



Vaasan yliopisto
UNIVERSITY OF VAASA

Vishnu Sureshkumar

Risk Management Strategies in Green Supply Chains: Overcoming Barriers in Indian SME's

School of Management

Master's thesis in Strategic Business
Development

Vaasa 2025

UNIVERSITY OF VAASA
School of Management

Author: Vishnu Sureshkumar

Title of the Thesis: Risk Management Strategies in Green Supply Chains:
Overcoming Barriers in Indian SME's

Degree: Master of Science in Economics and Business Administration

Programme: Strategic Business Development

Supervisor: Jukka Partanen

Year:2025 **Pages:80**

ABSTRACT:

As sustainability pressures unfold with an unprecedented intensity, Indian small and medium-sized enterprises (SMEs) are increasingly challenged to adopt Green Supply Chain Management (GSCM). In this study, the study explores the core internal and external risks that inhibit adoption of GSCM by Indian SMEs, based on an integrated theoretical framework that combines GSCM with supply chain risk management (SCRM). This study uses a qualitative, interpretivist methodological approach and undertakes multiple case studies with five Indian SMEs from various sectors to help contextualize the barriers of financial risk, technology limitations, regulatory ambiguity, and market competition. The study proposes a re-framed typology that defines sustainability risks as either strategic or operational, and highlights resilience strategies as a mediating variable. The study found that while technological advancements and the commitment of leadership can assist as enablers of GSCM, SMEs still lack customized risk models, green financing, and continued regulatory guidance. In conclusion, it will take multi-dimensional support such as policy initiatives, learning and capacity development, collaborative networks, and digital technologies for SMEs to enhance their resilience and maintain competitive advantage in the sustainable supply chain space. Overall, this study examines the theory by converging GSCM and SCRM together and provides insight for policymakers and managers of SMEs working through green transitions in developing economies.

KEYWORDS: Green Supply Chain, Risk Management, Resilience, SMEs, Sustainability, Environmental Risks

Table of contents

1 Introduction	5
2 Theoretical Background/Literature Review	9
2.1 GSCM in SMEs	13
2.2 Supply Chain Risk Management (SCRM) and Its Relevance to SMEs	16
2.3 Challenges Facing Indian SMEs in Adopting GSCM	19
2.4 Theoretical Framework	25
3 Methodology	28
3.1 Research Approach	28
3.2 The Sample: Case Firm Profiles and Selection Rationale	30
3.2.1 Sample Selection Criteria	30
3.2.2 Case Firm 1: Suryaja Foods	30
3.2.3 Case Firm 2: Fairytale Interiors	34
3.2.4 Case Firm 3: Metalman Auto Limited	36
3.2.5 Case Firm 4: DO Future Energy Solutions	38
3.2.6 Case Firm 5: Ecosun Power Solutions	41
3.2.7 Ethical Considerations in Case Selection	44
3.2.8 Contribution of the Sample to Research Objectives	44
3.3 Data Collection	44
3.4. Data Analysis	46
3.5. The Assessment of the Quality of the Data	49
4. Findings/Results	52
4.1. Internal Risk Factors and Operational Constraints	58
4.2. External Risk Factors and Regulatory Uncertainties	59
4.3. Enablers and Resilience Strategies	60
4.4. Summary of Key Findings and Revised Framework	62
5 Discussion	64
5.1. Theoretical Contribution	67
5.2. Managerial Implications	68

5.3. Limitations and Suggestions/Avenues for Future Research	68
References	70
Appendices	78

List of Tables

Table 1: Comparison of Present Study with Past Studies in GSCM and SCRM	65
---	----

List of Figures

Figure 1: Green Supply chain management (Taleghani & Taleghani, 2020)	9
Figure 2: SCRM Framework for Green Supply Chain Adoption - A conceptual diagram illustrating how SCRM integrates sustainability by identifying risks (internal and external) and implementing preventive strategies to mitigate failures in green adoption.	11
Figure 3: A theoretical framework for SCRM, (Oliver et. al, 2014)	17
Figure 4: Challenges in GSCM Adoption for Indian SMEs	20
Figure 5: Evaluation criteria of Data Quality	50
Figure 6: Frequency of Major Themes Identified from Thematic Analysis	53
Figure 7: Word Cloud Highlighting the Thematic Landscape of SME Narratives	54
Figure 8: Proportional Distribution of Key Themes Across the Dataset	55
Figure 9: Treemap of Themes and Relative Emphasis	56

1 Introduction

The present global business atmosphere is presently undergoing an unrivaled and irreversible transition, particularly fueled by an increased awareness of urgent environmental concerns (Luo et al., 2024). This transformative transition is generally motivated by major global issues such as climate change, a drastic depletion of resources, and various forms of pollution, which create tremendous pressure on organizations in all industries. This degree of pressure will create a reconsideration of existing operating methods that were once deemed sufficient. Therefore, environmental sustainability has surpassed being a compliance requirement and has strategically advanced as an element of long-term planning and value creation for firms. In this rapidly changing and complicated environment, Green Supply Chain Management (GSCM) has quickly gained considerable attention. It is understood as a holistic, integrated, methodical approach that environmentally considers each activity in the supply chain, such as the source of raw materials to, disposal of the product. Key Principles of GSCM are geared to accomplish a triple process, that is, to minimize the negative environmental effects, improve the efficiency of operations, and initiate sustainability innovations (Bhagawati & Venkumar, 2020). This deliberate inclusion in the supply chain eliminates the optional add-on of environmental considerations and enables a position for further innovative value-creation opportunities directly aligned with the company or brand's strategy, associated with business or profit models that contribute to sustainability for the short- and long-term. Overall, sustainable, environmentally based business development is a business necessity to enhance organizational sustainability, competitiveness, and economic development.

While larger corporations may have the resources, infrastructure, and abilities to shift towards greener supply chains, small and medium-sized enterprises (SMEs) face significantly greater barriers to doing so, especially in developing countries like India. While Indian SMEs have significant contributions to the economic output and job creation in the country, the limited resources, technological capabilities, regulatory vagueness, and low awareness of sustainability we see in SMEs, explicitly make GSCM less attainable, complex and uncertain (Gupta et al., 2025). These limitations represent a larger hesitation to adopt sustainable practices, and this will eventually jeopardize their ability to sustain and compete in an increasingly environmentally conscious world.

As India experiences a rapidly developing economy, a national emphasis on promoting industrial activity that is sustainable across all sectors is also becoming clear. In the context of this significant economic dimension, small and medium enterprises (SMEs) are a critical pillar of the

Indian economy. SMEs make substantial contributions, particularly with respect to the gross domestic product (GDP), jobs, contribution to export receipts, and regional development. India has a large and dynamic network of over 63 million SMEs, as statistics reported by the Ministry of Micro, Small, and Medium Enterprises show, whose roles in strengthening the economy, maintaining balance, and stimulating innovation cannot be overstated. These enterprises are often extremely important locally as they provide goods and services as well as serve as important nodes in larger supply chains (Omowole et al., 2024). In spite of their substantial economic stature and inherent dynamism, Indian SMEs are constantly challenged with overcoming a plethora of significant barriers to adopting substantial, environmentally sustainable practices. These barriers, but not restricted to these, include widespread inadequate financial resources; severely inadequate access to modern technologies; low levels of environmental concerns and awareness from affected stakeholders and management; and a widespread, substantial shortage of the right technical expertise to implement green initiatives. As such, making the transition to sustainable practices can be a prospect for the SME that might see it as an overwhelming enterprise.

Textile and apparel SMEs in regions like Tamil Nadu and Gujarat are increasingly adopting GSCM by using organic cotton, reducing water usage through efficient dyeing processes, and minimizing chemical waste to meet international sustainability standards for export markets. Electronics manufacturing SMEs in cities like Bengaluru and Noida focus on e-waste management, energy-efficient production, and sourcing conflict-free materials, driven by regulatory pressures and corporate buyer demands. Handicraft SMEs in Rajasthan and Uttar Pradesh integrate GSCM by using natural dyes, sustainable raw materials like bamboo, and eco-friendly packaging to appeal to niche, eco-conscious consumers. Agri-based SMEs in states like Assam, particularly in tea and coffee production, adopt organic farming practices, reduce pesticide use, and implement sustainable logistics to lower emissions while pursuing fair trade certifications. These SMEs across diverse sectors are motivated by market demands, regulatory compliance, and cost-saving opportunities, though they often face challenges like financial constraints and limited technological access.

Moving towards green supply chains in the Indian SME sector presents a multi-layered challenge influenced by institutional and structural influences (Malik et al., 2022). SMEs in India work in a fragmented and largely informal business environment. Environmental standards are difficult to apply since there are neither documented nor formalized processes in place. This structural informality hampers not only the development towards sustainability standards, but it also hinders a firm's ability to systematically adopt and implement green practices or methods across operations. Moreover, the variety of environmental initiatives will yield varied implementations

and likely hinder SMEs from fully realizing all the benefits of a sustainable supply chain framework.

The barriers for Indian SMEs to pursue GSCM are more complex when viewed within the scope of India's unstable and changing regulatory framework (Jha et al., 2024). Regulatory instability and policy shifts render an unpredictable business environment in which SMEs can barely keep up with the requirements of sustainability. Environmental legislation in India is known to come in cycles, and like the challenges of climate change, policies can be re-evaluated and shifted in response to global climate change obligations, technological innovation, and altered priorities in the government. But for SMEs having limitations on financial and managerial resources, sometimes the challenge of adapting to changes is nearly impossible. The amount of both physical and human resources adjustments entails significant changes to processes, partnerships, and allocation - all these changes require financial investments that SMEs may find unobtainable. Without regulatory frameworks offering long-range, dependable, and predictable guidance, it is difficult to convince SMEs to pursue a sustainable transformation, knowing that sustainability measures could be deemed non-compliant, or worse, financially draining for future sustainable initiatives.

With the absence of institutional support, the range of tools and lack of enforcement exacerbate the risks which leave SMEs subject to political or operational policy inconsistency and policy compliance difficulties. As environmental regulations become more stringent, enforcement is inconsistent and remains inequitable for SMEs who often do not have formalized standards of environmental compliance (Petts et al., 1999). SMEs operate in many cases within the informal economy or have sub-sectors with fragmented supply chains which make standardized compliance with environmental regulations difficult. Even when environmental regulatory agencies are in place, they often lack sufficient human resources to oversee sustainability compliance for the overly large SME sector, which leads to enforcement irregularities. As a result, SMEs can opt for partial compliance, and others operate entirely outside regulation, creating inefficiencies in the arms race with which they have to adopt and adhere to green sustainable mechanisms.

The lack of regulatory clarity leads to SME's uncertainty for investment in environmentally friendly technologies since they have concerns of being financially vulnerable should legislation change without notice. SMEs have limited access to some capital for investing in advanced green technologies e.g. packaging, energy efficient machines (Cenci et al., 2022), waste management technologies etc. But most SMEs are still reluctant to spend even small amounts in green infrastructure and machinery as there are no promises of stability, long term policy provisions, available resources/credit instruments like green credit lines or investment programs focused on sustainability. The result of this financial uncertainty slows the spread of alternative GSCM and

hinders SMEs from utilizing sustainability as a competitive advantage as a part of their basic business. With these interdependent regulatory and financial factors, it is critical that SMEs take a well-planned and informed approach to identifying the specific impeding factors blocking their transition toward sustainable supply chains. The study is designed to be able to bridge that knowledge gap by identifying and assessing key risk factors such as financial constraints, technology gaps, and policy unpredictability. By identifying key vulnerabilities, the study suggests strategies to work toward helping SMEs manage their sustainable implementation risks.

With regard to risk factors, the study underscores the need for policy interventions that cater to green adoption for SMEs. The policy framework needs to be focused on predictable and longer-term policy direction in order to develop business confidence and eliminate concerns of regulatory uncertainty. Governments need to focus on easing environmental regulatory compliance processes to eliminate red tape and also develop clear, transparent, and accessible regulatory frameworks for SMEs to work through. Finally, tailored capacity-building programs specific to SMEs can positively change business owners and managers room for learning how to implement sustainable practices while ensuring their fiscal viability. These programmes do not need to be overly complicated. However, they will need to address practical knowledge on the technical aspects of implementation, the risk management, and the sustainability solutions should be science-driven and scalable to allow SMEs without consuming all their resources to implement green supply chain models (Vujanović et al., 2021).

The overall goal of this study is to create an enabling environment for Indian SMEs to socially construct and embed green supply chain thinking into their operating practices, enhancing their global competitiveness. With sustainability increasingly becoming integral to long-term business viability, SMEs must not only meet environmental obligations but also leverage sustainability as a competitive advantage. SMEs also face significant hurdles in aligning their operations with global sustainability standards, which are critical for maintaining relevance in global markets while supporting economic growth and enhancing the long-term resilience of India's industrial ecosystem. This study aims to identify and prioritize the key risks associated with green supply chain management (GSCM) adoption among Indian SMEs, focusing on internal and external barriers that hinder sustainable practices. Specifically, it asks: *What are the key risks that Indian SMEs face in implementing green supply chains?*

2 Theoretical Background/Literature Review

The theoretical basis of the research is fundamentally built on two connected areas GSCM and SCRM (Ibrahim et al., 2023). Both areas provide important, relevant evidence to understand the issues, processes, and consequences of sustainability adoption in the world of supply chains, especially for small and medium enterprises (SMEs). With the situation in the business world becoming more complex, and country and geographic-level pressures to transition towards sustainability gaining momentum, the nascent field of GSCM and SCRM represents vital subject areas to analyze the risks, barriers, and factors for SMEs when working to embed sustainability into their supply chain modus operandi. This research provides a structured review of the relevant literature to develop an effective conceptual framework that can be followed with empirical studies. The study identifies knowledge gaps and works toward creating effective processes to facilitate the transition of SMEs to green supply chain models.

GSCM is a revolutionary concept that seeks to achieve environmental considerations for all functions of the supply chain - from raw material extraction, manufacturing, logistics, and distribution, to the final disposal/recycling of products as shown in Figure 1.



Figure 1: Green Supply chain management (Taleghani & Taleghani, 2020)

Traditional supply chain processes aimed to optimize efficiency and reduce costs, with limited consideration to environmental impacts. Businesses want to be environmentally responsible (for a number of reasons), but a multiplication of country responses (regulatory pressures), consumer expectations, employee standards, and corporate responsibility has driven many businesses globally to position sustainability at the forefront of supply chain strategy. GSCM is justified as an approach that allows organizations to reduce carbon footprints, reduce resource consumption,

avoid fines for breaching regulations, and improve corporate image beyond liability and chastisement, thereby making brands more positive in the eyes of stakeholders. While bigger firms have structured sustainability strategies to support their programs in industry and have the necessary financial and technological resources to deliver and implement initiatives, it becomes harder for SMEs to adopt the same level of green sourcing due to limitations of their operating structures. SMEs are recognized as the core of the industrial ecosystem in India and contribute meaningfully towards employment creation, regional development, and ultimately GDP. Yet, SMEs are often not equipped with structured sustainability frameworks, which limit their possibilities to implement green supply chain practices. Green supply chain management adoption is affected by a number of challenges, including financial (Khan et al., 2025), technical restraints, low environmental awareness, and poor supplier links due to fragmented supply networks. Unlike the advantages enjoyed by larger corporations in terms of economies of scale, institutional support, and formalized operational processes, SMEs often operate informally with some ad hoc tasks rather than sustainability programs. Often, the same sustainability task gets taken regardless of the operational context or industry, which results in wide variances of green adoption rates. SMEs have very real risks of being out of the full extent of above board sustainable practices, and worse still, being vulnerable to vague compliance standards and compliance rates, loss of opportunities, and some inefficiencies in their own environment or in their suppliers' environment.

Examining sustainability under the sustainable supply chain risk management (SCRM) framework permits an opportunity to consider the robust and possible risks associated with green adoption. SCRM aims at recognizing risks and preventive strategies to identify or mitigate failures back into the supply chain.

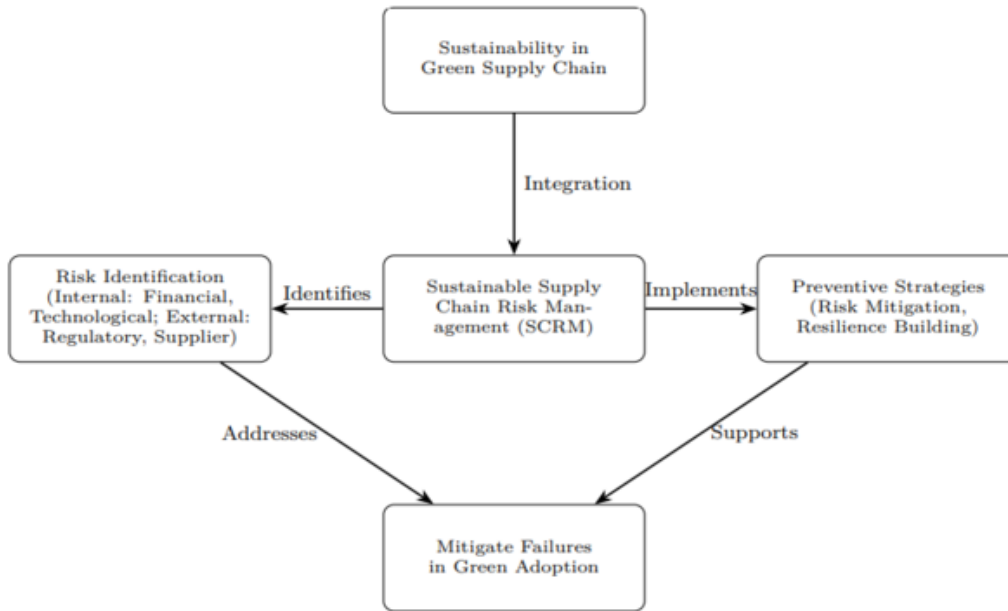


Figure 2: SCRM Framework for Green Supply Chain Adoption - A conceptual diagram illustrating how SCRM integrates sustainability by identifying risks (internal and external) and implementing preventive strategies to mitigate failures in green adoption.

Conventional supply chain risk management still communicates consumerism concerns related to compliance, where risks include reliability of the supplier, inventory, efficiency, logistics, and supply. However, green sourcing and green supply chains come with more depth of complexity. Environmental policy and regulations, consumer expectations/demand concerning sustainability or environmentally friendly manufacturing practices, climate-related disruption risks, and criteria of sustainable technological upgrading challenges create risks that need warning indicators in the supply chain. SMEs are particularly vulnerable to sustainability risks disproportionately as they do not necessarily have formal risk assessment systems, financial cushions, or contingency plans. Within the unified paradigmatic framework, risks can be classified as internal (endogenous) risks or external (exogenous) risks. Internal risks to SMEs arise from internal barriers of the SME itself, including financial limitations, managerial limitations, technological barriers, and employees opposing sustainability policies. Thus, internal risks influence the SME decision-making process for the investment of eco-efficient technologies, business structure strategy of supply chain processes, and employee adjustment to comply with sustainability policy. On the other hand, external risks arise in consideration of macro-environmental systems outside the SME's control. External risks include variable regulation policies, developing environmental compliance, supplier reliability, consumer demand for sustainability, and market volatility. It is more difficult to mitigate external risks because of unexpected policy changes and perceptions of weak

enforcement, and those negative perceptions decrease confidence and avoid long-term sustainability investment risks for SMEs.

The existing literature focuses on GSCM and SCRM think tanks principally in the context of large multinational corporations and does not give adequate attention to SMEs specifically or to the environmental sustainability risks organizations face during a transition from "conventional" supply chains to sustainable ones, particularly in the emerging market context such as India. Although scholars are discovering various challenges that SMEs face as they advance on the sustainability transition scale to a greener supply chain, there is limited empirical literature investigating SME risk exposure, mitigation or recovery actions, renewal processes, policy issues, and changes required from public policy accounts. The purpose of this study is to identify the limited resources associated with transitioning to sustainable supply chains within a theoretical framework that can be further enlarged or refined resource definitions to examine risk specific to Indian SMEs and provide structured, rational options to deliver SME sustainability resilience (Khan et al, 2025).

This study pools sustainability literature with risk management to provide a structured framework to understand the SME challenges with navigating sustainability and provide opportunities for targeted actions. These diverse methods - enhancing institutional support resources, regulatory clarity, and access to financial resources - will be foundational to assimilate GSCM and adapt to new requirements developed for and with SMEs. However, policymakers must ensure clear regulatory frameworks that are predictable to curtail compliance unpredictabilities will affect how SMEs choose to adopt green technologies. After that step is established, SMEs need green financing instruments that include sustainable linked loans, appropriate taxes, and subsidies that are designed for SME access and affordability.

In addition to financial, institutional, and regulatory support, industry collaborations and knowledge-sharing spaces can help enhance sustainability uptake by SMEs. Large businesses can demonstrate their support of sustainability initiatives with their suppliers through sustainable procurement strategies, eco-certification, transparency, sustainability reporting, and more sustainable consumption and production initiatives, which will build capacity for SMEs and supply chain initiatives. Supporting SMEs and encouraging sustainability requires facilitating access to technical skills, knowledge, tools for risk management, and digital mechanisms to accommodate the shift to green supply chains that avoid additional financial encumbrance through excessive oversight and compliance risks.

Overall, the theoretical framework can provide options for examining the intersection of GSCM and SCRM and provide insights into barriers, risks, and opportunities for SME sustainability transitions. As organizations across the globe move to incorporate environmental sustainability practices and accountant for sustainable outcomes into supply chain strategies globally, SMEs

must ensure that they comply with the environmental sustainability requirements while balancing their competitive abilities in market(s) transitioning to sustainability driven consumption and production markets (Omowole et al, 2024). A regulatory and institutional environment that supports SME sustainability plans, while they may need to challenge existing conventions to prosper in global economies and support the sustainable economy transition - it may require institutional and collaborative efforts from policy experts, financing resources, and industry collaborations to develop new practices in the transitioning to an economy where sustainability is a necessity not an option. This research seeks to support or provide a structured, in-depth analysis of a pathway to policy resources, financial restructuring actions, and industry and collaboration initiatives to support sustainable transitions for SMEs and deliver their sustainability resilience in the longer term.

2.1 GSCM in SMEs

GSCM is a disruptive concept that encompasses the incorporation of the environment into business-as-usual activities performed in traditional supply chain management almost anywhere in the supply chain. These activities include product design, sourcing raw materials, manufacturing, transport/distribution, use of an end product, and end-of-life disposal (Jose & Jeyalakshmi, 2025). GSCM provides firms with an avenue to achieve a variety of objectives, such as reducing environmental impacts, making better use of resources, enhancing corporate brand reputation, adhering to regulations, and building economic sustainability over time. As global business increasingly shifts toward sustainability, GSCM has developed from a peripheral environmental issue to a central element of corporate social responsibility (CSR) and sustainable business practices.

In considering the role of GSCM amongst small and medium enterprises (SMEs), we have identified both the potential for the sector and the challenges it faces. SMEs have inherent spatial flexibility and adaptability that enables quick response to market forces, forcing a move toward sustainability. SMEs may experiment with green technologies, implementing sustainable solutions at a local level far more easily than large organizations. SMEs are so intertwined into local and regional economies that relatively small environmental initiatives can encourage the potential for broader impacts at the ecosphere level, and make a contribution to sustainable industrial development.

While these attributes may be viewed as advantages, SMEs face a number of significant barriers that limit the uptake of GSCM. Most large firms have a dedicated sustainability unit/position and environmental management systems, while SMEs often juggle financial, human resource constraints, and managerial competency (Bhattacharya et al., 2023). These limitations restrict their ability to invest in green technologies, adopt green-led methods, or comply with strict regulations. Furthermore, a large number of SMEs belong to unrecognized niche markets that

have limited consumer awareness regarding environmental sustainability, thus lowering their perceived necessity to pursue green supply chain management.

Sometimes, in addition to resource restrictions, SME engagements in India complicate their transition to green supply chains. SMEs often operate informally and in divided segments without formal environmental protocols, scripts, or liability compliance. This makes it difficult to have a formalized transition to GSCM across SMEs and inconsistency across the sector. Even with the challenges SMEs face and the additional unpredictable nature of frequent policy shifts on sustainability, the general regulatory context is still evolving and changing, thereby creating uncertainty. Without consistent institutional support from public and private bodies, many SMEs will be less inclined to put their money behind sustainability choices because they run the risk of changing regulations making their decisions irrelevant and/or burdensome.

Despite their restrictions, SMEs hold enormous potential as a driver of bottom-up sustainability innovation (Burch et al., 2016). SMEs, by virtue of working more compactly, are more agile in responding to environmental solutions that are suited to local markets. By directly engaging with local supply chains, SMEs can make concentrated investments toward sustainability that can drive change across industries. To capitalize on this potential, it is still essential to develop tailored and focused interventions on their clear operational targets, ensuring the sustainability transition is meaningful economically and operationally. This includes a mix of financial incentives, collaboration, knowledge sharing approaches, and capacity building for the SME community. Accessing sustainable financing pathways can remove barriers to resources, and training programs can provide SME leaders with the understanding they need to properly follow through and implement the green supply chain (Ogunyemi & Ishola, 2024). Adopting GSCM is not only an SME effort; gaining widespread adoption in the SME sector requires a holistic approach across a broad range of stakeholders with a vested interest in both the economic and environmental feasibility of GSCM adoption. It is essential for policymakers and industry stakeholders to develop regulatory frameworks that are easier to navigate, put forward transparent sustainability standards, and create collaborative ecosystems to help SMEs transition to sustainability in an economically viable manner. Building strategic partnerships (or partnerships) among SMEs, governmental agencies, and private institutions can provide avenues for collaborative knowledge development, ensuring SMEs possess the tools and knowledge required to integrate sustainability into the SME operational model. Consumer awareness initiatives can also be a source of market-based incentives for SMEs to move towards greener practices, reinforcing the business case for sustainability.

While SMEs must overcome these financial, technological, and regulatory obstacles, it is also essential for the long-term sustainability of SMEs and their economic viability in an increasingly environmentally aware global economy. There are multiple dimensions to adopting GSCM; a

fundamental requisite is addressing the issues of financial accessibility, technology, regulatory clarity, and institutional frameworks. If financial, technological, and regulatory constraints are not addressed, SMEs that do not adopt GSCM will fall further behind in the global movement towards sustainability, which will impact SME competitiveness and economic viability in the long term.

Financial accessibility is yet one of the major barriers for widespread adoption of GSCM within the SME sector (Mankar et al., 2025). SMEs generally need to operate in highly constrained budgets that inhibit their ability to invest in green technologies, sustainable sourcing approaches, or newer, different production techniques. Government policies focus heavily on ensuring financial inclusivity through subsidized schemes and green loans, along with tax incentives; however, often the financial barriers that SMEs face are due to bureaucracy and awareness. Policymakers need to engage proactively with SMEs to refine the financial programs to cater to their needs, so that sustainability investments are not classed as burdens but instead as an opportunity for long-term cost savings and market expansion.

Technological empowerment is also critical for SMEs to advance towards sustainable supply chains. For example, large multinational enterprises have sustainability teams that develop research projects and test products, but SMEs often struggle with the technical aspect of adopting green supply chain innovation (Mankar et al., 2025). SMEs often do not have the technical capabilities to develop eco-efficient manufacturing, digitally track supply chains, or reduce waste. Therefore, research institutions and industry stakeholders must work together to develop funded, accessible education and training programs and knowledge sharing platforms to provide the required technical capabilities for transformation. Building an ecosystem where SMEs are connected to sustainability innovators will enable a smoother transition towards green supply chains, without omitting technological adoption barriers that disrupt change.

Lastly, a lack of regulatory clarity is another fundamental barrier. Environmental policies are implemented to endorse sustainability, but SMEs often experience inconsistencies with enforcing standards and compliance. The absence of long-term certainty around regulations dissuades SMEs from making larger resource commitments to green technologies due to the potential impact of abrupt, unanticipated policy changes on SME's overall operational costs, exposing them to further uncertainty. When informing SMEs involved with suppliers that they must comply with environmental policies, policymakers must provide clarity over environmental regulations and simple, structured guidance that will inform them what is required and what agro ecological adaptation options exist. This is not only important for limiting uncertainty for SMEs, but also for introducing a supportive sustainability environment to SMEs compared to the burden of sustaining regulations.

Institutional support and stakeholder collaboration are key elements of creating an enabling environment for SMEs. Governments, industry leaders, and sustainability organizations must work collaboratively to establish structured capacity-building programs that better equip small and medium-sized enterprises with the support and mentorship, and industry focus to appropriately adopt green supply chain management seamlessly. Sustainable supply chain relationships between SMEs and large businesses can help achieve sustainability take-up where a larger entity provides support for transition to becoming greener through knowledge transfer programs, supplier collaboration opportunities, along with market integration opportunities.

The practical adoption of GSCM into SMEs comes down to more than mere compliance- it comes down to ensuring SMEs have the opportunity to thrive in a global economy where sustainability is a core mechanism of long-term viability (Okeke, 2024) dominating the business landscape with sourcing integrity, carbon neutralization, and sustainable business resources. SMEs cannot just meet environmental demands but also make the most of sustainability opportunities, and by adopting a sustainability-focused innovation mindset, SMEs will have the capacity to operate more efficiently, save money, earn greater customer trust, and maintain their position in growing international landscapes.

The commitment to green supply chains is no longer optional- it is the cornerstone of a strategic way forward that will contribute to industrial resilience, resulting in new sustainable and economic growth pathways and value chains. An integrated support structure that includes financial incentives, technical support, regulatory stability, and cross-sector stakeholder grouping will ensure innovation remains the most productive outcome for SMEs, not staying afloat in this evolving space but continuing to thrive and contribute to the sustainability agenda globally.

2.2 Supply Chain Risk Management (SCRM) and Its Relevance to SMEs

Supply Chain Risk Management (SCRM) is an important framework to identify (Pham et al., 2022), assess, and manage risks that affect the productivity of supply chains. Risks can come from both an organization's internal factors, including operational impairment (e.g., loss of equipment operational state), workforce impediments (e.g., strikes), or a number of external risk events (e.g., natural disasters, geopolitical insecurity, market volatility, regulatory unpredictability). The significance of SCRM has increased due to recent world events, specifically the unprecedented disruptions caused by the COVID-19 pandemic, as organizations faced considerable supply chain fragility and identified the urgency and importance of proactive risk mitigation plans to protect economic sustainability (Jahin et al., 2023).

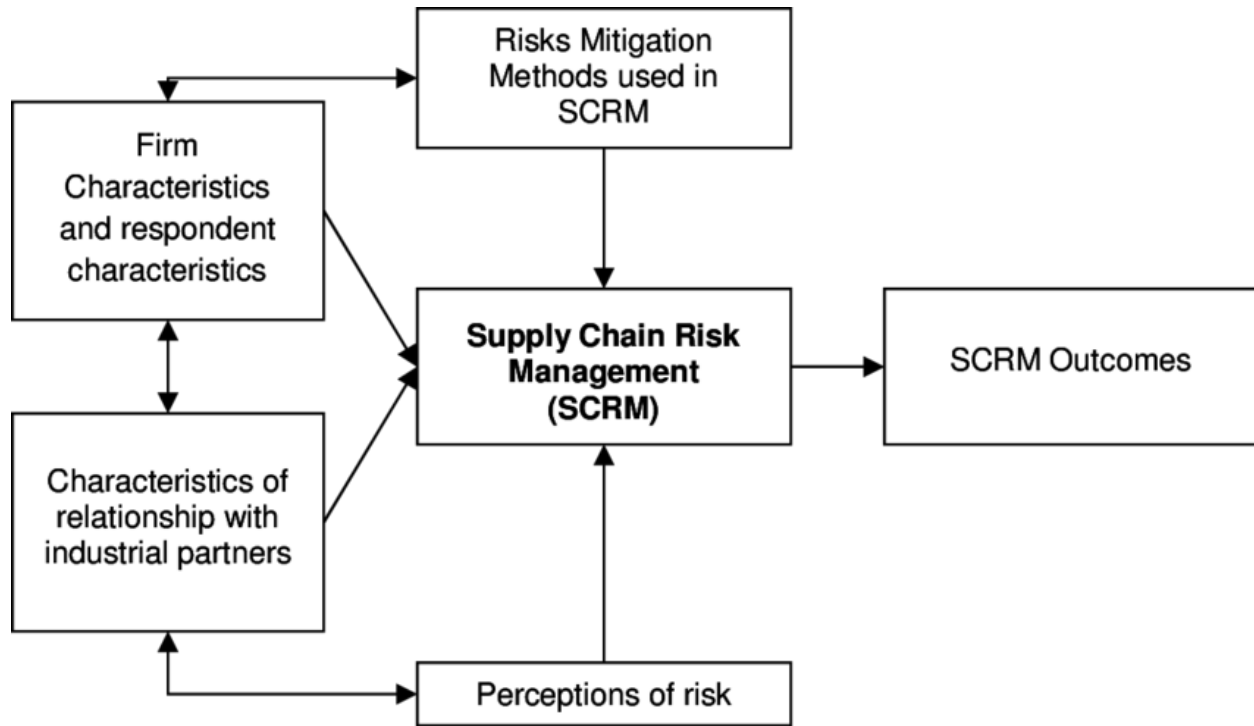


Figure 3: A theoretical framework for SCRM, (Olivier et. al, 2014)

Risk management is more complex in the context of GSCM (El Ayoubi & Radmehr, 2023). Moving toward sustainable (e.g., green) supply chains not only presents risks like any other supply chain transformation, but also additional challenges not found in ordinary operational risks. Evolving environmental regulations typically require existing business processes to undergo considerable changes as organizations are required to change existing documentation, commence new procurement processes, and deal with stricter waste disposal processes. SMEs are often confined by financial misunderstanding of environmental regulations or can only initiate operational changes aligned to new compliance demands based upon organizational structures that do not have the capacity to incur dramatic shifts in regulation or provide alternatives without considerable disruption to business models. In terms of environmental sustainability and the costs of investment (for example, eco-friendly packaging, energy efficient production systems, sustainable logistics, etc.), the technical and non-financial uncertainties contribute to considerable risk exposure for SMEs.

Another risk factor is the reliance on dependent specialized green suppliers. As businesses adopt sustainable practices, they are increasingly reliant on suppliers who can deliver on a number of environmental standards, while at the same time increasing supplier concentration that exposes them to more risk due to logistics delays and service failures from fewer available supply partners with limited flexibility. Supply chain disruptions can be caused by the availability of materials, delays in production, or other price shocks, which can disrupt supply chains for SMEs. SMEs

typically do not have the same range of financial and operational options available to soften the impacts of longer supply shocks. Supply chain disruptions can create financial burdens on SMEs that can far surpass the financial reserves, both operational and capital reserves, that SMEs have from continuously working on tighter margins. The financial pressures from these supply shocks can severely impact not only financial cash flow but ultimately profitability and long term viability of the SMEs system of government sustainably into their longer-term aspirations.

SMEs are most susceptible to risk exposure due to no formalized risk management structures (Crovini et al, 2021). Larger corporations typically have dedicated risk management teams, sophisticated analytical tools for forward flows of data to understand supply chain and logistics disruptions, and documented contingency plans to assist the corporation in navigating supply chain disruptions successfully. Alternatively, many SMEs typically utilize informal practices as their defaults for operational success through personal relationships and reactive decision-making without any structured risk assessment practices. The lack of forward planning exacerbates the SME's predicament as they are not proactively able to anticipate, assess, and mitigate risks before they become critical business issues (Babu & Yadav, 2023).

To reduce the impact of risks, SMEs must accept more structure through risk management frameworks that are cost-sensitive and scalable. Emerging digital technologies are advancing green supply chains and supply chain risk management, including big data analytics, blockchain-enabled supply chain tracking, artificial intelligence (AI)-enabled predictive modeling, and the Internet of Things (IoT). Technologies capable of continuously monitoring the supply chain in real-time will identify risks before those risks disrupt supply chains. Blockchain can build trust and accountability in supplier relationships - immutable transaction records improve compliance monitoring and limit the risk of fraud (Yildiz, 2021). AI-enabled predictive models leverage data to inform procurement planning, waste management, and overall sustainability metrics.

The wide-scale effective usage of a risk management system with digital tools requires initial investments in reliable infrastructure and workforce skill development, where SMEs often differ from larger enterprises (Omowole et al., 2024). The reality is that SMEs lack cost-effective access to technological tools or to workforce training; additionally, their workforce may not possess the technical skills to use such advanced risk management strategies. They can only fill this capacity gap through collaboration among policymakers, industry, actors, and banking institutions. Governments and other regulatory bodies must create specific projects to facilitate digital transformation in the SME sector (i.e., access to affordable technologies, subsidized training courses, knowledge-sharing, or conceptual collaboration systems), which will contribute towards SMEs innovating their sustainability capacity for managing risks in green supply chains. Building institutional support and collaborative strategies will, in fact, build the resilience of SMEs in green supply chains (Mehmood et al., 2025). The focus of policymakers should be the creation of

simplified regulatory systems that provide long-term certainty and guidance that minimize compliance uncertainty, and will also assist the leaders of SMEs in creating capacity-building programs that integrate sustainability opportunities and suggestions to not threaten their financial sustainability. Cross-sectoral collaboration between SMEs, colleagues in academia, and sustainability actors and experts may provide SMEs with the basic building blocks and warranties needed to identify and disseminate sustainability practices for adopting risk-aware strategies.

Identifying when to mitigate risks - and when to innovate sustainably - is imperative for SMEs within the sustainability context in today's global market, period. SMEs need to look at sustainable supply chain risk management (SCRM) as a value proposition, especially the wider value proposition of SCRM to not just be a problem avoidance strategy for disruptions. Instead, SMEs need to see SCRM as a strategy that allows them to be strategic and adaptive to discretion out of their control in the supply chain ecosystem, and ultimately realizing sustainability as a competitive advantage. Digital innovative technologies, and establishing risk - aware business cultures, can afford SMEs some protection from unknown obstacles whilst maintaining environmental sustainability commitments with the aims of ensuring compliance with regulatory frameworks, and also being a part of the global aligned interests changing supply chain practices sustainably.

Ultimately, creating valuable frameworks for SMEs with a process of risk management, digital transformation, and institutional support is critical for their participation in green supply chains. As SMEs work on building resilience, adaptive capacity, and innovation through sustainability, they can thrive in eco-conscious businesses, ensuring a competitive edge within their ever-evolving industrial ecosystem. SCRM and GSCM present an opportunity for SMEs to engage with their design framework of managing supply chains, moving from a form of reactive risk management toward a proactive infusion into the essence of their sustainable strategy to promote resilience and long-term growth.

2.3 Challenges Facing Indian SMEs in Adopting GSCM

The operational context of Indian SMEs presents an intricate set of intertwined structural, financial, technological, and regulatory challenges that severely inhibit their capacity to easily implement GSCM. These challenges range from an extreme scarcity of resources to a weak institutional framework and have established formidable barriers to the introduction of sustainable practices within SMEs. The capacity of SMEs to engage in a transition toward GSCM is further complicated by sociocultural factors, including low levels of environmental awareness, resistance to change, and a narrow focus on short-term profits, which combine to diminish the willingness and capacity of SMEs to commit to long term sustainability.

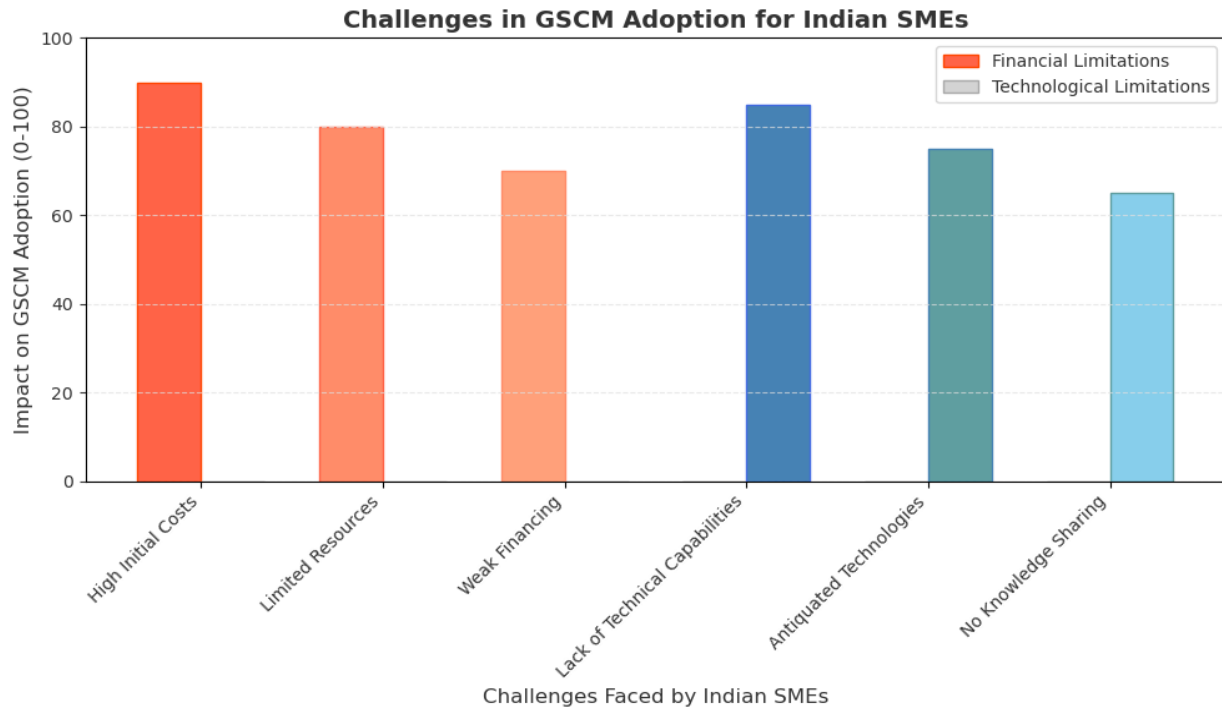


Figure 4: Challenges in GSCM Adoption for Indian SMEs

Among the challenges (Figure 4) confronting Indian SMEs are the severe limitations in financial resources. The introduction of GSCM involves high initial costs in order to invest in cleaner production technology, sustainable raw materials, energy-efficient and effective systems, and training for workers (Gawusu et al., 2022). Gonçalves et al. (2024) emphasize that small and medium-sized enterprises frequently encounter financial constraints, which restrict their ability to invest in and implement sustainable practices. However, the vast majority of Indian SMEs operate with very limited financial resources, thereby limiting their ability to reallocate money related to sustainability. Financing from external sources including government grants and green finance are weak and highly fragmented. In principle, many financing models, including government funding grants and green finance, have been established for a green transition, but they often rely on bureaucracy, a lengthy application process, and a lack of knowledge by SME owners to follow through on funding opportunities (Wasan et al., 2021). In the end, SMEs absorb a high cost of adopting green initiatives that is discouraging their attention to sustainability when weighed against their immediate operational liabilities.

Technological limitations also represent a significant impediment to GSCM adoption (Bolaji, 2024). Differing from larger firms with research and sustainability departments, SMEs typically lack the technical capabilities and know-how to fully realize systemic green practices. Given that SMEs usually utilize antiquated technologies, the incorporation of contemporary environmental management systems, carbon footprint decompression approaches, and waste management

systems is exceedingly taxing. Further complicating these challenges, SMEs lack technical capacities, knowledge, and structured channels for sharing knowledge, which should provide exposure to industry best practices, knowledgeable advisors, and networks to assist with transitioning towards sustainable models. Ultimately, SME's analog ignorance extends beyond sustainability strategies to any success in the implementation process.

The challenges presented to SMEs in India are compounded by regulatory uncertainty. An additional source of challenges for SMEs is regulatory uncertainty, although government policies and environmental regulations continue to focus on encouraging 'green' adoption, the compliance and enforcement mechanisms have been noted as weak, with enforcement of policies and a lack of consistency . In India, Micro, Small, and Medium Enterprises (MSMEs) face a range of challenges that constrain their development and threaten their sustainability. Key issues include restricted access to markets, inadequate skilled workforce, limited adoption of modern technologies, high capital costs, challenges in procuring raw materials, and substandard infrastructure (Dua, 2022). SMEs address evolving environmental problems relating to compliance, especially for those businesses without a firm compliance system or operating in fragmented supply chains. Regulatory uncertainty, including unclear long-term regulatory plans, has led to SMEs being reserved about investing in sustainability, especially with the concern of a sudden political pivot legally making their investment worthless. Fragmented supply chains also add structural challenges for Indian SMEs. In contrast to larger corporations that participate in organized and established supply chains, SMEs are more likely to operate or participate in loose and decentralized supply chains that lack consistent sustainability thinking. Lack of standard sustainability metrics and green procurement frameworks produces variable adoption rates and forces SMEs to remain decoupled from a full GSCM alignment. Not having supply chain partners (suppliers and distributors) willing to align with green practices also prevents SMEs from developing fully green supply chains. Any gaps here will need collective action towards supply chain transparency, collaboration, and the identification of shared environmental standards.

Even as structural and financial issues persist, sociocultural issues call into question SME perspectives on implementing GSCM. National values and organizational norms are important in shaping the adoption of Green Supply Chain Management (GSCM). Cultural dimensions such as individualism, uncertainty avoidance, and long-term orientation influence how SMEs interpret and implement environmentally sustainable practices (Elbaz et al., 2021; Hsu & Nguyen, 2023). Significant numbers of SMEs operate in market segments where consumer demand for environmentally sustainable products is weak, and therefore limit the business case for some form of greener adoption. Aside from a lack of consumer demand, there is often organizational inertia of SME stakeholders in developing a sustainable mindset, which is frequently associated

with either deeply embedded traditional business practices or a general ambivalence surrounding the necessity to adopt sustainable practices at all. Attitudinal change will depend on an appropriate level of awareness building, education, or, potentially, direct government intervention to help visualize the trade-offs that stem from operating businesses in a sustainability orientation.

Barriers preventing most Indian SMEs from increasing their GSCM adoption demonstrate a great need for a multi-dimensional support system that includes financial support (e.g., grants, subsidies, etc.), technical support (best practices advised), regulatory guidance clarity, and supply chain partners at each stage focusing on shared green practices. Gaps experienced by many SMEs will require structured systems to address distinct policies and programs for sustainability incentives, capabilities to build a coordinated approach for SMEs to develop a collective direction capable of accepting the weight of their capacity build, trust and transparency between the partner's trust, while allowing for sustainability benefits to arise in the long-term horizon. By encouraging 'safe spaces' from which SMEs can develop the skills, capabilities, and resources in order to systematically transition to GSCM, practitioners and policymakers will find a way to facilitate the development of Indian SMEs through GSCM practices into credible contributors to sustainable industrial development. To create a resilient SME sector able to flourish in a more ecologically conscious global marketplace, it is important to bolster institutional support and streamline regulatory frameworks.

To address these barriers, there will first need to be a paradigm shift in how sustainability is viewed, valued, and integrated into the SME ecosystem. According to Soda et al. (2015), training programs that emphasize Green Supply Chain Management (GSCM) principles can equip SMEs with the knowledge and skills necessary to implement sustainable practices effectively. In addition, Yadav and Yadav (2024) contend that financial incentives from government and private sector initiatives can make the adoption of GSCM practices more economically viable for SMEs. SMEs will need to start thinking of sustainability as a core strategic asset that advances efficiency, innovation, and long-term economic resilience, not as a compliance-driven obligation or secondary activity. This shift to a cohesive framework will rely on businesses, policy makers, tribal leadership, financial institutions, and industry icons working together to reshape operational models that embed sustainability at the heart of the SME functioning, no longer deviating as a resultant compliance requirement.

Facilitating this shift will largely refer to embedding a business mentality that acknowledges sustainability as a roadmap to competitive advantage, not merely a financial obligation. SMEs that are able to inject eco-friendly practices into the supply chain allow global environmental objectives to be met while staying ahead of the consumer preferences, regulatory pressures, and international market standards that will soon be recognized. The landscape of ESG reporting

worldwide is undergoing rapid transformation, driven by a growing demand for standardized frameworks that enhance transparency, comparability, and accessibility (Biswas & Gupta, 2023). Global sustainability frameworks are becoming stricter and SMEs that embrace, not wait for change, will only be enhancing their opportunities for business, positioning them for long-term customer loyalty, and establishing their brand identification; As one example sustainability enhances principles of efficiency, new material resources efficiencies and improved energy efficiencies can help lessen costs- creating cost savings-leaving businesses with greater potential for profitability that drive and keep their unique environmental impact at rest. A transformation of this magnitude must involve a multitude of actors. Policymakers must create clear and stable regulatory mechanisms to provide SMEs with certainty in their planning. The goal should be for SMEs to be able to plan to operate sustainably for the long term, rather than waiting until a regulatory requirement appears. Financial services companies must develop mechanisms to invest in a manner that is accessible and considerate of SME's needs, making green financing available to smaller firms who wish to implement sustainability in incremental steps, as opposed to solely to larger corporations. Industry leaders and sustainable development specialists must also provide knowledge-sharing activities, supplying SMEs with the fundamentals, data, and best practices that will allow them to transition toward green supply chains.

It is also important to recognize that building collaborative supply chain ecosystems will be necessary to accelerate the adoption of sustainability. Collaborative ecosystems facilitate the alignment of sustainability objectives among participants, supporting a collective approach to addressing environmental challenges (Klement et al., 2023). This is especially true for large enterprises, as they could effectively draw SMEs into their sustainability programs by offering a mentorship program and creating a relationship with SMEs as suppliers, and providing them with incentives toward more green practices. By building on the SME linkages in a larger industrial model, organizations can improve widespread adoption with less pressure to absorb individual financial burdens.

When sustainability is integrated more as a mode of operation, rather than an extended commitment, the SME sector will be in a better position to build organizations that are more resilient to economic volatility, increase competitiveness in the marketplace, and implement environmental objectives that will respond to pressures as they become evident as they grow. This journey does not have to be seen as a reaction to a regulatory hurdle to overcome, it can be seen as a necessary change towards innovation, efficiency, and long-term viability. By adopting sustainability practices into their core business models, SMEs can reduce costs through energy efficiency, reduce reliance on non-renewable resources, and build brand trust with environmentally aware consumers.

The call for sustainability innovation cannot be seen as an issue limited to one business; when it combines with others, it adds to the broader industry ecosystem and creates sustainable supply chain networks and economic viability. Integrating sustainability into innovation processes is critical for achieving economic growth and environmental responsibility, offering benefits such as cost savings, stronger brand reputation, and increased market resilience (Sahani, 2025). Policies need to allow SMEs to have regulatory clarity by allowing businesses to access compliance innovations with less uncertainty, which will allow for a long-term vision regarding investment in sustainable technologies. The provision of financial support through the use of sustainability-linked loans, subsidies, and grants can also reduce the financial burden of transitioning to more environmentally sustainable processes.

The empowerment through technology and related technical expertise is another important step in this process. SMEs necessitate accessible digital and data analytics, tools, and automations to integrate sustainability in their supply chain. Leveraging Information and Communication Technology (ICT) and big data analytics allows SMEs to process and interpret large datasets, supporting informed decision-making and the adoption of sustainable practices (Alabi et al., 2024). In addition, AI-driven platforms contribute to more efficient inventory management and supply chain operations by minimizing waste and enhancing forecasting precision, which is essential for sustainability (Al-Amin et al., 2024). SMEs can start optimizing their sustainability efforts using more advanced digital technologies such as blockchain for greater transparency in sourcing, AI-enabled predictive modelling for more efficient resources, and IoT-enabled monitoring devices for waste reduction. They will be able to increase efficiencies while reducing their environmental footprint.

An honest collaborative approach between SMEs and large corporations, policymakers, and sustainability practitioners must happen for all of this to take place swiftly. Collaborating across industries in partnerships can allow for a knowledge-sharing platform to help SMEs share best practices and identify training pathways tailored for their distinct needs, as well as drive engagement, interest, and innovation towards green business solutions. Influencing products that exhibit relevance towards sustainability means engaging global sustainability standards so that SMEs remain viable in international markets and opportunities, and purposeful contributors to the global shift towards greater awareness of responsible supply chain management.

Ultimately, sustainability must become the new normal core of SME's strategies to be effective. In summary, SMEs must be able to access the necessary policy frameworks, financing, and technology innovations by strengthening a collaborative and supportive platform ecosystem so that their struggles can be more than a temporary existence and enrich the behaviors of who they can potentially be in a world where sustainability does become the standard criterion for success, and not the latest trend. The sustainability shift towards resilience will not only reinforce

their ability to sustain a business but also offer more to contribute to the environmental goals of the world, and a sensible, responsible internet for the long-term future of industry.

2.4 Theoretical Framework

To explore the risk landscape of GSCM adoption in Indian SMEs, this research utilizes an eclectic, integrated theoretical source base that brings together constructs from GSCM and SCRM. Green Supply Chain Management (GSCM) emphasizes identifying environmental risks, such as regulatory changes and resource scarcity, while Supply Chain Risk Management (SCRM) provides metrics like the Cost of Risk that can be adapted to account for these environmental costs, thereby linking risk management with sustainable supply chain practices (Ritchie & Brindley, 2007; Zsidisin et al., 2024). Thus, it brings a systematic approach for classifying and approaching the risk understanding and management practices of SMEs, as they pursue their sustainability transition. This research develops a composite of the theoretical constructs with empirical work to systematically evaluate critical barriers and exposure of SMEs.

The integrated framework is intended to capture internal (endogenous) and external (exogenous) risk factors that SMEs face in pursuing sustainable practices in supply chain transformation. Internal risks are a function of resources, capability, and organizational shortcomings within the organization boundaries of SMEs. SMEs often face financial and human resource constraints, which limit their ability to invest in sustainable technologies, while a lack of skilled personnel and insufficient knowledge of modern technologies further hinders their adoption of sustainable practices (Bestvinova et al., 2022; Karmaker et al., 2022). The internal risks and factors also include financial shortfalls, a poor technological supply chain, inadequate workforce knowledge, and reluctance from the workforce to adopt new sustainability practices. There are also examples of banks not providing green financing to SMEs, technology can be costly to purchase and operate, and sustainability governance does not exist for SMEs. The lack of technical knowledge means that the implementation of GSCM is inconsistent, relative to the category of practice for GSCM.

In contrast, external risks originate from the larger macroeconomy and regulatory environment, which adds further levels of uncertainty and risk experienced by SMEs as they begin to adopt sustainable practices. Supply chains can be significantly disrupted by external shocks, including geopolitical tensions and pandemics, while variability in government sustainability policies adds further uncertainty, complicating SME's ability to plan and sustain long-term environmentally responsible practices (Bazile & Su, 2024). Policy intermittency, regulatory changes, supply chain disruptions, fluctuating and selfish consumer demand for sustainable products, and more broadly, global pressures from mainstream stakeholders contribute to greater risk distributed to the external environment. The Indian SME sector is faced with an inadequate system of enforcement and a patchy regulatory environment, which generally inhibits SMEs from

developing a climate conducive to the sustainable investment required for long-term viability. Many SMEs are reluctant to invest in 'green' technologies as they are at risk of having their investments wiped out by sudden policy shifts. The need to source specialist suppliers with very exact green standards also adds vulnerabilities to the supply chain, as they might not find vendors who provide sufficient choice in terms of the logistics systems, or simply the kindness of not bombarding their time with a lack of service.

By separating the strategic risks associated with the long term, around issues such as market positions, future investment options, and sustainable growth, from the operational risks associated with the daily workings of SMEs like inventory management, logistics coordination, and compliance, the framework provided gives a more nuanced understanding of SME's risk perceptions. As this framework identifies two levels of risk, SMEs can analyse the sustainability-related issues against their operational structure.

In establishing theoretical aspects of this framework into a usable format, this research will use a qualitative method, through in-depth interviews with SME managers, sustainability professionals, and policy makers. The primary focus of these interviews is to gain a real-world perspective of risk management practices, resilience-building practices, and their sustainability challenges. Once these interviews are analysed, this research will provide a tactical framework and recommendations for SMEs to improve adaptable capacity, reduce sustainability challenges, and improve resilience within the greening supply chain ecosystem. This framework, too, calls for interventionist actions to assist SMEs in their transitions to sustainability (Gennari, 2023). Financial incentives, regulatory support mechanisms and programs, industry partnerships, and capacity building will all need to be framed to address the specific constraints facing SMEs. Providing SMEs with access to reasonably priced green financing, developing SME technical capability, and supporting them by developing cross-sector collaborations will level the playing field to mitigate existing barriers to adoption.

This theoretical framework represents a significant contribution to closing knowledge gaps on the extent of risk exposure of Indian SMEs during their transition to green supply chains by framing how risk typologies, mitigation, and policy actions are analysed, offering a big picture analysis of the obstacles facing these enterprises taking considered steps towards sustainability. Recognising the nuances of risk in this context provides an opportunity to develop practical and tailored solutions addressing SME's unique structural and operational realities to ensure their GSCM transition is viable and of benefit to their business.

A key part of this transition is addressing institutional support and regulatory frameworks. Policymakers should establish enabling environments to assist SMEs so that they are not required to comply with sustainability obligations only - they are supported throughout these transitions. This means, regulatory mechanisms across environmental policies need to be streamlined for

consistency in support and with policies enabling long-term regulation and developed guidance to limit ambiguities regarding green adoption. An example of such support is provided by the European Union, which has introduced the Non-Financial Reporting Directive (NFRD) and the Corporate Sustainability Reporting Directive (CSRD) to guide SMEs in sustainability reporting, featuring a seven-step process to prioritize relevant topics (Gałkiewicz & Gaßner, 2023). Also financial incentives such as grants, subsidies, or lower interest loans with sustainability requirements, could potentially remove financial stresses preventing SMEs from investing in green technologies. In addition to this, government agencies will need to convene industry representatives to develop sustainability standards, in particular for SMEs, which signifies that sustainability can be consistent across multiple sectors.

Collaboration, knowledge sharing, and joint resource partnerships between SMEs and large global firms can expedite the transition to green practices. Strategic alliances with larger firms enable SMEs to obtain the necessary resources, technology, and expertise for sustainable practices, while joint research and development initiatives promote innovative solutions that support the implementation of green technologies (Soyombo et al., 2024). Industry experts and sustainability organisations must take a meaningful role in assisting with bringing the operational capacity and techniques required by SME leaders to help adopt a green agenda.

In summary, the results of this research can provide critical insight into how Indian SMEs can develop resilience and competitiveness in the face of dilemmas in sustainable supply chain transformation. The transition to green supply chains is more than an obligation, it serves as a strategy for industrial and economic sustainability. Building adaptability, entrepreneurialism, and collaboration with others will help SMEs maintain their position as necessary contributors to the transition to sustainable business practices, supporting them in their sustained growth in a greener global economy.

3 Methodology

3.1 Research Approach

The research utilized a qualitative approach for this study. Qualitative approach was chosen based on the research aim to investigate how Indian SMEs subjectively perceive, experience, and respond to the complexities and uncertainties related to adopting GSCM. As the sustainability transitions in SMEs tend to draw upon multi-layered context-driven dynamics - inclusive of resources, direct institutional support, technological capacity, and unit-based legitimacy - this research prioritised depth, meaning, and subjectivity over statistical representations and generalizable patterns.

Qualitative research approaches prove to be particularly advantageous for investigating emergent or under-explored phenomena, as is the case in domains with limited empirical evidence. GSCM in the context of Indian SMEs represents such an emergent and relatively under-explored, nuanced phenomenon. The growth of interest in many forms of sustainable organizational practices worldwide is acknowledged, and it also acknowledged some of the continued limitations of accessing ecological sustainability practices by Indian SMEs are apparent, scattered, and frequently untheorized in current academic literature. So, the qualitatively-based research permitted the researcher an observational snapshot of lived, contextual, practical, and organizational decision rationales associated with green supply chain management in SMEs.

The study is aligned with the interpretivist research paradigm, which considers reality to be subjectively constructed, and knowledge purposefully realized through exchange and relationships between the researcher and the researcher. This meant that an interpretivist view is opposed to realist approaches that assume objective truths and is instead anchored in multiple realities subjectively constructed based on potential qualitatively variable perception, experience, meaning, and interests. The research aimed to engage with leaders of SMEs through in-depth interviews in order to reveal how entrepreneurs make sense of green supply chains, what they perceive as key risks and enablers, and how they framed their strategic responses for the uncertain financial, operational, technological, and regulatory contexts they were facing.

The study used an exploratory research design as it was important to recognize the messy, evolving, and non-linear nature of green adoption within SMEs. Exploratory research is important when the phenomenon being researched is not well understood or there is no theoretical framework in place. Exploratory research design is an appropriate choice for the context of India as the adoption of green supply chains may be contingent on locally relevant factors, such as socio-economic diversity, regional disparities of development, inadequate infrastructure, and

fragmented and weak policy implementation while developing a comprehensive understanding of the green supply chain and its associated processes.

This study is based on 5 SMEs from India. In collecting primary data through interviews with the CEOs of each SME, this study took a structured approach that nevertheless allowed flexibility for the researcher to work from a set of questions, while also allowing for additional questions, context, and themes to arise from the lived experiences of the participants.

The conversations were recorded on following participant's informed consent, satisfying the ethical obligations of confidentiality and voluntary participation. Each recording was then transcribed and subsequently, the transcripts were reviewed and cleaned up for theme-based analysis. The result was an approach that recognized the complexity of participant's voices and experiences while still allowing the study to categorize and analyze systematically and rigorously.

The analysis process was inductive; therefore, a thematic categorization emerged from the data, rather than a rigid thematic organizational structure stemming from the researcher and their preconceived theoretical categories. This process allowed for inductive logic-based reasoning, not dissimilar from the exploratory purpose for which this study was intended to facilitate. Inductive reasoning proves useful here, especially in regard to remaining open to other forms of knowledge systems, including where the practices and processes of SMEs may differ from presumptive models people read in textbooks or poorly interpreted through Western frameworks such as GSCM.

Beyond understanding the risks that inhibit green supply chain adoption, this study also examined the internal and external enablers that make the adoption of sustainable transitions possible. Variables that contribute include leadership, technological innovation, availability of government initiatives, stakeholder demands, and infrastructure. From perspectives of exploratory and interpretive-based, this study endeavored to cultivate a broad, multi-faceted understanding of sustainability practices that are implemented in both constrained and ambitious business environments, with an SME focus.

In addition, qualitative design was adopted to provide the opportunity for participants to reflect and report their own meanings of green risks in their own language. This also helped articulate some contextual nuances like seasonal climate challenges, regional policy inconsistencies, and cultural regard toward environmental practices that would typically be simplified through a quantitative approach.

In conclusion, the research design integrating qualitative methodology and an exploratory approach informed by interpretivism was a conscious choice that aligned with the complex objective of this study. The complex objective was to expose the risk landscape of green supply chain adoption in Indian SMEs. This study captured the richness of localized, socially embedded

sustainability practices, acknowledging the roles of leaders of SMEs developing capacity within their organizations while disarming risk and offering strategic responses to India's changing environmental future.

3.2 The Sample: Case Firm Profiles and Selection Rationale

The sample for this study consisted of five small and medium-sized enterprises (SMEs) based in India, both of which have engaged in varying degrees of green supply chain practices. These firms were carefully selected using purposive sampling, a non-probability technique that enables researchers to focus on information-rich cases aligned with the study's objectives. The rationale for this sampling strategy was grounded in the desire to investigate firms that had firsthand experience with the practical complexities of adopting and managing sustainable supply chains in resource-constrained environments. By focusing on real-world contexts and managers with decision-making authority, the study ensured data collection from those with both strategic and operational insights into risk management in green transitions.

3.2.1 Sample Selection Criteria

The inclusion criteria for case firms were defined based on a set of operational and strategic attributes. These included:

- Active engagement or conscious efforts towards environmentally responsible practices, even in the absence of formal sustainability certification.
- Top-level managerial commitment to green supply chain integration, demonstrated through initiatives such as waste reduction, use of eco-friendly materials, or stakeholder engagement on sustainability issues.
- Sectoral diversity, to capture perspectives from both manufacturing and design-oriented business models.
- Willingness to participate, including openness to sharing operational challenges, risk perceptions, and insights into resilience strategies.

These criteria helped ensure that the case firms selected would provide a rich, diverse, and grounded understanding of how sustainability-driven risk management is navigated in Indian SME settings.

3.2.2 Case Firm 1: Suryaja Foods

Suryaja Foods is a small medium enterprise (SME) involved in food processing and fast-moving consumer goods (FMCG). The Kerala India organization, led by Mr. Naveen, manufactures tapioca-based products, including snacks, starches, and food ingredients and provides consulting services to other food manufacturers focused on the development of sustainable production

lines, operational efficiency, and processing innovation. By providing consulting services as well as product development solutions, Suryaja Foods has the opportunity to help improve the food processing niche of India's economy, providing valuable new food innovative products as well as food manufacturing innovations leading sustainable improvements for the food sector as a whole, given the extensive natural resource consumption and environmental impact of food processing; especially in agricultural based supplies. Sustainability is critical to the manufacturing plan of Suryaja Foods. Sustainability Initiatives and Integration with GSCM: Suryaja Foods has implemented an extensive list of GSCM practices to lessen waste, improve agricultural sustainability, and begin the transition to use renewable energy. One notable initiative is gelatinization technology, which can produce value-added products (edible coatings and industrial starches) utilizing tapioca starch waste byproducts, thus reducing the waste of raw materials, lowering operational cost (used within sustainable manufacturing guidelines), while maintaining good and desirable product quality. As part of its commitment to reducing waste, production managers monitor and manage the processing parameters to ensure optimal performance and a less wasteful output.

Suryaja Foods secures a steady supply of quality raw material by obtaining tapioca from Tamil Nadu since there is a greater land availability in Tamil Nadu than in Kerala, allowing market advantages. The firm diverts waste products, mainly the fibrous waste (injuries) from the tapioca production process, into organic fertilizers to sell to farmers in Tamil Nadu and Kerala. In doing so, they reduce the use of chemical fertilizers, improve the fertility of soils, and create a circular supply-chain model that is both environmentally and financially supportive. Suryaja Foods does not only provide the farmers with these fertilizers but also provides training on how to appropriately apply the manure and transition to responsible farming practices, positive and resilient farming practices as the firm recognizes the urgency of promoting climate-resilient and sustainable farming practices.

Energy conservation is a main component of the firm's GSCM practices. Inside the sugarcane facility, the firm makes an important step to sustainability by using bagasse, a renewable waste product as fuel and energy to create surplus energy for their energy intensive processes. This contributes to further reductions to carbon emissions, savings of energy costs, by reducing reliance on fossil fuels respectively. In addition, the firm will have solar energy panels installed and with governmental assistance in place covering 50% of the cost of the installation of the rooftop solar energy panels, the firm will use the solar power for its auxiliary needs and not grid use. However, challenges associated with funding the increased installation of solar energy, along with unresolved regulatory limitations from local utilities can complicate existing efforts involved in expanding into a complete solar energy model.

In addition to solar energy and organic fertilizers the firm practices responsible supply management, in the form of promoting responsible and environmental practices to farmers by supplying irrigation systems that are water and input-efficient. The firm is engaged in supplier monitoring for audit purposes and checking that environmental standards are being met regularly, in relation to the integrity of the tapioca supply chain. If institutionalized, these efforts will help to promote sustainable development dates in agriculture.

Challenges of an Ecological Sustainable GSCM: Although Suryaja Foods made significant strides towards the implementation of Sustainable GSCM practices in these ways, there are many barriers. One of the major impediments is that one has to rely on non-compostable plastic-aluminum packing that is important for food safety and integrity in humid environment as alternatives like cardboard or compostable options do not possess sufficient moisture barrier properties to prevent spoilage of product quality and maintain consumer food safety. Reducing the waste footprint of the firm is limited to the challenges presented in the FMCG sector.

Financial challenges remain a financial barrier for implementing GSCM. The costs associated with implementing green technologies (for example, packaging, additional solar investment) always gets obstructed by the initial financial outlay. Although the Government schemes helped reduce the costs incurred, and even provided some much needed momentum in one company's operations, the delays in the Government process for additional funding, as well as the appetite for risks involved presents another operational delay. The costs to test and certify sustainable packaging materials when combined with the time required for regulatory approvals takes a toll on the firm and undermines their efforts to scale their sustainability initiatives.

Due to the price sensitivity of the FMCG market and very low levels of consumer awareness regarding sustainable packaging for example, the demand for sustainable packaging becomes significantly lower. In this market, sustainability in purchasing is not at the forefront of consumers' minds, as affordability always outweighs sustainability, thus creating less financial incentive for Suryaja Foods to invest in GSCM which is ultimately beneficial, but is incurring increased costs without a financial gain.

Supply chain risks present problems too and in a state like Kerala that sources its tapioca from Tamil Nadu it is susceptible to delays in transport, (e.g. approximately 90% of tapioca is procured in Tamil Nadu during dry monsoon). This leaves the firm susceptible to vulnerabilities of the supply chain that include delays due to extreme weather or fluctuations in the market that will impact price as well. Transportation of developer's organic manure to the farmers and managing non-recyclable package waste builds up operational costs and carbon footprint, further fueled by Kerala's limited recycling systems. Understanding complexity brings about the necessity for solid risk management strategies.

Risk Reduction and Resilience Strategy: Suryaja Foods integrates Supply Chain Risk Management (SCRM) strategies into its strategy of risk reduction, with a demonstrated attitude of adaptive resilience. The company is involved at the highest level of collaboration with researchers and material scientists on government funded R&D projects, on biodegradable packaging by exploring bioplastics and paper-based composites which meet standards for food safety and moisture resistance. In a structured format supported by grants, these pilot projects ultimately comprehend reducing the scope of developing non-biodegradable systems while maintaining rightful integrity to the product.

For Suryaja Foods, working in a circular economy framework, turning tapioca waste into organic manure reduces waste for their partners while enabling their agricultural partners to leverage it for their products. Joining up with agricultural cooperatives assists with logistical issues relating to the notable amount of manure they have to redistribute, and also offer training to their farmers to incorporate sustainable practices that minimize risk associated with environmental impacts and resiliency at the supply chain level. Holding up a stock of tapioca will aid in ensuring production material when supply does not consistently provide, and the company has quarterly meetings with suppliers to help regularize sustainable practices and leave no room for deterioration of product.

Suryaja Foods is supported by Mr. Naveen, whose leadership, fostering a culture of sustainability to the employees. All employees receive training on waste segregation, energy efficient practices and will also likely be framed within thinking about Green Supply Chain Management principles when it comes to products that are food safe. Mr. Naveen wants continue to create awareness related to support for circular economy models and renewable energy for business decision makers, and represents the business and the industry to share with the government the inefficiencies of having different types of subsidies with different outcomes and the lack of inter-cooperation with variety industries of textiles, businesses competitions, and in the food processing industry that support sound, environmental practices, although does have ethical ramifications. Mr. Naveen is continually engaging with suppliers and stakeholders to showcase Suryaja Foods to advance sustainable food processing.

Value Added Strategic Considerations - Suryaja Food's Green Supply Chain Management (not solely limited packaging in resilient gelatinization technology, circular economy models and renewable energy practices is leading the way to become part of the majority of SMEs in the sector of food processing in India), may change the environmental load as registered small and medium enterprises prefer working with as-is SMEs value for environmental procumbent to support operational efforts: create some savings while reducing environmental footprint of your consumption - not as desirable; ultimately, it is the preference for some shared systems and consumable focused solutions over others suggesting initiating drinking in SIP 'conversational'

format of water in some and potentially many situations! The example and incomparable packaging build on a regional level aid in embracing a more common emerging moreover balanced environmental throughput by all business considerations in Suryaja Foods and but also toward upgrading model systems in India with some aim to realize the circular economy model pathways or other desired rational in merit of and into ideas and processes by apportioning synergies to sustainable development goals in India, for which assuming the role of Leadership-Driven Innovation, likewise considering supply chain or navigating complexities in its pathway points and forecast, if using this term similar to transitional development, offer and develop inherently sustainable systems.

3.2.3 Case Firm 2: Fairytale Interiors

Fairytale Interiors is an aggressive small and medium-sized enterprise (SME) in India that manufactures modular furniture and provides interior design solutions for residential and commercial clients. The operation is led by Mr. Sohail, CEO and has responsibility for the entire supply chain- designing, sourcing raw materials, manufacturing, delivery, installation, and post-sales. The firm serves a wide variety of clients, including residential customers, corporate office clients, and the hospitality industry and specializes in customized, space-efficient, modular furniture. In a resource-intensive industry, Fairytale Interiors uses various materials, including plywood, laminates, adhesives, and hardware; and has committed to sustainable practices using GSCM to minimize its resource requirements, waste generation, and environmental impact. However, as an SME, Fairytale Interiors has organizational, financial, and market-based pressures to implement GSCM and scale with environmentally sustainable options while still priced competitively within a price-sensitive market. Sustainability Practices and GSCM Implementation: Fairytale Interiors has introduced GSCM initiatives that have enabled it to commit to sustainability throughout its operations. One of the identified GSCM practices is local sourcing. For example, the Company uses local suppliers for plywood and laminates, which reduced transportation-related carbon emissions and logistics costs, combined with developing strong supplier relationships on paper, leading to quicker response times to need and added flexibility in production planning. The firm's standard practice is to formally audit suppliers several times per year to ensure compliance with environmental and quality standards, complying with its commitment to a sustainable supply chain. An example of a modal innovation is the material optimization software that creates efficient cutting layouts for plywood sheets and laminate sheets. This innovation helps to reduce material waste, increase the amount of usable modular components produced and minimizes the cost of production. Production managers work with Mr. Sohail as the supervisor, to ensure the software is optimized to customers' projects, all workers are trained to use the software properly and will improve environmental sustainability and operational efficiencies.

Waste management is the company's approach to a circular economy. They capture on-site losses in wood scraps and laminate offcuts and obtain the materials for recycling or upcycling. Usable scrap is converted into other small furniture elements, like drawer dividers or decorative parts. The company can extend the life cycle of unusable material. Losses that are not suitable for re-use are either posted on an e-commerce platform such as Amazon, Flipkart or donated to local artisans, schools and community groups for craft or educational projects. All of these efforts aid in reducing landfill waste and help create community value. Production managers enforce specific waste management processes with their teams, including programs to segregate materials as recycle, re-use, or waste in an accountable process that seeks benchmarks of improvement against sustainability targets. Employee engagement is the foundation for Fairytale Interiors sustainability approach. Mr. Sohail has advocated for regular training for employees around sorting waste, using energy-efficient equipment, and conserving materials. Production supervisors are accountable to monitor and discuss daily with their operators about these practices associated with implementing consistent sustainability practices. The organization also acknowledges employees by recognizing their new ideas for waste reduction with some rewards. This act has helped create an environmental view in the workplace for accountability of working towards effectively embedding GSCM.

Barriers to GSCM implementation - Fairytale Interiors faces the most difficult challenges to scaling their GSCM practices. There are limited financial resources to advance their use of green technologies such as solar energy to support their production in their manufacturing facilities for sawing, pressing, and laminating. Apart from the high cost of solar panels and installation, the process of obtaining subsidies takes considerable time with government bureaucracies. They focused their energy on financial viability, over sustainability. Fairytale Interiors is an SME and limited by capital and resource availability to take up green firm initiatives and unfortunately manage dual practices to complete a project in completion of resources used inside of the sustainability advance.

The market is very price driven and only limited customers demand to buy furniture with sustainability certifications. Customers will typically prefer more affordable products that are not sustainable products. Customers resort to using normal plywood or cheap adhesives for furniture, so luxuries like environmentally friendly furniture have non-consumer demand and little financial value for GSCM projects that incur costs with no revenue returns associated with higher price-marketing. This legitimate pricing issue under current market conditions supports the argument for customer education campaigns to grow demand for a furniture product that is sustainable.

Regulatory barriers exist in this mode of a modular furniture output industry to support implementing GSCM. The environmental compliance public process exists in automotive mass

manufacturing, renewable energy processes for sustainability, but not so for the furniture industry. There are competitors who can permit non-sustainable material use without regulation responsibility, and this is where Fairytale Interior's price disadvantage will fall. The dedicated commitment to become a sustainable furniture organization is becoming divergent in the market.

The supplier demand problem is again: lots of local cost cautious suppliers will accommodate all to minimize charge and margin to gain market share to sell low-cost normal laminates, adhesives, and follow a market-weighted convenience store for costs to measure factors like eco-friendly like backers or colored/low-cost unit costs. More supplier options for affordable costs, even for stakeholders in one resourcing option, must have to weigh in normal costs about upcycling or recycling out more raw material. In the wasted products/hazard/issues model. These suppliers then present future sourcing bottlenecks for the eco-friendly alternatives plus introduce new costs and high-cost risks for supply-chain issues.

3.2.4 Case Firm 3: Metalman Auto Limited

Metalman Auto Limited is a leading SME in India which is involved in the manufacturing of precision sheet metal and tubeless fabricated parts in the automotive and industrial sectors. This firm is run by Mr. Nishant Jairath who is the Director and supplies major original equipment manufacturers (OEMs) across the world including brands like BMW, CAT, and JCB, in the automotive, and construction sectors. Metalman Auto Limited has a solid operational footprint, as it uses advanced manufacturing to meet rigid quality and performance standards in a variety of applications. Metalman Auto Limited is significant to the Indian industrial ecosystem, and natives of India would understand Metalman Auto Limited's unique functions. Factors that created the integration of GSCM include regulatory obligations, OEM's demands, and publishing its responsibility towards Environmental, Social and Governance (ESG) strategies. Metalman Auto Limited is growing into a leader among Indian SMEs, although it is not without operational and strategic complications.

Sustainability Initiatives and GSCM integration. Metalman Auto Limited probably has one of the most elaborate GSCM policy development efforts, as it has a framework that is comprehensive and aligns well with its vision for environmental accountability consistent throughout its supply chain. For instance, one of the main initiatives is the introduction of renewable energy sources, which includes a one-megawatt solar power plant located near its main manufacturing facility, and the installation of rooftop solar panels on its production units. The firm and its stakeholders benefit from these initiatives as they immediately decrease and eliminate fossil fuels while saving on operational energy costs. Overall, Metalman Auto Limited not only reduced its energy footprint but included counsel on ways to lessen its carbon footprint as a firm and in the scope

of GSCM environmental protection, there will likely be further opportunities to invest in energy-efficient machinery that optimizes production and lessens its entire consumption of resources.

Waste management is also an important consideration for Metalman Auto Limited. Prior to and during the pandemic, Metalman Auto Limited developed robust waste separation and recycling systems that help collect, separate and recover metal scraps, plastics, and other factory waste. The metal scraps make their way to their partner recyclers while any waste that isn't metal finds its way into other forms of treasure as feedstock which not only reduces the waste sent to landfills, but also contributes to a circular economy. The firm also employs rainwater harvesting systems at its facilities that capture and reuse water both for business use and to replenish groundwater to help mitigate risk from water scarcity in India's variable climate and improved efficiency of resources.

To further develop its green supply chain, Metalman has utilized digital transformation through modern logistics and operations platforms. These systems digitize documentation and streamline transport logistics and improve monitoring and tracking. Collectively, these systems contribute to less paper use and less energy, and at the same time, reduce operational mistakes. The firm is also moving to alternative-energy vehicles, and electric/hybrid vehicles to improve logistics for last-mile and long-range deliveries and reduce emissions in its logistics, moving to OEMs demands on reducing emissions reporting on supply chain related activities. While this is at an early stage, this strategic business decision showcases the firm's commitment to decarbonising their supply chain.

Barriers to GSCM Adoption: While Metalman Auto Limited has continued to improve their process, the firm still experiences many impediments to the transition to a green supply chain. Limited financial resources can complicate adding GSCM components to the supply chain, and green supply chain technologies like the company's one megawatt solar plant and alternative-energy vehicles, have considerable capital investment. Though some of the investment was partially subsidized by the government, there are still operational follow-on costs to manage, especially workforce training to operate the technology, ongoing maintenance, and subscription costs for digital platforms which decrease the firm's viability for positive cash flow. This decreased control of cash flow creates additional challenges and issues with justifying the firm's green investments without a premium from its customers, which continues to limit the firm from expanding its green activities even if they are nice "cash" projects.

Moreover, regulatory unpredictability makes the company's sustainable endeavors increasingly complicated. Policies that do not specify the continuous nature of supportive financial incentives for green energy investments, such as the recent change to solar subsidies in India, challenges sound, long-term planning (investment) to create the business case for green supply chain and GSCM. Complicating and adding to the costs of adapting green practice in the supply chain, is the

environmental regulation variance across every Indian market and their compliance standards. Again, regulatory inconsistency is a recurring challenge that SMEs face in adopting sustainability.

Finally, grey supply chain suppliers are another significant blocker for GSCM. The challenge of the grey suppliers is that most upstream suppliers, at least the smaller ones, focus on drives to reduce costs, not innovate towards sustainability or an internal green supply chain. Their reluctance to invest in sustainable materials or processes creates bottlenecks in procurement and the firm has struggled with suppliers to get components that met its OEMs ESG expectations when they were initially sourcing material. The less certified green suppliers there are, the more specific nature of the supplier, and allowing to impact supply, there is an increased risk of delays or quality issues which add another layer of supply chain disturbances and puts additional pressure on expected production and deliveries to their customers.

Sustainable Transformation and Strategic Resilience: The firm also relies on Supply Chain Risk Management (SCRM) Systems and views GSCM, more like a continuous development & implementation process or journey for the company and recognizes that now is not the time for the corporation to shift to GSCM at once, instead achieving sustainable objectives will be viewed in action and projects in discrete phases as part of this transformation for Metalman Auto Limited. The initial project will be the lowest cost project.

3.2.5 Case Firm 4: DO Future Energy Solutions

DO Future Energy Solutions is a growing and responsive small and medium-sized enterprise (SME) domiciled in Kerala, India. It resides at the intersection of applied technology and environmental weal, designing and deploying solar energy solutions for organizations in the commercial and industrial sectors. The current Chief Executive Officer of do Future Energy Solutions is Mr. Sreeraj who leads the firm through all provisioning of solar panel systems and components along with a design, installation, and maintenance service. Do Future Energy Solutions operates in an Indian renewable energy sector that is growing quickly and purposefully, where sustainability is at the core of the firm. It defines its operational processes in relation to national and international goals for clean energy transition as well. Green Supply Chain Management (GSCM) is a foundational pillar of its business model considering procurement, logistics, and waste management. It has implemented processes to drive decision making based on sustainability, which both lessen the firm's overall sustainability "footprint", and add value to its market position as the economy incorporates sustainability into the corporate agenda.

Sustainability Initiatives in GSCM

The incorporation of sustainability strategies into an organizational framework is demonstrated through a variety of GSCM practices aimed at the firm's stakeholders. The most significant initiative for the firm is the green procurement policy to ensure that its suppliers carry out a

considerable effort to meet high-quality and environmental standards. The plan requires that the suppliers provide components with Bureau of Indian Standards (BIS) certification to ensure the integrity of systems to be installed, such as quality manufactured components for solar panels, inverters, batteries, and other components that are used to build a photovoltaic system. By choosing certified suppliers, the company addresses performance and environmental compliance in a more sustainable operation. This advantage covers not only the environmental impact from cheaper low quality products supplied from abroad, but it also limits unrealized reputational and technical risks from system failures. With the right supplier selection, Do Future Energy Solutions, will build on its credibility as a sustainable energy provider.

On the logistics front, the firm has taken numerous steps to reduce the impact of the transportation of components, reducing the carbon emissions associated with transportation. The company also recognizes the carbon cost of moving materials between geographies, and has researched and invested in smart logistics: route optimization algorithms, delivery consolidation plans, and load maximization. These measures improve efficiency of operations, limit fuel consumption, and reduce emissions. Working with local transportation companies also reduces travel time and transport distance too, reducing carbon intensity of logistics. Fuel efficient, and electric or hybrid vehicles where feasible, also help offset long term costs. As a whole, the logistics function employed by the firm follows the lean principles of GSCM- vanishing waste, increasing efficiency, and synchronizing desired operational practices with environmental considerations.

The company's focus on sustainable waste management can help address the issue with solar energy: how to effectively deal with production and end-of-life waste. If not taken care of properly, damaged solar panels, decommissioned batteries, and disposal of packaging materials, can pose an environmental hazard. The firm has established formal waste handling procedures to account for this. These processes incorporate systematic sorting processes that separate recyclable items such as glass, copper, and aluminum from hazardous items like lead-acid batteries and chemicals-based caulking. The firm partners with qualified recycling organizations to manage the disposal of these items in a sustainable manner and thereby redirect waste away from regular landfill channels. In addition, it conducts periodic or sometimes 'regular' internal audits to survey the status of these processes in order to measure success and weaknesses. It also uses audits to aid in operational improvements. The firm also passes its sustainability principles onto its clients by educating them on safe disposal practices of solar systems once their operational days have ended, allowing it to help its sector act responsibly. This 'thou shalt not make waste' philosophy allows the firm to help propagate a shared commitment across the supply chain ecosystem.

Challenges of GSCM Implementation

Although Do Future Energy Solutions has made great progress on implementing its green practices, it continues to face a variety of operational and systemic challenges on the implementation of GSCM. A key challenge exists in legislated surplus inventory when procuring the appropriate supplies. In particular, it continues to struggle to source BIS-certified components on a regular basis, due to a lack of local suppliers. This supply issue leads to high costs per unit of procured supplies, and a lack of reliability in receiving sufficient to fulfil orders which in turn disrupts delivery dates and the scheduling of projects. Additionally, the reliance on a limited supplier base puts the organization at risk of external shocks, including international export bans, raw material shortages, and disruption to global supply chains. All of these factors are particularly serious issues in the renewable energy space, as the need for specialized components will impede green supply chains (GSCs).

Constraints on cash flow make it difficult for the organization to grow and strengthen its GSCM practices. While companies can achieve a considerable driver of sustainability by employing technologies like GPS-based fleet tracking, digital inventory management (e.g. junk storage), and modular recycling units, adopting these technologies can entail sizable capital investments. The organization, as a small and medium enterprise (SME) in a capital-constrained market, finds it difficult to access funding for the larger amounts required for the transition to sustainable technologies. While the Indian government offers incentives and subsidies for renewable energy projects, there is significant bureaucracy to navigate, and this has spilled over into delayed payments and cash flows of months and thus poor planning of sustainable initiatives across the organization as to enabling the firm to broaden the financial scope and scale of planning for sustainability. With limited "green" financing products available to SMEs, there has been low impact, utilizing slow forms of finance, leading to reluctance for much larger capital investment on sustainable infrastructure.

A third challenge in adopting GSCM relates to a lack of infrastructure in rural and semi-urban environments where the organization's SMEs clients' stakeholders are situated. Many of these regions do not have the waste management and recycling infrastructure required to allow efficient GSCM practices. Transporting a volume of solar waste (e.g. broken panels, used batteries, mounting framing) from a location far away from the near-simulated landfill sites back to a lower volume, sort of certified recycling national center based in large urban environment serves to be prices further in allowing inefficient transport movements and seeking an alternative provider is unrealistic. The absence of nearby recycling partners may compel the SME to store the solar waste back before seeking to be recycled and engage with various levels of regulations in becoming compliant to the location of that potential landfill. The lack of such infrastructure represents perhaps a structural barrier toward returning to a circular economy via decentralized solar projects.

In conclusion, Do Future Energy Solutions has positioned itself well for sustainability, in its operational model, to the GSCM space. The future business model strategy causes us to link to green procurement, low carbon footprint, efficient distribution and transportation, as the identified areas of technical waste and responsible waste disposal categories link the firm closer towards a weak standard represented in the circular economy of sustainability. Although its action is weak, it is taking action today in areas that are considered no less sometimes constrained to the decisions in a market of SMEs to innovate new approaches in green, while knowing that its sequence follows in regulatory compliance along that journey. The on-going issues of constraints in the supply chain, availability of financial access to broaden the gap coverage and a reliance of infrastructure to develop circular economies all need incentivized progressive policies towards a supportive system that creates a path towards the support needed for SMEs to drive GSCM in the renewable energy sector.

3.2.6 Case Firm 5: Ecosun Power Solutions

Ecosun Power Solutions, a dynamic and future-oriented small and medium-sized enterprise (SME) based in India is engaged in providing end-to-end solar energy solutions. The company serves a wide range of clients, across many product and service sectors, domestically, commercially, and industrially, facilitating the decentralized deployment of renewable energy. Under Managing Partner Mr. Vyshak's leadership, the firm provides a complete solar system lifecycle service- system design, installation, preventive maintenance, and performance tuning. Additionally, the firm has expanded its offerings to provide solar panel servicing and cleaning, which sustains energy yield and prolongs the lifespan of installed systems.

Ecosun Power Solutions operates at a rapid pace in the dynamic Indian renewable energy industry, while sustaining environmental sustainability at the heart of work philosophy. Ecosun Power Solutions aligns its practices with national clean energy policies and global climate commitments, including the objectives of the Paris Agreement. GSCM is a key part of Ecosun Power Solutions' strategic lens for its supplier selection, logistics planning, and waste processes. Under their environmental responsibility practices, the company is able to meet the regulatory obligations whilst being competitive in a world, where sustainability considerations are becoming essential for customers and stakeholder decisions.

Sustainability Initiatives and GSCM Integration

Ecosun Power Solutions has established a number of strong sustainability initiatives that are based in GSCM. A green procurement policy is at the heart of Ecosun Power Solution's sustainability plan, that seeks to procure eco-certified products. The company sources solar panels, inverters, and accessory components only from the Bureau of Indian Standards (BIS) certified. This decision indicates that the company's materials meet the standards set out in various guidelines provided by the Ministry of New and Renewable Energy (MNRE) and Kerala

State Electricity Board (KSEB). This choice is made in order to ensure environmental adherence and also technical standards to increase system reliability for an extended life. The operation strives to limit its engagement with low-quality materials or non-compliant materials whenever possible in order to bolster the image of being a brand associated with high quality and environmental responsibility in energy solutions.

The company imposes various operational emissions reductions activities in the logistics arena to limit the carbon footprint of the operation. Ecosun makes use of route optimization software to develop the shortest and most cost-effective travel routes to customers for site visits or installations. The good or bad emissions metrics are captured in a technology that consolidates our delivery, limits the time wasted traveling, and runs as productive a fleet as possible. Additionally, the company is connecting with only local logistics providers to limit travel distances and consolidates deliveries requiring smaller commercial vehicles or, if bigger vehicles are required, they try to use the most fuel-efficient vehicles possible. This multi-pronged approach is also good for the company's bottom line as it ties shorter distances to deliver materials to lower transport costs, and lower greenhouse gas (GHG) emissions. These emissions reductions or lean operations provide further opportunity for the values of sustainability to intersect with efficiency and cost competitiveness.

Another big operational area for the company is waste reduction, much of which is a result of damaged panels, battery waste, and trucking or installing waste debris. Ecosun has established procedures for separating out, collecting, and disposing of the various waste streams. They separate materials that have a second-life like recyclable materials (e.g. glass, aluminum frames, copper wiring) from hazardous waste (e.g. lead-acid batteries). The company works with local waste recycling facilities that are either licensed or inspected by the government so they are assured that waste is handled correctly and that there are environmental compliances. Having local recycling partnerships reduces the company's reliance on landfill space and provides circular economy contributions. Furthermore, Ecosun conducts educational sessions with clients on proper product disposal and recycling practices at the end-of-life of the solar system. Through the education of stakeholders, the company can potentially provide a sustainability impact beyond its immediate operations. Conducting audits of waste management practices enables the company to track performance and identify inefficiencies while creating opportunities for continuous improvements.

Challenges of GSCM Implementation

Although Ecosun Power Solutions attempts to be exemplary in sustainability, the company realizes several barriers will be faced in pursuit of a full-scale GSCM implementation. One implementation barrier prevalent to the company is sourcing BIS-certified, environmentally friendly components. The limited suppliers for sourcing certified, eco-compliant suppliers can

create bottlenecks that leave the company in a position of indecision about procuring items. Furthermore, the few suppliers that exist have variable product compliance, or quality issues that postpone project timelines. Consequently, these supplier weaknesses put the company at higher levels of risk in the supply chain especially in times of market volatility or regulatory changes.

Ecosun also considers the financial aspects of GSCM alongside stakeholder engagement as a challenge to their GSCM framework. The company finds the high up-front costs for green-certified materials, cost related to energy-efficient transportation systems, and cost for waste segregation infrastructure an issue they are faced with. As a mid-sized company with only a limited amount of capital Ecosun often struggle to achieve the same financial capabilities to fund sustainability. While various MNRE schemes provide subsidies and incentives, slow process and delays in administration impede the firm from receiving these funds in a timely manner. This restricts the firm from scaling its sustainability efforts, or investing in advanced GSCM technologies such as real-time tracking systems, or modular recycling units.

Infrastructure challenges—especially in rural and geographical challenges exist that create further barriers to implementing GSCM. The locations of many of Ecosun's clients are in very remote areas which do not allow for the sufficient recycling facilities required, forcing the firm to transport recyclable waste to urban areas, increasing both financial and environmental costs to handle waste. Further, poorly maintained road infrastructure and a sporadic energy supply to hilly areas limits the firm's ability to achieve great logistics performance. Gaps in infrastructure continue to strengthen the urban–rural divide in deploying green energy and demonstrate systematic gaps at the SAME level within the renewables space.

Risk Mitigation and Strategic Resilience

To overcome the above challenges, Ecosun Power Solutions, for example, implements strategic SCRM strategies to amplify operational resilience. The firm implements multiple supply sourcing to mitigate procurement risk. Flooding the secondary supply base with BIS vendors while also identifying those vendors, allows Ecosun to focus on reducing single source suppliers, and creates the desire to sustain their business continuity. Secondly, the firm continuously supports its supply partners by providing technical consultation and quality improvement suggestions that would allow more vendors to establish eco-compliant elements and increase the ecosystem of eco-compliant vendors with the supply partner.

In order to mitigate delays in project implementation, Ecosun keeps a buffer stock of inbound critical items / components. Although there is a holding cost associated, it forms a trust with customers that projects would be delivered within the determined timing, forming a working relationship. Moreover, the firm develops scenarios towards uncertainty through good planning,

towards factors of policies, regulatory changes, BIS standards, news related to weather disruptions—particularly during monsoon season. These risk mitigation measures, whether that be stringent logistics plans, ensure Ecosun has a keen foresight strategy with respect to resilience, and sustainability.

3.2.7 Ethical Considerations in Case Selection

The selection process was guided by strict ethical principles. All participants were informed in advance of the study's purpose, the voluntary nature of their involvement, and their right to withdraw at any stage. Participants provided verbal consent, and all interview data were anonymized where required.

3.2.8 Contribution of the Sample to Research Objectives

By selecting five SMEs from distinct yet environmentally relevant industries, the study was able to achieve its central aim: to investigate how SMEs in emerging economies identify, perceive, and manage risks associated with adopting green supply chain practices. The sample provided insights into both internal enablers, such as leadership values and innovation mindset, and external constraints, such as financial limitations, policy gaps, and technological shortfalls. These insights formed the foundation for the thematic analysis that followed, allowing for a nuanced, experience-driven exploration of risk management and resilience building in sustainable SME operations.

3.3 Data Collection

The data collection was conducted using a qualitative research approach., mainly using interviews with key stakeholders within five purposively selected SMEs in India - Suryaja Foods (food processing), Fairytale Interiors (modular furniture and interior design), DO Future Energy Solutions of the Industry (consulting and solar solutions), Metalman Auto Limited (automotive manufacturing), and Ecosun Power Solutions (renewable energy). SMEs were purposively selected based on criteria of active involvement in green supply chain processes (for example, sourcing eco-friendly products, reduction of waste, or implementation of energy-efficient processing), representation from different sectors in order to capture different supply chain specifications and dynamics, and having senior people such as CEOs or operations manager available to take part in the research from each of the selected SMEs.

Potential SMEs were identified through a process of identifying potential SMEs using industry networks, business association recommendations, and online directories targeting sustainability-oriented SMEs. The potential SMEs indicated as a result of this process were contacted via a telephone, text message or email with an introduction to the purpose and scope of the study.

The first communication included an explanation of the confidentiality assurance measures provided, along with an information sheet to support obtaining informed consent, including the participant's right to withdraw from the research at any time.

The interview questions were designed and refined in a manner to directly address the research aims, as the respondents were prompted to discuss their organization's current green supply chain management practices, sustainability aspirations, perceived risks in respect of implementing GSCM, as well as their assessment of which of those risks were most serious or damaging, and their rationale for establishing that ranking. They were asked whether they perceived risks more directly as originating in internal effects (e.g., financial challenges, technology challenges, resisting organizational commitment) or external influences (e.g., acknowledgement of key supplier challenges, lack of regulatory adherence/stability, changing market demand), and to describe the origins of those risks, as a means of developing a more detailed understanding of where one thinks the risks were coming from. They were then asked to describe the stages of the supply chain where risks would be more concentrated (e.g., sourcing, production, logistics, distribution), and how the risk would present a possibility to interfere with operations and subsequently costs or compliance with environmental impact reduction approaches. The interviews were then designed to invite the respondents to demonstrate how they take responsibility to identify and monitor possible risks, whether they employed a formal methodology such as checklist, risk assessment and/or audit to map and assess risks, and what dimensions of risk perceived as difficult to manage because of the Indian SME context, including examples such as regulatory instability, market competition or weak infrastructure. Respondents were also asked whether or they felt a limited suite of resources (financial, human or technological) made them more exposed to risks, or if their resources required them to respond faster to risks, and would be some resources they would address first behind their rationale.

The interviews were conducted virtually through google meet and some participants preferred answering the question through Whatsapp audio recording due to their busy schedule.

Each of the five interviews included one key decision-maker from each SME to ensure the participants provided information based on their experiences in delivering GSCM. The sessions lasted from 20–25 minutes which provided enough time to get through all questions, while keeping to the schedule formed and respecting participants' time.

The researcher began the interview with the introduction script to build rapport, before moving through the questions while using probes following responses that invited further insights. For example, if the respondent from Suryaja Foods identified "regulatory unpredictability" as a

significant level of risk, the researcher would follow the respondent's response with a question such as, "How has that affected your compliance costs or sourcing decisions?" to probe for specific risks. In a similar vein, when Do future Energy Solutions raised rural logistics challenges as a risk concentration in distribution, a second question probed the delays of timelines for delivery, and the implications to customer satisfaction. The virtual context made transparency easier with the option of screen sharing the consent form and recording controls. There were minor connectivity problems in five interviews, which were solved fairly quickly, and did not result in anything substantial lost in the data. One respondent mentioned a recent change in policy that impacted the region, which was subsequently used in the analysis.

All recordings were transcribed by the researcher using a digital application. The researcher then manually transcribed each audio recording to accurately reflect the interviewee's regional accent and the correct usage of terms, such as "BIS-certified materials" or "gelatinization technology," that may have been inaccurately identified with use of a digital transcription application. Each transcript was attached to each recording, and the researcher reviewed the manuscript against the audio recording to correct errors or remove unnecessary filler words (e.g., um, you know), and intellectual property that could identify an organization was anonymized to eliminate any identifying names by generically naming supplier and/or client organizations by title (e.g., "Supplier A" for a supplier identified by Metalman Auto Limited).

To improve consistency between transcripts, the transcripts all used timestamps, included speaker identification (e.g., "Interviewer," "Respondent") and indicator prompts for pauses or interruptions, to ensure an easy-to-understand review of the transcripts for exploration contributing to traceability and audit trail for dependability. Audio recordings of the interviews and transcripts were kept on cloud platform (Google Drive) and restricted to only the researcher for security and confidentiality of the data.

Conducting the study was done in alignment with all ethical considerations to protect the participants and have the study executed ethically, with integrity. Each participant was provided with an informed consent form by email and reviewed the informed consent form during the Zoom call, which provided detail on the purpose of the study, that participants could withdraw from the study at any time without penalty, and brief descriptions to the meaning of confidentiality, and all participants consented. In consideration of commercial sensitivities, all identifiable references have been anonymised in each transcript and report. Participants were also assured that their data would only be used for the purpose of research, and not for the purpose of third party endorsements, as per ethical requirements.

3.4. Data Analysis

This section includes a detailed description of the analytical processes followed to prepare, analyse and synthesize answers derived from the empirical data taken from interviews with key

decision influencers from five Indian small and medium-sized enterprises (SMEs) based in India. We collected secondary sources in the form of relevant government documents, industry reports, and academic literature, to support our findings, particularly to provide broader context, depth, and a Launch Base for completion of our analysis. The key focus of the analytical process was to directly engage with the primary research question, *What are the key risks presented to Indian SMEs in adopting Green Supply Chains?* The analytical framework was informed by a mixed method '(quantitative and qualitative research methods) approach providing an analysis that is sensitive and over-arching, considering the risks, barriers and enablers associated with the adoption of Green Supply Chain Management (GSCM) activities in the Indian medium and small enterprise context wise. A mixed method approach was intentional in that it provides the benefits of both methodological approaches and allows for the more meaningful integration of the quantitative robustness of numbers and the qualitative meaning(s) that grows from it. The final important consideration was that many studies advocating defining the complex transition to sustainability processes inherently requires multi-paradigm research designed using rigorously structured methods to allow for a more comprehensive, evidence-based picture of the existing contextual dynamics integrating the transitions between people, business with sustainability processes in SMEs.

In particular, the first step of the analysis process required several preparation tasks to demonstrate the trustworthiness, dependability, and ethical soundness of the primary data set.

Each transcript was carefully cross-checked against the recruiting audio files, checking for transcription errors and recording the mistakes as I checked for accuracy and correctness.

To maintain research integrity and confidentiality toward participants, all identifiable information such as the names of individuals, organizations, clients, or suppliers were deleted. It is important to point out here for accuracy, but details about, verbal fillers, or irrelevant exchanges that served no purpose for the research aims were removed.

The aim of the qualitative analysis was to establish an empirical baseline by measuring the frequency of thematic components that appeared in the interview transcripts. Themes were coded deductively from the format of the interview guide and included, for example, (i) green supply chain practices, (ii) types of risk identified, (iii) severity of risks, (iv) where risks come from (internal, external), (v) where risks are most concentrated in the supply chain, (vi) operational and financial effects of risks, (vii) nature of processes of response and mitigation, (viii) challenges of working in the Indian SMEs, (ix) constraints of financial, technological, or human resources, and (x) risk prioritization processes. For each transcript, we completed a line-by-line reading and calculated the frequency of thematic mentions. These frequencies were then represented in a number of different formats where frequency is involved to assist interpretation and discourse around findings. The horizontal bar chart demonstrated the number of appearances of each

theme facilitating relatively easy comparison of prevalence. The pie chart represented the participation of each theme to the data. The word cloud represented thematic mapping with weight of description represented by the frequency of occurrence, facilitating visualization of the risk factors and GSCM practices that were most prominent in discussion. The treemap was used to represent the thematic hierarchy and distribution with the size of blocks representing frequency and color demonstrating visually distinguishable groups of codes. These visualizations were produced using a chart producing software that enabled consistent formatting, high accessibility and methodological transparency.

The qualitative analysis was undertaken as per Braun and Clarke (2006) well-known framework for thematic analysis. Thematic analysis was chosen because it is systematic yet flexible and emphasizes what is being said about patterns, meanings, and complexities in rich text-based data. Thematic analysis was done in an iterative manner involving three stages of coding. The first stage was open coding, where descriptive codes were derived inductively from a close reading of each transcript. The codes were based in the participant's language to ensure analysis was representative of lived experiences. For example, *"Solar panels were installed to reduce electricity expense" was coded as "technology adoption,"* while *"We have trouble with regulations that changed often" was coded as "regulatory uncertainty."* After descriptive analysis was completed, we proceeded to axial coding, a process where similar or related codes were grouped into overarching categories and sub-themes. Axial coding also allowed us to identify and interrogate connections between codes such as, *"financial constraints" and "lack of skilled labour," which were coded as "internal challenges,"* and the prominent co-occurrence of *"regulatory instability," indicated important interdependencies.* The final phase of the qualitative analysis was to retrieve themes from the previous sub-themes and develop core thematic constructs to directly address the research question. The main themes identified included *"Key Risks in GSCM Implementation," "Systemic Barriers to Green Transition," and "Contextual Enablers for Sustainability."* Throughout this phase of analysis, we engaged in sequential iterations to check for consistency and saturation amongst themes and were mindful of the salience and relevance of themes across cases.

As a means of enhancing the trustworthiness and credibility of our analysis, a qualitative data management software called NVivo was used to facilitate an analysis tool. We imported transcripts into NVivo and organized codes as 'nodes' so that we could retrieve and reorganize material into segments systematically. The software was utilized to explore thematic co-occurrences or, for instance, how many times "stakeholder pressure" appeared beside "strategic adaptation." As new themes were identified the nodes were adjusted, either combined, reorganized or renamed, to better reflect the interpretations developed. For example, a node initially labelled with the title "external risks" was adjusted to two separate nodes of "regulatory challenges" and "market volatility" to better reflect the nuances from the responses of study

participants. The decision protocols for the coding and themes were captured in NVivo built in memo and audit functions, ensuring the transparency and traceability of the analytic process in case further reflection or replication was needed.

Further, at the conclusion of individual analysis and assessment stages. The researcher sought to evaluate the quantitative analysis for high-frequency themes, through the depth and contextual richness of the qualitative findings. Attention was paid to their similarities, and for themes that warranted attention, frequency counts were checked to ensure mentions were not solely based on a repetitive mention by one respondent. In addition, secondary data sources were identified to affirm or counter suggestions drawn from the primary data. For example, the notion of regulatory complexity, observed in all interview transcripts, was compared with consent (or lack thereof) in existing policy documents, or with findings in industry-based white papers to establish consistency across broader systemic tendencies.

This analysis of the data for this study has provided a methodologically rigorous and conceptually robust approach to understanding the complexities and barriers faced by Indian SMEs adopting green supply chain management practices. By integrating frequency-based forms of quantification with inductive thematic analysis approach and supporting these forms with NVivo-assisted coding, data visualisation techniques, and triangulated evidence from a variety of sources/frequency data and situational knowledge, this study has provided a empirically-rich description of the risk landscape surrounding sustainability adoption. Further, the analytical framework in this study provides a relevant springboard for producing potentially successful suggestions for rich insights and evidence-based recommendations on policy, practice and future research about sustainability in SMEs in emerging economies like India.

3.5. The Assessment of the Quality of the Data

This section critically evaluates the quality of the data collected for this study, ensuring that the findings presented in Section 3.4 are robust, reliable, and aligned with the research objectives of exploring the drivers and barriers to Green Supply Chain Management (GSCM) adoption among Indian Small and Medium-sized Enterprises (SMEs) in the manufacturing sector.

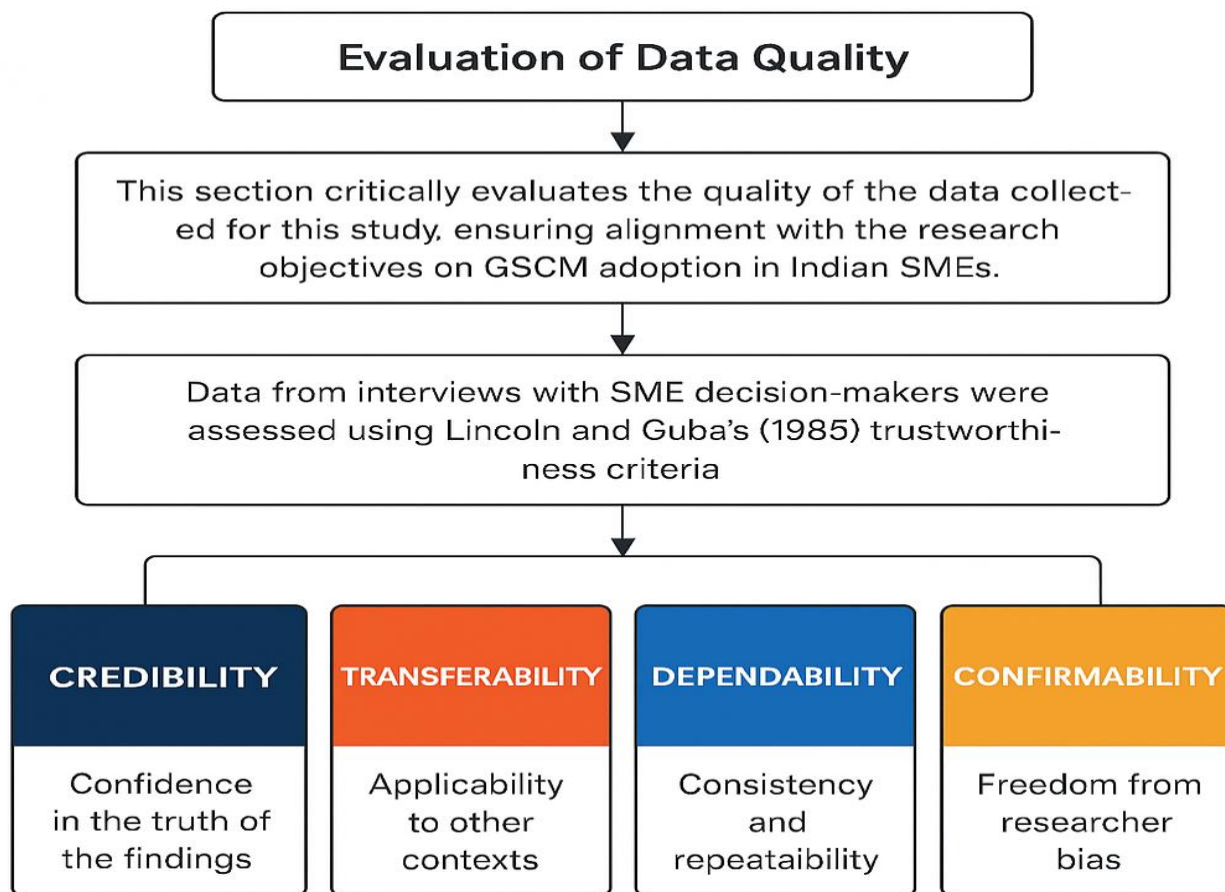


Figure 5: Evaluation criteria of Data Quality

The primary data, gathered through in-depth interviews with key decision-makers from 5 Indian SMEs, were subjected to a rigorous quality assessment using Lincoln and Guba’s (1985) trustworthiness criteria- credibility, transferability, dependability, and confirmability (Figure 5).

These criteria, widely recognized in qualitative research, provide a structured framework for evaluating the integrity of the data and the analytical process, ensuring that the study’s findings are trustworthy and defensible. This assessment is essential to establish the validity of the thematic insights derived in Section 3.4, thereby reinforcing the study’s contribution to the broader discourse on sustainability practices within the SME context.

Credibility was prioritized to ensure that the data accurately reflects the perspectives of the SME decision-makers regarding GSCM adoption. Several strategies were employed during data collection and analysis to enhance credibility. First, prolonged engagement with participants was achieved through extended interview sessions, each lasting approximately 20-25 minutes. This duration allowed the researchers to build rapport with participants, fostering an open dialogue that elicited detailed and authentic responses.

Transferability was addressed to ensure that the findings could be applied to similar contexts, despite the qualitative nature of the study. A thick description of the research context was provided, detailing the characteristics of the sampled SMEs (e.g., size, sector, geographic location in India), the decision-makers interviewed (e.g., CEOs, managers), and the specific focus on GSCM adoption in the manufacturing sector.

Dependability was ensured to demonstrate that the research process was consistent and replicable, thereby supporting the reliability of the findings. A comprehensive audit trail was meticulously maintained throughout the study, documenting each step of the data collection and analysis process. This trail included detailed records of interview schedules, audio recordings, transcriptions, manually created coding frameworks, and iterative revisions to the thematic structure. For instance, the initial open coding phase identified 72 descriptive codes, which were subsequently grouped into 15 sub-themes during axial coding and finally refined into the five core themes.

Confirmability was addressed to ensure that the findings were shaped by the participant's perspectives rather than the researchers' biases or preconceptions, thereby enhancing the objectivity of the study. Reflexivity was practiced throughout the research process, with the lead researcher maintaining a reflective journal to document personal assumptions, potential biases, and their influence on the analysis.

The assessment of data quality also considered potential limitations that could affect the trustworthiness of the findings. One limitation was the reliance on self-reported data from SME decision-makers, which may be subject to social desirability bias, where participants might overstate their commitment to sustainability practices. Another limitation was the sample size of 5 SMEs, which, while sufficient for qualitative depth, may not fully capture the diversity of the Indian SME sector.

4. Findings/Results

This section provides a rich and full account of the qualitative data obtained from interviews with key decision-makers from five small and medium-sized enterprises (SMEs) based in India. The five organizations selected were: Suryaja Foods (food processing), Fairytale Interiors (modular furniture and interior design), DO future energy (consulting specifically in solar solutions), Metalman Auto Limited (automotive manufacturing), and Ecosun Power Solutions (renewable energy technologies). The five firms were purposely chosen to provide a range of industrial sectors involved in sustainability transitions.

During the iterative interpretation of the coding process, five themes emerged as being most prominent through the interview data. These are: (1) Sustainable Practices and Innovation Technologies (measured 35 times), (2) Motivations and Enablers of Green Practices (30 references), (3) Stakeholders Roles and Market Pressure (28 references), (4) Internal Strengths and Limitations (25 references), and (5) Risk Management Strategies (20 references). In order to best visually represent the saliency and distribution of the themes, a number of visualizations were used to convey results using frequency analysis and thematic mapping.

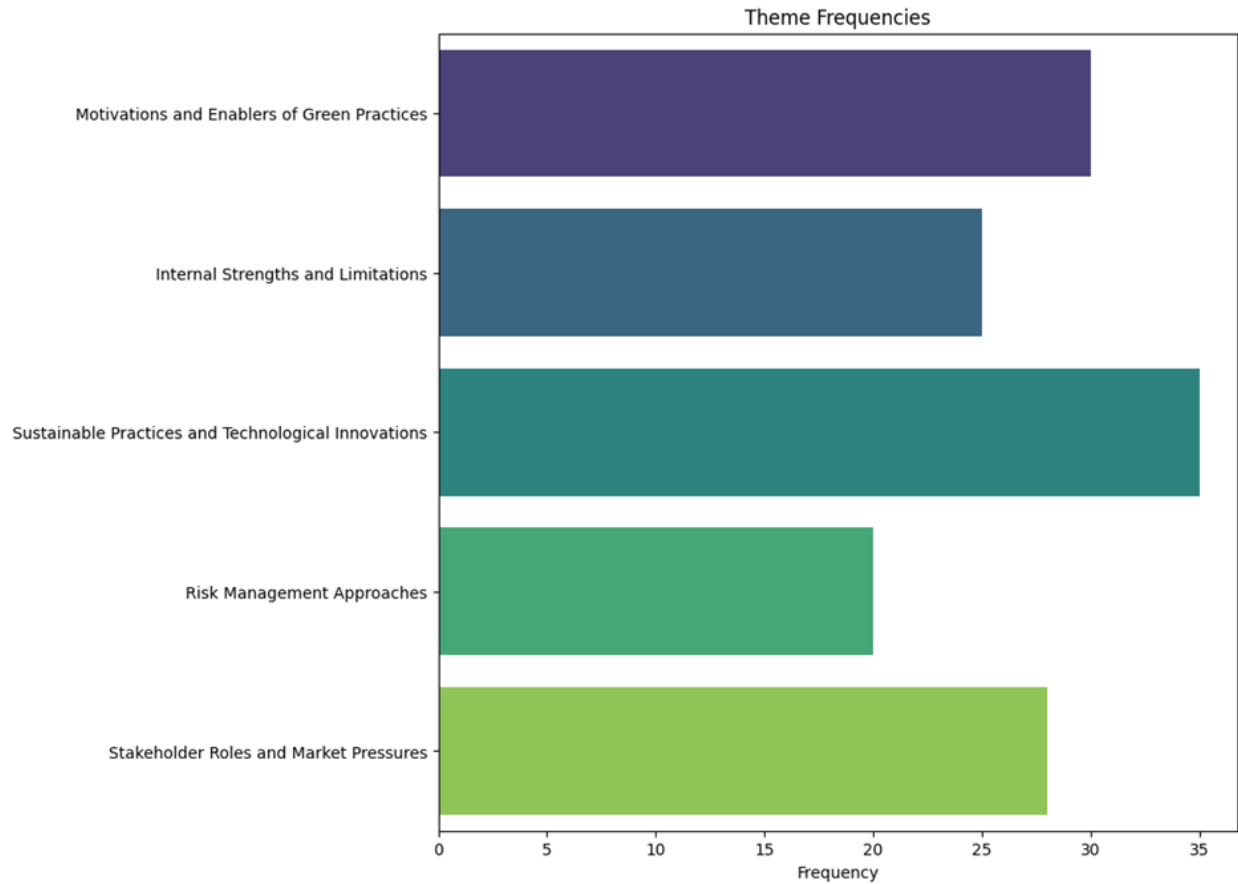


Figure 6: Frequency of Major Themes Identified from Thematic Analysis

The horizontal bar chart (Figure 6) illustrates the magnitude of the themes and displays the number of times each theme was coded during the analysis of the data set. As shown in the chart, Sustainable Practices and Technological Innovations is by far the most prominent theme among participants, suggesting that they clearly placed emphasis on sustainable innovations such as renewable energy, sustainable materials, and new technological innovations. The descending size of the bars for each theme communicates the relative importance or saliency of each theme that was the subject of participant attention. This chart is especially useful for establishing an upper-bound of the general emphasis given to these themes, as well as revealing the area of emphasis for SMEs in their discussions about GSCM.

While the chart reveals the areas of emphasis, it also shows areas that appear to be neglected - specifically, the area of risk management which is the area of lowest occurrence suggesting lesser-developed awareness, lesser-developed capacity, or lesser-developed prioritization.

In addition to the bar chart articulating numerical incidence, a more qualitative representation of term prominence was developed in the form of a word cloud, which captures the linguistic

emphasis of terms used by the study participants. This visualization represents a means of capturing some of the qualitative texture of SME narratives.

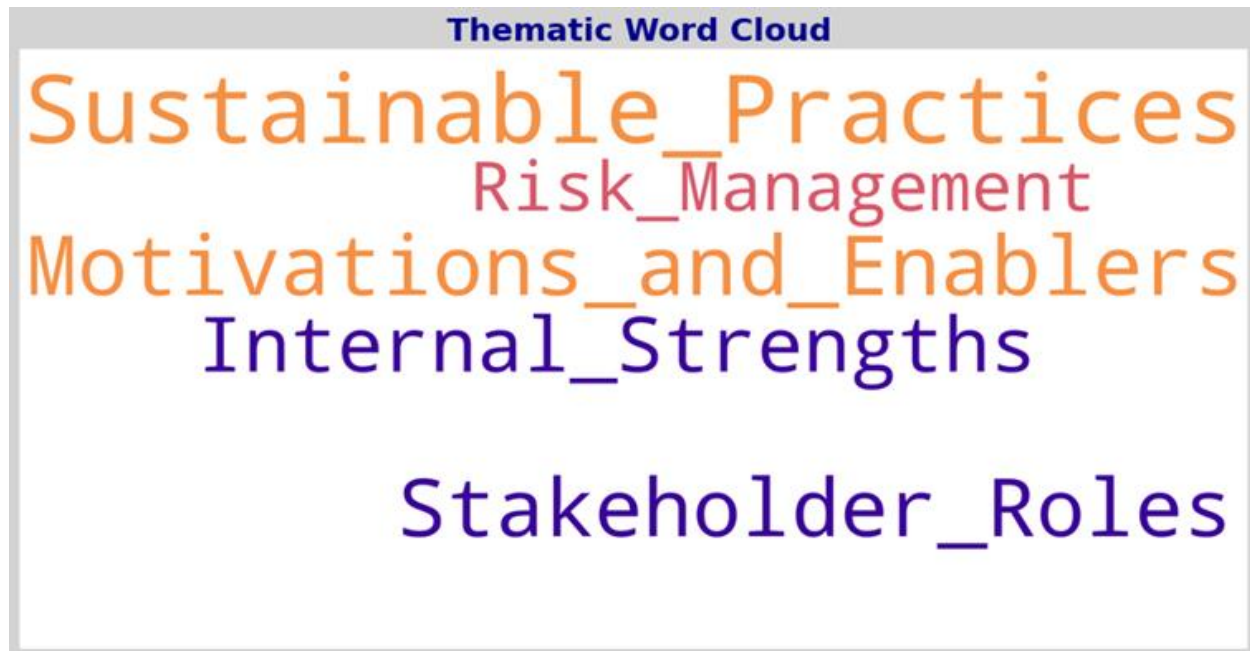


Figure 7: Word Cloud Highlighting the Thematic Landscape of SME Narratives

The word cloud (Figure 7) illustrates the most used words in the interviews where the size of language indicated frequency. For example, also included are significantly larger terms such as "Sustainable_Practices," "Stakeholder_Roles," "Regulatory_Uncertainty," and "Market_Demand," which speak to their emphatic importance to the participants in the research study. The visualization provides a reasonably intuitive and immediate means of impressions of the topics that take centre stage within the SAME discourse, and supports making a linguistic check against the themes coded. The weight of compliance, consumer expectations, and an innovation mindset can be characterized with a word cloud, and the emotional and very real connection to practical issues were also evident in some sectors.

The word cloud provides insights into how language captures the cognitive and cultural priorities in SMEs regarding what is emphasized, what is worrying, and how they think about sustainability challenges.

Another notable and important finding from the analysis showed how the risk management practices as applied by the SMEs in the study were weak and minimally developed. Most of the firms exhibited informal, often reactive, approaches to dealing with risk, which was evident in the statement made by one of the representatives from Metalman Auto Limited who stated that

they are proactive as issues arise which represents a typical sentiment expressed in the dataset. Few firms indicated using structured decision-making risk assessment or strategic foresight processes, and this dissonance can also be illustrated by the pie chart of data themes.

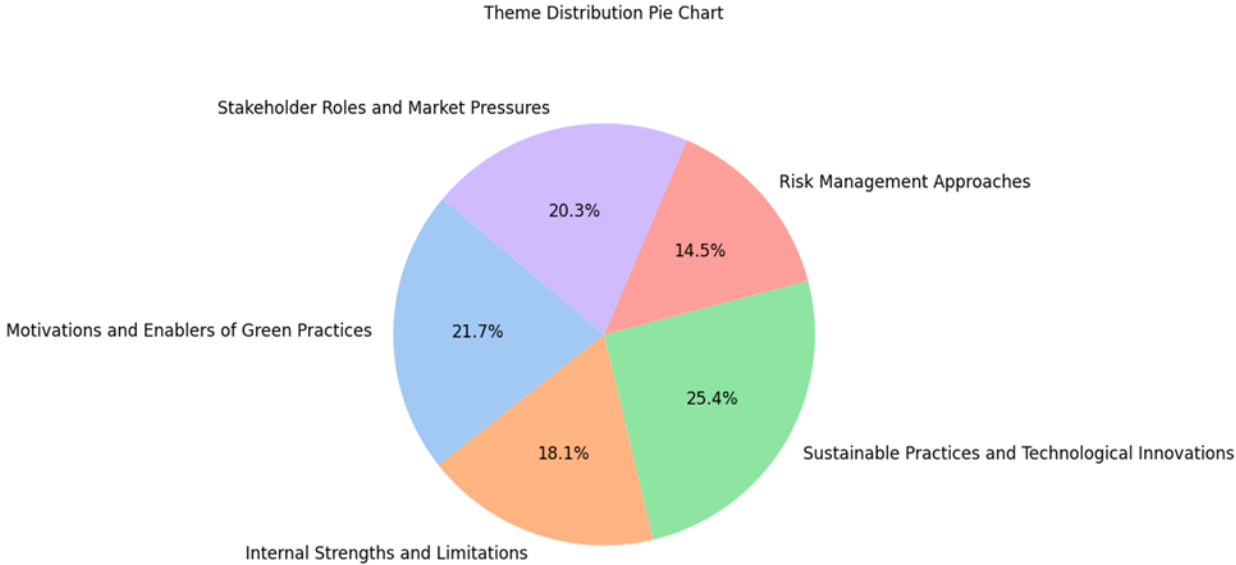


Figure 8: Proportional Distribution of Key Themes Across the Dataset

The pie chart (Figure 8) provides a proportional representation "Sustainable Practices and Technological Innovations" representing approximately 25.4% of the total, indicating prominence among GSCM themes. "Risk Management Approaches" takes up only 14.5%, which itself is a key visual takeaway that reinforces and reinforces the conclusion that formal consultation on risk preparedness has largely disappeared. Because of its segment based structure, the chart allows the reader to compare thematic relevance both quickly and clearly, bringing together a full picture of their current status in sustainability and resilience.

This visualization is critical as it demonstrates the lack of mention concerning risk management approaches and highlights the areas for policy and organizational intervention.

While as now possesses numerical and proportional evidence, it was equally important to visualize theme hierarchies and theme relations in a spatial way so a treemap was produced.

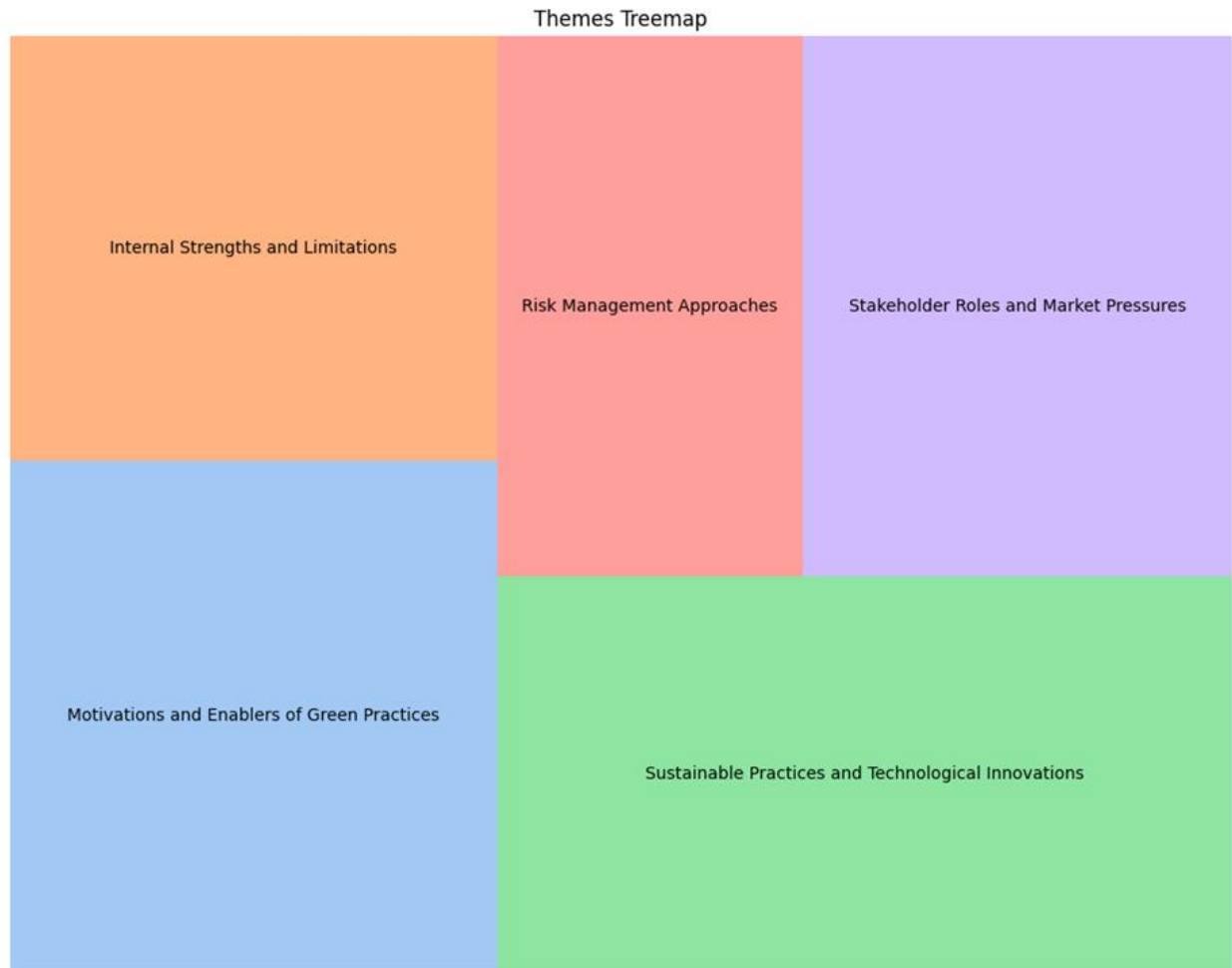


Figure 9: Treemap of Themes and Relative Emphasis

The treemap (Figure 9) lays out the five major themes as nested boxes according to their employment and relevance. Each block's size corresponds to frequency of occurrence and its placement represents their relevance as a theme.

Once again, "Sustainable Practices and Technological Innovations" becomes the largest block, providing a physical representation of its dominance across the interviews. In this instance, of course "Risk Management Approaches" has the smallest representation, compounding its superficial level of engagement.

In summary, a treemap (Figure 7) along with other categorizations discussed under measures of significance, not only provides information about quantity, but it demonstrates the way themes represent one another in terms of prominence and relational space. This visualization is particularly useful in showing the visual hierarchy of sustainability issues and re-emphasizing the gaps in strategic capacity of SMEs in relation to risk.

As a group these four visualisations provide a third dimensional view of the dataset, demonstrating not only the most pertinent areas of concern in terms of quantification and prioritisation but also as thematised within the wider discourse surrounding green supply chain transformation. Collectively the research implies that SMEs are continuing to make strides toward sustainability, and, while they are motivated and increasingly knowledgeable about sustainability development, they are faced with significant structural and strategic challenges alongside uncertainty and ambiguity.

For example, operational risks directly linked to sourcing raw materials, and logistics inefficiencies were cited frequently. *Ecosun Power Solutions highlighted delays due to the lack of physical infrastructure in rural areas and Suryaja Foods noted that fresh suppliers struggled to consistently provide quality organic ingredients. Regulatory uncertainty was also a consistent concern with DO future energy solutions of the Industry whose owner states that the never-ending changes in compliance standards don't allow us to plan. Accountability pressures from stakeholders further complicated matters, with Fairytale Interiors revealing issues wanting to meet management expectations with capability to practically implement.*

Despite the numerous barriers mentioned, there were also several contestable enablers identified. Certainly, innovation in terms of technology was prominently noted, particularly as AI driven optimisation and clean energy technologies. Notably, Fairytale Interiors evidenced Material optimisation that reduced waste, while Suryaja Foods reaffirmed the importance of committed leadership in relation to green transition. These enablers suggest that while SMEs could be hindered by internal constraint and external volatility, in the right context, innovation and top-level engagement could facilitate positive sustainability outcomes.

Collectively these insights offer the empirical basis for a conceptual framework to deliberately join Green Supply Chain Management (GSCM) and Supply Chain Risk Management (SCRM). The proposed framework treats internal contextual conditions (e.g. financial constraints, technological readiness, and organizational inertia) alongside external contextual conditions (e.g. market desire, regulatory dynamics, and supplier reliability) as interdependent influences on SME sustainability. Risk management is not presented in isolation, but as a mediating methodology connecting disruptive events to resilience strategies. Also, the role of stakeholder accountability can also be viewed as risks (misaligned or inconsistent expectations) and enablers (momentum for desired change through support, incentives, or pressure). Technological innovation was universally the most empowering factor, offering SMEs a path to compliance, efficiency, and competitive advantage.

This integrative perspective of sustainability, risk, and resilience provides a robust analytical prism for Indian SMEs to assess their GSCM journeys and highlights points of leverage for various interventions by SME, policymakers, and industry associations.

4.1. Internal Risk Factors and Operational Constraints

The examination highlighted that internal risk factors represent major barriers to GSCM, mainly arising from financial limits, technological shortcomings, organizational resistance, and managerial limitations. These risks, residing within the operational and structural boundaries of SMEs, belong to the internal risk category of the GSCM-SCRM framework (Section 2.4) and encapsulate Indian SMEs' true resource-constrained environment.

Financial Constraints: Financial constraints emerged as the main theme across all four case firms, evident when interviewees referred to green technologies' high upfront costs as a hurdle. Fairytale Interiors recognized the capital-intensive requirement around implementing solar energy at scale, making that option impractical, and resorted to less costly options, including AI-driven optimization of materials, which would reduce waste. Suryaja Foods discussed *"we face difficulty in shifting to biodegradable packaging because of the costs of moisture-resistant alternatives, which has to conform to food standards in the humid environment."* DO future Energy Solutions of the Industry stated *"lack of access to green finance and the risk that government subsidies would be delayed, and thus would lessen the firm's ability to scale more sustainable procurement."* Metalman Auto Limited discussed *"we are planning moving to renewable energy, however, the lack of pricing premiums for ESG-compliant products discourage the firm from pursuing future green opportunities."* These financial constraints highlight the need for greater access to financial instruments that support the transition of SMEs towards sustainability.

Technological Deficiencies: The lack of technical knowledge and access to up-to-date technologies were notable internal risk issues. DO future Energy Solutions of the Industry stated *"we struggled to find BIS-certified solar products, alongside not having sufficient technical knowledge that would help them improve their green procurement efforts."* Metalman Auto Limited stated *"we were unable to implement digital logistics platforms due to a lack of skilled workers and trained staff, and this gap continued to be an issue despite their solar power investments."* Fairytale Interiors stated that *"our older production technology limited our potential for adoption and implementation of advanced waste reduction systems, as they relied on slower manual processes."* Suryaja Foods pointed, we face *"technical difficulties of applying circular economy models, like turning their tapioca by-products into organic manure, which meant they needed specialized knowledge to advocate for the circular model."* The technological deficiencies observed will require adequate training and knowledge transfer initiatives for SMEs."

Organizational resistance and managerial limitations: The two other dimensions of internal risks focused on limited managerial expertise and organizational resistance. Fairytale Interiors also talked *"there is still resistance from employees in initiating segregation protocols around waste, which required additional campaigns and awareness in order for staff to comply."* Suryaja Foods

stated that *"informal sustainability/ESG governance structure and decision-making, which disperse or reduce systematic GSCM implementation"*, while at DO future Energy Solutions of the Industry, limited supplier vetting meant that the managerial inexperience with green procurement standards created more operational risk through increased contractor relationships being introduced. Metalman Auto Limited noted limited managerial bandwidth because their organizational structure was lean and meant they couldn't develop or engage with a holistic sustainability strategy. These observations highlighted a need to build the skills and expertise of firms' managers, as well as organizational capacity, to support the adoption of GSCM.

4.2. External Risk Factors and Regulatory Uncertainties

External risks linked to regulatory instability, supplier dependencies, and market pressures impact SMEs' ability to adopt GSCM. External risks arise from the operating environment surrounding the broader macroeconomic and regulatory perspective. They are aligned with the external risk dimension of the GSCM-SCRM framework and demonstrate the challenges of operating in India's dynamic policy landscape.

Regulatory Unpredictability: The possibility of unpredictable regulatory policy was discussed by all case firms, with practitioners reporting vague and inconsistent environmental policy variables, as well as gaps in enforcement policy as critical roadblocks. For example, Metalman Auto Limited highlighted that, *"due to significant changes in regulatory mandates, it was uncertain about investing in a green infrastructure investment over the long term, in the security of implementing derivatives of solar energy, because renewable energy rules may shift. Specifically, investments were measured when contracting for a one-megawatt solar power production facility."* Suryaja Foods also indicated *"there are problems with government bureaucracy in accessing government subsidy support for solar energy. As a result, the time taken to access government support delayed renewable energy efforts."* DO future energy solutions, too, referenced *"inconsistent levels of enforcement on environmental standards required for solar components. As a result, there is a shortage of certified suppliers which delays procurement activity."* Fairytale Interiors reported *"non-existence of stringent regulations in the modular furniture industry reduces the pressure from external stakeholders to innovate and adopt sustainable practices, which complicates the implementation of GSCM."* Overall, these results signify the need for fixed sustainability policies that are clearly outlined in regulatory frameworks.

Supplier Dependency: External risks are presented through dependency on selected green suppliers. For example, DO future energy solutions experienced interruptions in their procurement because of the limited number of available BIS-certified solar components. As if that were not enough, Fairytale Interiors indicated their supplier discouraged implementing other sustainable practices, such as using eco-friendly laminates, complicating the work they

needed to do to align supply chains with GSCM. Metalman Auto Limited suggested that they added unnecessary logistical costs through supplier actions because they did not know what their suppliers were doing to comply with ESG standards to keep costs low. Suryaja Foods also found that their suppliers would sometimes deviate from the sustainability value chain in sourcing biodegradable material for packaging that was also compliant with the food standards, which did not "cost" a supplier anything, but in reality was prioritized and confirmed by suppliers for cost reasons. Therefore, these risks suggest there continue to be significant risks that limit supply chain sustainability and too many dependencies of suppliers along the same value chain, and that collaborative partnerships could foster a better sustainable supply chain.

Market Pressures: Market characteristics, in particular, a lack of consumer demand for a sustainable offer, also limited GSCM adoptions. For example, while Fairytale Interiors had the furniture they produced sustainably certified, there was a lack of traction in the market in Kerala, which further limited any financial implications for the green investment to leverage any green cash flows from sustainability premiums. In contrast, the decision for Metalman Auto Ltd. to adopt the ESG investment criteria and standards was helped by their global OEM customers, including BMW, who indicated that they expected the company to have undergone its own sustainability transformation. Thus, the external stakeholders can enable and make compliance even more difficult. Suryaja Foods also noted the experience of low consumer awareness regarding sustainable product packaging, which dilutes the organization's ability to justify the costs of products that are biodegradable. DO future energy solutions pointed out that *"the limited demand of rural markets for solar made the adoption of green procurement practices unable to scale."* The above issues and difficulties stemming from distance to market relate again to the need for a dedicated opportunity to raise awareness to mobilize change to consumer demand for sustainable products.

4.3. Enablers and Resilience Strategies

Even in the face of challenges, SMEs were able to demonstrate resilience through the innovative practices they adopted, commitment from leadership, and collaboration with stakeholders. Sustainable practices and technological innovation emerged as the most common theme (35 occurrences, Figure 1), demonstrating the firms' direct focus on sustainability as a practical set of solutions. These factors and methods are also associated with the resilience aspect of GSCM-SCRM, demonstrating how SMEs translate available (internal and external) resources, at both levels, into an ability to navigate the complexities of adopting sustainability.

Technological innovations: SMEs were able to demonstrate innovative processes that facilitated sustainability practices while also mitigating operational risks. Suryaja Foods adopted gelatinization technology to convert its banana starch waste from production into organic manure. This promoted a circular economy model, as the company was also recycling this mass

into their production, while also preventing the waste of a raw material. Fairytale Interiors employed artificial intelligence-enabled manufacturing software to preserve as much raw material as possible while producing modular furniture and minimize scrap. In terms of sustainability, Metalman Auto Limited adopted a digital logistics platform to allow transport from their factory to the dealership, while also digitizing existing manual paperwork in shipping parts. DO future energy solutions pruned carbon emissions by employing transport optimization techniques associated with delivering solar panels. Overall, these technological initiatives illustrate that SMEs have the ability to translate environmental and operational returns through targeted investments; however, these small firms, by their nature, took incremental steps through various developmental stages (i.e., financially, technically).

Leadership commitment: Leadership commitment was an enabling factor for all firms, and reflected entirely in the support and encouragement from all CEOs described in the 5 firms. Each CEO fostered and facilitated a persistent, proactive stance on incorporating sustainability practices into their strategic options, even if the organizations' resources had limitations. The founder of Suryaja Foods promoted circular economy practices, like redistributing organic manure to farmers, meeting both sustainability and community participation. Leadership at Fairytale Interiors engaged employees by emphasizing employee training on compliance with waste segregation protocols. Management at Metalman Auto Limited established a priority around ESG compliance to meet the expectations of customers in the global OEM space, including consideration of solar power usage and specifications for water harvesting systems. Leadership with DO future energy solutions was focused on the supply chain actors and expanded its choice of suppliers in an attempt to diversify risk in sourcing, specifically to align the organization with initiatives for self-reliance in India. These examples highlight the importance of effective strategic vision by leadership to mitigate barriers around GSCM.

Stakeholder Collaboration: Stakeholder collaborative partnerships with suppliers, government agencies, and larger corporations supported the SME's ability to adopt GSCM. Metalman Auto Limited also benefited from the stakeholder partnerships it created with OEMs such as BMW to access platforms for education and knowledge-sharing to develop compliance with sustainability requirements for global OEM approvals. Suryaja Foods developed policies to benefit from government subsidies to install solar panels, despite stakeholder collaboration being impacted by bureaucratic issues of acquiring the subsidies, to transition to renewable energy. For Fairytale Interiors, collaborating with local suppliers supported a reduction in transportation emissions from replied orders. Lastly, DO future energy solutions collaborated with previously authorized, BIS-certified vendors to ensure the vendors would comply with environmental standards. These activities are an example of cross-sectoral collaborative partnerships that should sustain and strengthen the resilience of SMEs. However, in the case of all stakeholders, these examples also

emphasized the challenges faced with supplier reluctance and consistent policy support in relation to sustainability practices.

Risk Management Strategies. Risk management practices were used less frequently (20 occurrences, Figure 1); however, they were examples of pragmatic/cost-effective approaches. DO future energy solutions took several steps to diversify its supplier networks to reduce supplier dependency; the company also stored buffer stock to manage the flow of product in the supply chain. Metalman Auto Limited took a phased approach to sustainability, starting with small steps like rooftop solar panels and smaller-scale projects, before making larger budgets for investments. Suryaja Foods engaged the sanctions of government-funded research to explore sustainable packaging alternatives. These include adaptive resilience, which illustrates SMEs' ability to manage the trade-offs between financially viable options and sustainable environmental interests. The lower priority for delineating risks highlighted a lack of formalized risk management, which was not documented in host organizational SCRM practices, as they would typically be perceived to utilize more resources than are typically available to SME.

4.4. Summary of Key Findings and Revised Framework

The results suggest a complex interrelationship of internal and external risks that inhibit GSCM adoption by Indian SMEs, including financial risks, technological risks, compliance risks, supplier dependencies, and low market demand for sustainable products. Within the situation, SMEs are relatively resilient in terms of technological innovations to enable change, supportive leadership, and collaborative stakeholder efforts. Multiple sustainable practices and technological innovations emerged as the dominant theme (35 occurrences; see Figure 1), affirming the significant role of technology in enabling sustainability. Conversely, risk management practices were a less dominant theme (20 occurrences), indicating that there is a significant need for SMEs to formalize SCRM frameworks that understand the realities of SME operations.

The initial GSCM-SCRM framework (see Section 2.4) was modified using the results to provide a two-tiered risk classification (e.g., strategic risks and operational risks) and to recognize the role of resilience strategies in mediating risk impact. Risks were classified into internal (e.g., technological risks, financial risks, organizational risks) or external risks (e.g., regulatory risks, supplier risks, market risks) with resilience strategies (e.g., technology, leadership, collaboration) mediating risk impact. Distinct strategic risks, such as long-term investment planning and market positioning, and operational risks, such as supplier disruptions and compliance processes, were made explicit, providing a more nuanced view of SME's risk perceptions.

It is important to note that the revised GSCM-SCRM framework has been conceptualized as a hierarchical framework comprising five components: Green Supply Chain Management (GSCM), Supply Chain Risk Management (SCRM), Internal Risks, External Risks, and Resilience Strategies. GSCM represents the desired end state of achieving sustainability through supply chain functions

that may impact both internal and external risks. SCRM work involves acknowledging risks and mitigating risks to achieve continuity. Internal risks would consist of financial, technological, and organizational internal challenges faced by SMEs, and external risks would consist of regulatory, supplier, and market risks. Resilience strategies support SMEs in mitigating the impacts of risks resulting from GSCM adoption and would improve SCRM work. Importantly, the relationships between all variables/components are bidirectional; sustainable GSCM processes generate additional risks, risk management processes help to manage risks, and resilience strategies improve GSCM and SCRM work. This framework will provide a holistic lens to contextualize SMEs' volatility in transitioning toward sustainability, potentially directing tailored interventions to support SMEs in overcoming resource constraints or regulatory volatility. Furthermore, this framework will be used as a basis for the discussion and recommendations in Section 5.

5 Discussion

This section synthesizes the findings within the context of existing literature, offering theoretical contributions, managerial implications, (Table 1), and directions for future research. The study's insights into the risk landscape and resilience strategies of Indian SMEs adopting GSCM align with global sustainability trends while highlighting context-specific challenges in an emerging economy (Dhone & Perumandla, 2024). By integrating qualitative data with theoretical and empirical perspectives, this discussion provides a comprehensive analysis of how SMEs navigate the complexities of sustainability transitions, contributing to both academic discourse and practical applications.

Table 1 summarizes the comparison of prior studies and the current study on GSCM and SCRM in context of Indian SMEs. Previous studies focused on large companies and utilized GSCM and SCRM separately (e.g. Wieland & Wallenburg, 2012, Crovini et al., 2021) while the current study presents a framework that is both integrated and SME specific. It demonstrates how Indian SMEs can address sustainability risks by using affordable innovations, government support and partnerships in the context of emerging markets.

Table 1: Comparison of Present Study with Past Studies in GSCM and SCRM

Theme	Findings from Past Studies	Findings from Present Study	Contribution
Integration of GSCM & SCRUM	Treated as distinct frameworks (Wieland & Wallenburg, 2012)	Proposes an integrated GSCM-SCRUM model for SMEs, distinguishing strategic and operational sustainability risks	Fills gap by offering a unified SME-specific model grounded in Indian context
Firm Size Focus	Large firms dominate the literature (Crovini et al., 2021)	Focuses specifically on Indian SMEs and their unique sustainability risk exposure and prioritization	Extends discourse to underrepresented SME sector
Technological Innovation	Identified as key enabler, but mainly applicable to large firms (Jose & Jeyalakshmi, 2025)	Highlights cost-effective, frugal innovation in SMEs (e.g., AI material optimization, gelatinization tech)	Shows how SMEs can leverage affordable tech solutions for GSCM
Risk Management Emphasis	Limited attention to SCRUM for SMEs; assumes equal risk prioritization across firms (Turgay, S., & Aydın, A. 2023)	Highlights lack of tailored SME risk frameworks; advocates SCRUM adoption suited to SME capacities	Identifies a gap in SME-specific SCRUM tools; suggests phased, scalable strategies

Leadership & Organizational Alignment	Leadership seen as a success factor, mostly conceptual, Schuetz (2017)	Case examples (e.g., Fairytale Interiors) show how leadership-driven training links directly to sustainability outcomes	Provides empirical SME evidence for leadership-driven sustainability implementation
Government Support & Finance	Government incentives mentioned broadly; not deeply explored in SME context (Kumar, S., & Singh, P. 2023)	Real examples (e.g., Suryaja Foods solar harnessing) show SMEs engaging with subsidies and green financing	Deepens understanding of how Indian SMEs interact with policy-level instruments
Collaborative Supplier Relationships	Collaboration with OEMs emphasized in theory (Wang Hui-Mei, 2018)	Case studies (e.g., Metalman Auto, DO future Energy Solutions) show SMEs leveraging partnerships to meet standards and reduce procurement risks	Demonstrates practical SME alliances to enhance resilience and compliance
Circular Economy & Stakeholder Role	Stakeholder and leadership involvement conceptually emphasized (Aaltonen et al., 2024)	Shows their active role in building SME resilience and tech adoption in E-Commerce-driven economies	Highlights real SME pathways for circular transition in emerging markets

Contextual Relevance	Research mostly based in Western contexts (e.g., Canada, France)	Emphasizes India-specific challenges (e.g., regulatory uncertainty, low demand) and SME-specific operational contexts	Adds cultural, institutional, and resource-based insights relevant to emerging economies
----------------------	--	---	--

5.1. Theoretical Contribution

The purpose of the framework is to expand upon prior work which separates risks from SCRM and GSCM, while also analyzing resilience strategies as a mediating variable for sustainability risks as strategic risks (i.e. long-term sustainability investment plans and sustainability positioning of product in the market) and operational risks (i.e. breaches in supplier conduct, voluntary and obligated compliance procedures). The layers in the two-tier classification add depth and complexity to the discussion of sustainability risks that SMEs face while exploring how an SME prioritizes sustainability risks, as it highlights a missing aspect of the SME sustainability literature, which is primarily focused on large corporations (Crovini et al., 2021). The evidence gathered from Indian SMEs provides a uniquely contextualized perspective to developing the framework that extends and builds on established theories of GSCM and SCRM as applied internationally.

Notably, the prominence of sustainable practices and technology (35 occurrences) emphasizes the key role of technology in reducing internal risks, as asserted by Jose and Jeyalakshmi's (2025) description of technological innovation as a key driver for GSCM. The limited emphasis on risk management approaches (20 occurrences) reflects a theoretical gap related to applying SCRUM to SMEs, which indicates that existing frameworks may not fully consider how SMEs using E-commerce operate under resource constraints. This suggests that it has previously been assumed that risk strategies applied to sustainability are prioritized with the same intensity across firms; thus, there is a need for unique SME risk models for implementing SCRM. The research also pushes the frontiers of previous studies on circular economy transitions, which previously emphasized calling for the involvement of leadership and stakeholders as enablers by stressing their role in maintaining resilience in focus for an emerging economy, an aspect that is influenced by E-Commerce.

5.2. Managerial Implications

These findings provide actionable insights for SME managers who want to implement GSCM while managing scarce resources and uncertainty in the external environment. First, by implementing low-cost technology innovations, SMEs can support improved sustainability without utilizing financial resources.

Second, establishing leadership commitment and awareness of the sustainability goals at the employee level is necessary to address the potential for organizational resistance. Fairytale Interior's waste segregation initiative and training provided demonstrate that linking sustainable practices with the way the workforce performs their jobs matters in achieving the sustainability goal. It requires commitment and the training of employees through capacity-building opportunities such as workshops, or workshops facilitated by sustainability experts, where there is a role for managers to invest in building the capacity as their operation becomes more complex.

Third, while navigating complex governmental structures defines good practices for government subsidies, and qualities of a green financing program can help address the financial burden. The example of Suryaja Foods TPBEL partial harnessing of solar takes advantage of undertakings in plants not putting these avenues to good use, highlighting the learnings of these instruments and how managers need to engage policymakers vis-à-vis the systemic access that needs to be responsive by policymakers. Also, consider areas where SME organizations may access certain sustainability-linked loans or tax benefits.

Fourth, collaborative partnerships with suppliers and larger corporations will enable easier benefits from their knowledge support to meet global standards. Metalman Auto Limited partnerships, such as BMW as OEMs, took advantage of access to their environmental, social, and governance expertise. DO future Energy Solutions' sourcing diverse suppliers enables them to overcome procurement risks. Managers should consider prioritizing strategic allies in the sustainability domain for resilience in their corporate supply chain.

Finally, phased risk management strategies can create more value for the business while balancing sustainability objectives. The response of Metalman Auto Limited to solar and DO future Energy Solutions response in using a buffer stock exemplifies some consideration of SME realisation spending cost to mitigate risk from being rewarded for implementing sustainable production and sourcing.

5.3. Limitations and Suggestions/Avenues for Future Research

Like all research endeavors, the study has limitations that should be communicated and may allow for further avenues of research. First, while a sample size of five SMEs is fairly appropriate for qualitative depth, the diversity of the SME sector throughout India presents limitations to the generalizability of this study's findings. The SME sector in India is distinct given its regional,

industrial, and economic conditions (Kumar & Sharma, 2025). Future research could study larger, multi-regional samples of SMEs in an effort to examine how GSCM adoption varies across regions due to non-comparable policies and industrial ecosystems.

The second limitation to note from this study relates to self-reported data. Even though all information was gathered over the same time period, there was likely a social desirability bias whereby respondents over-represented their sustainability-intensive behaviors. Future research could use observational studies, or quantitative survey designs to validate qualitative findings in this area, for example, stating carbon emissions or waste reduction rates to provide a methodological measure.

The previous point relates to the third limitation to note regarding the study's use of risk management approaches; there appear to be only 20 occurrences of making use of a risk management approach. Figure 1 shows that the under-utilisation of SCRM is an area this research missed as part of SME sustainability transitions. Future research could explore why SMEs appear to place greater emphasis on technological innovations than on formalised SCRM. It would be interesting to know whether this reflects the SME option for quantitative behaviour for cost management, or perhaps alternative explanations are present, for example, lack of resources, lack of participation in SME awareness, and cultural factors. Future studies could also develop usable SCRM frameworks specifically for SMEs with usability features such as cost-free or less informed tools, such as AI-driven risk assessment.

References

1. Bhagawati, M.T., & Venkumar, P. (2020). *Evaluation of Green Supply Chain Management Practices in Small and Medium Enterprises in Pune Region*. In: Vasudevan, H., Kottur, V., Raina, A. (eds) *Proceedings of International Conference on Intelligent Manufacturing and Automation*. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-15-4485-9_29
2. Jomon Jose M., & Jeyalakshmi P. R. (2025). *Enhancing Sustainability: Green Supply Chain Management in Ayurvedic Manufacturing Industry*. <https://doi.org/10.1177/09726225241305180>
3. Bhattacharyya, A., Rahman, M. L., & Wright, S. (2023). Improving small and medium-size enterprise performance: Does working capital management enhance the effectiveness of financial inclusion?. *Accounting & Finance*, 63(4), 3943-3969. <https://doi.org/10.1111/acfi.13081>
4. Luo, Y., Li, X., Gong, X., & Jie, X. (2024). Barriers Encountered by Chinese Manufacturing SMEs in Pursuing High-Quality Development Under Environmental Objective Constraints. *The Journal of Environment & Development*, 33(4), 662-697. <https://doi.org/10.1177/10704965241258080>
4. Babu, H., & Yadav, S. (2023). A supply chain risk assessment index for small and medium enterprises in post COVID-19 era. *Supply Chain Analytics*, 3, 100023. <https://doi.org/10.1016/j.sca.2023.100023>
5. Jahin, M. A., Naife, S. A., Saha, A. K., & Mridha, M. F. (2023). Ai in supply chain risk assessment: A systematic literature review and bibliometric analysis. *arXiv preprint arXiv:2401.10895*. DOI:[10.48550/arXiv.2401.10895](https://doi.org/10.48550/arXiv.2401.10895)
6. Pham, H. T., Pham, T., Truong Quang, H., & Dang, C. N. (2022). Supply chain risk management research in construction: a systematic review. *International Journal of Construction Management*, 23(11), 1945–1955. <https://doi.org/10.1080/15623599.2022.2029677>
7. Gupta, P., Sharma, Y., & Chauhan, A. (2025). Investigation of green supply chain management practices and sustainability in Indian manufacturing enterprises using a structural equation modelling approach. *Scientific Reports*, 15,14909. <https://doi.org/10.1038/s41598-025-95940-9>

8. Crovini, C., Santoro, G., & Ossola, G. (2021). Rethinking risk management in entrepreneurial SMEs: Towards the integration with the decision-making process. *Management Decision*, 59(5), 1085-1113 <https://doi.org/10.1108/MD-10-2019-1402>.
9. Mehmood, S., Nazir, S., Fan, J., & Nazir, Z. (2025). Achieving supply chain sustainability: Enhancing supply chain resilience, organizational performance, innovation, and information sharing—Empirical evidence from Chinese SMEs. *Modern Supply Chain Research and Applications*, 7(1), 2-29 <https://doi.org/10.1108/MS CRA-01-2024-0002>.
10. Wasan, P., Kumar, A., & Luthra, S. (2021). Green finance barriers and solution strategies for emerging economies: The case of India. *IEEE Transactions on Engineering Management*, 71, 414-425. doi: 10.1109/TEM.2021.3123185
11. Bolaji, B. H. (2024). The influence of technological, organizational, and environmental factors on GSCM adoption among SMEs in Nigeria: The moderating effect of innovation capability <https://core.ac.uk/download/pdf/641063066.pdf>.
12. Vangeri, A. K., Badrinath, S., Anand, M. C. J., Shanmugathai, M., Meenatchi, N., & Boopathi, S. (2024). Green supply chain management in eco-friendly sustainable manufacturing industries. In *Environmental Applications of Carbon-Based Materials* (pp. 253-287). IGI Global. *Green Supply Chain Management in Eco-Friendly Sustainable* DOI: [10.4018/979-8-3693-3625-0.ch010](https://doi.org/10.4018/979-8-3693-3625-0.ch010).
13. Gennari, F. (2023). The transition towards a circular economy: A framework for SMEs. *Journal of Management and Governance*, 27(4), 1423-1457. <https://doi.org/10.1007/s10997-022-09653-6>
14. Cenci, M. P., Scarazzato, T., Munchen, D. D., Dartora, P. C., Veit, H. M., Bernardes, A. M., & Dias, P. R. (2022). Eco-friendly electronics—A comprehensive review. *Advanced Materials Technologies*, 7(2), 2001263. <https://doi.org/10.1002/admt.202001263>
15. Dhone, N., & Perumandla, S. (2024). Integrating Corporate Governance and Sustainability Practices in Indian SMEs Amid Industry 4.0: A Systematic Review. *IUP Journal of Corporate Governance*, 23(1)

16. Durrani, N., Raziq, A., Mahmood, T., & Khan, M. R. (2024). Barriers to adaptation of environmental sustainability in SMEs: A qualitative study. *PLOS ONE*, 19(5), e0298580. <https://doi.org/10.1371/journal.pone.0298580>
17. El Ayoubi, M. S., & Radmehr, M. (2023). Green food supply chain management as a solution for the mitigation of food supply chain management risk for improving the environmental health level. *Heliyon*, 9(2). <https://doi.org/10.1016/j.heliyon.2023.e13264>
18. Gawusu, S., Zhang, X., Jamatutu, S. A., Ahmed, A., Amadu, A. A., & Dj Miensah, E. (2022). The dynamics of green supply chain management within the framework of renewable energy. *International Journal of Energy Research*, 46(2), 684-711. <https://doi.org/10.1002/er.7278>
19. Ghosh, S., Mandal, M. C., & Ray, A. (2022). Exploring the influence of critical parameters on green supply chain management performance of small and medium-sized enterprises: An integrated multivariate analysis-robust design approach. *Cleaner Logistics and Supply Chain*, 4, 100057. <https://doi.org/10.1016/j.clscn.2022.100057>
20. Ibrahim, N., Sobry, S. C., Ismail, N. Z. F., & Harahap, A. Z. M. K. (2023). Supply Chain Risks, Green Supply Chain Management Practices and Organizational Performance: A Research Direction. *Information Management and Business Review*, 15(3(SI)), 429-438. [https://doi.org/10.22610/imbr.v15i3\(SI\).3499](https://doi.org/10.22610/imbr.v15i3(SI).3499)
21. Jha, P. K., Ghorai, S., Jha, R., & Singh, S. P. (2024). Emerging challenges of SMEs for the post-COVID-19 era: implications for resilience and sustainability. *The TQM Journal*. <https://doi.org/10.1108/TQM-03-2024-0104>
22. Karmaker, C. L., Al Aziz, R., Palit, T., & Bari, A. M. (2023). Analyzing supply chain risk factors in small and medium enterprises under fuzzy environments: Implications towards sustainability for emerging economies. *Sustainable Technology and Entrepreneurship*, 2(1), 100032. <https://doi.org/10.1016/j.stae.2022.100032>
23. Khan, T., Emon, M. M. H., Rahman, M. A., Hamid, A. B. A., & Yaakub, N. I. (2025). Bridging the gap: realizing GreenTech potential. In *AI and green technology applications in society* (pp. 91-122). IGI Global Scientific Publishing. DOI: [10.4018/979-8-3693-9879-1.ch004](https://doi.org/10.4018/979-8-3693-9879-1.ch004)

24. Kumar, L., & Sharma, R. K. (2025). Examining interdependencies among solution dimensions for sustainable development in SMEs based on the Industry 4.0 concept. *Kybernetes*, 54(4), 2137-2174. <https://doi.org/10.1108/K-09-2023-1674>
25. Malik, A., Sharma, P., Vinu, A., Karakoti, A., Kaur, K., Gujral, H. S., Munjal S., & Laker, B. (2022). Circular economy adoption by SMEs in emerging markets: Towards a multilevel conceptual framework. *Journal of Business Research*, 142, 605-619. <https://doi.org/10.1016/j.jbusres.2021.12.076>
26. Mankar, V. A., Katare, V., Lodhi, L., & Kaushik, T. K. (2025). A Study of Drivers and Barriers of Green Supply Chain Management Practices in the Context of Developing a Framework for SMEs. In *Leveraging AI for Innovative Sustainable Energy: Solar, Wind, and Green Hydrogen* (pp. 1-14). IGI Global Scientific Publishing. DOI: [10.4018/979-8-3373-0045-0.ch001](https://doi.org/10.4018/979-8-3373-0045-0.ch001)
27. Ogunyemi, F. M., & Ishola, A. O. (2024). Data-driven financial models for sustainable SME growth: Integrating green finance into small and medium enterprise strategies. *International Journal of Frontline Research in Science and Technology*, 1. DOI: [10.56355/ijfrst.2024.4.1.0053](https://doi.org/10.56355/ijfrst.2024.4.1.0053)
28. Okeke, A. (2024). Evaluating sustainable practices and supply chain management effectiveness in African small and medium-sized enterprises (SMEs). *Journal of Sustainability Research*, 6(2), e240033. <https://doi.org/10.20900/jsr20240033>
29. Omowole, B. M., Olufemi-Philips, A. Q., Ofodile, O. C., Eyo-Udo, N. L., & Ewim, S. E. (2024). Conceptualizing green business practices in SMEs for sustainable development. *International Journal of Management & Entrepreneurship Research*, 6(11), 3778-3805. DOI: <https://doi.org/10.51594/ijmer.v6i11.1719>
30. Omowole, B. M., Olufemi-Philips, A. Q., Ofodile, O. C., Eyo-Udo, N. L., & Ewim, S. E. (2024). Barriers and drivers of digital transformation in SMEs: A conceptual analysis. *International Journal of Scholarly Research in Science and Technology*, 5(2), 19–36. <https://doi.org/10.56781/ijrst.2024.5.2.0037>
31. Oyewole, A. T., Adeoye, O. B., Addy, W. A., Okoye, C. C., & Ofodile, O. C. (2024). Enhancing global competitiveness of US SMEs through sustainable finance: A review and future directions. *International Journal of Management & Entrepreneurship Research*, 6(3), 634-647. DOI: [10.51594/ijmer.v6i3.876](https://doi.org/10.51594/ijmer.v6i3.876)

32. Paiola, M., Agostini, L., Grandinetti, R., & Nosella, A. (2022). The process of business model innovation driven by IoT: Exploring the case of incumbent SMEs. *Industrial Marketing Management*, 103, 30-46. <https://doi.org/10.1016/j.indmarman.2022.03.006>
33. Sahani, T. (2025). Charting New Horizons: Innovation Meets Sustainability in Business. *Journal of Next-Generation Research* 5.0, 1(2). <https://doi.org/10.70792/jngr5.0.v1i2.46>
34. Paliwal, V. (2023). Adoption intention for blockchain technology in sustainable supply chain management by Indian micro, small, and medium enterprises. (Doctoral dissertation, SP Jain School of Global Management (India)). <https://www.proquest.com/openview/0261ca96a467f0267438a8b75bd2c3d4/1?pq-origsite=gscholar&cbl=2026366&diss=y>
35. Reshad, A. I., Biswas, T., Agarwal, R., Paul, S. K., & Azeem, A. (2023). Evaluating barriers and strategies to sustainable supply chain risk management in the context of an emerging economy. *Business Strategy and the Environment*, 32(7), 4315-4334. <https://doi.org/10.1002/bse.3367>
36. Rizal, A. S., Nuswantara, D. A., Hariyati, & Ali Alnajar, A. E. (2024). The role of Green Transformational Leadership and Green Product Innovation in Emerging Economies: Green Employee Behaviour and Green Human Resource Management as Intervening Variables. *Journal of Entrepreneurship & Business*, 5(3), 263 - 288. <https://doi.org/10.24123/jeb.v5i3.6867>
37. Vujanović, M., Wang, Q., Mohsen, M., Duić, N., & Yan, J. (2021). Recent progress in sustainable, energy-efficient technologies and environmental impacts on energy systems. *Applied Energy*, 283, 116280. <https://doi.org/10.1016/j.apenergy.2020.116280>
38. Klement, P., Auktor, G., Pal, T., Olivetti, E., Blondaut, J., Birn, L., Anding, M., & Knipfer, K. (2023). A strategic framework for achieving sustainability and resilience in global supply chains. *Hawaii International Conference on System Sciences (HICSS)*. DOI:[10.24251/HICSS.2023.449](https://doi.org/10.24251/HICSS.2023.449)
39. Zain, R. M., Ramli, A., Zain, M. Z. M., Yekini, L. S., Musa, A., Rahim, M. N. A., ... & Aziz, N. I. C. (2024). An Investigation of the Barriers and Drivers for Implementing Green Supply

- Chain in Malaysian Food and Beverage SMEs: A Qualitative Perspective. *WSEAS Transactions on Business and Economics*, 21, 2169–2189. DOI: [10.37394/23207.2024.21.179](https://doi.org/10.37394/23207.2024.21.179)
40. Petts, J., Herd, A., Gerrard, S., & Horne, C. (1999). The climate and culture of environmental compliance within SMEs. *Business Strategy and the Environment*, 8(1), 14–30. [https://doi.org/10.1002/\(SICI\)1099-0836\(199901/02\)8:1<14::AID-BSE175>3.0.CO;2-4](https://doi.org/10.1002/(SICI)1099-0836(199901/02)8:1<14::AID-BSE175>3.0.CO;2-4)
41. Soda, S., Sachdeva, A., & Garg, R. K. (2015). GSCM: practices, trends and prospects in Indian context. *Journal of Manufacturing Technology Management*, 26(6), 889–910. <https://doi.org/10.1108/JMTM-03-2014-0027>
42. Yadav, P., & Yadav, O. (2024). Optimizing Sustainability: Investigating The Integral Role of Green Supply Chain Management in Small and Medium-Sized Enterprises (Smes). *European Economic Letters (EEL)*, 14(1), 1331–1339. <https://doi.org/10.52783/eel.v14i1.1183>
43. Taleghani, A., & Taleghani, M. (2020). Green supply chain management.. https://www.researchgate.net/publication/341277694_Green_Supply_Chain_Management
44. Burch, S., Andrachuk, M., Carey, D., Frantzeskaki, N., Schroeder, H., Mischkowski, N., & Loorbach, D. (2016). *Governing and accelerating transformative entrepreneurship: exploring the potential for small business innovation on urban sustainability transitions*. *Current Opinion in Environmental Sustainability* (Vol. 22, pp. 26–32). DOI: [10.1016/j.cosust.2017.04.002](https://doi.org/10.1016/j.cosust.2017.04.002)
45. Lavastre, O., Gunasekaran, A., & Spalanzani, A. (2014). Effect of firm characteristics, supplier relationships and techniques used on Supply Chain Risk Management (SCRM): an empirical investigation on French industrial firms. *International Journal of Production Research*, 52(11), 3381–3403. <https://doi.org/10.1080/00207543.2013.878057>
46. Biswas, B., & Gupta, R. P. (2023). *Global ESG Regulatory Framework and Sustainability: Issues and Prospects*. In book: *Sustainable Roadmap Development Strategies in India: Paving the Way for a Better Future* (pp. 20–32). DOI: [10.31674/book.2023srdsi003](https://doi.org/10.31674/book.2023srdsi003)
47. Yildiz, H. (2024). Digitization and supply chain risk management. In *Trends, challenges and solutions in contemporary supply chain management: Digitization in supply chain management* (pp. 21–36). https://doi.org/10.1142/9789811286636_0003
48. Dua, S. (2022). The MSME conundrum: COVID troubles for an already troubled sector. *Shanlax International Journal of Management*, 10(2), 49–55. DOI: <https://doi.org/10.34293/management.v10i2.5271>

49. Wieland, A., & Wallenburg, C. M. (2012). Dealing with supply chain risks: Linking risk management practices and strategies to performance. *International Journal of Physical Distribution & Logistics Management*, 42(10), 887–905. <https://doi.org/10.1108/09600031211281411>
50. Ritchie, B., & Brindley, C. (2007). Supply Chain Risk Management and Performance: A Guiding Framework for Future Development. *International Journal of Operations & Production Management*, 27, 303-322. <http://dx.doi.org/10.1108/01443570710725563>
51. Zsidisin, G.A., Gaudenzi, B., Pellegrino, R. (2024). Supply Chain Risk and Organization Vulnerability. In: Strategic Sourcing . Palgrave Studies in Logistics and Supply Chain Management. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-52592-6_2
52. Turgay, S., & Aydin, A. (2023). Risk mitigation for SMEs: A step-by-step guide to implementing an effective framework. *Financial Engineering and Risk Management*, 6(8). Clausius Scientific Press. [https:// DOI:10.23977/ferm.2023.060808](https://doi.org/10.23977/ferm.2023.060808)
53. Schuetz, A. (2017). Effective Leadership and its Impact on an Organisation's Success. *Journal of corporate responsibility and leadership*, 3(3), 73-90. DOI:[10.12775/JCRL.2016.017](https://doi.org/10.12775/JCRL.2016.017)
54. Gonçalves, H., Magalhães, V. S. M., Ferreira, L. M. D., & Arantes, A. (2024). Overcoming Barriers to Sustainable Supply Chain Management in Small and Medium-Sized Enterprises: A Multi-Criteria Decision-Making Approach. *Sustainability*. <https://doi.org/10.3390/su16020506>
55. Kumar, S., & Singh, P. (2023). An Analysis of Government Support Programs for Small Business Development and Growth. *Scholedge International Journal of Business Policy & Governance*, 10(2). DOI:[10.19085/sijbpg100201](https://doi.org/10.19085/sijbpg100201)
56. Wang, H. M. (2018). Fostering Collaborations: A Knowledge-Acquisition Strategy for Contract Manufacturers in OEM Relationships. *International Business Research*, 11(11), 28-36. DOI:[10.5539/ibr.v11n11p28](https://doi.org/10.5539/ibr.v11n11p28)
57. Aaltonen, K., Derakhshan, R., Di Maddaloni, F., & Turner, R. (2024). Stakeholder engagement: Theoretical and methodological directions for project scholarship. *International Journal of Project Management*, 42(7), 102649. DOI:[10.1016/j.ijproman.2024.102649](https://doi.org/10.1016/j.ijproman.2024.102649)

58. Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*. DOI: https://ankara.lti.cs.cmu.edu/11780/sites/default/files/10-guba_lincoln_94.pdf
59. Hsu, P.-F., & Nguyen, T. (2023). Examining the cultural differences in disseminating green supply chain in global subsidiaries. *Journal of Business Research*, 164, 113982. <https://doi.org/10.1016/j.jbusres.2023.113982>
60. Elbaz, J., Iddik, S., & Oubal, M. (2021). *The effects of Cultural factors on GSCM implementation, Empirical evidence from Morocco*. 119, 03002. DOI: [10.1051/shsconf/202111903002](https://doi.org/10.1051/shsconf/202111903002)
61. Alabi, A. T., Ubandawaki, A. T., & Issa, S. O. (2025). The Role of Digital Technology in the Sustainability Strategies of SMEs. In T. Olubiyi, S. Suppiah, & C. Chidoko (Eds.), *The Future of Small Business in Industry 5.0* (pp. 347-378). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-7362-0.ch014>
62. Al-Amin, K., Ewim, C., Igwe, A., & Ofodile, O. (2024). AI-enabled intelligent inventory and supply chain optimization platform for SMEs. *Comprehensive Research and Reviews Journal*, 2, 1–12. DOI: 10.57219/crrj.2024.2.2.0030
63. Bestvinova, V., Praj, F., & Čambál, M. (2022). Identification of sustainability risks and their quantification in the conditions of small and medium-sized industrial enterprises. *MM Science Journal*, 2022(4), 6086–6090. DOI: [10.17973/MMSJ.2022_11_2022137](https://doi.org/10.17973/MMSJ.2022_11_2022137)
64. Bazile, J., & Su, Z. (2024). Strategic Intelligence of Small and Medium Enterprises Embedded in Global Supply Chains: A Framework for Resilience in the Face of Systemic Risks. *International Journal of Business and Management*. 19(3) DOI: [10.5539/ijbm.v19n3p179](https://doi.org/10.5539/ijbm.v19n3p179)
65. Gałkiewicz, D. P., & Gaßner, V. (2023). A Short Guidance for SME Sustainability Reporting at the EU Level. Conference: 7th International Scientific Conference ITEM Recent Advances in Information Technology, Tourism, Economics, Management and Agriculture DOI: [10.31410/ITEMA.2023.167](https://doi.org/10.31410/ITEMA.2023.167)
66. Soyombo, O. T., Odunaiya, O. G., Abioye, K. M., & Adeleke, A. G. (2024). SME collaboration models for accelerating clean energy innovations: Insights from emerging market economies. *International Journal of Management & Entrepreneurship Research*, 6(9), 3134–3149. DOI: <https://doi.org/10.51594/ijmer.v6i9.1584>

Appendices

Appendix A: Interview questions

This appendix presents the full list of interview questions used to collect data from stakeholders of small and medium-sized enterprises (SMEs). These structured interviews aimed to gather insights related to their supply chain practices and sustainability efforts.

Section A: Introduction

1. Can you briefly describe your role and responsibilities in your company?
2. What products or services does your company offer?
3. Is your company currently involved in any green or sustainable supply chain practices? If yes, please describe them.
4. What motivated your organization to explore or adopt green supply chain practices?

Section B: Theory-Based Questions

1. Resource-Based View (RBV)

5. What internal strengths (such as technology, knowledge, leadership, or skilled staff) have helped your company implement green supply chain initiatives?
6. What internal limitations or resource constraints hinder the adoption of green practices?
7. Has your company made any specific investments (e.g., equipment, software, training) to build green supply chain capabilities?

2. Institutional Theory

8. Have government regulations or environmental compliance norms influenced your decision to green your supply chain? How?

9. Do you observe any peer pressure or trends within your industry that influence your sustainability practices?
10. Are customers or global buyers demanding environmental compliance from your business or suppliers?

3. Stakeholder Theory

11. Who are the most important stakeholders when it comes to sustainability in your supply chain (e.g., customers, regulators, suppliers, NGOs)?
12. How do you manage conflicting demands (e.g., low cost vs green compliance) from different stakeholders?
13. Do you involve your suppliers or customers when making decisions about green initiatives?

4. Dynamic Capabilities Theory

14. How has your company responded to unexpected sustainability-related challenges in the supply chain (e.g., a ban on certain materials, supplier failure, climate events)?
15. Have you developed any new processes or partnerships as part of adapting to green supply chain needs?
16. Can you give an example where your company changed its supply chain strategy due to environmental considerations?

5. Contingency Theory

17. How does the size, location, or financial capacity of your business affect the way you approach green supply chain risks?
18. Do you find that different types of risks require different strategies? For example, is regulatory risk handled differently from reputational or supply risks?
19. Does your risk management approach change depending on the type of product or market you are targeting?

Section C: Risk & Strategy Reflection

20. What are the most critical risks you face in implementing green supply chain practices?
21. What strategies have proven most effective in managing those risks?
22. What kind of support (policy, financial, technological) would help SMEs like yours strengthen green supply chains?