to different suppliers for each project. Transient supplier relationships can impact project continuity and quality, leading to inconsistencies in material availability, pricing, and quality (Davies, 2024). They also hinder opportunities for innovation and value creation within construction projects. To address these challenges, a shift towards more collaborative procurement approaches and strategic supplier management practices may be necessary. Both Indian construction practices and research literature acknowledge the prevalence of these relationships (Doloi et al., 2017).

xviii. Main contractors recommend fostering teamwork, which will help with faster completion at a budgeted cost.

The criterion "S18" was ranked 15th by the experts with a mean of 3.63 and standard deviation of 0.77. It was considered important by 91% of the experts.

In the Indian construction industry, teamwork is a key factor in achieving faster project completion within budgeted costs. Research shows that effective teamwork leads to improved communication, coordination, and resource allocation, which are essential for project success. This culture of collaboration enhances efficiency and productivity, facilitating smoother project execution and timely delivery (Yap et al., 2020). According to Ali et al. (2020), teamwork also helps mitigate project risks and address challenges, encouraging proactive problem-solving and decision-making. It also fosters innovation and creativity, allowing for the exchange of ideas and expertise among team members, leading to novel solutions and improved project outcomes. Both Indian construction practitioners and research literature recognize the importance of teamwork in driving project efficiency, innovation, and success (Bhoda, 2023).

xix. A strong and visible transit network can increase market size.

The criterion "S19" was ranked 5th by the experts with a mean of 4.04 and standard deviation of 0.62. It was considered important by 100% of the experts.

Research in India reveals the importance of a robust and easily accessible transit network in the construction sector (Rawal et al., 2014). A well-connected transit system, including roads, railways, ports, and airports, enhances market accessibility, stimulates trade and commerce, and encourages investment in construction projects. This connectivity also contributes to the development of new markets and business hubs, driving demand for real estate and construction services (Foster et al., 2023). A visible and efficient transit network also serves as a catalyst for urban development and infrastructure investment, attracting developers and investors to capitalize on prime locations. Overall, a strong and visible transit network is crucial for augmenting market size, fostering economic vibrancy, and spurring construction development in India.

xx. Construction industry in India works in a very fragmented format

The criterion "S20" was ranked 7th by the experts with a mean of 3.96 and standard deviation of 0.86. It was considered important by 95% of the experts.

As per Ansari and Karthik (2022), the Indian construction sector exhibits a high degree of fragmentation, characterized by the presence of numerous small and medium-sized enterprises, contractors, subcontractors, and informal workers. This fragmentation leads to challenges in project coordination, communication gaps, and inefficiencies in resource allocation and utilization (Prabaharan and Shanmugapriya, 2023). It also poses obstacles to implementing sustainable practices and green supply chain management (GSCM) initiatives. However, research suggests that addressing fragmentation through collaborative efforts, capacity-building programs, and technology adoption can enhance the efficiency and sustainability of the industry. Initiatives such as promoting digital platforms for project management, fostering partnerships, and providing training on sustainable construction practices can streamline operations and drive the adoption of GSCM principles (Dharmayanti et al., 2023). By recognizing the unique characteristics of the sector and leveraging targeted interventions, stakeholders can work towards a more cohesive, efficient, and sustainable construction ecosystem in India.

xxi. Recycling waste for optimization of resources secures the overall project cost.

The criterion "S21" was ranked 14th by the experts with a mean of 3.71 and standard deviation of 0.91. It was considered important by 87% of the experts.

Recycling waste in the Indian construction industry is becoming increasingly popular as a cost-saving and sustainable practice. This practice reduces the need for virgin resources, lowers procurement costs, and minimizes waste disposal expenses. It also conserves energy and reduces greenhouse gas emissions associated with resource extraction and manufacturing processes. Encouraging waste recycling aligns with the principles of a circular economy, prolonging the usefulness of materials and mitigating resource depletion. Innovative techniques like onsite crushing and grinding of concrete debris can enhance resource efficiency, reduce dependency on finite resources, and mitigate environmental impacts (Abera, 2023). In the Indian construction industry, adopting recycling practices offers a solution to both economic and sustainability challenges. According to Fiksel et al. (2021), by integrating waste recycling into project planning and execution, construction companies can achieve cost savings, enhance project resilience, and demonstrate environmental stewardship, contributing to India's transition towards a more circular and sustainable construction sector.

xxii. The promotion of less embodied energy for construction materials is a sustainability criterion.

The criterion "S22" was ranked 8th by the experts with a mean of 3.88 and standard deviation of 0.68. It was considered important by 100% of the experts.

The Indian construction industry is focusing on promoting materials with lower embodied energy to mitigate environmental impacts and enhance project sustainability. High embodied energy materials, such as those derived from fossil fuels, contribute significantly to carbon emissions, resource depletion, and environmental degradation. According to Arenas and Shafique (2024), prioritizing materials with lower embodied energy content can minimize carbon footprints, conserve natural resources, and reduce dependence on non-renewable energy sources. This aligns with India's commitment to sustainable development and transitioning towards a greener, more resilient built environment (Sharma, 2018). Integrating sustainability considerations into material

procurement, design, and construction practices can lead to the adoption of alternative materials with lower environmental impacts, improved building performance, energy efficiency, and occupant comfort.

xxiii. India faces uncertainty in waste quantity estimation due to ineffective Waste management practices and multitudinous authority.

The criterion "S23" was ranked 1st by the experts with a mean of 4.21 and standard deviation of 0.78. It was considered important by 95% of the experts.

The Indian construction industry faces significant challenges in waste management due to ineffective practices and fragmented authority structures. Accurate waste estimation is difficult due to inconsistent data collection methods, inadequate reporting mechanisms, and decentralized waste management systems. The decentralized approach of multiple agencies and departments complicates waste management efforts (Singh, 2020). According to Ramakrishna (2023), to address these issues, a holistic approach integrating waste management into construction projects' planning, design, and execution phases is needed. Standardized waste tracking and reporting protocols can improve data accuracy and waste quantity estimation. Collaboration among government agencies, local authorities, construction firms, and waste management providers is crucial for developing comprehensive waste management strategies (Prema, 2021). Investing in technology and innovation, such as digital waste tracking systems and onsite recycling facilities, can also enhance waste management practices.

xxiv. We are lacking developed markets for green and recycled products at attractive price.

The criterion "S24" was ranked 2nd by the experts with a mean of 4.21 and standard deviation of 0.72. It was considered important by 100% of the experts.

According to Dey et al. (2022), the Indian construction industry faces challenges in attracting green and recycled products at attractive prices, despite growing awareness of sustainable practices. Factors such as limited demand, supply chain inefficiencies, and cost disparities between green and conventional materials contribute to this issue. The lack of standardized certifications and quality assurance mechanisms further complicates market development. To address these issues, government agencies, industry stakeholders, and

policymakers must create an enabling environment for green and recycled product markets (Agrawal et al., 2023). This includes incentivizing sustainable materials through tax incentives, subsidies, and procurement policies. Raising awareness among construction professionals, developers, and end-users is also crucial for stimulating demand and driving market growth (Boffo and Patalano, 2020). Collaborative initiatives between industry associations, research institutions, and government bodies can promote knowledge sharing, innovation, and market development for sustainable construction materials.

xxv. The better way to address supply chain interruption (transportation) in GSCM was discovered to be yard logistics.

The criterion "S25" was ranked 19th by the experts with a mean of 3.50 and standard deviation of 0.66. It was considered important by 95% of the experts.

According to Babu (2023), Yard logistics is a crucial strategy in the Indian construction industry to address supply chain disruptions, particularly in transportation. This approach, which involves optimizing material handling and storage, can reduce delays, increase costs, and cause project disruptions. By implementing Just-in-Time delivery systems and organizing material storage areas, construction companies can improve supply chain efficiency. Yard logistics also facilitates better coordination between suppliers, subcontractors, and construction teams, reducing idle time and inventory holding costs. It also aligns with the industry's sustainability efforts by minimizing carbon emissions associated with transportation activities (Hussein and Zayed, 2021). By optimizing transportation routes and reducing frequent material deliveries, yard logistics can lower the environmental footprint and improve operational resilience.

xxvi. Transportation is mostly reliant on procurement strategy and has control over waste management and reduction.

The criterion "S26" was ranked 23rd by the experts with a mean of 3.29 and standard deviation of 0.95. It was considered important by 79% of the experts.

Transportation in Indian construction projects is crucial for the smooth flow of materials and resources. Procurement strategies dictate the sourcing and acquisition of materials, affecting transportation requirements and logistics. Sustainable procurement practices, such as local sourcing, bulk purchasing, and efficient logistics, can minimize the need for

extensive transportation and reduce costs and environmental impacts (Luther, 2021). Efficient transportation can optimize material delivery routes, reduce transit times, and minimize material wastage. According to Hmamed et al. (2023), inefficient transportation can lead to delays, disruptions, and increased material losses, affecting waste management efforts. Incorporating waste management considerations into transportation planning can help mitigate these challenges. Nolz (2021) pointed out that strategies like just-in-time delivery methods, recycling programs, and optimizing vehicle loading capacities can enhance transportation efficiency while reducing waste generation.

xxvii. The GSCM guarantees minimum material loss during transportation.

The criterion "S27" was ranked 12th by the experts with a mean of 3.75 and standard deviation of 0.99. It was considered important by 95% of the experts.

Green Supply Chain Management (GSCM) is a crucial approach in the Indian construction industry to reduce material loss during transportation, thereby improving efficiency and sustainability. Inefficient transportation practices can lead to significant material losses, increased project costs, and environmental impact. In India, large-scale material transportation is common, making optimization of logistics crucial. GSCM practices include route optimization, proper packaging, and eco-friendly transportation modes. Technologies like GPS tracking and real-time monitoring systems can enhance visibility and control over transportation processes. Promoting recycled or locally sourced materials can also reduce material loss. According to Saada (2021), GSCM is a valuable framework for efficient and sustainable material transportation practices, enhancing operational efficiency, environmental conservation, and cost savings.

B. POLICY criteria

xxviii. Policy change can accelerate the green transformation of traditional supply chains.

The criterion "P1" was ranked 2nd by the experts with a mean of 4.13 and standard deviation of 0.68. It was considered important by 100% of the experts.

Policy change plays a crucial role in the green transformation of traditional supply chains in the Indian construction industry. Regulatory compliance, market incentives, stakeholder collaboration, and technology adoption are key factors in promoting sustainable practices.

These changes can be influenced by building codes, environmental regulations, and sustainability standards, which mandate eco-friendly materials, energy-efficient technologies, and waste management protocols. According to Chan et al. (2017), market incentives, such as tax incentives and financial support, stimulate demand for sustainable construction solutions, reducing financial barriers and incentivizing investment in green infrastructure projects. Stakeholder collaboration is also essential, as policy changes often involve multi-stakeholder consultations to shape regulatory frameworks and sustainability strategies. Technology adoption is also a key factor, as policy reforms encourage the integration of smart building systems, renewable energy technologies, and digital platforms for real-time monitoring and optimization of resource use. Institutional support ensures accountability, transparency, and continuous improvement in sustainable construction practices, contributing to India's sustainable development goals and aspirations for a greener built environment (Fallah Shayan et al., 2022).

xxix. A project can be managed effectively if the activities of independent organizations are integrated using SCM principles.

The criterion "P2" was ranked 3rd by the experts with a mean of 4.13 and standard deviation of 0.61. It was considered important by 100% of the experts.

According to Battula et al. (20220), research in the Indian construction sector highlights the importance of Supply Chain Management (SCM) principles in enhancing project management effectiveness. SCM principles streamline processes, coordinate activities, and optimize resources across different organizations, reducing delays, cost overruns, and resource wastage. They also enhance risk identification, mitigation, and contingency planning, promoting transparency, accountability, and proactive risk management strategies (Mehmood eta l., 2024). SCM principles prioritize quality control, standards compliance, and performance monitoring across the supply chain, ensuring consistency, reliability, and accountability in project deliverables. Effective SCM fosters closer relationships among stakeholders, promoting open communication and shared goals. SCM also integrates sustainability considerations into project management practices, minimizing environmental impact, promoting social responsibility, and optimizing resource utilization (Negri et al., 2021). By adopting an integrated SCM approach, construction organizations can unlock operational efficiencies, mitigate risks, and deliver

projects that meet stakeholder expectations while contributing to India's socio-economic and environmental objectives.

xxx. Do you think procurement policies can have a major impact on the other four supply chain elements? [Design, transportation, operation, and waste management]

The criterion "P3" was ranked 5th by the experts with a mean of 3.92 and standard deviation of 1.02. It was considered important by 91% of the experts.

Procurement policies are crucial in the Indian construction sector, influencing the design, transportation, operation, and waste management of the entire supply chain. They influence the selection of architects, engineers, and consultants, promoting green building practices and sustainable materials (Saferi et al., 2018). They also influence the selection of suppliers, vendors, and contractors for transportation, ensuring sustainability and cost-effectiveness. They also influence the procurement of equipment, machinery, and technology used in construction operations, prioritizing reliability, durability, and lifecycle costs (Harouache et al., 2024). They also govern the selection of suppliers and contractors for waste disposal, recycling, and remediation activities. Research literature highlights the interconnectedness of procurement policies with other supply chain elements, emphasizing how strategic decisions can have significant implications on project outcomes, stakeholder relationships, and sustainability objectives. According to Kotabe and Murray (2004), aligning procurement policies with broader supply chain goals can create value, mitigate risks, and improve project delivery and environmental stewardship.

xxxi. A better procurement policy needs effective software integration to attain sustainability.

The criterion "P4" was ranked 6th by the experts with a mean of 3.92 and standard deviation of 0.88. It was considered important by 95% of the experts.

The Indian construction sector is increasingly focusing on integrating procurement policies with software integration to achieve sustainability goals. This integration can improve efficiency by automating manual tasks, streamlining workflows, and reducing paperwork. This leads to time savings, cost reductions, and improved resource utilization. According to Chakrabarti (2023), software integration promotes transparency and

accountability by enabling real-time tracking and monitoring of procurement activities, enhancing decision-making and detecting potential compliance issues. It also facilitates sustainable sourcing practices by evaluating suppliers based on environmental, social, and ethical criteria. It also strengthens risk management capabilities by providing early warning signals for potential procurement-related risks. Karttunen et al. (2023) pointed out that, software-enabled data analytics drive continuous improvement across procurement processes, identifying opportunities for optimization and innovation. This strategic alignment with research-backed best practices highlights the importance of technology-enabled procurement management for achieving sustainable development goals and maintaining industry competitiveness (Sievo, 2023).

xxxii. Do you think current procurement policies are sufficient to meet evaluation and contract requirements in procurement?

The criterion "P5" was ranked 10th by the experts with a mean of 2.58 and standard deviation of 0.8. It was considered important by 62% of the experts (negative question).

According to Choudhary et al. (2021), Indian construction industry faces challenges in meeting evaluation and contract requirements due to various factors. These include the complexity of projects, lack of standardization in procurement practices, limited use of technology, compliance challenges, and evolving stakeholder expectations (Bello et al., 2021). Projects in India often involve diverse stakeholders, complex contractual arrangements, and unique requirements, leading to gaps in evaluation criteria and contract provisions. The lack of standardized procurement practices can result in inconsistencies in evaluation methods, contract terms, and performance metrics, making it difficult to ensure fairness and transparency (Larsen, 2010). Additionally, the lack of technology integration can lead to inefficiencies and delays in procurement processes. Compliance challenges, such as corruption, bid rigging, and favoritism, can undermine the integrity of evaluation processes and contract awards. To address these challenges, policymakers and industry stakeholders should adopt best practices in procurement management and leverage research literature to improve the effectiveness, fairness, and sustainability of procurement processes in the Indian construction context.

xxxiii. Do you wish to revise existing policies to manage invoice approval and disputes in procurement?

The criterion "P6" was ranked 7th by the experts with a mean of 3.58 and standard deviation of 0.72. It was considered important by 91% of the experts.

According to Raj et al. (2022), revising existing procurement policies in the Indian construction sector is crucial for improving efficiency, cost control, vendor relationships, compliance, and stakeholder satisfaction. This is due to the lack of clear guidelines and standardized procedures for invoice approval and dispute resolution, which can lead to delays and inefficiencies. Revising these policies can streamline the process, minimize delays, and improve overall procurement efficiency. Cost control can be achieved by controlling costs and preventing revenue leakage. Revising procurement policies that prioritize timely invoice processing and fair dispute resolution can foster positive vendor relationships, enhance supplier satisfaction, and promote supplier performance (Eriksson and Westerberg, 2009). Compliance and governance can be strengthened by incorporating best practices in invoice management. Stakeholder satisfaction can be enhanced by timely and accurate invoice approval processes, improving project outcomes and maintaining a positive reputation in the industry (Malacina et al., 2022).

xxxiv. Do you consider procurement policies to be at the top among other laws that comply with supply chain elements?

The criterion "P7" was ranked 8th by the experts with a mean of 3.46 and standard deviation of 0.83. It was considered important by 87% of the experts.

Procurement policies are crucial in the Indian construction industry for their significant influence on project outcomes, cost efficiency, and stakeholder relationships. They directly affect project costs, ensuring budget management and cost control. According to Beth (2007), procurement policies also govern supplier selection, impacting the quality, reliability, and timeliness of materials and services. They address risk management by establishing clear guidelines for contract terms, insurance requirements, and dispute resolution mechanisms. They ensure compliance with regulatory frameworks, industry standards, and ethical practices, promoting transparency and accountability in supplier selection and contracting processes (Overvest et al., 2024). Additionally, procurement policies facilitate stakeholder engagement by establishing communication channels,

feedback mechanisms, and performance evaluation criteria. Thus, procurement policies play a pivotal role in shaping supply chain dynamics, project outcomes, and stakeholder relationships in the Indian construction industry.

xxxv. Logistics services in construction require modifications to transportation law, as pollution is closely linked to transportation.

The criterion "P8" was ranked 4th by the experts with a mean of 4.13 and standard deviation of 0.54. It was considered important by 100% of the experts.

Research in India highlights the need for changes to transportation laws to address pollution concerns in the construction sector. Transportation plays a crucial role in the movement of materials, equipment, and personnel, but inadequate regulation has led to increased pollution levels, especially in urban areas (Ravi et al., 2023). Transportation-related emissions contribute to air pollution, affecting public health, environmental quality, and urban livability (Mumtaz et al., 2023). To tackle these issues, researchers suggest amendments to transportation laws and regulations that promote cleaner and more sustainable practices. These could include stricter emission standards for vehicles, fuel efficiency, congestion management, eco-friendly transport modes, green logistics practices, and regulatory compliance (Hertasning et al., 2024). By implementing these modifications, India can mitigate the environmental impact of construction logistics, promote sustainable development, and improve public health outcomes.

xxxvi. All building bylaws are tightly packed in India to safeguard the environment and workforce.

The criterion "P9" was ranked 9th by the experts with a mean of 2.88 and standard deviation of 0.9. It was considered important by 66% of the experts.

Research highlights the importance of building bylaws in India's construction industry, which regulate construction activities to ensure environmental sustainability and worker safety. These bylaws cover aspects like building design, materials usage, waste management, and worker welfare. They aim to minimize the environmental impact of construction projects by prescribing sustainable practices like energy-efficient designs and waste reduction strategies (Akanni et al., 2015). They also prioritize the safety and well-being of construction workers by establishing occupational health and safety standards.

Strict enforcement of bylaws is crucial for achieving environmental and social objectives. Regular monitoring, inspections, and penalties for non-compliance are also essential. Building bylaws need to evolve to address emerging environmental challenges and technological advancements, and they should be reviewed and revised periodically to incorporate innovative solutions and promote green building practices (Liu et al., 2022).

xxxvii. India needs to update its green building regulations in response to the construction industry's sharp and rapid increase in air pollution.

The criterion "P10" was ranked 1st by the experts with a mean of 4.42 and standard deviation of 0.72. It was considered important by 100% of the experts.

The Indian construction industry is a major contributor to air pollution due to rapid urbanization and industrial growth. High levels of dust and particulate matter, inadequate waste management, and polluting materials exacerbate environmental degradation and health hazards. According to Vierra (2016), updating green building regulations is crucial to address these challenges and mitigate the environmental impact of construction activities. By incorporating stringent air quality standards, emission controls, and sustainable construction practices, policymakers can promote cleaner technologies and materials. Additionally, updated regulations can incentivize the adoption of renewable energy sources like solar power and green building certifications like LEED and IGBC ratings. Additionally, the incorporation of green infrastructure elements such as green roofs, permeable pavements, and urban forests can mitigate air pollution, alleviate heat island effects, and promote biodiversity (Gupta and De, 2024).

C. CFW criteria

xxxviii. A better legal framework improves inventory visibility.

The criterion "F1" was ranked 5th by the experts with a mean of 3.88 and standard deviation of 0.68. It was considered important by 95% of the experts.

The Indian construction industry is leveraging a robust legal framework to improve inventory visibility and supply chain operations. This is crucial for timely material availability, minimizing stockouts, and preventing overstocking, which can lead to cost overruns and delays (Sharma, 2023). A well-defined legal framework provides clarity on property rights, contract terms, and liability, reducing disputes and uncertainties related to

material ownership and procurement (Glover, 2008). It also facilitates the implementation of inventory management systems and technologies, such as barcode scanning, RFID tagging, and real-time tracking, enhancing visibility into inventory levels and location. Compliance with these standards incentivizes construction companies to invest in digital solutions, leading to better decision-making and resource optimization (Ebekozien and Samsurijan, 2022). The legal framework also fosters trust and collaboration among supply chain partners, encouraging information sharing and joint problem-solving initiatives. This, in turn, optimizes supply chain operations, reduces costs, and delivers projects more efficiently.

xxxix. A conceptual framework promotes supplier diversity, legitimizes process flaws, and can satisfy multiple clients with a well-accepted design, overcoming temporary stakeholder relationships.

The criterion "F2" was ranked 6th by the experts with a mean of 3.83 and standard deviation of 0.7. It was considered important by 100% of the experts.

Conceptual frameworks are crucial in the Indian construction industry for promoting supplier diversity, legitimizing process flaws, and satisfying multiple clients through well-accepted designs. They help mitigate risks associated with dependency on a single supplier and enhance resilience against supply chain disruptions. These frameworks provide guidelines for assessing supplier capabilities, evaluating performance, and fostering collaborative relationships. They also help manage process flaws in construction projects by identifying, analyzing, and addressing weaknesses in workflows, communication channels, and decision-making processes. By legitimizing process flaws as opportunities for improvement, conceptual frameworks empower stakeholders to implement corrective actions and drive continuous improvement throughout the project lifecycle (Ma et al., 2018). They also enable the development of well-accepted designs that meet the diverse needs and expectations of clients, stakeholders, and end-users, fostering long-term relationships and repeat business in the competitive Indian construction market (Agrawal and Rahman, 2015). Overall, conceptual frameworks play a vital role in overcoming challenges in the Indian construction industry.

xl. Conceptual frameworks offer better solutions for flaws in planning and scheduling.

The criterion "F3" was ranked 7th by the experts with a mean of 3.79 and standard deviation of 0.72. It was considered important by 95% of the experts.

Research highlights the importance of conceptual frameworks in the Indian construction industry for addressing planning and scheduling shortcomings. Traditional methods often fail to anticipate and mitigate issues like delays, cost overruns, and inefficient resource utilization. Conceptual frameworks, such as Building Information Modeling (BIM), Lean Construction, and Integrated Project Delivery (IPD), offer a structured approach to identifying project requirements, defining objectives, allocating resources, and sequencing activities (El Mounla et al., 2023). These frameworks promote collaborative decision-making, information sharing, and continuous improvement, enhancing efficiency and productivity throughout the project lifecycle. In the Indian construction industry, where projects face regulatory environments, resource constraints, and logistical challenges, conceptual frameworks can overcome these deficiencies (Choudhary et al., 2021). By integrating advanced technologies, data-driven methodologies, and interdisciplinary approaches, stakeholders can anticipate, adapt to, and mitigate uncertainties, ultimately improving project outcomes and driving industry innovation.

xli. Risk management is easier when moving on with a legal framework.

The criterion "F4" was ranked 4th by the experts with a mean of 3.92 and standard deviation of 0.97. It was considered important by 87% of the experts.

Research highlights the importance of a robust legal framework in the Indian construction industry for effective risk management. A well-defined legal framework helps construction companies identify, assess, mitigate, and manage risks throughout the project lifecycle. Adhering to established legal requirements minimizes legal disputes, regulatory violations, and financial liabilities. It also ensures accountability, transparency, and fairness in contractual agreements, project procurement, and dispute resolution processes (Son, 2012). Comprehensive construction laws and regulations lead to fewer project delays, cost overruns, and disputes. In India, where the industry faces diverse regulatory frameworks, adherence to legal norms is crucial for promoting stability and predictability

in project delivery (Doloi et al., 2017). A robust legal framework enables companies to proactively address emerging risks related to environmental sustainability, health and safety, labor practices, and community engagement. According to Banaitiene and Banaitis (2012), aligning risk management practices with a well-defined legal framework is essential for navigating the complex operating environment of the Indian construction industry.

xlii. Better logistical planning and tight security characterize GSCM.

The criterion "F5" was ranked 8th by the experts with a mean of 3.71 and standard deviation of 0.69. It was considered important by 95% of the experts.

Research in India emphasizes the importance of better logistical planning and tight security in Green Supply Chain Management (GSCM). These strategies optimize resource utilization, reduce delays, and enhance project efficiency. They also protect construction sites from theft, vandalism, and unauthorized access. Advanced technology solutions like GPS tracking systems can enhance security measures (Raman et al., 2023). These strategies contribute to the success of GSCM initiatives by promoting efficiency, reliability, and sustainability across the supply chain. By prioritizing these aspects and adopting proactive measures, construction companies can optimize operations, mitigate risks, and achieve sustainable growth in a competitive environment.

xliii. A better conceptual framework enhances the safety and reliability of the construction process by allowing for detailed discussions with the client.

The criterion denoted as "F6" was rated as the top priority by the experts, achieving a mean score of 4.04 and a standard deviation of 0.62. This criterion was unanimously regarded as important by all experts.

Research shows that a well-structured conceptual framework is crucial in enhancing safety and reliability in the Indian construction sector. This framework facilitates detailed discussions with clients about their requirements, preferences, and expectations, allowing for proactive identification of safety hazards and risks (Hire et al., 2024). Early consultations lead to better project planning, design, and execution, aligning strategies with client expectations. In the Indian construction sector, where projects involve diverse stakeholders and complex requirements, effective client engagement is essential (Prabhu,

2016). Fostering collaborative relationships and soliciting client input throughout the project lifecycle ensures safety and reliability considerations are integrated. Client involvement in safety and reliability discussions leads to increased accountability and transparency, building trust and confidence between construction companies and clients (Lingard et al., 2020). Therefore, a better conceptual framework is essential for delivering projects that meet or exceed client expectations while maintaining the highest standards of safety and reliability.

xliv. The construction process becomes safe and reliable with a better conceptual framework.

The criterion labeled "F7" attained the second rank among the experts, with a mean score of 4.04 and a standard deviation of 0.55. This criterion was unanimously deemed important by all experts.

According to Thomas et al. (2023), research in India emphasizes the importance of a well-defined conceptual framework in the construction industry. A robust framework provides a structured approach to planning, execution, and management, enhancing safety and reliability. It helps stakeholders anticipate risks, mitigate hazards, and implement effective control measures. Adopting a comprehensive conceptual framework leads to improved project outcomes, reduced accidents and injuries, and enhanced construction quality. It serves as a guiding framework for all stakeholders, from project managers to workers and subcontractors (Sev, 2009). A robust conceptual framework fosters a culture of safety and reliability within the industry, promoting continuous improvement and innovation. By adhering to best practices and industry standards, construction companies can build a reputation for delivering safe, high-quality projects.

xlv. The absence of a post-monitoring mechanism causes a delay in the construction industry's sustainable integration cycle.

The criterion "F8" was ranked 3rd by the experts with a mean of 4.00 and standard deviation of 0.66. It was considered important by 100% of the experts.

Research highlights the importance of post-monitoring mechanisms in the Indian construction industry for sustainable integration. Without a robust mechanism, the integration of green building practices and sustainability initiatives can be delayed.

According to Rey et al. (2022) post-monitoring helps assess the long-term impact of sustainability initiatives, identify areas for improvement, and ensure compliance with standards. In the Indian construction sector, rapid urbanization and infrastructure development drive increased construction activities (Rani, 2021). Implementing sustainable practices is essential to mitigate environmental impacts and promote resource efficiency. However, without a post-monitoring mechanism, the effectiveness of these measures may diminish, leading to missed opportunities for improvement and potential environmental degradation (Lundberg, 2009). Establishing a comprehensive post-monitoring mechanism is crucial for sustaining the benefits of green construction practices in the Indian context.

5.3.4. Case study # 2

The study examines the successful implementation of COVID-19 policies in the Indian construction sector, highlighting the importance of considering environmental impact and the potential of a green framework for sustainable construction. The COVID-19 pandemic has significantly impacted the construction sector, revealing potential threats and resisters. A systematic literature survey and questionnaires were used to understand the green transformation of the Indian construction industry during and after the pandemic. 36 competitive factors were identified from 75 impactful cases, filtered based on their contribution to traditional supply chains and organized into seven categories during the pandemic. The study aims to help Indian construction organizations overcome the overwhelm of the pandemic and adopt green transformation strategies. A pilot study of semi-structured interviews and industry people conversations was carried out to verify the options chosen during the pandemic. A set of trends was jotted down and categorised into two main groups: trends that suggest a direct move towards a greener supply chain (positive trends) and trends that pose a greener business risk (conservative trends) [**Table** 5.11]. A multiple-choice questionnaire was created in light of the pilot study's findings, and 30 variables or factors were created in consideration of the replies (**Table** 5.12). The next phase of the research will focus on greening the 17 challenges through an appropriate framework, contributing to the strategic plan for sustainable construction with zero pollutant discharge. The study validated thirty green transition scenarios for the Indian construction sector during COVID-19 and post-COVID seasons, validating them with 60 trials from six professionals from the construction sector. A questionnaire survey

was conducted between May 15 and Jume 20, 2023, targeting various construction network/ecosystem in Kerala. The aim of this study is a quest towards pollution-free industrialization, particularly in the construction industry. Traditional supply chains present numerous risk elements, with project cost and information transparency being the most critical. COVID-19 has forced companies to find new pathways to keep their businesses alive, and all adoptions have been found to be ecologically sound. Virtual platforms have made enterprise resource planning, better yard logistics, and remote working possible.

Table 5.11: Favorable Trends for Green Supply Chains Amidst the Pandemic

Progressive trends (covid scenario) (T)	**Conservative trends (covid scenario) (T)**
2. No full stoppage of business [T_1,T_2,T_3]	1. Decline in business [T_3, T_{17}, T_{25}]
3. Market shut is managed via remote operations [T_4]	2. A lack of ERP causing a company to shut the business [T_4, T_{26}]
4. Virtual practices pause pollution [T_5]	3. Less social interactions [T_{27},T_{28}]
5. Less traffic curb [T_6,T_7]	4. Low information transparency [T_{21},T_{29}]
6. Controlled consumption [T_8]	5. Supply chain disruptions [T_{30}]
7. Resource planning [T_9]	6. High transportation cost [T_{31}]
8. Optimum utilization [T_8,T_{10}]	7. Broken CSR [T_{32}]
9. Demand for Skilled manpower [T_{11}]	8. Restrictive corporate policies [T_{33}]
10. Quest for alternatives [T_{12}]	9. Profit oriented supply chains [T_{34}]
11. Government interventions with legislations and subsidies [T_{13}, T_{14}]	10. Uncertainty in return on investments [T_{35}]
12. Financial inclusions by financial institutions [T_{15}]	11. Closure of green markets [T_{36}]
13. Work from home/ remote platform [T_{16}, T_{17}]	12. Less affinity to GSCM [T_{37}]
14. Better yard logistics [T_{18}]	13. High unemployment rate [T_{38}]
15. Customization and customer ratings [T_{19}]	14. Financial recession [T_{39}]
16. Better reverse logistics [T_{20}]	15. Monopolization of resources [T_{40}]
17. Demands for local manufacturers and suppliers [T_{21}]	16. Compromise in quality [T_{17}]
18. Provisional supply chains [T_{22}]	17. Global market shrinkage [T_3, T_{17}, T_{25}]
19. Virtual coordination [T_{23}]	18. Health hazards and safety issues [T_{16}, T_{17}]
20. Urgency for safety environment [T_{16}]	
21. Liberalization of regulations [T_{24}]	19. Delay in project submission [T_{27},T_{41}]

T_1,T_2,T_3 [Ogunnusi, et al., 2020; Kawmudi, et al., 2020; Vithana, et al., 2020]; **T_4** [Alenezi, 2020c]; **T_5** [Awasthi et al., 2022]; **T_6,T_7** [Ghosh et al.,2020; Goel et al., 2021]; **T_8** [Fapohunda and Chileshe, 2014]; **T_9** [Tarigan et al., 2021]; **T_{10}** [Anam, 2023]; **T_{11}** [Araya, 2021]; **T_{12}** [Adetooto et al., 2022]; **T_{13}, T_{14}** [Assefa, 2023; Rani et al., 2022]; **T_{15}** [Alenezi, 2020b]; **T_{16},T_{17}** [Alsharef, et al., 2021; Oey and Lim, 2021]; **T_{18}** [Russell et al., 2020]; **T_{19}** [Ahadian and Abadi, 2012]; **T_{20}** [Wibowo et al., 2022]; **T_{21}** [Ghandour, 2021]; **T_{22}** [Chakuu et al., 2020]; **T_{23}** [Karmaker et al., 2021]; **T_{24}** [Borthwick et al., 2020]; **T_{25}** [Kawmudi, et al., 2020]; **T_{26}** [Vijayadas, 2022]; **T_{27}, T_{28}** [Gamil and Alhagar, 2020; Pathirana, 2020]; **T_{29}** [Alenezi, 2020a]; **T_{30}** [King, et al., 2021]; **T_{31}** [Osuizugbo, 2020]; **T_{32}** [He and Harris, 2020]; **T_{33}** [Mirza et al., 2020]; **T_{34}** [Sutterby et al., 2023]; **T_{35}** [Szczygielski et al., 2022]; **T_{36}** [Poursoltan et al., 2021]; **T_{37}** [Berrones-Flemmig et al., 2022]; **T_{38}** [Pamidimukkala and Kermanshachi, 2021]; **T_{39}** [Biswas et al., 2021]; **T_{40}** [Amien et al., 2023]; **T_{41}** [Zamani, et al., 2021]

The result of the study conducted through semi-structured interviews and questionnaire surveys revealed that companies have managed to survive despite negative trends like supply chain disruptions and resource monopolization. The R platform was used to analyze the results from the 5-point scale Likert analysis, which includes challenges and opportunities for GSCM. Four out of 13 factors (Q4, Q20, Q24, and Q27) have been confirmed as opportunities for sustainable or green practices. The pandemic has primarily favored green channelization in the technical category, with all five factors implying technical matters. The survey found that pollution load-bearing capability is minimal for these practices, making them sustainable or green. The continuation of these practices will have tremendous scope for greening the entire supply chain. 17 challenges need to be considered for a framework for the ultimate green solution. The preference for green channelization during the pandemic is mainly in the technical category, with all five factors implying technical matters.

The 3D circle plot (see **Figure** 5.9) is a useful tool for analyzing dominant elements and the impact of COVID on the industry. It displays the connections between 30 variables and components, with colors representing contribution levels. The variable correlation plot shows the relationships between each variable, with smaller angles having a high correlation and angles 90˚ maintaining a neutral stance. Principal component analysis (PCA) is a useful tool for analyzing interconnections among variables and pointing towards similar objectives. In the Indian construction industry, PCA is used to analyze supply chain disruptions, administrative measures, technical deficiencies, fiscal inclusions, regulatory surges, and logistic issues. The leading 14 variables were highly important (mean ≥4) to the Indian construction industry during the pandemic, according to the ranking criteria, which is solely based on contribution, regardless of whether they are opportunities or challenges (see **Table** 5.13).

The study validated thirty construction practices for green transformation in the Indian building sector, with 13 recognized and 17 environmentally beneficial (mean >3). Challenges remain in administrative, financial, and logistical categories. The study aims to identify significant factors favoring green transformation, with financial category having the most disagree components. A detailed analysis of opportunities and challenges within each category can help develop a transition framework. The logistic category has five components, with three being challenges and two being opportunities. The PCA highlights

Table 5.12: Variables and factors considered for pandemic impacts assessment on Indian construction industry and probabilities of sustainability

No.	Variables		Factor	mean	sd	cat_ Code
Q27	OPPORTUNITIES	Virtual risk assessment and the collaboration of sustainable projects	Virtual risk space	3.86667	1.0328	TM
Q18		Technological saturation to improve sustainability	I4.0 technologies (I4T)	3.63333	0.88234	TM
Q2		Aid of AI in workforce management, material management, and safety management	Generative AI	3.6	0.55845	TM
Q30		Updating enterprise resource planning with AI and IoT	Enterprise Resource planning	3.56667	0.81025	TM
Q17		Lack of communication between parties	Info-transparency	3.23333	0.81025	TM
Q7		green adoption of permanent changes in the operational path	Sustainability	3.4	0.88681	AM
Q14		ongoing repairs to disrupted supply chains	Scheduling	3.23333	1.06352	AM
Q24		Demands for local manufacturers and suppliers	Local procurement	4.3	0.53043	LM
Q12		High demands for GSC in the post-COVID construction industry	GSCM	3.53333	0.76947	LM
Q25		Support from financial institutions during COVID-19	Financial Support	3.46667	0.96492	FM
Q20		Unstable cash flow and revenue, and a lack of funding	Liquidity crisis	3.23333	1.21246	FM
Q26		Frameworks to overcome similar kind of pandemics	Framework/strategy	3.76667	0.72174	RM
Q4		sustainable government measures in the construction sector	Policies & Regulations	3.43333	1.15519	RM
Q3	CHALLENGES	Supply chain disruption, technological shortfalls, and defunct risk management	Supply chain disruption	2.33333	0.87656	AM
Q11		Organisation is completely out of the risk (COVID-19)	Work-flow	2.63333	1.05713	AM
Q16		Workforce shortfall, transportation difficulties, and PMS operations	PMS	2.40000	0.71781	AM
Q10		Corporate reasons and suspension of work during COVID-19	Corporate matters	2.70000	0.69624	AM
Q5		Serious COVID-19 impacts on construction supply chain operations	Operational hazard	1.93333	0.86095	AM
Q9		Limits on virtual platforms	Technical defunct	2.26667	0.89947	AM
Q23		Sustainability Challenges of future projects	Project risk	2.10000	0.65613	AM
Q6		Impeccable challenges to the project meetings the targeted objectives	Scope creep	2.30000	0.53043	AM
Q8		Government aid during the pandemic	Govt support	2.86667	1.06511	FM
Q1		Persistence of cost overruns after the pandemic in the construction sector	Cost overruns	2.03333	0.84305	FM
Q28		Local government’s financial inflexibility	Subsidies	2.00000	0.78113	FM
Q19		The increase in the project's cost (matter of sustainability)	Green cost	1.93333	0.68561	FM
Q29		Monopolisation of resources and constraints on prolonged storage	Yard logistics	2.50000	0.96551	LM
Q13		Resource availability and project's scheduling and planning	Resource Scarcity	2.10000	0.70591	LM
Q15		Alternative materials: procurement and delivery	Effective procurement strategy	2.83333	0.94181	LM
Q21		An increase in claims, disputes, and litigations in post-COVID business	Litigation strategy	3.00000	1.19320	RM
Q22		Effective transition to remote work	Hi-tech	2.40000	0.55845	TM

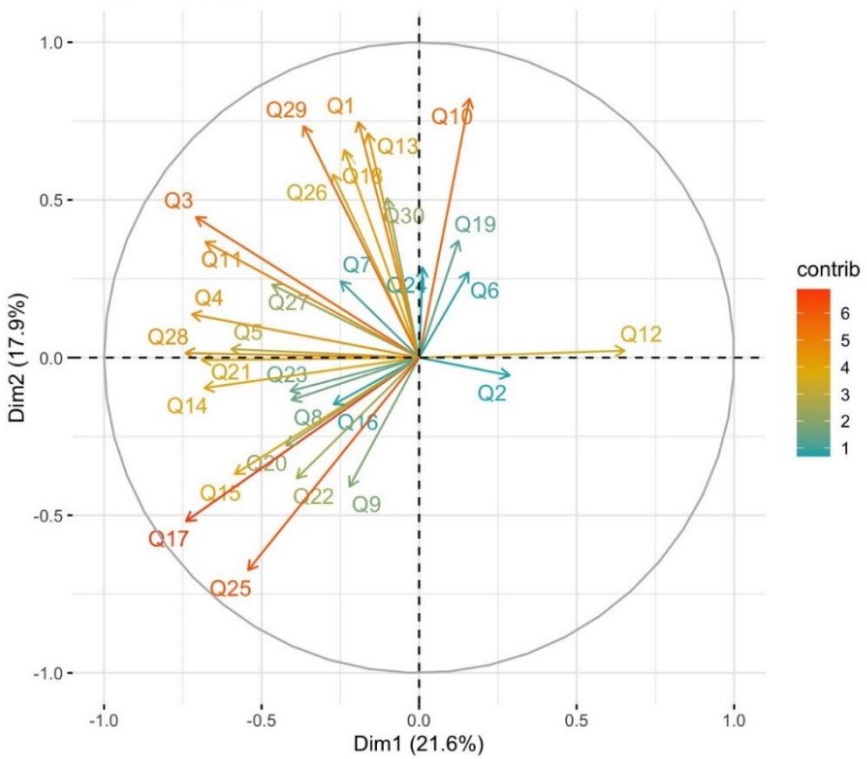


Figure 5.9: Heat Map Presenting the Correlation of Variables (Radial Variable Correlation Plot)

Table 5.13: Percentage Contribution And Ranking Based On Contributions Towards Green Shift

name	x	y	coord	cos2	contrib
Q1	-0.19264	0.746304	0.59408	0.59408	5.010305
Q2	0.287498	-0.05665	0.085864	0.085864	0.724155
Q3	-0.70806	0.445252	0.699596	0.699596	5.900198
Q4	-0.72072	0.137359	0.5383	0.5383	4.539874
Q5	-0.59611	0.02682	0.356071	0.356071	3.003007
Q6	0.156331	0.269729	0.097193	0.097193	0.819701
Q7	-0.24867	0.241939	0.120373	0.120373	1.015196
Q8	-0.40449	-0.13413	0.181602	0.181602	1.531579
Q9	-0.22111	-0.40914	0.216281	0.216281	1.824058
Q10	0.160049	0.820649	0.69908	0.69908	5.89585
Q11	-0.67833	0.366963	0.594795	0.594795	5.016333
Q12	0.652112	0.021974	0.425733	0.425733	3.590512
Q13	-0.16221	0.711313	0.532279	0.532279	4.489092
Q14	-0.68103	-0.09658	0.473137	0.473137	3.990306
Q15	-0.58492	-0.3696	0.478741	0.478741	4.037567
Q16	-0.27098	-0.14819	0.095388	0.095388	0.804475
Q17	-0.7397	-0.51883	0.816333	0.816333	6.884724
Q18	-0.23723	0.6583	0.489638	0.489638	4.129473
Q19	0.124797	0.370479	0.152829	0.152829	1.288917
Q20	-0.42189	-0.27827	0.25543	0.25543	2.154229
Q21	-0.69008	-0.00783	0.47627	0.47627	4.016731
Q22	-0.38837	-0.38286	0.297416	0.297416	2.508327
Q23	-0.40835	-0.10594	0.177971	0.177971	1.500955
Q24	0.010943	0.285638	0.081709	0.081709	0.689111
Q25	-0.54267	-0.67415	0.748976	0.748976	6.316658
Q26	-0.27363	0.580884	0.412301	0.412301	3.477235
Q27	-0.46637	0.230805	0.270773	0.270773	2.283623
Q28	-0.74168	0.014131	0.550292	0.550292	4.641011
Q29	-0.36685	0.733906	0.673198	0.673198	5.677564
Q30	-0.10128	0.505224	0.26551	0.26551	2.239236

name	Rank
Q17	**1**
Q25	**2**
Q3	**3**
Q10	**4**
Q29	**5**
Q11	**6**
Q1	**7**
Q28	**8**
Q4	**9**
Q13	**10**
Q18	**11**
Q15	**12**
Q21	**13**
Q14	**14**
Q12	**15**
Q26	**16**
Q5	**17**
Q22	**18**
Q27	**19**
Q30	**20**
Q20	**21**
Q9	**22**
Q8	**23**
Q23	**24**
Q19	**25**
Q7	**26**
Q6	**27**
Q16	**28**
Q2	**29**
Q24	**30**

the interrelations among all factors, making it crucial to consider opportunities when developing a green transformation framework.

A. Opportunity-factors

The COVID-19 pandemic has accelerated the adoption of sustainable practices in the construction industry, with virtual risk space, I4T technologies, and generative AI being key benefits. Modular construction can improve performance, reduce time, and eliminate waste, while AI is being used to improve project quality, worker safety, and efficiency. Enterprise resource planning (ERP) systems, integrated with IoT and AI, can automate key processes, manage complex systems, provide real-time visibility, and save money. Info-transparency has also been a key factor in the construction industry's adoption of digital transformation, with 66% of Indian companies prioritizing digital transformation for timely, cost-effective real estate project completion. Sustainability is prioritized in supply chains due to India's rapid urbanization, leading to increased electricity demand. Green supply chain management in the construction sector optimizes resource allocation, transportation, and environmental impact assessment, reducing waste and increasing production rates. Local procurement in circular or green supply chain construction offers benefits like reduced carbon footprint and lower transportation costs, but may not be feasible for all materials, especially specialized ones. Financial institutions play a crucial role in assisting companies in implementing green supply chain mechanisms, offering

specialized financing, risk assessment, green investment funds, technical assistance, and certification support. Green supply chain initiatives can help companies tackle financial challenges by integrating sustainability with operational strategies, leading to cost reduction, efficiency, long-term savings, government incentives, green financing, and collaboration. The (COVID-19) pandemic has highlighted the need for green supply chains to address environmental, financial, and ethical concerns. Research focuses on sustainable sourcing, waste reduction, energy efficiency, and partner collaboration. Policy and regulation during the pandemic have significantly impacted the construction industry, including health and safety protocols, project continuity, remote work, financial support, supply chain disruptions, labor mobility, and infrastructure projects.

B. Recommendations of the Case Study

The feedback gathered will contribute to refining and strengthening local sustainability policies, emphasizing the need for continuous dialogue, capacity building, and collaborative efforts.

Key findings include high awareness of sustainability-related policies in local jurisdictions, the importance of involving stakeholders, and the need for robust public consultation processes. Common challenges in implementation include resource constraints, limited technical expertise, and stricter enforcement. Capacity-building programs were identified as essential, and stricter enforcement during the approval and construction phases was advocated. Transparent and participatory public consultation processes were cited as essential for discussing and gathering input on sustainability-related policies.

Areas for improvement include more stringent monitoring, increased public awareness, and enhanced collaboration between local bodies and external organizations. Collaborations with external organizations, NGOs, and experts were reported, showcasing a willingness to leverage external expertise for sustainable initiatives. Successful implementation examples were provided, and many groups revealed upcoming initiatives to strengthen sustainability criteria in local policies.

5.4. Conceptual Framework for The Green Supply Chain Implementation

India is experiencing rapid urbanization and infrastructure development, leading to a transformative era for its construction sector. The demand for new structures and developments is increasing, necessitating a shift towards sustainable construction practices. The building segment plays a pivotal role in shaping the nation's future, and the challenges of resource depletion, environmental degradation, and climate change necessitate a departure from conventional methodologies. GSCM emerges as a tactical-contextual-approach that integrates sustainability into every phase of the construction supply chain. Policy change is crucial in steering the construction sector towards green practices, shaping industry norms, setting standards, and incentivizing environmentally responsible decision-making. This introduction serves as a prelude to a comprehensive exploration of GSCM, underscoring the symbiotic relationship between sustainable

construction and policy evolution in India. It sets the stage for a nuanced understanding of the challenges, opportunities, and transformative potential of policy-driven green deliverables for the construction related development sector in India.

CFW is very useful in the sense of defining concepts, identifying gaps, engaging stakeholders, formulating policies, highlighting interdependencies, setting objectives, incorporating best practices, monitoring and evaluating, communicating concepts, and adapting to context. It helps in defining goals, identifying stakeholders, setting objectives, learning from framework elements, establishing metrics, communicating concepts, and adapting policies to specific regions or countries. It has been shown in **Figure** 5.10, and its mode of operation has been depicted as a flowchart in **Figure** 5.11, which describes how the decisions have been developed scientifically and designed within a framework, flow of information, major sessions, etc.

Stakeholders suggest policy modifications, which can be incremental or gradually paradigmatic or paradigmatic. State-level authorities review these decisions and defer them for a feasibility study. The feasibility analysis comprises a set of exercises as depicted in framework (**Figure** 5.11). Once the feasibility analysis passes sustainability criteria, policy recommendations are made and a roadmap for implementation is developed. If the analysis fails to meet sustainability goals, the decision is forwarded back to the stakeholder level for further development. Final decisions for policy approval and public disclosure are made.

5.4.1. Blueprint for Sustainable Construction: Unveiling the Conceptual Framework for Green Supply Chain Management Implementation

As we look at it, the conceptual framework developed has three key activities based on the role of execution: policy landscape analysis, conceptual model for policy change and recommendations, and roadmap development. Once the recommendations are finalized, they are deferred to the administrative body for disclosure as incremental (a minor policy change or amendment), gradually paradigmatic (a step-by-step shift towards a new change), or paradigmatic (a completely new policy). Normal policy changes don't alter the policy's goals, while a paradigm shift involves a significant alteration in the policy domain's goals, such as shifting from prioritizing biomedical treatments to promoting

health. These changes can occur through a sequence of routine policy changes, forming a gradual policy change (Bryant, 2002).

1A. Policy Landscape Analysis:

The Policy Landscape Analysis is a crucial step in understanding the regulatory framework for construction, environmental sustainability, and supply chain practices. It involves identifying existing policies, gap analysis, and assessing enforcement mechanisms. A robust Policy Landscape Analysis is essential for fostering green supply chain practices in the Indian construction sector. It serves as a strategic roadmap for policymakers to address gaps and strengthen enforcement mechanisms, contributing to the sector's sustainable transformation. The analysis provides a foundation for informed policy formulation, enables strategic gap filling, enhances enforcement through targeted improvements, and ensures policies align with the evolving needs and challenges of the construction industry, promoting adaptability and relevance.

i. ***Identification of Existing Policies:*** In this phase, a thorough examination is conducted to identify and analyze current policies that govern the construction industry in India. This includes policies related to building codes, environmental regulations, and broader supply chain practices. The aim is to create a comprehensive inventory of existing regulations that directly or indirectly impact the sustainability of construction processes.

ii. ***Gap Analysis:*** Once the existing policies are identified, a gap analysis is performed to assess areas where current regulations fall short in addressing green construction and integrating sustainable supply chain practices. The analysis focuses on identifying loopholes, ambiguities, or areas not covered by the existing policies. This phase provides critical insights into the specific areas where policy reform or introduction is needed to foster sustainability.

iii. ***Assessment of Enforcement Mechanisms:*** The effectiveness of current enforcement mechanisms is a pivotal aspect of the analysis. This involves evaluating how well the existing policies are enforced and whether they lead to tangible outcomes in terms of sustainable construction practices. It includes an examination of regulatory bodies, inspection processes, and the penalties or

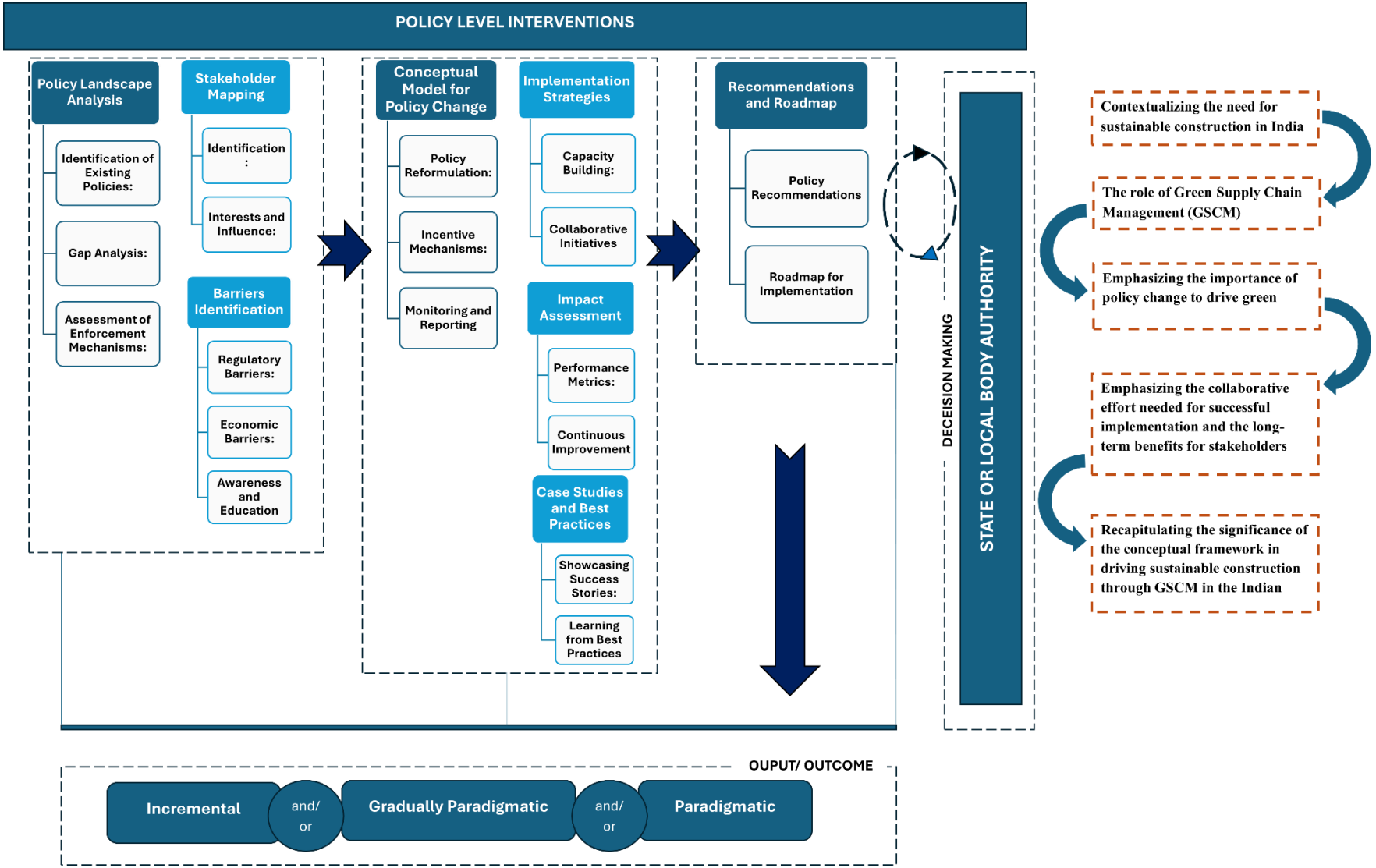


Figure 5.10: Conceptual Framework for the policy interventions for sustainable construction and GSCM

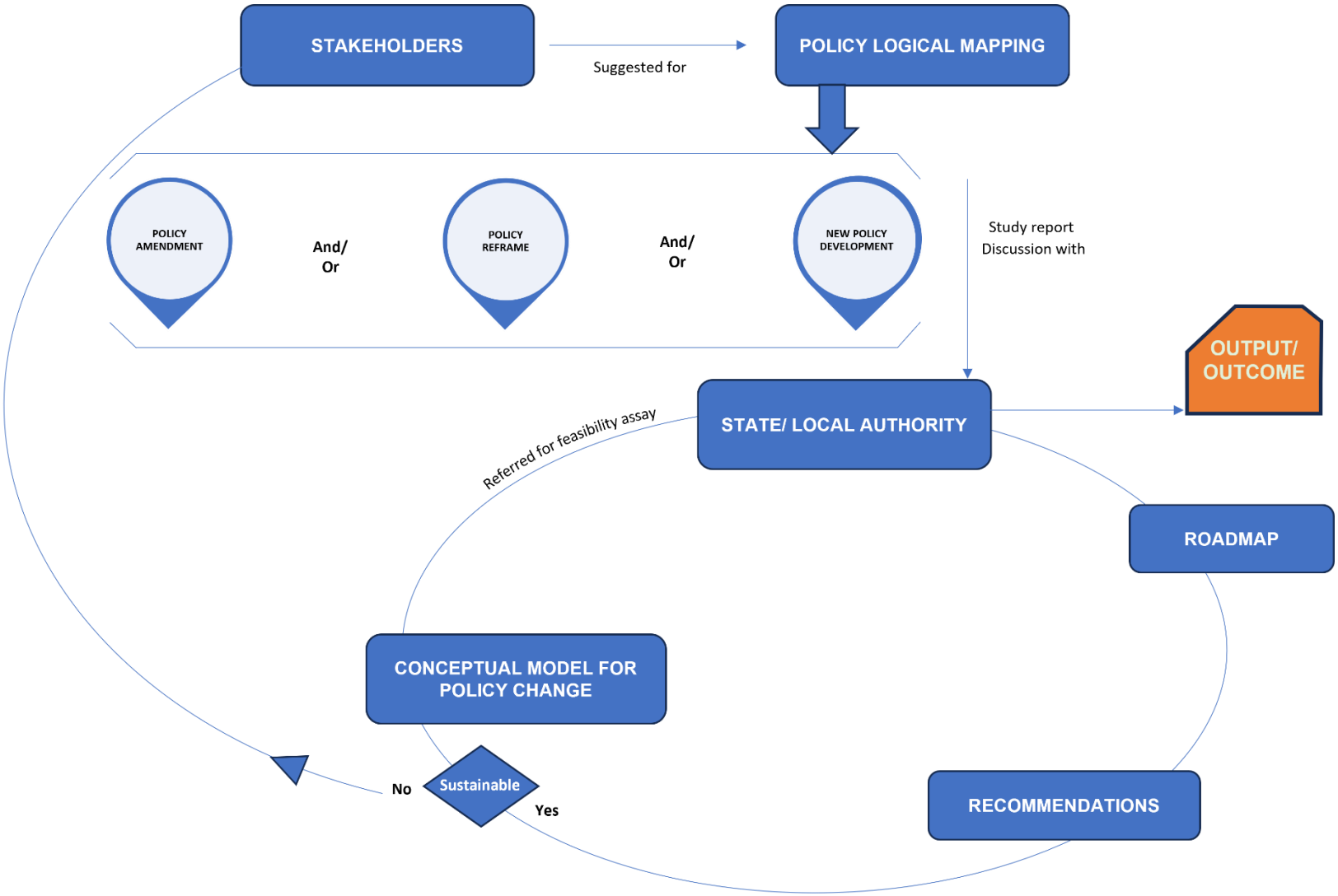


Figure 5.11: FLOW CHART: Conceptual Framework for the Policy Interventions for Sustainable Construction and GSCM

incentives associated with compliance or non-compliance. Understanding the strengths and weaknesses of enforcement mechanisms informs recommendations for enhancing or restructuring regulatory oversight.

*1B. **Stakeholder Mapping:** Enhancing Green Supply Chain Implementation in Indian Construction Sector*

Stakeholder Mapping is a crucial process for understanding the construction industry's sustainability initiatives. It involves identifying, categorizing, and understanding the interests and influence of stakeholders. This tool is essential for fostering collaboration and ensuring the success of green supply chain initiatives in the Indian construction sector. It provides a foundation for tailored engagement strategies considering the unique dynamics of each stakeholder group.

i. ***Stakeholder Identification:*** The first step in Stakeholder Mapping is the identification of diverse entities that play a role in or are impacted by the construction sector's sustainability efforts. This includes but is not limited to government bodies, regulatory agencies, industry players, non-governmental organizations (NGOs), local communities, and academia. The goal is to create a comprehensive list that encompasses the breadth of stakeholders associated with the building segment.

Stakeholders play a crucial role in policy formulation and change, ensuring comprehensive, diverse, and effective policies that address the needs of different interest groups. They include expert input from subject matter experts, industry representation from the construction industry, community engagement from local communities, government agencies, environmental advocacy groups, labor unions, financial institutions, local government officials, international organizations, and the general public. Expert input helps craft technically sound, feasible, and aligned policies with best practices. Industry representation ensures policies are realistic, consider operational challenges, and encourage industry compliance. Community engagement ensures policies are socially responsible, address local concerns, and contribute to community well-being. Government agencies provide legal and regulatory perspectives, while environmental advocacy groups advocate for sustainable policies. Labor unions address labor-related concerns and advocate for

worker rights. Financial institutions assess the economic feasibility of proposed policies, while local government officials contribute regional perspectives. International organizations provide a broader context and align with global sustainability standards. Public participation ensures democratic representation and diverse perspectives, ensuring policies reflect societal values, garner public support and enhance transparency.

Stakeholders in the construction sector include government bodies, industry players, NGOs, community representatives, and academia. These groups contribute diverse roles and perspectives to the sustainability discourse. Government bodies include regulatory authorities, urban planning departments, and environmental agencies. Industry players include construction companies, suppliers, architects, engineers, and green building councils. NGOs represent environmental organizations and advocacy groups.

ii. ***Interests*** **and Influence:** Understanding the interests and influence of each stakeholder group is crucial for effective engagement. This involves:

a) **Interests***:* Identifying what each stakeholder group values and prioritizes concerning sustainable construction. For example, a government body may be interested in policy compliance, while an NGO may focus on environmental conservation.

b) **Influence***:* Assessing the level of influence each group holds in shaping sustainable construction practices. Government bodies typically have regulatory power, while industry players might influence practices through innovation and adoption.

iii. Significance of Stakeholder Mapping:

Stakeholder mapping is a crucial for policy formulation, particularly in sustainable construction, as it offers several advantages. It allows for strategic engagement, enabling policymakers to tailor their engagement strategies to align with stakeholders' interests and support positive change. This approach fosters a collaborative environment conducive to policy implementation. Comprehensive stakeholder mapping promotes holistic decision-making, considering diverse perspectives and interests. This inclusive approach reduces the likelihood of

overlooking critical aspects that might affect policy success. Identifying stakeholders and understanding their roles facilitates the recognition of potential synergies and conflicts, enhancing policy effectiveness. By anticipating and addressing potential conflicts early, policymakers can navigate challenges and promote a collaborative synergy. Community involvement is also essential in stakeholder mapping. Recognizing community representatives as stakeholders allows policymakers to incorporate local perspectives, needs, and concerns into the decision-making framework. This community involvement enhances the legitimacy of policies and ensures they are more attuned to the specific context and requirements of the communities they impact.

*1C. **Pressure/Driver-Barriers Analysis:** Unveiling Challenges in Green Supply Chain Implementation:*

i. Pressure/Driver-Barriers Analysis:

Construction companies are increasingly adopting GSCM to improve their environmental image and meet the increasing demands on the environment. However, the Indian sector faces challenges in identifying the key drivers for GSCM implementation. 36 issues were identified under seven classes (see part 5.2.5.4.), all focused on efficient procurement and identifying obstacles to GSCM implementation in the construction sector. Drivers for GSCM implementation include existing laws and regulations, corporate policies, carbon emission audits, global green markets, foreign direct investment (FDI), special tax exemptions, cost-efficient products, and an intelligent approach to local environments. Incorporating new materials through collaboration with green product suppliers and technical experts can confer a competitive advantage in terms of cost savings or product differentiation. Barriers to Green Supply Chain Management (GSCM) implementation encompass challenges such as the scarcity of green materials, reliance on economically-driven linear supply chains, difficulties in assessing and monitoring supplier performance, concerns regarding the adoption of novel technologies, and legal considerations. Logistics barriers include conflicts with clients, apprehensions about technology transfer and inefficiencies, uncertainties regarding return on investment (RoI), complexities associated with new policies and regulations, and challenges in managing Internet of Things (IoT) integration. Technical hurdles involve reservations about technology transfer and

inefficiencies, uncertainties regarding RoI, operational complexities of new methodologies, and challenges in integrating IoT. Economic barriers encompass additional costs associated with eco-friendly packaging, the adoption of new systems, and the lack of access to bank loans to promote green products/processes. Regulatory hurdles pertain to authorities failing to offer adequate support and guidance for GSCM maintenance, while administrative challenges include resistance from top management to change existing investments, information systems, and practices. Understanding regulatory and economic barriers is crucial for advocating policy changes and incentivizing green supply chain initiatives, while administrative barriers and drivers are essential for effective implementation.

ii. Awareness and Education:

The success of sustainable building practices depends on the awareness and education of various stakeholders, including industry professionals, government officials, and the general public. The effectiveness of educational programs and training initiatives significantly influences attitudes and behaviors towards GSCM. A knowledgeable and well-trained stakeholder base contributes to the adoption and implementation of green practices, fostering a collective commitment to environmental responsibility and resource efficiency.

a) Stakeholder Knowledge:

Promoting sustainable construction requires assessing the understanding of stakeholders, including industry professionals, government officials, and the broader public. This involves assessing their awareness of GSCM benefits, energy-efficient technologies, and sustainable material sourcing. A well-informed stakeholder base is more likely to support and actively participate in the adoption of sustainable construction practices, such as life cycle assessments and sustainable material sourcing. This comprehensive understanding of the intricacies of sustainable construction is crucial for achieving sustainable development.

b) Training and Educational Programs:

The availability and effectiveness of training programs are crucial in promoting

sustainability in the construction industry. These programs, ranging from workshops to formal courses, aim to enhance technical skills and promote responsibility towards sustainable construction. Topics covered include resource efficiency, Waste Management and Recycling (3R's), Energy Efficiency & renewable energy integration, and green building certifications, EIA & Compliance with Environmental Regulations, Innovative Technologies and Construction Methods, Health and Safety in Sustainable Construction and Conservation of Water & Biodiversity. Government officials also benefit from training on policy intricacies and enforcement methodologies, ensuring a cohesive understanding and implementation of sustainability measures.

iii. Significance of Pressure-Barriers Identification:

a) Cost-Benefit Analysis:

- *Informed Decision-Making:* A cost-benefit analysis (CBA) is a crucial tool for decision-makers to understand the economic implications of GSCM policies, enabling them to make informed choices that balance environmental sustainability with economic considerations, thereby assessing the feasibility and desirability of a project or policy.
- *Resource Allocation:* The Cost-benefit analysis (CBA) is an instrumental tool that helps organizations efficiently allocate resources for sustainable practices. It compares the monetary value of benefits and costs, prioritizing projects based on their economic impact. This ensures that investments in sustainable practices yield positive returns while minimizing financial risks.
- *Risk Management:* Cost-benefit analysis (CBA) is a method used by organizations to assess potential risks and rewards associated with GSCM policies. It helps in proactively managing risks and leveraging opportunities, contributing to long-term sustainability and resilience. By assigning monetary values to benefits and costs, decision-makers can manage uncertainties and mitigate risks.

- *Transparent Communication:* CBA promotes transparent communication among stakeholders by presenting the project's economic rationale and expected outcomes in monetary terms, enabling clear understanding of its value.
- *Accountability and Evaluation:* CBA serves as a tool for accountability and evaluation, allowing decision-makers to compare projected and actual benefits and costs, promoting continuous improvement and accountability in decision-making processes after implementation.

b) Identification of External Pressures:

- *Market Trend Recognition:* Market trends, such as consumer preferences, emerging technologies, and industry innovations, can be identified early by organizations to align their strategies with market demands and stay competitive.
- *Competitor Analysis:* Pressure barrier analysis helps organizations understand competitors' actions and strategies, enabling them to develop more effective competitive strategies and differentiate themselves in the market.
- *Consumer Behavior Understanding:* Organizations must understand evolving consumer needs by identifying external pressures, such as sustainable product preferences or digital experiences, to tailor their products and services accordingly.
- *Market Entry and Expansion Opportunities:* Organizations can identify market opportunities by analyzing external pressures, recognizing market gaps, assessing regional demand, and understanding regulatory environments for expansion.
- *Risk Mitigation in Fluctuating Markets:* Identifying external pressures in markets helps organizations anticipate market fluctuations, enabling proactive risk mitigation strategies to navigate economic downturns or sudden demand shifts.

- *Innovation and Product Development:* External pressures often drive innovation, enabling organizations to invest in R&D to stay ahead of market trends and deliver innovative solutions to meet customer demands.
- *Supply Chain Optimization:* Identifying external pressures like supply chain disruptions or global trade policy changes helps organizations optimize their supply chains, ensuring efficiency, resilience, and responsiveness to market demands.
- *Market Positioning Strategies:* Organizations must understand external pressures like sustainability, quality, and cost-effectiveness to develop effective market positioning strategies that resonate with their target audiences.
- *Regulatory Environment:* External pressures often arise from government regulations and policies. Recognizing these pressures is essential for aligning GSCM policies with legal requirements.

c) Understanding Internal Barriers:

- *Organizational Culture:* Pressure barrier analysis helps identify internal obstacles within organizations, such as resistance to change or lack of awareness, which can hinder the adoption of GSCM practices.
- *Resource Constraints:* Identifying financial and expertise resource limitations is crucial for policymakers to develop effective strategies to overcome these barriers.
- *Communication Effectiveness:* Internal communication challenges within an organization can be addressed by enhancing communication channels, promoting transparency, collaboration, and open dialogue among team members.
- *Performance Management:* Internal barriers in performance management, such as unclear expectations, inadequate feedback, and ineffective measurement, can be addressed to improve practices, foster accountability, and promote continuous improvement.

d) Strategic Decision-Making:

- *Informed Policymaking:* Pressure barrier analysis aids policymakers in understanding the unique challenges faced by businesses and industries, enabling them to develop effective policies to directly address these issues.
- *Customized Solutions:* Policymakers can create tailored interventions based on identified pressures and barriers, which are more effective in promoting GSCM adoption.

e) Risk Mitigation:

- *Anticipating Challenges:* Policymakers can design proactively mitigating risks by anticipating potential pressures and barriers, enabling organizations to navigate challenges and uncertainties associated with sustainable practices adoption.

f) Promoting Stakeholder Engagement:

- *Engaging Stakeholders:* Policymakers can effectively engage stakeholders like businesses, suppliers, and consumers by understanding their pressures and barriers, resulting in more targeted and results-oriented collaboration.

g) Capacity Building:

- *Skill Development:* Capacity building enhances supply chain management skills and knowledge, ensuring stakeholders have the expertise to implement sustainable practices in GSCM.
- *Adaptability and Innovation:* Building capacity promotes adaptability to regulatory changes and market demands, enabling stakeholders to innovate and incorporate new technologies and methods that align with sustainability standards.
- *Effective Implementation:* Successful implementation of GSCM policies requires effective execution by those responsible, and capacity building

ensures individuals and organizations are well-equipped to navigate the complexities of sustainable supply chain management.

- *Monitoring and evaluation:* Capacity building improves Green Supply Chain Management monitoring and evaluation by providing professionals with essential skills, knowledge, and knowledge, enabling informed decision-making, compliance with regulations, and continuous improvement.

h) Policy Advocacy:

- *Influencing Decision-Makers:* Policy advocacy significantly influences decision-makers, including government officials, legislators, and industry leaders, by shaping policies that promote sustainability, particularly those related to Green Supply Chain Management (GSCM).
- *Raising Awareness:* Advocacy efforts raise sustainable practices awareness by mobilizing stakeholders and promoting policies promoting environmental responsibility, creating a collective voice for sustainable practices.
- *Driving Change:* Policy advocacy promotes sustainable practices at organizational and regulatory levels, driving systemic change and facilitating the policy development & implementation for GSCM.

i) Enhancing Policy Effectiveness:

- *Focused Interventions:* Pressure barrier analysis helps policymakers identify areas needing interventions for GSCM in the building sector, enhancing effectiveness and laying the groundwork for successful implementation. The targeted approach enhances the overall effectiveness of GSCM policies.

2A. Conceptual Model for Policy Change: Fostering Sustainable Construction through GSCM

The construction sector's dynamic landscape necessitates a comprehensive policy change model that promotes sustainable practices through Green Supply Chain Management

(GSCM). This model, which combines policy reformulation, strategic incentives, and effective monitoring, aims to steer the sector towards sustainability by leveraging Green Supply Chain Management principles, creating an environment conducive to widespread adoption of sustainable construction practices (see **Figure** 5.12).

i. **Policy Reformulation:** Proposing Amendments for Sustainable Construction Policies

The construction and supply chain sectors require a systematic and collaborative approach to policy changes. This involves conducting thorough research, analyzing existing policies, engaging with stakeholders, and incorporating green elements. This can help identify 'lacuna' in the current framework and project areas for improvement. Incorporating green elements can be achieved through policy amendment proposals, benchmarking against international best practices, and incorporating elements from other regions that align with local context and industry needs. Stakeholder consultation can be conducted through multi-stakeholder forums, public participation, and expert panels. Awareness campaigns can be launched through educational initiatives, highlighting the economic, environmental, and social benefits of incorporating green elements into construction and supply chain policies. Pilot programs can be implemented to test proposed policy changes on a small scale, identifying potential challenges and refining strategies. Learning from experience can be used to fine-tune policy recommendations, and sharing successes and lessons with stakeholders can build confidence in the proposed changes. Lobbying and advocacy can involve engaging influential advocates, such as environmental NGOs, industry leaders, and community influencers, who can champion the cause of green policy changes. Policy briefs can be developed to succinctly present the case for green supply chain policies, and a regulatory impact assessment (RIA) is conducted to evaluate the potential impacts of proposed policy changes. A comprehensive framework is developed to integrate various aspects of green supply chain practices into the broader policy landscape, ensuring coherence and consistency across different policies related to construction, environment, and supply chain.

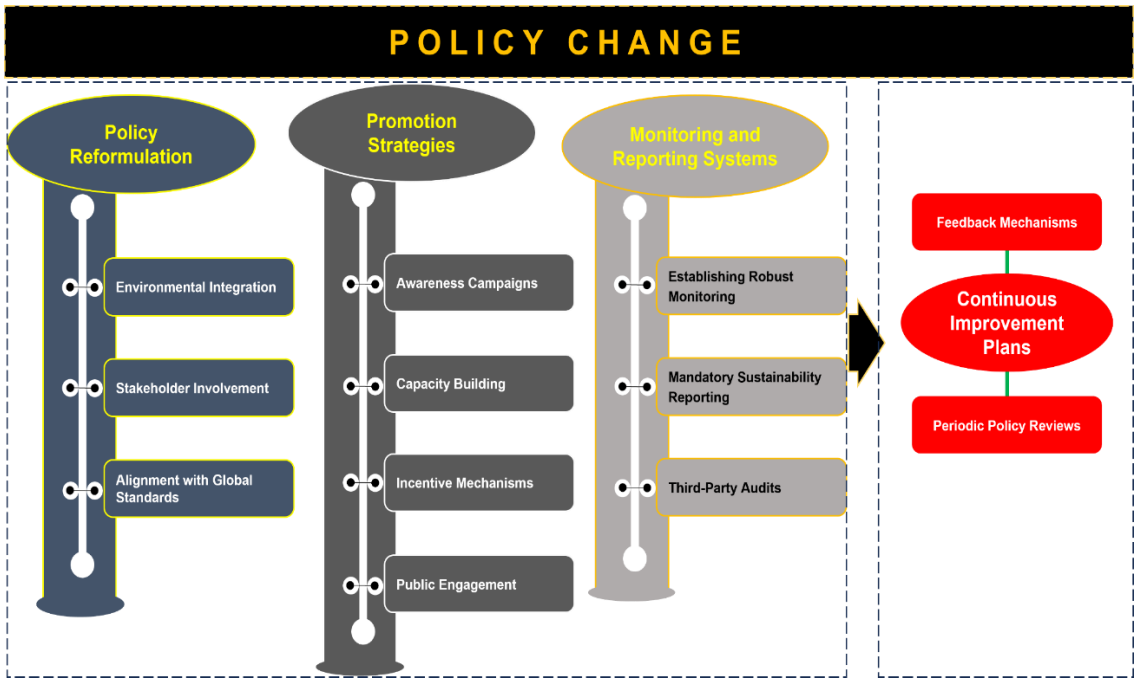


Figure 5.12: Conceptual Model for GSCM Policy Change in India

a) **Identification of Gaps:** Conducting a thorough analysis of existing policies related to construction, environmental sustainability, and supply chain practices to identify gaps and shortcomings.

b) **Incorporating Green Elements:** Recommending specific amendments or new policies that explicitly address sustainable construction and integrate GSCM principles. This entails incorporating clauses that prioritize the utilization of environmentally friendly materials, energy-efficient technologies, and sustainable procurement practices.

c) **Stakeholder Consultation:** Ensuring that the reformulation process involves consultation with a diverse range of stakeholders, including government bodies, industry players, NGOs, and community representatives. This promotes inclusivity and increases the likelihood of successful policy implementation.

ii. **Promotional Mechanisms:** Encouraging Adoption *via* Strategic Incentives

Sustainable construction can be promoted through various promotional practices. Financial incentives, such as tax credits and rebates, can offset the initial costs of implementing green construction measures. Low-interest loans can also be provided for projects that integrate sustainable elements, encouraging investment in eco-

friendly technologies. Recognition programs, such as green building certifications and awards, can also be established to recognize and showcase projects that meet or exceed sustainability criteria. Capacity building is essential, with training programs and workshops organized for professionals, architects, and builders to enhance their understanding of sustainable construction practices. Public awareness campaigns can educate the broader community about the benefits of sustainable construction, including its environmental, health, and overall well-being impacts. Government support programs, such as grants and subsidies, can incentivize innovation and the development of new, eco-friendly building solutions. Public-Private-partnerships (PPPs) can foster collaboration between the private and government sector to fund and implement sustainable construction projects. Market recognition can be achieved through consumer awareness campaigns, eco-labeling for construction materials, and streamlined approval processes for sustainable construction projects. Regulatory support can be achieved through streamlined approval processes and regulatory recognition. Demonstration projects can showcase the feasibility and benefits of sustainable construction, while tours and open houses can allow stakeholders to witness the features and benefits firsthand. Collaborative initiatives, such as industry collaborations and knowledge sharing platforms, can drive innovation and adoption of sustainable practices. By integrating these promotional practices, stakeholders can work collectively to promote sustainable construction and contribute to a more environmentally conscious and resilient built environment.

a) **Financial Incentives:** Designing incentive structures that provide financial benefits to construction companies embracing green supply chain practices. This could involve tax credits, subsidies, or grants to offset initial implementation costs.

b) **Recognition Programs:** Introducing recognition programs or certifications for construction projects that demonstrate exemplary adherence to sustainable practices. Such programs contribute to building a positive industry image and encourage healthy competition.

c) **Capacity Building:** Including provisions for training and capacity-building programs that enhance the skills of industry professionals in implementing GSCM. This ensures that companies are well-equipped to adopt and sustain sustainability procedures.

iii. **Monitoring and Reporting:** Ensuring Accountability and Transparency

To strengthen GSCM implementation in the building segment, several best practices can be implemented. These include establishing monitoring systems using Key Performance Indicators (KPIs), real-time monitoring using technology, mandatory reporting requirements for construction projects, and integrated reporting. Transparency platforms should be established for transparency of sustainability-related information, and annual sustainability reports should be mandated. Third-party audits should be implemented to verify the accuracy and reliability of sustainability reports submitted by construction companies. Certification programs should encourage participation in external assessments of a construction project's sustainability. Incentive-based compliance should be introduced, offering incentives for companies that demonstrate high levels of transparency in reporting. Compliance bonuses can motivate construction companies to prioritize GSCM. Continuous improvement plans should be established, with feedback mechanisms for ongoing improvement and periodic reviews of GSCM policies. Public engagement should involve the local community in monitoring and reporting processes, and social media platforms should be used to keep the public informed about GSCM initiatives. Training programs should be conducted for government officials, construction professionals, and auditors involved in monitoring and reporting to enhance their capacity to assess and evaluate GSCM compliance. Knowledge sharing platforms

should facilitate sharing of best practices in monitoring and reporting among stakeholders. By incorporating these strategies into policy frameworks, governments and industry stakeholders can strengthen the implementation of GSCM in the construction sector, fostering greater accountability, transparency, and environmental responsibility.

a) **Establishing Monitoring Systems:** Proposing the creation of robust monitoring systems to track and evaluate the implementation of sustainable construction policies. This involves regular assessments to ensure compliance with GSCM principles.

b) **Reporting Mechanisms:** Recommending transparent reporting mechanisms that require construction companies to provide data on their sustainability efforts. This data can be used to measure the environmental impact and overall effectiveness of green supply chain practices.

c) **Public Disclosure:** Advocating for public disclosure of sustainability performance, fostering transparency and accountability. This could involve the publication of sustainability reports or ratings for construction projects.

2B. Implementation Strategies for Green Supply Chain Management (GSCM) in Construction:

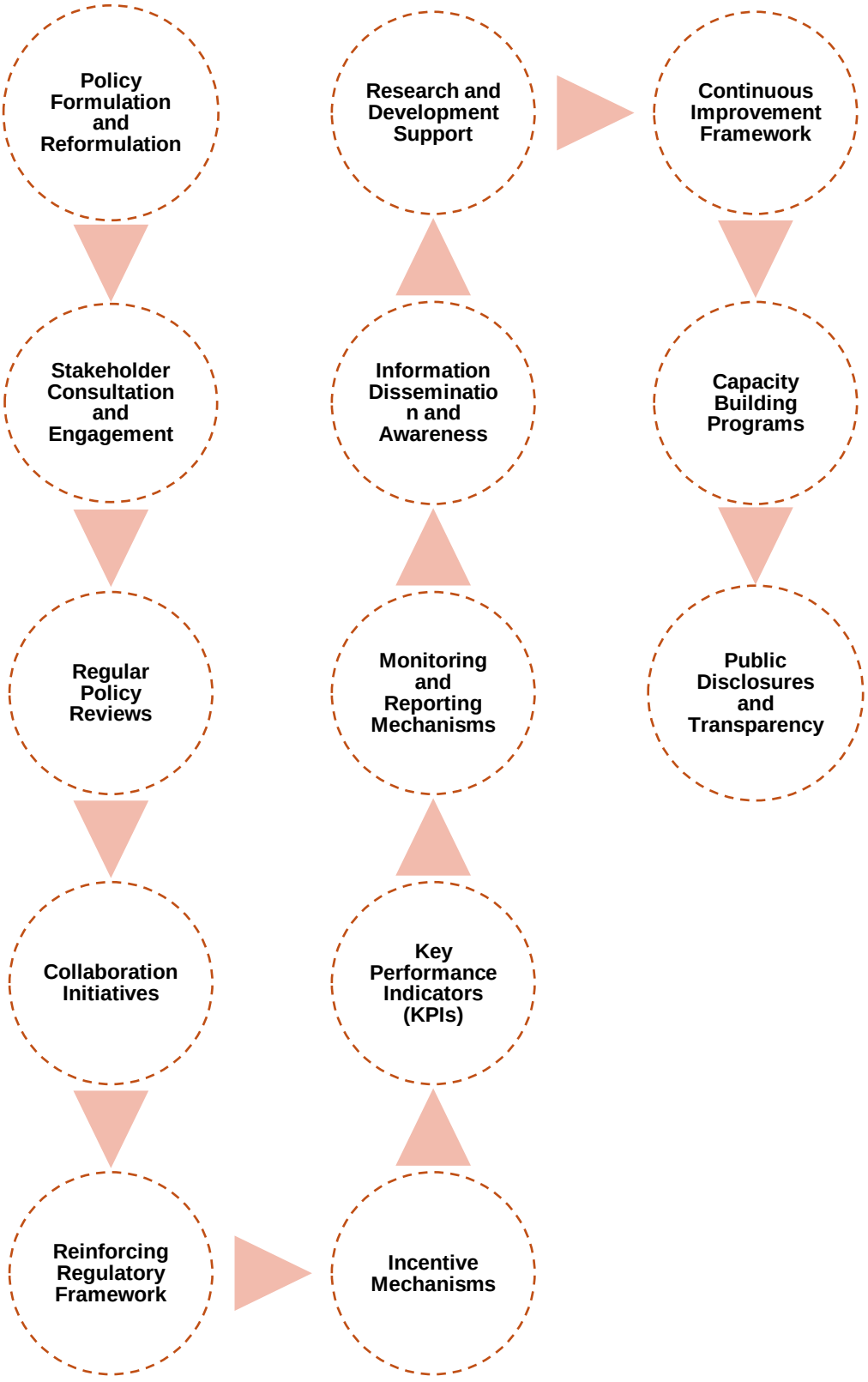


Figure 5.13: Implementation Framework for GSCM *via* Policy Interventions

GSCM in the construction sector requires robust strategies that focus on capacity building and collaboration among key stakeholders. The success of GSCM relies on the collective efforts of government officials, industry professionals, and workers. A two-pronged approach is needed: enhancing stakeholder capacity through educational programs and fostering collaboration among government, industry, and NGOs. These strategies contribute to the creation of a knowledgeable, skilled, and collaborative ecosystem essential for sustainable construction practices. The strategies include holistic skill development, cross-sector collaboration, knowledge exchange, and long-term sustainability. Capacity building equips stakeholders with the necessary skills to implement GSCM effectively, while cross-sector collaboration fosters synergy among diverse stakeholders. These strategies lay the foundation for the long-term sustainability of GSCM practices in the construction sector.

Figure 5.13 outlines a framework for GSCM implementation in the construction sector. It includes policy formulation, stakeholder consultation, regular policy reviews, collaboration, regulatory reinforcement, incentives, KPIs, monitoring, reporting, information dissemination, research support, continuous improvement, capacity building programs, and transparency.

i. Capacity Building: Enhancing Stakeholder Competence for Sustainable Construction Practices

Capacity building is crucial in promoting sustainable construction practices. It involves implementing educational programs targeting government officials, industry rofessionals, and workers to enhance their understanding of Green Supply Chain Management (GSCM) principles. Regular training workshops on sustainable construction practices, such as eco-friendly material usage, energy-efficient technologies, and waste reduction strategies, provide practical insights and hands-on knowledge for stakeholders. Certification programs, which formally recognize individuals and organizations who have undergone GSCM training, serve as incentives for active participation in capacity-building initiatives. This not only validates the expertise acquired but also establishes a skilled workforce capable of implementing and promoting sustainable practices. By incorporating these elements into a holistic capacity-building strategy, stakeholders can develop the competence needed to embrace and implement sustainable practices. This multifaceted approach ensures knowledge is disseminated broadly, reinforced through hands-on

experiences, and formal recognition, creating a well-prepared and motivated workforce for the adoption of GSCM in the construction sector.

ii. ***Collaborative Initiatives:*** *Promoting Synergy Among Government, Industry, and NGOs*

Green Supply Chain Management (GSCM) initiatives in the construction sector require collaboration among government, industry, and NGOs. Public-Private Partnerships (PPPs) encourage partnerships between private and government sector entities, facilitating the exchange of resources, expertise, and best practices. NGOs, specializing in environmental sustainability, can contribute to advocacy, awareness campaigns, and technical support for GSCM implementation. Their strengths enhance the outreach and impact of sustainability initiatives. Industry associations, on the other hand, collaborate with industry associations to create platforms for sharing experiences and promoting GSCM. They serve as conduits for disseminating information, organizing events, and establishing industry-wide standards for sustainable practices.

By fostering collaboration among industry players, associations contribute to the development of a unified approach to GSCM within the construction sector. These collaborative initiatives form the foundation of a comprehensive strategy, uniting stakeholders to address challenges and opportunities associated with GSCM.

2C. ***Impact*** *Assessment for Implementation Strategies in GSCM:*

The fulfilment of GSCM strategies requires a robust impact assessment framework to gauge their success. This framework should focus on key performance metrics and mechanisms for continuous improvement. It ensures accountability, adaptability, transparency, and strategic decision-making in the construction sector. Performance metrics establish clear accountability for the success of GSCM implementation, allowing objective measurement of progress. Continuous improvement mechanisms facilitate strategy adaptation to address emerging challenges, keeping GSCM initiatives relevant and effective. The assessment process enhances transparency by providing stakeholders with a clear understanding of the impact of GSCM strategies on sustainability goals. Informed by impact assessment results, organizations can make strategic decisions on resource allocation, policy refinement, and further investments in sustainable practices. **Table** 5.14 provides a comprehensive set of Performance Metrics for the construction

sector, focusing on Key Performance Indicators (KPIs) such as Compliance Rate, Resource Efficiency, Carbon Footprint Reduction, Waste Reduction Percentage, Energy Consumption Reduction, Sustainable Material Usage, Green Certification Achievements, Stakeholder Satisfaction Index, Implementation Cost vs. Savings, Environmental Impact Assessment Ratings, Innovation Adoption Rate, Community Engagement, Regulatory Compliance Index, Circular Economy Practices, and Incident Reports.

i. Performance Metrics

Table 5.14: Performance Metrics: Key Performance Indicators (KPIs) for Assessing Sustainability Success

Compliance Rate	Measurement of how well construction projects adhere to the established green supply chain policies and regulations.
Resource Efficiency	Evaluation of the efficient use of resources, including materials, water, and energy, in construction projects.
Carbon Footprint Reduction	Quantification of the reduction in carbon emissions achieved *via* the of GSCM implementation.
Waste Reduction Percentage	Calculation of the percentage decrease in construction-related waste through sustainable practices.
Energy Consumption Reduction	Measurement of the decrease in energy consumption attributed to the adoption of energy-efficient technologies.
Sustainable Material Usage	Assessment of the percentage of sustainable and eco-friendly materials used in construction projects.
Green Certification Achievements	Number of construction projects that attain recognized green building certifications, such as LEED or GRIHA.
Stakeholder Satisfaction Index	Surveys or assessments measuring the satisfaction of various stakeholders, including clients, builders, and the local community.
Implementation Cost vs. Savings	Comparison of the implementation costs of GSCM practices against the achieved savings over time.
Environmental Impact Assessment (EIA) Ratings	Scores assigned to construction projects based on their environmental impact assessments, considering factors like biodiversity preservation and emissions.

Innovation Adoption Rate	Percentage of new and innovative green technologies or practices adopted within the construction projects.
Community Engagement and Support	Indicators reflecting the level of engagement and support received from local communities for sustainable construction initiatives.
Regulatory Compliance Index	Evaluation of how well construction projects align with and adhere to the evolving regulatory frameworks for green construction.
Adoption of Circular Economy Practices	Assessment of how well circular economy principles, such as recycling and reusing materials, are integrated into the construction processes.
Incident Reports and Non-Compliance Instances	Monitoring the no. of incidents or instances of nonconformity with GSCM policies and identifying areas for improvement.

*ii. **Continuous Improvement Plan:** Sustainable Decision-Making Framework*

A continuous improvement plan is a strategy that involves continuously evolving policies to address emerging challenges and capitalize on opportunities. It uses data-driven decision-making to analyze feedback and policy reviews, providing evidence-based insights for policy adjustments. Policymakers can modify policies based on stakeholder feedback, introducing new measures or refining existing ones. The plan promotes transparency by making the policy review process visible to the public, building trust and confidence in the policymaking process. Accountability measures are incorporated to ensure adjustments are made responsibly and aligned with the overall objectives of sustainable construction through Green Supply Chain Management. This proactive approach ensures that policies remain effective, responsive, and aligned with the dynamic needs of sustainable construction practices.

Figure 5.14 outlines the Impact Assessment for Implementation Strategies in GSCM in the construction sector. It highlights factors like continuous improvement, KPIs, training, feedback, industry collaboration,

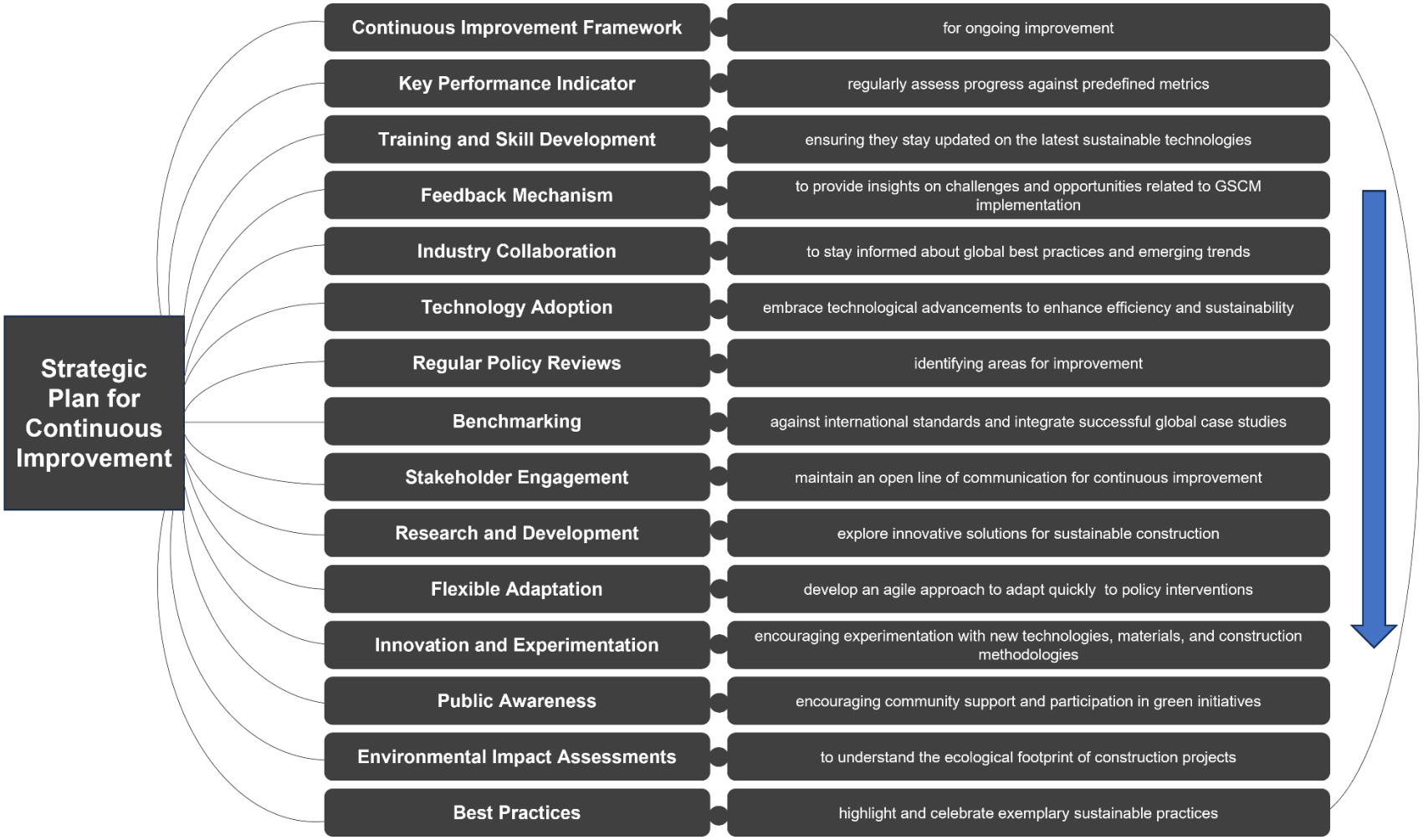


Figure 5.14: Impact Assessment for Implementation Strategies in GSCM

technology adoption, policy reviews, benchmarking, stakeholder engagement, research, flexibility, innovation, public awareness, environmental impact assessments, and best practices.

a) **Feedback Mechanism:** The policy involves active stakeholder engagement, including government officials, industry professionals, environmental experts, and the public, to gain valuable insights on policy implications. Regular surveys, consultations, and feedback sessions ensure that the experiences and concerns of those affected are considered, fostering inclusivity and shared responsibility.

b) **Periodic Policy Review:** Periodic policy reviews are a systematic evaluation of the effectiveness of implemented policies, assessing their achievement of goals and identifying unintended consequences. These reviews also help identify gaps or areas where policies may fall short, enabling policymakers to address challenges before they escalate.

iii. ***Constant Upgradation:*** *Adapting to Evolving Needs and Industry Standards*

The strategic plan for continuous improvement in GSCM implementation in Indian construction outlines a structured framework for continuous improvement, including regular assessments, feedback loops, and mechanisms for ongoing improvement. Key performance indicators (KPI) monitoring is also implemented, along with regular training and skill development for stakeholders. A feedback mechanism is established, encouraging input on challenges and opportunities related to GSCM implementation. Industry collaboration is fostered, with technology adoption such as Building Information Modeling (BIM) and data analytics being adopted. Regular policy reviews are conducted, identifying areas for improvement and aligning them with global standards. Benchmarking against global standards is conducted, integrating lessons learned from successful global case studies. Continuous stakeholder engagement is maintained, and resources are allocated for research and development initiatives. An agile approach is developed to adapt quickly to policy changes, encouraging innovation and experimentation. Public awareness campaigns are run, and environmental impact assessments are conducted to understand the ecological footprint of construction projects. Recognition programs are instituted to highlight and celebrate exemplary sustainable practices.

2D. Case Studies and Best Practices in GSCM for Policy Change:

The article highlights the importance of showcasing success stories and learning from best practices in GSCM for policy change. It highlights how countries with robust GSCM policies have reduced environmental impact, improved resource efficiency, and increased industry competitiveness. It also discusses local triumphs in implementing policy reforms, such as increased use of sustainable materials and reduced waste generation. The article also suggests extracting lessons from countries that have excelled in enforcing GSCM policies, such as incentives and stakeholder collaboration, and using these lessons to propose policy changes that align with local construction industry requirements. **Table** 5.15 showcases successful Green Supply Chain Management implementation examples, while **Table** 5.16 provides best practices for policy change and sustainability initiatives in the construction sector, facilitating learning opportunities.

i. Showcasing Success Stories:

Table 5.15: Showcasing Success Stories:

International Case Studies	*Example:* Showcase how countries with robust GSCM policies have experienced significant reductions in environmental impact, improved resource efficiency, and heightened industry competitiveness.	• Highlighting global success stories to highlight policy changes' positive impact. • Examining regional strategies for enhancing sustainability in construction supply chains. • Examining successful local case studies for tangible evidence of transformative policy changes.
Local Triumphs	*Example:* Explore how a city or region implemented policy reforms leading to increased use of sustainable materials, reduced waste generation, and improved overall environmental performance.	

ii. Learning from Best Practices:

Table 5.16: Learning from Best Practices:

Extracting Lessons	*Example:* Identify and analyze best practices in countries that have excelled in enforcing GSCM policies, such as incorporating incentives, setting clear standards, and fostering collaboration between stakeholders.	• International experiences provide valuable lessons for policy recommendations. • Understanding successful strategies in diverse contexts aids in policy development. • Global best practices shape policy recommendations, tailoring strategies to regional needs. • Success stories and best practices guide policy change in GSCM, driving sustainable transformation.
Informing Policy Recommendations	*Example:* Utilize lessons learned from countries with strong GSCM frameworks to propose policy changes that align with the unique characteristics and requirements of the local construction industry.	

3A. Recommendations and Roadmap for Green Supply Chain Practices in Construction:

The construction industry is undergoing a significant transformation towards green supply chain practices, a crucial step towards sustainable development. The adoption of these practices is essential for reducing environmental impact and promoting eco-friendly practices. A roadmap for green supply chain practices in construction outlines a strategic approach to implement these practices. The roadmap includes policy formulation and reformulation, stakeholder consultation and engagement, regulatory framework strengthening, incentive mechanisms, capacity building programs, information dissemination and awareness, collaboration initiatives, monitoring and reporting mechanisms, performance metrics and KPIs, a continuous improvement

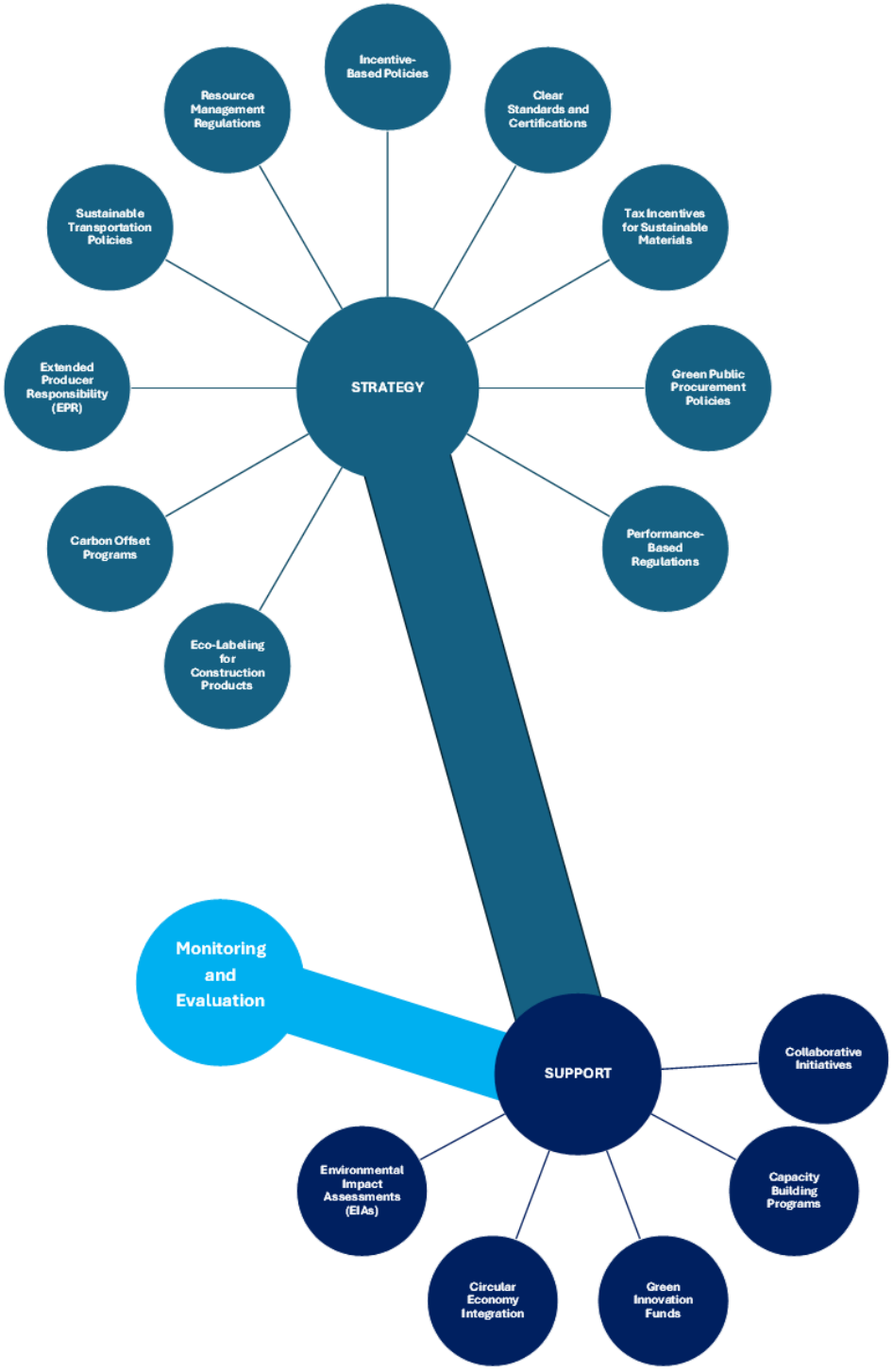


Figure 5.15: Recommendations for Green Supply Chain Practices in Construction

framework, research and development support, collaboration with international organizations, public disclosures and transparency, and regular policy reviews. The goal is to develop and refine policies that explicitly endorse and mandate green supply chain practices in construction, ensuring alignment with local industry needs and fostering

collaboration among stakeholders. By implementing these recommendations, the construction sector can align itself with sustainability goals, mitigate environmental impact, and contribute to a greener and more resilient future.

The policy design to disclosure phase is crucial, with the recommendation phase focusing on strategic considerations. Top stakeholders have room for improvement. The suggested policy should have a well-defined ME, a strategy component connecting ecolabelling and performance regulation, and a strengthen or support finger, connecting stakeholder collaboration and EIA. **Figure** 5.15 suggests strategies for improving GSCM in the construction sector, focusing on strategic shift, supportive measures, and monitoring and evaluation mechanisms. These include incentivizing green practices, fostering knowledge sharing, capacity building, environmental impact assessments, circular economy principles, green innovation funds, and robust monitoring mechanisms.

i. Policy Recommendations:

a) Strategic shift:

1. Incentive-Based Policies: Introduce policies that incentivize construction companies to adopt green supply chain practices.
2. Clear Standards and Certifications: Establish standards and certifications for green construction materials and practices.
3. Tax Incentives for Sustainable Materials: Implement incentives or rebates for construction projects using sustainable and eco-friendly materials.
4. Green Public Procurement Policies: Prioritize contractors and suppliers based on their commitment to sustainable practices.
5. Performance-Based Regulations: Shift towards performance-based regulations that focus on the outcomes and environmental performance of construction projects.
6. Eco-Labeling for Construction Products: Introduce eco-labeling schemes for construction products to provide consumers and builders with clear information about the environmental impact of materials.
7. Carbon Offset Programs: Explore the implementation of carbon offset programs within the construction industry to counterbalance the carbon footprint associated with construction activities.

8. Extended Producer Responsibility (EPR): Implement policies to hold manufacturers responsible for the entire life cycle of their products, encompassing disposal and recycling processes.
9. Sustainable Transportation Policies: Develop policies that promote the use of sustainable transportation for construction activities to reduce emissions.
10. Resource Management Regulations: Implement regulations focused on efficient resource management during construction activities.

b) Supportive/Strengthening the system:

1. *Collaborative Initiatives:*
    - Encourage collaborations between government bodies, industry associations, and NGOs for knowledge sharing and collective efforts in implementing green supply chain practices.
    - Harness combined expertise and resources for effective implementation.
2. *Capacity Building Programs:*
    - Develop and implement programs for government officials, industry professionals, and workers to enhance understanding of green supply chain practices.
    - Well-informed stakeholders are essential for successful policy implementation.
3. *Environmental Impact Assessments (EIAs):*
    - Introduce mandatory EIAs for construction projects to identify, predict, and mitigate potential environmental consequences.
    - Implement measures to minimize negative effects.
4. *Circular Economy Integration:*
    - Develop policies promoting circular economy principles within the construction sector.
    - Promote resource conservation and waste reduction.
5. *Green Innovation Funds:*
    - Establish funds or grants to support research and innovation in green construction practices.

c) Monitoring, Evaluation, Complaints, and Redressal Mechanisms:

1) Establish a robust monitoring and evaluation system to track the implementation of these policies.
2) Implement a mechanism for receiving and addressing complaints related to non-compliance or environmental concerns.
3) Ensure that redressal processes are transparent, accessible, and timely, promoting accountability within the construction industry.
4) These policy recommendations, along with effective monitoring and redressal mechanisms, collectively contribute to a comprehensive and impactful framework for promoting green supply chain practices in the construction sector.

ii. Roadmap for Implementation:

The Indian construction sector is set to implement a comprehensive strategy to enhance sustainability practices through a roadmap for Green Supply Chain Management (GSCM) enforcement. The roadmap focuses on stakeholder engagement, regulatory strengthening, and incentive mechanisms. It also emphasizes capacity building through educational programs and training workshops, fostering a skilled workforce capable of implementing sustainable practices. Information dissemination and awareness campaigns are crucial for widespread understanding and acceptance of GSCM principles. Collaboration with the private sector, NGOs, and industry associations is also aimed at creating synergies. The roadmap prioritizes robust monitoring and reporting mechanisms, performance metrics, and key performance indicators (KPIs). It encourages innovation and knowledge exchange through collaboration with international organizations. Public disclosures and transparency initiatives promote openness, and regular policy reviews ensure adaptability to evolving sustainability needs. If there was no definitive hibernation, the optimal roadmap—which is flexible since it is trustworthy for different components—could be finished in two to three years, as **Figure** 5.16 illustrates, which displays the component flow and time period.

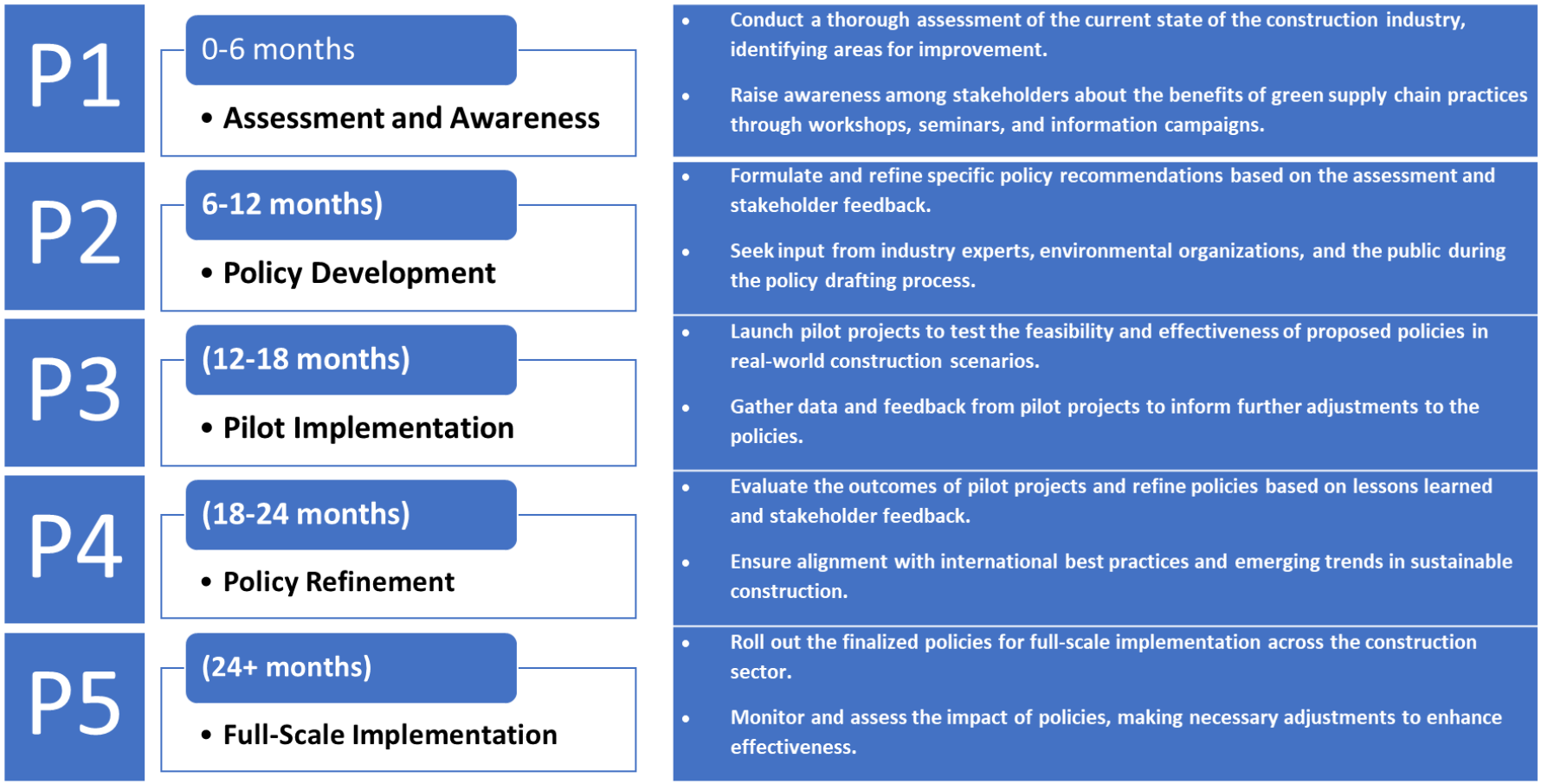


Figure 5.16: Roadmap for Implementation of the changes in policies for the sustainable construction

5.4.2. **ROADMAP**: Local governments' priorities for 'green' transformation

Local bodies can significantly promote sustainable construction by overcoming economic, political, regulatory, and financial obstacles. By adopting five key actions, they can create an environment conducive to sustainable construction, contributing to community well-being and environmental health. These actions require a coordinated, long-term commitment, and are crucial for a sustainable future that balances, socio-economic, and environmental outcomes. As the clock ticks, prioritizing these actions is essential (**Figure** 5.17).

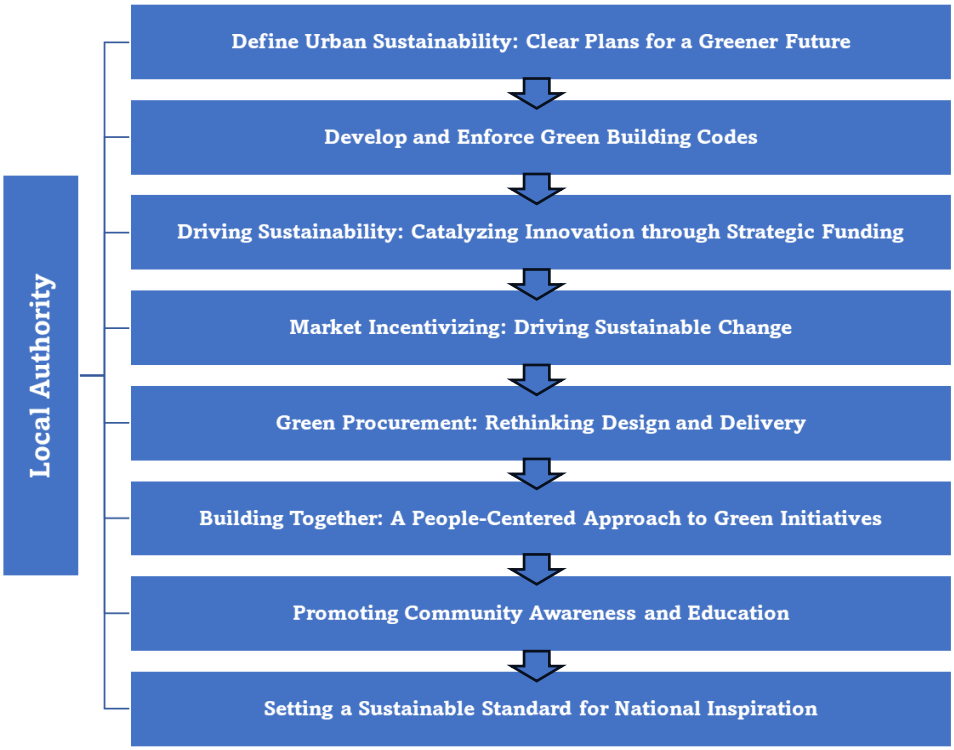


Figure 5.17: Local Governments' Strategies to Drive Sustainable Transformation

A. Define Urban Sustainability: Clear Plans for a Greener Future

Local bodies are integrating sustainability into urban planning to create resilient and sustainable communities. This proactive approach addresses environmental, social, and economic aspects of urban development. Key strategies include incorporating sustainability principles into master plans and zoning regulations, encouraging mixed-use development, prioritizing transit-oriented design, preserving green spaces, integrating energy-efficient infrastructure, and implementing smart city infrastructure (Sánchez and Govindarajulu, 2023). Community engagement is also crucial in the planning process,

ensuring that urban development aligns with residents' needs and aspirations. Sustainable land use practices are advocated for, minimizing urban sprawl and prioritizing efficient land utilization (Bibri et al., 2020). Climate-resilient design principles are integrated into urban planning to address climate change challenges. Economic viability is ensured by ensuring that sustainability measures contribute to long-term economic benefits, attracting businesses and fostering a robust local economy. Industry collaboration is essential in developing sector-specific roadmaps that reconcile long-term commitments with short-term action plans featuring measurable targets. Green action plans should be seamlessly integrated into all government endeavors, spanning infrastructure, housing, transport, defense, education, health, and social services (referencing Atalla et al., 2021). Centralized oversight by a single entity is crucial to ensure a cohesive approach across various sectors. Furthermore, local and regional governments must participate in policy formulation and be empowered to implement green initiatives (Salvador and Sancho, 2021).

B. *Develop* and Enforce Green Building Codes:

Local bodies play a crucial role in developing and enforcing green building codes to promote sustainable construction practices. These codes serve as regulatory frameworks that mandate and guide environmentally responsible construction. They should create comprehensive local green building codes tailored to their specific environmental conditions and community needs, outlining specific requirements and guidelines. Green building codes ought to require a variety of sustainable practices, encompassing energy efficiency, water conservation, waste reduction, and the utilization of environmentally friendly materials (utilitiesone, 2023). These mandates ensure that construction projects align with sustainability principles. Setting standards for energy efficiency in construction involves establishing clear standards for the use of energy-efficient appliances, lighting systems, insulation, and HVAC technologies (Krarti, 2018). Water conservation requirements include integrating measures such as installing water-efficient fixtures, rainwater harvesting systems, and landscaping practices that reduce water usage. Waste reduction strategies include recycling materials, minimizing construction waste, and adopting practices that contribute to a circular economy. Use of eco-friendly materials, such as certified wood, recovered materials, and low-emission paints, is also emphasized. Green building codes should be dynamic and subject to regular updates to align with evolving industry standards and technological advancements. Enforcement through

rigorous inspections, permits, and certifications ensures widespread compliance (Fakunle et al., 2020). Education and training programs should be implemented to familiarize architects, builders, and construction professionals with the nuances of green building codes. Incentives for compliance can include expedited permitting processes, fee reductions, or other benefits that motivate builders to embrace and exceed sustainability requirements. Collaboration with stakeholders, including architects, builders, and developers, during the formulation and updating of green building codes ensures that the codes are practical, feasible, and reflective of industry expertise (Liu et al., 2022).

C. Driving Sustainability: Catalyzing Innovation through Strategic Funding

Governments possess various policy tools to expedite investment in new infrastructure and technologies aimed at achieving climate objectives. Nevertheless, there is a substantial global funding shortfall, with only $25 billion currently earmarked (according to the IEA, 2021). A mission-oriented approach to public sector research and innovation can assist governments in directing their funding more effectively. This approach entails investing in targeted initiatives and fostering collaboration across different sectors to drive innovation. Governments can incentivize private sector participation in research and development by establishing an appropriate policy framework and conducive environment (OECD, 2016). Enhanced commitments from governments regarding infrastructure spending and comprehensive information on relevant investment pipelines can amplify funding opportunities and offer long-term stability for institutional investors and insurers. Additionally, governments must create conditions conducive for private enterprises to secure long-term funds in sectors where financial institutions are currently hesitant to make substantial investments (as proposed by Prasad et al., 2022). Potential solutions include tailored structured finance mechanisms for specific sectors, policies and mechanisms aimed at mitigating risks, and the provision of low-interest rate financing (Atalla et al., 2021). Climate finance taxonomies and other categorizations can aid in aligning investments with climate objectives.

D. Market Incentivizing: Driving Sustainable Change

Local bodies can play a crucial role in encouraging sustainable construction practices by providing tangible incentives. These incentives can include financial incentives like tax credits and rebates, cost-sharing programs, a tiered incentive system, recognition and

certification programs, expedited approval processes, collaboration with financial institutions, subsidized training programs, flexible development charges, and joint investment initiatives (Sokolowski et al., 2019). Public recognition and certification programs can help build a culture of continuous improvement and promote sustainable practices. Streamlined approval processes can save time and accelerate construction timelines. Collaborating with financial institutions can develop green financing options tailored for sustainable construction projects. Subsidized training programs can enhance skills and stay updated on the latest trends (OECD, 2018). Flexible development charges can be adjusted based on sustainability measures, with lower fees for eco-friendly initiatives acting as a financial incentive. Public-private partnerships can also be explored for investment in sustainable infrastructure. By providing meaningful incentives, municipalities can create a compelling business case for adopting sustainable construction practices and foster a collective commitment to environmental responsibility within the local building industry. Governments and regulatory bodies must enforce robust carbon accounting practices and standardized reporting frameworks to monitor environmental impact (citing Circo, 2007). The International Financial Reporting Standards Foundation has announced the establishment of the International Sustainability Standards Board (ISSB) by June 2022, while the Securities and Exchange Commission is progressing towards requiring corporate disclosures of climate risk exposure (Atalla et al., 2021).

E. Green Procurement: Rethinking Design and Delivery

Local bodies can enhance the design and delivery of green initiatives by implementing sustainable procurement policies. These policies guide the selection of materials and products for construction projects, focusing on environmental responsibility. These policies include prioritizing environmentally friendly materials and products, incorporating life-cycle assessments, relying on reputable environmental certifications, promoting energy-efficient products, encouraging the use of recycled and recyclable materials, embracing local sourcing, considering social responsibility, prioritizing long-term durability, staying updated on innovative and sustainable materials and technologies, and fostering transparency and inclusivity in the procurement process (Bidin et al., 2018).

To ensure success and avoid setbacks, governments need to articulate a clear vision, establish realistic timelines, allocate appropriate funding, and foster a supportive

regulatory framework. Achieving success hinges upon securing the necessary resources, workforce capabilities, and supply chain capacity. Adopting a "whole systems approach" that involves cross-government and cross-sector coordination is vital, enabling governments to grasp the intricate factors influencing program outcomes and devise strategies to address challenges (Atalla et al., 2021). Advances in integrated systems and analytical tools enable seamless interactions and informed decision-making. Governments are also tasked with preparing for the growing demand for new skills and expertise to implement green initiatives. Through targeted funding and the development of a national green skills plan, they can effectively forecast the quantity and nature of skills required, as well as invest in education and retraining programs (MSDE, 2015).

F. Building Together: A People-Centered Approach to Green Initiatives

Sustainable construction is a complex issue that requires collaboration from all sectors, including individuals and organizations. Local bodies can play a pivotal role in facilitating these partnerships by engaging local builders, architects, and developers in discussions about sustainable construction practices. They should encourage the adoption of green building principles, energy-efficient designs, and eco-friendly construction materials in their projects. Establish platforms for knowledge exchange, such as workshops or forums, where stakeholders can share best practices, innovative ideas, and success stories within the local construction community (Jeffery, 2009). Partner with environmental organizations to gain insights into the latest sustainable technologies, materials, and practices. Engage with educational institutions to promote sustainability education within the construction sector.

Leverage industry associations to align municipal policies with industry trends and standards. Establish joint initiatives that address specific sustainability challenges in the local construction industry and collaborate on pilot projects that showcase the feasibility and benefits of sustainable construction practices (Hamdan et al., 2021). Provide incentives for collaboration and highlight successful partnerships to inspire others to join the sustainability movement. By fostering collaboration with a diverse range of stakeholders, local government can build a strong foundation for the widespread adoption of sustainable building practices, contributing to the overall resilience and eco-friendliness of the built environment (Nelson, 2017).

Addressing climate change is a multifaceted challenge that demands cooperation across all sectors, encompassing individuals and organizations alike. Engaging the public through participatory means, such as online deliberation and citizens' assemblies, facilitates inclusive problem-solving and the formulation of climate action policies. Governments play a pivotal role in educating individuals on sustainable consumption practices and behaviors, including ethical investment, adoption of electric vehicles, retrofitting of homes for energy efficiency, and dietary changes. A "just" transition requires government investment, support, and careful targeting of interventions to ensure fair distribution of costs and benefits (Atalla et al., 2021).

G. Promoting Community Awareness and Education:

Local bodies can foster a culture of sustainability by actively promoting community awareness and education initiatives. This involves launching targeted awareness campaigns, hosting educational workshops and seminars, organizing informational sessions, implementing community engagement programs, partnering with educational institutions, establishing demonstration projects, developing online resources, introducing incentive programs, identifying and celebrating local sustainability champions, and establishing feedback mechanisms (UN, 2013). Awareness campaigns can be launched through various communication channels, such as social media, local newspapers, and community bulletins, to convey the benefits and importance of sustainable construction practices. Educational workshops and seminars can focus on green building practices, energy-efficient technologies, and the positive impact of sustainable development on the environment and quality of life. Informational sessions can bring together local experts, environmentalists, and industry professionals to share insights on eco-friendly building materials and energy conservation measures. Community engagement programs can involve residents in sustainable construction initiatives, such as participatory events, green building contests, or collaborative projects. Partnerships with educational institutions can enhance awareness among students and create a ripple effect as they share their knowledge with their families and communities (Jacob et al., 2015). Demonstration projects can showcase how green features can be seamlessly integrated into buildings, positively impacting energy efficiency, water conservation, and overall environmental health. Online resources, such as informational websites or portals, can serve as hubs for residents to access relevant materials, guidelines, and success stories related to green building

practices. Incentive programs can encourage residents and businesses to adopt sustainable construction methods, including recognition awards and tax incentives (Circo, 2007). Recognizing local sustainability champions within the community can inspire others to follow suit.

H. Setting a Sustainable Standard for National Inspiration

The public sector is a major contributor to climate change and environmental harm and is exalting to its maximum as the rate of development progresses. To address this, local governments should focus on identifying and mitigating environmental impacts. This includes monitoring and publishing carbon emissions, embracing carbon offsetting and removal, decarbonizing public buildings, and electrifying vehicle fleets. Reforming public procurement can improve carbon footprints and encourage sustainable consumption practices. Local governments should also harmonize sustainability reporting frameworks and upskill staff with appropriate data capabilities. Internationally, Nordic countries are increasingly recognized as pioneers in sustainability reporting. Finland's State Treasury, for instance, advocates for annual sustainability reports, while Herning in Denmark has been publishing "green" accounts since 2012 (referencing Walton, 2021). Additionally, the DK2020 project assists 20 municipalities in aligning their climate action endeavors with the objectives of the Paris Agreement (**Lorimer, 2021)**.

5.5. Conclusion

Despite the recognition of the importance of GSCM and sustainability, there is a gap in implementing GSCM practices and prioritizing sustainability. The study underscores the importance of worker safety, inclusive practices, fair labor standards, ethical sourcing, equitable distribution of benefits, community engagement, and preservation of cultural heritage. Energy efficiency, cost-saving measures, and resilience planning are essential for sustainability and the well-being of future generations.

The Delphi exercise analyzed the sustainable construction sector in India, identifying 45 sustainability criteria. The analysis, involving 24 experts, identified environmental sustainability, resource efficiency, regulatory compliance, stakeholder engagement, and technological innovation. Key findings emphasize factors such as material sourcing and usage, transportation efficiency, waste reduction strategies, stakeholder collaboration, and environmental regulations. These criteria serve as guiding principles for stakeholders in

the Indian construction sector, providing a roadmap for integrating sustainable practices into their supply chain operations.

The Green Supply Chain Management (GSCM) framework is a comprehensive strategy aiming to drive sustainable construction in India. It involves policies, stakeholder engagement, and strategic interventions to foster a sustainable construction ecosystem. The framework emphasizes the collective responsibility of government bodies, industry stakeholders, NGOs, and local communities in implementing sustainable construction.

Chapter VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

The construction sector plays a notable role in global GHG emissions and natural-resource depletion, prompting to focus on green supply chain principles. This study aims to assess key processes within the Indian construction sector that could integrate green supply chain principles, focusing on the unique challenges and opportunities in the Indian context. The objectives include identifying key processes that can effectively incorporate green supply chain principles, analyzing specific issues in the Indian context, identifying policy elements that influence green supply chain practices, and presenting a conceptual framework for intervention. The ultimate goal is to catalyze transformative change within the industry, aiming for carbon-neutrality. The study aims to provide actionable insights and strategic recommendations to drive progress towards a more sustainable and ecologically responsible construction industry. The study's findings will help policymakers at both national and local levels to adopt green supply chain principles and promote a more sustainable future.

6.2. Summary

The study sought to evaluate pivotal processes within India's construction industry for their potential to embrace green supply chain principles. It focused on specific challenges unique to the Indian context across different phases including design, procurement, transportation, implementation, and waste management. Furthermore, it aimed to identify policy factors in India that impact the integration of green supply chains in construction and propose a unified framework. Lastly, the study presented a conceptual model for policymakers to intervene at both national and local levels, with the goal of greening the construction sector and achieving carbon neutrality. The thesis embarked on a thorough exploration of the "*Green Transformation Of Supply Chains In Indian Construction Sector Through Policy Interventions,*" covering various aspects ranging from theoretical foundations to practical investigations. This summary chapter encapsulates the significant insights and contributions from each chapter, providing a cohesive understanding of the research journey.

The first chapter **introduction** sets the stage for the thesis by establishing the context, significance, and objectives of the study. It provides a roadmap for the subsequent chapters, outlining the research questions, hypotheses, and methodology.

1.1 Background and Rationale: This section offers insights into the broader context of supply chain management, highlighting its significance in various industries, including construction. It identifies challenges within the construction supply chain and emphasizes the emerging importance of green supply chain management practices.

1.2 Problem Statement: The problem statement articulates the specific issue or gap in the literature that the thesis aims to address. In this case, it may focus on inefficiencies, environmental impacts, or sustainability challenges within the construction supply chain.

1.3 Research Objectives: The research objectives delineate the goals and aims of the study, providing a clear direction for the research endeavor. These objectives serve as guiding principles for data collection, analysis, and interpretation.

1.4 Significance of the Study: This section underscores the importance of the research within the broader scholarly discourse and practical implications for industry stakeholders. It highlights the potential impact of addressing the identified gaps in knowledge.

1.5 Research Questions: The research questions frame the inquiry and guide the investigation into specific aspects of the research topic. They serve as focal points for data collection and analysis, aiming to uncover insights and solutions.

1.6 Scope of the Research: The scope of the research delineates the boundaries and limitations within which the study operates. It clarifies the specific aspects of the research topic that will be explored and the exclusion criteria.

1.7 Limitations of the Research: Acknowledging the limitations of the study is essential for maintaining transparency and credibility. This section highlights potential constraints, such as sample size limitations, data availability issues, or methodological constraints.

1.8 Research Methodology Overview: This segment offers a synopsis of the research methodology utilized in the study, encompassing the research design, data collection methods, and ethical considerations.

1.9 Thesis Organization: Finally, the chapter concludes by outlining the organization of the thesis, providing a roadmap for readers to navigate through the subsequent chapters and sections. It sets expectations for what will be covered in each part of the thesis.

Chapter 2 of the thesis, the Literature Review, critically evaluates existing scholarship pertaining to the research topic. Through a systematic synthesis of theoretical perspectives, empirical studies, and conceptual frameworks, it sheds light on key themes, debates, and trends in the field. This comprehensive review not only informs the theoretical framework but also identifies areas of convergence and divergence in existing knowledge, paving the way for novel insights.

2.1 Introduction: The chapter begins with an introduction that sets the stage for the literature review, outlining its purpose and scope within the broader context of the research topic.

2.2 International Perspectives: This section delves into international literature, focusing on sustainability and the construction sector. It explores various dimensions such as performance evaluation, energy management, waste management, transportation, and the role of Sustainable Development Goals (SDGs). Additionally, it examines supply chain management in the construction sector, including factors affecting SCM, risk management, monitoring, and operational performance. The section also discusses drivers and barriers in Green Supply Chain Management (GSCM), frameworks for GSCM, policy-level interventions, and the application of the Delphi Method.

2.3 National Perspectives: Similarly, this section explores literature from a national perspective, examining sustainability and the construction industry in the context of the specific country. It covers performance evaluation, energy management, waste management, and transportation issues. Additionally, it discusses SCM in the construction industry, focusing on GSCM monitoring. Like the international section,

it addresses drivers and barriers in GSCM, frameworks, policy-level interventions, and the use of the Delphi Method.

2.4 Gap Identification: Literature Review: The chapter concludes by identifying gaps in the existing literature. This critical analysis highlights areas where further research is needed, whether in terms of theoretical development, empirical investigation, or practical application. These identified gaps serve as the foundation for the subsequent chapters of the thesis, guiding the research toward generating new knowledge and insights.

Chapter 3 of the thesis, the Theoretical Framework, serves as the conceptual scaffolding for the study, drawing on established theories and models to interpret the research findings and guide the analysis. It ensures methodological rigor and coherence in the study's approach by elucidating the theoretical underpinnings of the research.

3.1 Introduction: The chapter begins with an introduction that sets the stage for the theoretical framework, outlining its purpose and scope within the broader context of the study.

3.2 Holistic Vision of Green Transformation: This section presents a holistic view of green transformation, encompassing concepts such as Life Cycle Assessment (LCA), Green Supply Chain Management (GSCM), Circular Economy, and the role of institutional theory in innovation-decision. It also explores the supply chain as the engine of change, emphasizing SCM principles, GSCM practices, reverse logistics, green procurement, and Corporate Social Responsibility (CSR).

3.3 Policy/Legal Framework: Here, the chapter discusses policy and legal frameworks that influence green transformation, including incentive mechanisms, waste management policies, public procurement policies, green certification programs, and environmental regulations.

3.4 Research & Development and Collaborative Platforms: Expert-Driven Consensus Building: This section outlines the use of expert-driven consensus-building methods, particularly the Delphi Method, for gathering insights and recommendations. It covers expert panel selection, iterative questioning processes,

anonymity, confidentiality, data integration, consensus building, and policy recommendations.

3.5 GSCM Implementation Framework: The chapter presents an implementation framework for GSCM, incorporating elements such as Life Cycle Assessment, Circular Economy principles, and green certification for sustainable technologies.

3.6 Regulatory Policies and Financial Frameworks: Here, the discussion extends to regulatory policies and financial frameworks that support green transformation efforts.

3.7 Integration of Theoretical Concepts: Finally, the chapter integrates theoretical concepts, emphasizing the role of the supply chain in green practices, the alignment of policy formulation with supply chain principles, the iterative nature of the Delphi Method, and the synergy across various theoretical frameworks.

Chapter 4 of the thesis, the Research Methodology, provides a comprehensive overview of the approach and procedures employed to address the research objectives. Through a detailed delineation of the research design, methods of data collection, sampling strategy, and analysis (data) techniques, this chapter ensures transparency and rigor in the research process, enhancing the credibility and validity of the findings.

4.1 Introduction: The chapter begins with an introduction that sets the stage for the research methodology, emphasizing the importance of adopting a robust approach to address the research questions (RQs).

4.1.1 Research Analytics: This section discusses the research analytics employed, particularly the use of a Multiple Research Approach - Triangulation, which involves integrating various data sources and methodologies to enhance the quality (reliability & validity) of the research findings.

4.2 Research Methodologies Adopted: Here, the chapter elaborates on the specific methodologies employed in the study, including:

- **Literature Survey:** The document outlines guidelines for conducting a literature survey and presents various methodologies, including Narrative Reviews, Mapping

or descriptive reviews, Scoping Reviews, Aggregative Reviews, Realist Reviews, and Critical Reviews. Additionally, the chapter delves into the systematic literature review (SLR) approach.

- **Semi-structured Interviews:** This section outlines the process of conducting semi-structured interviews, including data collection and analysis.
- **Case Studies:** The chapter details the approach to conducting case studies, covering both data collection and analysis procedures.
- **Questionnaire Survey:** It discusses the development, dissemination, and response rate of the questionnaire survey, highlighting the advantages of this method.
- **The Delphi Method:** Pros and cons of the Delphi method are presented, along with its scope, specificity, expert panel selection, and potential contributions to the research.
- **Triangulation:** The chapter explains the concept of triangulation, which involves integrating multiple data sources to corroborate research findings and enhance validity.

4.3 Data Analysis: Finally, the chapter discusses data analysis techniques, including assessing the 'quality of research' in terms of reliability, validity, credibility, transferability, dependability, and confirmability. It emphasizes the importance of using multiple techniques and ensuring thick descriptions, reflexivity, and peer debriefing to enhance the quality of both quantitative and qualitative research.

Chapter 5 of the thesis, Results and Discussion, delves into the empirical findings of the study and critically engages with their implications. Through a systematic analysis of the data collected, this chapter addresses the research questions and hypotheses, offering insights into the phenomenon under investigation. It contextualizes the findings within the theoretical framework and existing literature, fostering theoretical reflexivity and advancing scholarly discourse.

5.1 Introduction: The chapter begins with an introduction that sets the stage for presenting the empirical results and discussing their significance.

5.2 Key Processes in the Construction Sector: This section examines various key processes in the building segment, including the design phase, procurement, construction practices, transportation and logistics, and post-construction stages. It also identifies factors specific to the Indian construction supply chain that could facilitate a "green shift."

5.3 Specific Issues in the Indian Construction Supply Chain Concepts: Here, the chapter addresses socio-economic-environmental sustainability criteria and discusses sustainability gaps, barriers to GSCM, its implementation, and associated benefits. It also conducts a SWOT analysis and proposes a unified strategy.

5.4 The Imperative of Policy Mapping for Addressing Sustainability Gaps: This section emphasizes the importance of policy mapping for addressing sustainability gaps in the construction sector. It discusses the Delphi analysis process and presents the results, including GSCM criteria, policy criteria, and conceptual frameworks.

5.5 Stakeholder Analysis and Conceptual Framework for Green Supply Chain Implementation: The chapter explores stakeholder analysis for sustainable construction via GSCM in the Indian context. It presents a roadmap for local governments' priorities, outlines a conceptual model for policy change, and discusses implementation strategies, impact assessment, case studies, best practices, recommendations, and a roadmap for green supply chain practices.

5.6 Conclusion: Finally, the chapter concludes by summarizing the key findings and insights derived from the empirical analysis, highlighting their significance for advancing sustainable practices in the construction sector.

This Research thesis makes a significant contribution to the field of green-supply-chain management by amalgamating theoretical insights, empirical evidence, and methodological approaches. It clarifies crucial themes, identifies gaps, and presents innovative viewpoints, thereby enhancing comprehension and setting the stage for future investigations. The introductory chapter establishes the framework for the study, delineating its justification, objectives, and methodology. Chapter 2 offers a comprehensive examination of existing literature, synthesizing perspectives from both international and national sources. Chapter 3 integrates established theories and models to

inform the analysis and interpretation of research outcomes, ensuring methodological rigor and coherence. Chapter 4 provides a thorough overview of the research methodologies utilized, guaranteeing methodological rigor, transparency, and validity throughout the research process. It establishes the groundwork for robust data retrieval and analysis, thereby bolstering the credibility and reliability of the research findings.

6.3. CONCLUSION

The construction industry is increasingly promoting sustainable practices at every stage of construction, including design, material procurement, transportation, energy efficiency, waste management, and post-construction phases. Sustainable design practices, such as energy efficiency and life cycle assessments, are crucial. Material procurement strategies prioritize sustainable sourcing, including recycled content and locally available materials. Construction planning involves waste management strategies to minimize waste and optimize resource utilization. Eco-friendly techniques, energy-efficient equipment, and renewable energy integration are implemented. Transportation and logistics are optimized for efficiency and reduced emissions. Water conservation measures are integrated into construction activities. Beyond the construction phase, site management strategies preserve biodiversity and certifications like LEED, BREEAM, or GRIHA are pursued. Stakeholder engagement promotes awareness and adherence to sustainable practices. Post-construction, occupant training, commissioning, and monitoring ensure efficient building operations. Recycling and reuse of construction waste, along with legal compliance with environmental regulations, are integral components of a sustainable construction supply chain.

The Indian construction sector faces 28 obstacles in implementing Green Supply Chain Management (GSCM) practices, including existing laws, corporate policies, carbon emission audits, global green market, FDI, special tax exemptions, cost-efficient products, and an intelligent approach to local environment. Legislative strategies can help overcome these barriers and accelerate transformation. The study highlights the need for more effective GSCM practices in the Indian construction industry, with strategic opportunities for implementing GSCM in the sector. The Indian construction sector faces a complex challenge in integrating green supply chain concepts from the design phase to waste recycling. Challenges include procurement strategies, transportation logistics, execution

methodologies, and sustainable waste management practices. Green structures require energy-efficient architecture, responsible material choices, and life cycle assessments. Procurement faces challenges in sustainable material sourcing and localization to reduce environmental impacts. The execution phase requires incorporating green construction techniques like modular construction and prefabrication, along with energy-efficient equipment. Waste management planning is crucial to minimize construction waste and requires comprehensive recycling strategies. India faces sustainability gaps in implementing sustainable practices in construction projects, including a lack of green building practices, infrastructure deficiencies, urban sprawl, resource depletion, and social equity concerns. To address these challenges, India needs a multi-stakeholder approach, including promoting sustainable practices, enhancing resource efficiency, and safeguarding natural ecosystems. The Indian construction sector faces several challenges in implementing Green Supply Chain Management (GSCM), including legal frameworks, corporate policies, foreign direct investment, financial incentives, and customers seeking green products. Logistical, technical, social, economic, regulatory, and administrative barriers hinder the implementation of GSCM. Legislative pressure, corporate matters, global market, financial factors, customer demand, operational performance, and financial factors drive the adoption of green products. Logistics barriers include green materials, suppliers, technologies, legislation, lack of expertise, social barriers, economic barriers, regulatory barriers, and administrative difficulties. GSCM promotes environmental sustainability and reduces waste generation, resulting in cost savings, operational efficiency, and enhanced brand reputation. To successfully implement GSCM, the sector must adopt a unified strategy, including examining obstacles, investing in capacity building, promoting policy advocacy, and fostering a culture of continuous improvement and learning.

Policy mapping is a strategic method used to identify sustainability gaps in industries, particularly in the construction sector. In India, the building segment plays a fundamental role in shaping the sustainability landscape, with the formulation and implementation of policies wielding significant influence over the adoption of green initiatives within the construction supply chain. The National Building Code (NBC), ECBC, Smart Cities Mission, Heritage Conservation Policies, Environmental Impact Assessment Notification, National Urban Housing and Habitat Policy, National Skill Development Policy, National

Electronics Policy, National Urban Transport Policy, National Water Policy, and National Disaster Management Policy are some of the direct influences on the country's design and planning.

The Delphi method, combining qualitative and quantitative data collection, was used to analyze the sustainability of the Indian construction sector. The analysis involved three rounds: identifying GSCM criteria, examining policy elements influencing GSCM implementation, and elucidating the importance of a conceptual framework. The results of the analysis were presented in a summary, which aims to inform stakeholders, policymakers, and industry practitioners about sustainable practices in the sector.

The study identified 45 critical environmental sustainability criteria for the Indian construction sector's green transformation of supply chain elements, forming a conceptual framework for policy interventions. Notable points include the flexibility and scalability of GSCM practices, the importance of experienced stakeholders, challenges in SCM, Return on Investment (RoI), higher recycling costs and expenses for green products, GSCM improving cost efficiency and risk management, fostering multi-layer collaboration networks, the need for comprehensive policy interventions and technological advancements, the design stage playing a critical role in cost management, stakeholder engagement, and resource optimization in construction projects, Enterprise Resource Planning (ERP) systems enhancing organizational efficiency, planning and scheduling integral to GSCM, the importance of procurement, transportation, and construction, labour-only subcontracting complicating project management due to multiple tiers of subcontractors and coordination challenges, and the integration of AI and IoT with field surveys enhancing transportation supply chain functionality.

The Delphi analysis underscores the importance of developing a viable strategic framework for GSCM implementation in the Indian construction sector, underpinned by policy-level interventions. This framework serves as a strategic tool for navigating the complexities of the construction SC, driving innovation, and fostering a culture of sustainability.

India's rapid urbanization and infrastructure development are driving a shift towards sustainable construction practices. GSCM is a strategic framework that integrates sustainability into every phase of the construction supply chain. Policy change is crucial in

steering the sector towards green practices, setting industry norms, and incentivizing environmentally responsible decision-making. CFW is useful in defining goals, identifying stakeholders, formulating policies, highlighting interdependencies, setting objectives, incorporating best practices, monitoring and evaluating, communicating concepts, and adapting to context. Stakeholders suggest policy modifications, which are then reviewed by state-level authorities for feasibility studies. If the analysis fails to meet sustainability goals, decisions are forwarded back to stakeholder level for further development.

Policy Landscape Analysis is a crucial step in understanding the regulatory framework for construction, environmental sustainability, and supply chain practices. It involves identifying existing policies, gap analysis, and assessing enforcement mechanisms. This analysis helps identify loopholes, ambiguities, and areas for policy reform. The effectiveness of enforcement mechanisms is also assessed, evaluating regulatory bodies, inspection processes, and penalties.

Stakeholder Mapping is a crucial process for understanding the sustainability initiatives in the Indian construction sector. It involves identifying, categorizing, and understanding the interests and influence of various stakeholders, including government bodies, regulatory agencies, industry players, NGOs, local communities, and academia. These stakeholders play a crucial role in policy formulation and change, ensuring comprehensive, diverse, and effective policies that address the needs of different interest groups.

Pressure/Driver-Barriers Analysis: Unveiling Challenges in Green Supply Chain Implementation:

The Indian sector encounters hurdles in pinpointing the primary drivers for Green Supply Chain Management (GSCM) implementation. These drivers encompass various factors such as existing laws and regulations, corporate policies, carbon emission audits, global green markets, foreign direct investment (FDI), special tax exemptions, cost-effective products, and a strategic approach suiting to local environments. Conversely, barriers identified for GSCM implementation encompass challenges like the unavailability of green materials, the prevalence of economic-centric linear supply chains, difficulties in identifying and auditing supplier performance, issues related to novel technologies, and other legal considerations regarding adoption. Furthermore, logistical barriers encompass disputes with clients, apprehensions regarding technology transfer and inefficiency,

uncertainties surrounding return on investment (RoI), the intricacy of new policies and regulations, and inefficiencies in addressing challenges posed by the Internet of Things (IoT).

Conceptual Model for Policy Change: Fostering Sustainable Construction through GSCM:

The construction sector needs a comprehensive policy change model that promotes sustainable practices through Green Supply Chain Management (GSCM). This model combines policy reformulation, strategic incentives, and effective monitoring to steer the sector towards sustainability. Policy reformulation involves conducting thorough research, analyzing existing policies, engaging with stakeholders, and incorporating green elements. Incorporating green elements can be achieved through policy amendment proposals, benchmarking against international best practices, and incorporating elements from other regions that align with local context and industry needs.

Measurement and Reporting: Ensuring Accountability and Transparency

To improve GSCM in the construction sector, several best practices can be implemented. These include establishing monitoring systems using Key Performance Indicators (KPIs), real-time monitoring using technology, mandatory reporting requirements, and integrated reporting. Transparency platforms should be established, annual sustainability reports should be mandated, third-party audits should verify the accuracy of sustainability reports, certification programs should encourage participation in external assessments, incentive-based compliance should be introduced, and continuous improvement plans should be established. Public engagement and training programs can enhance compliance, and knowledge sharing platforms can facilitate sharing of best practices among stakeholders.

Implementation Strategies for GSCM in the construction sector require capacity building and collaboration among key stakeholders. A two-pronged approach is needed: enhancing stakeholder capacity through educational programs and fostering collaboration among government, industry, and NGOs. Educational programs targeting government officials, industry professionals, and workers enhance their understanding of GSCM principles. Certification programs validate expertise and establish a skilled workforce capable of implementing sustainable practices. Collaborative initiatives, such as Public-Private

Partnerships (PPPs), NGOs, and industry associations, promote synergy and facilitate the exchange of resources, expertise, and best practices.

The article highlights the importance of showcasing success stories and learning from best practices in Green Supply Chain Management (GSCM) for policy change. It highlights how countries with robust GSCM policies have reduced environmental impact, improved resource efficiency, and increased industry competitiveness. Local triumphs in implementing policy reforms are also discussed, suggesting lessons from successful practices.

The construction industry is undergoing a significant transformation towards green supply chain practices, which are essential for reducing environmental impact and promoting eco-friendly practices. A roadmap for green supply chain practices in construction includes policy formulation, stakeholder consultation, regulatory framework strengthening, incentive mechanisms, capacity building programs, information dissemination and awareness, collaboration initiatives, monitoring and reporting mechanisms, performance metrics and KPIs, a continuous improvement framework, research and development support, collaboration with international organizations, public disclosures and transparency, and regular policy reviews. The goal is to develop and refine policies that explicitly endorse and mandate green supply chain practices in construction, ensuring alignment with local industry needs and fostering collaboration among stakeholders.

The Indian construction sector is set to implement a comprehensive strategy to enhance sustainability practices through a roadmap for GSCM enforcement. The roadmap focuses on stakeholder engagement, regulatory strengthening, incentive mechanisms, capacity building through educational programs and training workshops, information dissemination and awareness campaigns, collaboration with the private sector, NGOs, and industry associations, robust monitoring and reporting mechanisms, performance metrics and key performance indicators (KPIs), innovation and knowledge exchange through collaboration with international organizations, public disclosures and transparency initiatives, and regular policy reviews.

The GSCM framework is a comprehensive strategy that aims to drive sustainable construction in India. It involves policies, stakeholder engagement, and strategic interventions to foster a sustainable construction ecosystem. GSCM is not just a set of

practices but a holistic approach that integrates environmental responsibility, economic viability, and social equity within the construction supply chain. It addresses policy gaps, fosters stakeholder collaboration, and provides actionable strategies for real-world implementation.

Stakeholder analysis is a key component of the GSCM framework in an Indian scenario. Stakeholders include government agencies, industry associations, environmental groups, and construction companies, with interests ranging from regulatory compliance to environmental sustainability and economic development. Stakeholder analysis helps in informed decision-making, conflict resolution, and enhanced collaboration for more sustainable initiatives.

Local governments can significantly promote sustainable construction by overcoming economic, political, regulatory, and financial obstacles. By adopting five key actions, they can create an environment conducive to sustainable construction, contributing to community well-being and environmental health. These actions require a coordinated, long-term commitment, and are imperative for a sustainable future to achieve a balance among ecological, economic, and societal outcomes.

6.3.1. Achieving the Objectives

6.3.1.1. Achieving objective 1: Assessing the key processes in construction sector having the potential to introduce green supply chain principles

The SLR, Case study and Delphi method (described in Section 4.3) were used to meet this objective. Questionnaire survey and systematic semi structured interviews also followed as part of the case study. Major events discussed by researchers globally and its viability, adaptability, adoption and contemporary practice were analysed throughout the case study#1. The five-element supply chain serving the processes starting from prefeasibility /feasibility study to utilization phase (described in Section 5.2). The three rounds of Delphi culminated in the identification of six Green Supply Chain Management (GSCM) components that were affirmed by the respondents as significant criteria (further elaborated in section 5.2.1). The developed criteria encompassed:

1. Enterprise resource planning (ERP)
2. Information Transparency (IT)

3. Reverse Logistics (RL)
4. Customer Satisfaction (CuS)
5. Yard Logistics (YL)
6. Green Energy (GE)

ERP focuses on process mapping, IT builds trust, reverse logistics reduces costs, and CS activates supply chains for innovative partners. Yard logistics faces challenges like late cargo or trailer loss, while green energy is crucial for clean, reliable power. Policy plays a significant role in renewable energy expansion. Three interviewees (a total of three) and thirty professional experts (a total of thirty respondents) were given the opportunity to remark on any of the matters included in the interview statement/guideline or the questionnaire in three of the research's techniques (the semi-structured interviews and questionnaire survey included within case study #1, directed to all three levels of stakeholders). There were no unfavourable remarks made by respondents or interviewees regarding the sustainability components' capacity to apply GSCM in Indian CS.

6.3.1.2. Achieving objective 2: To develop the/actors that are important/or UK public clients to better address sustainable construction in developing a procurement strategy

Objective 2 addressed the main obstacles and drivers for sustainability as well as what would allow the stakeholders to more effectively address these considerations. While Objective 1 concentrated on identifying the key processes and strategies to furnish the green shift to promote sustainability in the Indian CS. Employing a triangulation approach, both Systematic Literature Review (SLR) and semi-structured interviews were utilized to pinpoint the pivotal factors for Indian corporate sectors to enhance their approach towards sustainable construction, facilitate a paradigm shift towards green supply chain management, and craft an implementation strategy for furthering these objectives (#4). By using this method, reliability and validity were increased and findings were more confidently obtained (see Section 3.4.3). A total of 36 issues were found under seven primary categories; all of these were identified through the SLR exercise and validated by interviews (specifics are given in Chapter 5 & Table 5.6). Among them were:

1. Administrative Barriers (AB)
2. Fiscal Barriers (FB)

3. Operational Barriers (OB)
4. Technical Barriers (TB)
5. Regulatory Barriers (RB)
6. Corporate matters/Barriers (CB)
7. Logistic Barriers (LB)

6.3.1.3. Achieving objective 3:Identification of Policy elements in India which has direct and indirect influence on the green supply chain in construction industry and exploring their integration into a unified framework.

SLR, semi-structured interviews, and Delphi exercises were the primary methods used to accomplish Objective 3. For the purpose of cross-verifying the mapped policies, which affect Indian CS both directly and indirectly, was to confirm the effectiveness of policy interventions, a major challenge. This is greatly aided by the open-ended questions asked during the interviews for Case Study #2 (discussed in Section 5.3) and the elaborate questions asked during Delphi Round 1 (RQ1 and 2), which generously mapped Objective 3 of the research. The analysis (triangulation) of the responses gathered resulted in the confirmation of policies that play a part in the effective implementation of GSCM (discussed in Table 5.7). The principal rules are:

A. DESIGN AND PLANNING

1. National Building Code (NBC)
2. National Skill Development Policy
3. ECBC
4. National Policy on Electronics
5. Smart Cities Mission
6. National Urban Transport Policy
7. Heritage Conservation Policies
8. National Water Policy
9. Environmental Impact Assessment (EIA) Notification
10. National Policy on Disaster Management
11. National Urban Housing and Habitat Policy

B. PROCUREMENT

1. Public Procurement (Preference to Make in India) Order

2. National Skill Development Policy
3. Goods and Services Tax (GST)
4. National Policy on Electronics
5. Model Tender Document by Ministry of Finance
6. National Water Policy
7. Defence Procurement Procedure (DPP)
8. National Urban Transport Policy
9. Guidelines for Procurement of Goods, Works, and Services under National Disaster Response Fund (NDRF)
10. National Steel Policy

C. CONSTRUCTION

1. National Building Code (NBC)
2. National Urban Transport Policy
3. The building and other construction workers act, 1996
4. National Solar Mission
5. The contract labour act 1970
6. National Water Policy
7. Real Estate (Regulation and Development) Act, 2016 (RERA)
8. Swachh Bharat Mission
9. Environmental Impact Assessment (EIA) Notification
10. National Policy on Electronics
11. Goods and Services Tax (GST)
12. Make in India Initiative
13. Smart Cities Mission
14. The occupational health and working condition code 2020
15. New labour code 2022

D. TRANSPORTATION

1. National Highway Policy
2. National Urban Transport Policy
3. Metro Rail Policy
4. Goods and Services Tax (GST) Policy
5. Freight Corridor Policies

6. National Skill Development Policy
7. Public Procurement Policies for Construction
8. National Policy on Electronics
9. National Water Policy

E. CONSTRUCTION WASTE MANAGEMENT

1. Solid Waste Management Rules (2016)
2. National Environment Policy (2006)
3. E-Waste (Management) Rules (2016)
4. Goods and Services Tax (GST) Policy
5. Plastic Waste Management Rules (2016)
6. National Skill Development Policy
7. Extended Producer Responsibility (EPR)
8. National Urban Transport Policy
9. National Building Code (NBC)
10. National Water Policy

6.3.1.4. Achieving objective 4: Presenting a conceptual framework to the attention of policy makers at national and local level for necessary interventions to green the construction sector with the objective of achieving the ultimate goal of carbon-neutrality in the sector.

The SLR, semi-structured interview, and Delphi survey were utilized to accomplish this goal. The multilevel stakeholders (described in Section 5.5.2) who are in charge of or engaged in building and related development were the target audience. Similar to the conclusions of Case Study #2 (section 5.3.4), the outcomes support the need for and efficacy of a conceptual framework. The results show that the authorities adhere to (or intend to adhere to) policies/ strategies/ guidelines/ procedures that indicate the necessity of addressing all eco-environmental considerations (which were included in the questionnaire) and the majority of social and economic sustainability considerations in the contracts or procurement strategies for their construction projects.

The study reveals that authorities are not fully involved in policy-level intervention to optimize GSCM implementation and address sustainability criteria. The reliability test confirms acceptable internal inconsistency, with Cronbach alpha values of 0.5 (>0.7 or

higher indicating acceptable consistency). Lower responses may be due to ignorance or less research on the topic, requiring further attention to meet these criteria.

Case study #2 especially reveals that local authorities could effectively incorporate sustainability criteria into their strategies, policies, and procedures to provide effective construction supply chain management. Barriers that arose during the pandemic created a green inclination, which has been achieved through stringent policy implementation. The outcome was a green shift and a carbon-neutral supply chain. This includes raising awareness, developing policies, providing guidance, setting targets, implementing regulations, highlighting environmentally and socially responsible goods and services, adopting design standards, considering sustainability criteria in contract strategies, evaluating tenderer performance, promoting vendor compliance, managing risks, linking procurement to national initiatives, and collaborating with officers and specialists.

As summary, this discusses the strategies for addressing sustainability in construction supply chain management. The study recommends a governmental stance towards best value, incorporating sustainability as a primary objective in strategic plans, formulating an environmentally and socially conscious Green Supply Chain Management (GSCM) policy, highlighting the importance of sustainable construction across the supply chain, fostering dedication to sustainable construction through newsletters and stakeholder meetings, conducting sustainability assessments within the contracting strategy, and overseeing project operations through a strategic GSCM unit to ensure sustainability permeates all supply chain aspects.

6.3.2. The contribution of the study

6.3.2.1. Inferences:

The construction sector in India has the potential to integrate green supply chain principles across various processes, including design and waste recycling. However, specific challenges unique to the Indian context hinder seamless integration. Policy elements in India exert both direct and indirect influence on the adoption of ‘green’ SC practices in construction. Some policies support sustainability initiatives, while others present barriers that need to be addressed for effective integration.

This thesis tackles the absence of universally accepted, thorough, and evidence-supported sets of social, economic, and environmental sustainability criteria in formulating a green construction supply chain management strategy. It affirms the complete spectrum of

sustainability criteria that stakeholders should consider when addressing the Indian construction industry, ensuring no principles are overlooked. The research explores the potential of GSCM implementation in the Indian construction segment, using a comprehensive approach to analyze existing policies and regulations, focusing on their alignment with sustainable practices and GSCM principles.

The study aims to assess the policy landscape, identify GSCM effectiveness, develop a robust policy framework, and validate the framework through stakeholder consultations and expert reviews. The findings underscore the importance of GSCM in fostering sustainability in the Indian construction sector and serve as a blueprint for policymakers to enact legislation conducive to sustainable construction practices.

The thesis presents two case studies about two habitats addressing construction and infra-development organizations, one demonstrating successful green adoption for sustainable construction and the other as a good example for effective implementation of GSCM. Conclusions have been made regarding how Indian corporate sectors are addressing sustainability, particularly certain sustainability criteria, in their supply chain strategies, policies, guidelines, or procedures.

The discoveries made in this thesis have been presented;

- Methodological contributions include triangulation, the Delphi Method, and eclectic (for case studies).
- Delphi method used for stakeholder analysis, sustainability criteria procurement, and conceptual framework development.
- Eclectic approach promotes methodological diversity and flexibility.
- Framework developed to assist authorities in developing a sustainable supply chain management (GSCM) strategy.
- Overcomes confusion and disagreement in addressing sustainable supply chain management.
- Triangulation extends theory scope, improves reliability and validity of results.
- Donates to the development of construction SCM by reviewing Indian construction practices.

6.4. RECOMMENDATIONS

Promoting environmentally friendly building construction strategy is greatly aided by governmental and regulatory organizations. They ought to enhance their sustainability publications, reevaluate the financial constraints placed on public clients' expenditures, and broaden the regulations' purview to cover a greater spectrum of sustainability-related concerns. Organizations in the public sector ought to follow the law and offer sustainability-related training. All stakeholders should be involved, sustainability should be emphasized in project briefings, contract specifications, and evaluation processes, and payment systems should be connected to sustainability standards. Professional associations and educational establishments ought to promote sustainability and include sustainability principles into their policies and curricula.

6.4.1. Guidance for Governmental and Regulatory Entities

6.4.1.1. Advancement of Sustainable Construction Agenda

- Governments and regulatory bodies need to give precedence to a holistic sustainable construction agenda.
- They must demonstrate dedication, leadership, and responsibility in furthering the sustainability agenda.

6.4.1.2. Government's Sustainability Publications

- The government's publications on sustainability need improvement in quality and quantity.
- The introduction of new definitions and requirements for sustainable construction has added confusion among practitioners.
- The content of these publications might not align with the requirements of public sector practitioners in search of explicit guidance.

6.4.1.3. New *Strategy* for Sustainable Construction

- Governments should develop a new strategy focused on sustainable construction.
- The strategy should include policies, regulations, incentives, and capacity-building initiatives.
- The strategy should focus on actions and deliverables contributing to the sustainability target of green construction.

6.4.1.4. ***Reconsidering*** **Financial Restrictions**

- Governments should reconsider existing financial restrictions that may hinder the adoption of sustainable construction practices.
- This may involve revising budget allocations, offering subsidies or grants for sustainable projects, and exploring innovative financing mechanisms.

6.4.1.5. ***Separation*** **between Capital-Operational Budgets**

- Governments should consider implementing a clear split between operational & capital budgets.

6.4.1.6. **Policy Interventions for Green Shift**

- Analyze existing policies and regulations influencing green supply chain in construction.
- Identify gaps and inconsistencies in policies.
- Explore opportunities for integrating green supply chain elements.
- Advocate for supportive policies and incentives like tax breaks, subsidies, and green building certifications.

6.4.1.7. **More Mandatory Influence**

- Governmental and regulatory entities should exert more mandatory influence by implementing stricter regulations and standards for sustainable construction.
- Regulatory bodies ought to broaden the scope of regulations to encompass a broader array of sustainability concerns.

6.4.2. Sustainability Compliance in Public Sector

- Compliance with sustainability legislation and government policies is mandatory.
- The Race Relations Act requires local councils to eradicate discrimination and advocate for equality.
- Training on sustainability issues is crucial, especially for top-level supply chain decision makers.
- Timely contribution of all stakeholders (project) is essential.
- Communication and knowledge sharing about sustainability implementation should be improved.
- Networks between sustainability and supply chain professionals should be transparent.
- Emphasis should be placed on sustainability in project directs, contract descriptions, and valuation procedures.
- Encouragement of innovative solutions from tenderers.
- Promotion of sustainable procurement practices, capacity building, and monitoring mechanisms.
- Addressing lack of awareness, inadequate infrastructure, regulatory complexities, and economic constraints.

6.4.3. Sustainable Development efforts *via* R&D

- Professional and educational bodies are key in raising awareness about sustainable development.
- Economic-dominated commercial environments often overlook social and environmental values.
- Institutions can drive change in sustainability attitudes.
- Integrating sustainability values in governmental policies can stimulate demand for sustainable products.
- Research and development (R&D) holds a crucial role in driving innovation and nurturing sustainable practices.
- Recommendations include funding R&D initiatives, collaboration, and knowledge dissemination.
- Present research framework to policy makers at national and local levels.
- Highlight economic, environmental, and social benefits of transitioning to a carbon-neutral construction industry.
- Engage with government agencies, industry associations, and stakeholders for policy development and implementation.
- Encourage multi-stakeholder partnerships for sustainability goals.

6.4.4. Sustainability-Oriented construction Supply Chain Management

- Contractors adopting corporate social responsibility ensure sustainability in public client's construction contracts.
- Sustainability criteria include equality, diversity, health and safety improvement, and community disruption reduction.

- The supply chain should embrace a proactive approach, shifting from reluctance towards embracing change.
- Industry should integrate sustainability into supplier selection processes and contract agreements.
- Transparency and traceability within the supply chain should be fostered through digital platforms and blockchain technology.
- Collaboration and shared responsibility among stakeholders are encouraged for collective sustainability challenges.
- Comprehensive assessment of key processes for introducing green supply chain principles.
- Prioritization of processes like material sourcing, transportation, energy use, waste management, and construction methods.
- Implementation of green procurement practices, establishing criteria for selecting sustainable materials and suppliers.
- Encouragement of eco-friendly construction materials through incentives and regulations.

6.5. Further research

This study provides a foundation for understanding the challenges and opportunities in integrating sustainability within construction procurement processes. However, several knowledge gaps remain to be addressed. Future research should focus on assessing key processes, addressing specific Indian contextual challenges, integrating policy elements, and developing conceptual frameworks.

1. Assessing key processes: Future research should delve deeper into identifying activities and workflows where sustainable practices can be integrated seamlessly, minimizing environmental impacts and maximizing resource efficiency.

2. Addressing specific Indian contextual challenges: Understanding the complexities of design, procurement, transportation, execution, and waste recycling processes in the Indian context is crucial for overcoming barriers.

3. Exploring GSCM systems: Future research should explore the potential of different GSCM systems in achieving sustainability objectives. Comparative studies examining traditional procurement methods versus newer approaches can provide valuable insights into their respective impacts on sustainability outcomes.

4. Integrating policy elements in India that influence the green SC in the building segment is essential for facilitating more effective policy interventions.

5. Developing decision support systems: Future research should focus on integrating sustainability considerations into pre-qualification and selection procedures. By leveraging data analytics, modeling techniques, and stakeholder engagement, decision-makers can evaluate the environmental, social, and economic aspects of procurement options.

6. Development of conceptual frameworks: Future research should refine existing frameworks or develop new ones that explicitly address the objective of achieving carbon-neutrality.

7. Assessing operational and social costs: Future research should focus on quantifying the environmental and social benefits of sustainable procurement practices while considering potential trade-offs and unintended consequences. This holistic understanding is critical for ensuring sustainability initiatives are economically viable and socially equitable in the long run.

REFERENCES

Abdallah, T., Diabat, A. and Rigter, J. 2013. Investigating the option of installing small scale {PVs} on facility rooftops in a green supply chain. Int. J. Prod. Econ. 146 (2),465-477.

Abera, Y., 2023. Optimizing Construction Waste Recycling: Strategies, Technologies, and Environmental Impacts. p.30. https://doi.org/10.21203/rs.3.rs-3497942/v1

Abraham, P.S. and Gundimeda, H., 2018. 'Greening' the Buildings-An Analysis of Barriers to Adoption in India. Cities and the Environment (CATE), 10(1), p.10.

Adegbile, M., 2012. Development of a green building rating system for Nigeria. sustainable futures: architecture and urbanism in the Global South, Kampala, Uganda.

Adetooto, J., Windapo, A., Pomponi, F., Companie, F., Alade, K. and Mtya, A., 2022. Strategies to promote the acceptance of sandbag building technology for sustainable and affordable housing delivery: the South African case. *Journal of Engineering, Design and Technology*, (ahead-of-print).

AECOM, 2018. People's Republic of China: Construction and Demolition Waste Management and Recycling. Technical Assistance Consultant's Report. Project Number: 48105-001. Pp. 1-272

Afshari, A.R., Yusuff, R.M. and Derayatifar, A.R., 2012. An application of Delphi method for eliciting criteria in personnel selection problem. Scientific Research and Essays, 7(33), pp.2927-2935.

Agenda, I., 2016, May. Shaping the future of construction a breakthrough in mindset and technology. In World Economic Forum. https://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_report_020516.pdf

Aghimien, D.O., Aigbavboa, C.O. and Thwala, W.D., 2019. Microscoping the challenges of sustainable construction in developing countries. Journal of Engineering, Design and Technology, 17(6), 1110–1128. https://doi.org/10.1108/JEDT-01-2019-0002

Agrawal, A.K. and Rahman, Z., 2015. Roles and resource contributions of customers in value co-creation. International Strategic Management Review, 3(1-2), pp.144-160.

Agrawal, R., Agrawal, S., Samadhiya, A., Kumar, A., Luthra, S. and Jain, V., 2023. Adoption of green finance and green innovation for achieving circularity: An exploratory review and future directions. Geoscience Frontiers, p.101669.

Agumba, J. and Musonda, I., 2013. Experience of using Delphi method in construction health and safety research. Seventh International Conference on Construction in the 21st Century (CITC-VII) "Challenges in Innovation, Integration and Collaboration in Construction & Engineering" December 19-21 2013, Bangkok, Thailand.

Ahadian, B. and Abadi, A.G.M., 2012. Six Sigma pilot project selections using an MCDM approach. *Management Science and Engineering*, *6*(1), p.34.

Ahmed, F. and Ali, S.R., 2022. Strengthening the bridge between academic and the industry through the academia-industry collaboration plan design model. Frontiers in Psychology, 13, p.875940.

Ahmed, M., Thaheem, M.J. and Maqsoom, A., 2020. Barriers and opportunities to greening the construction supply chain management: cause-driven implementation strategies for developing countries. Benchmarking: An International Journal, 27(3), 1211–1237. https://doi.org/10.1108/BIJ-04-2019-0192

Ahn, Y.H., Pearce, A.R., Wang, Y. and Wang, G., 2013. Drivers and barriers of sustainable design and construction: The perception of green building experience. International Journal of Sustainable Building Technology and Urban Development, 4(1), pp.35-45. https://doi.org/10.1080/2093761X.2012.759887

Ahuja, V. and Yang, J., 2006. Communication protocol for building project management-The potential of IT enhanced approaches for the Indian building practice. In Proceedings of the CIB W89 International Conference on Building Education and Research, Hong Kong.

Akanni, P.O., Oke, A.E. and Akpomiemie, O.A., 2015. Impact of environmental factors on building project performance in Delta State, Nigeria. HBRC journal, 11(1), pp.91-97.

Akbari, M.A. and Qureshi, M., 2018. Methodological Assessment of Delays in Indian Construction Projects. Volume 4, Issue 03, DIP: 18.03.07/20180403 http://www.ijerad.redmac.in |March, 2018

Akça, Y., Esen, Ş. and Özer, G., 2013. The effects of education on enterprise resource planning implementation success and perceived organizational performance. International Business Research, 6(5), pp.168-179.

Al Khidir, T. and Zailani, S., 2009. Going green in supply chain towards environmental sustainability. *Global Journal of Environmental Research,* 3(3),246–251.

Alenezi, T.A.N., 2020a. COVID-19 Causes of delays on construction projects in Kuwait. International Journal of Engineering Research and General Science, 8(4), pp. 35-39.

Alenezi, T.A.N., 2020b. Minimising the delay factors on construction projects: A local case study in Kuwait City during COVID-19. International Journal of Engineering Research and General Science, 8(5), pp.5-8.

Alenezi, T.A.N., 2020c. The impact of COVID-19 on construction projects in Kuwait. International Journal of Engineering Research and General Science, 8(4), pp. 6-9.

Ali, A., Wang, H., Soomro, M.A. and Islam, T., 2020. Shared leadership and team creativity: Construction industry perspective. Journal of Construction Engineering and Management, 146(10), p.04020122.

Ali, B.M. and Akkaş, M., 2023. Assessing the Impact of Data Sciences and Smart Technologies in Air Conditioning Project Management: A Delphi Method Analysis within the Construction Industry. Buildings, 13(10), p.2581. https://doi.org/10.3390/buildings13102581

Alnahhal, M., Al Zaabi, F., Al Shehhi, N., Al Shehhi, M., Sakhrieh, A. and Al Hazza, M., 2021. Green supply chain management in the UAE construction industry. Indian Journal of Economics and Business, 20(2), pp.43-56.

Al-Rawe, Y.H.A. and Naimi, S., 2023. Project Construction Risk Estimation in Iraq Based on Delphi, RII, Spearman's Rank Correlation Coefficient (DRS) Using Machine Learning. International Journal of Intelligent Systems and Applications in Engineering, 11(5s), pp.335-342.

AlSanad, S., 2015. Awareness, drivers, actions, and barriers of sustainable construction in Kuwait. Procedia engineering, 118, pp.969-983.

Alsharef, A., Banerjee, S., Uddin, S.J., Albert, A., and Jaselskis, E., 2021. Early impacts of the COVID-19 pandemic on the United States Construction industry. International Journal of Environmental Research and Public Health, 18(4), pp. 1-21.

Alshehri, A., 2020. Value management practices in construction industry: An analytical review. The Open Civil Engineering Journal, 14(1), 10–19. https://doi.org/10.2174/1874149502014010010.

Alsudani, M.Q., Jaber, M.M., Ali, M.H., Abd, S.K., Alkhayyat, A., Kareem, Z.H. and Mohhan, A.R., 2023. Smart logistics with IoT-based enterprise management system using global manufacturing. Journal of Combinatorial Optimization, 45(2), p.57.

Amaral, R.E., Brito, J., Buckman, M., Drake, E., Ilatova, E., Rice, P., Sabbagh, C., Voronkin, S. and Abraham, Y.S., 2020. Waste management and operational energy for sustainable buildings: a review. Sustainability, 12(13), p.5337.

Ametepey, S.O., Aigbavboa, C.O. and Thwala, W.D., 2019. Assessment of the use of Delphi technique in sustainable infrastructure development research. In Creative Construction Conference 2019 (pp. 646-655). Budapest University of Technology and Economics. https://doi.org/10.3311/CCC2019-089

Ameyaw, E.E., Hu, Y., Shan, M., Chan, A.P. and Le, Y., 2016. Application of Delphi method in construction engineering and management research: a quantitative perspective. Journal of Civil Engineering and Management, 22(8), pp.991-1000. http://dx.doi.org/10.3846/13923730.2014.945953

Amien, D.H., Elbeltagi, E., Mashhour, I.M. and Ehab, A., 2023. Impact of COVID-19 on Construction Production Rate. Buildings 2023, 13, 1127.

Anam, A.S.M.T., 2023. Local Government Response to Covid-19 Crisis: A Study on Union Parishad in Bangladesh. *Dynamics of Public Administration*, *40*(1), pp.71-86.

Andal, E.R. and Juanzon, J.B.P., 2020. Identifying Risks in Implementing Sustainable Building Materials in Condominium Fit-out Projects Using Analytic Hierarchy Process. Civil Engineering and Architecture, 8(6), pp.1266-1276. https://doi.org/10.13189/cea.2020.080610

Andrade, C., 2020. Sample size and its importance in research. Indian journal of psychological medicine, 42(1), pp.102-103.

Ansah, S.K., Thwala, W.D. and Aigbavboa, C.O., 2021. Application of delphi technique in predicting total quality management constructs in ghanaian construction industry. In Proceedings of the International Conference on Industrial & Mechanical Engineering and Operations Management, December (pp. 26-27).

Ansari, S.A. and Karthik, D., 2022. Labor relation in construction industry in India. Materials Today: Proceedings, 60, pp.1581-1587.

Araya, F., 2021. Modeling the spread of COVID-19 on construction workers: An agent-based approach. Safety science, 133, p.105022.

Arenas, N.F. and Shafique, M., 2024. Reducing embodied carbon emissions of buildings–A key consideration to meet the net zero target. Sustainable Futures, p.100166.

Arif, M., Bendi, D., Toma-Sabbagh, T. and Sutrisna, M., 2012. Construction waste management in India: an exploratory study. Construction innovation, 12(2), 133–155. https://doi.org/10.1108/14714171211215912

Ashford, N.A. and Hall, R.P., 2011. The importance of regulation-induced innovation for sustainable development. *Sustainability*, *3*(1), pp.270-292.

Assefa, M., 2023. COVID-19 lockdown restrictions and small business survival strategy: government supporting schemes. *Business Perspectives and Research*, *11*(2), pp.227-245.

Atalla, G., Mills, M. and McQueen, J. (2021). These six government priorities can help accelerate the evolution to a green, net-zero future. https://www.ey.com/en_in/government-public-sector/six-ways-that-governments-can-drive-the-green-transition

Awasthi, S., Prathyusha, B., Fazeen Rasheed, A.K., Murgai, A. and Yadav, S., 2022. Green Innovation Practice For Organizational Performance And Sustainable Development. *Journal of Positive School Psychology*, pp.3195-3200.

Azhar, S., Nadeem, A., Mok, J.Y. and Leung, B.H., 2008, August. Building Information Modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects. In Proc., First International Conference on Construction in Developing Countries (Vol. 1, pp. 435-46).

Babu, P. 2023. Trends in Indian logistics services in 2023 and beyond. https://blog.tatanexarc.com/logistics/trends-in-india/

Bakchan, A., Faust, K.M. and Leite, F., 2019. Seven-dimensional automated construction waste quantification and management framework: Integration with project and site planning. *Resources, Conservation and Recycling*, *146*, pp.462-474.

Bal, M., Bryde, D., Fearon, D. and Ochieng, E., 2013. Stakeholder engagement: Achieving sustainability in the construction sector. Sustainability, 5(2), pp.695-710.

Balasubramanian, S. and Shukla, V., 2017. Green supply chain management: the case of the construction sector in the United Arab Emirates (UAE). Production Planning & Control, 28(14), pp.1116-1138. https://doi.org/10.1080/09537287.2017.1341651

Balasubramanian, S., 2012. A hierarchiacal framework of barriers to green supply chain management in the construction sector. Journal of Sustainable Development, 5(10). https://doi.org/10.5539/jsd.v5n10p15

Banaitiene, N. and Banaitis, A., 2012. Risk management in construction projects. Risk management-current issues and challenges, pp.429-448.

Bandara, W., Furtmueller, E., Gorbacheva, E., Miskon, S. and Beekhuyzen, J., 2015. Achieving rigor in literature reviews: Insights from qualitative data analysis and tool-support. Communications of the Association for Information systems, 37(1), p.8.

Bandara, W., Miskon, S. and Fielt, E., 2011. A systematic, tool-supported method for conducting literature reviews in information systems. In ECIS 2011 proceedings [19th European conference on information systems] (pp. 1-13). AIS Electronic Library (AISeL)/Association for Information Systems.

Bapna, M., 2015. 3 Key Questions for the Energy Industry Around a Global Climate Agreement. https://www.wri.org/insights/3-key-questions-energy-industry-around-global-climate-agreement

Baranikumar, D., Bikila, M.M.L. and Chala, M.G., 2021. Sustainable Green Supply Chain Management and Waste Management in Construction Industry. Journal of Contemporary Issues in Business and Government| Vol, 27(3), p.124. https://doi.org/10.47750/cibg.2021.27.03.017

Barbash, I.J., Rak, K.J., Kuza, C.C. and Kahn, J.M., 2017. Hospital perceptions of Medicare's sepsis quality reporting initiative. Journal of hospital medicine, 12(12), pp.963-968.

Battula, V.R., Namburu, S.K. and Kone, V., 2020. A study on factors involved in implementation of supply chain management in construction industry. Materials Today: Proceedings, 33, pp.446-449.

Beamon, B.M., 1999. Designing the green supply chain. *Logistics information management*, *12*(4), pp.332-342.

Behera, P., Mohanty, R.P. and Prakash, A., 2015. Understanding construction supply chain management. *Production Planning & Control*, *26*(16), pp.1332-1350.

Belay, S., Goedert, J., Woldesenbet, A. and Rokooei, S., 2021. A hybrid delphi-AHP based analysis of construction project-specific success factors in emerging markets: the case of Ethiopia. Cogent Engineering, 8(1), p.1891701. https://doi.org/10.1080/23311916.2021.1891701

Belcher, B.M., Rasmussen, K.E., Kemshaw, M.R. and Zornes, D.A., 2016. Defining and assessing research quality in a transdisciplinary context. Research Evaluation, 25(1), pp.1-17.

Beldek, T., Camgöz-Akdağ, H. and Hoşkara, E., 2016. Green supply chain management for construction waste: Case study for Turkey. International Journal of Sustainable Development and Planning, 11(5), pp.771-780. https://doi.org/10.2495/SDP-V11-N5-771-780

Bell, E., Bryman, A. and Harley, B., 2022. *Business research methods*. Oxford university press.

Bello, S.A., Oyedele, L.O., Akinade, O.O., Bilal, M., Delgado, J.M.D., Akanbi, L.A., Ajayi, A.O. and Owolabi, H.A., 2021. Cloud computing in construction industry: Use cases, benefits and challenges. Automation in Construction, 122, p.103441.

Benachio, G.L.F., Freitas, M.C.D. and Tavares, S.F., 2019. Green Supply Chain Management in the Construction Industry: A literature review. IOP Conference Series: Earth and Environmental Science, 225(1). https://doi.org/10.1088/1755-1315/225/1/012011

Bennett, N.J., Whitty, T.S., Finkbeiner, E., Pittman, J., Bassett, H., Gelcich, S. and Allison, E.H., 2018. Environmental stewardship: A conceptual review and analytical framework. *Environmental management*, *61*, pp.597-614.

Benny, M. and Joy, A., 2018. Green supply chain management in construction industry: A review. International Research Journal of Engineering Technology, 5 (11), pp.661-665.

Bergerson, J.A., Brandt, A., Cresko, J., Carbajales-Dale, M., MacLean, H.L., Matthews, H.S., McCoy, S., McManus, M., Miller, S.A., Morrow, W.R. and Posen, I.D., 2020. Life cycle assessment of emerging technologies: Evaluation techniques at different stages of market and technical maturity. *Journal of Industrial Ecology*, *24*(1), pp.11-25.

Berrones-Flemmig, C.N., Contreras, F. and Dornberger, U. eds., 2022. *Business in the 21st Century: A Sustainable Approach*. Emerald Publishing Limited.

Beth, E., 2007. Integrity in public procurement: Good practice from A to Z. Organisation for Economic Co-operation and Development (OECD).

Bhochhibhoya, S., Zanetti, M., Pierobon, F., Gatto, P., Maskey, R.K. and Cavalli, R., 2017. The global warming potential of building materials: An application of life cycle analysis in Nepal. *Mountain research and development*, *37*(1), pp.47-55.

Bhoda, S.K. 2023. Innovative Approaches in the Construction Industry: A New Paradigm for Building the Future. https://www.linkedin.com/pulse/innovative-approaches-construction-industry-new-paradigm-bhoda-swzzc/

Bibri, S.E., Krogstie, J. and Kärrholm, M., 2020. Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. Developments in the built environment, 4, p.100021.

Bidin, Z.A., Bohari, A.A.M., Rais, S.L.A. and Saferi, M.M., 2018, April. Green related practices for construction procurement. In IOP Conference Series: Earth and Environmental Science (Vol. 140, p. 012099). IOP Publishing.

Biswas, A., Ghosh, A., Kar, A., Mondal, T., Ghosh, B. and Bardhan, D.P.K., 2021, February. The impact of COVID-19 in the construction sector and its remedial measures. In *Journal of Physics: Conference Series* (Vol. 1797, No. 1, p. 012054). IOP Publishing.

Boell, S.K. and Cecez-Kecmanovic, D., 2015. On being 'systematic'in literature reviews. Formulating Research Methods for Information Systems: Volume 2, pp.48-78.

Boffo, R. and Patalano, R., 2020. ESG investing: practices, progress and challenges. Éditions OCDE, Paris.

Bon, R. and Hutchinson, K., 2000. Sustainable construction: some economic challenges. *Building Research & Information*, *28*(5-6), pp.310-314.

Borthwick, M., McAuley, D., Warburton, J., Anand, R., Bradley, J., Connolly, B., Blackwood, B., O'neill, B., Chikhani, M., Dark, P. and Shyamsundar, M., 2020. Mucoactive agent use in adult UK Critical Care Units: a survey of health care professionals' perception, pharmacists' description of practice, and point prevalence of mucoactive use in invasively mechanically ventilated patients. *PeerJ*, *8*, p.e8828.

Bowen, G.A., 2009. Document analysis as a qualitative research method. Qualitative research journal, 9(2), pp.27-40. https://biotap.utk.edu/wp-content/uploads/2019/02/document-analysis.pdf

Bradford, M. and Gerard, G.J., 2015. Using process mapping to reveal process redesign opportunities during ERP planning. Journal of Emerging Technologies in Accounting, 12(1), pp.169-188.

Branch, H.K., 2018. Strategies Construction Project Managers Use to Create Environmental Sustainability in Construction Projects (Doctoral dissertation, Walden University). https://www.proquest.com/docview/2151454103?pq-origsite=gscholar&fromopenview=true

Briner, R.B. and Denyer, D., 2012. Systematic review and evidence synthesis as a practice and scholarship tool. The Oxford Handbook of Evidence-Based Management ed. Rousseau D M (United States: OUP) chapter 7 pp 112-129

Broft, R., Badi, S.M. and Pryke, S., 2016. Towards supply chain maturity in construction. *Built Environment Project and Asset Management*, *6*(2), pp.187-204.

Brun, A., Karaosman, H. and Barresi, T., 2020. Supply chain collaboration for transparency. Sustainability, 12(11), p.4429.

Bryant, T., 2002. Role of knowledge in public health and health promotion policy change. Health Promotion International, 17(1), pp.89-98.

Budler, M., Quiroga, B.F. and Trkman, P., 2024. A review of supply chain transparency research: Antecedents, technologies, types, and outcomes. Journal of Business Logistics, 45(1), p.e12368.

Cader, J., Koneczna, R. and Smol, M., 2022. Corporate social responsibility as a significant factor of competitive advantage-a case study of energy companies in Poland. Energy Reports, 8, pp.7989-8001.

Cahyono, B.T., Pawar, A., Indrati, K. and Loupias, H., 2020. Synthesizing the influences of green supply chain management towards organisational outcomes. International Journal of Supply Chain Management, 9(3), pp.730-740. http://excelingtech.co.uk/

Calleja, G., Corominas, A., Martínez-Costa, C. and de la Torre, R., 2018. Methodological approaches to supply chain design. *International Journal of Production Research*, *56*(13), pp.4467-4489.

Carter, C.R. and Dresner, M., 2001. "Environmental purchasing and supply management: cross-functional development of grounded theory", Journal of Supply Chain Management, Vol. 37 No. 3, pp. 12-27

Casula, M., Rangarajan, N. and Shields, P., 2021. The potential of working hypotheses for deductive exploratory research. Quality & Quantity, 55(5), pp.1703-1725.

CDC, Office of the Associate Director for Policy. (2011). Definition of policy. PDF available upon request; please contact ADpolicy@cdc.gov

Chakrabarti, T. (2023). Top 15 Procurement Management Software. https://www.zluri.com/blog/procurement-management-software/

Chakuu, S., Godsell, J. and Glass, J., 2020. Supply chain productivity in construction. https://discovery.ucl.ac.uk/id/eprint/10129185/1/digest_-supply-chain-productivity-in-construction.pdf

Chan, A.P.C., Darko, A. and Ameyaw, E.E., 2017. Strategies for promoting green building technologies adoption in the construction industry—An international study. Sustainability, 9(6), p.969.

Chang, R.D., Soebarto, V., Zhao, Z.Y. and Zillante, G., 2016. Facilitating the transition to sustainable construction: China's policies. *Journal of Cleaner Production*, *131*, pp.534-544.

Chang, Y.T., Zhang, N., Danao, D. and Zhang, N., 2013. Environmental efficiency analysis of transportation system in China: A non-radial DEA approach. Energy policy, 58, pp.277-283. https://doi.org/10.1016/j.enpol.2013.03.011

Chen, B., Gegentana and Wang, Y., 2023. The Impact of Environmental Regulations on Enterprise Pollution Emission from the Perspective of "Overseeing the Government". *Sustainability*, *15*(14), p.11311.

Chen, P.K. and Ye, Y., 2022. Influence of creating an oligopoly through government intervention to improve partner collaboration intentions in the context of green supply chains. Environmental Science and Pollution Research, 29(5), pp.6433-6448.

Chen, Q., Feng, H. and de Soto, B.G., 2022. Revamping construction supply chain processes with circular economy strategies: A systematic literature review. *Journal of cleaner production*, *335*, p.130240.

Chen, Y., Lai, S., Wen, C., 2006. The influence of green innovation performance on corporate advantage in Taiwan. Journal of Business Ethics 67(4), 331–339.

Cheng, Z., Liu, J., Li, L. and Gu, X., 2020. The effect of environmental regulation on capacity utilization in China's manufacturing industry. *Environmental Science and Pollution Research*, *27*, pp.14807-14817.

Cherry, K. (2022). What Is a Case Study? An in-depth study of one person, group, or event. https://www.verywellmind.com/how-to-write-a-psychology-case-study-2795722

Cheung, M.W.L. and Vijayakumar, R., 2016. A guide to conducting a meta-analysis. Neuropsychology review, 26, pp.121-128.

Chi, N.K. and Long, P.Q., 2011. Solid waste management associated with the development of 3R initiatives: case study in major urban areas of Vietnam. Journal of Material Cycles and Waste Management, 13(1), pp.25-33. https://doi.org/10.1007/s10163-010-0312-y

Choudhary, M., Singh, A., Yadav, M., Senthilpandian, M. and Karthikeyan, K., 2021. Identifying Challenges of Construction Industry in India. Turkish Online Journal of Qualitative Inquiry, 12(6).

Chowdhury, M., Upadhyay, A., Briggs, A. and Belal, M., 2016, June. An empirical analysis of green supply chain management practices in Bangladesh construction industry. In *EurOMA Conference 2016* (pp. 1-10).

Chowdhury, M.R.I. and Srabon, M.R.T., 2018. Barriers to Adoption of Sustainable Construction Practices in Khulna City. In 4th International Conference on Advances in Civil Engineering 2018 (ICACE 2018), CUET, Chittagong, Bangladesh.

Chukwudi, I., Zhang, M. and Gable, G., 2019, December. Extensive theory testing using case study. In Proceedings of the 40th International Conference on Information Systems (ICIS 2019) (pp. 1-17). Association for Information Systems (AIS).

Circo, C.J., 2007. Using mandates and incentives to promote sustainable construction and green building projects in the private sector: a call for more state land use policy initiatives. Penn St. L. Rev., 112, p.731.

Cooper, J., 1994. Green logistics, European logistics: markets, management and strategy. Oxford: Blackwell Business.

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A. and Sheikh, A. 2011. The case study approach. BMC Med Res Methodol. Jun 27;11:100. doi: 10.1186/1471-2288-11-100. PMID: 21707982; PMCID: PMC3141799.

CSE, 2020. India manages to recover and recycle only about 1 per cent of its construction and demolition (C&D) waste, says new CSE analysis. Habitat Press Releases. https://www.cseindia.org/india-manages-to-recover-and-recycle-only-about-1-per-cent-of-its-construction-and-demolition-10326

Cui, T. and Zhang, J., 2018. Bibliometric and review of the research on circular economy through the evolution of Chinese public policy. Scientometrics, 116(2), pp.1013-1037. https://doi.org/10.1007/s11192-018-2782-y

Cxotoday, 2023. Charting India's Path to Supply Chain Excellence: Challenges, Opportunities, and Strategies. https://cxotoday.com/interviews/charting-indias-path-to-supply-chain-excellence-challenges-opportunities-and-strategies/

Dadhich, P., Genovese, A., Kumar, N. and Acquaye, A., 2015. Developing sustainable supply chains in the UK construction industry: A case study. International Journal of Production Economics, 164, pp.271-284.

Dadzie, J., Runeson, G., Ding, G. and Bondinuba, F.K., 2018. Barriers to adoption of sustainable technologies for energy-efficient building upgrade—semi-Structured interviews. Buildings, 8(4), p.57. https://doi.org/10.3390/buildings8040057

Dalglish, S.L., Khalid, H. and McMahon, S.A., 2020. Document analysis in health policy research: the READ approach. Health policy and planning, 35(10), pp.1424-1431.

Dalkey, N., 1969. An experimental study of group opinion: the Delphi method. Futures, 1(5), pp.408-426 (http://linkinghub.elsevier.com/retrieve/pii/S001632876980025X)

Daniel, E.I., Oshineye, O. and Oshodi, O., 2018, September. Barriers to sustainable construction practice in Nigeria. In Proceeding of the 34th Annual ARCOM Conference (pp. 3-5). Belfast: Association of Researchers in Construction Management. https://www.arcom.ac.uk/-docs/proceedings/03b99b49b476d24431f1f5b1b30c8da3.pdf

Darko, A. and Chan, A.P., 2017. Review of barriers to green building adoption. Sustainable Development, 25(3), pp.167-179. https://doi.org/10.1002/sd.1651

Darko, A., Chan, A.P.C., Ameyaw, E.E., He, B.J. and Olanipekun, A.O., 2017. Examining issues influencing green building technologies adoption: The United States green building experts' perspectives. Energy and Buildings, 144, pp.320-332. https://doi.org/10.1016/j.enbuild.2017.03.060

Darko, A., Chan, A.P.C., Yang, Y., Shan, M., He, B.J. and Gou, Z., 2018. Influences of barriers, drivers, and promotion strategies on green building technologies adoption in developing countries: The Ghanaian case. Journal of Cleaner Production, 200, pp.687-703. https://doi.org/10.1016/j.jclepro.2018.07.318

Darnall, N., Jolley, J., and Handfield, R. (2008) "Environmental management systems and green supply chain management: complements for sustainability?", Business Strategy and the Environment, Vol. 17, No. 1, pp. 30-45.

Dashore, K. and Sohani, N., 2008. Green supply chain management: A hierarchical framework for barriers. J. Sustain. Dev, 5, p.2011. http://www.ijettjournal.org

Daudt, H.M., Van Mossel, C. and Scott, S.J., 2013. Enhancing the scoping study methodology: a large, inter-professional team's experience with Arksey and O'Malley's framework. BMC medical research methodology, 13, pp.1-9.

Davies, J., 2024. The Benefits of Supplier Relationship Management. https://www.winman.com/blog/bid/366854/the-benefits-of-supplier-relationship-management

de Oliveira, U.R., Espindola, L.S., da Silva, I.R., da Silva, I.N. and Rocha, H.M., 2018. A systematic literature review on green supply chain management: Research implications and future perspectives. Journal of cleaner production, 187, pp.537-561. https://doi.org/10.1016/j.jclepro.2018.03.083

de Sousa Jabbour, A.B.L., de Oliveira Frascareli, F.C. and Jabbour, C.J.C., 2015. Green supply chain management and firms' performance: Understanding potential relationships and the role of green sourcing and some other green practices. Resources, Conservation and Recycling, 104, pp.366-374. https://doi.org/10.1016/j.resconrec.2015.07.017

DeJonckheere, M. and Vaughn, L.M., 2019. Semistructured interviewing in primary care research: a balance of relationship and rigour. Family medicine and community health, 7(2).

Deloitte, 2016. Using renewable energy to drive supply chain innovation. URL: https://www2.deloitte.com/us/en/pages/manufacturing/articles/renewable-energy-supply-chain-innovation.html (visited on 06 September 2022).

Dey, S., Sreenivasulu, A., Veerendra, G.T.N., Rao, K.V. and Babu, P.A., 2022. Renewable energy present status and future potentials in India: An overview. Innovation and Green Development, 1(1), p.100006.

Dharmayanti, N., Ismail, T., Hanifah, I.A. and Taqi, M., 2023. Exploring sustainability management control system and eco-innovation matter sustainable financial performance: The role of supply chain management and digital adaptability in indonesian context. Journal of Open Innovation: Technology, Market, and Complexity, 9(3), p.100119.

Diamond, I.R., Grant, R.C., Feldman, B.M., Pencharz, P.B., Ling, S.C., Moore, A.M. and Wales, P.W., 2014. Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies. Journal of clinical epidemiology, 67(4), pp.401-409.

Ding, G.K., 2014. Life cycle assessment (LCA) of sustainable building materials: an overview. Eco-efficient construction and building materials, pp.38-62.https://doi.org/10.1533/9780857097729.1.38

Djokoto, S.D., Dadzie, J. and Ohemeng-Ababio, E., 2014. Barriers to sustainable construction in the Ghanaian construction industry: consultants perspectives. Journal of Sustainable Development, 7(1), p.134–143. https://doi.org/10.5539/jsd.v7n1p134

Dlamini, L.N. and Yessoufou, K., 2022. Residents and Professionals' Perspectives on Energy and Water Consumption While Transiting from Conventional to Sustainable Housings in South Africa. Sustainability, 14(8), p.4498. https://doi.org/10.3390/su14084498

Doloi, H., Week, D. and Bora, A., 2017. Role of Regulatory Framework for Supporting Construction Industry in India. Epic Ser. Educ. Sci, 1, pp.351-360.

Domenech, T. and Bahn-Walkowiak, B., 2019. Transition towards a resource efficient circular economy in Europe: policy lessons from the EU and the member states. Ecological Economics, 155, pp.7-19. https://doi.org/10.1016/j.ecolecon.2017.11.001

Du, P., Zheng, L.Q., Xie, B.C. and Mahalingam, A., 2014. Barriers to the adoption of energy-saving technologies in the building sector: A survey study of Jing-jin-tang, China. Energy Policy, 75, pp.206-216. https://doi.org/10.1016/j.enpol.2014.09.025

Dube, A., Gawande, R.R. and Coe, D.B., 2011. Green Supply Chain management–A literature review. International Journal of Computer Applications, 975, p.8887.

Dube, A.S. and Gawande, R.S., 2016. Analysis of green supply chain barriers using integrated ISM-fuzzy MICMAC approach. Benchmarking: An International Journal, 23(6), 1558–1578. https://doi.org/10.1108/BIJ-06-2015-0057

Durdyev, S., Zavadskas, E.K., Thurnell, D., Banaitis, A. and Ihtiyar, A., 2018. Sustainable construction industry in Cambodia: Awareness, drivers and barriers. Sustainability, 10(2), p.392. https://doi.org/10.3390/su10020392

Ebekozien, A. and Samsurijan, M.S., 2022. Incentivisation of digital technology takers in the construction industry. Engineering, Construction and Architectural Management, (ahead-of-print).

Ebert, U., 2003. Environmental goods and the distribution of income. *Environmental and Resource Economics*, *25*, pp.435-459.

Egalogistics, 2021. What is Trailer Spotting and Why is it Important in Warehousing? https://egalogistics.com/what-is-trailer-spotting-and-why-is-it-important-in-warehousing/

Ekins, P., Domenech Aparisi, T., Drummond, P., Bleischwitz, R., Hughes, N. and Lotti, L., 2020. The circular economy: What, why, how and where. https://discovery.ucl.ac.uk/id/eprint/10093965/1/Ekins-2019-Circular-Economy-What-Why-How-Where.pdf

El Mounla, K., Beladjine, D., Beddiar, K. and Mazari, B., 2023. Lean-BIM Approach for Improving the Performance of a Construction Project in the Design Phase. Buildings, 13(3), p.654.

Elbarkouky, M.M.G. and Abdelazeem, G., 2013. A green supply chain assessment for construction projects in developing countries. WIT Transactions on Ecology and the Environment, 179, pp.1331-1341. https://doi.org/10.2495/SC131132

Elefsiniotis, P. and Wareham, D.G., 2005. ISO 14000 environmental management standards: their relation to sustainability. Journal of Professional Issues in Engineering Education and Practice, 131(3), pp.208-212.

Eriksson, P.E. and Westerberg, M., 2009. Effects of procurement on construction project performance. In International Conference on Management of Technology: 05/04/2009-09/04/2009.

Eštoková, A., Wolfová Fabiánová, M. and Ondová, M., 2022. Concrete Structures and Their Impacts on Climate Change and Water and Raw Material Resource Depletion. International Journal of Civil Engineering, pp.1-13.

Evangelista, P., Sweeney, E., Ferruzzi, G. and Carrasco, J.C., 2010. Green supply chains initiatives in transport and logistics service industry: an exploratory case study analysis. https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1064&context=nitlcon

Faisal, M. N., Banwet, D. K., Shankar, R., 2000. Supply chain risk management in SMEs: analyzing the barriers. International Journal of Management and Enterprises development 4(5), 588–607.

Fakunle, F., Opiti, C., Sheikh, A. and Fashina, A., 2020. Major barriers to the enforcement and violation of building codes and regulations: a global perspective. SPC Journal of Environmental Sciences, 2(1), pp.12-18.

Fallah Shayan, N., Mohabbati-Kalejahi, N., Alavi, S. and Zahed, M.A., 2022. Sustainable development goals (SDGs) as a framework for corporate social responsibility (CSR). Sustainability, 14(3), p.1222.

Fan, X. and Zhang, S., 2016. Performance evaluation for the sustainable supply chain management. *Sustainable Supply Chain Management*, pp.141-194.

Fapohunda, J.A. and Chileshe, N., 2014. Essential factors towards optimal utilisation of construction resources. Journal of Engineering, Design and Technology 12 (4), 461-474.

Farida, N., Handayani, N.U. and Wibowo, M.A., 2018. Developing indicators to implementing green material management in construction industry: a literature review. In E3S Web of Conferences (Vol. 73, p. 08009). EDP Sciences. https://doi.org/10.1051/e3sconf/2018730

Farrugia, P., Petrisor, B.A., Farrokhyar, F. and Bhandari, M., 2010. Research questions, hypotheses and objectives. Canadian journal of surgery, 53(4), p.278.

Fathalizadeh, A., Ghoddousi, P., Javid, A.A.S., Hosseini, M.R. and Ghosh, A., 2019. Integrating sustainability into construction project management: Barriers in developing countries. Modern Building Materials, Structures and Techniques: MBMST 2019, Selected Papers, pp.559-563. http://webu3.vgtu.lt/uni/stf/mbmst/559-563_MBMST_122.pdf

Feddes, A.R. and Gallucci, M., 2015. A literature review on methodology used in evaluating effects of preventive and de-radicalisation interventions. Journal for Deradicalization, (5), pp.1-27.

Fiksel, J., Sanjay, P. and Raman, K., 2021. Steps toward a resilient circular economy in India. Clean Technologies and Environmental Policy, 23, pp.203-218.

Finfgeld-Connett, D. and Johnson, E.D., 2013. Literature search strategies for conducting knowledge-building and theory-generating qualitative systematic reviews. Journal of advanced nursing, 69(1), pp.194-204.

Fink, A. 2003. How to Ask Survey Questions. 2nd edn. Califomia, Sage Publications.

Fink-Hafner, D., Dagen, T., Doušak, M., Novak, M. and Hafner-Fink, M., 2019. Delphi method: strengths and weaknesses. Advances in Methodology and Statistics, 16(2), pp.1-19.

Fitzpatrick M., 1983. The Definition and Assessment of Political Risk in International Business : A Review the of : Academy of Management Review 8(2): pp.249–254

Forbes (2021). The Construction Industry Is Getting Greener: Why, How, And What's Changing? URL:https://www.forbes.com/sites/sap/2021/08/25/the-construction-industry-is-getting-greener-why-how-and-whats-changing/?sh=49f1bed052bc (visited on 06 September 2022) .

Foster, V., Gorgulu, N., Straub, S. and Vagliasindi, M., 2023. The Impact of Infrastructure on Development Outcomes.

Gamil, Y. and Alhagar, A., 2020. The impact of pandemic crisis on the survival of construction industry: a case of COVID-19. *Mediterranean Journal of Social Sciences*, *11*(4), pp.122-122.

Gamil, Y., A. Abdullah, M., Abd Rahman, I., &Asad, M. M. (2020). Internet of things in construction industry revolution 4.0. *Journal of Engineering, Design and Technology*, 18(5), 1091–1102.

Ganeshan, R., Tyworth, J.E. and Guo, Y., 1999. Dual sourced supply chains: the discount supplier option. *Transportation Research Part E: Logistics and Transportation Review*, *35*(1), pp.11-23.

Garson, G.D., 2009. Computerized simulation in the social sciences: A survey and evaluation. *Simulation & Gaming*, *40*(2), pp.267-279.

Gaur, S., 2022. Understanding the importance of project planning and scheduling in Indian construction projects. Journal of Positive School Psychology, 6(3), pp.3535-3544.

Geng, R., Mansouri, S.A. and Aktas, E., 2017. The relationship between green supply chain management and performance: A meta-analysis of empirical evidences in Asian emerging economies. *International journal of production economics*, *183*, pp.245-258.

Ghandour, A.M.D., 2021. The Socioeconomic Impacts and Implications of the COVID-19 Pandemic and Omicron Variant: The Case of Sudan. *International Journal of Development and Economic Sustainability*, *9*(3), pp.36-56.

Ghansah, F.A., Owusu-Manu, D.G. and Ayarkwa, J., 2020. Project management processes in the adoption of smart building technologies: a systematic review of constraints. Smart and Sustainable Built Environment (Vol. 10, Issue 2, pp. 208–226). Emerald Group Holdings Ltd. https://doi.org/10.1108/SASBE-12-2019-0161

Ghobadian, A., Viney, H., Liu, J. and James, P., 1998. Extending linear approaches to mapping corporate environmental behaviour. *Business strategy and the environment*, *7*(1), pp.13-23.

Ghosh, A., Nundy, S. and Mallick, T.K., 2020. How India is dealing with COVID-19 pandemic. Sensors International, 1, p.100021. https://doi.org/10.1016/j.sintl.2020.100021

Gill, J. and Johnson, P. (2002). Research Methods for Managers. 3rd edn. London, Sage Publications, p.288.

Glover, J. (2008). "Framework Agreements : Practice and Pitfalls" https://www.fenwickelliott.com/research-insight/articles-papers/framework-agreements-practice-and-pitfalls

Goel, R.K., Saunoris, J.W. and Goel, S.S., 2021. Supply chain performance and economic growth: The impact of COVID-19 disruptions. *Journal of Policy Modeling*, *43*(2), pp.298-316.

Golini, R., Pinto, R., Guerlain, C. and Kalchschmidt, M., 2016. Supply chain management in the construction industry: a systematic literature review. Success project materials. https://doi.org/10.5281/zenodo.1243723

Gouch, D., Oliver, S. and Thomas, J., 2012. An Introduction to Systematics Reviews. City Road, London: Sage Publications.

Govindan, K., Kaliyan, M., Kannan, D. and Haq, A.N., 2014. Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International journal of production economics*, *147*, pp.555-568.

Govindan, K., Shaw, M. and Majumdar, A., 2021. Social sustainability tensions in multi-tier supply chain: A systematic literature review towards conceptual framework development. Journal of cleaner production, 279, p.123075.

Granato, R. 2020. The Growing Need for Digital Yard Management Systems. https://talkinglogistics.com/2020/09/09/growing-need-digital-yard-management-systems/

Guerzoni, M. and Raiteri, E., 2015. Demand-side vs. supply-side technology policies: Hidden treatment and new empirical evidence on the policy mix. Research Policy, 44(3), pp.726-747. https://doi.org/10.1016/j.respol.2014.10.009

Gupt, Y. and Sahay, S., 2015. Review of extended producer responsibility: A case study approach. *Waste Management & Research*, *33*(7), pp.595-611.

Gupta, A. and De, B., 2024. A systematic review on urban blue-green infrastructure in the south Asian region: recent advancements, applications, and challenges. Water Science & Technology, 89(2), pp.382-403.

Gupta, A., Lövbrand, E., Turnhout, E. and Vijge, M.J., 2012. In pursuit of carbon accountability: the politics of REDD+ measuring, reporting and verification systems. *Current Opinion in Environmental Sustainability*, *4*(6), pp.726-731.

Gupta, D. and Garg, A., 2020. Sustainable development and carbon neutrality: Integrated assessment of transport transitions in India. Transportation Research Part D: Transport and Environment, 85, p.102474. https://doi.org/10.1016/j.trd.2020.102474

Gupta, R., Gregg, M., Manu, S., Vaidya, P. and Dixit, M., 2019. Customized performance evaluation approach for Indian green buildings. Building Research & Information, 47(1), pp.56-74. https://doi.org/10.1080/09613218.2019.1525962

Habibi, A., Sarafrazi, A. and Izadyar, S., 2014. Delphi technique theoretical framework in qualitative research. The International Journal of Engineering and Science, 3(4), pp.8-13.

Hafez, F.S., Sa'di, B., Safa-Gamal, M., Taufiq-Yap, Y.H., Alrifaey, M., Seyedmahmoudian, M., Stojcevski, A., Horan, B. and Mekhilef, S., 2023. Energy efficiency in sustainable buildings: a systematic review with taxonomy, challenges, motivations, methodological aspects, recommendations, and pathways for future research. Energy Strategy Reviews, 45, p.101013.

Hakim, C., 1987. Research design: Strategies and choices in the design of social research (No. 13). George Allen & Unwin Ltd. USA and Canada, Routledge.

Hallowell, M.R. and Gambatese, J.A., 2010. Qualitative research: Application of the Delphi method to CEM research. Journal of construction engineering and management, 136(1), pp.99-107.

Hamdan, H.A., Andersen, P.H. and De Boer, L., 2021. Stakeholder collaboration in sustainable neighborhood projects—A review and research agenda. Sustainable Cities and Society, 68, p.102776.

Hamner, B., 2006. Effects of green purchasing strategies on supplier behaviour. In *Greening the supply chain* (pp. 25-37). London: Springer London.

Han, H., 2019. Governance for green urbanisation: Lessons from Singapore's green building certification scheme. Environment and Planning C: Politics and Space, 37(1), pp.137-156. https://doi.org/10.1177/2399654418778596

Hanna, N., Tamhankar, A.J. and Lundborg, C.S., 2023. The development of an integrated environment–human risk approach for the prioritisation of antibiotics for policy decisions. *Science of the Total Environment*, *880*, p.163301.

Harbert, T. 2020. Supply chain transparency, explained. https://mitsloan.mit.edu/ideas-made-to-matter/supply-chain-transparency-explained

Harland, C.M., 1996. Supply chain management: relationships, chains and networks. *British Journal of management*, *7*, pp.S63-S80.

Harouache, A., Abkar, M.M.A., Gamil, Y., Al-Shameri, A.S.A. and Gabir, A.A.M., 2024. Influence of Supply Chain Management on The Sustainable Construction Industry in Algeria. Frontiers in Built Environment, 10, p.1233266.

Harouache, A., Chen, G.K., Sarpin, N.B., Majeed, N. and Othman, J., 2021. The Mediation Effectiveness of Green Supply Chain Management Practices Toward Sustainable Development in Algerian Construction Industry. Journal of Contemporary Issues in Business and Government Vol, 27(1).

Harrison, J.S., Freeman, R.E. and Abreu, M.C.S.D., 2015. Stakeholder theory as an ethical approach to effective management: Applying the theory to multiple contexts. Revista brasileira de gestão de negócios, 17, pp.858-869. https://doi.org/10.7819/rbgn.v17i55.2647

Hart, C., 2018. Doing a literature review: Releasing the research imagination, Sage.

Hassan, A., 2023. Cost Control Measures for Successful Construction Project Management.

Hasson, F. and Keeney, S., 2011. Enhancing rigour in the Delphi technique research. Technological forecasting and social change, 78(9), pp.1695-1704. https://doi:10.1016/j.techfore.2011.04.005

He, H. and Harris, L., 2020. The impact of Covid-19 pandemic on corporate social responsibility and marketing philosophy. *Journal of business research*, *116*, pp.176-182.

He, Z., Wang, G., Chen, H. and Yan, H., 2022. Is Resilient Transportation Infrastructure Low-Carbon? Evidence from High-Speed Railway Projects in China. Computational Intelligence and Neuroscience, 2022. https://doi.org/10.1155/2022/3138413

Henry, A.L., 2013. Teaching Students to Write Literature Reviews: A Meta-Analytic Model. Handbook of Demonstrations and Activities in the Teaching of Psychology: Volume I: Introductory, Statistics, Research Methods, and History, p.228.

Herrmann, L., Nielsen, B.L. and Aguilar-Raab, C., 2021, June. The impact of COVID-19 on interpersonal aspects in elementary school. In *Frontiers in education* (Vol. 6, p. 635180). Frontiers Media SA. Sec. Leadership in Education| https://doi.org/10.3389/feduc.2021.635180

Hertasning, B., Hatta, I.W. and Samudra, A.A., 2024. Carbon Emission Mitigation: a Sustainable Transportation Perspective for Reforming the Law on Highways in Indonesia. Journal of Law and Sustainable Development, 12(1), pp.e2827-e2827.

Heurkens, E. and Dąbrowski, M., 2020. Circling the square: Governance of the circular economy transition in the Amsterdam Metropolitan Area. European Spatial Research and Policy, 27(2), pp.11-31. https://doi.org/10.18778/1231-1952.27.2.02

HHI, 2018. Importance of construction industry in the economy and use of construction equipments. https://www.hhilifting.com/importance-of-construction-industry-in-the-economy-and-use-of-construction-equipments/

Hillary, R., 2004. Environmental management systems and the smaller enterprise. *Journal of cleaner production*, *12*(6), pp.561-569.

Hire, S., Sandbhor, S. and Ruikar, K., 2024. A Conceptual Framework for BIM-Based Site Safety Practice. Buildings, 14(1), p.272.

Hmamed, H., Benghabrit, A., Cherrafi, A. and Hamani, N., 2023. Achieving a Sustainable Transportation System via Economic, Environmental, and Social Optimization: A Comprehensive AHP-DEA Approach from the Waste Transportation Sector. Sustainability, 15(21), p.15372.

Ho, J.C., Shalishali, M.K., Tseng, T.L.B. and Ang, D.S., 2009. Opportunities in green supply chain management. *The Coastal Business Journal*, *8*(1), p.2.

Hoejmose, S., Brammer, S. and Millington, A., 2012. "Green" supply chain management: The role of trust and top management in B2B and B2C markets. Industrial Marketing Management, 41(4), pp.609-620.

Hohnen, P. and Potts, J., 2007. Corporate social responsibility. *An implementation guide for business*. IISD; Internation Institute for Sustainable Development. http://www.yooyahcloud.com/MOSSCOMMUNICATIONS/c48Mx/2007_IISD_Corporate_Social_Responsibility.pdf

Hong, P., Kwon, H.B. and Jungbae Roh, J., 2009. Implementation of strategic green orientation in supply chain: An empirical study of manufacturing firms. European Journal of Innovation Management, 12(4), pp.512-532.

Hossain, M. U., A. Sohail and S. T. Ng (2019). "Developing a GHG-based methodological approach to support the sourcing of sustainable construction materials and products." Resources, Conservation and Recycling 145, 160-169.

Hosseini, M., N. Chileshe, R. Rameezdeen and S. Lehmann (2014). "Reverse logistics for the construction industry: Lessons from the manufacturing context." International Journal of Construction Engineering and Management 3(3), 75-90.

Hosseini, M.R., Rameezdeen, R., Chileshe, N. and Lehmann, S., 2015. Reverse logistics in the construction industry. Waste Management & Research, 33(6), pp.499-514.

Hou, J., Teo, T.S., Zhou, F., Lim, M.K. and Chen, H., 2018. Does industrial green transformation successfully facilitate a decrease in carbon intensity in China? An environmental regulation perspective. Journal of cleaner production, 184, pp.1060-1071. https://doi.org/10.1016/j.jclepro.2018.02.311

Howell L.D., 2014. Evaluating Political Risk Forecasting Models: What Works?: Thunderbird International Business Review 56(4): pp.305–316

Hsu, C.C. and Sandford, B.A., 2007. The Delphi technique: making sense of consensus. Practical assessment, research, and evaluation, 12(1), p.10. DOI: https://doi.org/10.7275/pdz9-th90

Hsu, C.C., Choon Tan, K., Hanim Mohamad Zailani, S. and Jayaraman, V., 2013. Supply chain drivers that foster the development of green initiatives in an emerging economy. International journal of operations & production management, 33(6), pp.656-688.

Hsu, C.C., Tan, K.C. and Mohamad Zailani, S.H., 2016. Strategic orientations, sustainable supply chain initiatives, and reverse logistics: Empirical evidence from an emerging market. *International journal of operations & production management*, *36*(1), pp.86-110.

Huang, M.C., Liu, T.C., Yen, G.F. and Chiu, C.Y., 2012. How to integrate supply chain as spider-web network through governance mechanism. Business Management Technology Quarterly [商管科技季刊], 13(4), pp.339-375.

Hung, Y., Hieke, S., Grunert, K.G. and Verbeke, W., 2019. Setting policy priorities for front-of-pack health claims and symbols in the European union: Expert consensus built by using a Delphi method. *Nutrients*, *11*(2), p.403.

Hussein, M. and Zayed, T., 2021. Critical factors for successful implementation of just-in-time concept in modular integrated construction: A systematic review and meta-analysis. Journal of cleaner production, 284, p.124716.

IEA, P., 2021. Net zero by 2050-a roadmap for the global energy sector. Int. Energ. Agency, 224.

ILO, 2014. *Start and improve your business: Implementation guide*. ILO. file:///C:/Users/User/Downloads/wcms_315262.pdf

ILO, 2019. Developing the construction industry for employment-intensive infrastructure investments. *International Labour Office, Geneva, Switzerland. Available online: https://www. ilo. org/wcmsp5/groups/public/---ed_emp/---emp_policy/---invest/documents/publication/wcms_734235. pdf (accessed on April 2023)*.

Ingle, P.V., 2020. Project Performance Assessment Using Modified Project Quarterback Rating System for Indian construction projects (Doctoral dissertation, National Institute of Technology Karnataka, Surathkal).

Ioannidis, J.P., Fanelli, D., Dunne, D.D. and Goodman, S.N., 2015. Meta-research: evaluation and improvement of research methods and practices. PLoS biology, 13(10), p.e1002264.

Irani, Z., Kamal, M.M., Sharif, A. and Love, P.E., 2017. Enabling sustainable energy futures: factors influencing green supply chain collaboration. Production Planning & Control, 28(6-8), pp.684-705. https://doi.org/10.1080/09537287.2017.1309710

Iyer-Raniga, U., Huovila, P. and Erasmus, P., 2021. Sustainable Buildings and Construction: Responding to the SDGs. Sustain. Cities Communities. (pp. 1–15). https://doi.org/10.1007/978-3-319-71061-7_61-1

Jabbour, C.J.C., Seuring, S., de Sousa Jabbour, A.B.L., Jugend, D., Fiorini, P.D.C., Latan, H. and Izeppi, W.C., 2020. Stakeholders, innovative business models for the circular economy and sustainable performance of firms in an emerging economy facing institutional voids. Journal of environmental management, 264, pp.1-12. https://doi.org/10.1016/j.jenvman.2020.110416

Jackley, M. (2023). Supply Chain Transparency Defined: Why It Matters and Its Benefits. https://www.oracle.com/in/scm/supply-chain-transparency/

Jacob, W.J., Sutin, S.E., Weidman, J.C. and Yeager, J.L. eds., 2015. Community engagement in higher education: Policy reforms and practice. Springer.

Jain, A., Bhandari, N.S. and Jain, N., 2018, February. Essential elements of writing a research/review paper for conference/journals. In 2018 5th international symposium on emerging trends and technologies in libraries and information services (ETTLIS) (pp. 131-136). IEEE.

Jamshed, S., 2014. Qualitative research method-interviewing and observation. Journal of basic and clinical pharmacy, 5(4), p.87.

Jankowicz, A.D., 2013. *Business research projects*. Springer. 1st edn. London, Chapman & Hall. https://doi.org/10.1007/978-1-4899-3384-3

Jayant, A. and Tiwari, A., 2018. Impact of green supply chain management practices in India. J Ind Mech, 2, pp.1-14. https://www.researchgate.net/publication/318721781

Jayarathna, C.P., Agdas, D. and Dawes, L., 2023. Exploring sustainable logistics practices toward a circular economy: A value creation perspective. Business Strategy and the environment, 32(1), pp.704-720.

Jeffery, N., 2009. Stakeholder engagement: A road map to meaningful engagement. Doughty Centre, Cranfield School of Management, 2, p.11.

Jelti, F., Allouhi, A., Büker, M.S., Saadani, R. and Jamil, A., 2021. Renewable power generation: A supply chain perspective. Sustainability, 13(3), p.1271.

Jenkins, A., 2021. A Guide to Reverse Logistics: How It Works, Types and Strategies. https://www.netsuite.com/portal/resource/articles/inventory-management/reverse-logistics.shtml

Jiang, Y., Zhao, D., Wang, D. and Xing, Y., 2019. Sustainable performance of buildings through modular prefabrication in the construction phase: A comparative study. Sustainability, 11(20), p.5658. https://doi.org/10.3390/su11205658

Jin, X., Ekanayake, E.M.A.C. and Shen, G.Q., 2022. Critical policy drivers for Modular integrated Construction projects in Hong Kong. Building Research & Information, 50(4), pp.467-484. https://doi.org/10.1080/09613218.2021.2010030

Jin, X., Shen, G.Q., Wang, Q.C., Ekanayake, E.M.A.C. and Fan, S., 2021. Promoting Construction Industrialisation with Policy Interventions: A Holistic Review of Published Policy Literature. International Journal of Environmental Research and Public Health, 18(23), p.12619. https://doi.org/10.3390/ijerph182312619

Jing, K.T., bin Ismail, R., Shafiei, M.W.M., Yusof, M.N. and Riazi, S.R.M., 2019. Environmental factors that affect the implementation of green supply chain management in construction industry: a review paper. Ekoloji, 28(107), pp.93-104. http://www.ekolojidergisi.com/download/environmental-factors-that-affect-the-implementation-of-green-supply-chain-management-in-5592.pdf

Jones, K., 2022. 4 Major Challenges Facing the Construction Industry. https://www.constructconnect.com/blog/4-major-challenges-facing-the-construction-industry

Joshi, K.A. and Kambekar, A.R., 2013. Optimization of energy in public buildings. In IC-RICE Conference Issue, November (pp. 423-427). http://www.ijret.org

Kadaei, S., Shayesteh Sadeghian, S.M., Majidi, M., Asaee, Q. and Mehr, H.H., 2021. Hotel construction management considering sustainability architecture and environmental issues. Shock and Vibration, 2021. https://doi.org/10.1155/2021/6363571

Kandananond, K., 2014. A roadmap to green supply chain system through enterprise resource planning (ERP) implementation. Procedia Engineering, 69, pp.377-382.

Karimpour, M., Belusko, M., Xing, K. and Bruno, F., 2014. Minimising the life cycle energy of buildings: Review and analysis. Building and environment, 73, pp.106-114. https://doi.org/10.1016/j.buildenv.2013.11.019

Karlsson, I., 2020. Decarbonization of Construction Supply Chains-Achieving Net-Zero Carbon Emissions in the Supply Chains Linked to the Construction of Buildings and Transport Infrastructure (Doctoral dissertation, Chalmers Tekniska Hogskola (Sweden)).

Karmaker, C.L., Ahmed, T., Ahmed, S., Ali, S.M., Moktadir, M.A. and Kabir, G., 2021. Improving supply chain sustainability in the context of COVID-19 pandemic in an emerging economy: Exploring drivers using an integrated model. *Sustainable production and consumption*, *26*, pp.411-427.

Karttunen, E., Lintukangas, K. and Hallikas, J., 2023. Digital transformation of the purchasing and supply management process. International Journal of Physical Distribution & Logistics Management, 53(5/6), pp.685-706.

Kashkol, A. M. and Talib, M. H. (2019). "Theory of Constraints in Construction Projects," J. Univ. Babylon Eng. Sci., vol. 27, no.2, pp. 109–124, 2019, DOI: https://doi.org/10.29196/jubes.v27i2.2302

Kaushik, M. and Guleria, N., 2020. The impact of pandemic COVID-19 in workplace. *European Journal of Business and Management*, *12*(15), pp.1-10.

Kaviya, B. and Hema, C (2015). Performance Management in Construction. International Journal of Innovative Research in Science, Engineering and Technology. Vol. 4, Issue 4, pp. 2093-2100.

Kawmudi, W.N., Jayasooriya, S., Rupasinghe, A., and Ariyarathna, K.C., 2020. Identification of the challenges imposed by COVID-19 pandemic on Sri Lankan Construction projects. In 13th International Research Conference of General Sir John Kotelawala Defence University, Colombo, Sri Lanka. pp. 35-44.

Kazmi, R. and Chakraborty, M., 2023. Identification of parameters and indicators for implementing circularity in the construction industry. Journal of Engineering and Applied Science, 70(1), p.77. https://doi.org/10.1186/s44147-023-00251-3

Kelly, R. C. and Ma, J. (2024). Enterprise Resource Planning (ERP): Meaning, Components, and Examples. https://www.investopedia.com/terms/e/erp.asp

Khan, S.S., 2020. Construction of Cooperative Environment and Institution for Green Building Supply Chain Subjects: Construction of Cooperative Environment. In Global Perspectives on Green Business Administration and Sustainable Supply Chain Management (pp. 197-210). IGI Global.

Khasreen, M.M., Banfill, P.F. and Menzies, G.F., 2009. Life-cycle assessment and the environmental impact of buildings: a review. Sustainability, 1(3), pp.674-701. https://doi.org/10.3390/su1030674

King, S.S., Rahman, R.A., Fauzi, M.A., and Haron, A.T., 2021. Mechanisms for addressing the impact of COVID-19 on infrastructure projects. In IOP Conference Series: Earth and Environmental Science, IOP Publishing. 682(1), p. 012047.

Kirun, S.S. and Varghese, S., 2015. A study on cost control using delphi techniques in construction projects. International Journal of Science Technology & Engineering, 2(5), pp.44-51.

Kniivila, M., 2007. Industrial development and economic growth: Implications for poverty reduction and income inequality. Industrial development for the 21st century: Sustainable development perspectives, 1(3), pp.295-333.

Korkmaz, S., Erten, D., Syal, M. and Potbhare, V., 2009, May. A review of green building movement timelines in developed and developing countries to build an international adoption framework. In Proceedings of the Fifth International Conference on Construction in the 21st Century: Collaboration and Integration in Engineering, Management and Technology, Istanbul, Turkey (Vol. 20).

Kotabe, M. and Murray, J.Y., 2004. Global sourcing strategy and sustainable competitive advantage. Industrial marketing management, 33(1), pp.7-14.

Krarti, M., 2018. Optimal design and retrofit of energy efficient buildings. Communities, and Urban Centers; Butterworth-Heinemann: Cambridge, MA, USA, pp.1-43.

Kripaa, 2012. ERP for Green Supply Chain Management. URL:https://www.ramco.com/blog/erp-for-green-supply-chain-management (visited on 09 September 2022)

Kulkarni, P.B., Ravi, K. and Patil, S.B., 2017. An investigation on green supply chain management and its scope in Indian construction industries. International Journal of Research and Scientific Innovation, 4 (9), pp.50-53.

Kumar, A., Buddhi, D. and Chauhan, D.S., 2012. Indexing of building materials with embodied, operational energy and environmental sustainability with reference to green buildings. Journal of Pure and Applied Science & Technology, 2(1), pp.11-22. http://nlss.org.in/wp-content/uploads/2012/01/Paper-2-Jan-12.pdf

Labansen, M.E. and Bastien, D., 2019, October. Development of a Greenlandic sustainable index for residential buildings. In IOP Conference Series: Earth and Environmental Science (Vol. 352, No. 1, p. 012064). IOP Publishing. https://doi.org/10.1088/1755-1315/352/1/012064

Labouze, E., Monier, V. and Puyou, J.B., 2003. Study on external environmental effects related to the life cycle of products and services. BIO Intelligence Service and O2 France for the European Commission, Directorate General Environment, Brussels.

Lakys, R.E., Saad, A., Ahmed, T. and Yassin, M.H., 2022. Investigating the drivers and acceptance of sustainable materials in Kuwait: A case study of CEB. Case Studies in Construction Materials, 17, p.e01330. https://doi.org/10.1016/j.cscm.2022.e01330

Lam, H.L., How, B.S. and Hong, B.H., 2015. Green supply chain toward sustainable industry development. In *Assessing and measuring environmental impact and sustainability* (pp. 409-449). Butterworth-Heinemann.

Lamba, N. and Thareja, P., 2016. Barriers of Green Supply Chain Management. A Review. Journal of Advanced Research In Manufacturing, Material Science & Metallurgical Engineering, 3(3), pp.4-15. https://www.researchgate.net/publication/321520044

Larsen, M.S., 2010. Methodology For Assessing Procurement Systems (maps). https://www.oecd.org/dac/effectiveness/45454394.pdf

Le, A., Rodrigo, N., Domingo, N. and Senaratne, S., 2023. Policy Mapping for Net-Zero-Carbon Buildings: Insights from Leading Countries. Buildings, 13(11), p.2766.

Le, T.T., 2022. How do corporate social responsibility and green innovation transform corporate green strategy into sustainable firm performance?. Journal of Cleaner Production, 362, p.132228.

Lee, S., Lee, B., Kim, J. and Kim, J., 2013. A financing model to solve financial barriers for implementing green building projects. The Scientific World Journal, 2013. The Scientific World Journal, vol. 2013, Article ID 240394, 10 pages. https://doi.org/10.1155/2013/240394

Leitner, P., Khalil, M. and Ebner, M., 2017. Learning analytics in higher education—a literature review. Learning analytics: Fundaments, applications, and trends: A view of the current state of the art to enhance E-learning, pp.1-23.

Lekan, A., Oluchi, E., Faith, O., Opeyemi, J., Adedeji, A. and Rapahel, O., 2018. Creating sustainable construction: Building Informatics Modelling and lean construction approach. Journal of Theoretical & Applied Information Technology, 96(10). http://www.jatit.org/volumes/Vol96No10/23Vol96No10.pdf

Lewis, V. 2021. Construction Absorbs Low-Skilled Casual Labour? The construction sector accounts for every fifth non-farm job in India. https://www.indiaspend.com/data-viz/construction-sector-labour-low-skilled-migrant-population-short-term-765841

Li, J., Liu, H., Zuo, J., Xia, R. and Zillante, G., 2018. Are construction enterprises ready for industrialized residential building policy? A case study in Shenzhen. Sustainable cities and society, 41, pp.899-906. https://doi.org/10.1016/j.scs.2018.06.033

Li, R.Y.M., Li, Y.L., Crabbe, M.J.C., Manta, O. and Shoaib, M., 2021. The impact of sustainability awareness and moral values on environmental laws. Sustainability, 13(11), pp.1-26. https://doi.org/10.3390/su13115882

Liberatore, M.J., Hatchuel, A., Weil, B. and Stylianou, A.C., 2000. An organizational change perspective on the value of modeling. *European Journal of Operational Research*, *125*(1), pp.184-194.

Lingard, H., Wakefield, R. and Walker, D., 2020. The client's role in promoting work health and safety in construction projects: balancing contracts and relationships to effect change. Construction management and economics, 38(11), pp.993-1008.

Linstone, H.A. and Turoff, M. eds., 1975. *The delphi method* (pp. 3-12). Reading, MA: Addison-Wesley.

Litman, T., 1996. *Transportation cost analysis for sustainability*. Victoria, Canada: Victoria Transport Policy Institute.

Liu, T., Chen, L., Yang, M., Sandanayake, M., Miao, P., Shi, Y. and Yap, P.S., 2022. Sustainability considerations of green buildings: a detailed overview on current advancements and future considerations. Sustainability, 14(21), p.14393.

Lockhart, J.W., 2022. Sourcing for Sustainability: How to Build a Transparent Supply Chain. https://www.shopify.com/ng/enterprise/blog/supply-chain-transparency

Loganathan, S. and Kalidindi, S. N., 2017. Labour Sub-Contracting Issues in the Indian Construction Industry. Conference: PMI Research and Academic Conference 2017 at Indian Institute of Technology Madras. https://www.researchgate.net/publication/316787265_Labour_Sub-Contracting_Issues_in_the_Indian_Construction_Industry

Lorimer, K., 2021. Measuring up to climate change - the challenges to sustainability reporting. https://www.publicfinancefocus.org/depth/2021/09/measuring-climate-change-challenges-sustainability-reporting?utm_source=Adestra&amp%3Butm_medium=email&amp%3Butm_term=

Love, P.E., Irani, Z. and Edwards, D.J., 2004. A seamless supply chain management model for construction. *Supply chain management: an international journal*, *9*(1), pp.43-56.

Ludwig, B. G., 1994. Internationalizing Extension: An exploration of the characteristics evident in a state university Extension system that achieves internationalization. Unpublished doctoral dissertation, The Ohio State University, Columbus.

Lundberg, K., 2009. Monitoring as an instrument for improving environmental performance in public authorities (Doctoral dissertation, Doctoral thesis. KTH–Environmental Management and Assessment Research Group. Department of Land and Water Resources Engineering. Royal Institute of Technology (KTH), Sweden).

Luong, I., 2023. Procurement and supply chain management: What are the differences? https://www.magestore.com/blog/procurement-in-supply-chain/

Luther, D., 2021. Supply Chain Sustainability: Why It Is Important & Best Practices. https://www.netsuite.com/portal/resource/articles/erp/supply-chain-sustainability.shtml

Luthra, S., Garg, D. and Haleem, A., 2014. Green supply chain management: Implementation and performance–a literature review and some issues. Journal of Advances in Management Research, 11(1), 20–46. https://doi.org/10.1108/JAMR-07-2012-0027

Lutkevich, B. (2023). supply chain. https://www.techtarget.com/whatis/definition/supply-chain

Ma, L., Le, Y., Li, H., Jin, R., Piroozfar, P. and Liu, M., 2018. Regional comparisons of contemporary construction industry sustainable concepts in the Chinese context. Sustainability, 10(11), p.3831.

Ma, X., Xiong, F., Olawumi, T.O., Dong, N. and Chan, A.P., 2018. Conceptual framework and roadmap approach for integrating BIM into lifecycle project management. Journal of Management in Engineering, 34(6), p.05018011.

Mahant, S.I. 2015. A Study of Correlation Between Supply Chain Management and Marketing Logistics at TATA Motors. Unpublished thesis. PESs Institute of Management and career Development Nigadi, Savitribai Phule Pune University. http://hdl.handle.net/10603/477937

Malacina, I., Karttunen, E., Jääskeläinen, A., Lintukangas, K., Heikkilä, J. and Kähkönen, A.K., 2022. Capturing the value creation in public procurement: A practice-based view. Journal of Purchasing and Supply Management, 28(2), p.100745.

Malviya, R.K. and Kant, R., 2015. Green supply chain management (GSCM): a structured literature review and research implications. Benchmarking: An international journal (Vol. 22, Issue 7, pp. 1360–1394). Emerald Group Holdings Ltd. https://doi.org/10.1108/BIJ-01-2014-0001

Mao, J., Sun, Q., Wang, X., Muthu, B. and Krishnamoorthy, S., 2020. The importance of public support in the implementation of green transportation in the smart cities. Computational Intelligence. Special issue article. pp. 1-15. https://doi.org/10.1111/coin.12326

Marcelino-Sádaba, S., González-Jaen, L.F. and Pérez-Ezcurdia, A., 2015. Using project management as a way to sustainability. From a comprehensive review to a framework definition. Journal of cleaner production, 99, pp.1-16. https://doi.org/10.1016/j.jclepro.2015.03.020

Marinelli, M., Konanahalli, A., Dwarapudi, R. and Janardhanan, M., 2022. Assessment of Barriers and Strategies for the Enhancement of Off-Site Construction in India: An ISM Approach. Sustainability, 14(11), p.6595.

Martino, J. P. 1993. Technological forecasting. The Futurist; Washington Vol. 27, Iss. 4, (Jul/Aug 1993): 13. https://www.proquest.com/openview/fa0c041eabfca3f0e5a9a9cd7b6f4be6/1.pdf?pq-origsite=gscholar&cbl=47758

Masoetsa, T.G., Ogunbayo, B.F., Aigbavboa, C.O. and Awuzie, B.O., 2022. Assessing construction constraint factors on project performance in the construction industry. Buildings, 12(8), p.1183.

Massoud, M.A., Fayad, R., El-Fadel, M. and Kamleh, R., 2010. Drivers, barriers and incentives to implementing environmental management systems in the food industry: A case of Lebanon. *Journal of cleaner production*, *18*(3), pp.200-209.

Mathiyazhagan, K., Datta, U., Singla, A. and Krishnamoorthi, S., 2018. Identification and prioritization of motivational factors for the green supply chain management adoption: case from Indian construction industries. Opsearch, 55(1), pp.202-219.

Mathiyazhagan, K., Govindan, K. and Noorul Haq, A., 2014. Pressure analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. International Journal of Production Research, 52(1), pp.188-202.

Mavi, K.R., Gengatharen, D., Kiani Mavi, N., Hughes, R., Campbell, A. and Yates, R., 2021. Sustainability in construction projects: a systematic literature review. Sustainability, 13(4), p.1932. https://doi.org/10.3390/su13041932

Mazzucca, S., Weatherly, C., Tabak, R. and Morshed, A.B., 2018. Using Delphi Panels to Assess Construction Safety Research to Practice: A Narrative Review. Washington University, pp.1-45.

Meacham, B., Bowen, R., Traw, J. and Moore, A., 2005. Performance-based building regulation: current situation and future needs. Building Research & Information, 33(2), pp.91-106. https://doi.org/10.1080/0961321042000322780

Meade, L., Sarkis, J. and Presley, A., 2007. The theory and practice of reverse logistics. *International Journal of Logistics Systems and Management*, *3*(1), pp.56-84.

Mehmood, S., Fan, J., Dokota, I.S., Nazir, S. and Nazir, Z., 2024. How to Manage Supply Chains Successfully in Transport Infrastructure Projects. Sustainability, 16(2), p.730.

Meng, K. and Fenn, P., 2019. Performance measurement for construction projects. Project Management Development–Practice and Perspectives, 25, p.89.

Messina, D., Barros, A.C., Soares, A.L. and Matopoulos, A., 2020. An information management approach for supply chain disruption recovery. The International Journal of Logistics Management, 31(3), pp.489-519.

Milios, L., 2018. Advancing to a Circular Economy: three essential ingredients for a comprehensive policy mix. Sustainability Science, 13(3), pp.861-878. https://doi.org/10.1007/s11625-017-0502-9

Ming, H.Y., Rashid, Z.Z.A. and Adnan, H., 2019, November. Analyse the Barriers that Influencing Green Design Implementation among the Contractors in Construction Industry. In IOP Conference Series: Earth and Environmental Science (Vol. 385, No. 1, p. 012045). IOP Publishing. https://doi.org/10.1088/1755-1315/385/1/012045

Mingaleva, Z., Vukovic, N., Volkova, I. and Salimova, T., 2019. Waste management in green and smart cities: A case study of Russia. Sustainability, 12(1), 1–17. https://doi.org/10.3390/SU12010094

Mirza, N., Rahat, B., Naqvi, B. and Rizvi, S.K.A., 2020. Impact of Covid-19 on corporate solvency and possible policy responses in the EU. The Quarterly Review of Economics and Finance. https://doi.org/10.1016/j.qref.2020.09.002

Mohajan, H.K., 2017. Two criteria for good measurements in research: Validity and reliability. Annals of Spiru Haret University. Economic Series, 17(4), pp.59-82.

Moisescu, O.I. and Gică, O.A., 2020. The impact of environmental and social responsibility on customer loyalty: A multigroup analysis among generations x and y. International Journal of Environmental Research and Public Health, 17(18), p.6466.

Mojumder, A. and Singh, A., 2021. An exploratory study of the adaptation of green supply chain management in construction industry: The case of Indian Construction Companies. Journal of Cleaner Production, 295, p.126400. https://doi.org/10.1016/j.jclepro.2021.126400

Mojumder, A., Singh, A., Kumar, A. and Liu, Y., 2022. Mitigating the barriers to green procurement adoption: An exploratory study of the Indian construction industry. Journal of Cleaner Production, 372, p.133505. https://www.sciencedirect.com/science/article/pii/S0959652622030864

Montag, L., 2023. Circular economy and supply chains: definitions, conceptualizations, and research agenda of the circular supply chain framework. *Circular Economy and Sustainability*, *3*(1), pp.35-75.

Mozaffari, M., Fazli, S. and Sedaghat-Seresht, A., 2012. Identifying the most critical project complexity factors using Delphi method: the Iranian construction industry. Management Science Letters, 2(8), pp.2945-2952. https://doi:10.5267/j.msl.2012.09.014

MSDE, 2015. National Policy for Skill Development and Entrepreneurship. pp 1-64. https://www.msde.gov.in/sites/default/files/2019-09/National%20Policy%20on%20Skill%20Development%20and%20Entreprenurship%20Final.pdf

Mudgal, R.K., Shankar, R., Talib, P. and Raj, T., 2010. Modelling the barriers of green supply chain practices: an Indian perspective. *International Journal of Logistics Systems and Management*, *7*(1), pp.81-107.

Mullen, P.M., 2003. Delphi: myths and reality. Journal of health organization and management, 17(1), pp.37-52.

Mumtaz, R., Amin, A., Khan, M.A., Asif, M.D.A., Anwar, Z. and Bashir, M.J., 2023. Impact of Green Energy Transportation Systems on Urban Air Quality: A Predictive Analysis Using Spatiotemporal Deep Learning Techniques. Energies, 16(16), p.6087.

Murray, R., 2017. How to write a thesis. McGraw-Hill Education (UK).

Nalewaik, A. and Venters, V., 2010. Cost benefits of building green. IEEE Engineering Management Review, 38(2), pp.77-87.

Narayanaswami, S., 2017. Urban transportation: innovations in infrastructure planning and development. The International Journal of Logistics Management, 28(1), 150–171. https://doi.org/10.1108/IJLM-08-2015-0135

Nasa, P., Jain, R. and Juneja, D., 2021. Delphi methodology in healthcare research: how to decide its appropriateness. World Journal of Methodology, 11(4), p.116. http://DOI:10.5662/wjm.v11.i4.116

Naz, F., Kumar, A., Majumdar, A. and Agrawal, R., 2022. Is artificial intelligence an enabler of supply chain resiliency post COVID-19? An exploratory state-of-the-art review for future research. Operations Management Research, 15(1), pp.378-398.

Negi, M., Ahuja, V. and Baruah, P., 2017. Sustainable supply chain management in Indian construction industry. In Proceedings of the National Conference on Sustainable Supply Chain Management an Indian Perspective (CRIMM), West Bengal, India (Vol. 10), pp.1–23. https://www.researchgate.net/publication/317002420

Negri, M., Cagno, E., Colicchia, C. and Sarkis, J., 2021. Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda. Business Strategy and the environment, 30(7), pp.2858-2886.

Nelson, J. (2017). PARTNERSHIPS FOR SUSTAINABLE DEVELOPMENT: Collective action by business, governments and civil society to achieve scale and transform markets. https://s3.amazonaws.com/aws-bsdc/PartnershipsforSD.pdf

Network, E., 2003. A toolkit for building better environmental inspectorates in Eastern Europe, Caucasus, and Central Asia. Assuring Environmental Compliance. EAP Task Force. pp.1-367. https://www.oecd.org/environment/outreach/34499651.pdf

Nhu, T., 2012. Online decision making-Couch Surfers and information technologies. https://www.academia.edu/76847395/Online_decision_making_Couch_Surfers_and_information_technologies

Ninlawan, C., Seksan, P., Tossapol, K. and Pilada, W., 2010, March. The implementation of green supply chain management practices in electronics industry. In *World Congress on Engineering 2012. July 4-6, 2012. London, UK.* (Vol. 2182, pp. 1563-1568). International Association of Engineers.

NITI Aayog (2019). Report of the Task Force on Project & Program. https://www.niti.gov.in/sites/default/files/2023-03/Task-Force-Report-on-Project-Program-Management.pdf

Nolz, P.C. 2021. Optimizing construction schedules and material deliveries in city logistics: A case study from the building industry. Flexible Services and Manufacturing Journal, 33(3), pp.846-878.

Norouzi, M., Chàfer, M., Cabeza, L.F., Jiménez, L. and Boer, D., 2021. Circular economy in the building and construction sector: A scientific evolution analysis. Journal of Building Engineering, 44, pp.1-18. https://doi.org/10.1016/j.jobe.2021.102704

Nureen, N., Liu, D., Irfan, M., Malik, M. and Awan, U., 2023. Nexuses among green supply chain management, green human capital, managerial environmental knowledge, and firm performance: evidence from a developing country. Sustainability, 15(6), p.5597.

O'Brien, W. J., Fischer, M. A., and Jucker, J. V., 1995. "An economic view of project coordination." Construction Management and Economics, 13(5), 393-400.

OECD, 2018. Financing Climate Futures: Rethinking Infrastructure Policy Highlights. https://www.oecd.org/environment/cc/climate-futures/policy-highlights-financing- climate-futures.pdf

OECD, Organisation for Economic Co-operation and Development, 2016. Innovating education and educating for innovation: The power of digital technologies and skills. https://www.oecd.org/education/ceri/GEIS2016-Background-document.pdf

Oey, E. and Lim, J., 2021. Challenges and action plans in construction sector owing to COVID-19 pandemic - A case in Indonesia real estates. International Journal of Lean Six Sigma. 12(4), pp. 835-858.

Ogunbiyi, M.A., 2014. The national building code and the construction industry professionals in Nigeria. International Journal of Social Sciences and Entrepreneurship, 1(12), pp.937-948.

Ogunnusi, M., Hamma-Adama, M., Salman, H., and Kouider, T. 2020. COVID-19 pandemic: The Effects and prospects in the construction industry. International Journal of Real Estate Studies, 14(2), pp. 120-123.

Ojo, E., Mbowa, C. and Akinlabi, E.T., 2014, January. Barriers in implementing green supply chain management in construction industry. In Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management, Bali, Indonesia, pp.1974-1981.

Okafor, C.C., Sydney Ani, U. and Ugwu, O., 2022. Critical solutions to the lapses of supply chain management in Nigeria's construction industry. International Journal of Building Pathology and Adaptation.

Okba, E.M. and Embaby, M.E., 2013. Sustainability and heritage buildings. Int. J. Eng. Res. Technol, 2, pp.1682-1690.

Okoli, C. and Schabram, K., 2015. A guide to conducting a systematic literature review of information systems research.

Opticvyu, 2021. Construction Planning / Construction Project. Top 10 Construction Project Management Challenges. https://blog.opticvyu.com/construction-project-management-challenges/

Orunbon, N. and Oluranti, F. (2023). Case study in educational management. https://www.researchgate.net/publication/375423992_CASE_STUDY_IN_EDUCATIONAL_MANAGEMENT

Osuizugbo, I.C., 2020. Disruptions and responses within Nigeria construction industry amid COVID-19 threat. Covenant Journal of Research in the Built Environment, 8(2), pp. 37-48.

Osuizugbo, I.C., Oyeyipo, O., Lahanmi, A., Morakinyo, A. and Olaniyi, O., 2020. Barriers to the adoption of sustainable construction. European Journal of Sustainable Development, 9(2), pp.150-162. https://doi.org/10.14207/ejsd.2020.v9n2p150

Overvest, M., Goedhart, S. And Emonds, R. (2024). Procurement Regulations – Your Guideline for Procurement 2024. https://procurementtactics.com/procurement-regulations/

Owusu-Manu, D.G., Debrah, C., Oduro-Ofori, E., Edwards, D.J. and Antwi-Afari, P., 2020. Attributable indicators for measuring the level of greenness of cities in developing countries: lessons from Ghana. Journal of Engineering, Design and Technology.

Palm, V., Finnveden, G. and Wadeskog, A., 2006. Swedish experience using environmental accounts data for integrated product policy issues. Journal of Industrial Ecology, 10(3), pp.57-72. www.mitpressjournals.org/jie

Pamidimukkala, A. and Kermanshachi, S., 2021. Impact of Covid-19 on field and office workforce in construction industry. Project Leadership and Society, 2, p.100018. https://doi.org/10.1016/j.plas.2021.100018

Papageorgiou, S., 2009. Critical Success Factors in ERP Systems Implementations in the Cypriot Public Sector. Unpublished dissertation for Master in Strategic Project Management (MSPME), Umeå University, pp-1-77.

Paré, G. and Kitsiou, S., 2017. Methods for literature reviews. In Handbook of eHealth evaluation: An evidence-based approach [Internet]. University of Victoria.

Paré, G., Trudel, M.C., Jaana, M. and Kitsiou, S., 2015. Synthesizing information systems knowledge: A typology of literature reviews. Information & management, 52(2), pp.183-199.

Park, S. H., Kim, Y.S. and Chin, S.Y. 2003. Implementation of Supply Chain Management in Construction Industry. *Korean Journal of Construction Engineering and Management*, *4*(3), pp.85-94.

Pathirana, L.P.D.S., 2020. Effect of COVID-19 and strategic response: A review on Sri Lankan construction industry. SSRG International Journal of Economics and Management Studies, 7(June), pp. 73-77.

Perron, G.M., 2005. Barriers to environmental performance improvements in Canadian SMEs. Dalhousie University, Canada.

Phillips, E. and Johnson, C., 2022. *How to Get a PhD: A handbook for students and their supervisors. 7e*. McGraw-Hill Education (UK). 3rd edn. Buckingham, Philadelphia, Open University Press.

Poursoltan, L., Seyed-Hosseini, S.M. and Jabbarzadeh, A., 2021. Green closed-loop supply chain network under the COVID-19 pandemic. Sustainability, 13(16), p.9407. https://www.mdpi.com/2071-1050/13/16/9407

Prabaharan, R. and Shanmugapriya, S., 2023. Identification of critical barriers in implementing lean construction practices in Indian construction industry. Iranian Journal of Science and Technology, Transactions of Civil Engineering, 47(2), pp.1233-1249.

Prabhu, P.G., 2016. Study on the influence of stakeholders in construction industry. International Journal of Engineering Technology, Management and Applied Sciences, 4(6), pp.31-45.

Prasad, M.A., Loukoianova, M.E., Feng, A.X. and Oman, W., 2022. Mobilizing Private Climate Financing in Emerging Market and Developing Economies. International Monetary Fund.

Prasath, M.K., 2014, January. Barriers in green supply chain management: an Indian foundry perspective. In Proceedings of the Second International Conference on Advances in Industrial Engineering Applications (ICAIEA 2014).

Prema, E., 2021, November. Solid Waste Management in the Construction Sector: A Prerequisite for Achieving Sustainable Development Goals. In IOP Conference Series: Earth and Environmental Science (Vol. 850, No. 1, p. 012007). IOP Publishing.

Priya, A., 2021. Case study methodology of qualitative research: Key attributes and navigating the conundrums in its application. Sociological Bulletin, 70(1), pp.94-110.

Procter, S. and Hunt, M. (1994) Using the Delphi survey technique to develop a professional definition of nursing for analysing nursing workload. Journal of Advanced Nursing, 19, pp. 1003-1014.

Pun, K.F. 2023., Desk Research on Selected Areas of Value Engineering and Management: A Preliminary Report. Pp 1-67. https://www.researchgate.net/profile/Kit-Fai-Pun-2/publication/377224068_Desk_Research_on_Selected_Areas_of_Value_Engineering_and_Management_A_Preliminary_Report/links/659bc69b6f6e450f19d5601f/Desk-Research-on-Selected-Areas-of-Value-Engineering-and-Management-A-Preliminary-Report.pdf

Pushpamali, N.N.C., Agdas, D. and Rose, T.M., 2020. Strategic decision making in construction supply chains: A comparison of reverse logistics strategies. Frontiers in Built Environment, 6, pp.1-11. https://doi.org/10.3389/fbuil.2020.593372

Quesada, G., Bailey, C. and Woodfin, B., 2011, June. An Analysis of Drivers and Barriers to Innovations in Green Supply Chain Practices in Mexico. In Proceedings Global Buinsess and Social Science Research Conference.

Quinn, J.B. and Hilmer, F.G., 1994. Strategic outsourcing. MIT Sloan Management Review, 35(4), p.43.

Rabie, M., 2016. Meaning of development. A theory of sustainable sociocultural and economic development, pp.7-15.

Rahman, M.H., Rahman, J., Tanchangya, T. and Esquivias, M.A., 2023. Green banking initiatives and sustainability: A comparative analysis between Bangladesh and India. Research in Globalization, p.100184.

Rai, A. 2013. Elevating Performance Management System Through Knowledge Management. Conference Paper. Conference on Management Conducted by Indian Institute of Management Bangalore, January 6-9. 2013At: Bangalore. https://www.researchgate.net/publication/326058452_Elevating_Performance_Management_System_Through_Knowledge_Management

Rai, H.M., Pal, A., Mishra, S. and Shukla, K.K., 2023. Use of Internet of Things in the context of execution of smart city applications: a review. Discover Internet of Things, 3(1), p.8.

Raj, A., Mukherjee, A.A., de Sousa Jabbour, A.B.L. and Srivastava, S.K., 2022. Supply chain management during and post-COVID-19 pandemic: Mitigation strategies and practical lessons learned. Journal of business research, 142, pp.1125-1139.

Rajhans, K., 2018. Effective communication management: A key to stakeholder relationship management in project-based organizations. IUP Journal of Soft Skills, 12(4), pp.47-66.

Ramakrishna, P., 2023. A Multi-Level Perspective: Construction and Demolition Waste Management System: Case Study: Bengaluru.

Raman, R., Sreenivasan, A., Ma, S., Patwardhan, A. and Nedungadi, P., 2023. Green Supply Chain Management Research Trends and Linkages to UN Sustainable Development Goals. Sustainability, 15(22), p.15848.

Randolph, J., 2019. A guide to writing the dissertation literature review. Practical assessment, research, and evaluation, 14(1), p.13.

Rani, H.A., Farouk, A.M., Anandh, K.S., Almutairi, S. and Rahman, R.A., 2022. Impact of COVID-19 on construction projects: the case of India. Buildings, 12(6), p.762. https://doi.org/10.3390/buildings12060762

Rani, M.J., 2021. Indian construction industry progress since 1995. In Construction Industry Advance and Change: Progress in Eight Asian Economies Since 1995 (pp. 43-62). Emerald Publishing Limited.

Rao, P. and Holt, D., 2005. Do green supply chains lead to competitiveness and economic performance?. *International journal of operations & production management*, *25*(9), pp.898-916.

Raoufi, M. and Fayek, A.R., 2021. Identifying actions to control and mitigate the effects of the COVID-19 pandemic on construction organizations: Preliminary findings. Public Works Management & Policy, 26(1), pp.47-55. https://doi.org/10.1177/1087724X20969164

Rashid, Y., Rashid, A., Warraich, M.A., Sabir, S.S. and Waseem, A., 2019. Case study method: A step-by-step guide for business researchers. International journal of qualitative methods, 18, p.1609406919862424.

Ravi, S.S., Osipov, S. and Turner, J.W., 2023. Impact of Modern Vehicular Technologies and Emission Regulations on Improving Global Air Quality. Atmosphere, 14(7), p.1164.

Ravi, V. and Shankar, R., 2005. Analysis of interactions among the barriers of reverse logistics. *Technological Forecasting and Social Change*, *72*(8), pp.1011-1029.

Rawal, T., Devadas, V. and Numar, N., 2014. Integrated multimodal transportation in India. In Changing Spectrum of Human Settlements and Planning Education, At Guru Ramdas School of Planning, GNDU, Amritsar, Conference paper.

Reche, A.Y.U., Junior, O.C., Estorilio, C.C.A. and Rudek, M., 2020. Integrated product development process and green supply chain management: Contributions, limitations and applications. Journal of Cleaner Production, 249, p.119429. https://doi.org/10.1016/j.jclepro.2019.119429

Renzi, A.B. and Freitas, S., 2015. The Delphi method for future scenarios construction. Procedia Manufacturing, 3, pp.5785-5791. http://creativecommons.org/licenses/by-nc-nd/4.0/

Reshma, R.E. and Laxmiprasad, M.D., 2014. An Investigation of Green Supply Chain Management in Indian Construction Sector. International Journal of Science and Research (IJSR) Volume 5 Issue 2, pp. 1782-1785.

Revell, A. and Rutherfoord, R., 2003. UK environmental policy and the small firm: Broadening the focus. *Business Strategy and the Environment*, *12*(1), pp.26-35.

Rey, E., Laprise, M., Lufkin, S., Rey, E., Laprise, M. and Lufkin, S., 2022. Sustainability Monitoring: Principles, Challenges, and Approaches. Neighbourhoods in Transition: Brownfield Regeneration in European Metropolitan Areas, pp.121-142.

Rowe, F., 2014. What literature review is not: diversity, boundaries and recommendations. European Journal of Information Systems, 23, pp.241-255.

RREN, 2023. Driving Safety and Quality: Importance of Regulatory Compliance in Indian Construction [RREN Consultants and Contractors Private Limited]. https://www.linkedin.com/pulse/driving-safety-quality-importance-regulatory-compliance/?trk=article-ssr-frontend-pulse_more-articles_related-content-card

Ruslin, R., Mashuri, S., Rasak, M.S.A., Alhabsyi, F. and Syam, H., 2022. Semi-structured Interview: A methodological reflection on the development of a qualitative research instrument in educational studies. IOSR Journal of Research & Method in Education (IOSR-JRME), 12(1), pp.22-29.

Russel, T. ed., 1998. *Greener purchasing: Opportunities and innovations*. Routledge. Sheffield, United Kingdom

Russell, D., Ruamsook, K. and Roso, V., 2020. Managing supply chain uncertainty by building flexibility in container port capacity: a logistics triad perspective and the COVID-19 case. Maritime Economics & Logistics, pp.1-22. https://doi.org/10.1057/s41278-020-00168-1

Saad, M. and Patel, B., 2006. An investigation of supply chain performance measurement in the Indian automotive sector. *Benchmarking: An International Journal*, *13*(1/2), pp.36-53.

Saada, R., 2021. Green transportation in green supply chain management. Green Supply Chain-Competitiveness and Sustainability.

Saferi, M.M., Bohari, A.A.M., Bidin, Z.A. and Rais, S.L.A., 2018, September. Green Procurement for Construction Project: The Roles of Stakeholder Values. In IOP Conference Series: Materials Science and Engineering (Vol. 429, No. 1, p. 012024). IOP Publishing.

Saka, N., Olanipekun, A.O. and Omotayo, T., 2021. Reward and compensation incentives for enhancing green building construction. *Environmental and Sustainability Indicators*, *11*, p.100138.

Sakai, S.I., Yoshida, H., Hirai, Y., Asari, M., Takigami, H., Takahashi, S., Tomoda, K., Peeler, M.V., Wejchert, J., Schmid-Unterseh, T. and Douvan, A.R., 2011. International comparative study of 3R and waste management policy developments. Journal of material cycles and waste management, 13(2), pp.86-102. https://doi.org/10.1007/s10163-011-0009-x

Salvador, M. and Sancho, D., 2021. The role of local government in the drive for sustainable development public policies. An analytical framework based on institutional capacities. Sustainability, 13(11), p.5978.

Salvador, M. and Sancho, D., 2021. The role of local government in the drive for sustainable development public policies. An analytical framework based on institutional capacities. Sustainability, 13(11), p.5978.

Samad, A.A.A., Hadipramana, J., Mohamad, N., Ali, A.Z.M., Ali, N., Inn, G.W. and Tee, K.F., 2018. Development of green concrete from agricultural and construction waste. In Transition Towards 100% Renewable Energy (pp. 399-410). Springer, Cham.

Samaraweera, B.G.T.N. and Gunawardhana, W.H.T., 2019. The authenticity of Sustainable Practices in Sri Lankan Construction Industry. Sri Lanka Journal of Real Estate, pp.14-45. https://www.researchgate.net/publication/344452934

San Cristóbal, J.R., Diaz, E., Carral, L., Fraguela, J.A. and Iglesias, G., 2019. Complexity and project management: Challenges, opportunities, and future research. Complexity, 2019.

Sánchez, F.G. and Govindarajulu, D., 2023. Integrating blue-green infrastructure in urban planning for climate adaptation: Lessons from Chennai and Kochi, India. Land use policy, 124, p.106455.

Sánchez-Flores, R.B., Cruz-Sotelo, S.E., Ojeda-Benitez, S. and Ramírez-Barreto, M.E., 2020. Sustainable supply chain management—A literature review on emerging economies. Sustainability, 12(17), p.6972.

Sanganal, A. and Geetha, A., 2014. Green and Energy Efficient Buildings: Case Study of Bangalore & Mysore. P.47. https://www.scribd.com/document/574071875/action-research-report-on-green-and-energy-efficient-technologies

Sanghavi, K., 2024. Revolutionizing Transportation with AI: Benefits, Use Cases, and Examples. https://syndelltech.com/ai-in-transportation/

SAP, 2018. SAP Yard Logistics: CUSTOMER: User Guide; Document Version: 1.0.0. https://help.sap.com/doc/a720da6de2b140efa7d652ad4714d619/2.0/en-US/loio10106f5589aabe19e10000000a423f68.pdf

Sapatnekar, S., Patnaik, I. and Kishore, K., 2018. Regulating infrastructure development in India. National Institute of Public Finance and Policy, New DelhiNo, 18, p.230.

Sarkar, A. and Mohapatra, P.K., 2006. Evaluation of supplier capability and performance: A method for supply base reduction. *Journal of Purchasing and supply management*, *12*(3), pp.148-163.

Sarkis, J., Zhu, Q. and Lai, K.H., 2011. An organizational theoretic review of green supply chain management literature. International journal of production economics, 130(1), pp.1-15. https://doi.org/10.1016/j.ijpe.2010.11.010

Sarkis, J., Zhu, Q. and Lai, K.H., 2011. An organizational theoretic review of green supply chain management literature. *International journal of production economics*, *130*(1), pp.1-15.

Sawhney, A., Agnihotri, R. and Kumar Paul, V., 2014, "Grand challenges for the Indian construction industry", Built Environment Project and Asset Management, Vol. 4 No. 4, pp. 317-334. https://doi.org/10.1108/BEPAM-10-2013-0055

Schmidt, F.L., 2017. Statistical and measurement pitfalls in the use of meta-regression in meta-analysis. Career Development International, 22(5), pp.469-476.

Seethamraju, R. and Sundar, D.K., 2013. Influence of ERP systems on business process agility. IIMB Management Review, 25(3), pp.137-149.

Sekaran, U. (2003) Research Methods for Business A Skill Building Approach. 4th edn. USA, John Wiley & Sons.

Sev, A., 2009. How can the construction industry contribute to sustainable development? A conceptual framework. Sustainable Development, 17(3), pp.161-173.

Shadrina, E.V., Vinogradov, D.V. and Kashin, D.V., 2022. Implicit incentives in green public procurement: Good intentions versus rigid regulations. *Ecological Economics*, *198*, p.107458.

Sharma, A. and Iyer, G.R., 2012. Resource-constrained product development: Implications for green marketing and green supply chains. Industrial Marketing Management, 41(4), pp.599-608. https://doi.org/10.1016/j.indmarman.2012.04.007

Sharma, A., Kumar, P. and Walia, A., 2020. Use of recycled material in WMA-future of greener road construction. Transportation Research Procedia, 48, pp.3770-3778. https://doi.org/10.1016/j.trpro.2020.08.042

Sharma, M., 2018. Development of a 'Green building sustainability model'for Green buildings in India. Journal of cleaner production, 190, pp.538-551.

Sharma, N. (2023). Balancing Inventory Holding Costs and Stockouts: Challenges and Solutions in Supply Chain Management. https://www.linkedin.com/pulse/balancing-inventory-holding-costs-stockouts-solutions-netish-sharma/

Sharma, R.K., Singh, P.K., Sarkar, P. and Singh, H., 2021. Sustainability in supply networks: finding the most influential green interventions using interpretive structural modeling technique. International Journal of Sustainable Engineering, 14(3), pp.293-303. https://doi.org/10.1080/19397038.2021.1929552

Shekarian, E., Ijadi, B., Zare, A. and Majava, J., 2022. Sustainable supply chain management: a comprehensive systematic review of industrial practices. Sustainability, 14(13), p.7892. https://doi.org/10.3390/su14137892

Shen, L.Y. and Tam, V.W., 2002. Implementation of environmental management in the Hong Kong construction industry. International Journal of Project Management, 20(7), pp.535-543.

Sheth, J.N., Sethia, N.K. and Srinivas, S., 2011. Mindful consumption: A customer-centric approach to sustainability. Journal of the academy of marketing science, 39, pp.21-39.

Shuai-ping, Y., 2018. Environmental Pollution in Construction Sites and Corresponding Green Construction Measures. Nature Environment and Pollution Technology, 17(4), pp.1287-1292.

Sievo, 2023. Procurement Analytics Demystified. https://sievo.com/resources/procurement-analytics-demystified

Sileyew, K. J., 2019. Research design and methodology (Vol. 7). Cyberspace. p.184. DOI:10.5772/intechopen.85731

Silvius, A.J. and Schipper, R.P., 2014. Sustainability in project management: A literature review and impact analysis. Social Business, 4(1), pp.63-96. https://doi.org/10.1362/204440814x13948909253866

Simons, S., Kinjawadekar, A. and Kinjawadekar, T.A., 2023. Assessing the impacts of ecological framework of Indian riverfront revitalization projects. Environment, Development and Sustainability, pp.1-31.

Singh, A. and Misra, S.C., 2020. Ordering drivers of green supply chain management practices in Indian construction industry: An impact assessment framework. International Journal of Quality & Reliability Management. https://doi.org/10.1108/ijqrm-03-2019-0076

Singh, A. and Trivedi, A., 2016. Sustainable green supply chain management: trends and current practices. Competitiveness Review (Vol. 26, Issue 3, pp. 265–288). https://doi.org/10.1108/CR-05-2015-0034

Singh, A., Kumar, V., Verma, P. and Kandasamy, J., 2023. Identification and severity assessment of challenges in the adoption of industry 4.0 in Indian construction industry. Asia Pacific Management Review, 28(3), pp.299-315.

Singh, B., Singh, N.N. and Sinha, P., 2017. Assessment of green supply chain management in an Indian industry. International Journal of Engineering Sciences & Research Technology, 6(6), pp.493-498. https://doi.org/10.5281/zenodo.817858

Singh, C., Mital, M. and Aggarwal, A., 2018. Transportation planning credits in green townships-A perspective. International Journal of Home Science 2018; 4(2): 206-210. https://www.homesciencejournal.com/archives/2018/vol4issue2/PartD/4-2-42-566.pdf

Singh, J., 2022. Concepts Of Inventory And Related Technical Terminologies: A Literature Review. 2022 IJRTI | Volume 7, Issue 8 | ISSN: 2456-3315. Pp-1784-96. https://www.researchgate.net/publication/363208885_CONCEPTS_OF_INVENTORY_AND_RELATED_TECHNICAL_TERMINOLOGIES_A_LITERATURE_REVIEW

Singh, S., 2020. Decentralized solid waste management in India: A perspective on technological options. New Delhi: National Institute of Urban Affairs, pp.290-304.

Siva, V., Hoppe, T. and Jain, M., 2017. Green buildings in Singapore; analyzing a frontrunner's sectoral innovation system. Sustainability, 9(6), p.919. https://doi.org/10.3390/su9060919

Skulmoski, G.J., Hartman, F.T. and Krahn, J., 2007. The Delphi method for graduate research. Journal of Information Technology Education: Research, 6(1), pp.1-21.

Snyder, H., 2019. Literature review as a research methodology: An overview and guidelines. Journal of business research, 104, pp.333-339.

Sokolowski, L.I., Maheshwari, A. and Malik, A., 2019. Green buildings: a finance and policy blueprint for emerging markets. https://documents1.worldbank.org/curated/en/586841576523330833/pdf/Green-Buildings-A-Finance-and-Policy-Blueprint-for-Emerging-Markets.pdf

Son, S., 2012. Legal analysis on public-private partnerships regarding model PPP rules. United Nations Commission on International Trade Law, Austria.

Song, D., 2021. A literature review, container shipping supply chain: Planning problems and research opportunities. Logistics, 5(2), p.41.

Sourani, A. and Sohail, M., 2014. The Delphi Method: Review and Use in Construction Management Research, International Journal of Construction Education and Research, 00:1–23, 2014. http://DOI:10.1080/15578771.2014.917132

Spekman, R.E., Kamauff, J.W. and Salmond, D.J., 1994. At last purchasing is becoming strategic. *Long range planning*, *27*(2), pp.76-84.

Srinivasan V., "Analysis of static and dynamic load on hydrostatic bearing with variable viscosity and pressure", Indian Journal of Science and Technology, ISSN : 0974-6846, 6(S6) (2013) PP.4777-4782.

Srivastav, P. and Gaur, M.K., 2015. Scope of green supply chain management in North Indian construction industries. Int J Adv Res Eng Appl Sci, 4(4), pp.53-73. https://www.researchgate.net/publication/323572744

Srivastava, S.K., 2007. Green supply-chain management: a state-of-the-art literature review. International journal of management reviews, 9(1), pp.53-80.

Stahel, W.R., 2013. Policy for material efficiency—sustainable taxation as a departure from the throwaway society. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 371(1986), p.20110567. https://doi.org/10.1098/rsta.2011.0567

Stanitsas, M., Kirytopoulos, K. and Leopoulos, V., 2021. Integrating sustainability indicators into project management: The case of construction industry. Journal of Cleaner Production, 279, p.123774. https://doi.org/10.1016/j.jclepro.2020.123774

Subramani, T. and Tamizhanban, S., 2016. Supply Chain Management In Construction Site By Using SPSS Software. International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), 5(3), pp.182-193.

Subramanian, N., 2011. Transportation Infrastructure Needs and Developments. New Building Materials & Construction World, 17(3), pp.106-124. www.infrastructurereportcard.org

Sui Pheng, L., Shing Hou, L., Pheng, L.S. and Hou, L.S., 2019. The economy and the construction industry. Construction Quality and the Economy: A Study at the Firm Level, pp.21-54.

Sumsion, T., 1998. The Delphi technique: an adaptive research tool. British Journal of Occupational Therapy, 61(4), pp.153-156. (http://journals.sagepub.com/doi/10.1177/030802269806100403)

Sundarakani, B., De Souza, R., Goh, M., Wagner, S.M. and Manikandan, S., 2010. Modeling carbon footprints across the supply chain. *International journal of production economics*, *128*(1), pp.43-50.

Susanti, B., 2020. Sustainability Performance Of Building Construction Projects In Indonesia. International Journal of Scientific & Technology Research, 9(6), pp.927-933.

Sutterby, P., Wang, X., Li, H.X. and Ji, Y., 2023. The impact of COVID-19 on construction supply chain management: an Australian case study. Engineering, Construction and Architectural Management. https://www.emerald.com/insight/content/doi/10.1108/ECAM-10-2021-0942/full/html?skipTracking=true

Sylvester, A., Tate, M. and Johnstone, D., 2013. Beyond synthesis: Re-presenting heterogeneous research literature. Behaviour & information technology, 32(12), pp.1199-1215.

Szczygielski, J.J., Charteris, A., Bwanya, P.R. and Brzeszczyński, J., 2022. The impact and role of COVID-19 uncertainty: A global industry analysis. *International Review of Financial Analysis*, *80*, p.101837.

Tafazzoli, M., Mousavi, E. and Kermanshachi, S., 2020. Opportunities and challenges of green-lean: an integrated system for sustainable construction. Sustainability, 12(11), p.4460. https://doi.org/10.3390/su12114460

Tarigan, Z.J.H., Siagian, H. and Jie, F., 2021. Impact of enhanced Enterprise Resource Planning (ERP) on firm performance through green supply chain management. *Sustainability*, *13*(8), p.4358.

Tayeh, B.A., Abu Aisheh, Y.I. and Abuzuhri, I.O., 2020. Factors Affecting Sustainability Performance during the Construction Stage in Building Projects-Consultants' Perspective. The Open Construction & Building Technology Journal, 14(1), 17–26. https://doi.org/10.2174/1874836802014010017

Teixeira, C.R.B., Assumpção, A.L., Correa, A.L., Savi, A.F. and Prates, G.A., 2018. The contribution of green logistics and sustainable purchasing for green supply chain management. *Independent Journal of Management & Production*, *9*(3), pp.1002-1026.

Templier, M. and Paré, G., 2015. A framework for guiding and evaluating literature reviews. Communications of the Association for Information Systems, 37(1), p.6.

Tengan, C. and Aigbavboa, C., 2017. A Delphi technique approach towards the need and relevance of onstruction project monitoring and evaluation practices. Journal of Construction Project Management and Innovation, 7(Supplement 1), pp.1968-1976.

Thipparat, T., 2011, September. Evaluation of construction green supply chain management. In *International Conference on Innovation Manage and Service* (Vol. 14, pp. 209-213).

Thomas, R.V., Nair, D.G. and Enserink, B., 2023. Conceptual framework for sustainable construction. Architecture, Structures and Construction, 3(1), pp.129-141.

Thomson, C.S. and El-Haram, M.A., 2019. Is the evolution of building sustainability assessment methods promoting the desired sharing of knowledge amongst project stakeholders?. Construction management and economics, 37(8), pp.433-460. https://doi.org/10.1080/01446193.2018.1537502

Tirth, V., Algarni, S., Agarwal, N. and Saxena, A., 2019. Greenhouse gas emissions due to the construction of residential buildings in Moradabad, India. *Applied Ecology & Environmental Research*, *17*(5).

Toriola-Coker, L.O., Alaka, H., Bello, W.A., Ajayi, S., Adeniyi, A. and Olopade, S.O., 2021, March. Sustainability barriers in Nigeria construction practice. In IOP Conference Series: Materials Science and Engineering (Vol. 1036, No. 1, p. 012023). IOP Publishing. https://doi.org/10.1088/1757-899x/1036/1/012023

Torres-Carrión, P.V., González-González, C.S., Aciar, S. and Rodríguez-Morales, G., 2018, April. Methodology for systematic literature review applied to engineering and education. In 2018 IEEE Global engineering education conference (EDUCON) (pp. 1364-1373). IEEE.

Tripathi, S. and Gupta, M., 2019. A current review of supply chain performance measurement systems. Advances in industrial and production engineering, pp.27-39.

Tukker, A. and Jansen, B., 2006. Environmental impacts of products: A detailed review of studies. Journal of Industrial Ecology, 10(3), pp.159-182. www.mitpressjournals.org/jie

Tunji-Olayeni, P.F., Mosaku, T.O., Oyeyipo, O.O. and Afolabi, A.O., 2018, May. Sustainability strategies in the construction industry: implications on Green Growth in Nigeria. In IOP Conference Series: Earth and Environmental Science (Vol. 146, No. 1, p. 012004). IOP Publishing. https://doi.org/10.1088/1755-1315/146/1/012004

Tykkä, S., McCluskey, D., Nord, T., Ollonqvist, P., Hugosson, M., Roos, A., Ukrainski, K., Nyrud, A.Q. and Bajric, F., 2010. Development of timber framed firms in the construction sector—Is EU policy one source of their innovation?. Forest Policy and Economics, 12(3), pp.199-206. https://doi.org/10.1016/j.forpol.2009.10.003

Udeagha, M.C. and Ngepah, N., 2023. The drivers of environmental sustainability in BRICS economies: do green finance and fintech matter?. *World Development Sustainability*, *3*, p.100096.

Ugwu, O.O. and Haupt, T.C., 2007. Key performance indicators and assessment methods for infrastructure sustainability—a South African construction industry perspective. Building and environment, 42(2), pp.665-680. https://doi.org/10.1016/j.buildenv.2005.10.018

Uilitiesone (2023). Green building codes and regulations Paving the way for sustainable construction. https://utilitiesone.com/green-building-codes-and-regulations-paving-the-way-for-sustainable-construction

Ullah, M., Zahid, M., Rizvi, S.M.A.E.R., Qureshi, Q.G.M. and Ali, F., 2022. Do green supply chain management practices improve organizational resilience during the COVID-19 crisis? A survival analysis of global firms. Economics Letters, 219, p.110802.

UN, 2013. Youth in action on climate change: inspirations from around the world. A publication of the United Nations Joint Framework Initiative on Children, Youth and Climate Change. Pp. 1-92. https://unfccc.int/resource/docs/publications/publication_youth_2013.pdf

UNEP, 2021. Launched: 2020 Global Status Report for Buildings and Construction. URL:https://globalabc.org/news/launched-2020-global-status-report-buildings-and-construction

UNEP, 2022. Global Status Report for Buildings and Construction. Towards a zero-emissions, efficient and resilient buildings and construction sector. URL:https://www.unep.org/resources/report/2021-global-status-report-buildings-and-construction

USEPA, 2023. Circular Economy. https://www.epa.gov/circulareconomy/what-circular-economy

Utilitiesone, 2023. Green building codes and regulations Paving the way for sustainable construction. https://utilitiesone.com/green-building-codes-and-regulations-paving-the-way-for-sustainable-construction

Vajjarapu, H., Verma, A. and Allirani, H., 2020. Evaluating climate change adaptation policies for urban transportation in India. International journal of disaster risk reduction, 47, p.101528. https://doi.org/10.1016/j.ijdrr.2020.101528

Varnäs, A., Balfors, B. and Faith-Ell, C., 2009. Environmental consideration in procurement of construction contracts: current practice, problems and opportunities in green procurement in the Swedish construction industry. Journal of cleaner production, 17(13), pp.1214-1222. https://doi.org/10.1016/j.jclepro.2009.04.001

Varndell, W., Fry, M. and Elliott, D., 2021. Applying real-time Delphi methods: development of a pain management survey in emergency nursing. BMC nursing, 20, pp.1-11.

Velenturf, A.P. and Purnell, P., 2021. Principles for a sustainable circular economy. *Sustainable Production and Consumption*, *27*, pp.1437-1457.

Verma, M., Dahal, D., Dhendup, S., Tshering, P., Drukpa, K. and Chencho, L., 2021. Study of sustainable construction practices: the Bhutan case study. Journal of Emerging Technologies and Innovative Research (JETIR), (Volume 8, Issue 4). pp. 102-108.

Vierra, S., 2016. Green building standards and certification systems. National Institute of Building Sciences, Washington, DC. https://www.wbdg.org/resources/green-building-standards-and-certification-systems

Vijayadas, S.J., 2022. GSCM AND CONSTRUCTION SECTOR: STRATEGIES FOR GREENING THE BUSINESS IN INDIAN CONTEXT. Global journal of Business and Integral Security. https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjZ-4bwvfqBAxWJZd4KHUwPA5IQFnoECAoQAQ&url=https%3A%2F%2Fgbis.ch%2Findex.php%2Fgbis%2Farticle%2Fdownload%2F131%2F95&usg=AOvVaw1MhlfvETxQLzMA9bGn_aJM&opi=89978449

Vithana, N.D.I., Bandara, K. and Jayasooriya, S.D., 2020. Impact of COVID-19 pandemic to construction industry in Sri Lanka. In the 13th International Research Conference General Sir John Kotelawala Defence University, Colombo, Sri Lanka. pp. 161-166.

vom Brocke, J., Schmid, A.M., Simons, A. and Safrudin, N., 2021. IT-enabled organizational transformation: a structured literature review. Business Process Management Journal, 27(1), pp.204-229.

Vom Brocke, J., Simons, A., Riemer, K., Niehaves, B., Plattfaut, R. and Cleven, A., 2015. Standing on the shoulders of giants: Challenges and recommendations of literature search in information systems research. Communications of the association for information systems, 37(1), p.9.

Vrijhoef, R., 1998. Co-Makership in Construction: Towards Construction Supply Chain Management, PhD, Thesis, Type, Delft University of Technology.

Vyas, V.A. and Reddy, V.R., 1998. Assessment of environmental policies and policy implementation in India. Economic and Political weekly, pp.48-54.

Walton, R. (2021). Biden decarbonization focus shifts to buildings, with goal to triple efficiency, see up to $200B in savings. https://www.utilitydive.com/news/biden-decarbonization-focus-shifts-to-buildings-with-goal-to-triple-effici/600420/

Walton, R. (2021). Biden decarbonization focus shifts to buildings, with goal to triple efficiency, see up to $200B in savings. https://www.utilitydive.com/news/biden-decarbonization-focus-shifts-to-buildings-with-goal-to-triple-effici/600420/

Wang, K., Ying, Z., Goswami, S.S., Yin, Y. and Zhao, Y., 2023. Investigating the role of artificial intelligence technologies in the construction industry using a Delphi-ANP-TOPSIS hybrid MCDM concept under a fuzzy environment. Sustainability, 15(15), p.11848. https://doi.org/10.3390/su151511848

WareIQ, 2022. 10 Best Reverse Logistics Companies for Efficient Returns Management in eCommerce in India in 2024. https://wareiq.com/resources/blogs/reverse-logistics-companies/

WBCSD, 2018. Transforming the Built Environment. https://www.wbcsd.org/actions/transforming-the-built-environment/

Wee, B.V. and Banister, D., 2016. How to write a literature review paper?. Transport reviews, 36(2), pp.278-288.

Wibowo, M.A., Handayani, N.U. and Mustikasari, A., 2018. Factors for implementing green supply chain management in the construction industry. Journal of Industrial Engineering and Management, 11(4), pp.651-679. https://doi.org/10.3926/jiem.2637

Wibowo, M.A., Handayani, N.U., Mustikasari, A., Wardani, S.A. and Tjahjono, B., 2022. Reverse logistics performance indicators for the construction sector: a building project case. Sustainability, 14(2), p.963. https://doi.org/10.3390/su14020963

Wick, C., 2023. In an era of increasing Sustainable Building Practices: Paving the Way for a Greener Future. https://www.linkedin.com/pulse/sustainable-building-practices-paving-way-greener-future-cameron-wick-k7nvc

Wieland, A., 2021. Dancing the supply chain: Toward transformative supply chain management. Journal of Supply Chain Management, 57(1), pp.58-73.

Wiguna, I.P.A., Rachmawati, F., Rohman, M.A. and Setyaning, L.B.T., 2021. A framework for green supply chain management in construction sector: A case study in Indonesia. Journal of Industrial Engineering and Management, 14(4), pp.788-807. https://doi.org/10.3926/jiem.3465

Willar, D., Trigunarsyah, B., Dewi, A.A.D.P. and Makalew, F., 2023. Evaluating quality management of road construction projects: a Delphi study. The TQM Journal, 35(7), pp.2003-2027. https://www.emerald.com/insight/1754-2731.htm

Windapo, A.O. and Cattell, K., 2013. The South African construction industry: Perceptions of key challenges facing its performance, development and growth. Journal of construction in developing countries, 18(2), p.65.

Witell, L., Snyder, H., Gustafsson, A., Fombelle, P. and Kristensson, P., 2016. Defining service innovation: A review and synthesis. Journal of Business Research, 69(8), pp.2863-2872.

Wittke, K., 2014. The contribution of stakeholder theory to supply chain management: A theory evaluation (Bachelor's thesis, University of Twente). http://essay.utwente.nl/65394/1/Wittke_BA_MB.pdf

Wongthongchai, J. and Saenchaiyathon, K., 2019. The application of interpretive structural modeling technique (ISM) to study adopting model of green supply chain management. International Journal of Engineering and Technology, 8, pp.96-101.

Wu, H., Li, C., Liu, Z., Guo, Y., Li, Y., Hou, X., Li, Y., Zhao, S. and Li, F., 2023. Construction and empirical research of the evaluation index system of environmental protection enterprises' competitiveness based on the Delphi and AHP methods. Water Reuse, 13(2), pp.205-219. http://creativecommons.org/licenses/by/4.0/

Wu, J., Xia, Q. and Li, Z., 2022. Green innovation and enterprise green total factor productivity at a micro level: A perspective of technical distance. *Journal of Cleaner Production*, *344*, p.131070.

Wyawahare, A. and Udawatta, N., 2017. A Framework for Successful Implementation of Green Supply Chain Management (GSCM) in Construction Organisations. EPiC Series in Education Science, 1, pp.402-410.

Xia, B. and Chan, A.P., 2012. Measuring complexity for building projects: a Delphi study. Engineering, Construction and Architectural Management, 19(1), pp.7-24. https://eprints.qut.edu.au/48623/

Xie, Y., Zhao, Y. and Chen, Y., 2020, December. Green Supply Chain in Construction Sector, Government Intervention, Partnerships and Green Practices. In International Conference on Resource Sustainability-Sustainable Urbanisation in the BRI Era (pp. 93-106). Springer, Singapore.

Yadav, S. and Ray, G.S., 2015. Supply chain management in flyover projects in India. Journal of Construction in Developing Countries, 20(1), p.25. http://web.usm.my/jcdc/vol20_1_2015/JCDC%2020(1)%202015-Art.%202%20(25-47).pdf

Yang, Y., Chen, J., Lee, P.K. and Cheng, T.C.E., 2023. How to enhance the effects of the green supply chain management strategy in the organization: A diffusion process perspective. Transportation Research Part E: Logistics and Transportation Review, 175, p.103148.

Yap, J.B.H., Leong, W.J. and Skitmore, M., 2020. Capitalising teamwork for enhancing project delivery and management in construction: Empirical study in Malaysia. Engineering, Construction and Architectural Management, 27(7), pp.1479-1503.

Yap, J.B.H., Lim, B.L. and Skitmore, M., 2022. Capitalising knowledge management (KM) for improving project delivery in construction. Ain Shams Engineering Journal, 13(6), p.101790. https://doi.org/10.1016/j.asej.2022.101790

Yin, R. K. 1993. Applications of Case Study Research USA, Sage Publications.

Yin, R. K. 1994. Case Study Research: Design and Methods. 2nd edn. USA, Sage Publications.

Yousuf, M.I., 2007. Using expertsopinions through Delphi technique. Practical assessment, research, and evaluation, 12(1).

Yu, Z., 2020. Research on Problems and Countermeasures of Green Logistics Development in China. In Global Perspectives on Green Business Administration and Sustainable Supply Chain Management (pp. 192-196). IGI Global.

Yuan, R., Guo, F., Qian, Y., Cheng, B., Li, J., Tang, X. and Peng, X., 2022. A system dynamic model for simulating the potential of prefabrication on construction waste reduction. Environmental Science and Pollution Research, 29(9), pp.12589-12600. https://doi.org/10.1007/s11356-021-14370-y/Published

YuLin, C. and HuiHo, Y. 2010. The Influence of Environmental Uncertainty on Corporate Green Behavior: An Empirical Study with Small and Medium-Size Enterprises. Social Behavior and Personality, 38(5), 691-696.

Yusuwan, N.M., Adnan, H., Rashid, Z.Z.A., Ismail, W.N.W. and Mahat, N.A.A., 2019, November. Consensus Views on the Success Elements for Extension of Time Claim (EoT) in the Malaysian Construction Industry: A Modified Delphi Study. In IOP Conference Series: Earth and Environmental Science (Vol. 385, No. 1, p. 012062). IOP Publishing. https://doi:10.1088/1755-1315/385/1/012062

Zamani, S.H., Rahman, R.A., Fauzi, M.A. and Yusof, L.M., 2021. Effect of COVID-19 on building construction projects: Impact and response mechanisms. In 4th National Conference on Wind & Earthquake Engineering. In IOP Conference Series: Earth and Environmental Science, 682(1), p.012049. IOP Publishing.

Zavadskas, E.K., Šaparauskas, J. and Antucheviciene, J., 2018. Sustainability in construction engineering. Sustainability, 10(7), p.2236. https://doi.org/10.3390/su10072236

Zeng, N., Liu, Y., Mao, C. and König, M., 2018. Investigating the relationship between construction supply chain integration and sustainable use of material: Evidence from China. Sustainability, 10(10), p.3581. https://doi.org/10.3390/su10103581

Zhang, C. and Wang, T., 2021. Using Integrated Assessment Approach to Prioritise Performance Indicators for Sustainable Construction and Development of Secondary Campuses. https://assets.researchsquare.com/files/rs-148683/v1_covered.pdf?c=1631851998

Zhang, M., Li, L. and Cheng, Z., 2021. Research on carbon emission efficiency in the Chinese construction industry based on a three-stage DEA-Tobit model. Environmental Science and Pollution Research, 28(37), pp.51120-51136. https://doi.org/10.1007/s11356-021-14298-3/Published

Zhao, X., 2021. Stakeholder-associated factors influencing construction and demolition waste management: A systematic review. Buildings, 11(4), p.149. https://doi.org/10.3390/buildings11040149

Zhu, Q. and Cote, R.P., 2004. Integrating green supply chain management into an embryonic eco-industrial development: a case study of the Guitang Group. Journal of Cleaner Production, 12(8-10), pp.1025-1035.

Zhu, Q. and Geng, Y., 2013. Drivers and barriers of extended supply chain practices for energy saving and emission reduction among Chinese manufacturers. *Journal of cleaner production*, *40*, pp.6-12.

Zhu, Q. and Sarkis, J., 2004. Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of operations management*, *22*(3), pp.265-289.

Zhu, Q. and Sarkis, J., 2006. An inter-sectoral comparison of green supply chain management in China: drivers and practices. *Journal of cleaner production*, *14*(5), pp.472-486.

Zhu, Q., Sarkis, J. and Lai, K.H., 2007. Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *Journal of cleaner production*, *15*(11-12), pp.1041-1052.

Zhu, Y., Li, Y., Qian, Y., Chen, J. and Chen, J., 2008. Informization implementation for Chinese retailers. *Tsinghua Science & Technology*, *13*(3), pp.362-367.

Zorn, T. and Campbell, N., 2006. Improving the writing of literature reviews through a literature integration exercise. Business Communication Quarterly, 69(2), pp.172-183.

Zuo, J. and Zhao, Z.Y., 2014. Green building research–current status and future agenda: A review. Renewable and sustainable energy reviews, 30, pp.271-281. https://doi.org/10.1016/j.rser.2013.10.021

Zutshi, A. and Sohal, A., 2004. A study of the environmental management system (EMS) adoption process within Australasian organisations—2. Role of stakeholders. *Technovation, 24*(5), pp.371-386.

ANNEXURES

Appendix I

I-A: Invitation to Participate in the Semi-Structured Interview

Subject: Invitation to Participate in Exclusive Interviews on [Topic/Area of Interest]

Dear.....,

The invitation is extended to a distinguished guest to partake in a series of interviews concerning the implementation of Green Supply Chain Management (GSCM) within the Indian Construction (CS) sector. These interviews aim to delve into pivotal trends, obstacles, and advancements in the supply chain aspects within CS. The guest's participation is highly valued as it will enrich the discussions, thereby contributing to a more comprehensive grasp of the subject matter. The research initiative is presently underway at SSBM University, concentrating on fostering sustainable construction practices through GSCM strategies. The interviews will engage experts and professionals capable of offering valuable insights aligned with the research objectives.

1. Assessing the key processes in construction sector having the potential to introduce green supply chain principles.
2. Specific issues in Indian context, which make the integration of green supply chain concepts in the construction sector processes ranging from design, procurement, transportation, execution, and waste recycling.
3. Identification of Policy elements in India which has direct and indirect influence on the green supply chain in construction industry and exploring their integration into a unified framework.
4. Presenting a conceptual framework to the attention of policy makers at national and local level for necessary interventions to green the construction sector with the objective of achieving the ultimate goal of carbon-neutrality in the sector.

The interview, which is expected to last 15-20 minutes, can be conducted in person or over the phone or online. The participants will be kept confidential. A report summarizing the results will be sent after the study. The interview details will be tailored to the participants' schedule and preferences. The interview is expected to be stimulating and engaging, benefiting both the audience and the participants. The interviewer is requested to inform the interviewer of their availability and coordinate logistics. The interviewer appreciates the participant's expertise and looks forward to their participation in the research project. The interviewer is interested in hearing the participant's views on the subject and would appreciate an interview at their convenience.

Warm regards,

[SJ Vijayadas]

[SSBM]

[Batch no.]

I-B: Interview Handbook

Effective GSCM implementation via policy interventions in Indian construction sector: *Interviews*

[Some explanations and clarifications for some of the phrases that are used (or may be used during the interview) and successive Interview questions]

Definitions and Clarifications

Sustainable construction and its social, economic, and environmental dimensions

Sustainable construction describes the application of sustainable development to the construction segment.

Sustainable development is broadly defined as: *'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' [Brundtland, 1987]*

Sustainable development is a social progress that balances economic growth and employment with environmental protection and resource use, promoting a 'triple bottom line' of environmental, social, and economic accountability, ensuring everyone's needs are met.

An ongoing research project at SSBM University aims to identify key criteria encompassing the social, economic, and environmental dimensions of sustainable construction for effective implementation of Green Supply Chain Management (GSCM) in the Indian construction sector. The identified criteria are as follows:

SOCIAL SUSTAINABILITY: This dimension involves addressing the needs of society, including users, neighbors, the community, workers, and other project stakeholders.

ECONOMIC SUSTAINABILITY: This aspect focuses on enhancing profitability through the efficient utilization of resources (human, materials, financial), effective design, and sound management, planning, and control practices.

ENVIRONMENTAL SUSTAINABILITY: This dimension aims to mitigate harmful and irreversible effects on the environment by promoting the efficient use of natural resources, advocating for renewable resources, and safeguarding the soil, water, and air from contamination.

D. Social sustainability:

xiii) Addressing Health and Well-being Concerns: Importance of ensuring worker health and well-being.

xiv) Formalizing Labor Practices: Importance of formalizing labor practices and promoting worker rights for social sustainability.

xv) Addressing Community Displacement: Importance of engaging with affected communities and respecting their rights.

xvi) Promoting Gender Disparities: Importance of promoting gender equality and creating a safe work environment.

xvii) Investing in Skill Development and Training: Importance of investing in vocational training programs and capacity-building initiatives.

xviii) Addressing Health and Safety: Importance of stricter enforcement of safety regulations, provision of safety training, and implementation of safety protocols.

xix) Enhancing Client Satisfaction: Importance of improving project management capabilities, fostering effective communication, and ensuring transparency in project delivery.

xx) Addressing Ethical Considerations: Strengthening regulatory oversight, promoting ethical business practices, and enforcing labor standards.

xxi) Enhancing Community Engagement: Importance of community participation, conducting social impact assessments, and incorporating community feedback into project planning.

xxii) Strengthening Labor Rights and Welfare: Importance of strengthening labor rights enforcement, providing social security benefits, and improving access to affordable housing and healthcare.

xxiii) Addressing Labor Rights and Welfare: Importance of community engagement in decision-making processes.

xxiv) Promoting Inclusion and Equity: Challenges faced by vulnerable groups, including women, marginalized communities, and informal settlements.

E. Economic sustainability

i) Cost Overruns: Adopting green building practices can reduce operational costs and mitigate risks.

ii) Dependency on Non-renewable Resources: Transitioning to green construction practices can reduce reliance on finite resources and enhance economic viability.

iii) Low Productivity and Efficiency: Inefficient practices and outdated technologies can hinder economic growth and competitiveness.

iv) Lack of Investment in Green Infrastructure: Despite increasing awareness, there remains a deficiency in investment in green infrastructure initiatives in India.

v) Market Demand for Sustainable Buildings: With increasing environmental awareness, there is a growing demand for green buildings.

vi) Return on Investment (ROI): Many construction projects struggle to achieve satisfactory ROI due to cost overruns, delays, and inadequate market demand.

vii) Employment Generation: Challenges related to job quality, skill development, and labor rights lead to issues like underemployment and informal employment.

viii) Value for Money: Inefficiencies, corruption, and lack of transparency in procurement and project management processes can lead to wastage of resources.

ix) Whole Life Costing: Inadequate maintenance planning and budget allocation can lead to premature infrastructure deterioration and higher life cycle costs.

x) Infrastructure Financing: Limited availability of long-term financing, high interest rates, and regulatory constraints hinder infrastructure development and economic growth.

xi) Housing Affordability: High property prices, land scarcity, and inadequate housing finance options contribute to housing unaffordability and exclusion.

xii) Informal Economy: Formalizing the sector and improving labor standards are crucial for promoting economic sustainability and livelihood security.

F. Environmental sustainability

i) Resource Depletion: The construction industry consumes vast amounts of natural resources, leading to environmental degradation.

ii) Sustainable practices like using recycled materials and minimizing resource consumption can conserve resources.

iii) Pollution and Emissions: Construction activities contribute to air, water, and soil pollution.

iv) Green building techniques, pollution control measures, and cleaner construction methods can mitigate these impacts.

v) Habitat Destruction: Urbanization and infrastructure development often result in habitat destruction and loss of biodiversity.

vi) Sustainable land use planning, preserving green spaces, and ecological design principles can minimize habitat loss.

vii) Climate Change: The construction sector contributes significantly to greenhouse gas emissions.

viii) Waste Generation: Waste management practices like recycling, reuse, and waste reduction can minimize environmental impact.

ix) Renewable Energy Share: The construction sector's share of renewable energy is relatively low. Energy-efficient building designs, renewable energy sources, and reducing carbon emissions are essential strategies.

x) Greater emphasis on integrating renewable energy technologies into building design and construction practices is needed.

xi) Reverse Logistics: Limited infrastructure and awareness for reverse logistics contribute to environmental pollution and resource depletion.

xii) 3R's: Strategies to minimize waste generation, maximize material reuse and recycling, and encourage sustainable construction practices are essential.

xiii) Local Procurement: The construction industry often relies on imported materials and equipment, leading to higher carbon emissions.

xiv) Biodiversity and Sensitive Area Conservation: Inadequate environmental assessment and enforcement of regulations exacerbate threats to biodiversity and ecological integrity.

DELPHI EXPERT PANEL: The panel consists of 30 academics or professionals who are experts in multidisciplinary supply chain fragments like design, procurement, transportation, execution and waste management. Through a multi-staged information exchange among the panel experts, consensus on important issues can be arrived at attempting to complement and triangulate earlier quantitative study on the subject.

SUPPLY CHAIN MANAGEMENT (SCM): SCM involves overseeing materials, information, and finances from suppliers to manufacturers, wholesalers, retailers, and consumers, focusing on product, information, and financial flow within the supply chain (Lutkevich, 2023).

GSCM: Zhu and Sarkis [2006] conceptualize GSCM as the integration of environmental thinking with operations management in the SC, starting with the product design and passing through the selection of raw materials, manufacturing processes, transportation and delivery, and the final consumer arriving at the final destination after use.

COST EFFICIENCY: Cost efficiencies are business strategies aimed at reducing the cost of creating a product or performing an activity without compromising quality. Determining cost efficiencies involves comparing the benefits of the output to the costs of the input. By measuring the revenue generated against expenses incurred, this highlights potential areas of improvement for organizations to save money and improve efficiencies (Indeed, 2022).

TRADITIONAL SUPPLY CHAIN (TSC): The TSC is defined as an integrated manufacturing process, wherein the Supplier supplies raw materials or semi-finished goods to the manufacturer, which are then manufactured or assembled into final products. The finished goods are sent to the wholesaler, then to the retailer, and finally delivered to customers (Deshmukh and Vasudevan, 2014).

POLICY: The CDC defines "Policy" as a law, regulation, procedure, administrative action, incentive, or voluntary practice of governments and other institutions.

POLICY INTERVENTION: Policy intervention infrastructure refers to physical and organizational structures or systems developed or utilized to support the implementation of government-directed policies, often backed by established or purposefully developed infrastructure (Barbash et al., 2017).

GREEN TRANSFORMATION: Green transformation can be defined as combining economic growth with environmental care to ensure a high quality of life for present and future generations through effective and rational use of available resources (Cheba et al., 2022).

CIRCULAR ECONOMY: The circular economy is a model of production and consumption that involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products to extend their life cycle and reduce waste. It is a system-focused approach aimed at eliminating waste through superior design of materials, products, and systems. The EPA and other federal agencies have pursued a circular economy approach since 2009, focusing on reducing negative lifecycle impacts of materials, including climate impacts, harmful materials, and decoupling material use from economic growth (USEPA, 2023).

INVENTORY VISIBILITY: Inventory visibility is crucial for efficient order fulfillment operations, enabling accurate tracking of supply chain levels and locations. Advances in technology like RFID and barcode scanners automate inventory tracking, reducing man-hours and capital. It helps predict peak demand, prevent stockouts, and track specific products/orders (Romaine, 2022)

ENTERPRISE RESOURCE PLANNING (ERP): ERP software streamlines construction operations, including accounting, project management, procurement, and human resources. Key applications include project management, financial management, supply chain management, document management, and HR/payroll. Implementation requires organizational work and learning from mistakes (Vijayadas, 2022).

INFORMATION TRANSPARENCY (IT): Transparency in business involves reporting clear, meaningful information, fostering trust between stakeholders. In construction, it involves providing real-time project progress updates, maintaining transparent financial records, sharing information about the supply chain, and ensuring compliance and safety for effective decision-making, efficient project management, and effective communication (Vijayadas, 2022).

YARD LOGISTICS (YL): Automated yards integrate GPS, sensors, and IoT, improving customer service and reducing fuel dependency. Efficient yard logistics for construction companies

include inventory management, equipment tracking, yard layout optimization, and security measures to reduce idle time, prevent material shortages, and enhance project efficiency (Vijayadas, 2022).

VALUE MANAGEMENT: According to BS EN12973:2020, value management is a basic idea used in current management systems and techniques that are based on value- and function-oriented behaviors, procedures, and thought processes. It is especially committed to fostering innovation, fostering synergy, skill development, and people motivation in order to maximize an organization's total performance (Pun, K2023).

CONCEPTUAL FRAMEWORK: A conceptual framework is a theoretical structure used to guide research, analysis, and understanding in a specific field. It defines key concepts, guides research, organizes data, supports theory development, and facilitates effective communication among scholars and practitioners (Divya Sreekumar, 2023).

ROI: Return on investment (ROI) is one of the financial performance measurements used to evaluate the efficiency of a capital investment and operation or compare the efficiency of different investment projects. It is calculated by dividing the benefit (investment return) by the cost of the investment. The result is expressed as a percentage or a ratio (Wu and Buyya, 2015).

LABOUR-ONLY SUBCONTRACTING: A labor-only subcontractor typically provides only labor and works under the direction of their employer. They are usually hired to work on a project when additional help is required.

MULTITUDINOUS AUTHORITY: In governance, "multitudinous authority" refers to a broad range of individuals or entities, whereas "authority" usually denotes the capacity to decide, impose regulations, or exert control over a particular area.

POST-MONITORING MECHANISM: A post-monitoring mechanism is a procedure for assessing and reviewing project or program results after implementation. It involves gathering, analyzing, evaluating, reporting, and providing feedback on data. It helps ensure that resources are used effectively, objectives are achieved, and lessons are considered for upcoming initiatives (Indeed, 2022).

I-C: Semi-structured Interview

Questionnaire #1

1. General Information		
Your name:	*Organization & Position:*	*Area of Expertise:*

II. Research Questions

RQ1. What are the main sustainability criteria that stakeholders should consider when creating a green/carbon neutral infra-developmental strategy?	
RQ2. What are the crucial elements/factors for green supply chain mechanism in the Indian setting and better addressing sustainable construction?	
RQ3. What barriers have stakeholders found that need to be removed at an earlier stage to achieve circular economy in construction industry via GSCM in an Indian scenario?	
RQ4. In their green strategies, policies, guidelines, or practices, how do well authorities in India impose sustainability criteria?	
RQ5. How much do local-level authorities in India observe or plan to follow the policies, procedures, or guidelines that point out the sustainability constraints and necessitate sustainability criteria in the green strategies or contracts for infra-development projects?	
RQ6. Identify the stakeholders best fit to sort out constrains that better address the scope of greening the Indian construction sector and develop a policy framework?	
Please add any comments you would like to make:	

Thank you very much for your time and effort

I-D: Semi-structured Interview

Questionnaire #2

Survey Title: Assessment of Local Authorities' Approach to Sustainability Policies

Thank you for participating in this survey. The objective is to understand how local authorities in India are addressing sustainability criteria in their policies and regulations. Your insights are valuable for assessing the current state of sustainability practices. Please answer the following questions thoughtfully.

Personal profile:

1. **Name:**
2. **Role/Position:** [Specify if the respondent is from the following]

   1. *Local Government Officials;* ***2.*** *Policy Makers;* ***3.*** *Government Departments;* ***4.*** *Urban Planners and Architects;* ***5.*** *Community Representatives;* ***6.*** *Industry Representatives;* ***7.*** *Environmental Experts;* ***8.*** *Researchers;* ***9.*** *International Organizations;* ***10.*** *Supervisory Bodies*

Technical information

1. Are you aware of the existence of sustainability-related policies or regulations in your local jurisdiction?
2. How are sustainability criteria integrated into the formulation of local policies and regulations?
3. To what extent are stakeholders, including the public, involved in the formulation of sustainability policies?
4. What challenges, if any, do you face in implementing sustainability criteria outlined in policies?
5. Is there any ongoing capacity-building program to enhance the understanding of officials regarding sustainable construction practices?
6. How are the sustainability criteria enforced during the approval and construction phases of projects?
7. Describe the public consultation processes in place for discussing and gathering input on sustainability-related policies.
8. To what extent do local sustainability policies align with national and state-level guidelines?
9. Can you provide examples of successful implementation of sustainability criteria in construction projects within your jurisdiction?
10. Are there any upcoming initiatives or plans to strengthen sustainability criteria in local policies?
11. How is feedback from the public and stakeholders collected regarding the effectiveness of sustainability policies?
12. In your opinion, what areas need improvement in the current approach to sustainability in local policies?

13. Are there collaborations or partnerships with external organizations, NGOs, or experts to enhance sustainability efforts?

Thank you for completing the survey. Your responses will contribute to understanding the landscape of sustainability policies at the local to national level.

I-E: Information about the Semi-structured Interviews conducted

ID	Key-Point	Type of interview	Date of Interview	Time of interview	Place of Interview	Target Group	Featured professionals
S/I-1	Key processes	Virtual	10/11/2022	09:30a.m.	-	1˚,2˚, &3˚ level stakeholders	2, 3, 5, 10, 17 & 19
S/I-2	Confirmation of GSCM elements	Personal	21/11/2022	08:30a.m	NHRI, TVM	1˚,2˚, &3˚ level stakeholders	5, 9, 17, 18 & 14
S/I-3	Validation of SI-2 and Q/S#1	Virtual	27/11/2022	3:45 p.m.	-	1˚,2˚, &3˚ level stakeholders	5, 9, 17, 18 & 14
S/I-4	Effectiveness of Policy Intervention	Virtual	7/12/2022	04:00p.m.	-	1˚,2˚, &3˚ level stakeholders	16, 12, 15, 11, 7 & 9
S/I-5	Pressure-Barrier Analysis (PBA)	Personal	10/12/2022	02:30p.m.	Heather Smart, Statue, TVM	1˚,2˚, &3˚ level stakeholders	10, 11, 15, 17, 18 & 19
S/I-6	Sustainability criteria B →O	Virtual	17/05/2023	02:30p.m.	-	1˚,2˚, &3˚ level stakeholders	9, 11, 16, 17, 18 & 19
S/I-7	Unified FW; which stakeholders do can act well?	Personal	11/08/2023	09:30a.m.	Felicity Square, Statue, TVM	1˚&2˚ level stakeholders	10, 11, 15, 16 & 17
S/I-8	Validation of SI-7 and Q/S#2	Virtual	07/10/2023	01:00p.m.	-	1˚&2˚ level stakeholders	7, 8, 9, 12 & 13
S/I-9	Checking CFW (Obj#4)	Virtual	23/10/2023	l:30p.m.	-	1˚&2˚ level stakeholders	2, 3, 4, 6, 7, 8, 10, 12, 15, 16 & 17

1. Academic Researchers 2. Architects 3. Civil Engineers 4. Community Stakeholders 5. Construction Managers 6. Economists 7. Educators and Researchers 8. Energy Efficiency Experts 9. Environmental Advocates 10. Environmental Scientists 11. Financial Analysts 12. Government Officials 13. Green Building Professionals 14. Industry Experts 15. Legal Experts 16. Policy Analysts 17. Supply Chain Managers 18. Sustainability Engineers 19. Urban Planners

Appendix II

II-A: Details of the case studies conducted

		Case Study #1	Case Study #2
A	**Case Study Details**	South India Province Case Study	Three-Level Stakeholders Case Study
B	**Location**	South India Province	Kerala
C	**Participants**	Various stakeholders involved in the construction supply chain	Three levels of stakeholders: government authorities, industry representatives, and community members
D	**Objective**	To assess GSCM criteria existing in the construction supply chain	To identify urgent issues and challenges in implementing GSCM practices
E	**Methodology**	Semi-structured interviews, document analysis	Semi-structured interviews, stakeholder workshops
F	**Key Findings**	Identification of GSCM practices, drivers, and barriers	Identification of pressing sustainability issues, barriers to GSCM implementation, and recommendations for improvement
G	**Recommendations**	Strategies for enhancing GSCM adoption, policy recommendations	Stakeholder engagement strategies, policy interventions, capacity building initiatives

II-B: Request to perform a case study on the Kerala Building Contractors Association located in Kerala State

Subject: Request to Conduct a Case Study on Sustainable Construction Practices of Kerala Building Contractors Association

Dear.....,

I am reaching out to seek authorization to carry out a case study focusing on the sustainable construction initiatives undertaken by the Kerala Building Contractors Association (KBCA). This study aims to explore how KBCA integrates Green Supply Chain Management (GSCM) principles to promote sustainability within the construction sector in Kerala. The research project is being undertaken at SSBM University, and I am interested in gathering insights from construction organizations in the southern region of India, particularly those in Kerala, such as KBCA. The study will primarily involve conducting interviews with relevant stakeholders to investigate the implementation of sustainable construction practices within KBCA's projects.

This case study aims to investigate the Kerala Construction Chamber Association (KBCA)'s integration of sustainable construction principles into its operations and supply chain management processes. The study will investigate the KBCA's approach to promoting sustainable construction practices, its integration of green procurement, logistics, and waste management practices, its collaborative efforts with suppliers and contractors, the challenges faced in implementing sustainable practices, and the success stories of its initiatives. Interviews with relevant stakeholders will provide valuable insights into the organization's strategies, experiences, and future directions in promoting sustainable construction practices. The research will be carried out with strict adherence to ethical and professional principles, maintaining the utmost standards of academic integrity. It aims to offer significant insights into KBCA's endeavors to foster sustainable construction methods, thereby contributing to the progression of sustainability within Kerala's construction sector.

Warm regards,

[SJ Vijayadas]

[SSBM]

[Batch no.]

II-C: The interview guide used for several interviews conducted as part of the case studies across the southern Indian region and the state of Kerala

Part 1: General Information	
1.1 Your name &Position:	1.2 Field of Expertise:
1.3 Organization Name and Type: (Private / NGO / Public / Others)	1.4 Nature of Organization (for local authorities): (Panchayat / Municipality / Corporation)
1.5 Location of Organization (please circle the correct answer): a. Kerala b. Tamil Nadu c. Karnataka d. Telangana e. Andhra Pradesh	1.6 Geographic Area of Operation for Your Organization: (e.g., Bangalore)
Part 2: General Information : organizational performance	
1.7 What are the main drivers or motivations for your organization to consider implementing Green Supply Chain Management (GSCM) practices within its operations and supply chain?	
1.8 What is the size and scope of your organization's operations, including the number of employees, annual revenue, and geographic reach?	
1.9 Types of construction Supply chain in which the organisation is focused: (e.g. procurement, transport etc.)	
1.10 How do you currently assess or measure the environmental impact of your organization's supply chain activities, if at all? Are there any specific metrics or indicators used to evaluate sustainability performance?	
1.11 What do you perceive as the main challenges or barriers to implementing GSCM practices within your organization's supply chain, and how do you plan to address or overcome them?	
1.12 Finally, what are your expectations or anticipated outcomes from implementing GSCM practices within your organization's supply chain, and how do you envision measuring success in this regard?	
Part 3: GSCM via policy intervention	

Address the perception of government policies and regulations in promoting sustainability in construction supply chains and suggests specific interventions or incentives to encourage green practices among stakeholders.	
What your organization should consider major policy elements related to sustainable construction and sustainability in developing green supply chain strategies or contracts for its construction projects?	
What sustainability/GSCM requirements are crucial for the organization to effectively handle sustainable building before, during, and after pandemics and other damaging phases?	
What barriers must the organization overcome in order to build a conceptual framework that will allow the principles of GSCM to be implemented effectively with regard to sustainable construction? Which stakeholder would be best suited to handle the same?	
Are there any comments or observations concerning the implementation of sustainable construction practices and strategies for GSCM? For instance, these may encompass: • Addressing unresolved issues in sustainable construction procurement. • Identifying policies, strategies, processes, and procedures for sustainable construction. • Assessing the necessity or desirableness of sustainability considerations.	

Thank you for sharing your insights and perspectives. Your input will be invaluable in identifying opportunities for enhancing sustainability and addressing challenges within Indian construction supply chains. If you have any additional thoughts or suggestions, please feel free to share them before we conclude the interview.

II-D: Information about interviews conducted for different case-studies

	ID	Key-Point	Type of interview	Date & Time of Interview	Place of interview	Target Group	Featured professionals
CASE STUDY #1	I-1	Key players @ GSCM	Virtual	10/11/2022 09:30-10.45a.m.	-	2˚ level stakeholders	Civil Engineer or Construction Industry Specialist
	I-2	Issues @indian construction sector	Virtual	21/11/2022 08:30- 9.00 a.m	-	2˚ level stakeholders	Supply Chain Management Expert & Environmental Policy Analyst or Researcher
	I-3	SEE sustainability criteria and SWOT results	Virtual	27/09/2022 3:45 -5.30 p.m.	-	1˚ level stakeholder	Government Policy Advisor or Advocate & Environmental Policy Analyst or Researcher
CASE STUDY #2	I-4	Covid Policy Intervention *[Strategy and effectiveness]*	Virtual	7/10/2023 04:00-5.30p.m.	-	1˚ level stakeholder	Government Policy Analyst or Economist
	I-5	Covid Policy Intervention *[Constrains and Tactics adopted]*	Personal	7/10/2023 03:00-5.30p.m.	SC Office, Pappanamcode, TVM	2˚ level stakeholder	Construction Industry Executive and Academic Researcher

Appendix III

III-A: Invitation to Participate in the Questionnaire Survey (Case Study)

Date

Name and address of the **Respondent**

SJ VIJAYADAS
Department of Business Administration,
SSBM university, Geneva campus,
Switzerland,
E-mail: sj.vijayadas@gmail.com Tele: xxxxxxxxxx

Subject: Invitation to Participate in Questionnaire Survey on Green Supply Chain Management in Indian Construction

Dear ----------

I am reaching out to you regarding a substantial research endeavour focused on implementing sustainable construction practices in India through procurement strategies. This project seeks to explore the potential for green transformation within the Indian construction sector. Currently underway at SSBM University, this research initiative delves into the realization of sustainable construction through procurement tactics. As part of this project, we are conducting a questionnaire survey to gather insights from professionals within the construction supply chain in prominent Indian construction firms. The insights gathered from this survey aim to offer valuable guidance in aligning strategies for Green Supply Chain Management (GSCM) implementation with the principles of sustainable development.

SSBM University is conducting a research project on sustainable construction in India through procurement strategies. The project involves a questionnaire survey to gather perspectives from leading Indian construction organizations on the scope and potential of Green Supply Chain Management (GSCM) implementation. Participation in the survey will provide essential guidance in developing strategies for aligning procurement practices with sustainable development principles. The questionnaire is attached to the email and will be completed within 10-15 minutes. The response will be confidential and used solely for research purposes.

A comprehensive report summarizing the survey results will be shared with all participants. Your participation will not only benefit the research but also contribute to advancing sustainability practices within the Indian construction sector. If you have any questions, require further information, or need additional copies of the questionnaire, please contact the sender.

Thank you for your time, cooperation, and valuable contribution to the research endeavor.

Yours sincerely,

SJ VIJAYADAS
Research Scholar (PhD programme)
Department of Business Administration, SSBM University

III-B: GENERAL INFORMATION SHEET

Introduction:

Welcome to the interview handbook for exploring the implementation of Green Supply Chain Management (GSCM) practices within your organization. This handbook provides a series of questions to guide our discussion on various aspects of GSCM. Please refer to the definitions of key words provided below for clarity.

Or

Welcome to the interview handbook for exploring the impact of the COVID-19 pandemic on the construction sector and strategies for post-pandemic recovery. This handbook provides a series of questions to guide our discussion. Please refer to the definitions of key words provided below for clarity.

The purpose of the questionnaire is to gather insights from individuals overseeing or participating in construction supply chains across all three stakeholder levels, with a focus on sustainability in construction projects. All responses will remain confidential, and the data will solely be utilized for research purposes. Neither individuals nor their respective organizations will be identifiable in any resulting analysis. The findings from the questionnaire survey aim to offer valuable guidance for enhancing the implementation of Green Supply Chain Management (GSCM) in alignment with sustainable development principles.

Guidance on completing and returning the questionnaire

The questionnaire involves questions which ask the respondents to put a tick in the appropriate box to indicate their response. For example, if the respondent's response regarding the consideration "improving health and safety performance" is ''yes", then his/her response will appear as shown below (the respondent can use the mark or any other mark to indicate the response).

- Below are definitions and explanations intended to provide clarity on certain terms and statements utilized in the questionnaire.
- Should you need more space, feel free to utilize additional sheets.
- Kindly return the completed questionnaire using the enclosed stamped addressed envelope.
- A response within two weeks would be greatly appreciated.
- Should you require further information, clarifications, or additional copies of the questionnaire, please feel free to reach out to me at your convenience.

E-mail: sjvijayadas@gmail.com Tel: vvvvvvvvvvvvv Fax: vvvvvvvvvvvv

Definitions and Clarifications

Competitiveness: Competitiveness refers to the involvement or offering of goods, services, or ideas through competition. It pertains to the ability of an entity to outperform its rivals in the market, achieve market dominance, and maintain an advantageous position.

Corporate Green Policies: Organizational guidelines, rules, or initiatives aimed at promoting environmental sustainability and reducing the ecological footprint of business operations.

Cost Overruns: Exceeding the budgeted amount for a construction project due to unforeseen expenses or delays.

Economic Key Performance Indicators (KPIs): Economic Key Performance Indicators (KPIs) are metrics used to evaluate the economic performance of an organization. These include client satisfaction for products and/or services, defects, safety measures, predictability in cost and time for design and construction, construction costs, construction time, profitability, and productivity.

Enterprise Resource Planning (ERP): Integrated software systems used by organizations to manage various aspects of their business processes, including planning, procurement, manufacturing, and distribution.

Ethical Practices: Ethical practices in procurement involve implementing measures to prevent fraud and corruption. This includes establishing mandatory codes of conduct for members and employees, policies on fraud prevention, financial regulations, and schemes of delegation. Ethical practices ensure professional and honest behavior, adherence to procurement procedures, and equal treatment of suppliers.

Green Suppliers and Green Technologies: Suppliers and technologies that prioritize environmental sustainability by minimizing resource consumption, reducing emissions, and promoting eco-friendly practices.

Green Supply Chain Management (GSCM): The integration of environmental considerations into all stages of the supply chain, including product design, material sourcing, manufacturing, transportation, and end-of-life disposal, with the aim of reducing environmental impact while maximizing economic and social benefits.

GSC (Green Supply Chain): The integration of environmentally sustainable practices into the construction supply chain, including sourcing, procurement, production, and distribution.

Improving Workforce Satisfaction: Improving workforce satisfaction refers to addressing issues that affect the quality of the construction workforce's working conditions, rewards, quality of management, and available training opportunities to enhance overall job satisfaction and productivity.

Information Transparency: The practice of openly sharing information and data across all levels of an organization and its supply chain to enhance visibility, accountability, and decision-making.

Logistics Strategies: Logistics strategies involve managing the flow of goods, materials, equipment, and people from their origin to their destination. These strategies ensure that the right products reach the right place, in the right quantity, and at the right time to meet customer demand.

Logistics Visibility: The ability to track and monitor the movement of goods and materials throughout the supply chain in real-time, enabling better inventory management, risk mitigation, and customer service.

Material Management: The systematic control and optimization of materials used in construction projects, including procurement, storage, and usage.

Procurement Routes: Procurement routes are the methods used to deliver the procurement strategy for a project. They include contract strategies that determine the level of integration of design, construction, and ongoing maintenance, and support the main project objectives in terms of risk allocation, delivery, and incentivization.

Procurement Strategy: The procurement strategy identifies the best way to achieve the objectives of a project and obtain value for money. It involves decisions about funding mechanisms, asset ownership, and risk management. The aim is to achieve an optimal balance of risk, control, and funding for the project.

Reverse Logistics: The process of managing the return of products and materials from the end-user or consumer back to the manufacturer or supplier for recycling, refurbishment, or disposal.

Risk Management: The process of identifying, assessing, and mitigating risks that may impact the successful completion of construction projects.

Safety Management: The implementation of measures and protocols to ensure the safety of workers and compliance with health and safety regulations at construction sites.

Seeking Intergenerational Equity: Seeking intergenerational equity involves considering the costs and impacts of current construction activities on future generations. It aims to achieve fairness between generations by ensuring that significant social, environmental, and financial costs are not passed on to future generations.

Social Capital: Social capital refers to the structures and networks that help maintain and develop human capital within communities. This includes families, businesses, trade unions, schools, voluntary organizations, and other social institutions that foster collaboration and mutual support.

Social Exclusion: Social exclusion encompasses poverty, low income, and wider causes and consequences of deprivation. It refers to situations where individuals or groups experience a combination of linked problems such as unemployment, poor skills, discrimination, inadequate housing, crime, poor health, and family breakdown.

Stakeholders: Stakeholders are individuals or groups who have an interest in, are involved in, or are affected by the activities and outcomes of a change initiative or project. They may include clients, suppliers, employees, government agencies, local communities, and other relevant parties.

Supply Chain Disruption: The interruption or breakdown in the flow of materials, information, or services within the construction supply chain.

Sustainability Measures: Practices and initiatives aimed at reducing the environmental impact and promoting long-term sustainability in the construction sector.

Sustainable Construction: Sustainable construction applies the principles of sustainable development to the construction industry. It involves producing, planning, designing, building, altering, and maintaining the built environment in a manner that promotes social progress, economic growth, environmental protection, and prudent resource use.

Technological Shortfalls: Inadequacies or deficiencies in the use of technology to support construction operations and project management.

Value for Money: Value for money refers to the optimal combination of whole-life cost and quality to meet the user's requirements. It involves assessing the cost-effectiveness of a project or investment in terms of its benefits and outcomes over its entire lifecycle.

Whole Life Costs: Whole life costs of a built asset or facility include all costs incurred throughout its lifecycle, from acquisition to disposal. This encompasses acquisition costs, operating costs, internal resources, risk allowances, predicted alterations, refurbishment costs, and sustainability and health and safety aspects.

Workforce Management: The process of efficiently organizing and overseeing the labor force involved in construction projects.

III-C: QUESTIONNAIRE SURVEY - 1

[south Indian province]

SURVEY OBJECTIVE

This survey forms an integral component of our research initiative aimed at fostering strategies for green supply chain management (GSCM) within the construction industry. Its purpose is to gauge professionals' comprehension, perspectives, and practices concerning supply chain sustainability and environmentally conscious, carbon-neutral GSCM in India, particularly within the construction domain.

COMPLETION AND SUBMISSION OF THE QUESTIONNAIRE

The questionnaire is structured to be completed within approximately 10 minutes. We sincerely appreciate your cooperation and kindly request that you return the completed questionnaire via email using the provided contact information below.

S.J. Vijayadas, PhD scholar, SSBM Email: sj.vijayadas@gmail.com

Alternatively, you have the option to fill out the online version of this questionnaire, accessible at the following link:
https://docs.google.com/forms/d/e/1FAIpQLSe1_F8S9bbTi5gcfcU9Rnti8plT44cIqB55aEGGPpoDpFEpfQ/viewform?usp=sf_link

All responses will be treated in strict confidentiality with identity protected

Q1 – What type of organisation do you work in?

Government Firm		General Contracting	
Building Contractor		Property Developer	
Civil Engineering Contractor		Project Management Consultancy	
Consulting Engineering		Other, (Please specify)	

Q2 – What is your primary job title?

1. Management 2. Engineering/Design 3. Title allied to the field

Q3 – How long have you been working in construction industry projects?

2. < 5yrs b) 5-10yrs c) 10-15yrs d) >15yrs

Q4 – What is the orientation in your organisation construction management procedures? (You can tick more than one)

3. Experience / SCM / Consultant-vendor supplied / other (*Please* specify) ……

Q5 – Number of Fully GSCM adopted projects

4. 1) 0 2) 1 3) 2-4 4) 5 and above

Q6 – Partly GSCM adopted projects

5. 1) 0 2) 1 3) 2-4 4) 5 and above

Q7 – Several criteria are utilized to gauge supplier performance, as outlined below:

1. Financial and managerial robustness, ensuring stability and favorable cost structure over the long term.
2. Quality assurance system (including certifications acquired and adherence to quality standards).
3. Capability in physical distribution.
4. Manufacturing capability (including adaptability and technical support).

5. Proficiency in information systems, including the utilization of enterprise resource planning (ERP) systems.

6. Adherence to environmental regulations and ethical standards, demonstrating integrity.

7. Degree of innovation incorporated in technology and receptiveness to new research.

8. Infrastructure available at the company's location.

Q8 – Please prioritise the technical barriers identified by your firm among the following.
a) More time to develop new products b) scarcity of technical skill c) legislative support d) Other please specify,

Q9 – Please prioritise the economic barriers identified by your firm among the following barriers
a) Increased initial expenditure on environmental management initiatives

b) Expenses associated with environmental certifications (e.g., ISO 14000/14001)

c) Elevated procurement costs for environmentally friendly materials, components, and products sourced from a limited selection of green suppliers

d) Other please specify,

Q10 – Regulatory compliance has been identified? please explain its significance.
A. Adherence to more stringent domestic and international regulations will enhance the company's favorable corporate reputation.

B. Varied environmental regulations and standards across different countries will impose challenges on the firm's global supply chain operations.

C. Other please specify,

Q11 – How do the Enterprise Resource Planning (in order to make sure that future processes of company do not become complicated, as well as to handle scalability, in terms of carbon footprint) contribute to your company and prioritise according to your experience?
a) More customers b) Less competition c) Others please specify,

Q12 – Constrains associated with your Enterprise Resource Planning
a) Cost b) Security c) Policy d) Technology e) IoT/AI f) Other please specify,

Q13 – Implementation of information transparency (identifying and retrieving data from all links in your supply chain) obstacles identified
a) Security b) Cost c) Policy d) Technology e) Others, please specify,….

Q14 – Why does your company depend on logistics visibility (real-time monitoring of supply chain) among the following:
a) Avoid damaging b) Mishandling of cargo c) Others please specify, …….

Q15 – How many customers value the operational performance of your company
a) 10% b) 25% c) 50% d) 75% e) 100%

Q16 – From the experience, your customers prioritise the following
a) Efficient cost structure b) Product qualityc) Speed d) Responsiveness

Q17 – How often are Yard logistics (helps you stay in control of your yard processes. It covers various modes of transport of your cargo) reviewed critically at your company?
1) Daily 2) Weekly 3) Monthly 4) Quarterly 5) Others please specify,……

Q18 – What does your company use for quality metrics in Yard logistics?

a) Cost saving b) Error free c) Reliability d) Timely delivery e) Others (specify)
f) All of the above

Q19 – How do you lower the cost of reverse logistics (There is an opportunity for cost savings by using recycled/ salvaged materials to new sites)?

a) Better yard logistics b) Policy change c) Other (specify) d) All

Q20 – How does reverse logistics reduce business risks?

a) Propagate the company policy b) Excess market c) Others (specify) d) All

Q21 – Please indicate the level of interaction with your suppliers on the following reverse logistics issues and prioritise them accordingly

a) Related to purchase
b) Technology know-how
c) LCA
d) Product recovery
e) New design of product
f) Mentoring of suppliers
g) Company policy

Q22 – Please indicate the level of interaction with your customers on reverse logistics issues following

a) Related to purchasing
b) Product development
c) Product service
d) Incentives for offering returned products
e) Company future plan
f) Production cost
g) Technology know-how
h) No interaction

Q23 – Please rank the barriers that affect the performance measurement of reverse logistics

a) Resistance by employees as it may control them
b) Low priority by the management
c) Lack of coordination in SC
d) Uncertainty in returned products
e) Difficulties in measurement of performance indicators

Q24 – How would you describe the willingness of developers to install green energy in buildings?

1) Very weak 2) Weak3) Neutral 4) Strong 5) Very strong

Q25 – How often do you refer to green building codes in your practices?

1) Never or not aware 2) Rarely3) Sometimes 4) Often 5) Always

Q26 – Please mark your company strategies in relation to green supply chain management in construction sector Consider a typical project you manage with the attributes of GSCM and answer the following questions.

	General	Are you familiar with the following aspects?	
		Y	N
1	Do you think your organization does recognize the benefits that are possible from implementation Green supply chain management		
2	Does Green supply chain management help to increase organizational rewards?		
3	Are you certain that your company has endorsed Corporate green policies		

4	Do you think whether Enterprise Resource Planning affects the speed of the project		
5	Have your company chart out green suppliers and green technologies		
6	Does your agency allow contractors to use technologies at their discretion		
7	Do you think your company is highly info-transparent		
8	Do you think Information transparency is beneficial for you company progress		
9	Is your company capable of real-time monitoring of your cargo?		
10	Do you think it (Logistics visibility) is essential to win claim / win insurance and disputes		
11	Extra green cost for greening the business- are they forth to afford it (majority)		
12	Recycled product inclusion – attitude of customers (majority)		
13	Are they asking for green suppliers and green purchase, design, transport, etc.		
14	Do you think reverse logistics has the best prospects in green cost management		
15	Do you think yard logistics should be part of the company's strategy		

END OF THE QUESTIONNAIRE-

Thank you for your participation!

III-D: QUESTIONNAIRE SURVEY -2

[Kerala state region]

AIM OF THE SURVEY

This questionnaire survey is part of the research programme contributing strategies in relation to green supply chain management (GSCM) in the construction sector. It is to check with emphasis on how the COVID pandemic had struck the business, how it revived, and the positive, sustainable shifts towards GSC that emerged during the post-COVID time. The survey aims to identify professionals' understanding, attitudes, and behaviours with respect to supply chain sustainability and eco-friendly, carbon-neutral supply chains in India, especially in the construction sector.

Respondent based

Q1 – What type of organisation do you work in?

Financial advisors		Construction manager	
Building contractor		Property developer	
Academician		Project manager	
Consulting engineering		Other, (Please specify)	

Q2 – What is your primary job title?

6. Management 2. Engineering/Design 3. Title allied to the field

Q3 – How long have you been working in construction industry projects?

a) < 5yrs b) 5-10yrs c) 10-15yrs d) >15yrs

Q4 – What is the orientation in your organisation construction management procedures? (You can tick more than one)

Experience / SCM / Consultant-vendor supplied / other (*Please specify*)

……

Q5- Number of Fully /Partly GSCM adopted projects

1) 0 2) 1 3) 2-4 4) 5 and above

Likert - assessment

No.	How much were the following aspects used in a GSCM project	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
	Statements	1	2	3	4	5
1.	Did you find that cost overruns persist after the pandemic in the construction sector?					
2.	AI found helpful workforce management, material management, and safety management?					
3.	Are you fed up with supply chain disruption, technological shortfalls, and defunct risk management?					
4.	Do you expect more nominal government measures in the construction sector to be sustainable?					
5.	Does COVID-19 have a serious impact on construction supply chain operations?					
6.	There are impeccable challenges that can be faced to keep the projects meeting the targeted objectives.					
7.	Do you consider permanent changes to your construction works and processes, especially towards going green?					
8.	In the face of the pandemic, did you get any benefit from the government?					
9.	Did COVID-19 affect your project[s] more than your tackling limits and limited virtual platforms?					
10.	Did you have your corporate Reasons for the suspension of work during COVID-19					
11.	Have you completely escaped the impact of COVID-19 on your work flow?					
12.	Have you noticed GSC in the construction industry in post-COVID has high demands?					
13.	Scarcity of material affected the project's scheduling and planning.					
14.	Are you still worried about the supply chain disruptions that were prominent during COVID?					
15.	There are difficulties in finding suitable alternative materials, storing materials, and delivering them.					
16.	Did the pandemic remind you that you are experiencing a shortfall in the workforce, difficulties in transportation, a shortage of construction equipment, a lack of experts, and a perfect PMS for scheduling and planning?					
17.	Are you looking for a solution for Lack of communication between parties disrupts the progress of work and workflow.					
18.	Are you in agreement with the urgency of advanced technologies to improve sustainability?					
19.	A major financial issue was found to be the increase in the project's cost.					
20.	You are equipped to manage unstable cash flow and revenue and a lack of funding.					
21.	Do you agree that post-COVID businesses face an increase in claims, disputes, and litigation?					
22.	You are worried about a lack of practises in virtual working, insufficient support to adapt to new technologies, and an ineffective transition to remote work.					
23.	There are challenges to the sustainability of future projects.					
24.	COVID time showed an increase in demands for local manufacturers and suppliers.					
25.	A lower interest rate support for the loan and other favourable loan programmes provided by the government					
26.	recommends improvements to existing systems, internal reviews, workplace design, and material planning.					
27.	Encouraging virtual risk assessment and collaboration for sustainable projects					
28.	You are worried about the lack of financial flexibility for local government.					
29.	You have experienced poor storage on construction sites, monopolisation of construction materials, and damage to materials due to prolonged storage.					
30.	encourages AI and IoT to resolve issues with poor site management, communication flaws, and delays in work progress and reporting.					

END OF THE QUESTIONNAIRE- *Thank you for your participation!*

Appendix IV

IV-A: Letter of Invitation – Delphi Study

UO/Reg.No.

SSBM Date: XXXX

Dear **Dr. XXX,**

I am a doctoral candidate and "Green transformation of supply chains in the construction sector in India via policy interventions" is the topic of my DBA research programme at SSBM University. With the ultimate goal of making the construction industry carbon neutral, the primary purpose of this research project is to bring a conceptual framework for required interventions to green the industry to the attention of national and local governments. Experts in the field of the construction supply chain are invited to participate in a Delphi study, which is proposed as a complement to the quantitative results obtained previously from surveys in the local construction industry. This will allow a wider range of experience and insights to be introduced to the conceptual framework. Your involvement on this Delphi expert panel would have helped manage construction supply chains for both creating a green environment and the Indian construction industry.

An information document on the specifics of this Delphi research is sent with this email invitation. Kindly go over the information sheet. Should you decide to take part, kindly fill out the informed consent form and return it to me via email or regular mail. I will send the questionnaire your way after I have received your signed informed consent form. Multiple information-sharing rounds could be required. I will gather answers from every panellist in the Delphi process for analysis in each round of surveys. You will be informed of the outcomes.

Please be certain that neither you nor anybody else will be able to identify the replies you provide. This study is autonomous, conducted for academic reasons alone, and is not supported by any business in the industry. There will be no impact on your current or future employment with your firm or academic institution from anything you answer on the questionnaire.

I intend for you to take part in this Delphi research. Studies on new topics, such as green transformation and sustainable building methods, could not be carried out without the support of individuals like you. There is no cost for you to abstain from participation, which is entirely optional.

To address any queries or worries you may have with answering the questionnaire or taking part in this research, please email me at sj.vijayadas@gmail.com. Please contact Professor **Minja Bolesnikov**, my doctorate research supervisor, at minja@ssbm.ch if you have any issues concerning your rights as a study participant. On April 15, 2020, the University Academic Council gave their approval for this project.

Sincerely,

SJ VIJAYADAS

`

IV-B: Information Sheet – Delphi Study

GREEN TRANSFORMATION OF SUPPLY CHAIN OF INDIAN CONSTRUCTION SECTOR TO GREEN VIA POLICY LEVEL INTERVENTIONS

Researcher (DBA Candidate)

S J VIJAYADAS

Swiss School of Business and Management School Geneva
Telephone +41 (022) 508-7796 and Enail Address: contact@ssbm.ch

Research Supervisor

MINJA BOLESNIKOV, PhD

Swiss School of Business and Management School Geneva
Geneva Business Center
Avenue des Morgines 12
1213 Genève
Switzerland
Telephone +41 (022) 508-7796 and Enail Address: contact@ssbm.ch

As an expert in the field of construction supply chain (green/sustainability), you are invited to join the Delphi expert panel for a research study. Please answer all the questions in the questionnaire.

The study aims to supplement a quantitative study on key processes in the construction sector, introducing green supply chain principles and policy elements in India. Eligible participants must meet two out of three selection criteria: 1) project management professional or academic with peer-reviewed publications in sustainability; 2) construction project manager with extensive experience in managing sustainability activities in India and/or overseas; and 3) at least five years of recent experience in researching, teaching, or practicing sustainability/circular economy/lean principles in construction/GSCM. The research process involves answering a questionnaire after reading an information sheet. In each round of questionnaires, it takes no more than 15 minutes to complete. Please send the completed questionnaire back to the sender via email at sj.vijayadas@gmail.com. The questionnaires should be completed within two weeks of each round of information exchange, which may involve multiple rounds. The collected information will be used to prepare for subsequent rounds, if any.

This research study does not compensate participants and allows them to withdraw at any time without penalty. Data collected will be stored securely and confidentially, with results published based on analysis without individual data disclosure. Data collected in physical form will be securely locked in a filing cabinet, while soft data will be stored in a password-protected USB key. The researcher will destroy all data five years after graduation. If you have any comments, concerns, or questions about the research, contact the researcher listed at the top of the form, the research supervisor listed at the top of the form, or the Chair of the University Research Ethics Committee. If you remain unhappy and wish to complain formally, contact the researcher listed at the top of the form.

Details can be obtained from the university website: https://www.ssbm.ch/connect-with-us/

Glossary

DELPHI EXPERT PANEL: The panel consists of 30 academics or professionals who are experts in multidisciplinary supply chain fragments like **design, procurement, transportation, execution and waste management.** Through a multi-staged information exchange among the panel experts, consensus on important issues can be arrived at attempting to complement and triangulate earlier quantitative study on the subject.

ECONOMIC SUSTAINABILITY. It is defined as increasing profitability through efficient use of resources (human, materials, financial), effective design and good management, planning and control

ENVIRONMENTAL SUSTAINABILITY: It is defined as preventing harmful and irreversible effects on the environment by efficient use of natural resources, encouraging renewable resources, protecting the soil, water, air from contaminations and other:

SOCIAL SUSTAINABILITY: It is defined as responding to the needs of society including users, neighbors, community, workers and other project stakeholders

GSCM *Zhu and Sarkis [2006]* conceptualize GSCM as the integration of environmental thinking with operations management in the SC, starting with the product design and passing through the selection of raw materials, manufacturing processes, transportation and delivery, and the final consumer arriving at the final destination after use.

COST EFFICIENCY: Cost efficiency involves business strategies aimed at reducing the cost of product creation or activity performance without compromising quality. Assessing cost efficiencies entails comparing the benefits of output to the costs of input. By evaluating the revenue generated against incurred expenses, organizations can identify potential areas for improvement to save money and enhance efficiencies (Indeed, 2022).

TSC: Traditional supply chain refers to an integrated manufacturing process where suppliers provide raw materials or semi-finished goods to manufacturers, which are then fabricated or assembled into final products. These finished goods are subsequently distributed to wholesalers, retailers, and ultimately delivered to customers (Deshmukh and Vasudevan, 2014).

SUSTAINABILITY: "meeting the needs of the present without compromising the ability of future generations to meet their own needs"(Brundtland, 1987)

GREEN TRANSFORMATION: Green transformation refers to the integration of economic growth with environmental stewardship to ensure a high quality of life for both present and future generations. It entails leveraging advancements in civilization and efficiently utilizing available resources to achieve sustainable development (Cheba et al., 2022).

VALUE MANAGEMENT: According to BS EN12973:2020, Value Management is a fundamental concept incorporated into existing management systems and methodologies, emphasizing value and function-oriented thinking, behaviors, and methods. It focuses on inspiring individuals, fostering skill development, fostering synergies, and promoting innovation to maximize the overall performance of an organization.

INVENTORY VISIBILITY: Inventory visibility is crucial for efficient order fulfillment operations, enabling accurate tracking of supply chain levels and locations. Advances in technology like RFID and barcode scanners automate inventory tracking, reducing man-hours and capital. It helps predict peak demand, prevent stockouts, and track specific products/orders (Romaine, 2022)

Enterprise resource planning (ERP): ERP software streamlines construction operations, including accounting, project management, procurement, and human resources. Key applications include project management, financial management, supply chain management, document management, and HR/payroll. Implementation requires organizational work and learning from mistakes (Vijayadas, 2022).

Information transparency (IT): Transparency in business involves reporting clear, meaningful information, fostering trust between stakeholders. In construction, it involves providing real-time project progress updates, maintaining transparent financial records, sharing information about the supply chain, and ensuring compliance and safety for effective decision-making, efficient project management, and effective communication (Vijayadas, 2022).

Yard logistics (YL): Automated yards integrate GPS, sensors, and IoT, improving customer service and reducing fuel dependency. Efficient yard logistics for construction companies include inventory management, equipment tracking, yard layout optimization, and security measures to reduce idle time, prevent material shortages, and enhance project efficiency (Vijayadas, 2022).

CONCEPTUAL FRAMEWORK: A conceptual framework is a theoretical structure used to guide research, analysis, and understanding in a specific field. It defines key concepts, guides research, organizes data, supports theory development, and facilitates effective communication among scholars and practitioners (Divya Sreekumar,2023)

ROI: Return on Investment (ROI) serves as a financial performance metric utilized to assess the effectiveness of a capital investment or operation, or to compare the efficiency of various investment projects. Calculating ROI involves dividing the investment return (benefit) by the cost of the investment. The resulting figure is typically expressed as a percentage or ratio (Wu and Buyya, 2015).

LABOUR-ONLY SUBCONTRACTING: Labour-only subcontracting involves the provision of labor services by a subcontractor who works under the direction of their employer. Typically, labour-only subcontractors are engaged to provide additional assistance on a project when needed.

MULTITUDINOUS AUTHORITY: In governance, "multitudinous authority" refers to a broad range of individuals or entities, whereas "authority" usually denotes the capacity to decide, impose regulations, or exert control over a particular area.

POSTMONITORING MECHANISM: A procedure for assessing and reviewing project or programme results after implementation is known as a post-monitoring mechanism. It entails gathering, analysing, evaluating, reporting, and providing feedback on data. It aids in ensuring that resources are used effectively, objectives are reached, and lessons are taken into account for upcoming initiatives (indeed, 2022)

Participation in this study is voluntary. There is no cost to you for participating. You may refuse to participate or discontinue your involvement at any time without penalty. You are free to withdraw from this study at any time.

This Delphi information sheet is for you to keep. Wishing that the above have adequately addressed your concerns and that you agree to participate in this Delphi study.

IV-C: INFORMED CONSENT FORM – DELPHI

GREEN TRANSFORMATION OF SUPPLY CHAIN OF INDIAN CONSTRUCTION SECTOR TO GREEN VIA POLICY LEVEL INTERVENTIONS

Consent for participation in Delphi study

Please read the below message and tick box:

- ☐ I understand that the project is designed to gather information about academic work on GSCM and the policy framework in the Indian construction sector. I will be one of 30 experts being recruited for this research.
- ☐ I am aware that my participation will not result in payment. I won't be penalised if I withdraw or stop participating at any point.
- ☐ Participation involves responses to the questionnaire. There may be more than two rounds of information exchanges. I will be approached repeatedly. I recognize that this research does not need any audio or video tape recording.
- ☐ I am aware that my identity as an expert participant in this study will remain anonymous and that the researcher will not use my name in any publications. Records and data shall be used in accordance with established data usage rules that safeguard the privacy and confidentiality of people and organisations.
- ☐ I understand that this research study has been reviewed and approved by the SSBM academic council for doctoral programs on business developments.
- ☐ I've read and comprehended the information sheet that was given to me. I am able to ask questions concerning the study, and I am satisfied with the researcher's response.
- ☐ My voluntary consent to take part in this study is granted.

My printed Name My signature with Date

IV-D: BACKGROUND INFORMATION OF DELPHI PARTICIPANTS

Code No.	Stakeholder Level	Background	Specialism
D1	Secondary	Chairman of Habitat Technology Group, is a pioneer in sustainable habitat development. His organization integrates technology with ecological principles to address housing and urban challenges. Sankar's visionary approach prioritizes eco-friendly construction, energy efficiency, and affordability. He is also a respected figure in academia and research, authored numerous publications, and has inspired professionals and communities to adopt holistic approaches to habitat development. His dedication to excellence and sustainability has earned him widespread recognition.	ARCHITECT
D2	Primary	**D2** is a prominent figure in energy efficiency and renewable energy, with over three decades of experience in various sectors. He has led initiatives to promote energy efficiency and renewable energy adoption in Kerala, including the Director of the Energy Management Centre in Kerala and the head of the Small Hydro Promotion Cell. He has also been involved in the UNIDO Regional Centre for Small Hydro Power, promoting sustainable energy solutions on a regional scale. His expertise in electrical engineering and business administration has equipped him with a comprehensive understanding of energy domain. His international training experiences in Germany, China, Japan, and the United States have further enriched his knowledge. His visionary leadership, extensive experience, and global perspective continue to drive positive change in the energy sector.	SUSATIANABILITY CONSULATANT
D3	External	**D3**, a 34-year-old expert in the Transport Planning Department at the School of Planning and Architecture, has made significant contributions to transport planning and urban development. He has authored 37 publications and guided four doctoral theses. He is actively involved in professional bodies like the Chartered Institute of Logistics and Transport, Institute of Urban Transport, Indian Roads Congress, and Institute of Rail Transport. He has served on committees and expert groups, and is a jury member for national awards and technical monitoring committees.	MANAGEMENT CONSULTANT

D4	**Primary**	**D4**, a professional with over 9 years of experience, is a dedicated professional in promoting sustainability in the built environment. He served as Area Convenor of the Sustainable Buildings Division at The Energy and Resources Institute (TERI) and is an Associate Fellow within the Sustainable Infrastructure Programme. He has led numerous projects, including Sustainable Space Heating Solutions in the Himalayan Region and standardization of health-energy nexus in Punjab.	**QUALITY AUDITOR**
D5	**Secondary**	**D5,** a seasoned professional in civil engineering and integrated project management, has a 37-year career in civil construction and maintenance works within integrated government projects. He has experience in townships, mines, and thermal stations. He excels in procurement of construction materials and inventory control, ensuring optimal utilization and cost-effectiveness. His strategic approach to resource management contributes to project success. He has also made significant contributions to sustainability initiatives through large-scale afforestation in mined-out areas, aligning with the Government of India's developmental programs. With a proven track record,	**STRUCTURAL ENGINEER**
D6	**External**	**D6,** has 37 years of experience in civil engineering, specializing in water supply, construction, procurement of materials, and township maintenance. He has managed 28,000 residential and industrial buildings and played a pivotal role in overseeing a 1000 MW thermal power plant. His comprehensive understanding of large-scale infrastructure development projects makes him a seasoned professional capable of handling complex challenges with finesse and expertise.	**CONSTRUCTIONN MANAGER**
P1	**Primary**	**P1,** is a seasoned civil engineer and infrastructure development professional with a distinguished career. He is currently the Team Leader at CDM Smith India and chairman of CEDC, BIS. He has contributed to prestigious projects such as the Jawaharlal Nehru Stadium, ISBT Flyovers, and the renovation of Vigyan Bhavan in Delhi. He has also contributed to infrastructure development through projects like the Lajpat Nagar Flyover and the signature bridge across the Yamuna at Wazirabad in Delhi. He has received numerous accolades and awards, including the Lifetime Achievement Award from the Indian Concrete Institute and the CIDC Viswakarma Public Officer Award.	**CONSTRUCTIONN MANAGEMENT**

P2	**Primary**	**P2,** had been the Additional CEO and Chief Buyer Officer for States, responsible for driving procurement strategies and fostering partnerships across sectors. He is instrumental in driving the adoption of Government e-Marketplace (GeM) within buyer organizations, managing States, and coordinating tender analysis. He also leads buyer-specific development programs, oversees tech issues, and coordinates escalations. He is also involved in onboarding cooperative societies, monitoring GOTT Project Management Units, and serving on the Service Committee and ACEO Committee.	**MATERIAL SPECIALIST**
P3	**Secondary**	**P3,** is a Project Management Professional (PMP) with over 30 years of experience in the Oil & Gas industry. He has worked as a Project Management Consultant for the Government of Kerala Projects, Procurement Expert for Kerala Solid Waste Management Project, and Procurement Manager for various projects. He has also worked as a Senior Contracts Engineer at Qatar Petroleum and as a Senior Contract Management Professional at ONGC Limited. He holds certifications from the Project Management Institute (USA) and the Association for Project Management (UK) - Level D.	**COST ESTIMATION**
P4	**Primary**	**P4,** a 37-year-old with expertise in technology development, government roles, and consulting, is currently leading Kerala's transition to the Knowledge Economy. He has worked in various roles, including COO/CEO, and has experience in technology development and development sectors. He has led mission-critical projects in decentralised planning, administrative reforms, service delivery, e-gov, and energy. He has also worked as a lecturer and member of the Board of Studies for courses in imaging technology, computer science, and futures studies and won several national and international awards. He is currently implementing a flagship project to provide employment to 2 million educated unemployed in Kerala.	**EXPERT COORDINATOR**
P5	**External**	**P5,** is the Founding Partner and Chief Consultant at Ganesh Technical Consultancy Services (GTCS). With 25 years of experience in the construction industry, he has expertise in feasibility studies, conceptualization, architectural design, building services, and Green Building Designs. Nair is known for his meticulous task analysis skills and costing abilities. He has designed some of the largest rainwater harvest reservoirs globally and is committed to continuous improvement and innovation in designs. Nair is also well-versed in Green Building practices and is known for his strong communication skills.	**INVENTORY CONTROL**

P6	**External**	**P6**, a 37-year-old professional with extensive experience in civil construction and procurement, has been instrumental in implementing major projects in mines and thermal power plants. He has been responsible for formulating comprehensive safety measures and selecting agencies for civil, mechanical, and electrical works. His proactive approach and meticulous vendor selection process have contributed to the successful completion of numerous projects, earning him a reputation as a reliable and capable professional.	**REAL ESTATE ANALYST**
C1	**Primary**	**C1**, a Civil Engineer with over 53 years of experience in the Housing, Infrastructure, Rural and Urban Development sectors, has served as the Chairman & Managing Director of Housing & Urban Development Cooperation (HUDCO) for 23 ½ years. He has worked in various Government of India Expert Groups on Housing, Urban Development, Building Technologies, Disaster Mitigation and Sustainable Development. He has received 15 distinguished awards for his work, including "Best Chief Executive of the Year" by the National Foundation of Indian Engineers. He is also a strong advocate of sustainable development and the green building movement.	**QUALITY AUDITOR**
C2	**External**	**C2**, a renowned environmental planner and sustainable development expert, has over 30 years of experience in India. As the Head of Environmental Planning (NIUA), she had performed her tasks with excellence and has contributed to various committees and initiatives promoting sustainable urban development. Her research on biodiversity conservation, zoo planning, urban habitat enhancement, and ecosystem services has led to her being session chair and panel member at seminars, and her expertise in legal and institutional frameworks.	**ENVIRONMENTAL PLANNER**
C3	**Secondary**	**C3,** is a skilled multi-disciplinary MEP consultant with over 40 years of experience in building services engineering. He specializes in electrical and ELV systems design, HVAC systems, plumbing systems, fire protection systems, EHT substations, relay coordination and short circuit studies, and electrical safety audits. His expertise extends to designing electrical systems, HVAC systems, plumbing systems, fire protection systems, EHT substations, relay coordination and short circuit analyses, and electrical safety audits. His expertise has led to his firm's position as a leading integrated MEP consultant in Kochi, Kerala. His commitment to excellence and customer-centric approach has earned him a reputation for reliability, professionalism, and quality service delivery.	**MANAGEMENT CONSULTANT**

C4	**Primary**	**C4,** is a 45-year-old civil engineer with a Master of Technology in Transportation Engineering. He has made significant contributions to Central and State Government organizations, particularly in the telecommunication field. With over 35 years of experience, he has a strong background in sustainable development designs and construction practices, focusing on minimizing environmental impact. He has also been instrumental in driving sustainable development initiatives in the telecommunication field. As the Chief Technical Examiner of Projects in the Finance Department of the Government of Kerala, he ensures quality norms and transparency in major civil engineering projects. His leadership and expertise continue to drive sustainable development and excellence in engineering practices.	**CONSTRUCTION MANAGER**
C5	**Secondary**	**C5,** is a seasoned Chartered Engineer with 27 years of experience in the construction industry, 22 years in the Middle East Gulf region. He is skilled in project management, contract administration, quantity surveying, quality control, team leadership, client relations, and fast-track project execution. He is an Accredited Professional (AP) of the Indian Green Building Council, demonstrating expertise in sustainable and green building practices. He has experience in multi-disciplinary projects, DPR, tendering, contract document preparation, and architectural review.	**PROJECT MANAGER**
C6	**Primary**	**C6,** is a renowned professional in sustainable architecture and energy efficiency, known for his expertise in environmental stewardship and innovative design. He holds the LEED Accredited Professional designation and has completed numerous LEED-certified and GRIHA-rated projects across various locations. His portfolio includes projects like ABN AMRO Bank's LEED Platinum, CISCO Vrindavan Technology Park's LEED Platinum, CISCO Cessna Business Park's LEED v3 Platinum, and the LEED Gold Minestone Diamond Factory. He has also conducted technical reviews and assessments for various LEED Certified and GRIHA-rated projects. His areas of specialization include energy consultancy, simulation and modeling, natural ventilation and hybrid buildings, and thermal comfort and solar passive design.	**SUSTAINABILITY ENGINEER**

T1	**Primary**	**T1,** has a distinguished career in the maritime industry, notably serving as the Managing Director and CEO of Vizhinjam International Seaport Limited, a Government of Kerala Undertaking. His leadership journey includes pivotal roles at Pondicherry Port, Pondicherry SEZ Company, and ADD Industrial Park, showcasing his extensive experience. Armed with an MTech and PhD in Ocean Engineering and a BSc in Civil Engineering, T1 possesses specialized expertise in shipping, ports, engineering, project management, and strategic leadership. With over 35.8 years of professional experience, he has honed his skills and knowledge in various leadership positions, demonstrating his commitment to the industry.	**TRANSPORTATION MANAGER**
T2	**Secondary**	**T2,** is a seasoned professional in transportation engineering and project management, currently serving as the Head of the Transport Planning Section at L&T Ramboll Consulting Engineers Ltd. With a Master's degree in Transport Planning from the School of Planning and Architecture, his expertise spans Highways, Transportation Engineering, Traffic Engineering, Transportation Planning, and Road management. He contributes significantly to organizations like KIIFB and L&T Infrastructure Engineering Limited, demonstrating a strong commitment to excellence in project planning and logistics.	**TRANSPORTATION ENGINEER**
T3	**External**	**T3**, a senior engineering consultant at Habog, has over 16 years of experience in transportation planning and consulting. He is part of a dynamic team focused on delivering exceptional services in various sectors. He prioritizes collaboration with clients, focusing on continuous improvement and knowledge sharing. He regularly contributes to the firm's blog, enhancing its reputation as a leader in the public infrastructure sector.	**SUSTIANBILITY TRANSPORTATION PLANNER**
T4	**External**	**T4,** is a seasoned infrastructure professional with extensive experience in planning, designing, and constructing infrastructure assets like roads, ports, and marine terminals. With a Master's Degree in Marine Technology from the UK, he delivers innovative and sustainable solutions to complex infrastructure challenges. With a commitment to excellence and continuous learning, he remains at the forefront of infrastructure innovation, contributing to successful global project execution.	**URBAN PLANNER**

T5	**External**	**T5**, an experienced industrial engineer and SAP consultant, has eight years of experience in industrial engineering, supply chain management, and project implementation. He specializes in sales and distribution, implementing SAP solutions in production-based companies. His expertise in project management, process improvement, and supply chain optimization has helped organizations streamline operations, improve productivity, and drive growth. His analytical skills and strategic mindset make him a valuable asset for organizations seeking SAP technology for business transformation and growth.	**SUPPLY CHAIN SPECIALIST**
T6	**External**	**T6,** a logistics and supply chain specialist with three years of sole experience, has led process improvement initiatives to enhance efficiency, reduce costs, and ensure seamless operations. She is proactive with process enhancement that has led to cost savings and operational excellence. Her expertise in procurement, inventory management, transportation, and distribution has earned her recognition as a valuable asset in the industry.	**LOGISTIC ANALYST**
W1	**Secondary**	**W1**, a 40-year-old Chief Engineer from the East Delhi Municipal Corporation, has extensive experience in planning, monitoring, executing, and managing projects across various sectors. He has participated in numerous technical seminars and contributed to discussions on green building, tall structures, and GIS. He has also been involved in urban facility development and solid waste management projects. He has held memberships in professional institutions and played a pivotal role in implementing Swachh Bharat Mission initiatives, promoting waste segregation, upgrading public facilities, and enhancing solid waste management practices. During his tenure, EDMC received accolades, including the Gold Skotch Award for its construction and demolition facility.	**SUSTAINABILITY ENGINEER**
W2	**Secondary**	**W2,** was a Director and Senior Professor of Civil Engineering at BITS Pilani-Pilani campus. He holds a Ph.D. in Structural Engineering from the Indian Institute of Science and has held visiting positions at the University of Canterbury, National University of Singapore, Carnegie Mellon University, and Tel Aviv University. Barai has published over 240 papers in international journals and has co-authored three books. His expertise includes green technology, recycled construction materials, computational techniques, fracture mechanics, and interdisciplinary fields like computer-aided engineering and artificial intelligence.	**ENVIRONMENTAL SPECIALIST**

W3	**Primary**	**W3,** is a civil engineer with expertise in pavement materials and sustainable road construction technologies. She excelled at BASF Construction Chemicals and later worked at CSIR-CRRI, advancing highway materials for flexible pavements. She specializes in material characterization, ensuring quality and reliability in flexible pavement construction projects. She has made academic contributions, including six journal publications and twelve paper presentations.	**SOLID WASTE RECYCLING SPECIALIST**
W4	**Secondary**	**W4**, the Managing Executive of IEISL's Waste Processing Plant in Shastri Park, manages over 10,000 tons of waste daily. With over 20 years of experience, IEISL has initiated pilot projects across cities and secured projects for the National Capital Region Transport Corporation. He promotes the use of recycled materials in construction, promoting environmental sustainability and resource conservation. His leadership positions IEISL as a leader in waste management.	**DECONSTRUCTION BUILDING RECYCLING**
W5	**Secondary**	**W5,** is a seasoned professional with extensive experience in waste management, sanitation, and environmental planning. He has held various roles at Re Sustainability Limited and other companies, including Environmental Planner at the Central Pollution Control Board, AVP at Ramky Enviro Engineers Limited, and Head of Strategy, Growth, and Transformation at Re Sustainability Limited. His expertise in project management, sustainability, and environmental science has significantly impacted the industry.	**RESTORATION SPECIALIST**
W6	**Primary**	**W6**, a 38-year civil engineering and pollution control expert in Kerala, has been a leader in environmental conservation and sustainable development. He has spearheaded initiatives to control pollution and address global warming challenges in the industrial and construction sectors. As Chairperson of the Kerala State Pollution Control Board, He has significantly contributed to environmental sustainability and a culture of responsible development in Kerala. His dedication to environmental protection and sustainable practices has left an indelible mark on Kerala's landscape.	**ENVIRONMENTAL SPECIALIST**

IV-D1: DELPHI QUESTIONNAIRE

GREEN TRANSFORMATION OF SUPPLY CHAIN OF INDIAN CONSTRUCTION SECTOR TO GREEN VIA POLICY LEVEL INTERVENTIONS

First Round Discussion

Instructions

- ✓ Kindly respond to the provided open-ended question. It should take approximately 15 minutes to complete.
- ✓ Once finished, please return the completed questionnaire to the sender via email at sj.vijayadas@gmail.com.
- ✓ Thank you for your valuable participation in this research study.

Question

Earlier quantitative study on supply chain management in the Indian construction industry shows that no success criterion was identified significant impacting on green transformation of construction industry. While in India, social sustainability is the goal of development, in practice it ignores environmental sustainability completely and economic sustainability to an extent, preferring economic factors.

I. Please correlate (please mark ✓) the statement and reasons following to arrive at a plausible conclusion. (*Not restricted to a single*)

Statement: Statutory compliance is found to be the only way to green the business, even for smaller construction organizations.

R1: Green transformation will likely be delayed due to government's ineffective or delayed enforcement for profit-driven businesses.

R2: The likelihood of regular green adoption is reduced when there is insufficient green distribution (markets) available at reasonable prices.

R3: Corporate regulations should expand for more corporate environment responsibility (CER), as the building industry claims substantial equivalent carbon (Ceq) contributions.

II. WHAT GENERAL OPINIONS DO YOU HAVE ABOUT THE FOLLOWING RESEARCH QUESTIONS?

RQ1: Which supply chain interventions are most appropriate for achieving sustainability in the construction industry?

- Recycled and Sustainable Materials:
- Local Sourcing:
- Energy-Efficient Design:

- Prefab and Modular Construction:
- Lifecycle Analysis (LCA):
- Digital Collaboration:

any other please specify ----------

RQ2: Does the Indian scenario's policy/regulation leave adequate room for action to bring about sustainability? [*Such as conceptual frameworks, urban development and building regulations, policies for renewable energy, green building, etc.]*

YES	NO
Please add two points to your thoughts	
1.	
2.	

RQ3: Which policies need to be addressed right away (modify) in order to keep the construction industry sustainable?

1. **Procurement policy**

The Indian Contract act, 1872; manual of procurement on goods/works, 2022; The competition act, 2002, (any other please specify----------)

2. **Design and forecasting**

CPHEEO, 2019; Building Byelaws, 2016; Design act 2000; (any other please specify----------)

3. **Transportation**

Carriers act, 1865; Carriage by road act 2007; emission standards for construction equipment vehicles, 2017; national highway authority act, 1988; the control of national highway act, 2002; motor transport works act, 1961; (any other please specify----------)

4. **Construction and operation**

KMBR, 2019; Contract labour act, 1970; the electricity act, 2003; workmen's compensation act, 2009; OSH code, 2020; payment of wages act, 1936; interstate migrant workmen act, 1979; green rating manual, 2019; (any other please specify----------)

5. **Waste management**

SWM, 2016; guidelines sustainable habitat, 2014; EPA, 1986; noise pollution, 2000, (any other please specify----------)

IV-D2: DELPHI QUESTIONNAIRE

GREEN TRANSFORMATION OF SUPPLY CHAIN OF INDIAN CONSTRUCTION SECTOR TO GREEN VIA POLICY LEVEL INTERVENTIONS

Second Round Discussion

Instructions

Please answer the following question. It takes about 10 minutes to complete. Please send the completed questionnaire back to sender via email at sj.vijayadas@gmail.com. Thank you for your participation in this 2nd round Delphi research study.

Question

"The subsequent statements are formulated based on the collective input from the Delphi expert panel regarding the significance of economic, environmental, and social sustainability impacts on the success of construction project implementation."

SCALE

(1) Strongly Disagree; (2) Disagree; (3) Neither Agree nor Disagree; (4) Agree; (5) Strongly Agree.

SUSTAINABILITY		**1**	**2**	**3**	**4**	**5**
1.	GSCM improves overall cost efficiency and eliminates uneven risks.					
2.	GSCM practices are flexible and scalable compared to traditional supply chains, so they offer better customer reliability for the organization.					
3.	Experienced stakeholders are the key for effective supply chain building.					
4.	GSCM is a 'multi-layer collaboration network' that offers maximum-risk elements.					
5.	Environmental consideration is at the bottom of sustainability measurements.					
6.	A profit-oriented green business is hard to achieve, especially for smaller firms.					
7.	Policy change can accelerate the green transformation of traditional supply chains.					
8.	A better legal framework improves inventory visibility.					
9.	Efficient project management often hinges on the seamless integration of activities across diverse organizations, a feat achievable through the application of Supply Chain Management (SCM) principles.					
10.	SCM faces challenges due to temporary stakeholder relationships, value management, early project involvement, and information transparency gaps due to inferior relationships with suppliers and subcontractors.					
11.	A conceptual framework promotes supplier diversity, legitimizes process flaws, and can satisfy multiple clients with a well-accepted design, overcoming temporary stakeholder relationships.					

DESIGNING		1	2	3	4	5
12.	RoI is the main financial concern for clients that catalyzes green transformation					
13.	The design stage calibrates improving cost-management, right stakeholder selection, and optimizing resource utilization.					
14.	Enterprise Resource Planning (ERP) is based on system internal policies.					
15.	Planning and scheduling are integral parts of GSCM.					
16.	Conceptual frameworks offer better solutions for flaws in planning and scheduling.					
17.	Risk management is easier when moving on with a legal framework.					
PROCUREMENT		**1**	**2**	**3**	**4**	**5**
18.	Do you think procurement policies can have a major impact on the other four supply chain elements? [Design, transportation, operation, and waste management]					
19.	A better procurement policy needs effective software integration to attain sustainability.					
20.	Do you agree that procurement heavily depends on design but has supremacy over transportation and construction?					
21.	Do you think current procurement policies are sufficient to meet evaluation and contract requirements in procurement?					
22.	Do you wish to revise existing policies to manage invoice approval and disputes in procurement?					
23.	Do you consider procurement policies to be at the top among other laws that comply with supply chain elements?					
24.	The complexity of labor-only subcontracting arises from the presence of multiple tiers of subcontractors within a single project environment.					
25.	Due to bidding-based selection, main contractors can maintain transient relationships between suppliers and main contractors.					
26.	Main contractors recommend fostering teamwork, which will help with faster completion at a budgeted cost.					
TRANSPORTION		**1**	**2**	**3**	**4**	**5**
27.	The transportation supply chain may be more functional when AI and IoT are integrated with field surveys.					
28.	Logistics services in construction require modifications to transportation law, as pollution is closely linked to transportation.					
29.	The better way to address supply chain interruption (transportation) in GSCM was discovered to be yard logistics.					
30.	Transportation is mostly reliant on procurement strategy and has control over waste management and reduction.					
31.	Better logistical planning and tight security characterize GSCM.					
32.	A strong and visible transit network can increase market size.					

33.	The GSCM guarantees minimum material loss during transportation.					
EXECUTION/ OPERATION		**1**	**2**	**3**	**4**	**5**
34.	Building code familiarization is not a hectic job.					
35.	A better conceptual framework enhances the safety and reliability of the construction process by allowing for detailed discussions with the client.					
36.	The construction process becomes safe and reliable with a better conceptual framework.					
37.	All building bylaws are tightly packed in India to safeguard the environment and workforce.					
38.	The construction industry in India operates in a highly fragmented manner.					
WASTE MITIGATION		**1**	**2**	**3**	**4**	**5**
39.	Recycling waste for optimization of resources secures the overall project cost.					
40.	The promotion of less embodied energy for construction materials is a sustainability criterion.					
41.	India faces uncertainty in waste quantity estimation due to ineffective waste management practices and multitudinous authority.					
42.	India needs to update its green building regulations in response to the construction industry's sharp and rapid increase in air pollution.					
43.	We are lacking developed markets for green and recycled products at attractive price.					
44.	Clients may be compelled to adopt unsustainable construction practices due to higher recycling costs, which are a result of the increased costs for green products.					
45.	The absence of a post-monitoring mechanism causes a delay in the construction industry's sustainable integration cycle.					

IV-D3: DELPHI QUESTIONNAIRE

GREEN TRANSFORMATION OF SUPPLY CHAIN OF INDIAN CONSTRUCTION SECTOR TO GREEN VIA POLICY LEVEL INTERVENTIONS

Third Round Discussion

Instructions

Analyzing the experts' answers to the second-round questionnaire—which includes your answers—is the third stage of the continuing Delphi exercise. Experts who participated in the previous phase of the questionnaire can edit and revise the material they previously submitted.

To provide feedback, each questionnaire item will be given two values that represent its relative relevance. Your assessment of the item's relevance level from the second round is represented by the first score, which is displayed in column C. The second score, which is shown in column D, is the average of all the experts' assessments for the item's relevance level from the second round.

You could review your second-round scores using the scale given below during this phase. Kindly update your score for each item in column E. If your reevaluated score is the same as your initial score, check the box to indicate that your importance level from the second round has not changed.

SCALE

(1) Strongly Disagree; (2) Disagree; (3) Neither Agree nor Disagree; (4) Agree; (5) Strongly Agree.

Please take the time to complete the exercise, which should take approximately 10 minutes. Kindly send the filled-out questionnaire back to the sender via email at sj.vijayadas@gmail.com. Thank you for your valuable participation in this third round Delphi research study.

Your name

Appendix V

Regulatory Framework for the Indian Construction Industry and Supply Chain

NO.	NAME OF ACT	CORE/SPECIFICITY
Design and forecasting		
1	**NBC 2016**	The National Building Code (NBC 2016) is a comprehensive guideline for the design and construction of buildings. It covers various aspects such as structural design, fire safety, accessibility, building materials, plumbing, electrical installations, ventilation, lighting, energy conservation, sustainable practices, occupancy classification, building height and area, fire resistance, escape routes, structural stability, earthquake resistance, water supply, waste management, maintenance, and regulatory compliance. The code outlines guidelines for fire safety measures, accessibility requirements for persons with disabilities, building materials, plumbing standards, electrical installations, ventilation requirements, and recommendations for lighting design. It also promotes energy conservation through efficient building design and construction practices. The code categorizes buildings based on occupancy types, including residential, commercial, industrial, or institutional. It specifies limitations on building height and floor area, prescribes fire-resistance ratings for building elements, and defines safe and accessible escape routes. It also ensures structural stability and integrity during construction, occupancy, and environmental loads. The code also includes provisions for earthquake-resistant design and construction in seismic zones, potable water supply systems, storage tanks, and distribution networks. It also encourages waste reduction and recycling practices for construction and demolition activities. Regular maintenance and inspection of buildings are crucial for safety and longevity. Compliance with national building standards and regulations is mandated to ensure uniformity and consistency in construction practices. Overall, the NBC 2016 serves as a valuable resource for building designers and architects alike.
2	**IGBC, 2019**	The Indian Green Building Council (IGBC) is a leading body in India dedicated to promoting green building practices and sustainability in the built environment. It offers green building certification programs, including LEED, for various building types, provides guidelines and standards for sustainable building design, construction, and operation, promotes resource efficiency, energy conservation, and environmental sustainability in buildings, encourages the use of environmentally friendly materials and technologies in construction projects, and conducts research and development activities to advance green building technologies and practices. The council collaborates with government agencies, industry partners, and academic institutions to promote green building initiatives and advocates for policy reforms and regulations to support sustainable development in the construction sector. It recognizes buildings that demonstrate excellence in sustainability and environmental performance, provides technical assistance and consulting services to help project teams achieve green building certification, hosts events, workshops, and conferences to raise awareness and disseminate

		knowledge about green building practices, and offers specialized certification programs for different building types. The IGBC also supports the development of green building materials and technologies through research and innovation, and collaborates with international green building councils and organizations to share best practices and knowledge. It advocates for green building policies and incentives at the national, state, and local levels to accelerate sustainable development, and offers tools, resources, and guidelines for project teams to achieve green building certification efficiently.
3	**ECBC, 2017**	The Energy Conservation Building Code (ECBC) is a voluntary code developed by the Bureau of Energy Efficiency (BEE) in India to promote energy efficiency in buildings. It sets minimum energy performance standards for commercial buildings, addressing aspects such as building envelope, lighting, HVAC systems, and electrical systems. The code encourages the use of energy-efficient materials and technologies, integrating renewable energy sources like solar power. Compliance with ECBC can lead to reduced energy bills for building owners and occupants, reduce greenhouse gas emissions, and contribute to achieving sustainability goals and green building certifications. The code defines specific requirements for different climate zones in India, including insulation materials, thermal performance, and high-efficiency HVAC systems. It also emphasizes proper sizing and efficient operation of HVAC systems. ECBC compliance documentation and energy audits are required, and it requires compliance documentation and energy audits. The code is periodically updated to incorporate advancements in technology and best practices, and it facilitates knowledge exchange and dissemination through conferences and seminars. It aligns with international standards and best practices in energy efficiency, supports India's commitments to global climate change mitigation efforts, and can lead to job creation in the green building sector.
4	**National Urban Housing and Habitat Policy, 2017**	All Indian urban dwellers are to have access to affordable housing through the National Urban Housing and Habitat Policy (NUHHP), 2017, with a particular emphasis on economically disadvantaged and marginalized populations. It encourages the expansion of rental housing markets, affordable rental housing, inclusive housing construction, and the rehabilitation of slums. The strategy promotes the development of housing infrastructure, smart housing solutions, and novel financing methods. Public-private partnerships (PPPs) for housing construction, institutional improvement and capacity building, and land use planning and regulation are also highlighted. The policy also contains guidelines for keeping an eye on and assessing housing-related policies and initiatives. Through the promotion of inclusive, sustainable, and equitable urban housing development, the strategy seeks to enhance the standard of living for all Indian city dwellers.
5	**Design act 2000**	India is a member of the World Trade Organization's Paris Convention and has signed the Patent Cooperation Treaty. Under the Act of 2000, Locarno classification has been adopted and the introduction of "Absolute Novelty" makes it possible to judge a novelty on the basis of prior publication of any article. The Act allows the district courts to transfer cases to the high courts where the jurisdiction is present, and the quantum of punishment is enhanced in case of infringement. It also revokes the secrecy of two years of a registered design and contains provisions for the avoidance of certain restrictive conditions. The Design Act of 2002 is an Act to consolidate and amend the law relating to the protection of designs. Its main objective is to protect new or original designs from getting copied, and to ensure that the creator, originator or artisan of any design is not deprived of their reward for creating it. It also provides provisions for substitution of the application before registering the design.

6	**Manual on storm water drainage systems: CPHEEO Operation & Maintenance and Part C Management, 2019**	Lack of finance, inadequate data, multiplicity of agencies, inadequate training of personnel, non-availability of operation and maintenance manuals, lack of awareness of the importance of storm drainage facilities, and lack of management all contribute to poor operation and maintenance of urban storm water drainage systems. Volume 1 of the Manual contains the planning and engineering design of various elements of storm water drainage systems and is organized in the following chapters: Chapter 1 deals with the issues of the urban drainage system in India, Chapter 2 covers the planning aspects of urban storm water drainage projects, Chapter 3 contains rainfall analysis and the development of IDF curves using empirical and probabilistic methods, Chapter 4 deals with runoff estimation resulting from urban catchments by various methods, and Chapter 5 covers the hydraulic design of storm water drains with applicable flow equations. Chapter 6 covers additional design considerations for special areas to be considered while designing storm water drains in hilly and coastal areas, and Chapter 7 covers the structural design and handling of storm water through pumping. Chapter 8 covers the planning and design of rainwater harvesting to be used for artificial recharge of ground water and attenuation of flashfloods. This manual is designed to assist engineers, planners, designers, architects, geographers, and hydrologists in the planning and design of urban storm water drainage systems in the country. It covers the methodology for using existing drains to allow excess runoff to percolate into the groundwater, as well as emerging practices such as Water Sensitive Urban design (WSUD), low impact development (LID), and sustainable urban drainage systems (SUDS). Best Management Practices (BMPs) for storm water Drainage systems are also discussed. The second volume of the manual is divided into two parts: Operation and Maintenance, which deals with operation and maintenance, inspection, replacement, and rehabilitation of storm water drains, and Management, which focuses on public awareness, capacity building, and institutional arrangement and financial sustainability.
7	**Smart Cities Mission, 2015**	The Smart Cities Mission, launched in India in 2015, aims to transform selected cities into sustainable, citizen-friendly urban centers using technology and innovation. The mission involves preparing Smart City Proposals (SCPs) and a competitive selection process, with 100 cities selected. Area-based development is emphasized, with pan-city initiatives implementing smart solutions across the city. The mission promotes an integrated approach to urban development, involving various sectors such as transportation, water supply, sanitation, solid waste management, energy, housing, and urban planning. Technology and innovation are central, with IoT devices, sensors, data analytics, and digital platforms being deployed. Public-Private Partnerships (PPPs) are encouraged for financing and managing smart city projects. Citizen engagement and sustainable development practices are also emphasized. Capacity building initiatives are included, and monitoring and evaluation mechanisms are in place.
8	**Heritage Conservation Policies**	The Ancient Monuments and Archaeological Sites and Remains Act (AMASR), 1958, and the Antiquities and Treasures Act, 1972, are key legislations in India that protect and manage cultural heritage and archaeological artifacts. The AMASR declares ancient monuments and archaeological sites as protected, regulates excavations, prohibits alterations without permission, and controls the export of antiquities to prevent illicit trafficking. The Archaeological Survey of India (ASI) is responsible for the conservation, maintenance, and management of these sites. The Antiquities and Treasures Act, 1972, regulates the ownership, acquisition, transfer, and disposition of these treasures. The Act also grants the central government the power to declare objects as antiquities or art treasures based on their historical, cultural, or artistic significance. The ASI plays a crucial role in implementing and enforcing the Act. Both acts indirectly contribute to design and forecasting by preserving historical and archaeological sites and artifacts, inspiring creative design and shaping future trends in architecture, urban planning, and cultural preservation.

9	**Building bye-laws, 2016**	Building bye-laws are legal tools used to regulate coverage, height, building bulk, and architectural design and construction aspects of buildings to protect them against fire, earthquakes, noise, structural failures, and other hazards. In India, there are still many small and medium-sized towns that do not have building bye-laws, leading to excessive coverage, encroachment, and haphazard development. TCPO has prepared "Model Building Bye-Laws 2016" for the guidance of the state governments, urban local bodies, urban development authorities, etc., which is an improvement over the previous Model Building By-Laws brought out in 2004. The reasons for revising the bye-laws include growing environmental concerns, increased safety and security measures, technological developments, Swachh Bharat Mission, and focus on Ease of Doing Business. The Draft Model Building Bye-laws, 2016, was circulated to central government agencies and institutes to obtain their comments and suggestions. A National Workshop was held on February 18, 2015 to obtain comments and suggestions from the State Town and Country Planning Departments, Urban Development Authorities, Municipal Corporations, Schools of Planning, and other related stakeholders. A review meeting was held on July 6, 2015, and comments were received from the Ministries of Culture, Consumer Affairs, Food and Public Distribution, Housing and Urban Poverty Alleviation, Power, Water Resources, River Development, Ganga Rejuvenation, and Civil Aviation. The salient features of the MBBL-2016 are safety and security, sustainability and green buildings, streamlining building permit approvals, ease of doing business, low-income housing, flexible FAR prescriptions, and updated IS Codes for BIS. The document provides provisions for Barrier-Free Environment, Environmental Concerns, Adoption for Modern Construction Technology, Disaster Management and Fire Safety, Swachh Bharat Mission, Ease of Doing Business, Rainwater Harvesting, and Effects of Communication Technology. It is hoped that the document will be useful for state governments, urban local bodies, development authorities, state town planning departments, and other planning agencies in revising their respective building bye laws.
10	**National Policy on Disaster Management, 2009**	The National Policy on Disaster Management (NPDM) in India, enacted between 2009 and 2019, aims to reduce disaster risk, prepare for response, and recover from disasters. It emphasizes risk assessment and vulnerability mapping to identify areas prone to hazards, such as climate change-exacerbated floods, cyclones, and landslides. The policy also advocates for building codes and standards that incorporate disaster-resilient design principles, promoting safer infrastructure. It advocates for land-use planning and regulation that considers disaster risk, ensuring compliance with zoning regulations and environmental safeguards. The policy also establishes early warning systems for various hazards, enabling proactive measures to protect construction sites and infrastructure. The policy also supports capacity building and training for construction professionals, encourages community engagement in disaster risk reduction efforts, supports research and innovation in disaster risk reduction and climate resilience, and guides post-disaster recovery and reconstruction efforts.
11	**Zoning Regulations- kottayam**	Zoning is a device of land use planning used in a master plan, derived from the practice of designating permitted uses of land based on mapped zones. It is the public regulation of land and building use to control the character of a place. Areas will be zoned under various categories, such as low density residential zone, high density residential zone, commercial zone, Town center, mixed zones I and II, public and semi-public zones, institutional promotion zone, industrial zone, transportation zone, park and open space, Thazhathangadi Heritage Zone, Storage/Godown Zone, solid waste management zone, paddy/wetland zone, land reserved for government purposes, dry agriculture zone, water body, medical college scheme area, Kodimatha house plots and green strips. Zoning regulations will specify the details regarding the nature of uses "permitted," "restricted," and "prohibited" in each zone. The Kottayam Medical College Area Development Plan is marked as a separate zone in the proposed land use map and the regulation of the said plan is applicable to the particular area.

12	**National Skill Development Policy, 2015**	The National Skill Development Policy 2015 aims to enhance the capacity of the construction workforce to adapt to and mitigate the impacts of climate change. It includes training in green building practices, climate adaptation, renewable energy skills, and integrating climate data into design and forecasting processes. The policy encourages climate data and projections to anticipate future climate impacts and design infrastructure more resilient. It supports research and innovation in climate-resilient design solutions, investing in new materials, technologies, and methodologies. The policy also promotes community engagement and awareness programs on climate-resilient construction practices, fostering a culture of sustainability and resilience. Incentives for climate-smart construction include tax breaks and subsidies, encouraging private sector investment in climate-resilient infrastructure. Overall, the policy aims to strengthen designing and forecasting in construction to combat climate change.
13	**National Policy on Electronics**	The National Policy on Electronics (NPE) 2019 in India aims to promote domestic manufacturing, research and development, and innovation in the electronics industry. It indirectly contributes to designing and forecasting in construction to overcome climate change challenges. The policy encourages the adoption of green technologies, such as energy-efficient appliances and renewable energy systems, which can be integrated into construction projects to improve energy efficiency and reduce carbon emissions. It also supports the development of smart building solutions and IoT devices for building automation and energy management. The policy also emphasizes data-driven decision-making, enhancing connectivity infrastructure, and promoting capacity building and skill development in emerging technologies related to electronics and construction. It also fosters collaboration between the electronics and construction industries to develop integrated solutions for sustainable and climate-resilient buildings.
14	**The Design (Amendment) Rules, 2021**	The Design (Amendment) Rules, 2021, came into effect on January 25, 2021, with the notification in the Official Gazette by the Department for Promotion of Industry and Internal Trade. The design classification system in India was based on the tenth edition of the Locarno Classification, but now designs will be classified according to the 13th edition, which contains 32 classes and 237 sub-classes. The 2021 Amendment Rules introduced 'startup' as a category of applicants, defined as any Indian entity recognized by a competent authority as a startup under the 'Startup India Initiative'. There is a simplification of the fee structure regarding transfer of rights and an overall reduction in fees for small entities. Electronic service of documents by means of email and mobile phones is provided, and the Design Office has been mandated to keep a record of the mobile numbers that are to be given along with the address as a mode for the service of documents. The templates of Form 1 and Form 24 now feature four different categories of applicants, i.e., natural persons, start-ups, small entities, and others.
PROCUREMENT		
1	**The Indian Contract Act, 1872**	The Indian Contract Act, 1872 is a crucial legislation in India that governs the law of contracts. A contract is a legally binding agreement between two or more parties that establishes rights and obligations. The act outlines the legal framework for contract formation, performance, and enforcement in India. Key features include the definition of a contract, essential elements of a contract, types of contracts, offer and acceptance, consideration, capacity, free consent, lawful object, and intention to create legal relations. The act recognizes various types of contracts, including sales, bailment, agency, work and labor, and guarantee contracts. Contracts must be mutually agreed upon, supported by consideration, and have legal capacity. Free consent is essential for a contract to be valid. Void and voidable contracts lack essential elements or are against public policy. Contracts can be performed when both parties fulfill their obligations, and breached parties can seek remedies such as damages, specific performance, or injunctions. Contingent contracts depend on specific events and are outlined in the act. Quasi-contracts are recognized in certain situations to prevent unjust enrichment. The

		Indian Contract Act, 1872, is a vital piece of legislation that underpins commercial and personal transactions in India, providing a legal framework for parties to enter into agreements with confidence.
2	WAREHOUSE BYE LAWS, 1976	The Bye-laws for warehousing non-hazardous goods require applicants to submit an application, including duty bills and invoices, and declare if the goods fall within the specified class and description. Hazardous goods are considered dangerous, and packages containing considerable value are accepted for storage by special arrangement. The Trustees cannot accept liability for loss or damage to goods stored in open spaces. Warrant goods are issued on Form 4, Appendix D, and non-warrant goods are granted on Form 5, Appendix E. Warrants can be exchanged or divided without assigning the goods. If warrants are lost or mislaid, duplicates will be issued, but an engagement and a substantial surety must accompany the application. The goods covered will be stopped immediately until duplicates are issued or missing warrants are produced. A charge of one rupee will be made for every duplicate warrant issued. Rent for goods deposited in the Trustees' Warehouses will be charged per week, starting from the date of application. Goods placed in the warehouse remain at the risk and expense of depositors until a receipt or warrant is granted. Owners must pay the Trustees all costs and expenses, including cleaning and disinfecting the storage area. The Trustees are not liable for damage or loss suffered by merchandise while in the warehouses, but responsibility will only be admitted when the damage or loss was due to a lack of proper care. Non-warrant goods will not be delivered until all rents and charges are paid, but this rule may be relaxed for convenience.
3	**Public Procurement (Preference to Make in India) Order, 2022**	The Public Procurement (Preference to Make in India) Order, 2022, is a policy designed to promote domestic manufacturing and production in India by giving preference to domestically manufactured goods and services in government procurement processes. The order outlines qualifications criteria, price preference, exemptions, and support for Micro, Small, and Medium Enterprises (MSMEs). It also promotes a transparent and competitive procurement process, with government agencies required to monitor compliance. The order aims to stimulate domestic manufacturing, boost economic growth, create employment opportunities, align with the Make in India initiative, encourage innovation and technology development, support sustainable development, and enhance self-reliance by promoting domestic manufacturing capabilities and supply chains.
4	**Manual on Procurement of Works, 2022**	The new Manual on Procurement of Works has been extensively revised in keeping with GFR 2017 and in consonance with the fundamental principles of transparency, fairness, competition, economy, efficiency and accountability. The overall aim is to increase productivity in work and make administration more responsive. Efforts have been made to maintain concordance between organizational goals, procedures of work and functionaries entrusted with the responsibility of discharging them.
5	**Guidelines for Procurement of Goods, Works, and Services under National Disaster Response Fund (NDRF), 2020**	The Guidelines for Procurement of Goods, Works, and Services under the National Disaster Response Fund (NDRF) can accelerate national procurement policy to tackle climate change. They prioritize climate-resilient infrastructure, promote green technologies, integrate climate risk assessment, support indigenous solutions, advocate for capacity building and training, incorporate environmental criteria, and establish mechanisms for monitoring and evaluation. These measures help build infrastructure that can withstand climate change impacts, reduce greenhouse gas emissions, and promote indigenous innovation. They also encourage the procurement of goods and services from domestic suppliers, fostering local industries and indigenous innovation. The guidelines also advocate for capacity building and training to enhance the skills of stakeholders involved in disaster response and recovery efforts. They also establish mechanisms for monitoring and evaluating climate-sensitive procurement decisions.
6	**Manual on Procurement of Goods,**	The Manual on Procurement of Goods has been revised in accordance with GFR 2017 to ensure transparency, fairness, competition, economy, efficiency, and accountability. Ministries and departments are advised to supplement this manual with their own detailed

	2022	manuals, Standard Bidding Documents, and Schedule of Procurement Powers.
7	**Arbitration and Conciliation (Amendment) Act, 2015**	The Amendment Act outlines the Independence, Disqualification, and Obligations of Arbitrators at the Time of Appointment. The model fees for arbitrators and High Courts vary from Rs. 45,000 (Rupees forty-five thousand) to Rs 30 (Rupees thirty) lakhs for various slabs of disputed value, with a sole arbitrator entitles to 25% (twenty-five percent) extra above the model fee. Disqualification from appointment is a long and exhaustive list of specific circumstances which act as a bar against any person from being appointed as an arbitrator in a dispute. Disclosures are required as per the Sixth Schedule of the Act, which removes any ambiguity and ensures uniformity. conflict of interest, time constraints, fast-tracking arbitration, oral arguments to be held on a day-to-day basis, and fast-track procedure are all part of the Arbitration Act. Conflict of Interest is the existence of any past or present relationship with or interest in any of the parties or in relation to the subject matter in dispute. Time constraints require arbitrators to disclose all circumstances which may affect their ability to deliver an award within 12 months. Fast-track arbitration requires arbitrators to deliver the award within six months.
8	**Assam Public Procurement Act, 2017**	The aim is to establish legal frameworks for procurement procedures by public entities to ensure efficient, efficient, and accountable procurement. This includes transparency, fair treatment of bidders, and public confidence in good governance. The state government will facilitate a procurement facilitation cell, ensuring timely delivery of intended outcomes, high standards of transparency, fairness, and equality towards bidders. The government will support state policies on social, economic, and environmental issues, and assure the public and stakeholders about the process's probity and integrity. The goal is to foster public confidence in the procurement process and ensure the delivery of intended outcomes.
9	Goods and Services Tax (GST) Act, 2017	The Goods and Services Tax (GST) Act, 2017 in India introduced a unified indirect tax system, a dual GST structure, and the Integrated Goods and Services Tax (IGST) for inter-state transactions. The GST Council, made up of representatives from central and state governments, is responsible for recommending GST rates and exemptions. GST is levied on the supply of goods and services, with threshold limits for businesses with annual turnovers below specified limits. The Act allows registered businesses to claim input tax credit for taxes paid on inputs, input services, and capital goods used in business. Small businesses can opt for the composition scheme, which allows them to pay GST at a fixed rate and file simplified returns. The GST Act also provides rules for the place of supply, the Reverse Charge Mechanism, e-invoicing and e-way bills, anti-profiteering measures, and the GSTN (Goods and Services Tax Network). The Act also empowers tax authorities to conduct audits and assessments, provides mechanisms for appeals and adjudication, and includes anti-evasion measures.
10	**Defense Procurement Procedure (DPP)**	The Defense Procurement Procedure (DPP) and the Model Tender Document by the Ministry of Finance, 2021, are two procurement processes that can complement each other. The DPP categorizes procurement into Buy (Indian), Buy and Make (Indian), and Buy (Global) with specific guidelines. It emphasizes indigenous production, technology transfer, and collaboration through initiatives like the Strategic Partnership model. The DPP also includes provisions for offsets, requiring foreign suppliers to invest in Indian defense manufacturing. It promotes transparency and integrity in procurement to prevent corruption and malpractices. The Model Tender Document can be boosted by aligning with DPP standards, incorporating defense-specific provisions, streamlining contracting processes, enhancing transparency and integrity, facilitating indigenous production, and integrating offset requirements. This synergy can enhance India's defense preparedness and indigenous manufacturing capabilities.

11	THE KERALA SHOPS AND COMMERCIAL ESTABLISHMENTS ACT, 1960	The Kerala Shops and Commercial Establishments Act, 1960 is a state-level legislation in Kerala, India, aimed at regulating working conditions, employment terms, and other aspects related to retail shops and commercial enterprises. The act covers both public and private establishments, outlines working hours, overtime conditions, employment conditions, leave entitlements, health and safety measures, employment of women and minors, employment records, wages, holidays, and children's employment. It also mandates the provision of weekly rest days and holidays, prohibits the employment of children in certain occupations, and establishes regulations for adolescents. The act designates certain authorities for inspection to ensure compliance with its provisions. Non-compliance with the act can result in penalties, fines, and legal consequences for employers. The act aims to protect the rights and interests of employees working in various commercial establishments, ensuring fair working conditions, benefits, and facilities, and promoting their welfare.
12	Model Tender Document by Ministry of Finance, 2021	The Model Tender Document by the Ministry of Finance, 2021, is a standardized framework for tendering processes across various government departments and agencies in India. It provides standardized templates and formats for preparing tender documents, ensuring consistency and clarity in the process. The document incorporates relevant legal provisions, guidelines, and regulations governing public procurement to ensure compliance with applicable laws and policies. It outlines the scope and objectives of the work, technical specifications, evaluation criteria, bid submission requirements, contractual terms and conditions, bidder qualification requirements, pre-bid conferences, bid opening and evaluation procedures, confidentiality and non-disclosure provisions, and compliance monitoring and reporting mechanisms. Tender documents are crucial for implementing policy initiatives and promoting transparency and accountability in the procurement process. Model Tender Documents (MTDs) have been developed for the procurement of goods and non-consultancy services, rationalizing and simplifying the structure of tender documents. They align provisions with various procurement policies, national and international best practices, and are issued in soft templates for easy customization by user departments. The formulation and release of these MTDs are part of a continuous process of reviewing existing rules and procedures and being monitored by the Cabinet Secretary as a special campaign from 2nd October, 2021 to 31st October, 2021.
13	**National Steel Policy**	The National Steel Policy, 2023 aims to tackle climate change by promoting sustainable procurement and design practices within the steel industry. It advocates for green procurement practices, promoting sustainable raw materials from environmentally responsible suppliers, and promoting energy efficiency and emissions reduction measures. The policy also promotes circular economy principles, encouraging the reuse, recycling, and repurposing of steel products and by-products. It incorporates life cycle assessment methodologies into procurement and design processes, enabling informed decision-making to minimize environmental impacts. The policy supports the adoption of green building standards and certification schemes, promoting sustainable steel products in construction projects. The policy encourages innovation and research in sustainable steel production technologies and materials, fostering environmentally friendly steel products and manufacturing practices. The policy facilitates capacity building and collaboration among stakeholders in the steel industry, government agencies, research institutions, and civil society organizations to promote sustainable procurement and design practices. The policy aims to promote the adoption of environmentally responsible practices within the steel industry, reduce its carbon footprint, and contribute to global efforts to mitigate climate change. The policy includes a vision and objectives, investment promotion, technology upgradation and innovation, environment and sustainability, raw material security, quality standards and certification, trade and export promotion, infrastructure development, human resource development, regulatory framework, and monitoring and review mechanisms.
14	**General Guidelines For E-Procurement Under Central Public**	e-Procurement requires the bidders to enroll on the CPP Portal, using a valid Digital Signature Certificate (DSC) and Valid email address. The bidders will be required to submit their bids online on the e-Procurement module.

	Procurement Portal	
15	**General Instructions on Procurement and Project Management 2021**	It aimed at the fact that it has always been a concern and challenge for the government and its agencies to execute public projects on time, within the approved budget, and with good quality. The draft guidelines inter alia stated: "Endeavour should be to explore the possibility of employing alternative procurement methods and other emerging trends apart from regularly used methods of procurement"
16	**THE KARNATAKA TRANSPARENCY IN PUBLIC PROCUREMENTS ACT, 1999**	An Act to provide for ensuring transparency in public procurement of goods and services by streamlining the procedure in inviting, processing and acceptance of tenders by Procurement Entities, and for matters related thereto. it is expedient in the public interest to render the process of procurement of goods and services by procurement entities transparent by streamlining the procedure for inviting, processing, and accepting tenders. An in-depth evaluation of the e-Procurement Project is needed to provide policy guidance for developing a new strategy for future e-government projects.
17	**Manual for Procurement of Consultancy & Other Services, 2022**	In the last few years, the Government of India has issued new instructions in the domain of public procurement. Some of these important changes include introduction of Central Public Procurement Portal (CPPP), Government e-Marketplace (GeM), preferential market access for micro and small enterprises, inclusion of integrity pact, etc. The GFR has been revised comprehensively in March 2017 covering inter-alia these set of new instructions. Consequently the Manual of Procurement too has been revised after a decade and within a month of the release of GFR 2017. The new Manual on Procurement of Consultancy and other Services has been extensively revised in keeping with GFR 2017 and in consonance with the fundamental principles of transparency, fairness, competition, economy, efficiency and accountability. Efforts have been made to cover all major aspects of procurement in this Manual in a user- friendly manner. The manual is the outcome of extensive consultations in two stages with Ministries/Departments/PSUs and other organizations over a period of six months.
18	**The Competition Act, 2002**	The Competition Act, 2002 provides for the establishment of a Commission to promote and sustain competition in markets, prevent practices having an adverse effect on competition, protect consumer interest, and ensure freedom of trade. In India, the Competition Commission of India (CCI) is a quasi-judicial and regulatory body entrusted with the task of enforcement of the Act. It has extraterritorial jurisdiction, an inquiry into anticompetitive conduct, sector-specific regulatory work, competition advocacy, and the power of appointment of professionals. The Commission is vested with inquisitorial, investigative, regulatory, and adjudicatory powers, and under Section 64, the Commission can frame regulations. The Competition Appellate Tribunal (COMPAT) is another body entrusted with hearing and disposing of appeals against any direction or decision or order of the CCI. The Commission may initiate an inquiry on its own motion, on the basis of information and knowledge in its possession, or on receipt of evidence. The Competition Act provides for the Director General's office as a separate investigative wing to assist the CCI. The DG is responsible for making enquiries, examining documents, and making investigations into complaints. The Act grants the CCI powers of summoning witnesses, examining them on oath, requiring the discovery and production of documents, receiving evidence on affidavits, issuing commissions for the examination of witnesses, etc. The Act also lays down the advocacy function of the CCI and grants it extraterritorial jurisdiction over anticompetitive conduct. Any anticompetitive activity taking place outside India but having an appreciable adverse effect on competition within India shall be subject to the application of the Competition Act. Under s. 21 of the Act, any statutory authority can suo motto or on request of a party before it can make a reference to CCI. CCI must give its opinion within sixty days of receipt of such a reference from such a

		statutory authority. The Competition Act, 2002 provides that the authority that made reference shall consider the opinion of the Commission and give its findings and reasons on the issues. Section 21A of the same language provides for reference by CCI to any statutory authority. The key provisions of the Act include Section 3, 4, 5 and 6, dealing with anti-competitive agreements, abuse of dominance, and regulation of combinations. The term 'agreement' is defined broadly, and Section 3(1) of the Act prohibits an anti-competitive agreement and declares it void.
19	**Whistle Blowers Protection Act, 2011 and the Whistle Blowers Protection (Amendment) Act, 2015**	The Act seeks to protect whistleblowers, i.e., persons making a public interest disclosure related to an act of corruption, misuse of power, or criminal offense by a public servant. The time limit for making any complaint or disclosure to the competent authority is seven years, and the designated agency cannot entertain any disclosure relating to any inquiry ordered under the Public Servants (Inquiries) Act, 1850, or the Commissions of Inquiry Act, 1952. Additionally, the Amendment Act, 2015, prohibits the reporting of a corruption-related disclosure if it falls under any 10 categories, including information related to sovereignty, strategic, scientific, or economic interests, or the incitement of an offense. However, if information related to (ii), (v), (vi), and (x) is available under the Right to Information Act, 2005, then it can be disclosed under the Act. The Designated Agency has the powers of a Civil Court under the Code of Civil Procedure, 1908, and the Code of Criminal Procedure, 1973, and the Indian Penal Code. If the agency is of the opinion that a public authority has committed a wilful misuse of power, it can recommend corrective measures such as initiating proceedings against the public servant or other administrative and corrective steps. If the public authority does not agree, it must record the reasons for such disagreement. No obligation to maintain secrecy or other restrictions upon the disclosure of information can be claimed by any public servant in the proceedings before the Designated Agency. It is the responsibility of the Central Government to ensure that no person who has made a disclosure is victimized on the ground that such a person had made a disclosure. If any person is victimized or likely to be victimized on the above-mentioned grounds, he may contact the designated agency and the designated agency may pass appropriate directions in this respect. If an offence under this act has been committed by any Head of the Department, every person who was responsible for the conduct of the business of the company shall be deemed guilty of the offense unless he proves that the offense was committed without his knowledge or that he exercised all due diligence. No court can take cognizance of any offense save on a complaint made by the designated agency.
20	**Sales of Goods Act, 1930**	Agreements for the sale of goods are governed by contract law, but certain peculiar features, such as the transfer of ownership of the goods and quality aspects, are not covered by the Contract Act. The Sale of Goods Act, 1930 defines goods as every kind of movable property, including stocks and shares, growing crops, goodwill, patents, trademarks, electricity, water, gas, and so on. The Act lays down the conditions for making that happen, and the moment when the property in goods passes from the seller to the buyer is significant for the following reasons: ownership, risk follows ownership, and the buyer can exercise proprietary rights over the goods. The Sales of Goods Act lays down the Doctrine of Caveat Emptor, which states that the buyer must act with due diligence when buying goods, and that it is not the seller's duty to point out defects. Statutory variations in taxes and duties must be borne by the buyer even if there is no express stipulation in the contract.
21	**MANUAL ON POLICIES AND PROCEDURES FOR PURCHASE OF GOODS, 2006**	The most important details are that public buying should be conducted in a transparent manner to bring competition, fairness and elimination of arbitrariness, and that the text of the tender document should be user-friendly, self-contained, comprehensive, unambiguous, and relevant to the objective of the purchase. The specifications of the required goods should be framed giving sufficient details in such a manner that it is neither too elaborately restrictive as to deter potential tenderers or increase the cost of purchase. Restrictions on who is qualified to tender should conform to extant Government policies and be judiciously chosen so as not to stifle competition amongst potential tenderers. The procedure for preparing and submitting tenders, deadline for submission, date, time &

		place of public opening of tenders, requirement of earnest money and performance security, parameters for determining responsiveness, evaluating and ranking of tenders and criteria for full or partial acceptance of tender and conclusion of contract should be incorporated in the tender enquiry. Tenders should be evaluated in terms of the criteria already incorporated and sufficient time should be allowed to prepare and submit their tenders. Suitable provisions should be kept in the tender document allowing the tenderers reasonable opportunity to question the tender conditions, tendering process, and/or rejection of its tender and the settlement of disputes, if any, emanating from the resultant contract. Negotiations with the tenderers must be discouraged. Public procurement procedures must conform to exemplary norms of best practices to ensure efficiency, economy and accountability. To reduce delays, each Ministry/Department should prescribe appropriate time frame for each stage of procurement, delineate the responsibility of different officials and agencies involved in the purchase process, delegate purchase powers to lower functionaries, and ensure conclusion of contract within the original validity of the tenders. In exceptional circumstances, price negotiations may be resorted to, but only with the lowest evaluated responsive tenderer and with the approval of the competent authority. The name of the successful tenderer should be notified by the purchase organization and the rate contracts should remain available without any break.
22	**Ministry of Micro, Small and Medium Enterprises 2012**	The Central Government has notified the Public Procurement Policy for Micro and Small Enterprises (MSEs) Order, 2012, mandating mandatory procurement from micro and small enterprises, based on core principles of competitiveness, adhering to sound procurement practices, and execution of orders in accordance with a fair, equitable, transparent, competitive, and cost-effective system. The policy requires central ministries, departments, and public sector undertakings to meet an annual procurement goal of 20% from micro and small enterprises, with special provisions for scheduled castes or scheduled tribes. Reporting of targets in annual reports and price quotation in tenders is essential for strengthening the policy. The Central Ministries, Departments, or Public Sector Undertakings must organize vendor development programs and enter into rate contracts with micro and small enterprises and prepare an annual procurement plan for purchases. Micro and Small Enterprises shall be facilitated by providing tender sets free of cost, exempting them from payment of earnest money, adopting e-procurement, and setting up Grievance Cell.
23	**The Rajasthan Transparency Public Procurement Act, 2012**	In relation to a public procurement, the procuring entity shall have the responsibility and accountability to - (a) ensure efficiency, economy and transparency; (b) provide fair and equitable treatment to bidders; (c) promote competition; and (d) put in place mechanisms to prevent corrupt practices.
24	**TAMIL NADU TRANSPARENCY IN TENDERS ACT, 1998**	The Act prohibits or procures goods or services except by tender. It also regulates tender regulation, appointment of Bulletin Officers, appointment of Tender Inviting Authority and Tender Accepting Authority, and appointment of an officer or a committee consisting of such number of officers as may be prescribed as the tender accepting authority. The Tender Bulletin is available for sale in the office of the Tender Bulletin Officer and at other places specified by him. The Tamil Nadu Government Business Rules shall be followed for tender acceptance, and the Tender Inviting Authority shall invite tenders in the form of a notice and communicate the Notice Inviting Tenders to the Bulletin Officers. The Tender Accepting Authority shall cause an objective evaluation of the tenders and accept the lowest tender ascertained on the basis of objective and quantifiable factors specified in the tender document. If the price of the lowest tender is higher than the prevailing market rate or the schedule of rates, the tender accepting authority may negotiate a reduction of price with that tenderer. The Tender Accepting Authority shall not accept a tender if it has been banned by any Procuring Entity, divide the procurement among such tenderers, keep a record of the reasons why, pass orders accepting the tender, and intimate the information regarding the name and address of the tenderer whose tender has been accepted, along with the reasons for the rejection of other tenders, to the appropriate Tender Bulletin Officers. The government may pass such interlocutory orders as they deem

		fit. The Tender Accepting Authority may reject a tender if the price quoted is higher than the schedule of rates or the prevailing market price.
CONSTRUCTION		
1	**Real Estate (Regulation and Development) Act, 2016 (RERA)**	The Real Estate (Regulation and Development) Act, 2016 (RERA) is a significant Indian legislation aimed at regulating the real estate sector, promoting transparency, accountability, and efficiency in transactions. It primarily focuses on regulating developers and ensuring timely project delivery, but indirectly contributes to sustainable construction practices. RERA mandates project registration with the regulatory authority, requiring developers to provide detailed information about the project. It also requires developers to adhere to project timelines, reducing environmental impacts and promoting efficient construction practices. RERA also requires developers to deposit a percentage of project funds into a separate escrow account, promoting financial discipline and transparency. It also requires developers to adhere to quality standards, building codes, safety regulations, and environmental norms, ensuring environmentally responsible construction. RERA empowers homebuyers by requiring transparency in project details and obtaining necessary approvals. This indirectly contributes to the long-term sustainability of the built environment and the preservation of natural resources for future generations.
2	**THE BUILDING AND OTHER CONSTRUCTION WORKERS (REGULATION OF EMPLOYMENT AND CONDITIONS OF SERVICE) ACT, 1996**	The Central Building and Other Construction Workers' Advisory Committee and State Advisory Committee are established to advise the Central Government on matters related to the administration of the Act. These committees represent employers, building workers, associations of architects, engineers, accident insurance institutions, and other interests. External committees consist of persons specially qualified in building or construction work to advise the government on rules under the Act. The Building and Other Construction Workers' Welfare Board is a body established by the State Government to manage the welfare of building workers. It ensures that building workers are registered and eligible for benefits provided by the Board from its Fund. Building workers must be 18 years old but not 60 years old and have been engaged in construction work for at least 90 days in a year. The Board may waive payment of contributions for financial hardships and allow building workers to deposit the contribution in arrears. The Board of Directors of a Building and Other Construction Workers' Welfare Fund provides assistance to building workers and their families, including grants and loans. Employers must maintain registers, records, and provide welfare measures for building workers. In establishments with over five hundred workers, employers must form a Safety Committee and appoint a safety officer with prescribed qualifications. The Indian Penal Code outlines penalties for various offenses related to safety measures, construction work, obstructions, and other violations. Violations can result in imprisonment, fines, or both. The Act allows individuals aggrieved by penalties to appeal within three months of the imposition of the penalty.
3	**THE CONTRACT LABOUR (REGULATION AND ABOLITION) ACT, 1970**	The Contract Labour (Regulation and Abolition) Act, 1970, was enacted in India's twenty-first year to regulate the employment of contract labour in certain establishments and provide for its abolition in certain circumstances. The Act applies to establishments with twenty or more workers employed or were employed on any day of the preceding twelve months as contract labour, and to contractors employing twenty or more workers. The Central Government may apply the provisions of the Act to any establishment or contractor employing such a number of workers after giving two months' notice. The Act does not apply to establishments where work only of an intermittent or casual nature is performed.

		The Industrial Disputes Act, 1947 defines appropriate government as the Central Government, while the state government is the government of the state where the other establishment is situated. A workman is considered contract labour when hired by or through a contractor, with or without the knowledge of the principal employer. The Uttar Pradesh Act outlines the powers and responsibilities of the Central or State Boards in regulating establishments, including the formation of committees for specific purposes, payment of fees and allowances for their members, and the establishment of committees for specific purposes. The Act also outlines the process for granting licenses to contract labour in establishments, which must be submitted in a prescribed form, detailing the location, nature of the work, and other details. The licencing officer may investigate the application and follow prescribed procedures. A license is valid for a specified period and can be renewed if necessary. If a license is revoked or suspended due to misrepresentation or non-compliance with conditions, the officer may revoke or suspend the license. The Act outlines penalties for obstructing inspectors, contravening provisions regarding contract labor, and other offenses. Companies committing offenses are considered guilty if the company and its employees are involved. Compounding of offenses can be done by a competent officer for a sum of fifty percent of the maximum fine. The Central Government has the power to give directions to the State Government on the implementation of the Act, remove difficulties, and make rules for carrying out the Act's purposes.
4	**THE OZONE DEPLETING SUBSTANCES (REGULATION AND CONTROL) RULES, 2000**	The Ozone Depleting Substances (Regulation and Control) Rules, 2000, were published by the Indian government on January 25, 2000, under the Ministry of Environment and Forests number S.O.69(E). The rules regulate the production and consumption of ozone-depleting substances, requiring individuals to obtain a license from the authority and ensure that the license does not exceed the calculated consumption level of the substances in the relevant twelve-month period. The Central Government is responsible for notifying the government of the calculated base level of consumption and production for each group of ozone-depleting substances. No person or entity can sell, stock, exhibit for sale, or distribute ozone-depleting substances after a specified date, unless registered with the authority and given a declaration. The regulations prohibit new investments in ozone-depleting substances, import, export, and sale of products made with or made with ozone-depleting substances, and require registration, cancellation, and appeal. The registration is valid for the period specified in Schedule IX and must be renewed. Monitoring and reporting requirements include maintaining records and filing reports for individuals producing, importing, exporting, or selling ozone-depleting substances, stocking or purchasing them, receiving technical or financial assistance from international organizations or the Central Government, reclaiming or destroying ozone-depleting substances, and manufacturing, imports, exporting, or selling compressors. Records maintained in accordance with these sub-rules must be made available for inspection.
5	Environmental Impact Assessment (EIA) Notification, 2006	The Environmental Impact Assessment (EIA) Notification, 2006 is a regulatory framework in India that outlines the process for assessing the environmental impacts of development projects and ensuring their compliance with environmental regulations. It applies to various developmental activities and categorizes projects into Category A and Category B, requiring mandatory environmental clearance from the central government and state-level assessments. Developers are required to prepare a comprehensive EIA report detailing potential environmental impacts, mitigation measures, and alternatives considered. Public consultation is crucial, allowing affected communities, stakeholders, and the general public to provide feedback and suggest mitigation measures. The EIA Notification mandates the formulation of an Environmental Management Plan (EMP) outlining measures to mitigate adverse environmental impacts, enhance environmental performance, and monitor compliance with environmental regulations throughout the project lifecycle. Once granted, environmental clearance is subject to periodic review and monitoring by regulatory authorities. Developers are legally obligated to implement the EMP, adhere to stipulated environmental conditions, and comply with all relevant

		environmental regulations throughout the project's construction, operation, and decommissioning phases. The EIA Notification is important for construction designing and forecasting for several reasons. It helps in early identification of environmental impacts, integration of environmental considerations into design, forecasting environmental consequences, identifying alternatives, public consultation and stakeholder engagement, compliance with legal and regulatory requirements, enhanced project sustainability, risk reduction and cost savings, and ensuring compliance with environmental standards.
6	**New Labour Code, 2022**	The Indian government has formulated four Labour Codes, including the Code on Wages, 2019, Industrial Relations Code, 2020, Code on Social Security, 2020, and Occupational Safety, Health and Working Conditions Code, 2020. These codes aim to strengthen workers' protection, including unorganized workers, in terms of statutory minimum wage, social security, and healthcare. Important provisions include a statutory right for minimum wages and timely payment, a uniform definition of 'wages' across all four codes, provision for annual health check-ups and medical facilities, the provision of an appointment letter for every employee, and a re-skilling fund for skill development. The government can extend benefits to unorganised workers, gig workers, platform workers, and their families through Employees' State Insurance Corporation or Employees' Provident Fund Organization. Workers engaged in Fixed Term Employment (FTE) are entitled to all benefits available to permanent employees and are eligible for gratuity if they serve for one year. Workers are entitled to annual leave with wages after 180 days, and the Employees' Provident Fund is now applicable to all industries.
7	**The Occupational Safety, Health and Working Conditions Code, 2020 (OSH Code)**	The Occupational Safety, Health and Working Conditions Code, 2020 (OSH Code) is a comprehensive labor legislation in India that modernizes existing laws related to occupational safety, health, and working conditions. It was introduced to simplify and streamline the regulatory framework governing workplace safety and welfare, making it more relevant to contemporary labor practices. The code, one of four labor codes introduced by the Indian government, came into effect on September 28, 2020, and aims to provide a more organized set of regulations for safeguarding workers' well-being in different sectors. Key features include scope and applicability, definitions, registration of establishments, occupational safety and health measures, working conditions, welfare provisions, leave types, penalties for non-compliance, compliance and inspections, establishment of advisory boards, and worker participation. The code also recognizes the importance of trade unions and workers' participation in matters related to safety and health. It is a significant step towards simplifying and modernizing labor regulations in India, aiming to improve workers' well-being and ensure safer and healthier working environments.
8	**Make in India Initiative, 2014**	The Make in India initiative, launched in 2014, aims to transform India into a global manufacturing hub by promoting domestic manufacturing, attracting foreign investment, fostering innovation, and enhancing competitiveness. It encourages local sourcing of sustainable building materials, technology transfer, green manufacturing practices, renewable energy integration, skill development, certification, and government support. The initiative supports sustainable construction practices by promoting eco-friendly materials, renewable energy, and skill development, while also offering incentives and tax breaks for green manufacturing facilities.
9	**National Solar Mission, 2012**	The National Solar Mission, launched in 2010, aims to promote sustainable development in India's energy sector by promoting the adoption of solar energy in buildings. It encourages the use of rooftop solar photovoltaic (PV) systems, providing financial incentives and subsidies for solar PV installation. The mission supports net metering and feed-in tariffs, allowing building owners to feed surplus solar energy back into the grid or receive compensation for excess electricity exported. The mission also promotes energy efficiency standards, promoting the use of energy-efficient materials and design practices. The mission aligns with green certification and rating systems, such as LEED and GRIHA, to encourage sustainable construction practices. The mission also includes capacity building and awareness programs to educate stakeholders about the benefits of solar energy integration in buildings and sustainable construction techniques.

10	**UTILISATION OF FLY ASH FROM COAL OR LIGNITE BASED THERMAL POWER PLANTS [S.O.763(E), 14th September 1999]**	The Indian government has issued a draft notification requiring coal or lignite-based thermal power plants to promote fly ash use in building materials and construction activities within a specified radius of one hundred kilometers. The directive aims to protect the environment, conserve top soil, and prevent fly ash discharge from these plants. Construction agencies must use fly ash-based products in construction projects, and each plant must establish a dispute settlement committee to ensure environmentally sound handling and transport of fly ash. The directive also prohibits construction or design of roads or flyover embankments with top soil, and the use of fly ash for compaction and reclamation. The directive applies to all mine agencies, public and private sectors, and mines of all minerals, metals, or items. Coal or lignite-based thermal power plants must ensure the utilisation of their ash by selling fly ash to utilities, making pond ash available free of charge to brick and tile manufacturers, and at least 20% of dry ESP fly ash available free of charge to units manufacturing fly ash or clay-fly ash bricks, blocks, and tiles. The Central Government has constituted a Monitoring Committee to monitor the implementation of the provisions and ensure compliance with the provisions. State authorities are responsible for ensuring a Memorandum of Understanding or other arrangement for using fly ash or fly ash-based products between thermal power plants and construction agencies or contractors.
11	Coarse and Fine Aggregate for Concrete Specification_ BIS, 2016	RA can be used as coarse aggregate and RCA can be used as coarse and fine aggregates in accordance with this standard.
12	Air act 1981	In the early 1970s, the effects of climate change from pollution became apparent, leading to the United Nations General Assembly on Human Environment in Stockholm in 1972. India faced issues with air pollution due to factors like stubble burning and improper industrial practices. To combat these issues, the Air (Prevention and Control of Pollution) Act of 1981 was enacted under the Indian Constitution. The act defines air pollutants as solid liquid or gaseous substances that can cause harm to the environment, humans, plants, animals, or property. The act also established the Central Pollution Control Board (CPCB) and the State Pollution Control Board (SPCB) for individual states. Non-compliance with the CPCB directives can result in imprisonment of 1 year, with the possibility of 6 years with a fine and an additional fine of 5000Rs per day.
13	**THE BATTERIES (MANAGEMENT AND HANDLING) RULES, 2001**	Manufacturers, importers, assemblers, and reconditioners are responsible for collecting used batteries, ensuring they are similar to new ones, filing half-yearly returns, setting up collection centers, ensuring safe transportation, and raising public awareness about lead hazards. Importers must register with the Central Pollution Control Board for five years, with the possibility of cancellation or renewal based on compliance status. Dealers and recyclers have specific responsibilities, including collecting and returning used batteries, filing half-yearly returns, ensuring safe transportation, and preventing environmental damage. Recyclers must apply for registration with the Ministry of Environment and Forests, ensure strict compliance, and maintain records. Consumers and bulk consumers are responsible for disposing of used batteries properly, depositing them with dealers, manufacturers, importers, assemblers, registered recyclers, or at designated collection centers. A computerized tracking system will be developed for battery distribution, auction, transport, re-processing, sale of re-processed lead, and lead sales.
14	THE CODE ON SOCIAL SECURITY, 2020	The Social Security Code 2020 aims to regulate both organized and unorganised sectors in India, extending social security benefits during sickness, maternity, and disability to all employees and workers across different organizations. The code integrates nine labour laws related to social security into one integrated code, including the Employees Compensation Act, 1923, Employees State Insurance Act, 1948, Employees Provident Fund and Miscellaneous Provisions Act, 1952, Employees Exchange (Compulsory Notification of Vacancies) Act, 1959, Maternity Benefit Act, 1961, Payment of Gratuity Act, 1972, Cine Workers Welfare Fund Act, 1981, Building and Other Construction Workers Cess Act, 1996, and Unorganised Workers' Social Security Act, 2008.

		The code has widened coverage by including the unorganised sector, fixed-term employees, gig workers, platform workers, and inter-state migrant workers in addition to contract employees. It applies to everyone on wages in an establishment, irrespective of occupation. The revised definition of employees now includes workers employed through contracts, self-employed workers who have migrated from another state, gig workers, and platform workers. Digitization of records and returns will help in the exchange of information among stakeholders and funds set up by the government, ensure compliance, and facilitate governance. Maternity benefits are not made universal and are currently applicable for establishments employing 10 workers or more. The proposed code does not include the unorganised sector, leaving women engaged in the unorganised sector outside the purview of maternity benefits. Stringent penalties for non-deposit of employees' contributions include a penalty of Rs 100,000 and imprisonment of 1-3 years. The delivery of social security benefits is still fragmented and administered by multiple bodies, making it confusing and difficult for workers to access their entitlements. While the SS Code 2020 tries to bring informal workers under social security, it doesn't fully achieve its goal of making social security universal. Employers should take responsibility for providing social security to their workers, as they benefit from their productivity.
15	**Code of Wages Act 2019**	The Indian government has proposed rules for the Code of Wages Act 2019, which aims to reduce income inequalities, bridge gender wage gaps, and alleviate poverty. Informal workers make up 93% of India's total working population and contribute to over 60% of the country's GDP. The new wage code aims to address issues like multiple wage definitions, low wages, and formalization of the economy. It aims to universalize minimum wage provisions and ensure "Right to Sustenance" for every worker. The new wage code will be set by the Centre and revised every five years, while states will fix minimum wages for their regions. It subsumes four labour laws: the Payment of Wages Act, 1936, Minimum Wages Act, 1948, Payment of Bonus Act, 1965, and Equal Remuneration Act, 1976. Concerns with the new wage code include potential starvation wages, the deduction of wages clause, and an unclear inspection framework. Starvation wages, currently guaranteed at just ₹178 per day, may continue to exist and promote forced labor. The deduction clause may lead to reduced bargaining power and right of association, as informal sector employers dominate workers due to caste and higher social status. To move forward, the government should focus on "Need Based Minimum Wage," covering nutrition, healthcare, education, housing, and provisions of old-age. Guaranteed minimum wage should be treated as a fundamental constitutional right for every citizen of India. The revision of minimum wages is required every five years, and minimum wages should be adjusted to inflation to align with market volatility. Furthermore, the National Commission for Labours should be formed to streamline labor market issues and resolve discrepancies in national level minimum wage computation. For the minimum wage system to play a meaningful role in aligning protection with sustainable growth, it must be properly designed, its goals clarified, and its enforcement made effective.
16	**THE ELECTRICITY ACT, 2003**	The Electricity Act, 2003 is a significant Indian legislation aimed at modernizing the country's electricity sector. It aimed to promote competition, efficiency, and private investment, ensuring reliable and affordable electricity for all citizens. The Act introduced the unbundling of state electricity boards (SEBs) into separate entities for generation, transmission, and distribution, enhancing efficiency and accountability. It established regulatory bodies at both central and state levels, promoting open access and competition, power trading, renewable energy promotion, consumer rights, tariff regulation, private sector participation, and cross-border trade. The Act also aimed to promote renewable energy sources, consumer rights, tariff regulation, private sector participation, and cross-border trade between India and neighboring countries. Despite its challenges, the Act has played a significant role in shaping India's electricity sector.

17	**The Workmen's Compensation Act, 1923**	The Workmen's Compensation Act, 1923, is a significant legislation in India that provides compensation for workers or their dependents in case of injury or death during employment. The act aims to provide financial support and relief to workers and their families in case of work-related injuries or fatalities. The Act applies to all employees, including laborers, workers, and employees engaged in specific employments, covering both industrial and non-industrial establishments. The Act imposes strict liability on employers to compensate employees for injuries or deaths that occur during the course of employment. It provides a compensation schedule for various types of injuries or disabilities, including temporary and permanent disabilities, as well as death. In cases of fatal accidents, the Act outlines the compensation payable to the dependents of the deceased worker. Employers are required to report any injuries or accidents resulting in disablement or death to the appropriate authorities. The Act allows employers to insure their liability through an insurance policy, relieves them from the direct financial burden of compensation payments. Employees are required to notify their employer of any injury or accident during their employment within a specified time frame. The Act also outlines the procedure for making a claim for compensation, including the submission of an application to the appropriate authorities. The Act prescribes penalties for employers who fail to comply with its provisions, including fines and imprisonment. It also provides for the review and appeal of decisions related to compensation claims. Some employments are excluded from the scope of the Act.
18	**THE EMPLOYEES' STATE INSURANCE ACT, 1948**	The Employees' State Insurance Act, 1948 is a crucial social security legislation in India that provides health and medical benefits to workers and their dependents. It applies to non-seasonal factories employing ten or more persons and non-power using factories employing twenty or more persons. The act establishes the Employees' State Insurance Corporation (ESIC), a statutory body responsible for administering the scheme and ensuring its effective implementation. Both employers and employees contribute to the ESI scheme, with employers contributing a certain percentage of the employee's wages, and employees contributing a smaller percentage of their own wages. The ESI scheme offers medical benefits, cash benefits, and maternity benefits for pregnant insured women. The act establishes regional and local offices to oversee the scheme and outlines penalties for non-compliance.
19	**THE EMPLOYEES' PROVIDENT FUNDS AND MISCELLANEOUS PROVISIONS ACT, 1952**	The Employees' Provident Funds and Miscellaneous Provisions Act, 1952 is a crucial social security legislation in India that provides financial security to employees in the organized sector after retirement or incapacitation. The act mandates employers to establish and contribute to a provident fund for the benefit of their employees, with both employers and employees contributing a certain percentage of the employee's wages. The act allows employees to withdraw their provident fund accumulation upon retirement, resignation, or superannuation, with partial withdrawals allowed for specific purposes. The accumulated provident fund balance earns interest, which is determined by the government and declared annually. Penalties and offenses include non-compliance with provisions, failure to contribute to the fund, false representation, and obstruction of authorized officers. The act establishes the Employees' Provident Fund Organization (EPFO) to oversee the implementation of the scheme, manages funds, maintains accounts, and ensures compliance with the act's provisions. The act also establishes the Employees' Pension Scheme, providing pension benefits to employees after retirement or incapacitation, funded through contributions from employers, employees, and the government.
20	**The Bangladesh Environment Conservation Rules, 1997**	The Bangladesh Environment Conservation Rules, 1997, are a set of rules aimed at preserving the environment and promoting sustainable development. They cover various aspects of environmental protection, including the declaration of ecologically critical areas, the installation of catalytic converters or diesel particulate filters in vehicles, and the application of environmental clearance certificates. Industrial units and projects are classified into four categories: Green, Orange: A, Orange B, and Red. An environmental clearance certificate is issued to all existing and proposed units and projects in the green category, followed by an Environmental Clearance Certificate for those in the orange-A, orange-b, and red categories. Entrepreneurs must apply to the Divisional Officer of the Department

		in Form 3 with appropriate fees and provide necessary documents. The Environmental Clearance Certificate is a legal document outlined by the rules, including an Environmental Impact Assessment report, Environmental Management Plan (EMP), no objection certificate, emergency plan, relocation and rehabilitation plan, and other necessary information. The certificate's validity period is three years for Green Category units and one year for other cases. The Appellate Authority must follow a procedure to hear the appeal, including a certified copy of the notice, order, or direction, a copy of the Environmental Clearance Certificate, and a Treasury Chalan showing proof of deposit of the appeal fee.
21	**EQUAL REMUNERATION ACT, 1976**	The Equal Remuneration Ordinance, 1975, is a law in India that mandates equal pay for equal work for both men and women. It was promulgated by the President to implement this provision in the International Women's Year and provides equal remuneration for men and women workers for the same work or work of similar nature. The act prevents discrimination based on sex and ensures no discrimination against women's recruitment. It comes into force three years after its passing and requires employers to pay equal remuneration to both genders. The Act empowers the government to appoint authorities to hear and decide complaints related to contravention of provisions or non-payment of wages. Employers are obligated to maintain registers and documents related to their workers. Inspectors can be appointed by the government to investigate compliance with the Act or its rules. Penalties for non-compliance include simple imprisonment for one month, fines up to ten thousand rupees, imprisonment for three months, and imprisonment for two years. The act does not apply to cases affecting women's employment or special treatment related to childbirth, retirement, marriage, or death.
22	**The Factories Act, 1948**	The Factories Act, 1948 is a crucial Indian legislation that regulates the conditions of work in factories, ensuring the safety, health, and welfare of workers. It was enacted to address challenges related to industrial employment, working conditions, and workplace safety during a time of rapid industrialization. The act applies to factories engaged in manufacturing processes and hazardous activities with power and employing ten or more workers. It outlines health and safety provisions, including cleanliness, ventilation, temperature, lighting, and other factors that contribute to a safe work environment. The act also stipulates maximum working hours, working hours, and overtime regulations. It also mandates the provision of welfare provisions, including canteens, restrooms, washrooms, and first aid. It also restricts the employment of young persons and women in hazardous occupations and women during specific hours and processes. The act mandates annual leave with wages for workers, and outlines safety measures for machinery, equipment, and manufacturing processes. Employers are required to maintain registers and records, and the act provides for inspection and penalties for non-compliance. The act also grants the government powers to make rules for the effective implementation of its provisions and provides a framework for resolving disputes related to the act's interpretation and application.
23	**The Hazardous Substances Act, 1973**	The Hazardous Substances Act, 1973, is a law in the Philippines that regulates the handling of hazardous substances and electronic products. It prohibits the importation, manufacture, sale, use, operation, application, modification, disposal, or dumping of such substances and products. The Act defines hazardous substances as substances, mixtures, products, or materials declared as hazardous substances. Import means import into the Republic by any means, and importer includes any person in possession of or entitled to the custody or control of any hazardous substance. Label refers to any brand or mark appearing on or attached to a grouped hazardous substance or its package. The Hazardous Substances Amendment Act, 1992, outlines regulations for the production, acquisition, disposal, importation, and exportation of Group IV hazardous substances. The Director-General may issue a license for carrying on business as a supplier of Group I hazardous substances, selling, letting, using, operating, or applying any Group III hazardous substance, and installing a Group III hazardous substance on specified premises. The license is valid for an indefinite period but may be renewed on application and payment

		of the prescribed fee. Appeals to the Minister can be made against decisions or conditions imposed by the Director-General. Licenses can be suspended or cancelled if the holder has provided false or misleading information, contravened or failed to comply with conditions, or has been convicted of an offence rendering them unsuitable. The Customs and Excise Act, 1964 allows the Commissioner for Customs and Excise to examine, control, and dispose of imported substances. If a substance is under the Commissioner's control but not yet complied with, it can pass from his control with the Director-General's concurrence. However, the importer must provide a guarantee to the Director-General that they will pay the Director-General for the benefit of the State Revenue Fund if they fail to comply with certain conditions. If a substance is deemed unsuitable for import, the Director-General may direct its confiscation, destruction, return to the port of shipment, importation, or disposal. The Act prohibits disclosure of certificates or reports on the analysis or examination of samples for legal proceedings or when required by any court or law. Violations result in penalties such as fines, imprisonment, forfeiture, and disposal of goods. The Minister may authorize local authorities to enforce provisions of the Act, and the Director-General may authorize officers of the Department of Health, Welfare, and Pensions to exercise powers conferred or imposed on the Director-General.
24	**THE INCOME-TAX ACT, 1961**	The Income Tax Act, 1961 is a comprehensive legislation in India that governs the taxation of income earned by individuals, companies, and other entities. It outlines the framework for taxing various types of income, provides guidelines for calculating taxable income, and determines the residential status of individuals and entities. The Act defines income tax rates and slabs based on the type and amount of income earned, and allows for deductions and exemptions. The Act also mandates the filing of returns for individuals and entities earning taxable income, outlines penalties for non-compliance, and provides procedures for assessing income and filing appeals against tax assessments. It also defines taxation rules for companies, including domestic and foreign companies operating in India. The Act also outlines requirements for advance tax payments and Tax Deducted at Source (TDS) on various types of payments. It includes provisions to prevent tax evasion and aggressive tax planning, such as General Anti-Avoidance Rules (GAAR) and transfer pricing regulations. The Income Tax Act, 1961 is subject to regular amendments through Finance Acts presented during annual Union Budgets. It plays a crucial role in generating revenue for the government and ensuring equitable taxation practices.
25	**The Forest (Conservation) Act, 1980**	The Forest (Conservation) Act, 1980 is a crucial environmental legislation in India that regulates the diversion of forest land for non-forest purposes, aiming to maintain ecological balance and conserve forest resources. The act aims to address concerns related to deforestation, habitat loss, and environmental degradation caused by the conversion of forest land for developmental activities. The act applies to all forest lands, including unclassified forests and wastelands, and requires prior approval from the central government for any diversion. The process of diversion involves submitting a formal proposal to the central government, which is examined by an appointed Expert Committee. The central government then decides whether to approve or reject the proposal. The act also mandates compensatory afforestation, requiring an equivalent area of non-forest land to be afforested or reforested to compensate for the loss of forest land. Violations of the act can lead to penalties, fines, and imprisonment. The act also allows for appeals and reviews of decisions made under the act.
26	**THE INDUSTRIAL RELATIONS CODE, 2020**	The Industrial Relations Code, 2020 is a significant labor reform legislation in India aimed at consolidating and simplifying laws related to industrial relations, trade unions, and employment conditions. It aims to promote ease of doing business, enhance workers' rights, and create a more harmonious industrial environment. The code consolidates and amends laws related to trade unions, industrial disputes, and conditions of employment, including the Industrial Disputes Act, 1947, the Trade Unions Act, 1926, and the Industrial Employment

		(Standing Orders) Act, 1946. It introduces clear definitions of terms like "worker" and "employer" and provides provisions for trade union registration and recognition. The code also outlines the framework for preventing and resolving industrial disputes through negotiation, conciliation, and arbitration. It mandates the formulation of uniform model standing orders that specify terms and conditions of employment for different categories of workers. The code recognizes fixed-term employment and provides guidelines for engagement of workers on fixed-term contracts. It also outlines procedures for retrenchment and closure of industrial establishments, requires employers to provide notice and compensation to affected workers, and revises the formula for calculating retrenchment compensation. The code also emphasizes occupational safety and health, emphasizing employers' responsibility to provide a safe and healthy working environment.
27	**The Minimum Wages Act, 1948**	The Minimum Wages Act, 1948 is a labor legislation in India that aims to ensure fair wages for workers and prevent exploitation by setting minimum wage rates. The act defines minimum wage as the minimum amount of remuneration an employer must pay a worker for work performed during a specified period, which cannot be lower than the prescribed minimum wage rate. The act empowers both Central and State governments to fix and revise minimum wages for various scheduled employments within their jurisdictions, considering factors such as work nature, skill required, geographical location, and cost of living. The act also provides provisions for fixing hours of work and paying overtime wages for work performed beyond these hours. The act specifies the responsibilities of employers to pay minimum wages and outlines penalties for non-compliance, including fines and imprisonment. The government can appoint inspectors to ensure employers comply with minimum wage provisions, conduct inquiries, examine records, and take necessary actions to enforce the act. Workers can file complaints or claims if they believe they are not receiving the prescribed minimum wages, and the act provides for periodic revisions to account for changes in the cost of living and other relevant factors.
28	**The Noise Pollution (Regulation and Control) Rules, 2000;**	The increasing ambient noise levels in public places, resulting from industrial activity, construction, and mechanical devices, have detrimental effects on human health and psychological well-being. To maintain ambient air quality standards, the Central Government has established the Noise Pollution (Regulation and Control) Rules, 2000, which define various areas and zones, including industrial, commercial, residential, and silence areas. The State Government is responsible for addressing noise pollution, including vehicular movements, and development authorities, local bodies, and other concerned authorities must consider all aspects of noise pollution as a parameter of quality of life. Silence areas around hospitals, educational institutions, and courts may be declared as such. The authority enforces noise pollution control measures and ensures compliance with ambient air quality standards. Restrictions on loud speakers and public address systems are in place, with the State Government permitting them during night hours or during cultural, religious, or festive occasions of a limited duration not exceeding fifteen days in a calendar year. Violations in silence zones result in penalties for those who play music, use sound amplifiers, beat drums, blow horns, exhibit performances, burst sound-emitting fire crackers, or use loud speakers or public address systems.
29	**Payment of Gratuity Act, 1972**	The Payment of Gratuity Act, 1972 is an Indian labor law that governs the payment of gratuity to employees who have completed a certain period of continuous service with an employer. The act covers both private and public sectors and is applicable to establishments with ten or more employees. Eligibility criteria for gratuity include completing a minimum of five years of continuous service with the same employer. The gratuity amount is calculated using a formula, which is 15 days' wages for each completed year of service, subject to a maximum limit set by the government. Employers are required to pay the gratuity amount within 30 days of its payable date. Employees can nominate a beneficiary to receive the gratuity amount in case of their death. Termination conditions include superannuation, retirement, resignation, death, or disability. In

		certain cases, gratuity can be forfeited. If an employer denies an eligible employee their gratuity, the employee has the right to seek redressal through an authority established by the act. Non-compliance with the act can result in penalties, including fines and imprisonment. The Act plays a crucial role in providing financial security to employees who have served an organization for a significant period.
30	**THE PAYMENT OF WAGES ACT, 1936**	The Payment of Wages Act, 1936 is an Indian labor law that regulates the payment of wages to workers in various industries and sectors. Its primary objective is to ensure timely and accurate wages, prevent unfair deductions, and promote a fair payment system. The act applies to all industries and establishments, covering both organized and unorganized sectors. It prescribes a regular wage period, allowing workers to pay wages through various methods, including cash, check, or electronic means. The act regulates deductions from wages, restricting permissible deductions and prohibiting delayed payments. Wages must be paid on a working day and during working hours, ensuring employees have a reasonable opportunity to receive their payments. Employers are required to maintain accurate records of wages, deductions, and related information. The act establishes a mechanism for settling wage-related disputes, with the government appointing a labor commissioner to hear and decide. Penalties for employers who fail to pay wages include fines and imprisonment. Employers are held liable for ensuring wages are paid correctly and on time, and non-compliance may lead to legal consequences.
31	**The Fatal Accidents Act, 1855**	The Fatal Accidents Act, 1855, is an Act in India that provides compensation to families for loss caused by a person's death due to an actionable wrong. The act aims to hold the wrongdoer liable for damages for the injury caused by their actions, even if death had not occurred. The suit for compensation is for the benefit of the deceased's family, including the wife, husband, parent, and child. The suit is brought by the executor, administrator, or representative of the deceased, and the court may award proportionate damages to the loss resulting from the death. The amount recovered, after deducting all costs and expenses, is divided among the parties. There is a limit to one action or suit for the same subject matter of complaint, and a claim for loss of estate may be added. The executor, nominee, or representative of the deceased may insert a claim for and recover any pecuniary loss to the deceased's estate, which when recovered, will be deemed part of the deceased's assets. The plaintiff must provide a full particular of the person or persons for whom or on whose behalf the suit is brought and the nature of the claim in respect of which damages shall be sought.
32	**THE INDUSTRIAL DISPUTES ACT, 1947**	The Industrial Disputes Act, 1947 is a significant labor legislation in India that aims to prevent and resolve industrial disputes between employers and workers. The act covers various issues related to labor management, employment conditions, and dispute resolution in industries. Key provisions include the definition of an industrial dispute, establishment of works committees, appointment of conciliation officers, establishment of boards of conciliation, appointment of courts of inquiry, reference to labor courts and tribunals, prohibition of retrenchment, layoff and closure rules, regulations for strikes and lockouts, penalties for violations, and recognition of trade unions' role in representing workers' interests. The act also prohibits employers from retrenching workers without prior permission from the appropriate government authority. The act also establishes rules for temporary and permanent work suspension and closure, and penalties for violations. Trade unions are recognized as a means of representing workers' interests and allowing for dispute resolution through collective bargaining. The Industrial Disputes Act, 1947 promotes industrial harmony and stability, regulating labor relations and protecting workers' rights.
33	**THE INTER-STATE MIGRANT WORKMEN (REGULATION OF EMPLOYMENT AND CONDITIONS OF SERVICE)**	The Inter-State Migrant Workmen (Regulation of Employment and Conditions of Service) Act, 1979, was enacted by Parliament in the Thirteenth Year of the Republic of India to regulate the employment of inter-state migrant workers and provide their conditions of service. The Act applies to every establishment where five or more inter-state migrant workmen are employed or who were employed on any day of the preceding twelve months. The term "inter-state migrant workman" refers to any person recruited by or through a

	ACT, 1979	contractor in one state under an agreement or other arrangement for employment in an establishment in another state. The Act prohibits the employment of inter-state migrant workers without registration in establishments. If an application for registration is not received within a month, the registering officer must register the establishment and issue a certificate of registration within fifteen days. If the registration is deemed useless or ineffective, the registering officer may revoke it with the principal employer's approval. Contractors cannot recruit individuals in a state for employment in another state without a license issued by the appropriate government. Licenses may contain conditions, including terms, remuneration, hours of work, and wages. Contractors are responsible for providing information to the specified authority in the state from which an inter-state migrant workman is recruited and employed. Wages payable to an inter-state migrant workman must be paid in cash, and a displacement allowance equal to fifty percent of the monthly wages payable at the time of recruitment is payable. The Industrial Disputes Act, 1947 allows for the referral of industrial disputes related to inter-state migrant workers to authorities in the state where the worker is employed. The Central Government has the power to exempt certain establishments or contractors from the Act's provisions and can give directions to the state government on its implementation. The Central Government has the power to make rules for the purposes of this Act, including registration, grant, renewal, investigation, license conditions, appeals, wage rates, and conditions of service for inter-state migrant workers. These rules must be laid before each House of Parliament for thirty days.
34	**The Payment of Bonus Act, 1965**	The Payment of Bonus Act, 1965 is a crucial labour legislation in India that regulates the payment of bonuses to eligible employees in certain establishments. The act aims to provide financial incentives to employees and promote industrial peace by rewarding their contributions to the success of the establishment. Eligible employees are defined by the act, and the bonus is calculated as a percentage of the employee's annual salary or wages, subject to a maximum limit. Bonuses are typically paid annually within eight months from the close of the financial year. Disqualifications may apply to certain categories of employees, such as those in managerial or administrative positions or those dismissed for misconduct. The act allows for set-offs and deductions, including those related to losses incurred by the establishment and certain statutory payments. Employers are required to maintain accurate records and submit annual returns to the appropriate government authority. Bonus payments must be made in cash, and non-compliance can lead to penalties, fines, and legal consequences for employers. The act sets a maximum limit on the bonus calculation, which is determined by the government and may change over time. Advisory committees are established to facilitate communication between employers and employees on bonus-related matters. Disputes related to bonus payments can be referred to the appropriate government authority or labour court for resolution.
35	**The Public Liability Insurance Act, 1991**	The Public Liability Insurance Act, 1991 is a crucial legislation in India that mandates the insurance of industrial units handling hazardous substances. The act aims to provide immediate relief to those affected by accidents involving hazardous substances. The act applies to units handling hazardous substances and requires them to take out insurance policies to cover their liability. In case of an accident resulting in death, bodily injury, or property damage, the owner or occupier must notify the appropriate authorities and the insurance company promptly. The owner or occupier is liable for any death, injury, or property damage resulting from an accident. The act mandates that every owner or occupier of an industrial unit handling hazardous substances must take out an insurance policy covering their liability, obtained from an insurer approved by the government. The act also establishes the "Environmental Relief Fund" to provide immediate relief to victims of accidents involving hazardous substances. The act empowers the government to appoint authorities responsible for overseeing and implementing the provisions of the act, including assessing and disbursing relief and ensuring compliance with insurance requirements. Penalties and offenses are prescribed for non-compliance, including fines and imprisonment.

		The Act promotes environmental safety and accountability in the industrial sector by ensuring that industrial units handling hazardous substances are financially responsible for any accidents and providing immediate relief to affected persons.
36	**The Sexual Harassment of Women at Workplace (Prevention, Prohibition, and Redressal) Act, 2013**	The Sexual Harassment of Women at Workplace (Prevention, Prohibition, and Redressal) Act, 2013 is an Indian law aimed at protecting women from sexual harassment at work. The Act defines "aggrieved woman" as any woman of any age, "appropriate government" as a workplace established, owned, controlled, or financed by funds provided by the Central Government, the State Government, or any workplace not covered under sub-clauses, and "employee" as a person employed at a workplace for regular, temporary, ad hoc, or daily wage basis. Sexual harassment in the workplace is prohibited, and any instances of such harassment can be considered sexual harassment. The Internal Complaints Committee, formed by employers, handles complaints and can hold proceedings for up to three years. The Local Committee, constituted by district officers, receives complaints and forwards them to the concerned committee within seven days. The Central Government can grant funds to the State Government for the payment of fees or allowances under sub-section (4) of section 7. A woman can file a complaint of sexual harassment within three months of the incident, and her legal heir can file a complaint. The Internal Committee or Local Committee can settle the matter through conciliation, recording the settlement and forwarding it to the employer or District Officer. The inquiry into the complaint must be completed within 90 days, and during the pendency of the inquiry, the Committee may recommend actions such as transferring the woman or respondent to another workplace, granting leave, or providing other relief. The Sexual Harassment of Women at Workplace Act (SHARPA) requires employers to provide a safe working environment, display the consequences of sexual harassment, organize workshops and awareness programs, and provide necessary facilities for dealing with complaints and conducting inquiries. Employers who fail to comply with the Act may face a fine of up to fifty thousand rupees, and if convicted of an offense punishable under the Act, they may face double the punishment as a first conviction.
37	**The Water (Prevention and Control of Pollution) Cess Act, 1977**	The Water (Prevention and Control of Pollution) Cess Act, 1977 is a law in India that imposes a cess on water consumed by individuals and local authorities involved in certain industries. It applies to all states and Union territories except Jammu and Kashmir and comes into force on a date specified by the Central Government through notification in the Official Gazette. The act defines "local authority" as a municipal corporation, council, cantonment board, or other body responsible for supplying water under the law. The act also requires the affixing of meters for measuring and recording water consumption. If a person or local authority fails to comply with any provisions of the Water (Prevention and Control of Pollution) Act, 1974 or any of the standards laid down by the Central Government under the Environment (Protection) Act, 1986, the cess will be calculated and payable at a rate specified by the Central Government. The Water (Prevention and Control of Pollution) Act, 1974 provides for the installation of plants for sewage or trade effluent treatment. If a person or local authority is liable to pay cess, they are entitled to a rebate of 25% of the cess payable from a prescribed date. However, they cannot be entitled to any rebate if they consume water exceeding the maximum quantity or fail to comply with provisions of the Act. The proceeds of cess levied under Section 3 are first credited to the Consolidated Fund of India, and the Central Government may pay to the Central Board and every State Board from time to time, after deducting expenses on collection. If a person or local authority fails to pay any amount of cess payable under Section 3 to the State Government within the specified date, they are liable to pay 4 interest at a rate of 2% for every month or part of a month comprised in the period from the date on which such payment is due till such amount is actually paid. The Central Government has the power to exempt industries from the levy of water cess by notification in the Official Gazette, based on factors such as the nature of the raw material used, manufacturing process, effluent generated, source of water extraction, effluent-receiving bodies, and production data. Rules for carrying out the purposes of this Act must be laid before each House of Parliament for

		thirty days, and any modification or annulment will not affect the validity of anything previously done under the rule.
38	**THE EXPLOSIVES ACT, 1884**	The Explosives Act, 1884 is a significant Indian legislation that regulates the manufacture, storage, possession, use, sale, and transport of explosives. Its primary purpose is to ensure safety and prevent accidents related to explosives, which can pose serious risks to human life and property. The act applies to all explosives, including those used for blasting, fireworks, and other industrial, scientific, or military purposes. It requires individuals and entities involved in the manufacture, storage, sale, or transport of explosives to obtain licenses and permissions from the appropriate government authorities. The act empowers the government to make rules and regulations for the manufacture, storage, sale, and transport of explosives, covering safety standards, storage conditions, labeling, and transportation procedures. It specifies certain explosives that are prohibited for civilian use, except under special circumstances and with specific permissions. The act provides guidelines for safe storage and handling of explosives, including the construction and maintenance of magazines and the qualifications of persons handling explosives. The act also prescribes penalties, fines, and imprisonment for violations of its provisions, including unauthorized possession, use, or sale of explosives. Government authorities are empowered to inspect facilities and enforce compliance with the act's provisions. The act allows for the seizure and forfeiture of unlawfully possessed or used explosives. Legal immunity is provided to government officials and employees acting in good faith in their duties under the act.
39	**MATERNITY BENEFIT ACT, 1961**	The Maternity Benefit Act, 1961 is a crucial Indian legislation that provides maternity benefits and safeguards to women employees during pregnancy and childbirth. The act ensures the health and employment rights of women workers by ensuring they have access to maternity leave and benefits. The act applies to all establishments with ten or more employees, and women must have worked in the establishment for at least 80 days in the twelve months preceding their expected delivery date. Maternity leave is granted to women for a maximum of 26 weeks, with a maximum of 12 weeks for women with two or more surviving children. During maternity leave, women are entitled to full wages or salary, and employers must ensure payment is made as usual. A medical bonus is mandated for women who do not receive antenatal care under the Employee State Insurance (ESI) scheme, covering medical care expenses. Employers are prohibited from terminating or dismissing a woman employee during maternity leave, which is considered unlawful. Returning from maternity leave, women are entitled to return to the same position they held before taking maternity leave or to a similar position with equivalent pay and benefits. Employees must give their employer notice of their pregnancy and the date they intend to start their maternity leave. Government authorities are empowered to inspect establishments for compliance with the act's provisions, and non-compliance can result in penalties for employers. The Maternity Benefit Act, 1961 is a significant piece of legislation that addresses the unique needs and challenges faced by women employees during pregnancy and childbirth, promoting gender equality and protecting women's rights in the workforce.
TRANSPORTATION		
1	**National Urban Transport Policy, 2014**	The National Urban Transport Policy (NUTP) of 2014 is a comprehensive framework for improving urban transportation systems in India. It emphasizes integrated planning, infrastructure development, public transit, non-motorized transport, traffic management, environmental sustainability, and accessibility for all segments of society. The policy aims to address urbanization challenges such as congestion, pollution, road safety, and inadequate transportation infrastructure. It also aims to improve the quality of life for urban

		residents by reducing travel times, improving accessibility, and mitigating environmental impacts. The NUTP's focus on infrastructure development and traffic management contributes to economic growth and competitiveness. It also promotes public health by encouraging the use of public transit and non-motorized transport modes, reducing air pollution, noise pollution, and road accidents. Furthermore, the policy fosters sustainability by reducing energy consumption, minimizing carbon emissions, and conserving natural resources.
2	The Motor Vehicles Act, 1988	The Motor Vehicles Act, 1988 is a comprehensive legislation in India that regulates the use of motor vehicles on public roads and ensures road safety. It sets requirements for obtaining driving licenses, mandates registration of motor vehicles, establishes traffic rules and regulations, emphasizes road safety measures, mandates third-party insurance coverage for vehicles, outlines procedures for reporting accidents, and provides compensation to victims and their families. Penalties and offenses are stipulated for various offenses, including overspeeding, drunken driving, driving without a valid license, and violating traffic rules. The act also regulates transport vehicles, including commercial vehicles, taxis, buses, and goods carriers. The National and State Transport Authority is established to regulate and coordinate motor vehicle operations. The act mandates adherence to pollution control norms and emissions standards, including emission testing and pollution control certificates. The government can issue orders for the recall of motor vehicles if a defect poses a threat to safety. Penalties for offenses related to motor vehicle violations range from fines to imprisonment. The Act has been amended multiple times to address evolving challenges in transportation and road safety.
3	**THE CARRIERS ACT, 1865**	The Carriers Act 1865 laid down the rights and liabilities of the Common Carrier, limiting their liability for loss or damage to goods. However, the transport scenario has changed significantly since its enactment, with various modes of transport now having separate enactments, and the liability specified in the existing Act becoming inadequate and irrelevant. The Carriers Act 1865 was repealed and replaced by a new Act to cater to the current requirements of transport, trade and commerce. The committee recommended repeal and re-enactment to regulate and limit the liability of Common Carriers, provide for registration of Common Carriers, ensure proper statistical reporting, regulate carriage of hazardous and dangerous goods, and provide for rule making powers. The Carriage by Road Act 2007 defines a Common Carrier as a person other than the government engaged in the business of transporting goods or people from place to place on hired basis by motorized transport on road for all persons indiscriminately. The liability of the Common Carrier for loss or damage to any consignment is limited to such amount as may be prescribed having regard to the value, freight and nature of goods, documents or articles of the consignment. For delay beyond the period agreed upon in the goods forwarding note, compensation is payable in accordance with the value, freight and nature of goods, documents or articles of the consignment or as may be specified in accordance with the terms of higher risk rate. Common carriers are responsible for the loss, destruction, damage, deterioration or non-delivery of any consignment entrusted to them, except for acts of God, war, civil commotion, arrest, restraint or seizure.
4	The Motor Transport Workers Act, 1961	The Motor Transport Workers Act, 1961 is an Indian legislation aimed at improving the working conditions and welfare of motor transport workers. It addresses various aspects of employment in the motor transport sector and protects workers' rights. The act applies to motor transport undertakings involved in carrying passengers or goods by road for hire or reward. Key features of the act include definitions for terms such as motor transport undertaking, worker, and employer, registration of motor transport undertakings, appointment of authorities, working hours, overtime, leave entitlement, health and safety measures, welfare facilities, conditions of service, appeals, and penalties for violations. The act provides definitions for terms such as motor transport undertaking, worker, employer, and more, and mandates registration with government authorities. It also outlines provisions for overtime work, leave

		entitlement, health and safety measures, welfare facilities, conditions of service, appeals, and penalties for violations. Employers who fail to comply with the act may face fines and other consequences.
5	Freight Corridor Policies	The Dedicated Freight Corridor (DFC) project in India aims to revolutionize the country's freight transportation system by creating exclusive corridors for freight trains, separate from the passenger train network. The project gained momentum with the establishment of the Dedicated Freight Corridor Corporation of India Limited (DFCCIL) in 2006. The DFC consists of two main corridors: the Eastern Dedicated Freight Corridor (EDFC) and the Western Dedicated Freight Corridor (WDFC). The EDFC spans 1,856 kilometers and the WDFC, 1,504 kilometers, spans 1,504. The project has demonstrated progress in infrastructure development, technology integration, and public-private partnerships. Once fully operational, the DFC is expected to significantly enhance India's freight transportation network, benefiting industries, businesses, and the economy. The Freight Corridor Policy in India outlines the government's vision, objectives, and strategies for efficient and sustainable management of freight transportation infrastructure, emphasizing the integration of advanced technologies, multimodal connectivity, environmental sustainability, and public-private partnerships. The DFC project is a monumental endeavor aimed at transforming India's freight transportation landscape and contributing significantly to its growth and development.
6	**National Water Policy, 2023**	The National Water Policy 2012 and 2023 emphasize the importance of water conservation, efficient use, and sustainable water management practices to address water scarcity and depletion. The 2012 policy promoted Integrated Water Resource Management (IWRM) to ensure optimal utilization of water resources while considering ecological, social, and economic aspects. The 2023 policy emphasizes demand management, a holistic approach to water management, institutional reforms, green infrastructure, decentralized water management, inclusive and equitable access, water quality management, and resilience to climate change. The National Water Policy can indirectly influence freight transport through its impact on water infrastructure development, intermodal connectivity, and overall logistics efficiency. The policy may prioritize the development and maintenance of waterways for navigation, promote inland water transport (IWT), and integrate water transport with other modes of transport to create seamless multimodal logistics corridors. Water transport can reduce transportation costs, alleviate congestion, support economic development, and promote environmental benefits. By promoting the use of waterways, the policy can help reduce the environmental footprint of freight transport and promote sustainable logistics practices. Additionally, the policy can support economic development in regions with access to navigable water bodies, stimulate trade, industrial growth, and job creation, contributing to regional and national economic prosperity. Overall, the National Water Policy of 2023 reflects evolving priorities, emerging challenges, and advancements in water resource management approaches.
7	**THE NATIONAL HIGHWAYS ACT, 1956**	The National Highways Act, 1956, is an Act enacted by Parliament in the Seventh Year of the Republic of India to declare certain highways as national highways and related matters. It grants the Central Government the power to acquire land, make inspections, surveys, and inquires. It allows for objections within 21 days of publication and declares the land free from all encumbrances upon publication. The land vests in the Central Government free from all encumbrances upon publication. The competent authority may direct the owner or other person in possession of the land to surrender or deliver it within sixty days of the notice. If a person refuses or fails to comply, the competent authority may apply to the Commissioner of Police or the Collector of a District. The Central Government may enter land for national highway construction or other work, determining the amount payable as compensation for land acquisitions and user rights. The competent authority must give a public notice in two local newspapers inviting claims from interested parties, and if the amount is not acceptable, an arbitrator appointed by the Central Government can determine it.

		The amount determined under Section 3G must be deposited before taking possession of the land. National highways vest in the Union, including all lands, bridges, culverts, tunnels, causeways, carriageways, and structures. The Central Government is responsible for developing and maintaining national highways, but may direct functions to be exercisable by the State or subordinate authorities. The Central Government can issue directions to the State government on the implementation of the Act or any rules, notifications, or orders. Fees for services or benefits rendered on national highways may be levied by the Central Government, and those who commit mischief by injury to national highways may face imprisonment, fines, or both. Rules for carrying out the purposes of this Act may provide for the deposit of funds, fees, inspections, reports, and other provisions.
8	**THE INLAND VESSELS ACT, 2021**	The Inland Vessels Bill, 2021 was passed by Parliament today to replace the Inland Vessels Act, 1917 (1 of 1917) and usher in a new era in the inland water transport sector. It will ensure seamless, safe and economical trade and transportation by inland vessels using the inland waterways. The new Act will be adaptive and favourable for future technological developments, capable of facilitating present and future prospects of trade and transportation and safe navigation by inland vessels. Benefits include uniform applicability of rules and regulations to ensure seamless, safe and economical trade and transportation. The proposed legislation outlines standards for classification and categorization of mechanically propelled vessels, registration of vessels, identification and categorization of special category vessels, and the implementation of the provisions by State Governments. It also provides for a Central Data Base/E-Portal for registration/crew database, higher standards to ensure safety, technological advancements in vessel construction and usage, provisions regarding wreck and salvage, principles of liability and limitation of liability, casualties and investigation, ease of compliance for service providers and service users, and a platform for the State Governments to regulate the unregulated sector of non-mechanically propelled vessels.
9	**THE INLAND WATERWAYS AUTHORITY OF INDIA ACT, 1985**	This Act provides for the constitution of an Authority for the regulation and development of inland waterways for shipping and navigation. It defines "appurtenant land" as all lands appurtenant to a national waterway, "Authority" as the Inland Waterways Authority of India, "channel" as any waterway, "conservancy" as dredging, training, closure, diversion or abandoning channels, "conservancy measures" as measures for purposes of conservancy, and "infrastructure" as structures such as docks, wharves, jetties, landing stages, locks, buoys, inland ports, cargo handling equipment, road and rail access and cargo storage spaces. Compulsory acquisition of land for the Authority is allowed under the Land Acquisition Act, 1894 or any other corresponding law. This Act applies to the Indian Ports Act, 1908 (15 of 1908) and the Major Port Trusts Act, 1963 (38 of 1963). It does not affect the jurisdiction, functions, powers or duties of the Conservator of any port or the Board of Trustees for any major port. It also does not affect the operation of the Inland Vessels Act, 1917 (1 of 1917) or any other Central Act or State or provincial Act with respect to shipping and navigation on any national waterway. The Authority may delegate certain of its powers and functions under this Act, including the powers under section 35. Authentication of orders and other instruments of the Authority must be done by the Chairman or any other member authorised by the Authority in this behalf. Members, officers and employees of the Authority must be public servants within the meaning of section 21 of the Indian Penal Code. Protection of action taken in good faith is also protected. The Central Government has the power to supersede the Authority if it is unable to discharge its functions or if it has made a default and the financial position of the Authority or the administration of any national waterway has deteriorated. Before issuing a notification, the Central Government must give the Authority a reasonable opportunity to show cause why it should not be superseded.
10	**Multimodal Transportation of Goods Act, 1993**	The multimodal transport document is a document that governs the transport of goods between India and outside India, involving multiple modes of transport. It confers rights, obligations, and defenses on parties involved, including the Multimodal Transport

		Operator, who undertakes to perform the transport, accepts responsibility for agents' actions, and assumes liability for loss or damage. The document grants negotiating rights to the goods, and the holder is entitled to receive or transfer the goods. Reservations are made if the document contains inaccuracies or lacks reasonable means of checking. The consignor guarantees the accuracy of particulars about the goods' nature, marks, number, weight, and dangerous character for inclusion in the document. The consignor indemnifies the Multimodal Transport Operator against loss resulting from inaccuracies or inadequacies of the particulars. Dangerous goods must be labeled appropriately and handed over to the operator. The Multimodal Transport Operator is liable for loss resulting from loss or damage to goods, delay in delivery, and consequential loss or damage arising from such delay if the occurrence that caused the loss took place while the goods were in their charge. The liability for loss or damage when the stage of transport where the loss or damage occurred is not known is calculated by reference to the value of the goods at the place and time they are delivered to the consignee or at the place and time when, in accordance with the contract of multimodal transport, they should have been delivered. The Multimodal Transport Operator's liability for loss resulting from delivery delay is limited to the freight payable for the goods delayed, but not exceeding the total freight payable under the Multimodal Transport Contract. The limits of liability do not apply if the loss, damage, or delay resulted from an act or omission of the Multimodal Transport Operator, servants, agents, or other persons using their services for the performance of the Multimodal Transport Contract. If the goods are not taken delivery within a reasonable time, the Multimodal Transport Operator may place them in safe custody or place them at the consignee's risk and expense.
11	**Fast Tracking Freight In India A Roadmap For Clean And Cost-Ffective Goods Transport Niti Aayog, Rmi, And Rmi India, June 2021**	India has been the world's fastest-growing major economy for four of the past five years due to rising demand for goods and services. The logistics sector represents 5% of GDP and employs 2.2 crore people. India handles 4.6 billion tonnes of goods each year, amounting to a total annual cost of INR 9.5 lakh crore. The GOI is pursuing a range of actions to improve its logistics performance, such as developing dedicated rail-based freight corridors, improving capacity and connectivity of coastal and inland water-based shipping, building out road infrastructure projects, and creating supportive policies.
12	**THE CARRIAGE BY AIR ACT, 1972**	The Carriage by Air Act was passed in 1972 and enforced in 1973. It aims to apply the Warsaw Convention for the amalgamation of laws relating to International Carriage by Air, which covers all or any carriage. It extends to the whole of India and is highlighted in the preamble. The Carriage by Air Act, 1972 is the domestic legislation governing air carriage and contains the three international air conventions India is a member of. It contains three Schedules and an Annexure, and provides essential standards, increased compensation in cases of death or wounding, and checks on air carriers. It also introduces "fifth jurisdiction" with respect to the right to sue successive or the actual carrier. Section 5 of the Carriage Act states that notwithstanding any other law applied in India, the various Schedules will be applied for ascertaining the liability of the air carrier. It also excludes the application of other laws in instances of wounding, death, or loss and damage of unchecked and checked baggage. Additionally, Section 6 and 6 A highlight the change of the sum (Francs or SDR) into Indian rupees at the prevailing exchange rate on the date on which the sum is to be paid.
13	**THE CARRIAGE BY ROAD ACT, 2007**	The Act provides for the regulation of common carriers, limiting their liability and declaration of the value of goods delivered to them to determine their liability for loss of, or damage to, such goods occasioned by the negligence or criminal acts of themselves, their servants or agents and for matters connected therewith or incidental thereto.

14	**PORT OF CHENNAI (RESPONSIBILITY FOR GOODS) REGULATIONS, 1975**	The Central Government has made the Port of Chennai (Responsibility for Goods) Regulations, 1975 to exercise the powers conferred by section 126, read with section 42 and 43, of the Major Port Trusts Act, 1963. The regulations come into force on the date of their publication in the Official Gazette and apply to the Port Trust of Chennai. The definitions in the regulations are as follows: "Act" means the Major Port Trusts Act, 1963, "Port" means the Port of Chennai, and "Section" means a section of the Act. The form of receipt referred to in subsection (2) of section 42 shall be given in the form annexed to the Regulations. The period of responsibility and the period of notice under section 43 are as follows: No responsibility shall attach to the Board after a period of seven clear working days from the date of taking charge of the goods, and the notice of loss or damage to the goods shall be given within a period of seven clear working days from the date of taking charge of the goods.
15	**The Control Of National Highways (Land And Traffic) Act, 2002**	An Act to provide for control of land within the National Highways, right of way and traffic moving on the National Highways and also for removal of unauthorized occupation thereon.
16	**Battery Powered Vehicles, 2022**	The Government launched the FAME India Scheme in 2015 to promote electric and battery eco-friendly vehicles. Phase-II of the scheme is being implemented for five years with a budget of Rs. 10,000 crores. The Ministry of Road Transport & Highways has taken steps to promote electric mobility in the country, such as notifying GSR 167(E) for conversion, exempting Battery Operated Transport Vehicles from permit requirements, notifying the registration mark for Battery Operated Transport Vehicles, and exempting Battery Operated Vehicles from payment of fees. The Government of India has issued advisory to all States and Union Territories regarding incentivization of electric vehicles, sale and registration of electric vehicles without batteries, and promotion of battery operated vehicles. The upfront cost of battery-operated vehicles is higher than conventional vehicles, but the operational cost is lower. To facilitate the establishment of Charging Infrastructure for Electric Vehicles, the Ministry of Heavy Industries (MHI) has launched Phase-II of FAME India Scheme, which provides for INR 1000 Crores for installation of Charging Infrastructure for Electric Vehicles.
17	**Emission standards for Construction Equipment vehicles 2017**	Diesel driven agricultural tractor, power tiller, construction equipment and combine harvester must comply with standards of gaseous pollutants when tested on duty cycle. Test procedure must be as per AIS: 137. The sampling size must be one day average production, fuel must be reference fuel or commercial fuel, NOx control measures must be correct, vehicles must meet conformity requirements, and emission sampled must not exceed 100 percent limit values.
18	**THE INDIAN CARRIAGE OF GOODS BY SEA ACT, 1925**	The Indian Carriage of Goods by Sea Act was enacted on 21st September 1925 and covers various definitions such as "carrier, contract of carriage, carriage of goods, goods, and ship". At the start of the journey, the carrier is bound to take proper care and diligence, such as making the ship safe to go at sea, properly equipping the ship, and seeing whether the refrigeration and other cooling parts in the ship are proper and in good working condition. After the ship is loaded, the shipper can ask for a bill of lading, which will show weight, quantity, pieces of goods, necessary marks, time that the ship will reach the destination, and insurance coverage for any loss or damages. The ship or carrier is not responsible for any loss caused by the sea, acts of god, acts of war, riots, civil disturbances, segregated restriction acts of public enemies, saving or trying to save the life of property at sea, insufficiency in packing, insufficiency or not exact marking on goods, latent defects not discoverable by due diligence, or if there is any fire caught on the ship or carrier. The shipper or carrier is also not responsible for any act or mistake done by their servant or agent. The main purpose of lading the bill is to ensure that the rules mentioned in the act will bring uniformity and stability.
19	**THE INDIAN RAILWAY BOARD**	The Indian Railway Board Act, 1905 is an Act to provide for investing the Railway Board with certain powers or functions under the Indian Railways Act, 1890 (9 of 1890). The Central Government may invest the Railway Board with all or any of the powers or

	ACT, 1905 **ACT NO. 4 OF 1905.**	functions of the Central Government under the Indian Railways Act, 1890 (9 of 1890), with respect to all or any railways, and with the power of the officer referred to in section 47 of the Act to make general rules for railways administered by the Government. Any notice, determination, direction, requisition, appointment, expression of opinion, approval or sanction, to be given or signified on the part of the Railway Board, shall be sufficient and binding if in writing signed by the Secretary to the Railway Board.
20	**THE LAND PORTS AUTHORITY OF INDIA ACT, 2010**	The Authority has the power to develop, sanitize and manage facilities for cross border movement of passengers and goods at designated points along the international borders of India. It can plan, construct and maintain roads, terminals and ancillary buildings, plan, procure and install communication, security, goods handling and scanning equipment, provide space and facilities for immigration, customs, security, taxation authorities, animal and plant quarantine, warehouses, cargo and baggage examination yards, parking zones, banks, post offices, communication facilities, tourist information centres, waiting halls, canteen, refreshment stalls, public conveniences, health services and such other services as may be deemed necessary, construct residential buildings for its employees, establish and maintain hotels, restaurants and restrooms, establish and maintain warehouses, container depots and cargo complexes, arrange for postal, money exchange, insurance and telephone facilities, make appropriate arrangements for the security of integrated check posts, ensure prevention and control of fire and other hazards, regulate and control the movement of vehicles, and co-ordinate and facilitate the working of agencies engaged to undertake various activities at the integrated check posts. The Authority must form companies, take necessary steps, set up joint ventures, and undertake other activities at the integrated check post in the best commercial interests of the Authority. It must consult the Government of India or State Government and consider the development of land port services and the efficiency, economy and safety of such service. The Land Ports Authority of India (LPAI) is a statutory organisation that reports to the Ministry of Home Affairs. It was established under the Land Ports Authority of India Act of 2010. LPAI is in charge of developing, maintaining, and managing border infrastructure in India. The Land Port Authority (LPA) recently celebrated its tenth anniversary. India's land borders with Afghanistan, China, Nepal, Bhutan, Bangladesh, Myanmar, and Pakistan total 15,000 km.
21	**Methanol Economy for India, 2017**	Methanol is a renewable fuel that can be used in India at a cost of 19 Rs. A litre, at least 30% cheaper than any available fuel. It can reduce diesel consumption by at least 20% in the next 5-7 years and save Rs. 6000 Crores annually from reduced LPG bills. The Methanol blending program with Gasoline will further reduce fuel bills by at least 5000 Crores annually in the next 3 years. Coal and Stranded Gas linkages are import policy initiatives to be taken. The final roadmap for 'Methanol Economy' is targeting an annual reduction of 100 Billion $ by 2030 in crude imports. A cabinet note on Methanol in Inland Waterways and Marine Sector and overall adaptation of 'Methanol Economy' will be moved shortly.
22	**THE MAJOR PORT AUTHORITIES ACT, 2021**	An Act to provide for regulation, operation and planning of Major Ports in India and to vest the administration, control and management of such ports upon the Boards of Major Port Authorities and for matters connected therewith or incidental thereto.
23	**THE MAJOR PORT TRUSTS ACT, 1963**	An Act to make provision for the constitution of port authorities for certain major ports in India and to vest the administration, control and management of such ports in such authorities and for matters connected therewith. The most important details in this text are that if a company commits an offence under this Act, every person who was in charge of and responsible to the company for the conduct of business of the company, as well as the company, shall be deemed to be guilty of the offence and liable to be punished accordingly. Additionally, if the offence was committed with the consent or connivance of, or if the commission of the offence is attributable to any negligence on the part of, any director, manager, secretary or other officer of the

		company shall also be deemed to be guilty of the offence and liable to be punished accordingly. The Central Government can supersede the Authority if it is unable to perform its duties or has exceeded or abused its powers. Upon publication of the notification, the Chairperson and Members of the Authority must vacate their offices and all the powers and duties of the Authority must be exercised and performed by the Central Government. On expiration of the period of supersession, the Central Government can extend it or reconstitute the Authority as provided in section 47A.
24	**Mormugao Port Trust (Handling of freight containers containing Dangerous/Hazardous Cargo) Regulations, 1988**	All dangerous/hazardous cargo entering the Port area must be classified, packaged, labelled and/or marked in accordance with the IMO Code and be declared by the ship/shipper accordingly. The container hall also be marked as such and shall be accompanied by a Packing Certificate issued by the Operating Company indicating the contents. (2) Stowage–No ship carrying containers carrying dangerous/hazardous cargo on board shall enter the Port unless the containers are stowed and so documented according Section 12 of IMO Code as applicable.
25	**NATIONAL AIRPORTS AUTHORITY ACT, 1985**	The Directorate-General of Civil Aviation (DGCA) regulates and controls civil aviation activity in the country, focusing on construction and maintenance of domestic airports, procurement and maintenance of navigational aids, and regulatory functions. However, the DGCA's functioning has been difficult due to its constructions being executed by the Central Public Works Department (CPWD), purchases routed through the Department of General Services (DGS), and personnel recruited through the UPSC. To improve efficiency and flexibility, an Experts Committee was set up to recommend setting up a statutory authority for developing domestic airports and air traffic services. The proposed Authority would provide a statutory authority for the development, construction, and management of domestic airports, as well as navigational and tele-communication facilities and air traffic control services at airports in different parts of the country. The proposed Authority would not cause additional financial burdens or liabilities on the Central Government and would have functional advantages. The Act will apply to all aerodromes, civil enclaves, and aeronautical communication stations, except those subject to the International Airports Authority Act, 1971, and aerodromes and airfields controlled by armed forces.
26	**Prevention of Collision on National Waterways Regulations, 2002**	The Prevention of Collusion on National Waterways Regulations, 2002, are issued by the Inland Waterways Authority of India to prevent collisions on national waterways. These regulations apply to all vessels on the National Waterways and require them to adhere to the rules, considering precautions required by seamen and vessel limitations. The risk of collision is determined by factors such as visibility, traffic density, manoeuvrability, river conditions, navigational hazards, shore, navigational aids, channel marking, speed restrictions, draught, and background light. Vessels must navigate narrow channels safely, avoid crossing navigable channels, and navigate with caution near bends or other areas. The regulation applies to vessels within sight of one another, sailing, head-on, and crossing situations. Overtaking is defined as coming up with another vessel from a direction more than 22.5 degrees aft of its beam. Mechanically propelled vessels must alter their course to starboard to pass on the port side of the other. In restricted visibility, vessels must make appropriate sound signals and exhibit lights, proceed at a safe speed, and have due regard for prevailing conditions. The regulations also outline regulations for lights and shapes on vessels, ensuring compliance in all weathers. The Inland Vessels Act, 1917 allows vessels to be exempt from compliance until two years after the regulations take effect, including the installation of lights with color specifications and intensity, repositioning of mast headlights and side lights, and the installation of lights with ranges prescribed in Regulation 22. Appeals can be made within ten days of receiving an order, and the decision of the officer responsible for deciding the appeal will be final.

27	**National waterway, Safety of Navigation and Shipping Regulations, 2002**	The National Waterways, Safety of Navigation, and Shipping Regulations, 2002, are regulations enacted by the Inland Waterways Authority of India to ensure the safety of navigation and shipping on national waterways. These regulations cover various aspects of navigation, including marking navigable channels, traffic signals, passing through bridges, locks, reducing speed, drifting, crossing navigable channels by ferry vessels, and providing navigational and meteorological information. Vessels must be certified of survey and registration, possess a certificate of competency, and bear identification marks on their hulls. They must ensure that their vessels, convoys, and side-by-side formations are suitable and within the limits specified by the Competent Office. Additionally, vessels must prevent objects from projecting beyond their sides, which could pose a danger to other vessels, rafts, floating establishments, or installations on or adjacent to the waterways. The Inland Vessels Act, 1917 outlines rules for mooring and anchoring vessels in ports, requiring vessels to be securely fastened to withstand current and adjust to changes in water level. Pilotage is classified by the Competent Officer, who arranges the positioning of experienced pilots and provides services to vessels in areas where pilotage is declared compulsory. Penalties include failure to regulate speed, drift, safe distance, observing navigational and meteorological information, obtaining endorsement on a Certificate of Survey, maintaining a valid Certificate of Competency, bearing identification marks, complying with waterway limits, causing an object to project beyond the side of the vessel, non-compliance with safety requirements for over-dimensional cargo, anchoring the vessel outside designated areas, improper mooring, observing the river stretch for compulsory pilotage, failing to observe instructions to the master, and failing to observe instructions to the owner. The Act also applies to mechanically propelled vessels making voyages on national waterways.
28	**THE NATIONAL HIGHWAYS AUTHORITY** **OF INDIA ACT, 1988**	The National Highways Authority of India Act, 1988, established an Authority for the development, maintenance, and management of national highways in India. The Authority is a corporate body with perpetual succession, power to acquire, hold, and dispose of property, and can transfer assets and liabilities from the Central Government. It is competent to enter and perform contracts for its functions. The Authority is responsible for surveying, managing, and regulating national highways, providing facilities and amenities, and advising the Central Government on highway development. Additional capital and grants may be provided, and the National Highways Authority of India Fund is constituted to cover expenses. The Authority prepares budgets, invests in Central Government securities, and borrows money from various sources. The Authority can delegate powers and functions under the Act to members, officers, and employees, subject to specific conditions and limitations. Members, officers, and employees are considered public servants under Section 21 of the Indian Penal Code. The Authority can undertake works on behalf of the government or local authority, and can temporarily divest the Authority from national highway management. The Central Government can issue directions on policy questions and make rules for carrying out the Act's provisions, including terms of office, members' powers, non-recurring expenditure, budget preparation, investment, accounts, auditing, and more. The Authority can also make regulations, such as meeting times, service terms, contract forms, and advertisements. If difficulties arise, the Central Government may issue an order inconsistent with the Act, which must be laid before each House of Parliament for thirty days.
29	**Regulations on Cargo & Traffic in Inland Ports on National Waterways (DRAFT-2012)**	The "Regions on Cargo and Traffic in Inland Ports on National Waterways, 2012" apply to all vessels and barges carrying dangerous or non-dangerous cargo berthing and exiting from Inland Ports and Terminals on National Waterways. These regulations are divided into two chapters: (a) Regulations on non-dangerous cargo and traffic on national waterways and (b) Regulations on dangerous cargo, including their transportation, handling, and storage in Inland Ports. Chapter I applies to both types of vessels and barges carrying non-dangerous or dangerous cargo, while Chapter II is exclusive to vessels carrying dangerous cargo. The regulations will be effective from the date they are notified in the Government of India's Gazette. All vessels must moor, unmoor, or anchor in accordance with the Inland Port in charge's orders. Masters and owners of vessels must obey the directions and offer no obstruction. They must ascertain the draught to which their vessel may load and be held liable for any

		damage caused by their vessels or crew to the Authority's works or property. All vessels within the Inland Port premises are at the risk of their master or owners, who are held responsible for any loss or damage arising from faulty navigation or breaking adrift from their anchorage or mooring.
30	**Draft Regulations for TRANSPORT, HANDLING AND STORAGE OF DANGEROUS GOODS in Inland Ports on National Waterways PART I**	The "Transport, Handling, and Storage of Dangerous Goods in Inland Ports Regulations, 2012" are regulations framed under sub-sections 1, 2(g), 2(h), and 2(i) of Section 35 of the IWAI Act, 1985. They come into force on the date of publication after the Central Government's approval. These regulations apply within the limits of all inland ports on national waterways and lands under the control and supervision of an officer appointed by the authority or nominated by the competent authority for the purpose of supervising the handling, storage, and disposal of dangerous goods. The master of vessels carrying dangerous goods must display a red flag and light from sunrise to sunset. They must depute a responsible person to personally supervise operations, take necessary precautions, keep firefighting gear in readiness, and maintain efficient communication with the responsible person on the shore and signal station (IWAI Tower). They must provide and use equipment specified in the EMS Schedule as published by the IMO and MFAG. The owner or agent must make a true and correct declaration of the dangerous goods to be handled in the inland port and those in transit through the inland port, whether in containers or other packages. Cases or receptacles of each class of dangerous goods brought into the port area shall comply strictly with the packaging standard stipulated in the IMDG Code. If any case or receptor of dangerous goods is damaged or starts leaking during handling in the port, preventive measures as indicated by the competent authority shall be followed. Repairs to damaged cases or receptors or repackaging their contents shall be carried out under the supervision of the competent authority, subject to special restrictions as applicable to individual classes of dangerous goods. The marking, labeling, and packing of all hazardous goods will be as prescribed in the IMDG Code. Handling any goods in a leaky, damaged, or deteriorated condition shall be done only on the specific instructions of the competent authority. Agents, consignors, and consignees of dangerous goods and occupiers or custodians of all premises within the port area must observe and/or cause to be observed all safety precautions required by the competent authority and prescribed in these Regulations. If the amount deposited is not adequate, the port may recover its expenses by selling the cargo.
31	**Guidelines for National Sustainable Urban Freight Transport System, 2020**	Freight transport in urban areas is poorly understood and lacks a methodology for analyzing and planning urban freight movement, distribution, and commodity infrastructure and services. To achieve urban sustainability, new models for managing urban freight movements are needed, with local authorities playing a pro-active role. The National Framework for 'Urban Freight' provides a template for city planners and administrators to develop strategies, infrastructure interventions, and operational management plans to address urban freight. The framework is based on five key principles: understanding logistics issues from different stakeholder groups' perspectives, providing comprehensive data and insights in all aspects of trade and logistics, establishing a clear roadmap with clear role and responsibility allocation, identifying short-term, medium-term, and long-term strategies for urban freight management, financial support, institutional support, and capacity building, and ensuring forward and backward linkage of the urban freight plan with state and national policy. Urban freight planning should be done in conjunction with planning for public and private vehicles. The framework categorizes cities based on factors such as size, population, regional context, and economic character. It focuses on understanding current issues and market assessment, mapping freight infrastructure, and addressing logistics implications for industries, wholesale markets, and retail and business freight movement.

		Stakeholder interactions are crucial in planning, designing, and implementing interventions for urban freight management. Establishment-based freight surveys (EBFS) are an effective technique for understanding logistics in cities, providing data on goods flow and vehicle activity. Data collection and analysis are essential for mapping the current urban commodity value chain, helping planners understand the challenges specific to commodities moving in the city. A strategy basket covers various interventions such as policies, programs, and projects, with a focus on land use-related initiatives and infrastructure and traffic-related initiatives. The urban freight management process involves a multifaceted approach that involves various stakeholders and agencies working together to achieve desired outcomes. This includes extensive stakeholder outreach, data collection, detailed assessment and analysis, and implementing structural and long-term initiatives. A city action plan is a key product of the planning process, defining recommended policies, programs, processes, and improvements. Performance measures (PMs) are crucial for gauging the degree to which goals and objectives are achieved.
32	**THE CENTRAL ROAD AND INFRASTRUCTURE FUND ACT, 2000**	The Central Road and Infrastructure Fund Act, 2000, was enacted by Parliament in the fifty-first year of the Republic of India and came into force on November 1, 2000. It aims to provide statutory status to the Central Road and Infrastructure Fund for the development and maintenance of national highways, railway projects, and infrastructure improvements. The act levies and collects cess on motor spirit, such as petrol and high-speed diesel oil, and other related matters. The Central Government may credit the proceeds of cess levied under Section 3 to the Consolidated Fund of India, and may credit such proceeds from time to time after deducting collection expenses. The Central Government may appoint a Central 4 Road and Infrastructure Fund for the purposes of this Act, which can be credited for any sums paid under Section 4 or Section 5, unspent part of the cess already levied for the development and maintenance of national highways, sums realized by the Central Government in carrying out its functions or administration of this Act, and any fund provided by the Central Government for the development and maintenance of state roads. The Central Government has the power to administer the Fund and take decisions regarding investment in roads and other infrastructure projects. Starting from March 1, 2005, the Central Government will allocate fifty paise from the amount of rupee two as additional duty of customs and excise on petrol, levied under sub-sections 103 and 111 of the Finance Act, 1998 (21 of 1998) and sub-sections 116 and 133 of the Finance Act, 1999 (27 of 1999), exclusively for the development and maintenance of national highways. The Central Government will administer the share of the fund to be spent on the development and maintenance of state roads based on the criteria formulated under clause (iv) of sub-section (1) of Section 10. The Central Road Fund Ordinance, 2000 (Ord. 5 of 2000), is repealed.
33	**THE INDIAN PORTS ACT, 1908**	The Indian Ports Act, 1908 consolidates enactments related to ports and port charges, covering ports mentioned in the first schedule and parts of navigable rivers and channels. It does not apply to vessels belonging to the Central Government, State Government, or foreign Princes or States. The government has the power to extend or withdraw the Act or certain portions thereof by notification in the Official Gazette. The Act may extend or withdraw the limits of any port in which it is in force, subject to any rights of private property. The government may make port-rules consistent with this Act for various purposes, including regulating the time and hours at which vessels may enter, leave, or be moved in a port, berths, stations, anchorages, striking yards and top masts, anchoring, bunkering, keeping free passages, anchoring, fastening, mooring, unmooring, moving and warping, mooring buoys, chains, and other moorings, and fixing rates for the use of moorings when belonging to the government or boats. The Indian Ports Act, 1889, regulates various aspects of port management, including regulating the use of piers, jetties, landing places, wharves, quays, warehouses, and sheds, licensing and regulating catamarans, flats, cargo, passenger, and other boats, and determining cargo and crew quantities. It also sets fees for services, regulates fires and lights, enforces signals and signal lights, and regulates crew members and employment.

		The act requires the owner or master of vessels to provide curtains, double awnings, windsails, and temporary screens to protect officers and crew from heat. If a person disobeys a rule, they may be punished with a fine of up to one thousand rupees. The government appoints a conservator for every port subject to the Act, with the conservator giving and enforcing directions for vessels within the port. The conservator can remove obstructions within the port limits, and the owner is responsible for paying reasonable expenses. Special rules for shipping and port conservation include injuring buoys, beacons, and moorings, wilfully loosening vessels from moorings, improperly discharging ballast, and graving vessels within prohibited limits. The government is not responsible for acts or defaults of port officials or pilots, nor for damage sustained by vessels due to defects in moorings or other government-owned items.
34	**Transportation of Goods(Through Foreign Territory) Regulations, 1965**	The Central Board of Excise and Customs has issued the Transportation of Goods (Through Foreign Territory) Regulations, 1965, which apply to goods transported from one part of India to another through a route partly over a foreign country. These regulations require the consignor to deliver a bill and a declaration at the foot of the bill. The person-in-charge of a vessel must obtain written permission to load goods before loading them on a conveyance. Before loading goods, the consignor or person-in-charge must execute a bond with a certain amount not exceeding the value of the goods. The person-in-charge of the conveyance must prepare multiple sets of manifests and deliver them to the proper officer at the customs station. The officer must then endorse the manifest, retain one copy, and return the other two copies to the person-in-charge. The person-in-charge must also deliver bills at the destination station and clear goods unless written permission is given by the proper officer. The bond's terms are that if the person-in-charge or the consignor produces proof within a specified time, the bond is void. If proof is not furnished, the executor is liable to pay the export duty leviable on the goods and any penalties imposed by the proper officer under the Customs Act, 1962, the Imports and Exports (Control) Act, 1947, or the Foreign Exchange Regulation Act, 1947, and forfeit the entire amount of the bond. The proper officer may permit the person-in-charge of conveyances or the consignor of goods to enter into general bonds for the transport of goods.
35	**Flex-fuel Methanol to reduce Green House Emissions**	The government has notified mass emission standards for flex-fuel Methanol M15, M100, and Methanol MD 95 vehicles. M-15 is a blend of 15% methanol and 85% gasoline, which can reduce GHG emissions by 5-10% and improve air quality. M-15 fuel blending is optional and not mandatory in the near future.
36	**Vehicles on Alternative Fuels**	The government has taken proactive steps to promote alternative fuels and reduce pollution in the country. Notifications have been issued specifying mass emission standards for various fuels, including compressed natural gas, biodiesel, flex-fuel, ethanol, LNG, and flex-fuel Methanol vehicles. The government also mandates mass emission standards for BS-VI from April 1, 2020. The government has also notified retrofitting hybrid electric systems and outlined the type approval procedure for electric hybrid vehicles. Registration marks for battery-operated vehicles are yellow on green background, while permits are granted for ethanol and methanol fuel-powered vehicles.
37	**THE NATIONAL WATERWAYS ACT, 2016**	The National Waterways Act, 2016, was enacted by Parliament in the sixty-seventh year of the Republic of India to make provisions for existing national waterways, declare certain inland waterways to be national waterways, and regulate and develop them for shipping and navigation purposes. The Act will come into force on a date specified by the Central Government. The existing national waterways specified in the Schedule, along with their limits, will continue to be national waterways for shipping and navigation purposes, subject to modifications made under the Act. The regulation and development of waterways under the Central Government's control will continue

		as if they were declared national waterways under the Act. The inland waterways specified at serial numbers 6 to 111 in the Schedule, along with their limits, are declared national waterways for shipping and navigation purposes. The Union of Waterways specified in the Schedule for certain purposes declares that it is expedient in the public interest for the Union to take control of the regulation and development of the waterways specified in the Schedule for shipping and navigation to the extent provided in the Inland Waterways Authority of India Act, 1985. The Act also amends Section 2 of Act 82 of 1985, substituting "national waterway" with the inland waterway declared by Section 2 of the National Waterways Act, 2016. The Act repeals certain enactments, including the National Waterway (Allahabad-Haldia Stretch of the Ganga Bhagirathi-Hooghly River) Act, 1982, the National Waterway (Sadiya-Dhubri Stretch of Brahmaputra River) Act, 1988, the National Waterway (Kollam-Kottapuram Stretch of West Coast Canal and Champakara and Udyogmandal Canals) Act, 1992, the National Waterway (Talcher-Dhamra Stretch of Rivers, Geonkhali-Charbatia Stretch of East Coast Canal, Charbatia-Dhamra Stretch of Matai River, and Mahanadi Delta Rivers) Act, 2008, and the National Waterway (Kakinada-Puducherry Stretch of Canals and the Kaluvelly Tank, Bhadrachalam-Rajahmundry Stretch of River Godavari, and Wazirabad-Vijayawada Stretch of River Krishna) Act, 2008.
WASTE MANAGEMENT		
1	**GUIDELINES FOR IMPLEMENTATION OF GREEN BUILDING NORMS**	Instructions for implementation of the Green Building Norms in Defence Projects/ Works. Formulation of detailed technical guidelines to achieve ‘Green’ points in consonance with GRIHA Manuals will be done at HQ CE Command to have uniform benchmark criteria. Till such time guidelines from HQ CE Command are issued, CE Zones/ CCEs will adopt guidelines given in respective GRIHA Manual.
2	**National Missionon Sustainable Habitat 2021-2030**	Though the two-pronged approach of mitigation and adaptation, the union government is augmenting capacity to ensure that we build climate resilience on an unprecedented scale. With the objective of making sustainable habitats through improvements in energy efficiency of buildings, management of solid waste, and modal shift to public transport, NMSH is a vital cog in India’s thrust towards reducing CO_2eq emissions in the country.
3	**Solid Waste Management Rules (2016)**	The State Pollution Control Board shall be responsible for reviewing the implementation of these rules. The developers of the Special Economic Zone, Industrial Estate, and Industrial Park are to earmark at least 5% of the total area of the plot or a minimum 5 plots or sheds for recovery and recycling facilities. Notify buffer zones for the solid waste processing and disposal facilities of more than 5 TPD in consultation with the SPCB and ensure compulsory purchase of power generated from such waste-to-energy plants by DISCOMs. and provide appropriate subsidies or incentives for such Waste to Energy Plants Refuse derived fuel (RDF) promotion: no landfilling for non-recyclable waste having a calorific value of 1500 K/cal/kg Demands a state policy for solid waste management. User fee for solid waste management; spot fine for littering No person should throw, burn, or bury the solid waste generated by him, on streets, open public spaces outside his premises, or in the drain, or water bodies. Generator will have to pay 'User Fee' to waste collector and for 'Spot Fine' for Littering and Non-segregation.

4	**The National Environment Policy (NEP), 2006**	The National Environment Policy (NEP), 2006 was an effort towards India's commitment to clean environment and making positive contribution to international efforts. The NEP builds on the various earlier policies which had addressed the challenges of environment and need of sustainable development prior to this policy.
5	**CPWD Green Rating Manual, 2019**	Green rating systems link sustainability policy to planning and design so that the overall project vision is used throughout the process. These rating systems also promote stakeholder participation and provide milestones that help to monitor progress and keep the project team on track. Green ratings assess a building based on its predicted performance over its entire life cycle — conception through operation. This results in the development of buildings that consume fewer natural resources without sacrificing the acoustic, thermal, and visual comfort of its occupants.
6	**Guidelines for managing Construction and Demolition waste in Kerala, 2022**	The objectives of these guidelines are to: a. standardise the facility requirement for C&D Waste Management in all Local Self Government Institutions (LSGIs) in the State b. standardise the procedure for licensing and operation of C&D Waste Management facilities in all LSGIs. c. regulate the management of C&D Waste in the State. d. promote reuse of C&D waste and thereby reduce the quantum of waste to be processed e. make recycling of C&D waste mandatory in the State f. enable cities to achieve garbage-free city star rating as per SBM Urban 2.0 guidelines g. develop a monitoring mechanism in the State for managing C&D waste
7	**The Swachh Survekshan 2020**	The Swachh Survekshan 2020 covered 4,242 cities and introduced the concept of 'Continuous Survekshan' to ensure that the Mission outcomes are sustained through a continuous quarterly monitoring and verification. Since 2016, in order to create healthy competitiveness and to evaluate the performance of ULBs, the Annual Swachh Survekshan (cleanliness survey) is carried out, under which the ULBs are ranked based on various parameters of cleanliness
8	**Guidelines sustainable habitat, 2014**	The guidelines are based on reports of National Mission on Sustainable Habitat by Ministry of Urban Development and draft code on "Approach to Sustainability" as part of NBC 2005. The guidelines are intended to be used by CPWD architect/engineers in day to day decision making process with regard to use and evaluation of materials and technology on sustainability parameters.
9	**CPCB Guidelines On Environmental Management Of Construction & Demolition (C &**	The C&D debris is a source of construction material. Technologies for its processing are well developed and plant and equipments are available for processing of this material for smallest quantity to a large quantities.

	D) Wastes, 2017	
10	**Extended Producer Responsibility (EPR)**	Extended Producer Responsibility (EPR) is a policy that requires manufacturers, importers, and retailers to take responsibility for their products' environmental impact throughout their lifecycle. It mandates producers to consider the environmental impact at every stage, from raw material extraction to disposal or recycling. EPR also requires producers to cover costs associated with disposal, often built into the product price. It promotes sustainable design, encouraging producers to use recyclable materials, reduce packaging, and be easily disassembled for recycling. EPR policies are often implemented through government regulations, requiring stakeholder collaboration. EPR can lead to increased recycling rates, reduced landfill waste, and reduced environmental pollution.
11	**Plastic Waste Management Rules (2016)**	The Plastic Waste Management Rules (2016) in India aim to address plastic pollution and promote sustainable waste management. Key points include Extended Producer Responsibility (EPR), registration of producers with State Pollution Control Boards, a hierarchy for waste management, phase-out of non-recyclable multilayered plastic, local authorities' responsibilities, ban on plastic waste import, establishment of a Plastic Waste Management Cell, recognition of the informal sector, penalties for violations, and public awareness campaigns. The rules also emphasize the importance of integrating the informal sector into formal waste management systems and promoting public awareness and education campaigns. The rules aim to promote responsible waste management practices and reduce plastic pollution.
12	**E-Waste (Management) Rules (2016)**	The E-Waste (Management) Rules, 2016 in India define e-waste as electrical and electronic equipment discarded by consumers or bulk consumers. The rules introduce Extended Producer Responsibility (EPR), making producers responsible for collection, channelization, recycling, and disposal. Producers must register with the State Pollution Control Board or Pollution Control Committee, and can fulfill their obligations through authorized Producer Responsibility Organizations. Targets for collection and recycling are set, and authorized collection centers are established. E-waste exchange platforms are encouraged, and refurbishment and repair are encouraged to extend equipment's useful life. Training and capacity building are emphasized, and consumer awareness programs are conducted. Incineration of e-waste is prohibited due to environmental and health hazards. Importing used equipment for charity or reuse is restricted. Recyclers and dismantlers must obtain authorization from the State Pollution Control Board. Hazardous substance restrictions are in place. Producers contribute to the E-Waste Management Fund.
13	**The Water (Prevention and Control of Pollution) Act, 1974,**	The Water (Prevention and Control of Pollution) Act, 1974, was enacted in India to prevent and control water pollution and maintain water wholesomeness. It establishes boards for implementing these measures and assigns powers to them. The Act applies to states in Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Rajasthan, Tripura, and West Bengal. The Central Pollution Control Board is a body corporate with perpetual succession and a common seal, responsible for exercising its powers and performing its functions. The State Board is constituted by the Central Government and can sue or be sued. Members of a board, other than a member-secretary, hold office for a term of three years, ending when the member ceases to hold office. The Central Government or State Government may remove a board member before the expiry of their term after giving them a reasonable opportunity to show cause against it. Joint Boards are formed under agreements involving environmental protection, agriculture, fishery, industry, trade, and pollution control. The Water (Prevention and Control of Pollution) Amendment Act, 1988 prohibits the use of streams or wells for the disposal of polluting matter. State Boards in India are responsible for maintaining a register with conditions for outlets and effluent, which must be open to

		inspection. Consent is considered unconditional after four months of application, and existing discharge of sewage or trade effluent is subject to Section 25 provisions. The State Board and other agencies have the power to provide information when poisonous, noxious, or polluting matter is discharged into a stream, well, sewer, or on land.
14	**The Bio-Medical Waste (Management and Handling) Rules, 1998**	The Bio-Medical Waste (Management and Handling) Rules, 1998, are a set of rules issued by the Central Government under Sections 6, 8, and 25 of the Environment (Protection) Act, 1986. These rules apply to all individuals who generate, collect, receive, store, transport, treat, dispose of, or handle biomedical waste in any form. Biomedical waste is defined as any waste generated during the diagnosis, treatment, or immunisation of humans or animals, research activities, or production or testing of biologicals. The rules outline the duty of every occupier of an institution generating biomedical waste to ensure its handling without adverse effect on human health or the environment. Biomedical waste must be segregated into containers or bags at the point of generation, labeled according to Schedule III, and transported only in vehicles authorized by the competent authority. If untreated biomedical waste is stored beyond 48 hours, the authorised person must obtain permission from the prescribed authority and take measures to ensure it does not adversely affect human health or the environment. The Bio-Medical Waste (M&H) (Second Amendment) Rules, 2000 establish the prescribed authority for enforcing these rules in states and union territories. The Director General, Armed Forces Medical Services, is responsible for enforcement in healthcare establishments like hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, and blood banks. Authorization for handling biomedical waste is granted for a period of three years, including an initial trial period of one year. Applications for authorization must be disposed of within ninety days. The Central Pollution Control Board monitors the implementation of rules in Armed Forces healthcare establishments under the Ministry of Defence. Every occupier or operator must submit an annual report detailing the categories and quantities of biomedical waste handled in the preceding year. Records related to the generation, collection, reception, storage, transportation, treatment, disposal, and handling of biomedical waste must be maintained and subject to inspection and verification by the prescribed authority.
15	**2019_kmbr amendment _C&D**	Amendment of building rules regarding rain water storage, farm permit for cattle, etc.
16	**C&D_rules_016@CPCB**	This is to ensure environmentally sound management of C& D waste. While granting the authorization, the SPCB would assess and ensure the availability and adequacy of infrastructure with C&D facilities to meet the prescribed environmental norms. Duties of waste generators, service providers would envisage people's participation (Jan Bhagidari) in scientific management of C & D waste
17	**CDW_Strategy_Draft Final**	Although the C&D Waste Management Rules were notified in 2016, little progress has been made in the intervening two years in terms of widespread adoption of C&D waste processing and utilisation in India. Therefore, it is necessary to understand the importance/benefits of proper C&D waste management as well as identify the challenges and roadblocks so that an effective implementation strategy can be adopted.
18	**Circular-Economy-in-Municipal Solid and Liquid waste-**	The sub-committee recommends

	management-2021	(i)reduction in virgin construction raw material usage in different building projects and (ii) extending tax rebates on recycled C&D products.
19	**MoUD Circular dated 28 June, 2012**	Erstwhile MoUD vide its circular dated 28th June, 2012 has desired all states to set up C&D waste recycling facilities in all the cities/towns with population over 1 million. It would also reduce the pressure on natural resources that are being otherwise exploited for building and road construction materials resulting in adverse impact on the environment.
20	**MSW manual 2016**	Municipal authorities should make bye-laws as well as special arrangements for storage, transportation, processing, and disposal of C&D waste as per the revised rules.
21	**National Action Plan on Climate Change (NAPCC), 2021**	There are eight ―National Missions‖ which form the core of the National Action Plan. They focus on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation. 1. National Solar Mission 2. National Mission for Enhanced Energy Efficiency 3. National Mission on Sustainable Habitat 4. National Water Mission 5. National Mission for Sustaining the Himalayan Eco-system 6. National Mission for a Green India 7. National Mission for Sustainable Agriculture 8. National Mission on Strategic Knowledge for Climate Change
22	**Technology Advisory Group (TAG) report 2005**	The 2005 TAG report on India's technological development and policy formulation provides valuable insights into innovation, infrastructure, regulation, and education. It outlines key issues, strategies, and challenges in the technology sector, aiding policymakers in growth and development. Identify appropriate and cost effective technologies for solid waste management, to provide technical assistance and capacity building to ULBs in India.
23	**SOP- Siting requirements and pollution control measures in construction & demolition waste processing plants, KSPCB, 2022**	Guidelines to follow while handling SW - Pollution control measure to be provided in construction sites, collection centers, Processing Centers and waste transportation