STRATEGIES FOR TRANSITION TO SUSTAINABLE BUSINESS MODELS (SBMS) IN KEY MANUFACTURING SECTORS IN INDIA

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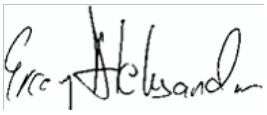
APPROVED BY 

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Dedication

My successful completion of this doctorate program is dedicated primarily to my family. To my wife, who accompanied me every moment during the writing of this research. Her continuous encouragement and sacrifice has been a motivating factor behind the completion of this work. To my son, whose presence and constant encouragement are a source of strength and inspiration for me. He has sacrificed my mental presence at a number of occasions for this study. Thank you both for your patience and understanding during the doctoral study.

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ABSTRACT

STRATEGIES FOR TRANSITION TO SUSTAINABLE BUSINESS MODELS (SBMS) IN KEY MANUFACTURING SECTORS IN INDIA

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The transition to Sustainable Business Models (SBMs) in the Indian manufacturing sector is hindered by financial constraints, resource limitations, managerial resistance, and sector-specific adoption barriers. While sustainability awareness has increased, implementation remains fragmented, with significant gaps between intent and execution. This study investigates the challenges, awareness levels, strategic approaches, stakeholder collaboration, and innovation drivers influencing SBM adoption across key manufacturing industries in India.

A quantitative research methodology was employed, with primary data collected from 153 respondents across major manufacturing sectors, including Chemicals & Plastics, Infrastructure, Steel & Cement, Automobile & Transportation, Consumer Electronics & Capital Goods, Pharmacy & Healthcare, Textiles, and Agriculture & Food Processing. Statistical techniques such as ANOVA, Chi-Square, Kruskal-Wallis H Test, T-Test, and Multiple Regression Analysis were applied to assess sectoral differences, identify key challenges, and explore the factors affecting sustainability-driven innovation.

The findings reveal that resource unavailability, high developmental costs, and managerial hesitancy are the most significant obstacles to SBM adoption. Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare sectors face the greatest challenges, particularly regarding financial constraints, operational inefficiencies, and lack of industry-wide collaboration. While awareness of sustainability practices is growing, many industries remain in early or mid-level stages of preparedness, with structured implementation still limited. Companies in the Automobile & Transportation and Consumer Electronics & Capital Goods sectors demonstrate relatively higher engagement, while Textiles and Agriculture & Food Processing lag in structured sustainability transitions.

Circular economy principles, digital transformation, and green supply chain initiatives are emerging as key drivers of sustainability adoption. However, industry collaboration remains low, with many firms reluctant to share knowledge or engage in joint sustainability efforts with competitors. Financial incentives, policy interventions, and stronger managerial commitment are identified as essential enablers for accelerating the transition toward sustainable practices.

This study contributes to the discourse on sustainable manufacturing in India by offering sector-specific insights, strategic recommendations, and policy implications. Addressing the identified barriers through financial support mechanisms, regulatory reforms, and cross-industry collaboration will be crucial in fostering a more sustainable and competitive manufacturing landscape in India.

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CHAPTER I:

INTRODUCTION

1.1 Introduction

In recent years, sustainability has emerged as a critical priority for businesses worldwide, driven by environmental concerns, regulatory pressures, and shifting consumer preferences. As one of the most significant contributors to resource consumption and environmental impact, the manufacturing sector is pivotal in transitioning toward sustainable business models (SBMs). Manufacturing is a key driver of economic growth in India, contributing significantly to GDP, employment, and industrial development. However, the sector faces mounting challenges, including resource depletion, carbon emissions, waste management, and regulatory compliance. The need for a structured transition to sustainable business practices is more pressing than ever.

Sustainable Business Models (SBMs) provide a framework for integrating environmental, social, and economic sustainability into business operations. Unlike conventional models, which prioritise short-term profitability, SBMs focus on long-term value creation by adopting circular economy principles, green technology, and responsible resource management. While global manufacturing leaders have made significant strides in sustainable transformation, Indian manufacturing firms are still navigating the complexities of this transition. Challenges such as financial constraints, technological gaps, regulatory uncertainties, and a lack of awareness about sustainability benefits hinder large-scale adoption.

This dissertation explores the strategies for successfully transitioning to SBMs in key Indian manufacturing sectors. It aims to identify the major drivers, barriers, and enablers of adopting sustainability while evaluating government initiatives, industry best

practices, and policy recommendations. By addressing these aspects, the study seeks valuable insights for businesses, policymakers, and stakeholders striving to align India's manufacturing industry with global sustainability standards.

The following sections of this chapter provide a deeper understanding of the manufacturing sector's role in sustainability, the global emphasis on sustainable business practices, the importance of SBMs, the challenges specific to India, and the regulatory framework shaping this transition. The study's research objectives, scope, and significance are also outlined, establishing a clear direction for the subsequent chapters.

1.2 Overview of India's Manufacturing Sector

- **The Role of Manufacturing in India's Economic Growth**

India's manufacturing sector has played a crucial role in the country's economic transformation over the last decade. With government initiatives, foreign direct investments, and evolving industrial policies, the sector has significantly contributed to GDP growth, employment generation, export expansion, and infrastructure development. Despite facing challenges such as regulatory hurdles and labor inefficiencies, manufacturing continues to be a key driver of economic progress.

The manufacturing sector has been a significant contributor to India's Gross Domestic Product (GDP), with its share hovering around 16-18% over the past decade. The Make in India initiative launched in 2014 aimed to boost this contribution to 25%, though achieving this target remains a challenge. The Gross Value Added (GVA) of the manufacturing sector has grown consistently, indicating its increasing role in economic expansion. However, factors such as complex regulations and labor market challenges have hindered the full realization of India's manufacturing potential. Studies suggest that while the government's policy interventions have strengthened the sector, achieving long-

term sustainability will require continued reforms (Sangwan, 2016; Arjune & Kumar, 2022).

Manufacturing has contributed significantly to employment, directly engaging over 27.3 million people while also supporting millions in ancillary sectors. However, employment growth in this sector has been uneven, with some states witnessing substantial gains while others lag behind. The shift towards automation and capital-intensive industries has also impacted labor absorption. The growth of Micro, Small, and Medium Enterprises (MSMEs) has been instrumental in employment generation, especially in rural and semi-urban areas, contributing to regional economic development and social progress. MSMEs have been a critical component of industrial expansion, but the sector still faces issues related to access to finance, infrastructure, and scalability (Bai, Jakhar & Vashist, 2014; Banik, 2018).

India’s infrastructure development, particularly through industrial corridors and smart manufacturing clusters, has enhanced supply chain efficiency and global competitiveness. The government's push for ease of doing business, including reforms in taxation, such as the introduction of the Goods and Services Tax (GST), and labor laws, has encouraged industrial expansion. However, regulatory complexities still pose challenges to business operations. Investment in logistics, digital manufacturing, and smart factories has improved industrial efficiency, but further reforms are needed to sustain long-term growth. Industrial policies have focused on reducing bureaucratic inefficiencies, but the success of these measures has been mixed, with businesses still facing difficulties in land acquisition and compliance with multiple regulations (Bhavani, 2018).

India's manufacturing exports have risen, with key sectors such as automobiles, pharmaceuticals, and electronics playing a significant role. The sector has attracted

substantial Foreign Direct Investment (FDI), reaching $21.34 billion in FY22, reflecting investor confidence in India's industrial potential. The Production Linked Incentive (PLI) scheme has further boosted investments in high-growth sectors like semiconductors, mobile manufacturing, and renewable energy, reinforcing India's position as a global manufacturing hub. Despite these positive trends, concerns remain about the reliance on imports for key industrial components and the need to strengthen domestic supply chains to reduce vulnerabilities in global trade fluctuations (Khurana, 2018).

Despite its growth, India's manufacturing sector faces significant hurdles, including land acquisition issues, infrastructure gaps, and labor inefficiencies. The shift towards sustainability is gaining traction, with increasing investment in green manufacturing, electric vehicles (EVs), circular economy practices, and renewable energy adoption. The government has introduced policies to support environmentally friendly production methods, but challenges such as financial constraints and technological gaps persist in the adoption of sustainable practices. While green manufacturing initiatives are being promoted, their implementation at scale remains a work in progress due to the need for technological upgradation and financial incentives (Kakar, 2017; Das & Das, 2020).

The manufacturing sector has been a crucial pillar of India's economic development over the past decade, contributing to GDP growth, employment, exports, and infrastructure advancements. While policy interventions and investments have led to significant improvements, challenges such as regulatory complexities and labor inefficiencies remain. Strengthening industrial policies and focusing on sustainable growth will be key to realizing India's vision of becoming a global manufacturing hub. Continued investment in innovation, technology, and skill development will be essential for sustaining long-term industrial growth and global competitiveness.

- **Key Industries Driving the Indian Manufacturing Sector**

India's manufacturing sector has experienced substantial growth over the years, with industries such as automobiles, pharmaceuticals, electronics, chemicals, textiles, and petrochemicals emerging as dominant players. These industries have played a crucial role in the country's economic development by generating employment, increasing exports, and attracting foreign direct investments. The success of these industries can be attributed to various factors, including government policies, technological advancements, infrastructure development, and increasing market demand.

The automobile industry is one of the most significant contributors to India's manufacturing GDP, accounting for approximately 7.1% and 49%. India has become the fourth-largest automobile market in the world, driven by strong domestic demand, a growing middle class, and government initiatives such as the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme. The Production Linked Incentive (PLI) scheme has further accelerated the production of electric vehicles, positioning India as a global hub for EV manufacturing. The rise of domestic manufacturers such as Tata Motors and Mahindra, along with international giants like Toyota and Hyundai expanding their presence, has further strengthened the sector (Khurana, 2018).

The pharmaceutical industry has also emerged as a key player, contributing around 3.5% to India's GDP. India is recognized as the third-largest producer of medicines globally and accounts for nearly 50% of the world's vaccine supply. The availability of skilled labour, advanced research facilities, and a strong regulatory framework have driven the industry's success. Policies such as Pharma Vision 2020 and relaxed foreign direct investment regulations have encouraged global pharmaceutical companies to invest in India. Additionally, the production of generic drugs and increased

demand for healthcare solutions have further fueled the sector's expansion (Puwar, Jalan & Garg, 2018).

The electronics and mobile manufacturing sector has proliferated, mainly due to the Make in India initiative and the PLI scheme. India is now the second-largest mobile phone manufacturer in the world, with global companies such as Apple, Samsung, and Xiaomi establishing production units in the country. The increasing domestic demand for electronic goods, a skilled workforce, and government incentives have significantly boosted manufacturing. The recent push for semiconductor and chip manufacturing is expected further to elevate India's global electronics supply chain position, reducing import dependency and strengthening the country's technological capabilities (Singh & Kumar, 2022).

India's chemical and petrochemical industries are among the fastest-growing sectors, contributing more than 13% to manufacturing GDP. The muscular availability of raw materials, a growing domestic market, and increased foreign investments have propelled this industry forward. Speciality chemicals, including agrochemicals, polymers, and surfactants, have witnessed significant demand due to their applications in industrial production. The government's ease of doing business initiatives and a shift towards research and development have enhanced India's competitiveness in the global chemical industry (Vasa, Aggarwal & Rebernik, 2014).

The textile and apparel industry has remained one of India's most significant manufacturing sectors, contributing nearly 5% to GDP and accounting for 12% of total exports. As the second-largest textile exporter in the world, India benefits from abundant raw materials such as cotton and jute, low labour costs, and well-established supply chains. The government's incentives under the PLI scheme and the Technology Upgradation Fund Scheme (TUFS) have helped boost production, particularly in high-

value textiles such as technical and synthetic fibres. Despite global competition, India's textile industry remains a crucial employment generator and an important contributor to foreign exchange earnings (Thomas, 2013).

India's transition toward sustainable manufacturing has gained momentum, with significant investments in renewable energy, solar panel manufacturing, battery production, and green hydrogen. The National Solar Mission has positioned India as one of the top producers of solar panels, with a focus on increasing domestic production to reduce import dependency. The PLI scheme for Advanced Chemistry Cell (ACC) battery storage is expected to bolster domestic battery manufacturing, supporting India's ambition to achieve net-zero carbon emissions by 2070. These initiatives contribute to economic growth and align with global sustainability goals (Das & Das, 2020).

The growth of these industries can be attributed to several factors. Government policies and incentives such as Make in India, Atmanirbhar Bharat (Self-Reliant India), and the PLI scheme have played a crucial role in providing manufacturers with financial support, tax benefits, and incentives. Technological advancements, including automation, artificial intelligence, and Industry 4.0, have enhanced production efficiency and competitiveness in global markets. Foreign direct investment has also been instrumental in driving industrial expansion, with relaxed FDI regulations attracting significant investments in the automobile, electronics, and pharmaceutical sectors. The availability of a skilled workforce and intense research and development initiatives have further contributed to the sector's success, making India a preferred destination for high-tech manufacturing. Additionally, improved industrial infrastructure, smart cities, and logistics networks have reduced production costs and improved supply chain efficiency, further boosting manufacturing growth (Kathuria & Natarajan, 2013).

India's manufacturing sector continues to evolve, with industries such as automobiles, pharmaceuticals, electronics, chemicals, textiles, and renewable energy leading the way. Government support, foreign investments, technological advancements, and skilled labour have positioned India as a global manufacturing hub. However, infrastructure bottlenecks, regulatory complexities, and global market fluctuations remain key concerns. Addressing these challenges through policy reforms and investments in innovation and digitalization will be essential for sustaining long-term industrial growth and competitiveness in the global market.

- **Trends and Developments in Indian Manufacturing**

India's manufacturing sector is transforming significantly due to technological advancements, policy initiatives, and global market shifts. Several emerging trends are shaping the sector's future, including Industry 4.0 adoption, sustainable and green manufacturing, digitalization, skill development, and increased foreign direct investment (FDI). These trends are expected to enhance productivity, improve efficiency, and position India as a global manufacturing hub.

One of the most significant trends is the adoption of Industry 4.0 technologies, including artificial intelligence (AI), automation, the Internet of Things (IoT), cloud computing, and cyber-physical systems. Industry 4.0 revolutionizes manufacturing processes by enabling real-time monitoring, predictive maintenance, and intelligent factory automation. Companies are increasingly integrating digital twins, robotics, and AI-driven analytics to enhance efficiency and reduce operational costs. The rapid expansion of smart manufacturing and digital factories is helping Indian industries optimize production, reduce downtime, and improve product quality. However, the lack of a skilled workforce and high initial investment costs remain challenges for full-scale implementation (Xu, Xu & Li, 2018).

Green and sustainable manufacturing is another crucial trend shaping the industry, driven by global climate change commitments and increasing environmental regulations. Indian manufacturers focus on energy-efficient production methods, carbon footprint reduction, and circular economy practices. The government has introduced various incentives to promote the adoption of renewable energy sources, electric vehicles (EVs), and green hydrogen technology in industrial production. The emphasis on zero-waste manufacturing, resource efficiency, and eco-friendly product innovations is expected to create a competitive advantage for Indian firms in global markets. However, sustainable manufacturing requires investment in clean technologies, regulatory compliance, and industry-wide collaboration (Prabhakar, 2024).

Digitalization and intelligent supply chain management are also redefining India's manufacturing landscape. Integrating blockchain, big data analytics, and cloud computing enhances supply chain transparency, reduces lead times, and improves inventory management. With the rise of e-commerce and digital platforms, manufacturers focus on on-demand production and mass customization to cater to diverse consumer preferences. Implementing smart logistics, automated warehouses, and AI-driven demand forecasting will enhance operational efficiency and reduce costs (Singh, Bhardwaj, Singh, Chaturvedi, Kumar & Gupta, 2021).

The future of work in Indian manufacturing is also undergoing significant transformation due to automation and digital advancements. The demand for skilled labour in advanced manufacturing technologies is increasing, requiring upskilling and reskilling initiatives. The rise of robotic process automation (RPA) and AI-driven production lines is expected to replace repetitive manual jobs while creating new opportunities in high-tech manufacturing. To address the skills gap, the government and private sector invest in vocational training programs, skill development centres, and

collaborations with academic institutions. However, managing technological unemployment and workforce transition remains a key challenge for policymakers (Mehta & Awasthi, 2019).

Increased foreign direct investment (FDI) and global supply chain realignment are also shaping the future of Indian manufacturing. The Make in India and Atmanirbhar Bharat (Self-Reliant India) initiatives have attracted major global players in electronics, automobiles, and pharmaceuticals to set up manufacturing units in India. The government has implemented ease-of-doing-business reforms, tax incentives, and infrastructure development programs to attract more investment. The shift of global supply chains away from China due to geopolitical tensions and COVID-19 disruptions has positioned India as a preferred destination for diversified manufacturing hubs. However, land acquisition issues, regulatory complexities, and logistics inefficiencies must be addressed for sustained FDI growth (Khurana, 2018).

The Indian manufacturing sector is also witnessing the rise of smart factories and digital twins for enhanced production efficiency. Companies use AI-driven predictive maintenance, real-time monitoring systems, and digital simulations to optimize production. The Factory of the Future concept, where cloud-based manufacturing and AI-driven quality control improve overall operational efficiency, is gaining traction. The transition towards hyper-automation and 5G-enabled industrial communication is expected to revolutionize factory operations, reducing downtime and improving productivity (Salierno, Leonardi & Cabri, 2021).

The pharmaceutical and healthcare manufacturing sector also embraces AI, automation, and data-driven drug discovery. The increasing demand for personalized medicine, vaccine production, and biotechnology innovations has led to the rapid adoption of AI-driven diagnostics, predictive analytics, and automated drug formulation.

Integrating Industry 4.0 in pharmaceutical manufacturing is expected to improve precision, reduce costs, and enhance regulatory compliance (Kimta & Dogra, 2024).

1.3 Growing Global Emphasis on Sustainability in Business

- **The Shift Towards Sustainable Business Practices Worldwide**

As businesses worldwide increasingly prioritize sustainability, companies across various industries are adopting environmentally friendly practices, circular economy models, and corporate social responsibility (CSR) strategies to reduce their ecological footprint. The shift toward sustainability is driven by stricter government regulations, changing consumer preferences, and the need for long-term business resilience. Indian manufacturers can learn from these global transitions by integrating sustainable practices into their operations, supply chains, and business models.

One of the primary ways global businesses have transitioned toward sustainability is by adopting green manufacturing and circular economy principles. Companies in developed economies are focusing on waste reduction, resource efficiency, and product lifecycle management to minimize environmental impact. Many multinational corporations have adopted closed-loop production systems, where products are designed to be reused, refurbished, or recycled at the end of their lifecycle. This approach reduces waste and enhances cost efficiency and regulatory compliance. Indian manufacturers can benefit by implementing lean and agile manufacturing strategies focusing on waste minimization and energy-efficient processes, as demonstrated in studies on sustainable manufacturing practices in Indian industries (Gupta, Dangayach, Singh, Meena & Rao, 2018).

Another significant transition is the incorporation of sustainability into supply chain management. Global firms ensure suppliers adhere to environmental and ethical

standards, emphasizing responsible sourcing, fair labour practices, and reduced carbon footprints. Companies like Unilever, Tesla, and IKEA have adopted green supply chain strategies by sourcing sustainable materials, optimizing logistics, and reducing greenhouse gas emissions across the supply chain. Indian businesses, particularly in the automobile and textile industries, can adopt similar sustainable supply chain management (SSCM) practices by integrating social and environmental responsibility into their procurement and distribution strategies (Kaur & Sharma, 2018).

Businesses worldwide also leverage advanced technologies such as Industry 4.0 and smart manufacturing to improve sustainability. Digital transformation through artificial intelligence (AI), the Internet of Things (IoT), and blockchain enables real-time resource usage monitoring, predictive maintenance, and energy optimization. Adopting smart factories and automation in developed countries has improved production efficiency, reducing energy consumption and material wastage. Indian manufacturers, particularly in MSMEs and large-scale manufacturing, must integrate digitalization and IoT-based sustainability tracking to enhance operational efficiency while reducing carbon footprints (Luthra & Mangla, 2018).

A crucial lesson from global firms is the transition from green manufacturing to fully sustainable manufacturing, which involves environmental, economic, and social factors. Many companies initially focused on green manufacturing—implementing pollution control measures and energy efficiency—but later expanded their approach to sustainable manufacturing by addressing broader issues like carbon neutrality, employee well-being, and social responsibility. Indian manufacturers should recognize that sustainability is reducing emissions and creating an inclusive, fair, and resilient industrial ecosystem (Rehman & Seth, 2024).

Corporate social responsibility (CSR) and regulatory compliance have also been critical in global sustainability transitions. In developed economies, CSR is legally mandated and deeply integrated into corporate strategies, ensuring that companies take responsibility for their environmental and social impact. India's mandatory CSR policy under the Companies Act (2013) has encouraged businesses to invest in sustainability projects, but there is still a gap in effective implementation and transparency. Indian firms must strengthen their CSR reporting and environmental governance to align with international standards (Kottala, 2021).

Additionally, sustainable innovation has become a key driver of long-term success in global manufacturing. Many companies invest heavily in R&D for eco-friendly product design, renewable energy integration, and biodegradable materials. Tesla's success in the electric vehicle (EV) industry and Apple's commitment to 100% carbon-neutral products exemplify how innovation can drive sustainability. Indian firms, particularly in automobiles, pharmaceuticals, and electronics, must focus on sustainable R&D and innovation to remain competitive in international markets (Khurana, Haleem & Mannan, 2019).

Another critical takeaway from global businesses is the importance of sustainability-driven policy advocacy and industry collaboration. Developed nations have established public-private partnerships, industry consortiums, and sustainability standards that guide companies toward greener operations. For example, the European Union's Green Deal and Carbon Border Adjustment Mechanism (CBAM) incentivize businesses to reduce emissions and transition to cleaner technologies. Indian industries can benefit from greater collaboration between the government, research institutions, and private enterprises to drive sustainable policies and industry-wide transformation (Toke & Kalpande, 2019).

Despite significant progress in sustainable transitions globally, challenges such as high investment costs, resistance to change, and regulatory complexities persist. However, businesses that have successfully adopted sustainability strategies have demonstrated increased brand value, operational efficiency, and long-term profitability. Indian manufacturers need to view sustainability not as a regulatory burden but as a competitive advantage that enhances resilience, attracts investments, and ensures long-term growth.

- **Corporate Responsibility and ESG in the Global Market**

Environmental, Social, and Governance (ESG) criteria have become a fundamental part of corporate strategy, influencing how businesses operate, make investment decisions, and respond to regulatory and consumer expectations. ESG integration is no longer an optional consideration but a critical element for ensuring long-term business sustainability, risk mitigation, and enhanced stakeholder trust.

One of the most significant ways ESG has influenced global business strategies is through investment and financial performance considerations. Investors increasingly favor companies with strong ESG commitments, as sustainable business practices are associated with lower risk, improved financial resilience, and higher long-term returns. Many investment funds, including pension funds and sovereign wealth funds, now prioritize ESG-compliant companies, which has encouraged businesses worldwide to integrate ESG metrics into their corporate governance structures. Research highlights that ESG considerations significantly impact financial performance, with firms demonstrating strong ESG commitments attracting more investment and enjoying better stock performance (Putra & Budastra, 2024).

Additionally, the rise of ESG-focused regulations and policies has compelled businesses to align with environmental and social standards. Governments and regulatory bodies worldwide are implementing stricter ESG disclosure requirements, compelling companies to adopt sustainable practices in compliance with international standards. The European Union's Sustainable Finance Disclosure Regulation (SFDR) and the Task Force on Climate-related Financial Disclosures (TCFD) are examples of frameworks pushing corporations toward greater transparency and accountability in their ESG commitments. These regulations ensure that companies integrate sustainability into their financial and operational reporting, thereby increasing corporate responsibility (Hassan et al., 2024).

ESG has also played a crucial role in shaping corporate risk management strategies. Companies with strong ESG frameworks tend to be better prepared to handle environmental risks such as climate change, natural disasters, and resource shortages. Social and governance aspects of ESG help businesses mitigate reputational risks and regulatory penalties associated with unethical labor practices, corruption, and discrimination. ESG-driven risk assessment allows firms to anticipate market shifts, adapt to changing consumer demands, and comply with emerging sustainability laws (Warouw et al., 2024).

The social component of ESG is influencing business strategies by compelling companies to focus on diversity, inclusion, labor rights, and corporate social responsibility (CSR). Consumers today expect businesses to be socially responsible, fostering fair wages, workplace diversity, and ethical supply chain practices. Firms that fail to address social concerns risk losing customers and facing public backlash. The increasing importance of employee well-being, human rights, and community

engagement is shaping how businesses interact with stakeholders and build their corporate reputation (Passas et al., 2022).

Governance, the third pillar of ESG, is shaping business strategy by ensuring that corporate leadership prioritizes ethical decision-making, accountability, and transparency. Companies with strong governance structures are more resilient to fraud, corruption, and mismanagement, ultimately gaining stakeholder trust. Effective governance is essential for securing investor confidence and ensuring regulatory compliance. Studies indicate that well-governed firms are better positioned to navigate crises, such as the COVID-19 pandemic, and emerge stronger from economic downturns (Chen, 2024).

Another major area where ESG is driving transformation is in supply chain management. Companies are now incorporating sustainable procurement practices, reducing carbon emissions, and ensuring ethical labor conditions across their supply chains. Businesses with extensive global supply chains, such as Apple, Unilever, and Nestlé, have committed to carbon neutrality, responsible sourcing, and ethical supplier relationships. ESG compliance in supply chains helps firms reduce exposure to legal and reputational risks while ensuring long-term business sustainability (Bibby, 2024).

Moreover, the role of ESG in mergers and acquisitions (M&A) has grown significantly. ESG considerations are now a key factor in evaluating M&A deals, as companies seek to align with sustainable business models. Firms that integrate ESG principles into their M&A strategies benefit from higher valuations, reduced regulatory scrutiny, and improved stakeholder confidence. ESG-driven M&A strategies allow firms to create value while mitigating risks associated with environmental and social liabilities (Siddhartha, 2024).

Despite the many advantages of ESG integration, businesses face challenges such as greenwashing, lack of standardized ESG metrics, and regulatory complexity. Some

companies falsely claim ESG compliance without making significant changes to their operations, misleading investors and consumers. Additionally, there is no universally accepted ESG reporting standard, which complicates cross-industry comparisons and investor decision-making. Policymakers and industry leaders must work toward harmonizing ESG reporting frameworks to ensure meaningful and comparable disclosures (David et al., 2024).

1.4 Importance of Sustainable Business Models (SBMs)

- **Core Principles of Sustainable Business Models**

Sustainable business models in manufacturing are structured around the need to balance economic growth with environmental and social responsibility. As industries transition towards sustainability, they integrate key principles that enable resource efficiency, circular economy practices, stakeholder collaboration, and long-term resilience. Research on sustainable business models highlights several core principles that define how manufacturers can align profitability with sustainability.

One of the foundational principles of sustainable business models is the triple bottom line (TBL) approach, which emphasizes economic, environmental, and social value creation. Unlike traditional business models that focus solely on financial profit, sustainable business models integrate environmental responsibility by minimizing waste, reducing carbon emissions, and optimizing energy consumption. They also prioritize social factors such as fair labor practices, workforce well-being, and community engagement. The TBL approach ensures that businesses not only generate profit but also contribute to long-term environmental sustainability and societal well-being (Agwu & Bessant, 2021).

Another essential principle is circular economy integration, which involves designing production processes to maximize resource efficiency and minimize waste. Circular manufacturing promotes practices such as product life extension, remanufacturing, recycling, and waste valorization. Companies like those in the automotive and electronics sectors have successfully adopted circular economy strategies by focusing on component reuse and recycling rather than linear production models that lead to excessive waste generation. This shift toward closed-loop systems reduces dependency on raw materials and contributes to resource sustainability (Pieroni, McAloone & Pigosso, 2019).

Stakeholder-driven sustainability is another fundamental aspect of sustainable business models. Modern manufacturers actively involve customers, suppliers, policymakers, and local communities in their sustainability initiatives. By fostering collaborative innovation, transparent governance, and responsible sourcing, companies ensure that sustainability efforts are embedded across the supply chain. Businesses that engage in multi-stakeholder partnerships tend to achieve better sustainability outcomes by aligning their objectives with industry standards, regulatory policies, and consumer expectations (Bocken, Boons & Baldassarre, 2019).

Eco-design and sustainable product development also play a vital role in sustainable manufacturing. Companies are increasingly adopting life-cycle assessment (LCA) methodologies to ensure that products are designed with sustainability in mind, from raw material extraction to disposal. The adoption of green materials, biodegradable packaging, and energy-efficient production technologies helps manufacturers reduce environmental impact. Sustainable product innovation also leads to cost savings, regulatory compliance, and competitive advantage, making it a crucial element in long-term business success (Comin et al., 2019).

Digitalization and Industry 4.0 technologies have further enhanced sustainable manufacturing by optimizing resource utilization, predictive maintenance, and supply chain transparency. Technologies such as the Internet of Things (IoT), blockchain, artificial intelligence (AI), and data analytics allow manufacturers to monitor sustainability metrics in real time, reducing inefficiencies and environmental impact. Smart factories and automated energy management systems help companies track their carbon footprint, optimize energy use, and improve operational efficiency. Integrating digital technologies into sustainable business models enables manufacturers to achieve both economic growth and environmental responsibility (Kazokova & Lee, 2022).

Sustainable business models also emphasize corporate social responsibility (CSR) and ethical governance. Companies that integrate fair labor practices, employee welfare programs, and ethical supply chain management into their business models experience higher stakeholder trust and brand loyalty. Ethical governance frameworks, such as ESG (Environmental, Social, and Governance) compliance, have become essential for companies to attract investors and maintain a positive corporate reputation. Businesses that incorporate transparency, accountability, and ethical leadership into their operations build long-term resilience against market disruptions and regulatory challenges (Gazzola et al., 2024).

A crucial principle shaping sustainable business models is resilience and adaptability to climate risks and regulatory shifts. Climate change, resource scarcity, and policy changes necessitate that manufacturers adopt flexible and risk-aware business strategies. Companies that proactively invest in renewable energy, sustainable supply chains, and low-carbon technologies are better positioned to navigate future challenges. Integrating sustainability into core business operations enables companies to remain competitive while reducing exposure to environmental risks (Brozović, 2020).

- **Long-Term Benefits of Sustainability for Businesses**

Sustainable business models have become a crucial strategy for organizations aiming to balance profitability with long-term resilience, environmental responsibility, and social impact. Companies that integrate sustainability into their operations tend to experience enhanced financial performance, risk mitigation, competitive advantage, and operational efficiency. Research highlights that businesses adopting sustainable models not only strengthen their market positioning but also improve stakeholder trust, regulatory compliance, and innovation capacity.

One of the primary ways sustainability drives financial success is through cost reduction and resource efficiency. Sustainable manufacturing and operational processes focus on waste minimization, energy conservation, and circular economy practices, which significantly reduce operational costs. For example, companies that invest in renewable energy sources, energy-efficient production techniques, and resource optimization strategies experience lower long-term expenditures. Studies have shown that businesses implementing sustainability-focused operational models achieve higher profitability by reducing material costs and improving resource utilization (Dembek & York, 2019).

Another major financial benefit is risk management and resilience. Companies that prioritize sustainability are better equipped to handle market fluctuations, regulatory changes, and environmental risks such as climate change-related disruptions. Organizations with strong Environmental, Social, and Governance (ESG) compliance have better access to capital, as investors and lenders increasingly favor companies demonstrating sustainability commitments. Sustainable business models enhance corporate risk mitigation by integrating long-term financial planning, climate risk

assessment, and ethical governance, thereby ensuring financial stability even during economic downturns (Achumie, Ewim, Adeleke, Okeke & Mokogwu, 2024).

Sustainability also contributes to long-term operational success by fostering innovation and competitive advantage. Businesses that incorporate sustainability into their product development processes create eco-friendly products, develop energy-efficient technologies, and adopt digital transformation strategies such as smart manufacturing and Industry 4.0. Sustainable companies are more likely to attract high-value customers, secure government incentives, and gain preferential treatment in supply chain partnerships. Research suggests that organizations focusing on sustainability-driven innovation outperform competitors in terms of market expansion and consumer loyalty (Comin, Aguiar, Sehnem, Yusliza, Cazella & Julkovski, 2019).

Another key contributor to long-term success is the impact of sustainability on employee satisfaction, talent attraction, and productivity. Businesses that integrate corporate social responsibility (CSR), ethical labor practices, and workplace sustainability programs experience higher employee retention, increased engagement, and improved overall workforce performance. Employees prefer organizations that prioritize social impact and environmental responsibility, which directly influences workplace productivity and company culture. Research on sustainable leadership highlights that businesses prioritizing employee well-being and sustainability-driven corporate policies enjoy higher levels of organizational commitment and operational efficiency (Cioca, Wehbe, Popescu & Popescu, 2020).

Sustainable business models also contribute to long-term financial stability through investment attractiveness and shareholder value enhancement. Investors and financial institutions are increasingly adopting ESG investment frameworks, rewarding companies that demonstrate strong sustainability governance, ethical business practices,

and responsible environmental policies. Companies integrating sustainability in their financial decision-making experience higher stock market valuation, lower volatility, and stronger investor confidence. Studies have found that firms that integrate sustainable finance principles into their corporate governance frameworks are better positioned to access long-term capital and maintain financial growth (Schoenmaker & Schramade, 2020).

One of the most significant impacts of sustainability is its role in improving brand reputation and customer loyalty. Consumers today are more likely to engage with brands that exhibit environmental consciousness, ethical sourcing, and fair-trade principles. Companies that prioritize sustainability enhance customer trust, attract premium market segments, and benefit from long-term revenue streams. Research highlights that businesses that integrate sustainability into their core branding strategies see improvements in customer acquisition, brand equity, and market differentiation (Egieya, Ewuga, Omotosho, Adegbite & Oriekhoe, 2023).

Sustainability also plays a role in enhancing regulatory compliance and reducing legal risks. Governments and international organizations are tightening climate regulations, carbon taxation, and ESG reporting mandates, making it imperative for companies to align with these new standards. Businesses that proactively integrate sustainable business models are better prepared for regulatory shifts, avoiding fines, legal disputes, and reputational damage. Research suggests that companies that preemptively adopt sustainability policies benefit from greater policy incentives and regulatory flexibility (Bakoğlu, 2023).

Despite the clear advantages of sustainability-driven business models, organizations face challenges such as initial investment costs, complexity in measuring sustainability performance, and balancing short-term profitability with long-term

sustainability goals. However, companies that successfully implement sustainable strategies experience higher resilience, stronger financial returns, and long-term growth.

1.5 Current Challenges in the Indian Manufacturing Landscape

- **Economic and Technological Constraints in the Sector**

The transition to sustainability in Indian manufacturing faces significant challenges, primarily due to financial and technological limitations. While sustainability is crucial for long-term business viability, economic growth, and regulatory compliance, high capital investment requirements, limited access to finance, inadequate technological adoption, and policy constraints hinder the transition process. Research highlights that these barriers impact both large-scale and small-scale manufacturers, affecting their ability to implement green practices, innovate in sustainable manufacturing, and achieve long-term competitiveness.

One of the key financial barriers is limited access to finance for small and medium-sized enterprises (SMEs). Despite their role in driving India's manufacturing sector, SMEs struggle to secure funding for sustainability initiatives due to high initial investment costs, lack of credit availability, and stringent lending criteria. Studies indicate that financial constraints hinder the ability of small firms to transition into sustainable business practices, leading to slow adoption of green technologies and inefficient resource management. The inability to access finance is particularly problematic for firms seeking to implement energy-efficient technologies, carbon-neutral operations, and circular economy models (Rabbani & Raj, 2024).

Another major financial limitation is the high upfront costs of green innovations and long payback periods. While sustainable technologies such as renewable energy systems, green manufacturing equipment, and pollution control mechanisms reduce long-

term operational costs, they require significant capital investment. Many Indian manufacturers struggle to justify these investments due to the delayed financial benefits and uncertainties regarding return on investment (ROI). Research shows that while green product innovation attracts investors, green process innovations often face challenges in demonstrating immediate profitability, making businesses hesitant to invest in sustainable production methods (Investor Perception and Green Innovation, 2023).

The technological limitations affecting sustainability transition in Indian manufacturing stem from low adoption rates of Industry 4.0 technologies, lack of skilled workforce, and inadequate infrastructure. The integration of artificial intelligence (AI), the Internet of Things (IoT), and automation is essential for achieving sustainable manufacturing, yet Indian firms face challenges in acquiring, implementing, and maintaining these technologies. Studies indicate that while smart sensors and robotics improve sustainability, cyber-physical systems and big data analytics have low sustainability adoption rates in Indian industries due to limited expertise and high costs. Additionally, the fear of job losses due to automation further slows down the adoption of Industry 4.0 solutions in the Indian workforce (Pasi, Mahajan & Rane, 2020).

A significant issue also arises from the slow pace of digital finance development in manufacturing, which affects the ability of firms to invest in green transitions. Research suggests that digital finance, green funding mechanisms, and sustainable investment platforms can play a crucial role in accelerating sustainability efforts. However, many Indian manufacturing firms lack access to digital financial tools and investment channels, limiting their ability to transition toward a low-carbon economy. Policymakers are advised to strengthen financial supervision, improve digital infrastructure, and develop green finance frameworks to bridge this gap (Yu, 2024).

Another major constraint impacting the sustainability transition is balancing industrial growth with environmental responsibility. Studies show that financial and technological innovations initially contribute to environmental degradation, as industries continue to rely on fossil fuels, outdated production techniques, and inefficient energy consumption. While long-term technological advancements can eventually lead to improved environmental performance, in the short term, Indian manufacturers struggle to align economic expansion with sustainability goals. The findings highlight that transitioning to sustainable manufacturing requires a stronger regulatory framework, improved energy efficiency policies, and increased investment in renewable energy sources (Ursavaş, Bil & Yılancı, 2024).

Despite these challenges, the research suggests that manufacturers who successfully navigate financial and technological constraints experience improved business performance and environmental impact. A study on the transition from green manufacturing to sustainable manufacturing highlights that effective policy implementation, government incentives, and market pressures drive firms toward sustainability. However, without adequate financial support and technology adoption, businesses remain hesitant to transition. The research suggests that government interventions, public-private collaborations, and supply chain stakeholder engagement are essential in accelerating sustainable manufacturing adoption in India (Rehman & Seth, 2024).

- **Policy and Regulatory Challenges Affecting Sustainability**

Sustainability policies have been instrumental in guiding businesses and industries toward environmental responsibility, social governance, and long-term economic growth. However, despite their growing importance, existing policies often

face implementation gaps, regulatory inconsistencies, and enforcement challenges that hinder their overall effectiveness. Research highlights that while command-and-control regulations, market-based policies, and voluntary sustainability programs have contributed to sustainability advancements, critical gaps remain in monitoring, compliance, and cross-sectoral coordination.

One of the primary challenges in sustainability policy effectiveness is the gap between regulatory intent and enforcement. Studies indicate that many environmental regulations exist primarily as tick-box compliance requirements rather than genuine sustainability commitments. While governments and industries recognize the importance of sustainability, inconsistent enforcement mechanisms, weak regulatory supervision, and bureaucratic inefficiencies reduce the impact of these policies. Research suggests that regulatory policies must incorporate clear enforcement mechanisms, penalty structures, and independent oversight bodies to ensure genuine sustainability progress (Teichmann & Wittmann, 2022).

Another major issue affecting sustainability policies is the lack of harmonization between different regulatory frameworks. Environmental regulations often vary significantly across industries, regions, and countries, leading to discrepancies in compliance requirements and market competitiveness. Studies on global sustainability policies highlight that fragmented regulatory landscapes make it difficult for businesses to adopt a unified sustainability strategy, particularly for multinational corporations operating across jurisdictions. The lack of an integrated approach limits the effectiveness of sustainability policies and creates loopholes that companies can exploit to bypass stringent environmental standards (Adanma & Ogunbiyi, 2024).

The effectiveness of policies in sustainable supply chain management is also questioned due to the complexity of globalized production networks. While market-based

policies and voluntary sustainability standards encourage companies to adopt greener supply chain practices, research shows that lack of mandatory sustainability reporting, insufficient government incentives, and limited access to green financing create barriers to achieving sustainable supply chains. Firms that wish to transition to greener operations often struggle due to financial constraints, high implementation costs, and weak consumer demand for sustainable products (Darnall, Welch & Cho, 2019).

One of the significant regulatory gaps in sustainability policies is the insufficient integration of technological innovation with environmental governance. Many policies emphasize sustainability goals without adequately addressing the role of technological advancements in achieving these objectives. Research highlights that technological innovation is a key driver of sustainability, yet policy frameworks often fail to incentivize green R&D, digital transformation, and renewable energy adoption. The lack of financial support for industrial digitalization, weak intellectual property protection for sustainable innovations, and limited collaboration between governments and research institutions hampers progress in sustainable development (Adanma & Ogunbiyi, 2024).

Another regulatory gap that affects sustainability policy effectiveness is the slow adaptation of regulatory frameworks to emerging sustainability challenges. Environmental policies are often designed based on historical sustainability challenges, failing to address new threats such as climate change-driven economic disruptions, biodiversity loss, and resource depletion. Policymakers must adopt adaptive governance structures that evolve with emerging sustainability risks, incorporating real-time data, AI-driven monitoring, and blockchain transparency in regulatory enforcement (Brouillat & Saint Jean, 2020).

Additionally, the effectiveness of sustainability regulations is often undermined by corporate lobbying, resistance from industries, and economic trade-offs. While strict

environmental policies are necessary for reducing carbon footprints, they may increase operational costs for businesses, leading to resistance from industrial stakeholders. Research suggests that policies need to balance economic incentives with environmental goals, ensuring that market-based instruments such as carbon credits, tax incentives, and subsidies for sustainable industries complement traditional regulatory approaches (Chen & Yu, 2024).

Despite the challenges, some sustainability policies have demonstrated notable successes in promoting corporate ESG performance. Policies that incorporate public-private partnerships, green finance mechanisms, and regulatory synergies have led to measurable sustainability improvements in certain industries. For example, dual regulation approaches that combine citizen environmental supervision with carbon trading policies have been effective in driving sustainable business transitions. However, these policies require strong governance frameworks, transparent reporting mechanisms, and stakeholder collaboration to maximize their impact (Chen & Yu, 2024).

1.6 Government Initiatives and International Commitments (e.g., SDGs, Paris Agreement)

- **India's Sustainability Policies and Regulations**

The Indian government has played a significant role in driving sustainability in the manufacturing sector through various policies, regulations, and incentives. Policies such as Make in India, Atmanirbhar Bharat, the National Manufacturing Policy, and the Perform, Achieve, and Trade (PAT) scheme have promoted sustainable industrial growth. Despite these efforts, challenges such as inconsistent implementation, financial barriers, and lack of technological readiness continue to hinder full adoption. Research highlights

that while certain initiatives have been successful, gaps remain in policy enforcement, green financing, and supply chain sustainability.

One of the most impactful government interventions has been the promotion of Sustainable Manufacturing Practices (SMPs). The implementation of SMPs in Indian manufacturing industries has been facilitated by policies encouraging lean manufacturing, sustainable product design, and agile supply chain operations. A study found that sustainable product and process design, lean practices, and supply chain sustainability are key drivers of sustainable manufacturing in India. However, inadequate awareness and regulatory ambiguities limit their widespread adoption (Gupta et al., 2018).

Another significant policy initiative is Industry 4.0 and smart manufacturing adoption. The government has introduced incentives for automation, IoT, and AI-driven sustainability initiatives. However, the adoption of smart manufacturing remains limited due to financial constraints, lack of technological infrastructure, and insufficient managerial commitment. A study highlighted that many Indian industries are struggling to integrate smart and sustainable manufacturing practices due to economic and technical challenges (Aggarwal et al., 2021).

Sustainable Supply Chain Management (SSCM) policies have also gained attention, particularly in key manufacturing industries such as automobile, electronics, and textiles. The government has encouraged waste reduction, green logistics, and ethical sourcing practices. However, the adoption of SSCM practices varies significantly across sectors, with the textile industry lagging behind. Research indicates that while automobile and electronics firms have made progress, financial and regulatory gaps continue to impede full-scale implementation of SSCM (Mathivathanan et al., 2019).

The Green Supply Chain Management (GSCM) framework is another area where the Indian government has pushed for greater adoption. Government regulations,

particularly pollution control mandates and extended producer responsibility (EPR) laws, have played a key role in driving sustainable practices. Research suggests that central and regional government regulations are the most significant motivators for adopting GSCM practices. However, lack of standardization and limited state-level enforcement weaken policy effectiveness (Dhull & Narwal, 2018).

Government-led sustainable energy efficiency programs such as the PAT scheme and the Renewable Energy Purchase Obligations (RPOs) have incentivized manufacturers to adopt clean energy solutions and reduce carbon footprints. However, research shows that the effectiveness of these policies is often compromised by inadequate financial incentives, slow bureaucratic approvals, and technological gaps (Das, 2018).

The Make in India and Atmanirbhar Bharat initiatives have also influenced sustainable practices by encouraging domestic manufacturing and reducing import dependency. These initiatives emphasize eco-friendly production methods, sustainable resource utilization, and innovation in green technologies. However, research indicates that the majority of SMEs lack the necessary funding and technical know-how to transition to sustainable operations, limiting the broader impact of these policies (Singh & Thakar, 2018).

Despite these positive developments, the Indian government's policies still face critical regulatory gaps. One major issue is the lack of coordination between national and state-level sustainability regulations, leading to inconsistent enforcement and compliance disparities. Another challenge is the slow implementation of green finance initiatives, which limits access to capital for businesses looking to adopt sustainable technologies. Moreover, regulatory frameworks do not adequately support technological transitions,

particularly for small and medium enterprises (SMEs), which struggle with automation and digital transformation (Lakhan et al., 2019).

- **Government Incentives for Sustainable Manufacturing**

The Indian government has introduced several incentives and support mechanisms to help businesses transition to sustainable models, aligning with the country's environmental and economic goals. These initiatives focus on promoting clean energy, efficient resource utilization, and sustainable industrial practices through financial incentives, regulatory support, and policy frameworks.

One of the most significant programs is the Production Linked Incentive (PLI) Scheme, which provides performance-based incentives for domestic manufacturing across key sectors, including electronics, automotive, and renewable energy. The PLI scheme aims to enhance India's global competitiveness while encouraging sustainable production methods and reducing reliance on imports. Businesses that meet incremental sales targets for domestically manufactured products can benefit from financial incentives, boosting investments in green technology and sustainable infrastructure.

In addition to direct financial incentives, the Green Credit Programme, launched in 2023, offers market-based rewards for voluntary environmental actions. Businesses participating in initiatives such as afforestation, water conservation, sustainable agriculture, and waste management can earn 'green credits,' which can be traded or used to meet sustainability commitments. This program is designed to encourage proactive environmental responsibility and provide an economic value for sustainability efforts.

To promote eco-friendly infrastructure, the government offers tax incentives for green buildings. Businesses investing in sustainable building assets, such as solar panels, rainwater harvesting systems, and energy-efficient designs, can claim up to 100%

depreciation on their costs. Additionally, certain state governments provide subsidies and reimbursements for commercial projects that obtain green building certifications, making it more financially viable for businesses to construct and operate in an environmentally sustainable manner.

The government's focus on renewable energy is also reflected in policies such as the National Solar Mission, which supports businesses in adopting solar energy solutions. Capital subsidies, tax benefits, and low-interest financing are available for companies installing solar power systems, contributing to India's goal of achieving net-zero carbon emissions by 2070. These initiatives encourage businesses to shift towards cleaner energy sources and reduce their dependency on fossil fuels.

Energy efficiency in industries is further promoted through the National Mission for Enhanced Energy Efficiency (NMEEE), part of the broader National Action Plan on Climate Change. One of its key components, the Perform, Achieve, and Trade (PAT) scheme, assigns energy reduction targets to high-consumption industries and allows trading of energy-saving certificates. This market-driven approach provides financial incentives for companies that implement energy-efficient technologies and meet sustainability benchmarks.

Additionally, various state-level incentives complement national programs by offering capital subsidies, tax rebates, and additional financial support for setting up renewable energy projects. These incentives differ across states, with some regions providing specialized support for industries investing in green technology, waste management, and clean manufacturing.

These initiatives highlight the Indian government's commitment to fostering sustainability in manufacturing and other business sectors. By providing financial incentives, regulatory frameworks, and market-based solutions, India is encouraging

businesses to integrate sustainability into their operations, improve energy efficiency, and adopt green technologies. However, challenges such as bureaucratic delays, financial constraints for small businesses, and gaps in policy implementation still need to be addressed to maximize the effectiveness of these programs. With continued policy refinement and increased industry participation, India's transition to sustainable business models can become a more achievable and impactful goal.

1.7 Research Problem

India's manufacturing sector plays a crucial role in economic growth, contributing significantly to GDP, employment, and industrial development. However, this progress comes at an environmental cost, with manufacturing activities being one of the largest contributors to carbon emissions, pollution, and resource depletion. The traditional linear economy model of "Take-Make-Dispose" has led to excessive resource consumption and waste generation, posing a serious threat to environmental sustainability. While global industries are making strides toward integrating sustainable business models (SBMs), the transition in India remains slow and challenging.

A major issue hindering this transition is the lack of awareness and willingness among manufacturers to adopt sustainable practices. Many companies still prioritize short-term profitability over long-term environmental and social responsibility, making them reluctant to invest in green technologies and sustainable business models. This reluctance is further exacerbated by financial and technological constraints. The high upfront costs associated with sustainable processes, limited access to funding, and inadequate technological advancements make it difficult for businesses, especially small and medium enterprises (SMEs), to shift toward sustainability.

Regulatory and policy gaps also present significant obstacles. While India has introduced various environmental regulations and sustainability initiatives, their inconsistent enforcement and lack of industry-specific guidelines create uncertainty among businesses. The absence of strong government incentives and a structured framework for sustainability further discourages companies from actively engaging in the transition. Additionally, operational and supply chain challenges add complexity to sustainability efforts. The current supply chain ecosystem does not fully support circular economy principles, and the lack of green procurement policies makes it difficult for manufacturers to source sustainable materials and implement eco-friendly production processes.

Another critical barrier is the limited collaboration between industry players. Unlike in many developed nations where companies, policymakers, and research institutions work together to develop sustainability strategies, Indian manufacturers often operate in silos. The lack of industry-wide knowledge sharing and the absence of well-documented SBM case studies specific to the Indian context result in skepticism regarding the feasibility and benefits of sustainability initiatives.

Given these challenges, it is evident that the transition to sustainable business models in Indian manufacturing requires a structured, strategic approach. The absence of clear frameworks, financial incentives, and industry collaboration slows down progress, leaving businesses unprepared for the global shift toward sustainability. This study aims to address these gaps by identifying key barriers, analyzing industry best practices, and providing actionable recommendations to facilitate the adoption of sustainable business models in Indian manufacturing. By bridging these knowledge gaps and proposing effective strategies, this research will contribute to India’s sustainable development goals

and help the manufacturing sector align with global sustainability standards while maintaining economic viability.

1.8 Purpose of Research

This research aims to develop strategies for transitioning to Sustainable Business Models (SBMs) in key manufacturing sectors in India. As global industries shift toward sustainability, Indian manufacturers face financial, regulatory, and technological barriers that hinder SBM adoption. This study seeks to identify these challenges, analyze global best practices, and propose sector-specific strategies to facilitate a smooth transition.

By evaluating current unsustainable practices, industry-specific constraints, and successful case studies, the research will provide practical recommendations tailored to the Indian context. It will also assess the role of policies, regulations, and technological advancements in driving sustainability while maintaining profitability.

The ultimate goal is to create a structured framework to guide Indian manufacturers in adopting SBMs, aligning with circular economy objectives and global sustainability commitments. The findings will benefit business leaders, policymakers, and industry stakeholders by fostering a sustainable and competitive industrial ecosystem in India.

1.9 Significance of the Study

The transition to Sustainable Business Models (SBMs) is crucial for the Indian manufacturing sector to align with global sustainability trends, meet regulatory requirements, and ensure long-term business viability. However, the sector faces significant challenges, including financial constraints, regulatory gaps, and technological limitations, which hinder the adoption of sustainable practices. This study is significant as

it provides valuable insights and strategic recommendations to address these barriers and facilitate a structured transition toward SBMs.

The research contributes to business leaders, policymakers, and industry stakeholders by offering sector-specific strategies for implementing sustainability without compromising profitability. By analyzing successful global case studies, it provides a comparative perspective that Indian manufacturers can adapt to their operations. Furthermore, the study highlights the role of government policies, financial incentives, and technological advancements, encouraging industries to integrate sustainability into their core business models.

From an academic perspective, this study fills a critical research gap by providing a comprehensive analysis of SBM adoption in India's manufacturing sector, an area that remains underexplored. It also supports India's circular economy initiatives and global sustainability commitments, such as the UN Sustainable Development Goals (SDGs) and the Paris Agreement.

By addressing the challenges and opportunities of sustainability in Indian manufacturing, this research will serve as a valuable resource for decision-makers, researchers, and sustainability practitioners, fostering a more sustainable and competitive industrial ecosystem in India.

1.10 Research Purpose and Questions

The purpose of this research is to develop strategies for transitioning to Sustainable Business Models (SBMs) in key manufacturing sectors in India. As industries worldwide shift towards sustainability, Indian manufacturers face financial, regulatory, and technological barriers that slow their adoption of SBMs. This study aims to identify

these challenges, analyze global best practices, and propose actionable strategies to facilitate a smooth and effective transition.

By evaluating current unsustainable practices, industry-specific constraints, and successful SBM case studies, this research seeks to provide practical recommendations tailored to the Indian manufacturing landscape. Additionally, it examines the role of policies, regulations, and technological advancements in promoting sustainability while ensuring business growth and competitiveness.

The ultimate goal is to create a structured framework that helps Indian manufacturers integrate sustainability into their operations, aligning with circular economy principles and global sustainability commitments. This research will serve as a valuable resource for business leaders, policymakers, and industry stakeholders working towards a more sustainable and competitive industrial sector in India.

Research Questions

1. What are the major challenges in creating sustainable business models (SBMs) across key manufacturing sectors in India?
2. How do the stages of awareness and readiness for circular economy and sustainable practices vary across sectors?
3. What strategies and innovations are being planned or implemented by Indian manufacturing sectors to transition to sustainable business models?
4. To what extent are Indian manufacturing companies collaborating with competitors and stakeholders to achieve sustainability goals?
5. What factors drive or hinder the successful implementation of sustainability-focused innovations in manufacturing?

Research Hypothesis

H1: Major challenges in creating SBMs across key manufacturing sectors in India are significantly influenced by financial, regulatory, and technological constraints.

H2: Awareness and readiness for circular economy and sustainable practices vary significantly across manufacturing sectors based on industry type and market maturity.

H3: The adoption of SBMs in Indian manufacturing is driven by a combination of regulatory mandates, technological innovations, and cost-saving opportunities.

H4: Higher collaboration between Indian manufacturing companies, competitors, and stakeholders leads to greater success in achieving sustainability goals.

H5: The successful implementation of sustainability-focused innovations in Indian manufacturing is significantly influenced by leadership commitment, investment in R&D, and external support from policy incentives.

CHAPTER II:

REVIEW OF LITERATURE

2.1 Introduction

Sustainable Business Models (SBMs) have gained increasing attention as industries worldwide recognize the need to integrate environmental, social, and economic sustainability into their operations. The manufacturing sector, as a significant contributor to resource consumption and environmental degradation, plays a crucial role in this transition. In India, manufacturing industries are at a crossroads where adopting SBMs is no longer an option but a necessity to ensure long-term business viability, regulatory compliance, and alignment with global sustainability trends. However, the transition to SBMs is complex, requiring changes in business practices, policies, and technological frameworks.

This chapter reviews existing literature on SBMs and their relevance to manufacturing, focusing on the challenges, sectoral readiness, strategies, policy frameworks, and the role of collaboration in sustainability adoption. It explores the global trends in sustainable manufacturing, examining best practices from developed economies and assessing how Indian industries compare in terms of awareness and implementation. The chapter further investigates the key barriers to SBM adoption in India, such as financial constraints, policy gaps, technological limitations, and industry resistance to change. A sectoral analysis highlights how different industries vary in their sustainability preparedness, identifying those leading the shift and others lagging in adoption.

Additionally, the literature review examines strategies for SBM transition, discussing business model innovations, technological advancements, and the role of circular economy principles. It also assesses government policies and international commitments, analyzing the effectiveness of India's sustainability regulations and their

alignment with global frameworks like the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement. Finally, the chapter highlights the role of collaboration among stakeholders, including businesses, policymakers, and industry associations, in promoting sustainability-driven initiatives.

2.2 Concept of Sustainable Business Models (SBMs)

Sustainable Business Models (SBMs) are designed to integrate economic, environmental, and social sustainability by aligning business practices with long-term sustainability goals. SBMs go beyond traditional profit-driven models by incorporating the Triple Bottom Line (TBL) approach, which balances financial profitability with environmental stewardship and social responsibility. Various studies highlight how SBMs contribute to these three pillars of sustainability.

Economically, SBMs provide long-term financial stability by reducing resource dependency, lowering operational costs, and increasing brand value. Companies that implement sustainable practices, such as circular economy principles and green technologies, often experience cost savings from improved energy efficiency, waste reduction, and optimized supply chains. A study on SBM implementation in industries suggests that businesses adopting sustainability frameworks improve their financial resilience by focusing on value creation beyond immediate profits (Merghani, 2021). Moreover, investors and stakeholders are increasingly prioritizing companies with strong Environmental, Social, and Governance (ESG) commitments, making SBMs a strategic advantage for businesses seeking long-term investment and market expansion (Lee & Fu, 2024).

From an environmental perspective, SBMs contribute to sustainability by minimizing carbon footprints, reducing waste, and promoting eco-friendly product

design. Unlike traditional linear business models that follow a "take-make-dispose" approach, SBMs embrace circular economy principles that prioritize resource efficiency, recycling, and renewable energy integration. Research indicates that SBM frameworks help industries shift from polluting practices to more sustainable alternatives by emphasizing closed-loop production systems and sustainable material sourcing (Hao & Dragomir, 2024). Companies that integrate sustainable manufacturing technologies also benefit from compliance with environmental regulations, reducing the risks of legal penalties and reputational damage (Kabalska, 2021).

Socially, SBMs enhance workforce well-being, fair labor practices, and community engagement. Many sustainable business models emphasize stakeholder inclusivity, ethical labor conditions, and corporate social responsibility (CSR). Companies adopting SBMs are more likely to foster inclusive employment opportunities, safe working conditions, and equitable wealth distribution within their industries. Studies have shown that organizations prioritizing social sustainability experience higher employee retention, customer loyalty, and public trust (Ringvold, Saebi & Foss, 2022). Moreover, SBM frameworks encourage businesses to consider the broader societal impact of their operations, including ethical sourcing, fair wages, and responsible governance (Rauter et al., 2019).

2.3 Sustainability in Manufacturing

Sustainable manufacturing has become a global priority due to increasing environmental concerns, regulatory frameworks, and consumer preferences for eco-friendly products. Countries worldwide are adopting innovative technologies and business strategies to integrate sustainability into manufacturing processes. The transition toward sustainable manufacturing involves reducing carbon footprints, minimizing waste,

adopting green technologies, and ensuring ethical labour practices. Global trends in sustainable manufacturing include the integration of circular economy principles, innovative manufacturing technologies, and green supply chain management, which improve both economic and environmental outcomes. However, while global manufacturers rapidly shift toward sustainable practices, the Indian manufacturing sector faces challenges in fully integrating these advancements due to financial, regulatory, and technological barriers.

One of the key global trends in sustainable manufacturing is the adoption of lean and agile (leagile) manufacturing principles to enhance sustainability. By integrating lean manufacturing techniques, businesses can reduce resource waste, optimize production efficiency, and lower environmental impact. Agile practices complement these efforts by ensuring flexibility and responsiveness to market demands. Studies indicate that these approaches effectively achieve global sustainability goals, particularly in industries that require high efficiency and reduced carbon footprints (Mathiyazhagan et al., 2021). However, in the Indian context, while some industries, such as the automotive sector, have implemented agile strategies, many manufacturing units, especially small and medium enterprises (SMEs), struggle to adopt these models due to financial constraints and lack of technical expertise.

Green supply chain management is another key trend shaping sustainable manufacturing worldwide. Global businesses focus on sustainable procurement by ensuring suppliers adhere to environmental and social standards. Apple and Unilever have incorporated green procurement practices into their supply chains to reduce emissions, enhance energy efficiency, and support ethical sourcing. A study analyzing sustainable procurement trends across manufacturing and service sectors found that while international markets emphasize sustainability in supplier contracts, Indian manufacturers

are still in the early stages of integrating green supply chain management (Upadhyay, Sheetal & Khan, 2023). Although awareness about sustainable procurement is growing in India, challenges such as regulatory gaps, inconsistent enforcement, and financial limitations hinder widespread adoption.

The Indian automobile sector has been making strides in environmental sustainability by adopting green manufacturing practices, including recycling, marketing, and logistics. A study on Indian automobile manufacturing firms highlighted that companies prioritize sustainable practices such as eco-friendly product design, waste reduction, and cleaner production methods (Karurkar, Unnikrishnan & Panda, 2018). However, despite these advancements, challenges such as high costs associated with green technology adoption, lack of commitment from top management, and difficulties securing renewable energy sources continue to impede progress.

While sustainability practices in manufacturing have gained significant momentum in developed economies, India lags in regulatory enforcement and policy support. A comparative analysis of sustainability trends in Indian and global markets highlights that many multinational corporations have successfully adopted voluntary sustainability standards. In contrast, Indian manufacturers struggle with implementation due to insufficient awareness and financial incentives (Taimasova, Kasterine & Lamolle, 2019). In contrast, developed countries provide strong policy support, financial incentives, and technological innovation grants to accelerate the transition toward sustainable manufacturing.

Innovative and sustainable manufacturing technologies are also crucial in driving global sustainability efforts. Industry 4.0 technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain, are being integrated into manufacturing processes to improve energy efficiency, optimize supply chains, and reduce

environmental impact. In developed nations, businesses leverage these technologies to monitor real-time sustainability metrics, enhancing transparency and accountability. However, in India, the adoption of innovative and sustainable manufacturing remains limited due to economic and technological constraints. A study exploring the adoption of smart manufacturing in Indian industries found that while large corporations have started integrating Industry 4.0 technologies, SMEs face barriers such as high costs, lack of skilled labour, and weak infrastructure (Aggarwal et al., 2021).

The comparison between global best practices and the Indian context highlights key differences in implementing sustainability initiatives. Developed economies have well-established sustainability frameworks, policy-driven enforcement, and financial support mechanisms that enable businesses to transition smoothly toward sustainable manufacturing. In contrast, Indian industries, particularly SMEs, struggle with financial limitations, weak regulatory enforcement, and slow adoption of green technologies. Despite these challenges, Indian manufacturers are gradually progressing toward sustainability through government-led initiatives such as the Perform, Achieve, and Trade (PAT) scheme, which incentivizes energy efficiency improvements.

2.4 Key Challenges in SBM Adoption in India

One of the primary barriers to SBM adoption in Indian manufacturing is the lack of commitment from top management and limited financial support. Studies in the pharmaceutical and plastic manufacturing sectors highlight that sustainability initiatives often fail to gain traction without strong leadership commitment. For instance, the pharmaceutical sector in Himachal Pradesh faces challenges in implementing sustainable manufacturing due to financial constraints and an absence of clear industry-wide sustainability mandates. A study analyzing the sustainability transition in pharmaceutical

industries found that firms struggle with aligning sustainability goals with profitability, making them hesitant to invest in green technologies (Jamwal et al., 2020). Similarly, the plastic manufacturing sector is under extreme pressure to adopt sustainable practices due to growing concerns over pollution. However, weak government interventions and financial constraints prevent firms from investing in green technologies (Khandelwal & Barua, 2019).

Another major challenge is the complexity of sustainable supply chain management (SSCM). India's electronics and automobile industries have struggled with integrating sustainability into their supply chains due to a lack of policy support and supplier resistance. Research indicates that many electronics manufacturers in India cannot implement SSCM effectively because of fragmented regulatory frameworks and technological limitations. Studies have categorized these barriers into policy-related, human resource, and technological challenges, with a lack of clear government incentives emerging as a key factor (John, 2022). Similarly, in the automobile sector, researchers have identified financial burdens, poor supplier commitment, and lack of regulatory clarity as significant impediments to sustainability transitions (Chakma & Rai, 2020).

The oil and gas sector faces unique challenges due to its capital-intensive nature and dependency on traditional energy sources. A study using the Interpretive Structural Modeling (ISM) approach found that market competition, financial risks, and lack of governmental incentives are among the industry's most significant barriers to sustainable transformation. The study emphasized that sustainability adoption requires strong management commitment and leadership to navigate financial and technological challenges (Raut et al., 2018).

Challenges are even more pronounced for small and medium enterprises (SMEs). Many SMEs operate with limited financial resources and face stiff competition from

larger firms, making investing in sustainable business practices difficult. Studies have shown that SMEs often struggle with technological upgradation, lack of government support, and organizational rigidity. In the post-globalization era, SMEs in India have faced challenges in integrating sustainability into their operations due to reduced market competitiveness, lack of access to modern technology, and poor innovation capacity (Singh & Mohanty, 2020).

The iron and steel industry, a key sector in India's manufacturing landscape, faces additional barriers due to its high energy consumption and carbon emissions. A study examining climate change mitigation strategies in the Indian iron and steel sector identified the absence of robust policy frameworks and lack of access to cost-effective, sustainable technologies as the primary barriers. The study emphasized that firms in this sector need pragmatic technology solutions and long-term policy commitments to drive sustainability (Singh, Pradhan & Patil, 2023).

Furthermore, the construction industry, which relies heavily on traditional materials and methods, is slow in adopting Sustainable Building Materials (SBMs) due to high costs, lack of awareness, and limited availability of eco-friendly alternatives. Research in this area found that financial constraints, uncertain future legislation, and lack of government incentives prevent businesses from investing in green infrastructure (Eze, Sofolahan & Omoboye, 2023).

Despite these barriers, some industries have made progress. The automobile sector has implemented green logistics, eco-friendly production methods, and recycling initiatives. However, industry-wide adoption remains challenging due to inconsistent policy enforcement and the lack of a standardized framework for sustainable business practices.

2.5 Sector-Specific Readiness for Sustainable Practices

Sustainability awareness, preparedness, and adoption vary significantly across different manufacturing sectors in India due to differences in industry characteristics, regulatory frameworks, financial resources, and supply chain structures. While some industries, such as automobiles and electronics, have made significant progress in integrating sustainability into their operations, others, such as textiles and small-scale manufacturing units, lag due to financial and technological barriers.

The automobile sector in India has been at the forefront of sustainable manufacturing due to strict environmental regulations, increasing global competition, and consumer demand for greener vehicles. A comparative study on adopting Sustainable Supply Chain Management (SSCM) practices across the automobile, electronics, and textile sectors in India found that the automobile sector has made significant progress in incorporating sustainability initiatives, including lean manufacturing, waste reduction, and alternative energy sources. However, while more prominent players in the sector, such as Tata Motors and Mahindra & Mahindra, have made strides in sustainability, smaller component manufacturers often struggle due to financial constraints and a lack of expertise in sustainability practices (Mathivathanan et al., 2019).

The electronics industry in India has also shown high awareness and preparedness for adopting sustainability. The sector has benefited from global regulatory pressures, mainly from European and American markets that demand sustainable sourcing and production. Many large electronics manufacturers in India have adopted green supply chain management practices, using recycled materials and improving energy efficiency. The electronics sector has slightly outpaced the automobile industry in sustainability transformation due to stringent international norms imposed by global buyers and export

markets. However, e-waste management and inadequate recycling infrastructure remain major obstacles (Mathivathanan et al., 2019).

On the other hand, the textile industry has shown lower awareness and adoption of sustainability practices compared to automobiles and electronics. Despite being one of the largest manufacturing sectors in India, the textile industry has been slow to transition to sustainable manufacturing due to cost constraints, lack of government incentives, and weak enforcement of environmental regulations. Many small-scale textile units rely on traditional manufacturing processes involving high water consumption, chemical usage, and waste generation. A study on SSCM practices found that textiles ranked the lowest in sustainability adoption due to low investment in green technologies and weak compliance with environmental norms (Mathivathanan et al., 2019).

Sustainability adoption is also influenced by commitments to corporate social responsibility (CSR) and regulatory mandates. A study on social sustainability in Indian manufacturing supply chains found that industries with strong CSR policies and government incentives are more likely to implement sustainable business practices. Large pharmaceutical and consumer goods corporations have integrated social sustainability aspects, including worker safety, ethical labour practices, and community engagement, into their operations. However, smaller firms often struggle to implement such initiatives due to financial and logistical barriers (Kottala, 2021).

The construction and infrastructure sector is another area where sustainability adoption remains inconsistent. While some large infrastructure firms have implemented green building practices, sustainable procurement remains underdeveloped. A study comparing sustainable procurement across manufacturing and service sectors in India found that while manufacturing firms emphasize cost and efficiency in sustainability adoption, service sector firms focus more on green technology commitments and CSR

initiatives (Upadhyay, Sheetal & Khan, 2023). This highlights the variation in sustainability adoption priorities across industries.

An expert system-based decision-making framework for sustainable manufacturing benchmarking in India identified automobile, steel, textile, and plastic industries as key sectors requiring sustainability improvements. The study ranked the automobile sector as the most effective in sustainable manufacturing practices, followed by steel, textiles, and plastics. While the automobile sector leads in green initiatives, the steel and textile industries struggle with sustainability due to high energy consumption and limited access to eco-friendly technologies (Mandal, Mondal & Ray, 2024).

Despite these challenges, there has been an increasing push for sustainable business models across industries, particularly in response to international trade pressures, consumer demand, and government policies. However, a study on sustainable production practices in Indian manufacturing found that while many firms claim to follow sustainability practices, actual implementation remains limited and is often restricted to specific departments within organizations. The main barriers identified include unclear financial benefits, lack of strong government policies, and resistance to change (Jha et al., 2023).

2.6 Strategies for SBM Transition in Manufacturing

Business model innovations and technological advancements are crucial in accelerating the transition to Sustainable Business Models (SBMs) in the Indian manufacturing sector. By integrating sustainable value creation, digital transformation, and innovative business strategies, Indian manufacturers can align with global sustainability goals while improving economic performance and reducing environmental impact.

One of the key business model innovations in sustainable manufacturing is the adoption of Product-Service Systems (PSS). This model shifts the focus from selling products to offering integrated product-service solutions that extend product lifecycles and reduce resource consumption. Research highlights that PSS-based business models contribute to sustainability by promoting remanufacturing, reusability, and material efficiency. Companies implementing this model experience lower environmental impact and increased customer engagement due to value-driven services rather than single-use product sales (Sousa-Zomer & Cauchick-Miguel, 2019).

Intellectual Property (IP)-driven business models also provide a competitive edge for sustainable transformation. The SBM-IP Canvas framework integrates intellectual property considerations into SBMs to enhance commercial viability while delivering environmental and social benefits. This model emphasizes open innovation and sustainable licensing agreements, ensuring that technological advancements are leveraged for sustainability transitions (Hernández-Chea et al., 2020). By aligning IP strategies with sustainability goals, Indian manufacturers can protect green innovations while encouraging broader industry adoption.

The integration of Industry 4.0 technologies is another critical factor driving SBM adoption. Technologies like the Internet of Things (IoT), cloud computing, additive manufacturing, and AI-driven analytics enhance supply chain sustainability and operational efficiency. A study in the Indian automotive sector highlights how Industry 4.0 accelerates business model innovation by optimizing energy use, reducing waste, and improving supply chain resilience. The research emphasizes the role of collaborative supplier networks in supporting small-scale manufacturers through digital platforms and automated processes (Krishnan et al., 2024). However, challenges such as high implementation costs and skill shortages remain barriers to widespread adoption.

Sustainability-driven business model innovation also relies on partnership-based approaches. Collaborative ecosystems, particularly business-NGO partnerships, have been identified as enablers of SBM transformation. Businesses can access new knowledge, sustainable financing, and responsible supply chain networks by fostering cross-sector collaborations. Studies suggest that such partnerships facilitate the scaling of sustainable manufacturing by ensuring inclusive business practices and environmental impact assessments (Aagaard & Lodsgård, 2018).

Another promising avenue for sustainable business model innovation is the circular economy approach, where companies prioritize remanufacturing, material reuse, and waste-to-resource conversion. A study on electric vehicle (EV) battery second-use industries highlights that SBM archetypes tailored for circular economy applications can drive sustainability innovations while maintaining economic profitability. The study found that remanufacturing and upcycling strategies contribute to cost savings, regulatory compliance, and environmental efficiency in EV manufacturing (Reinhardt et al., 2020). Similar models can be applied in the Indian steel, electronics, and plastic manufacturing sectors to reduce dependency on virgin materials and minimize industrial waste.

Additionally, digitalization in sustainable business models plays a pivotal role in enabling scalable and efficient transitions. A bibliometric analysis of digitalization and business model innovation found that digital tools such as blockchain for supply chain traceability, AI for predictive maintenance, and big data analytics for energy optimization are crucial for sustainable manufacturing. These technologies enhance decision-making capabilities and improve transparency in environmental performance tracking (Ogrean, Herciu & Țichindelean, 2024).

Despite these advancements, barriers such as financial limitations, regulatory bottlenecks, and resistance to organizational change hinder widespread SBM adoption in

India. To overcome these challenges, researchers suggest businesses adopt a dual innovation approach that balances green technology investment with business model transformation. Companies integrating SBM innovations alongside digitalization and sustainability goals achieve superior corporate performance and long-term resilience (Zhou et al., 2023).

2.7 Government Policies and International Commitments

India's sustainability policies have made significant strides in promoting Sustainable Business Models (SBMs), but their effectiveness in driving large-scale adoption varies across industries. These policies align with global sustainability commitments, such as the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement. However, challenges persist regarding enforcement, financial support, and industry-wide integration.

One of the key sustainability initiatives in India is corporate social responsibility (CSR) regulations, which mandate that companies above a certain revenue threshold allocate a percentage of their profits to social and environmental causes. Research analyzing CSR spending among India's Maharatna Central Public Sector Enterprises (CPSEs) found that their sustainability efforts align with the SDGs, particularly in poverty alleviation, education, and healthcare. However, the study also highlights that these CSR activities focus more on social development than on integrating sustainable business models into core operations (Leena et al., 2023). This suggests that while CSR mandates help fund sustainability projects, they do not necessarily drive fundamental business model transformations towards sustainability.

India's Swachh Bharat Abhiyan (SBA) has been another major policy initiative, promoting environmental sustainability through large-scale public engagement in waste

management and cleanliness campaigns. A case study on SBA found that it strategically incorporated the "3R" principles—Reduce, Reuse, and Recycle—aligning with global sustainability goals. However, the study also identified gaps in green financing, green incubation, and sustainable public-private partnerships, which are crucial for translating short-term campaigns into long-term sustainable business models (Dash & Dash, 2021). This indicates that while sustainability campaigns raise awareness, their impact on systemic industrial transformation remains limited.

In the manufacturing sector, government policies have encouraged the adoption of sustainable materials and green production processes. A study examining sustainable material selection in Indian industries found that policy pressures, combined with customer demand and global market expectations, have encouraged firms to integrate sustainable materials into their supply chains. However, enforcement remains inconsistent, and many industries still rely on cost-driven decision-making rather than sustainability-driven innovation (Jamwal et al., 2021). This highlights the challenge of ensuring that sustainability policies translate into widespread adoption rather than selective compliance.

India's sustainability policies also align with global financial frameworks aimed at promoting green growth. The Reserve Bank of India (RBI) has pushed for Sustainable Finance Schemes, including green bonds and priority sector lending for green projects. A study on sustainable finance in India found that international financial institutions such as the World Bank, SIDBI, and NABARD have played a crucial role in providing capital for green projects, including renewable energy, electric vehicles, and sustainable infrastructure. However, the study also pointed out that India's green financing ecosystem is still underdeveloped compared to global standards, with inadequate incentives for small and medium-sized enterprises (SMEs) to transition to sustainable business models

(M. K. M. et al., 2022). This gap in green financing limits the ability of smaller firms to invest in sustainability transitions.

India has also begun transitioning towards a circular economy model, which aligns with global best practices in sustainability. A study on India's circular economy transition highlighted that major corporations are adopting sustainability-driven business practices, including waste-to-resource initiatives and extended producer responsibility (EPR). However, the study also identified corporate inertia, regulatory uncertainty, and a lack of industry collaboration as barriers preventing a broader shift towards circular economy principles (Dhiwar et al., 2023). This underscores the need for better industry-government collaboration and policy consistency to promote sustainable business model adoption.

Despite these efforts, leadership remains a critical factor in the success of sustainability policies. A study on leadership in sustainable business practices in India found that transformational and ethical leadership styles significantly influence the extent to which sustainability principles are embedded within organizations. The study emphasized that corporate leaders who integrate ethical decision-making, vision-driven sustainability strategies, and stakeholder engagement are more likely to successfully transition to SBMs. However, India's business environment still lacks strong leadership development programs focused on sustainability (D'Souza, 2024). This suggests that policy effectiveness could be improved by fostering sustainability leadership at the corporate level.

In comparison to global sustainability policies, India's approach remains more reactive than proactive. Countries such as Germany, the Netherlands, and Japan have implemented strict carbon pricing mechanisms, green taxation policies, and sustainability-driven innovation grants, ensuring that businesses transition towards SBMs

out of necessity rather than choice. India's policies, on the other hand, still rely heavily on voluntary compliance and external incentives rather than strict regulatory mandates. This creates a gap in accountability, allowing many businesses to operate unsustainably while making only minimal adjustments to comply with environmental regulations.

2.8 Role of Collaboration and Stakeholder Engagement in Sustainability

Collaboration among Indian manufacturing firms with competitors, policymakers, and stakeholders for sustainability initiatives has gained traction in recent years, though it remains uneven across industries. While some sectors have made significant progress in green supply chain collaboration and regulatory compliance, others face barriers such as financial constraints, competitive secrecy, and lack of industry-wide standards.

A study on environmental collaboration in supply chains highlights that firms engaging in green supply chain management (GSCM) practices with suppliers and customers report improved sustainability performance. External pressures, including institutional regulations and customer expectations, significantly influence organizations to adopt collaborative sustainability strategies. However, these partnerships often remain limited to compliance-driven motives rather than proactive environmental responsibility (Ahmed et al., 2020). This indicates that while supply chain collaborations exist, they are often reactive rather than strategic, reducing their long-term impact.

In the electronics manufacturing sector, firms are increasingly collaborating with third-party reverse logistics providers (3PRLPs) to manage electronic waste (e-waste). This type of partnership ensures compliance with government legislation while enhancing corporate sustainability reputations. A study on environmental management in the Indian electronics industry found that OEMs (original equipment manufacturers) benefit from engaging in sustainability-focused partnerships, leading to better compliance, customer

satisfaction, and competitive advantages. However, challenges such as varying levels of commitment and unclear sustainability metrics often hinder deeper collaboration (Govindan et al., 2019).

A broader industry-wide approach has been observed in the Indian aerospace sector, where strategic supplier partnerships have played a role in enhancing environmental and social sustainability in supply chains. Research suggests that strategic partnerships improve long-term sustainability outcomes by fostering resource-sharing, joint R&D initiatives, and the adoption of global best practices. However, gaps remain in policy standardization, making it difficult for firms to sustain collaborations over extended periods (Yogindra & G.S., 2022).

In the textile industry, collaboration plays a crucial role in achieving sustainability, particularly in sustainable product development and eco-friendly materials. A study examining collaborative approaches in the textiles industry highlights that companies that integrate business-to-business collaboration, regulatory compliance, and value-chain partnerships are more likely to develop sustainable solutions. However, many firms struggle with supply chain fragmentation, misalignment of sustainability goals, and regulatory inconsistencies, which limit the effectiveness of these collaborations (Abreu et al., 2020).

Despite these sectoral advancements, a major gap remains in direct collaborations between competitors on sustainability initiatives. Many industries view sustainability as a competitive differentiator rather than a collective responsibility, limiting cross-industry knowledge sharing and standardization of sustainability practices. This contrasts with global best practices where industries often cooperate on sustainability research, shared sustainability infrastructure, and circular economy initiatives.

Government support for collaboration has also played a key role in driving sustainability in manufacturing. However, many Indian firms report low participation in government-led sustainability partnerships due to bureaucratic hurdles, inconsistent policy enforcement, and lack of financial incentives. A study on corporate social responsibility (CSR) in Indian manufacturing found that while 70% of large corporations have started incorporating ESG (Environmental, Social, and Governance) criteria into their business strategies, many SMEs lag due to limited engagement with policymakers and industry bodies (Jangir & Meena, 2024).

2.9 Literature Review Gaps

While the literature on Sustainable Business Models (SBMs) in Indian manufacturing provides valuable insights into sustainability practices, adoption challenges, and sectoral variations, several gaps remain in the existing research. Identifying these gaps can help shape future studies and policy recommendations for a more effective transition toward sustainability.

One significant gap in the literature is the lack of empirical studies on SBM adoption in specific Indian manufacturing industries. While broad sectoral analyses exist, there is limited in-depth research on how individual industries, such as automotive, textiles, electronics, and steel, vary in their sustainability transitions. Most studies provide a generalized overview rather than sector-specific case studies that examine unique barriers, opportunities, and strategies tailored to each industry.

Another key gap is the insufficient exploration of financial mechanisms that support sustainability transitions. While some studies discuss financial constraints as a barrier to SBM adoption, there is limited research on green financing models, investment incentives, and the role of financial institutions in promoting sustainability. There is a

need for a deeper examination of how venture capital, green bonds, and sustainability-linked loans can accelerate SBM adoption, particularly for small and medium enterprises (SMEs) that struggle with high upfront costs.

The role of digital transformation and Industry 4.0 technologies in sustainable manufacturing is also underexplored. While existing research acknowledges the potential of IoT, AI, blockchain, and data analytics in improving sustainability outcomes, there is insufficient empirical evidence on how Indian manufacturers are integrating these technologies into their business models. Future studies should focus on real-world implementations, cost-benefit analyses, and scalability challenges associated with digital transformation in sustainable manufacturing.

Despite the discussion on policy frameworks and global sustainability commitments, there is a lack of research on the effectiveness of existing regulations in driving sustainable transitions. While policies such as the Perform, Achieve, and Trade (PAT) scheme, Extended Producer Responsibility (EPR), and CSR mandates are mentioned, there is limited analysis of their real-world impact on manufacturing firms. Future research should assess policy effectiveness, enforcement gaps, and compliance challenges faced by businesses under India's sustainability regulations.

Collaboration among stakeholders, including competitors, policymakers, and industry associations, is highlighted in the literature, but there is little discussion on how cross-industry partnerships can drive sustainability innovations. Research should explore successful collaborative models, joint research initiatives, and industrial sustainability consortia that have effectively promoted green manufacturing practices. Additionally, the extent of knowledge-sharing between global and Indian firms in sustainability adoption remains unclear, requiring further study.

The circular economy framework is discussed as a key driver of SBMs, but there is limited research on its implementation challenges in India. While studies highlight circular economy principles, there is a need for more focused research on reverse logistics, waste-to-resource conversion, and industrial symbiosis across different manufacturing sectors.

Lastly, consumer and market-driven factors influencing sustainable manufacturing are not well studied in the Indian context. The role of consumer awareness, sustainable product demand, and green marketing strategies in driving SBM adoption remains unclear. Future research should explore how changing consumer preferences and sustainability-conscious branding impact Indian manufacturers' willingness to invest in SBMs.

2.10 Summary

This chapter provides a comprehensive review of existing literature on Sustainable Business Models (SBMs) and their significance in the Indian manufacturing sector. It highlights the growing recognition of sustainability as a critical aspect of business strategy and operational efficiency. The chapter begins by defining SBMs and their role in integrating economic, environmental, and social sustainability through the Triple Bottom Line (TBL) framework. It emphasizes how SBMs go beyond traditional profit-driven models by fostering resource efficiency, waste reduction, and responsible governance.

The review further explores sustainability in manufacturing, focusing on global trends and best practices. It outlines how developed economies have successfully integrated Industry 4.0 technologies, circular economy principles, and green supply chain management (GSCM) to enhance sustainable production. The chapter compares these

global trends with the Indian context, highlighting the challenges Indian manufacturers face in implementing sustainability initiatives due to financial constraints, regulatory inconsistencies, and technological limitations. The automobile and electronics industries have shown significant progress in sustainable transitions, while the textile and steel industries continue to lag due to cost and policy-related barriers.

Key barriers to SBM adoption in India are identified, including lack of financial support, weak regulatory enforcement, and insufficient technological infrastructure. The literature suggests that management commitment, government incentives, and collaborative frameworks play crucial roles in overcoming these challenges. The chapter also examines sector-specific readiness for sustainability adoption, emphasizing variations in awareness, preparedness, and implementation strategies across different manufacturing industries.

Strategies for SBM transition in India are explored, including business model innovations such as Product-Service Systems (PSS), circular economy frameworks, and digital transformation through Industry 4.0 technologies. The chapter discusses the role of collaborative ecosystems, sustainable financing mechanisms, and policy-driven incentives in enabling the shift towards sustainability. It highlights the importance of partnerships between businesses, policymakers, and industry associations in fostering sustainable manufacturing practices.

Government policies and international commitments are critically analyzed, assessing India's alignment with global sustainability frameworks such as the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement. While India has introduced sustainability policies, gaps in implementation, enforcement, and industry compliance remain significant obstacles. The chapter also underscores the need for

stronger financial mechanisms, clearer regulatory mandates, and leadership-driven sustainability initiatives to accelerate SBM adoption.

Finally, the review identifies gaps in existing research, pointing to the need for empirical studies on SBM adoption in specific industries, financial barriers, policy effectiveness, and stakeholder collaboration. It highlights the limited exploration of digital transformation in sustainability, green financing models, and circular economy implementation challenges in the Indian context.

CHAPTER III:

METHODOLOGY

3.1 Overview of the Research Problem

The research problem focuses on the challenges and strategies for transitioning to Sustainable Business Models (SBMs) in key manufacturing sectors in India. The study highlights that while sustainability is a pressing global concern, the manufacturing sector faces significant barriers to adopting sustainable practices, including resource unavailability, lack of awareness, financial constraints, and resistance to innovation. Many industries continue to operate under a linear "take-make-dispose" model, which leads to environmental degradation and resource depletion. Despite growing awareness of Circular Economy principles and Environmental, Social, and Governance (ESG) mandates, there remains a gap between intent and implementation. Key hurdles include a lack of technological innovation, reluctance to allocate resources for sustainability initiatives, and uncertainty about financial returns from SBMs. The research seeks to identify these barriers, assess sectoral readiness, and explore potential strategies—including policy recommendations, collaborative frameworks, and technological interventions—to facilitate the successful adoption of SBMs. Through a combination of literature review, case studies, and empirical analysis, the study aims to provide actionable insights for policymakers, business leaders, and stakeholders to drive sustainability transitions in Indian manufacturing.

3.2 Research Purpose and Questions

This research aims to analyze the transition to Sustainable Business Models (SBMs) in key manufacturing sectors in India, identifying the barriers, awareness levels, strategies, and factors influencing sustainability adoption. Given the growing environmental concerns, resource depletion, and regulatory pressures, manufacturing

industries must shift from linear production models to circular and sustainable business practices. This study aims to explore sector-specific challenges, levels of preparedness, collaboration among stakeholders, and the role of innovation in sustainability-driven transitions. The research also seeks to provide data-driven insights that can guide policymakers, business leaders, and industry professionals in formulating effective strategies for SBM implementation.

To achieve these objectives, the study is guided by the following research questions:

- What are the significant barriers (e.g., resource unavailability, financial constraints, lack of concept clarity) hindering the adoption of SBMs in Indian manufacturing sectors?
- How aware and prepared are different manufacturing sectors in India for adopting sustainable practices, and how do they compare regarding SBM readiness?
- What strategies, innovations, and sustainable design concepts are being explored or implemented by Indian manufacturers to transition towards SBMs?
- What is the level of cooperation and collaboration among firms and stakeholders, and what barriers prevent effective partnerships in sustainable business transitions?
- What are the key factors (organizational culture, mindset, resource allocation, external relationships) drive or hinder the successful implementation of sustainability-driven innovations in manufacturing?

By addressing these research questions, this study aims to bridge the gap between awareness and implementation, providing sector-specific and cross-sectoral recommendations to support the successful transition to sustainable business models in Indian manufacturing.

3.3 Research Design

The research design for this study follows a quantitative methodologies to comprehensively analyze the transition to Sustainable Business Models (SBMs) in key manufacturing sectors in India**.** The study is structured around three primary components**:** a literature review**,** survey-based data collection**,** and statistical analysis to identify key challenges and sectoral readiness for SBM adoption. The literature review forms the theoretical foundation, synthesizing existing frameworks, challenges, and best practices related to sustainable business model innovation (SBMI), circular economy principles, and environmental, social, and governance (ESG) factors.

Primary data was collected through a structured questionnaire distributed among 160 respondents from different manufacturing sectors for empirical analysis. The questionnaire captured insights on major hurdles, awareness levels, ongoing sustainable initiatives, and organizational perspectives on SBM adoption. Responses were categorized into different stages such **as** "Nascent," "Well Aware," and "Not at All" to evaluate sectoral preparedness. Various statistical tests were conducted to ensure the robustness of findings, including ANOVA, Chi-Square, Kruskal-Wallis H Test, and T-Tests, which assessed sectoral differences in SBM awareness and adoption levels. Multiple Regression Analysis was also applied to identify the influence of factors like management mindset, innovation strategies, and implementation challenges on sustainable business transitions.

3.4 Identifying Key Barriers to SBM Adoption

Objective:

To identify and analyze the major hurdles—such as resource availability, concept clarity, and cost factors—that hinder the adoption of Sustainable Business Models (SBMs) in Indian manufacturing sectors.

Methodology

To identify and analyze the significant hurdles hindering the adoption of Sustainable Business Models (SBMs) in the Indian manufacturing sector, the study employs a quantitative research approach**.** Primary data was collected through a structured questionnaire distributed among 160 respondents from key manufacturing sectors, focusing on challenges such as resource availability, concept clarity, cost constraints, and long-term impact understanding. The questionnaire responses were categorized into industry segments: Automobile & Transportation, Chemicals & Plastics, Infrastructure, Steel & Cement, Textiles, Consumer Electronics & Capital Goods, Pharmacy & Healthcare, and Agriculture & Food Processing**.**

To **ensure** statistical validity, the study applied ANOVA (Analysis of Variance) to assess whether the challenges faced by different sectors significantly differ. The Chi-Square Test of Independence examined relationships between categorical variables, determining whether specific hurdles are more prevalent in particular sectors. Additionally, observations and graphical interpretations were conducted to highlight sectoral variations in concept clarity, ignorance, resource unavailability, and long-term impact understanding**.** The findings from these analyses provided data-driven insights into the every day and sector-specific challenges in SBM adoption, forming the basis for policy recommendations and targeted interventions.

3.5 Assessing Awareness and Preparedness for Sustainability

Objective:

To assess the levels of awareness and preparedness for sustainable practices across different manufacturing sectors and categorize them into stages such as "Nascent," "Well Aware," or "Not at All."

Methodology

A quantitative survey-based approach was employed to evaluate the awareness levels and preparedness of different manufacturing sectors for adopting Sustainable Business Models (SBMs)**.** A structured questionnaire was distributed among 160 respondents from key manufacturing sectors, gathering insights on their understanding of sustainable practices, circular economy principles, and environmental responsibility. The responses were categorized into distinct awareness levels: "Not at All," "Nascent," "Mid-Level," and "Well Aware." This classification helped identify sectors leading in sustainability adoption versus those requiring capacity-building initiatives.

To ensure statistical rigor, two key tests were performed: the Kruskal-Wallis H Test, which measured whether awareness levels varied significantly across different sectors, and an Independent Samples T-Test, which compared awareness levels between two selected sectors (e.g., Automobile & Transportation and Chemicals & Plastics**).** These tests helped determine whether sector-specific interventions are necessary or if a universal awareness campaign would be more effective.

3.6 Exploring Strategies and Innovations for SBM Transition

Objective

To explore the strategies, innovations, and sustainable design concepts that are being planned or implemented by key manufacturing sectors in India for the transition towards SBMs.

Methodology

Primary data was collected through a structured questionnaire distributed to 160 respondents across various manufacturing sectors. The questionnaire captured insights on the current status of sustainable product design and development, categorizing responses into stages such as "Thoughts Only," "Initial Discussions," "Design Stage," "Development & Trials," and "Others." Additionally, respondents were asked about management perspectives on sustainable product development**,** classified under "Initial Thoughts Only," "Understand Its Importance," "An Action Plan Is Demanded," and "Go Ahead Given for Trials."

To validate and analyze these responses, multiple regression analysis was conducted to examine the impact of management attitudes, innovation interest, and SBM initiatives on adopting sustainability. This helped identify the key factors driving or hindering the transition towards sustainable strategies in different sectors. The regression model assessed correlations between industry actions and their management's stance on sustainability, providing a quantitative measure of strategic readiness.

3.7 Analyzing Collaboration and Stakeholder Engagement

Objective

To investigate the level of cooperation and collaboration among firms and stakeholders**,** as well as the barriers preventing effective partnerships in the transition to SBMs.

Methodology

A quantitative survey-based approach was employed to investigate the level of cooperation and collaboration among firms and stakeholders in the transition towards Sustainable Business Models (SBMs)**. A** structured questionnaire was distributed among

160 respondents across key manufacturing sectors, including Automobile & Transportation, Chemicals & Plastics, Infrastructure, Steel & Cement, Textiles, Consumer Electronics & Capital Goods, Pharmacy & Healthcare, and Agriculture & Food Processing. The questionnaire aimed to assess the extent of stakeholder engagement, existing collaborative initiatives, and barriers preventing effective partnerships in sustainability adoption. Participants were asked to indicate their organization's level of cooperation with suppliers, policymakers, regulatory bodies, and industry peers in implementing sustainability strategies.

The Chi-Square Test of Independence was applied to analyze the collected data to determine the relationship between industry sectors and their level of stakeholder collaboration. This test helped assess whether specific sectors exhibited higher partnership engagement than others. Additionally, the Kruskal-Wallis H Test was used to compare variations in collaboration efforts across different industries, particularly in terms of joint sustainability projects, resource-sharing initiatives, and regulatory compliance coordination.

3.8 Examining Drivers and Barriers to Sustainability Innovations

Objective

To identify and examine the factors that either drive or hinder the successful implementation of sustainability-driven innovations in the manufacturing sector, considering organizational culture, mindset, resource allocation, and external relationships.

Methodology

Primary data was collected through a structured questionnaire distributed among 160 respondents from key manufacturing sectors, including Automobile &

Transportation, Chemicals & Plastics, Infrastructure, Steel & Cement, Textiles, Consumer Electronics & Capital Goods, Pharmacy & Healthcare, and Agriculture & Food Processing. The questionnaire identified organizational culture, mindset, resource allocation, external relationships, and regulatory constraints as key influencing factors in SBM implementation. Respondents were asked to rate these factors on a Likert scale, measuring their impact on sustainability adoption, innovation initiatives, and operational challenges.

Multiple Regression Analysis was applied for data analysis to assess the relationship between management mindset, innovation interest, resource availability, and the likelihood of sustainability implementation. This test helped quantify the influence of internal organizational culture and external market factors on sustainable business model adoption. Additionally, ANOVA (Analysis of Variance) was used to determine if significant differences existed between sectors regarding sustainability drivers and barriers**.** At the same time, the Chi-Square Test of Independence was conducted to evaluate the correlation between industry type and key challenges faced in implementing sustainability-driven innovations.

The combination of quantitative statistical testing provided a holistic perspective on the drivers and challenges of sustainability-driven innovations**.** It offered actionable recommendations for industry leaders and policymakers to facilitate a smoother transition towards sustainable business models in India's manufacturing sector.

3.9 Population and Sample

The study's population comprises professionals, stakeholders, and decision-makers from various key manufacturing sectors in India, including Automobile and transportation, Chemicals and plastics, Infrastructure, Steel and cement, Textiles,

Consumer Electronics and capital Goods, Pharmacy and healthcare, Agriculture and Food Processing. These sectors were chosen based on their significant environmental impact and potential for transitioning to Sustainable Business Models (SBMs).

The sample was drawn using a structured questionnaire distributed to 160 respondents from these sectors. The respondents included senior managers, sustainability officers, operations heads, and other key personnel responsible for sustainability initiatives within their organizations. The sampling method ensured diverse representation across different industries to capture variations in awareness, challenges, and readiness for SBM adoption. The responses were categorized based on sector, level of understanding, engagement in sustainability initiatives, and key barriers faced, allowing for a comprehensive analysis of SBM transition strategies in Indian manufacturing.

3.10 Participant Selection

The participants for this study were selected based on their direct involvement in manufacturing operations, sustainability initiatives, and decision-making processes within key manufacturing sectors in India. The study targeted senior managers, sustainability officers, operations heads, and other relevant professionals with insights into the barriers, awareness levels, and strategic planning related to Sustainable Business Models (SBMs). A structured questionnaire was distributed among 160 respondents across major sectors, including Automobile & Transportation, Chemicals & Plastics, Infrastructure, Steel & Cement, Textiles, Consumer Electronics & Capital Goods, Pharmacy & Healthcare, and Agriculture & Food Processing.

To ensure a diverse and representative sample, purposive sampling was used to select participants with expertise in sustainability adoption, circular economy practices,

and environmental impact management. The selection process ensured that individuals from both large-scale industries and mid-sized enterprises were included to capture sectoral differences in SBM implementation**.** Additionally, the questionnaire responses were categorized based on awareness levels, engagement in sustainable practices, and perceived challenges. This allowed for a nuanced analysis of industry readiness and strategic requirements for sustainability transitions.

3.11 Instrumentation

This study's primary instrument for data collection was a structured questionnaire designed to gather insights into the barriers, awareness levels, and strategic approaches toward Sustainable Business Models (SBMs) in Indian manufacturing sectors. The questionnaire comprised 15 questions divided into five key sections aligned with the study's objectives. These sections focused on identifying significant hurdles in SBM adoption, assessing awareness and preparedness levels, exploring ongoing sustainable initiatives, analyzing stakeholder collaboration, and evaluating factors influencing sustainability-driven innovations.

The questionnaire used open-ended questions to capture quantitative insights. The Likert scale was used to measure levels of awareness (e.g., "Not at All," "Nascent," "Mid-Level," and "Well Aware"**),** barriers to SBM adoption (e.g., concept clarity, resource unavailability, cost constraints), and engagement in sustainability initiatives (e.g., "Thoughts Only," "Initial Discussions," "Design Stage," "Development & Trials"). Additionally**,** demographic questions ensured a diverse representation across various manufacturing sectors and organizational roles.

A pilot test was conducted among a small group of industry professionals before full-scale data collection to validate the instrument. The responses were then analyzed

using statistical methods**,** including ANOVA, Chi-Square Test, Kruskal-Wallis H Test, T-Test, and Multiple Regression Analysis, to ensure data reliability and meaningful interpretation.

3.12 Data Collection Procedures

The data collection for this study was conducted using a structured questionnaire designed to capture insights from 160 respondents across key manufacturing sectors in India. The questionnaire was circulated electronically to ensure a broad reach and efficient response collection**.** The participants included senior managers, sustainability officers, operations heads, and industry professionals from the Automobile & Transportation, Chemicals & Plastics, Infrastructure, Steel & Cement, Textiles, Consumer Electronics & Capital Goods, Pharmacy & Healthcare, and Agriculture & Food Processing sectors. These respondents were strategically selected based on their involvement in sustainability planning, policy implementation, and operational decision-making.

The questionnaire was divided into five sections, each aligned with a specific research objective. The questions covered barriers to SBM adoption, awareness and preparedness levels, strategic innovations, stakeholder collaboration, and factors influencing sustainability-driven initiatives. Before full-scale distribution, a pilot test was conducted with a small subset of industry professionals to validate the questionnaire's clarity, reliability, and relevance. After incorporating the necessary refinements, the final questionnaire was disseminated via email and professional networks. Respondents were given a fixed timeline to complete the survey, with follow-up reminders to maximize participation.

Upon receiving responses, the data was cleaned, categorized, and coded for analysis. Statistical tests, including ANOVA, Chi-Square Test, Kruskal-Wallis H Test, T-Test, and Multiple Regression Analysis, were applied to ensure robust insights into sectoral differences, relationships between variables, and key drivers of SBM adoption.

3.13 Data Analysis

The data collected from 160 respondents across key manufacturing sectors in India was systematically analyzed using quantitative technique to derive insights into the transition to Sustainable Business Models (SBMs). The analysis process involved multiple stages, including data cleaning, categorization, statistical testing, and interpretation to ensure accuracy, reliability, and meaningful conclusions.

Initially, the responses were cleaned and coded to remove inconsistencies and categorize data based on sectors, awareness levels, sustainability engagement, and key barriers. The structured questionnaire provided numerical data (Likert scale responses, categorical selections) and open-ended insights, allowing for a multi-dimensional analysis.

Statistical Tests Applied:

ANOVA (Analysis of Variance) – Used to determine whether significant differences existed between sectors regarding barriers to SBM adoption (e.g., resource unavailability, cost constraints, concept clarity). The results showed that these challenges were uniformly experienced across industries, indicating that broad-based strategies rather than sector-specific interventions may be effective.

Chi-Square Test of Independence – Applied to examine relationships between variables such as awareness levels and sector type, management perspectives and strategic implementation, and innovation interests across different industries. The results

confirmed that while some variations existed, sustainability challenges were primarily shared across sectors, reinforcing the need for cross-sectoral policy frameworks.

Kruskal-Wallis H Test—This Test compares awareness levels between sectors, categorizing responses into "Not at All," "Nascent," "Mid-Level," and "Well Aware." This helps understand sectoral differences in sustainability readiness and informs recommendations for awareness campaigns and capacity-building programs.

Independent Samples T-Test – Conducted to compare awareness levels and sustainability engagement between specific sectors (e.g., Chemicals & Plastics vs. Automobile & Transportation). The results indicated that some industries were more proactive in adopting sustainable initiatives, while others required additional support in policy guidance and resource allocation.

Multiple Regression Analysis – Applied to assess the impact of management attitudes, innovation interest, and external factors on sustainability adoption. This statistical approach quantified how organizational culture, resource availability, and regulatory pressures influenced the likelihood of implementing SBMs.

Graphical Interpretation & Sectoral Insights:

To visually represent findings, graphs and charts were used to highlight key trends, including:

Barriers to SBM Adoption: Identifying which hurdles (e.g., resource unavailability, concept clarity) were most critical in specific sectors.

Awareness Levels Across Sectors: Categorizing sectors into different levels of sustainability preparedness.

Management Perspectives on SBM Strategies: Comparing industries based on their readiness to initiate, develop, or implement sustainable practices.

Innovation Interest & Implementation Hurdles: Examining the gap between interest in sustainability innovation and actual execution.

Conclusion of Data Analysis:

The results highlighted that resource constraints, financial concerns, and lack of collaboration were the most significant barriers to SBM adoption. While awareness of sustainable practices increased, implementation remained a challenge due to operational hurdles and regulatory uncertainties. The statistical tests confirmed that sectoral differences existed in the pace of sustainability adoption, necessitating both generalized policy measures and industry-specific interventions.

3.14 Research Design Limitations

While the research design effectively captures insights into the transition to Sustainable Business Models (SBMs) in key manufacturing sectors in India, several limitations must be acknowledged. First, the sample size of 160 respondents, though diverse, may not entirely represent India's wide range of manufacturing industries, including minimal and medium-sized enterprises (SMEs) that often face unique sustainability challenges. The study relies heavily on self-reported data collected through a structured questionnaire, which may introduce response bias, as participants might provide socially desirable answers rather than reflecting actual industry practices. Additionally, while statistical tests such as ANOVA, Chi-Square, Kruskal-Wallis H Test, T-Test, and Multiple Regression Analysis provide robust quantitative insights, they may not fully capture the complexity of organizational decision-making, behavioural factors and external market influences that impact SBM adoption.

Another limitation arises from the study's cross-sectional nature, which captures data at a single point in time, limiting the ability to track longitudinal changes in SBM

adoption and the evolving sustainability landscape in the manufacturing sector. Furthermore, the study does not include in-depth interviews or focus group discussions, which could have provided a richer contextual understanding. Finally, the study focuses on internal organizational challenges and strategic approaches. Still, external policy, regulatory frameworks, and supply chain dynamics—which play a crucial role in sustainability transitions—are not deeply explored. These limitations suggest that future research could expand the sample size, incorporate longitudinal data, and employ mixed-method approaches, such as interviews and real-time case studies, to provide a more holistic view of SBM adoption in Indian manufacturing.

3.15 Conclusion

The study provides a comprehensive analysis of the barriers, awareness levels, and strategic approaches necessary for transitioning to Sustainable Business Models (SBMs) in key manufacturing sectors in India. The findings reveal that resource unavailability, financial constraints, and lack of collaboration are the most significant hurdles to sustainability adoption, while concept clarity and awareness levels vary across sectors. Despite a growing interest in sustainability-driven innovations, practical implementation remains challenging due to operational inefficiencies and regulatory uncertainties. The statistical tests applied, including ANOVA, Chi-Square, Kruskal-Wallis H Test, T-Test, and Multiple Regression Analysis, confirm that while specific sectors are proactive in adopting sustainable initiatives, others require targeted interventions to bridge the awareness-to-implementation gap.

The research highlights that a unified, cross-sectoral strategy—complemented by sector-specific interventions, policy support, and industry collaboration—is essential for accelerating SBM adoption. The study also underscores the importance of managerial

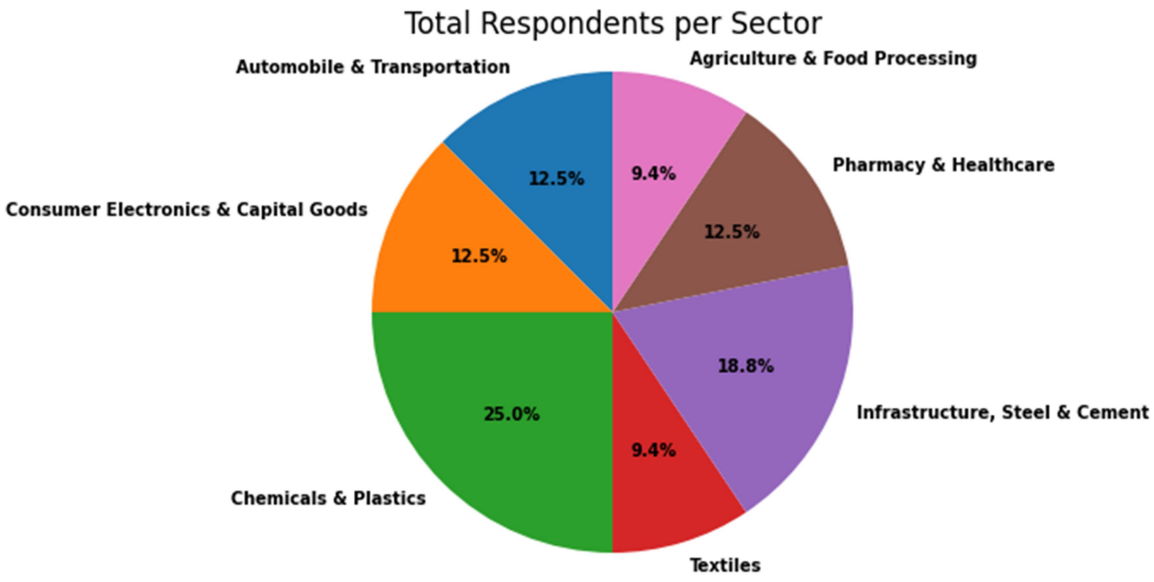
commitment and innovation in overcoming sustainability challenges. While the findings provide valuable insights for policymakers, industry leaders, and sustainability professionals, the study's limitations, such as self-reported data, cross-sectional design, and absence of longitudinal tracking, indicate the need for future research with larger sample sizes and mixed-method approaches, including qualitative interviews and real-time case studies. Overall, this research contributes to the growing discourse on sustainability in manufacturing and offers actionable recommendations to support India's transition towards environmentally and socially responsible business practices.

CHAPTER IV:

RESULTS

4.1 Introduction

The highest proportion of respondents comes from the Chemicals & Plastics sector **(**25.0%**),** indicating significant engagement in sustainability discussions from this industry. Infrastructure, Steel & Cement (18.8%) also has a notable presence, showing a strong interest in sustainable business model (SBM) adoption. Automobile & Transportation (12.5%)**,** Consumer Electronics & Capital Goods (12.5%)**,** and Pharmacy & Healthcare (12.5**%)** each contribute equally, reflecting moderate representation. Textiles (9.4%) **and** Agriculture & Food Processing (9.4%) have the lowest participation, suggesting lower involvement or awareness regarding sustainability transitions.



Interpretation:

The Chemicals & Plastics sector's high representation aligns with previous findings that it faces significant resource constraints**,** regulatory pressures, and the need

for innovation in sustainable practices. The Infrastructure, Steel & Cement industry also demonstrates strong engagement, likely due to the high environmental impact of cement production and increasing focus on green infrastructure solutions.

The Automobile & Transportation and Consumer Electronics & Capital Goods sectors show moderate engagement, which may indicate ongoing efforts in electric mobility, energy-efficient technologies, and circular economy initiatives**.** The lower participation from the Textiles and Agriculture & Food Processing sectors suggests either limited sustainability awareness or fewer structured initiatives in these industries, reinforcing the need for policy-driven interventions and increased industry collaboration to accelerate sustainability adoption in these sectors.

Overall, the sectoral distribution of respondents reflects varied levels of awareness, resource allocation, and readiness for SBM adoption, with **industries** heavily reliant on raw materials and industrial processes showing the highest engagement. This insight can help policymakers and business leaders design targeted interventions to enhance sustainability efforts across all sectors.

4.2 Identifying Key Barriers to SBM Adoption

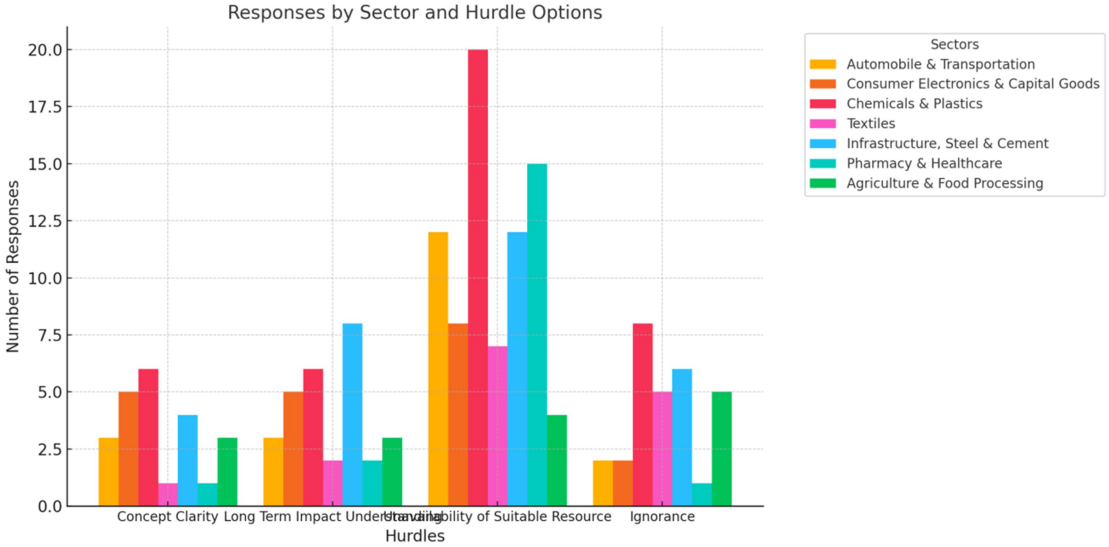


Figure 1 Major Hurdles

The analysis highlights key challenges in the adoption of Sustainable Business Models (SBMs) across manufacturing sectors. Concept clarity received low responses across sectors, with Consumer Electronics & Capital Goods (5) and Chemicals & Plastics (6) reporting slightly higher concerns, while Textiles and Pharmacy & Healthcare (1 each) indicated minimal issues. Long-term impact understanding showed moderate awareness, with Infrastructure, Steel & Cement (8) leading, followed by Chemicals & Plastics (6), while Textiles and Pharmacy & Healthcare (2 each) demonstrated relatively better awareness. Unavailability of suitable resources emerged as the most critical hurdle, particularly in Chemicals & Plastics (20), Infrastructure, Steel & Cement (12), and Pharmacy & Healthcare (15), whereas Agriculture & Food Processing (4) and Automobile & Transportation (12) reported lower but still significant challenges. Ignorance levels were generally low, with Chemicals & Plastics (8) and Infrastructure, Steel & Cement (6) reporting the highest concerns, while Pharmacy & Healthcare (1) and Automobile & Transportation (2) indicated good stakeholder awareness.

Interpretation

The graph underscores the critical role of resource availability and operational capacity in enabling sustainable business transitions, particularly in sectors like Chemicals & Plastics and Infrastructure, Steel & Cement. While awareness and conceptual clarity are less prominent issues, targeted efforts to address resource constraints and foster long-term planning are essential to overcome the barriers highlighted in this analysis.

4.3 Assessing Awareness and Preparedness for Sustainability

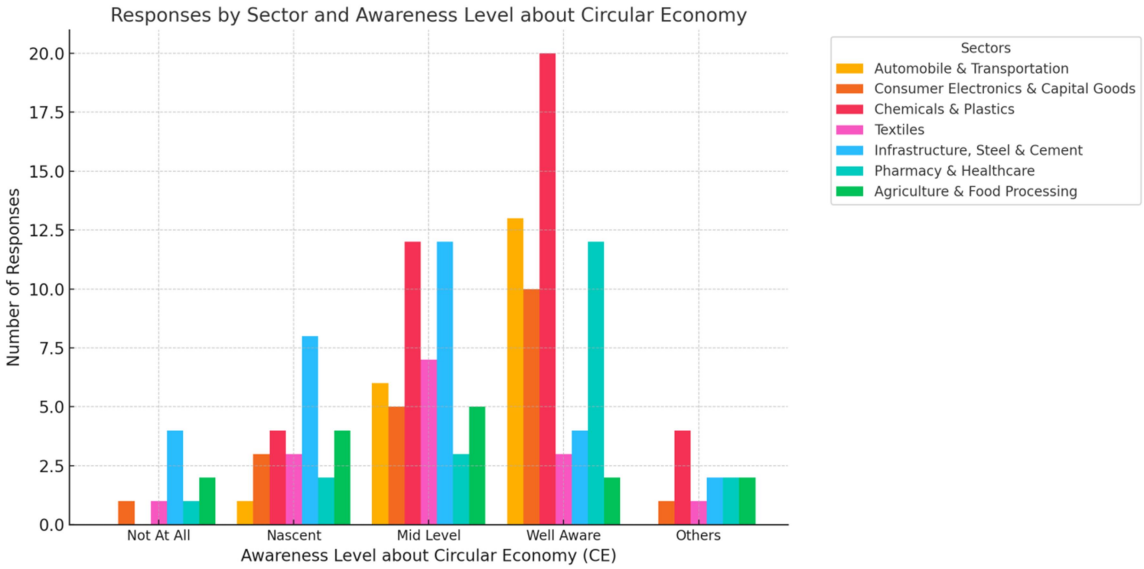


Figure 2 Awareness Level about Circular Economy

The analysis of awareness levels in Sustainable Business Models (SBMs) across sectors reveals varying degrees of engagement. Complete unawareness ("Not At All") is rare, with Infrastructure, Steel & Cement (4) showing the highest response, while other sectors report negligible concerns. Early-stage awareness ("Nascent") is moderate in Infrastructure, Steel & Cement (8) and Chemicals & Plastics (4), but lower in Pharmacy

& Healthcare (2) and Consumer Electronics & Capital Goods (3). Mid-level awareness is strong across sectors, particularly in Chemicals & Plastics (12) and Infrastructure, Steel & Cement (12), with Textiles (7) and Agriculture & Food Processing (5) showing moderate progress. High awareness ("Well Aware") dominates in Chemicals & Plastics (20), Automobile & Transportation (13), and Pharmacy & Healthcare (12), while Textiles (3) and Agriculture & Food Processing (2) lag behind. Alternative viewpoints ("Others") are minimal, with Chemicals & Plastics (4), Infrastructure, Steel & Cement (2), and Pharmacy & Healthcare (2) indicating limited perspectives beyond the predefined categories.

Interpretation

The graph indicates significant progress in CE awareness across sectors, with Chemicals & Plastics, Automobile & Transportation, and Pharmacy & Healthcare demonstrating strong engagement. However, sectors like Infrastructure, Steel & Cement, Textiles, and Agriculture & Food Processing require targeted efforts to enhance their understanding and move beyond nascent or mid-level awareness. The minimal presence of unawareness suggests a positive trend in CE adoption, although further actions are needed to bring all sectors to the "Well Aware" stage.

4.4 Exploring Strategies and Innovations for SBM Transition

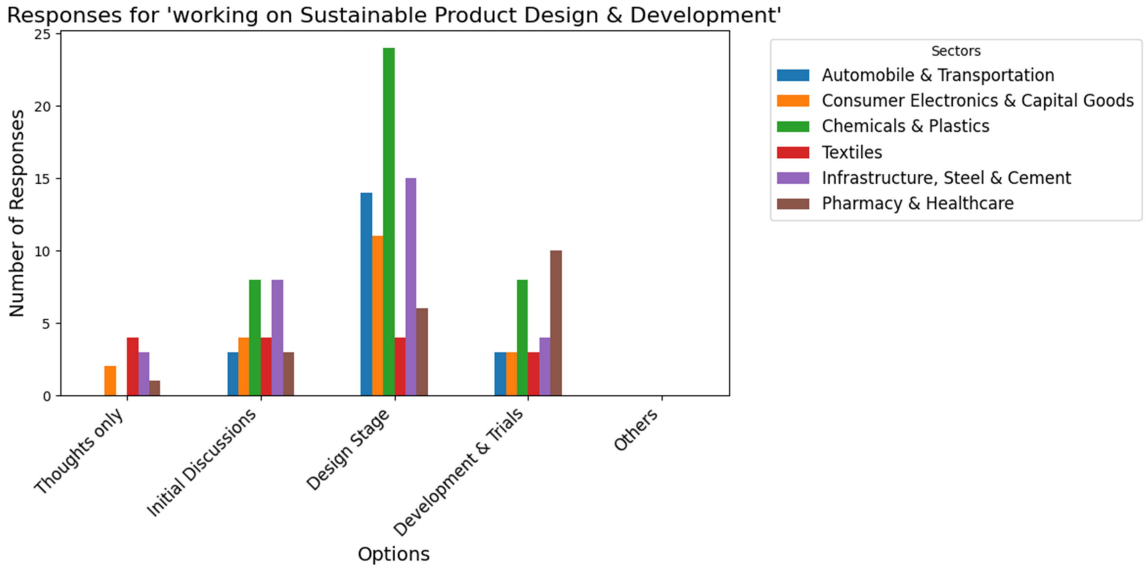


Figure 3 Sustainable Product Design & Development

The analysis of sustainable product design and development stages across sectors reveals varying levels of engagement. Minimal responses were recorded in the "Thoughts Only" category, ranging between 2 to 4 responses across all sectors. "Initial Discussions" showed increased engagement, with Infrastructure, Steel & Cement and Chemicals & Plastics (8 each) leading, followed by Consumer Electronics & Capital Goods (4). The "Design Stage" emerged as the most dominant, with Chemicals & Plastics (25), Infrastructure, Steel & Cement (15), and Automobile & Transportation (14) showing the highest participation. "Development & Trials" responses were moderate, with Chemicals & Plastics (10), Pharmacy & Healthcare (8), and Infrastructure, Steel & Cement (5) leading, while Automobile & Transportation and Consumer Electronics & Capital Goods (3 each) had lower engagement. The "Others" category recorded no responses across all sectors, indicating minimal alternative approaches beyond the predefined stages.

Interpretation:

The Design Stage category clearly dominates, indicating that most sectors are focused on designing sustainable products. Chemicals & Plastics and Infrastructure, Steel & Cement are leading sectors actively engaged at this stage. Development & Trials responses are moderate, highlighting that some sectors like Chemicals & Plastics and Pharmacy & Healthcare are transitioning towards implementation phases of sustainability efforts. Initial Discussions responses, with Infrastructure, Steel & Cement and Pharmacy & Healthcare leading, reflect early-stage exploration in some sectors. Minimal responses in Thoughts Only and Others categories suggest that most sectors have moved beyond mere ideation or informal discussions about sustainability. Chemicals & Plastics emerges as a front-runner across all stages, with high responses in both design and implementation phases.

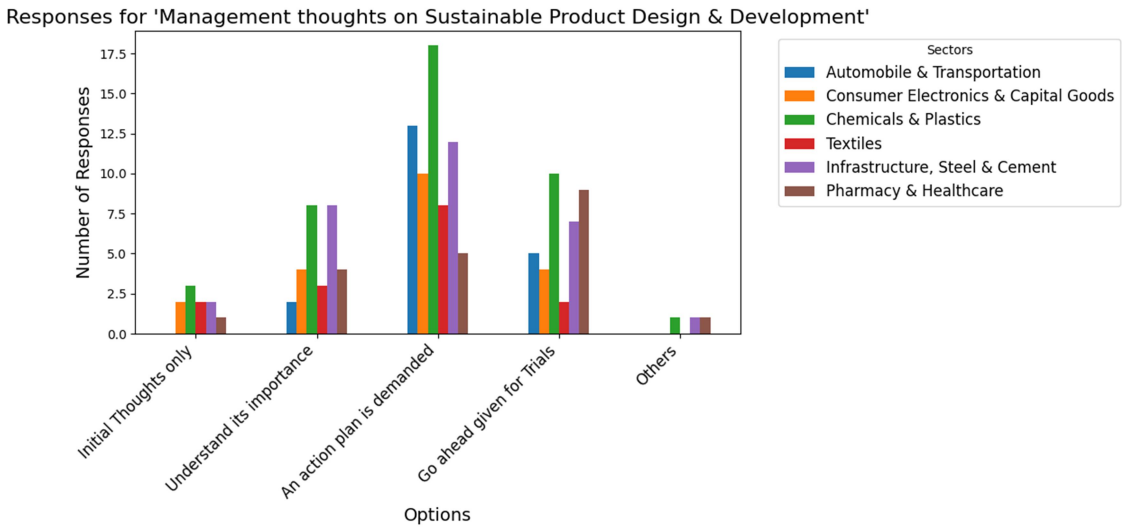


Figure 4 Management Thoughts on SPD

The analysis of management perspectives on sustainable product design and development reveals varying levels of commitment across sectors. "Initial Thoughts Only" received minimal responses, with Pharmacy & Healthcare and Infrastructure, Steel & Cement (1-2 responses each), while Automobile & Transportation and Consumer

Electronics & Capital Goods (2-3 responses each) showed slightly higher engagement. "Understand Its Importance" saw a noticeable rise, led by Infrastructure, Steel & Cement and Chemicals & Plastics (8 each), with other sectors contributing moderate responses (4 each). "An Action Plan Is Demanded" dominated, with Chemicals & Plastics (18) and Infrastructure, Steel & Cement (12) leading, followed by Pharmacy & Healthcare and Automobile & Transportation, showing strong demand for strategic implementation. "Go Ahead Given for Trials" had moderate responses, with Chemicals & Plastics (10), Pharmacy & Healthcare (9), and Infrastructure, Steel & Cement (6) taking the lead, while Automobile & Transportation (5) and Consumer Electronics & Capital Goods (4) reported lower engagement. The "Others" category recorded negligible responses across all sectors (1 response), indicating limited perspectives outside the predefined categories.

Interpretation:

The category "An Action Plan Is Demanded" received the highest responses across sectors, particularly in Chemicals & Plastics and Infrastructure, Steel & Cement . This suggests that management in these sectors is keen on developing clear and actionable strategies for sustainable product design and development. The "Understand Its Importance" category shows significant engagement in sectors like Pharmacy & Healthcare and Infrastructure, Steel & Cement , indicating that management in these industries is building awareness and recognizing the value of sustainable practices. The "Go Ahead Given for Trials" category highlights sectors actively transitioning from planning to implementation, with Chemicals & Plastics and Pharmacy & Healthcare showing the strongest movement in this direction. The "Initial Thoughts Only" category reflects minimal engagement, suggesting that most sectors have moved beyond the ideation phase. Responses in the "Others" category are negligible, implying limited alternative viewpoints outside the predefined options.

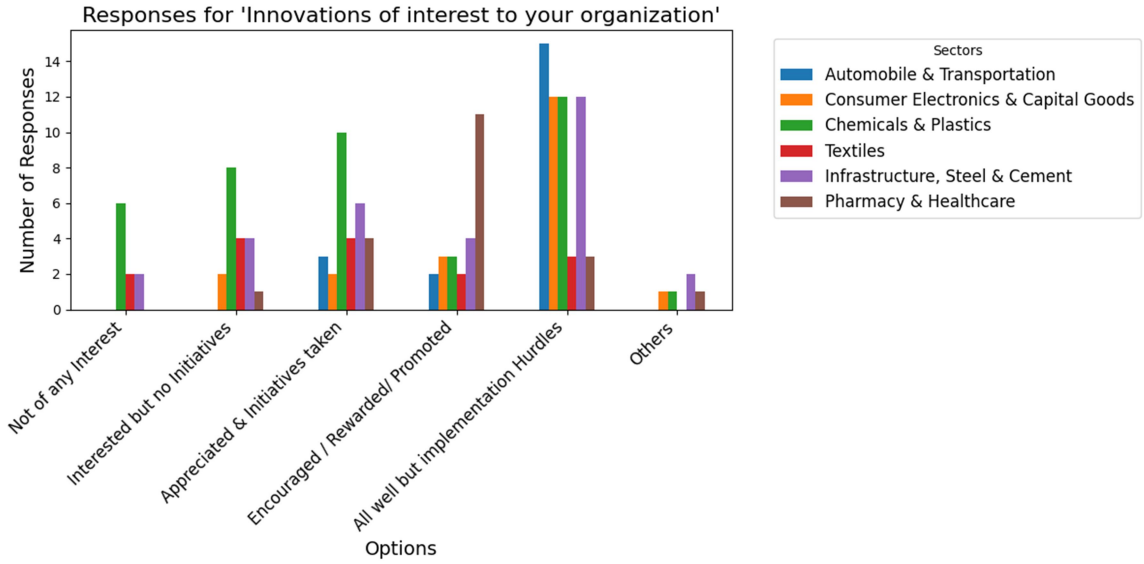


Figure 5 Innovation of Interest to your organization

The analysis of organizational interest and engagement in sustainability innovations shows varying levels of commitment across sectors. "Not of Any Interest" received minimal responses, with Chemicals & Plastics (6) recording the highest, while Automobile & Transportation, Consumer Electronics & Capital Goods, and Infrastructure, Steel & Cement (2 each) showed limited disengagement. "Interested but No Initiatives" indicated moderate engagement, led by Chemicals & Plastics (8), with other sectors reporting 3-4 responses each. "Appreciated & Initiatives Taken" showed increased participation, with Chemicals & Plastics (10) and Infrastructure, Steel & Cement (6) leading, while Pharmacy & Healthcare (4) and Automobile & Transportation (3) also demonstrated notable involvement. "Encouraged / Rewarded / Promoted" saw significant responses, with Pharmacy & Healthcare (11) leading, followed by moderate engagement in other sectors (6-8 responses each). "All Well but Implementation Hurdles" emerged as the dominant category, with Automobile & Transportation (15) and other

sectors reporting significant barriers. The "Others" category had minimal responses (0-2), indicating limited perspectives beyond the predefined classifications.

Interpretation:

The All Well but Implementation Hurdles category receives the highest responses across all sectors, particularly in Automobile & Transportation, Chemicals & Plastics, and Infrastructure, Steel & Cement. This indicates that while there is interest and initial progress in innovation, practical challenges in implementation are a significant barrier. The Encouraged / Rewarded / Promoted category also shows strong engagement, especially in Infrastructure, Steel & Cement and Chemicals & Plastics, reflecting that these sectors actively promote and reward innovation. The Appreciated & Initiatives Taken category highlights active steps taken toward innovation, with Chemicals & Plastics and Infrastructure, Steel & Cement leading. The Interested but No Initiatives category, with Chemicals & Plastics and Pharmacy & Healthcare responses, indicates areas where interest exists but actionable steps are lacking. The Not of Any Interest and Others categories have negligible responses, implying that most sectors recognize the importance of innovation.

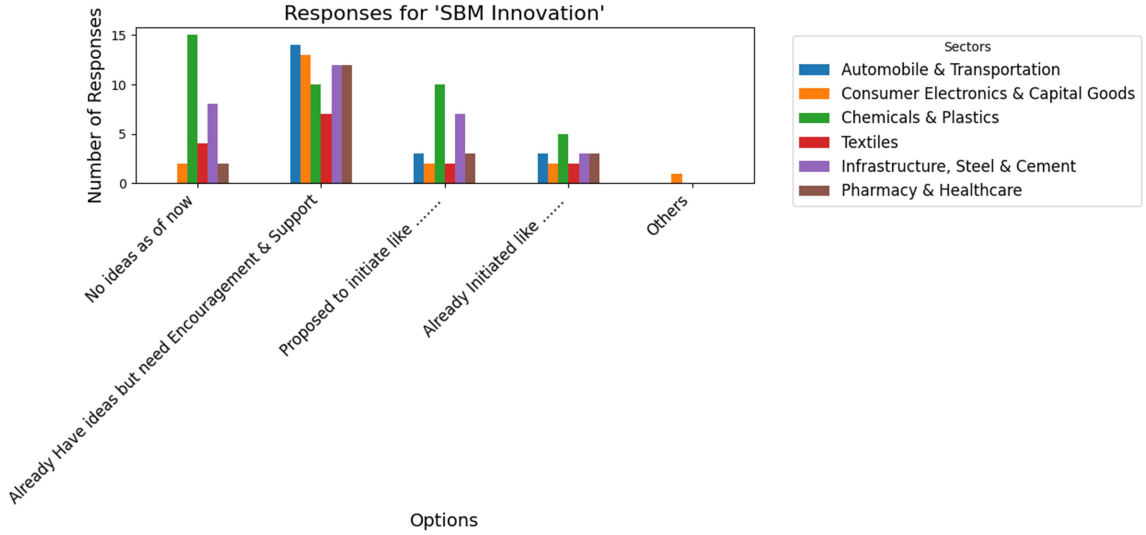


Figure 6 SBM Innovation

The analysis of idea generation and initiative-taking in sustainability efforts shows varying levels of engagement across sectors. "No Ideas as of Now" received minimal responses, with Textiles (2) leading, while Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare (1 each) showed limited disengagement. "Already Have Ideas but Need Encouragement & Support" emerged as a prominent category, with Automobile & Transportation (14), Infrastructure, Steel & Cement (12), and Pharmacy & Healthcare (12) leading, while other sectors recorded 8-10 responses each. "Proposed to Initiate Like..." showed significant engagement, with Chemicals & Plastics (10) and Infrastructure, Steel & Cement (7) taking the lead, while other sectors reported 2-3 responses each. "Already Initiated Like..." recorded relatively lower responses, with Chemicals & Plastics (5), Pharmacy & Healthcare (5), and Infrastructure, Steel & Cement (5) leading, while other sectors had 2-3 responses each. The "Others" category had minimal responses, with Consumer Electronics & Capital Goods (1) being the only sector reporting, while all others showed no responses.

Interpretation:

The category "Already Have Ideas but Need Encouragement & Support" dominates across sectors, especially in Chemicals & Plastics , Infrastructure, Steel & Cement , and Pharmacy & Healthcare. This suggests that while many sectors have conceptualized ideas, they require resources, guidance, or motivation to implement these ideas effectively. The "Proposed to Initiate Like..." category also shows strong engagement, particularly in Chemicals & Plastics and Infrastructure, Steel & Cement , indicating readiness to transition from planning to execution stages. The "Already Initiated Like..." category, with Chemicals & Plastics and Pharmacy & Healthcare leading, highlights sectors that have begun implementing sustainable business model innovations but are fewer in number compared to those in earlier stages. The "No Ideas

as of Now" category has negligible responses, suggesting that most sectors are already engaged in discussions or planning related to SBM innovation. The "Others" category remains insignificant, indicating limited alternative viewpoints or unique approaches outside the predefined options.

4.5 Analyzing Collaboration and Stakeholder Engagement

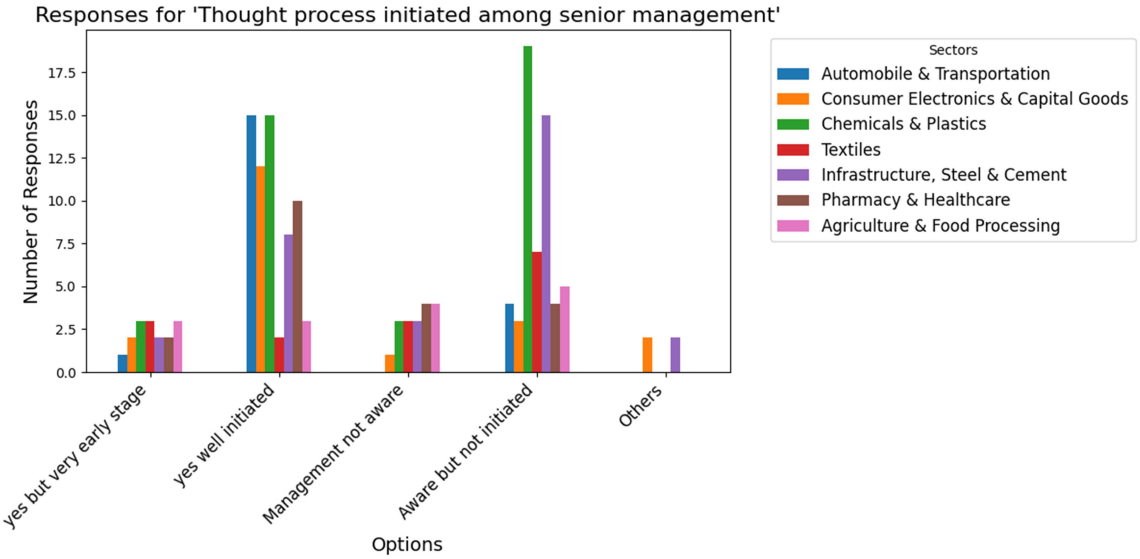


Figure 7 Thought Process Initiated among Senior Management

The analysis of sustainability initiatives and management awareness across sectors reveals varied levels of progress. "Yes but Very Early Stage" received relatively low responses, with Chemicals & Plastics, Agriculture & Food Processing, and Textiles (3 each) leading, while other sectors recorded 1-2 responses each. "Yes Well Initiated" emerged as the most dominant category, with Chemicals & Plastics and Automobile & Transportation (15 each), Consumer Electronics & Capital Goods (12), and Pharmacy & Healthcare (10) showing strong engagement, while other sectors also demonstrated significant involvement. "Management Not Aware" had minimal responses, with

Infrastructure, Steel & Cement and Textiles (2 each) reporting the highest values, while Automobile & Transportation and Agriculture & Food Processing registered only 1 or no responses. "Aware but Not Initiated" showed moderate engagement, led by Chemicals & Plastics (6), Pharmacy & Healthcare (4), and Infrastructure, Steel & Cement (4), with Consumer Electronics & Capital Goods and Automobile & Transportation (3 each) also showing interest. The "Others" category recorded negligible responses, with only Consumer Electronics & Capital Goods (1), while all other sectors reported none.

Interpretation:

The "Yes Well Initiated" category dominates, especially in Chemicals & Plastics ,Infrastructure, Steel & Cement , and Pharmacy & Healthcare. This indicates strong leadership and engagement by senior management in these sectors for driving sustainable initiatives. The "Aware but Not Initiated" category, with moderate responses in Chemicals & Plastics and Pharmacy & Healthcare, reflects sectors where awareness exists, but actionable steps are yet to be taken. Minimal responses in "Management Not Aware" and "Yes but Very Early Stage" categories suggest that most sectors are beyond the early stages of awareness and have initiated some level of action. The Others category has negligible responses, indicating that senior management thought processes largely align with the predefined categories.

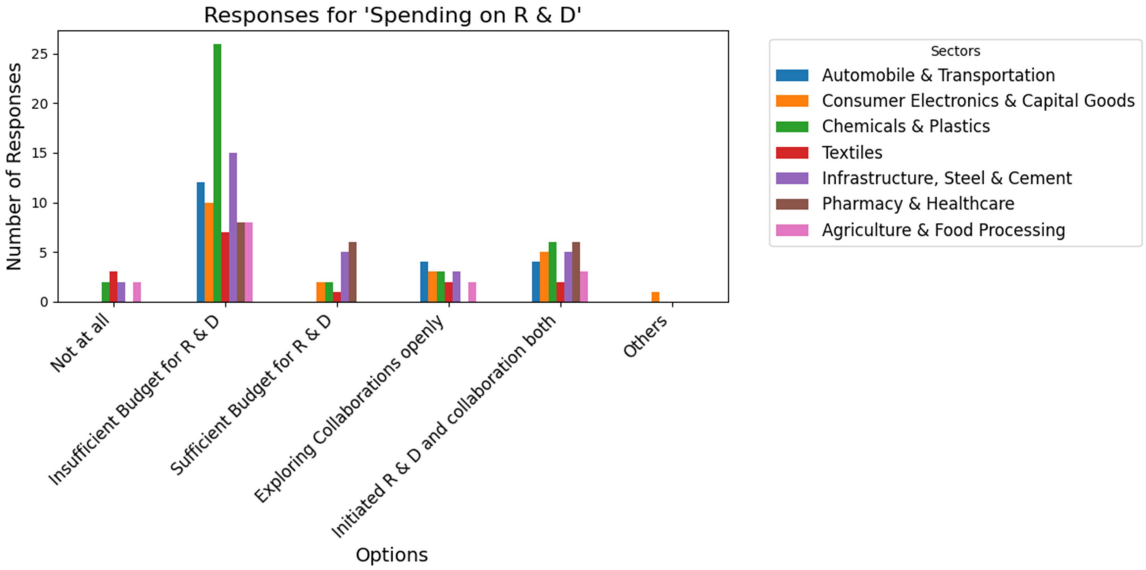


Figure 8 Spending on R & D

The analysis of R&D investment and collaboration in sustainability initiatives across sectors highlights varying levels of commitment. "Not at All" received minimal responses, with Textiles (3) leading, while Automobile & Transportation and Consumer Electronics & Capital Goods (1 or none) showed negligible disengagement. "Insufficient Budget for R&D" had moderate responses, with Pharmacy & Healthcare (6) and Infrastructure, Steel & Cement (5) leading, while other sectors recorded 0-2 responses. "Sufficient Budget for R&D" emerged as the most dominant category, led by Chemicals & Plastics (26), Infrastructure, Steel & Cement (15), and Automobile & Transportation (12), while Pharmacy & Healthcare (8) and Consumer Electronics & Capital Goods (10) also showed significant engagement. "Exploring Collaborations Openly" had moderate responses, with Automobile & Transportation (4) leading, while other sectors recorded 2-3 responses. "Initiated R&D and Collaboration Both" showed lower engagement, with Pharmacy & Healthcare and Chemicals & Plastics (6 each), Consumer Electronics & Capital Goods and Infrastructure, Steel & Cement (5 each), while other sectors recorded

3-4 responses. The "Others" category had minimal responses, with only Chemicals & Plastics (1).

Interpretation:

The Insufficient Budget for R&D category dominates, particularly in Chemicals & Plastics , Infrastructure, Steel & Cement , and Automobile & Transportation. This indicates that these sectors prioritize R&D spending and are well-positioned to innovate and adopt sustainable practices. The Exploring Collaborations Openly and Initiated R&D and Collaboration Both categories highlight growing interest in collaborative R&D efforts, especially in Pharmacy & Healthcare and Infrastructure, Steel & Cement . This shows a positive trend towards partnerships in innovation. The sufficient Budget for R&D category, with notable responses in Infrastructure, Steel & Cement and Pharmacy & Healthcare, reflects financial constraints in these sectors, which may hinder their innovation potential. The Not at All and Others categories have negligible responses, suggesting that most sectors recognize the importance of R&D and are at least engaging with the topic to some extent.

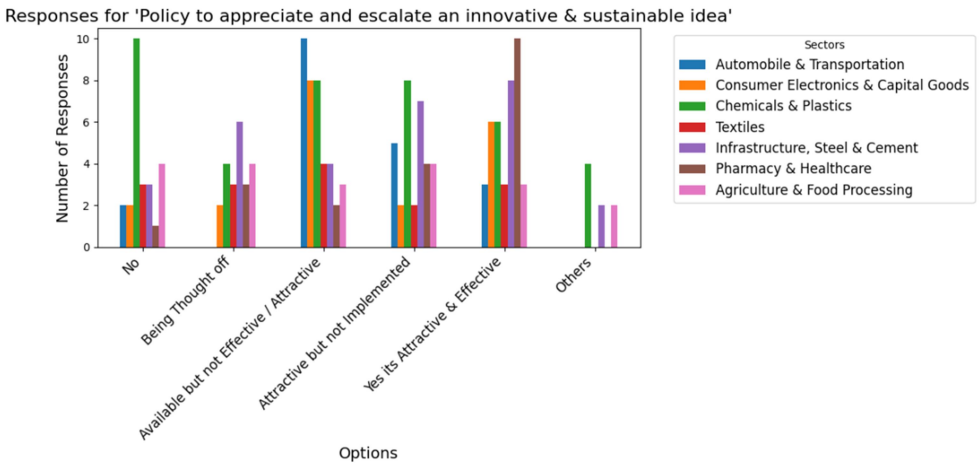


Figure 9 Policy to Appreciate & Escalate an innovative & Sustainable Idea

The analysis of sustainability initiatives and their effectiveness across sectors reveals diverse levels of engagement. "No" received significant responses, with Chemicals & Plastics (10) and Agriculture & Food Processing (4) leading, while other sectors recorded 3-4 responses each. "Being Thought Off" had moderate responses, led by Infrastructure, Steel & Cement (6), with Consumer Electronics & Capital Goods and Pharmacy & Healthcare (2-4 responses each) showing lower engagement. "Available but Not Effective/Attractive" saw moderate engagement, with Automobile & Transportation (10), Chemicals & Plastics, and Consumer Electronics & Capital Goods (8 each) taking the lead, while other sectors recorded 3-4 responses. "Attractive but Not Implemented" had lower engagement, with Chemicals & Plastics (8) and Infrastructure, Steel & Cement (7) leading, while other sectors recorded 2-4 responses each. "Yes, It's Attractive & Effective" received strong responses, with Pharmacy & Healthcare (10), Infrastructure, Steel & Cement (8), and Chemicals & Plastics (6) leading, while other sectors also showed notable engagement. The "Others" category had negligible responses, with only Chemicals & Plastics (4), while other sectors recorded none.

Interpretation:

The No category indicates that a notable number of sectors, particularly Chemicals & Plastics and Infrastructure, Steel & Cement , lack policies to support innovative and sustainable ideas. This highlights a significant gap that needs to be addressed. The Being Thought Off category reflects sectors like Infrastructure, Steel & Cement and Agriculture & Food Processing where policies are in the planning stage but not yet implemented. The Available but Not Effective/Attractive and Attractive but Not Implemented categories highlight sectors like Chemicals & Plastics and Infrastructure, Steel & Cement, where existing policies either lack appeal or remain unexecuted. The Yes, It's Attractive & Effective category demonstrates that some sectors, particularly

Pharmacy & Healthcare and Infrastructure, Steel & Cement , have successfully implemented policies to encourage and scale innovative ideas. The Others category is negligible, indicating that sectoral responses align well with the predefined categories.

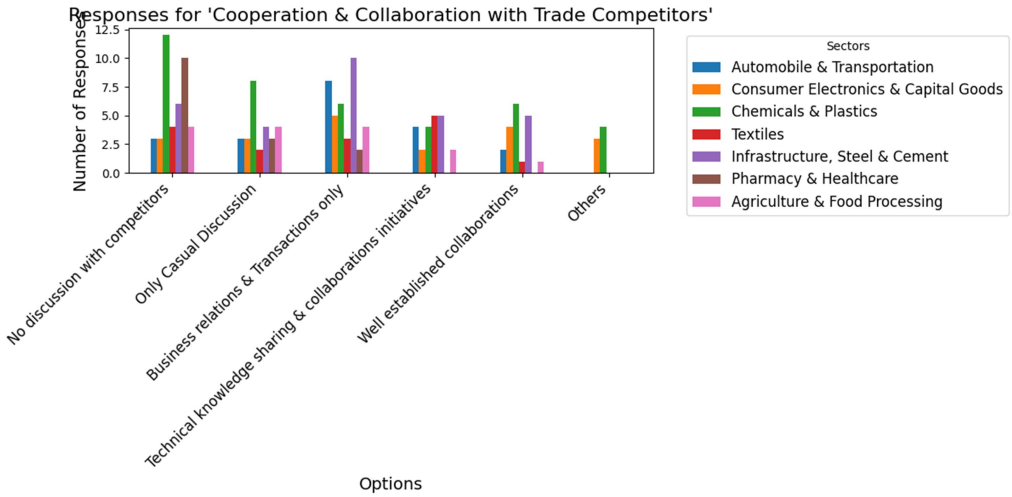


Figure 10 Cooperation & Collaboration with Trade Competitors

The analysis of collaboration and knowledge-sharing among competitors highlights varying levels of engagement across sectors. "No Discussion with Competitors" received significant responses, with Chemicals & Plastics (12), Pharmacy & Healthcare (10), and Infrastructure, Steel & Cement (6) leading, while other sectors recorded 3-4 responses each. "Only Casual Discussion" showed moderate engagement, with Chemicals & Plastics (8) leading, followed by Consumer Electronics & Capital Goods and Automobile & Transportation (2-4 responses each). "Business Relations & Transactions Only" had evenly spread engagement, led by Infrastructure, Steel & Cement (10), Automobiles (8), and Chemicals & Plastics (6), while other sectors, including Textiles and Agriculture & Food Processing, recorded 3-5 responses each. "Technical Knowledge Sharing & Collaboration Initiatives" showed moderate engagement, with

Infrastructure, Steel & Cement and Textiles (5 each), followed by Chemicals & Plastics and Automobile & Transportation (4 each), while other sectors recorded 2 responses each. "Well Established Collaborations" had lower engagement, with Chemicals & Plastics (6), Infrastructure, Steel & Cement (5), and Consumer Electronics & Capital Goods (4) leading, while other sectors recorded 1-2 responses each. The "Others" category had negligible responses across all sectors.

Interpretation:

The No Discussion with Competitors category highlights a significant reluctance to engage with competitors, especially in Agriculture & Food Processing and Pharmacy & Healthcare . This indicates a need for fostering collaborative opportunities in these sectors. The Only Casual Discussion and Business Relations & Transactions Only categories suggest that most interactions are limited to informal or transactional exchanges, with notable engagement in Infrastructure, Steel & Cement and Pharmacy & Healthcare. The Technical Knowledge Sharing & Collaboration Initiatives category shows growing interest, especially in Infrastructure, Steel & Cement and Pharmacy & Healthcare . This reflects an emerging willingness to collaborate on technical aspects but indicates room for expansion. The Well Established Collaborations category highlights a few sectors, such as Pharmacy & Healthcare and Infrastructure, Steel & Cement , that have developed more formal and structured collaboration frameworks. Minimal responses in the Others category suggest that most sectors align with the predefined categories.

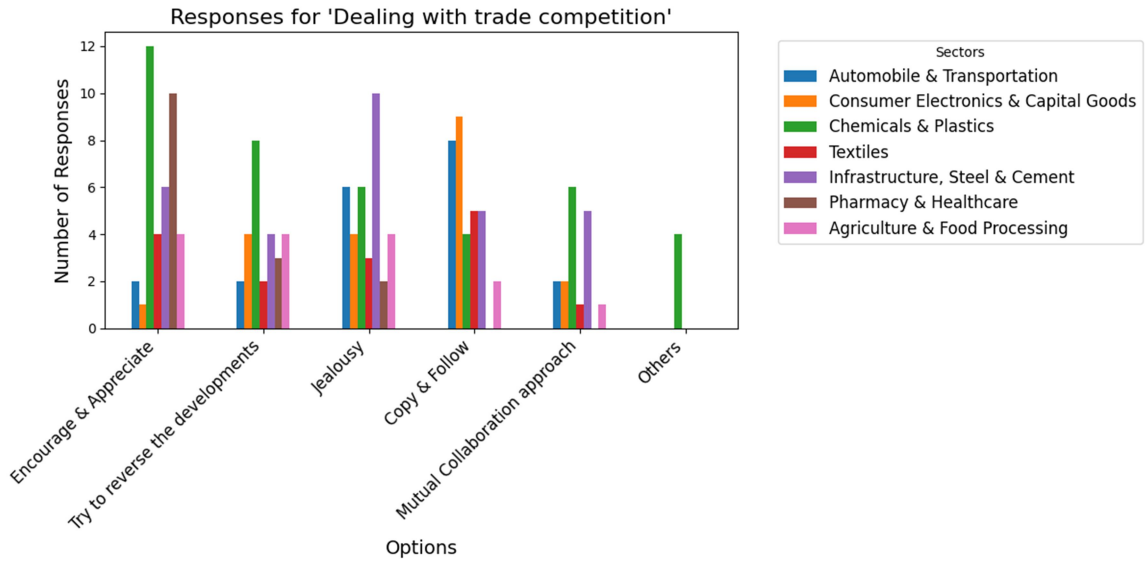


Figure 11 Dealing with Trade Competition

The analysis of industry attitudes toward trade competition and collaboration highlights diverse approaches across sectors. "Encourage & Appreciate" received strong responses, with Chemicals & Plastics (12) and Pharmacy & Healthcare (10) leading, while Infrastructure, Steel & Cement (6) and Agriculture & Food Processing (4) showed moderate engagement. "Try to Reverse the Developments" had lower responses, with Chemicals & Plastics (8), Infrastructure, Steel & Cement, and Consumer Electronics & Capital Goods (4 each) leading, while other sectors recorded minimal responses (2-3 each). "Jealousy" showed significant responses, with Infrastructure, Steel & Cement (10) and Chemicals & Plastics (6) leading, while other sectors also demonstrated engagement. "Copy & Follow" emerged as a dominant approach, with Consumer Electronics & Capital Goods (9) and Automobile & Transportation (8) leading, while other sectors recorded moderate engagement. "Mutual Collaboration Approach" was relatively balanced, with Chemicals & Plastics (6) and Infrastructure, Steel & Cement (5) showing willingness to collaborate, while other sectors also indicated interest. The "Others"

category had minimal responses, with Chemicals & Plastics (4), while all other sectors recorded none.

Interpretation:

Encourage & Appreciate is a prevalent approach in Chemicals & Plastics and Pharmacy & Healthcare , reflecting a positive attitude towards acknowledging and learning from competitors. The Copy & Follow approach, with high responses in Consumer Electronics & Capital Goods and Pharmacy & Healthcare, suggests a competitive yet adaptive strategy in these sectors. Jealousy, a notable response in Infrastructure, Steel & Cement and Agriculture & Food Processing , indicates a competitive tension that could hinder collaborative opportunities. The Mutual Collaboration Approach, with balanced responses across sectors like Chemicals & Plastics and Infrastructure, Steel & Cement, reflects a willingness to work together despite competition. Minimal engagement in the Try to Reverse the Developments and Others categories suggests that direct opposition or alternative strategies are less favored.

4.6 Examining Drivers and Barriers to Sustainability Innovations

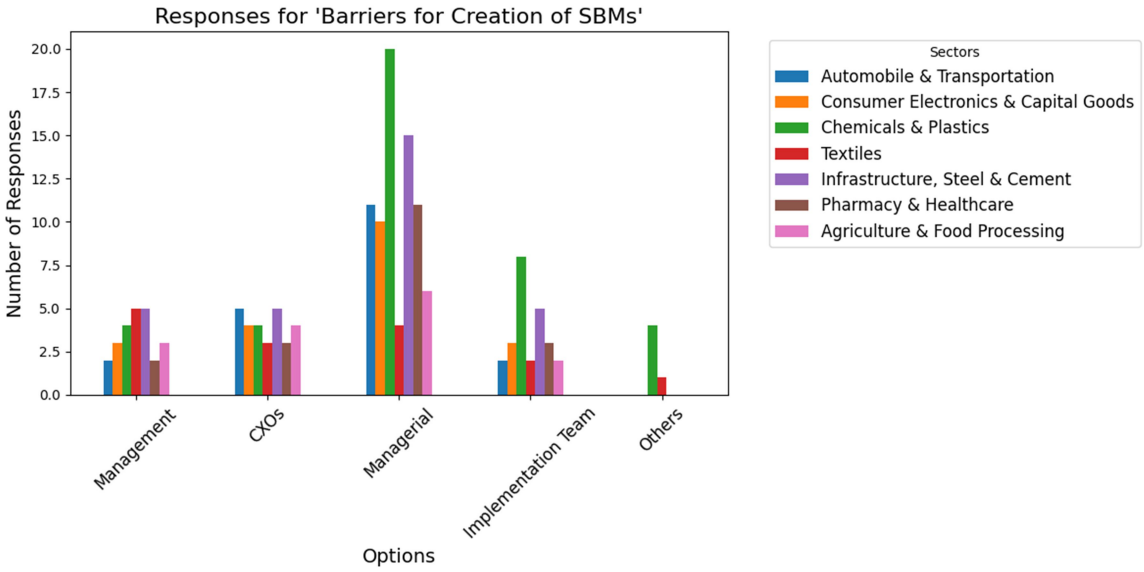


Figure 12 Barriers for Creation of SBMs

Observation:

"Management" received relatively low responses, with Infrastructure, Steel & Cement and Textiles (5 each) leading, followed by Chemicals & Plastics (4), while Automobile & Transportation and other sectors recorded minimal responses (2-3 each). "CXOs" showed moderate engagement, with Infrastructure, Steel & Cement and Automobile & Transportation (4 each) leading, while other sectors recorded 3-4 responses each. "Managerial" emerged as the most prominent category, with Chemicals & Plastics (20), Infrastructure, Steel & Cement (15), and Pharmacy & Healthcare (11) leading, while Automobile & Transportation (11) and Consumer Electronics & Capital Goods (10) also showed significant engagement. "Implementation Team" had lower responses, with Chemicals & Plastics (8), Infrastructure, Steel & Cement (5), and Pharmacy & Healthcare (3) leading, while Automobile & Transportation (2) and other sectors recorded minimal engagement. The "Others" category had negligible responses, with Textiles (1) being the only sector reporting, while all others recorded none or negligible responses.

Interpretation:

The Managerial category dominates as the most significant barrier to creating SBMs across all sectors, particularly in Chemicals & Plastics , Infrastructure, Steel & Cement , and Pharmacy & Healthcare . This indicates that managerial inefficiencies or resistance may be the primary bottleneck in transitioning to SBMs. The CXOs and Management categories highlight moderate challenges, especially in Infrastructure, Steel & Cement and Chemicals & Plastics. These indicate that leadership-level buy-in and strategic support could be improved. The Implementation Team category shows lower engagement, with Chemicals & Plastics leading. This suggests that the operational

execution of SBM initiatives is less of a barrier compared to managerial challenges. Minimal responses in the Others category imply that the challenges mostly align with the predefined categories, leaving little room for alternative or unique barriers.

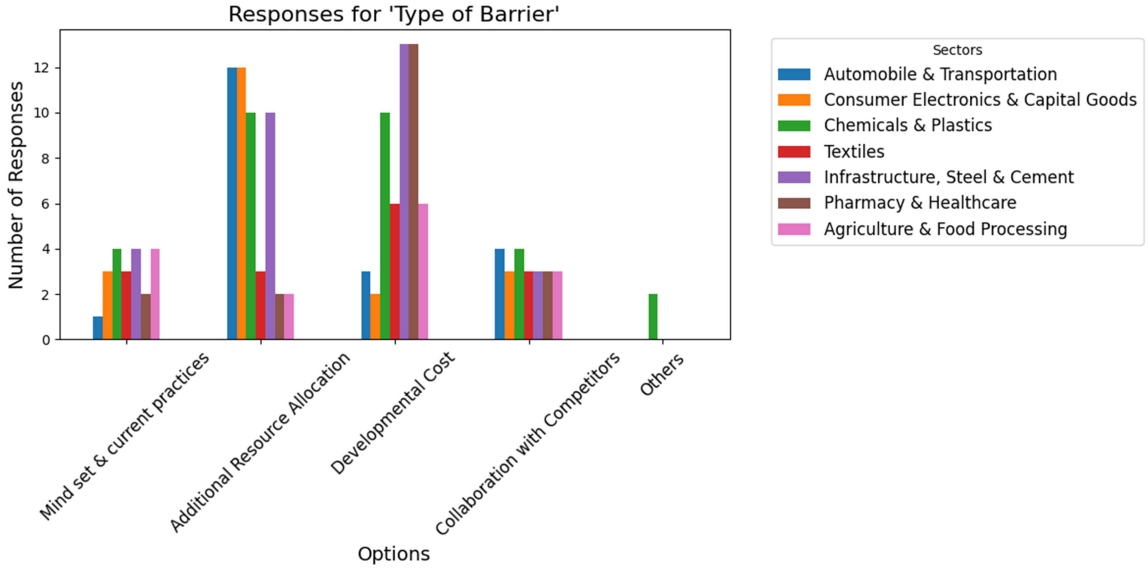


Figure 13 Type Of Barrier

"Mindset & Current Practices" received relatively low responses, with Chemicals & Plastics and Infrastructure, Steel & Cement (4 each) leading, while Pharmacy & Healthcare and Agriculture & Food Processing (2-3 each) showed minimal engagement. "Additional Resource Allocation" emerged as one of the most prominent categories, with Consumer Electronics & Capital Goods and Automobile & Transportation (12 each) leading, followed by Chemicals & Plastics (10) and Infrastructure, Steel & Cement (10), indicating significant resource demands. "Developmental Cost" was identified as the most dominant barrier, with Infrastructure, Steel & Cement (13), Chemicals & Plastics (10), and Pharmacy & Healthcare (13) leading, while other sectors also acknowledged cost as a major challenge. "Collaboration with Competitors" received relatively low responses, with Chemicals & Plastics (4), while other sectors recorded minimal

engagement (3 or fewer responses). The "Others" category had negligible responses, with Chemicals & Plastics (2) being the only sector reporting, while all others recorded none.

Interpretation:

Developmental Cost is the most significant barrier across sectors, particularly in Infrastructure, Steel & Cement and Pharmacy & Healthcare. This highlights the financial burden of transitioning to sustainable practices, which may deter widespread adoption. Additional Resource Allocation also stands out as a key barrier, especially in Infrastructure, Steel & Cement and Chemicals & Plastics. This indicates a lack of sufficient resources (e.g., funds, infrastructure, or manpower) required to implement sustainable models. Mindset & Current Practices, though less prominent, reflects the inertia or resistance to change, especially in sectors like Chemicals & Plastics and Infrastructure, Steel & Cement. Collaboration with Competitors is perceived as a minor barrier across sectors, with most responses below 3, indicating that competitive dynamics are not a primary concern for these industries in adopting sustainable practices. The Others category has negligible responses, suggesting that the primary barriers align well with the predefined categories.

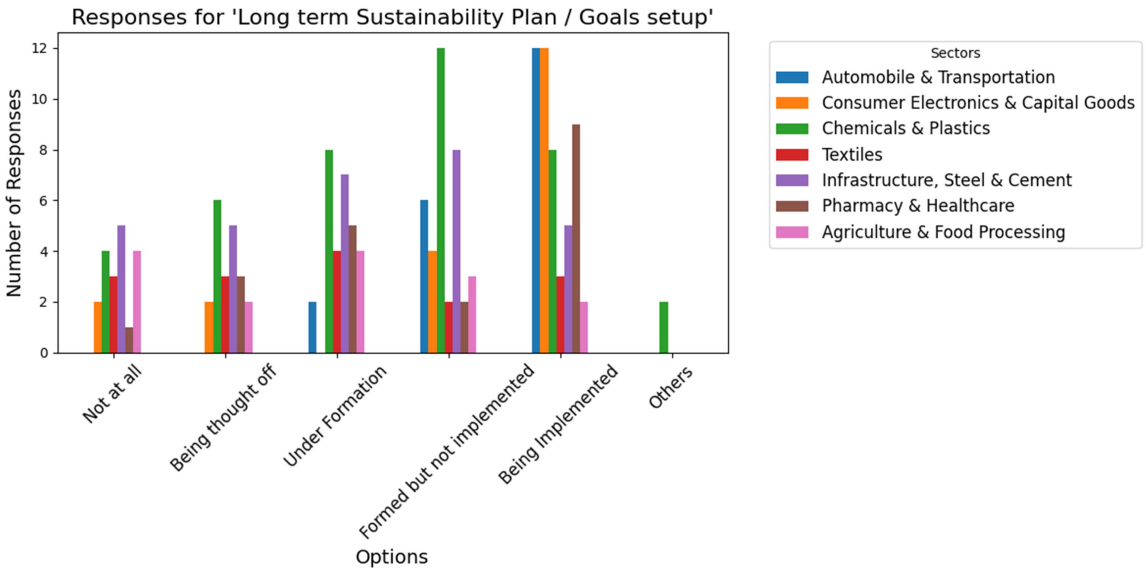


Figure 14 Long Term Plan/ Goals Setup

"Not at All" received minimal responses, with Infrastructure, Steel & Cement (5), Agriculture & Food Processing (4), and Chemicals & Plastics (4) leading, while other sectors recorded 3 or fewer responses. "Being Thought Off" showed moderate engagement, with Chemicals & Plastics (6) and Infrastructure, Steel & Cement (5) leading, while Pharmacy & Healthcare and Textiles (3-4 each) and Consumer Electronics & Capital Goods (2) showed lower involvement. "Under Formation" saw significant responses, led by Chemicals & Plastics (8), Infrastructure, Steel & Cement (7), and Pharmacy & Healthcare (5), while Textiles and Agriculture & Food Processing (4 each) also showed engagement. "Formed but Not Implemented" had high responses, with Chemicals & Plastics (12), Infrastructure, Steel & Cement (8), and Pharmacy & Healthcare (7) leading, while Consumer Electronics & Capital Goods recorded 3-4 responses. "Being Implemented" was the most dominant category, led by Consumer Electronics & Capital Goods (12), Chemicals & Plastics (8), and Automobile & Transportation (12), while Pharmacy & Healthcare (9) and Infrastructure, Steel & Cement (5) showed moderate involvement, and Textiles (5) recorded slightly lower

engagement. The "Others" category had negligible responses, with 1-2 responses across all sectors.

Interpretation:

The Being Implemented category dominates across most sectors, particularly in Consumer Electronics & Capital Goods and Chemicals & Plastics. This reflects a strong commitment by these sectors to actively pursue their long-term sustainability goals. The Formed but Not Implemented category highlights sectors like Chemicals & Plastics and Infrastructure, Steel & Cement where plans have been developed but are yet to be executed, indicating a need for better operationalization strategies. The Under Formation category, with high responses in Chemicals & Plastics and Infrastructure, Steel & Cement , suggests ongoing efforts to create structured sustainability plans in these industries. The Not at All and Being Thought Off categories indicate sectors like Chemicals & Plastics and Agriculture & Food Processing where sustainability planning is still in its nascent stages or absent. Minimal responses in the Others category suggest that most sectors align with the predefined options, leaving little room for unique or alternative scenarios.

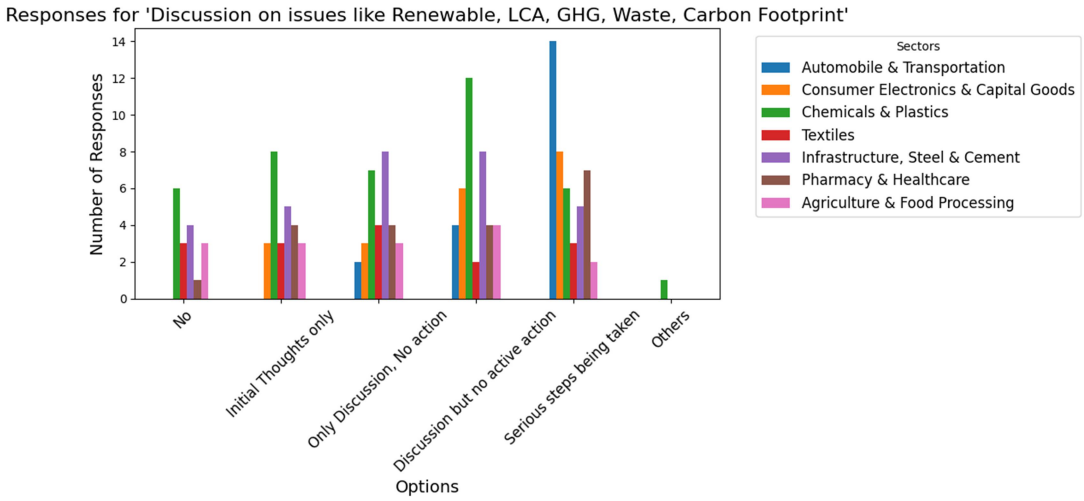


Figure 15 Discussion on issues like Renewable, LCA, GHG, Waste

"No" received minimal responses, with Chemicals & Plastics (6) and Textiles (3) leading, while Agriculture & Food Processing and Infrastructure, Steel & Cement (3-4 each) showed slight engagement, and other sectors recorded negligible responses. "Initial Thoughts Only" had moderate engagement, with Chemicals & Plastics (8) and Infrastructure, Steel & Cement (5) leading, while other sectors recorded 3-4 responses each. "Only Discussion, No Action" showed significant engagement, led by Infrastructure, Steel & Cement (8) and Chemicals & Plastics (7), while other sectors recorded 3-5 responses. "Discussion but No Active Action" had consistently high responses, with Chemicals & Plastics (12), Infrastructure, Steel & Cement (8), and Consumer Electronics & Capital Goods (6) leading, while Agriculture & Food Processing and Textiles (2-4 each) showed lower engagement. "Serious Steps Being Taken" was the most dominant category, with Automobile & Transportation (14), Consumer Electronics & Capital Goods (8), and Pharmacy & Healthcare (7) leading, while other sectors recorded 2-5 responses each. The "Others" category had negligible responses, with only Chemicals & Plastics (1), while all other sectors recorded none.

Interpretation:

The Serious Steps Being Taken category dominates across sectors, particularly in Automobile & Transportation , Chemicals & Plastics , and Pharmacy & Healthcare. This indicates that these sectors have moved beyond discussions and are actively addressing sustainability challenges. The Discussion but No Active Action category, with high responses in Infrastructure, Steel & Cement and Chemicals & Plastics, suggests a gap between awareness and implementation, highlighting the need for translating discussions into tangible actions. The Only Discussion, No Action category, with Infrastructure, Steel & Cement and Pharmacy & Healthcare leading, reflects sectors where awareness exists but actionable steps are still lacking. Minimal responses in the No category suggest that most sectors are engaged in discussions about sustainability issues, even if actions are limited. The Initial Thoughts Only category reflects early-stage engagement in sectors like Infrastructure, Steel & Cement and Pharmacy & Healthcare, indicating an opportunity for deeper exploration and planning.

4.7 Summary of Findings

The study provides a comprehensive analysis of the barriers, awareness levels, and strategic approaches influencing the adoption of Sustainable Business Models (SBMs) in key manufacturing sectors in India. Findings indicate that concept clarity and awareness levels vary across industries, with Consumer Electronics & Capital Goods and Chemicals & Plastics demonstrating slightly higher understanding. At the same time, Textiles and Pharmacy & Healthcare face minimal challenges in this area. Despite growing awareness, resource unavailability, financial constraints, and developmental costs are significant barriers to sustainability adoption, particularly in the Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare sectors.

Strategic readiness for sustainability implementation remains in the early stages, with many industries still in the "Initial Discussions" or "Design Stage" rather than full-scale execution. Automobile & Transportation, Consumer Electronics & Capital Goods, and Pharmacy & Healthcare are more engaged in adopting sustainable initiatives. However, operational execution remains limited, reflecting the need for more substantial management commitment and structured action plans. The managerial level exhibits the highest commitment, particularly in Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare, while CXOs and higher management show moderate involvement. However, implementation teams report lower engagement, indicating that sustainability efforts are yet to be fully integrated at the operational level.

Collaboration and competitive approaches also play a crucial role in shaping sustainability transitions. Many industries prefer a "Copy & Follow" approach, particularly in Consumer Electronics & Capital Goods and Automobile & Transportation, rather than pioneering sustainability strategies. Jealousy and competitive pressures are evident, especially in Infrastructure, Steel & Cement and Chemicals & Plastics, where industries hesitate to share best practices. Well-established collaborations remain limited, with Chemicals & Plastics and Infrastructure, Steel & Cement leading in cross-industry sustainability partnerships but showing low overall engagement in collaborative initiatives.

While awareness of SBMs is growing, practical implementation remains slow due to financial constraints, lack of collaboration, and management hesitancy. Developmental costs and resource allocation challenges are key roadblocks, requiring policy interventions, monetary incentives, and industry-wide collaborations to facilitate a smoother transition towards sustainable business models in Indian manufacturing. These findings provide data-driven insights that can support business leaders, policymakers, and

sustainability professionals in developing strategic reforms and industry-wide solutions for SBM adoption.

4.8 Conclusion

The study highlights the current state, challenges, and strategic pathways for transitioning to Sustainable Business Models (SBMs) in key manufacturing sectors in India. While awareness of sustainability practices is increasing, implementation remains slow and fragmented due to financial constraints, resource unavailability, lack of collaboration, and management hesitancy. Findings suggest that while some sectors, such as Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare, are taking proactive steps, others, like Textiles and Agriculture & Food Processing, still lag in structured sustainability initiatives. The dominance of developmental costs as a barrier across industries highlights the need for financial support, investment incentives, and policy-driven interventions to accelerate sustainability transitions.

Moreover, collaborative efforts among industries remain low, with most companies preferring a competitive or cautious approach rather than openly engaging in knowledge-sharing initiatives. While managerial commitment to sustainability is evident, implementation teams still exhibit lower engagement, reflecting the gap between strategic planning and operational execution. The study underscores the importance of more substantial management commitment, stakeholder collaboration, and sector-specific policy interventions to drive effective sustainability adoption.

To overcome these barriers, businesses must focus on strategic investments in R&D, resource optimization, and cross-sector collaboration. At the same time, governments and policymakers should introduce financial incentives and regulatory frameworks to encourage faster and more effective adoption of SBMs. The study

provides valuable insights for industry leaders, sustainability professionals, and policymakers, serving as a foundation for future research and practical strategies to foster a greener, more sustainable industrial landscape in India.

CHAPTER V:

DISCUSSION

5.1 Discussion of Identifying Key Barriers to SBM Adoption

The transition toward Sustainable Business Models (SBMs) in Indian manufacturing remains challenging due to multiple structural, financial, technological, and organizational barriers. While awareness of sustainability is increasing, the implementation of SBMs varies across industries, with certain sectors such as Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare facing more significant obstacles compared to Textiles and Agriculture & Food Processing. The study findings highlight that these barriers are not uniform and are shaped by sector-specific dependencies on resources, regulations, and market dynamics.

Among the most critical barriers is the unavailability of sustainable resources, which poses a significant challenge for industries dependent on raw materials and energy-intensive production. The Chemicals & Plastics (20 responses), Infrastructure, Steel & Cement (12), and Pharmacy & Healthcare (15) sectors reported the highest concerns regarding resource constraints, indicating difficulties in accessing alternative, eco-friendly raw materials and energy-efficient technologies. In addition to resource availability, financial constraints and high developmental costs emerged as dominant barriers, with Infrastructure, Steel & Cement (13), Chemicals & Plastics (10), and Pharmacy & Healthcare (13) sectors expressing concerns about the high initial costs of sustainability transitions. Unlike multinational corporations in developed economies, many Indian firms lack access to green financing mechanisms such as sustainability-linked loans, tax credits, and investment incentives, limiting their ability to fund sustainability initiatives.

Conceptual clarity regarding SBMs also remains a challenge, as certain industries struggle to integrate sustainability into their business operations effectively. The study finds that Consumer Electronics & Capital Goods (5) and Chemicals & Plastics (6) reported concerns about the lack of clear guidelines and frameworks for SBM adoption. Additionally, long-term impact understanding varies, with Infrastructure, Steel & Cement (8) and Chemicals & Plastics (6) demonstrating moderate awareness, while Textiles and Agriculture & Food Processing (2 each) lag behind. This gap in understanding prevents industries from recognizing the long-term cost efficiencies, investor confidence, and brand reputation benefits associated with sustainable transitions. The absence of standardized industry-wide sustainability guidelines and fragmented regulatory enforcement further hinders widespread SBM implementation.

Another major challenge is organizational resistance to change, particularly at the managerial level. The study reveals that Chemicals & Plastics (20), Infrastructure, Steel & Cement (15), and Pharmacy & Healthcare (11) report the highest reluctance from middle and senior management in adopting sustainability-driven changes. Companies fear operational disruptions, high upfront investments, and uncertain returns on sustainability measures, which contribute to a culture of hesitation rather than proactive transformation. Moreover, the lack of direct incentives and regulatory enforcement further discourages firms from prioritizing SBM integration. Many businesses still view sustainability as a compliance obligation rather than a strategic business opportunity, limiting the extent to which SBM principles are embedded in corporate decision-making.

Collaboration and knowledge-sharing among competitors also remain significant roadblocks to SBM adoption. The study finds that many firms hesitate to engage in collaborative sustainability efforts, with "No discussion with competitors" being a common response in Chemicals & Plastics (12) and Pharmacy & Healthcare (10). Unlike

global best practices where industries share sustainability research, invest in joint circular economy initiatives, and co-develop green infrastructure, Indian firms tend to operate independently, limiting the potential for large-scale transformation. Competitive secrecy and a lack of industry-wide sustainability coalitions further exacerbate this issue, preventing companies from leveraging collective resources and knowledge.

These findings suggest that overcoming SBM adoption barriers requires multi-dimensional interventions, including financial support, policy incentives, industry-wide training, and leadership-driven cultural shifts. Expanding low-interest green financing schemes, offering tax benefits for sustainability investments, and enforcing stricter environmental regulations could help reduce financial constraints. Additionally, developing sector-specific sustainability roadmaps with clear implementation guidelines would improve conceptual clarity and strategic planning. Encouraging management advocacy for sustainability, integrating sustainability goals into executive performance evaluations, and fostering internal sustainability champions within organizations would further help in overcoming resistance to change.

To facilitate industry-wide collaboration, policymakers should introduce public-private sustainability initiatives, cross-industry knowledge-sharing platforms, and sustainability innovation hubs. These efforts would help companies break competitive silos and encourage a more unified approach to SBM adoption. Strengthening collaborations between research institutions, businesses, and government agencies could also accelerate innovation in sustainable manufacturing, ensuring that firms have access to both technical expertise and financial resources to support their sustainability transitions.

The findings indicate that while awareness of SBMs is growing, practical implementation is hampered by financial limitations, resource shortages, and resistance to

change at the managerial level. The lack of cross-industry collaboration and weak regulatory enforcement further slow down SBM adoption. Addressing these challenges requires a collective effort from policymakers, business leaders, and sustainability professionals to ensure that sustainability transitions become a strategic necessity rather than an optional initiative.

5.2 Discussion of Assessing Awareness and Preparedness for Sustainability

Assessing awareness and preparedness for sustainability in Indian manufacturing reveals significant variations across industries, with some sectors demonstrating strong engagement while others remain at nascent stages. The findings indicate that Chemicals & Plastics, Automobile & Transportation, and Pharmacy & Healthcare exhibit higher levels of awareness, whereas Infrastructure, Steel & Cement, Textiles, and Agriculture & Food Processing lag behind in understanding and implementing sustainability principles. This disparity underscores the uneven progress in transitioning toward Sustainable Business Models (SBMs), driven by differences in regulatory pressure, industry-specific challenges, and market demands.

The study findings show that complete unawareness ("Not at All") is rare, suggesting that sustainability concepts are no longer foreign to Indian manufacturers. However, Infrastructure, Steel & Cement (4 responses) had the highest unawareness levels, indicating that despite its significant environmental footprint, the sector still faces gaps in recognizing the urgency of sustainable transformation. At the same time, early-stage awareness ("Nascent") is moderate, particularly in Infrastructure, Steel & Cement (8) and Chemicals & Plastics (4), reflecting that while sustainability is acknowledged, it is yet to become a core strategic focus in these industries. This stage signifies a growing but incomplete understanding of circular economy principles and environmental

responsibility, often limited to policy compliance rather than proactive sustainability integration.

A more encouraging trend is the dominance of mid-level awareness across multiple sectors, with Chemicals & Plastics (12) and Infrastructure, Steel & Cement (12) reporting strong engagement, suggesting that sustainability is increasingly being discussed within corporate strategies. However, while textile (7) and Agriculture & Food Processing (5) sectors show moderate progress, their lower engagement levels indicate that these industries may require greater exposure to sustainability frameworks, structured training, and policy-driven incentives to accelerate their adoption of sustainable practices. The highest awareness levels ("Well Aware") were recorded in Chemicals & Plastics (20), Automobile & Transportation (13), and Pharmacy & Healthcare (12), reflecting greater preparedness for implementing sustainability-driven changes, possibly due to global market expectations, regulatory compliance, and stakeholder demand for ESG commitments.

Despite this overall awareness growth, the transition from awareness to preparedness remains uneven across sectors. The study reveals that while awareness is increasing, sustainability adoption remains limited to discussion and planning stages rather than full-scale execution. This trend is visible in the Design Stage category, which dominates across sectors, with Chemicals & Plastics (25), Infrastructure, Steel & Cement (15), and Automobile & Transportation (14) leading. While this indicates a positive direction, it also suggests that many businesses are still in the early stages of sustainability transformation, focusing on product design rather than operational implementation. Similarly, "Development & Trials" responses were moderate, with Chemicals & Plastics (10) and Pharmacy & Healthcare (8) leading, suggesting that only a few sectors are actively moving toward testing and refining sustainability solutions.

Management perspectives on sustainability also play a crucial role in determining the preparedness of different industries. The study findings reveal that "An Action Plan Is Demanded" received the highest responses, particularly in Chemicals & Plastics (18) and Infrastructure, Steel & Cement (12). This indicates that while sustainability is recognized as a strategic priority, organizations still require clear execution plans, resource allocation, and leadership direction to move forward. The "Understand Its Importance" category shows notable engagement, particularly in Pharmacy & Healthcare and Infrastructure, Steel & Cement, suggesting that management recognizes sustainability as valuable but is yet to translate this understanding into action-oriented initiatives. The "Go Ahead Given for Trials" category had moderate responses, particularly in Chemicals & Plastics (10) and Pharmacy & Healthcare (9), signifying that these sectors are actively testing sustainable product designs but have yet to reach full implementation.

The level of interest in sustainability innovation further reinforces this observation. While most industries acknowledge sustainability's importance, implementation remains a challenge. The "All Well but Implementation Hurdles" category received the highest responses, particularly in Automobile & Transportation (15) and Infrastructure, Steel & Cement, reflecting operational barriers, financial constraints, and limited regulatory incentives as key obstacles to effective sustainability adoption. Meanwhile, "Encouraged / Rewarded / Promoted" received strong engagement, especially in Infrastructure, Steel & Cement and Chemicals & Plastics, suggesting that these sectors are beginning to incentivize and promote sustainability efforts within their organizations. However, the "Interested but No Initiatives" category, with moderate responses in Chemicals & Plastics and Pharmacy & Healthcare, highlights sectors where awareness exists but actionable steps are lacking, often due to unclear sustainability policies or resistance to change.

The findings also highlight a gap between industry awareness and collaborative sustainability efforts, particularly in senior management thought processes. The "Yes, Well Initiated" category dominates in Chemicals & Plastics (15), Automobile & Transportation (15), and Consumer Electronics & Capital Goods (12), suggesting that sustainability discussions are actively taking place at the executive level. However, the "Aware but Not Initiated" category remains significant, particularly in Chemicals & Plastics and Pharmacy & Healthcare, showing that while sustainability is recognized, structured actions have yet to be implemented across the organization.

A critical limitation to sustainability preparedness is the allocation of resources for R&D. The study reveals that while certain industries, such as Chemicals & Plastics (26) and Infrastructure, Steel & Cement (15), reported having "Sufficient Budget for R&D," other sectors struggle with financial constraints. Pharmacy & Healthcare (6) and Infrastructure, Steel & Cement (5) reported "Insufficient Budget for R&D," indicating that financial limitations remain a key hurdle for transitioning from sustainability discussions to real-world applications. Similarly, while "Exploring Collaborations Openly" and "Initiated R&D and Collaboration Both" categories indicate growing interest, engagement remains relatively low, especially in sectors such as Consumer Electronics & Capital Goods and Agriculture & Food Processing.

These findings suggest that awareness of sustainability is growing, but preparedness for implementation remains fragmented. Sectors with higher awareness levels, such as Chemicals & Plastics and Automobile & Transportation, are making strides toward sustainability but still require structured action plans and financial support. On the other hand, sectors such as Textiles and Agriculture & Food Processing require targeted interventions, including regulatory incentives, financial grants, and industry-wide collaboration, to accelerate their sustainability transitions.

To bridge this gap between awareness and preparedness, Indian manufacturers must adopt a multi-pronged approach that includes sector-specific training programs, policy-driven financial incentives, and stronger collaboration among industries. Businesses should also integrate clear sustainability roadmaps within their corporate strategies, linking sustainability goals to executive performance indicators to ensure greater accountability. Furthermore, government-led sustainability initiatives, industry workshops, and knowledge-sharing platforms could help lagging sectors such as Infrastructure, Steel & Cement and Agriculture & Food Processing move beyond basic awareness toward active implementation.

5.3 Discussion of Exploring Strategies and Innovations for SBM Transition

The exploration of strategies and innovations for transitioning to Sustainable Business Models (SBMs) in Indian manufacturing highlights a diverse landscape where some industries are actively pursuing sustainability initiatives while others remain in the early planning stages. The findings indicate that sectors like Chemicals & Plastics, Infrastructure, Steel & Cement, and Automobile & Transportation are leading in sustainable product design and development, whereas Textiles and Agriculture & Food Processing show lower levels of engagement. While many organizations acknowledge the need for sustainability-driven innovations, practical implementation remains hindered by financial, managerial, and operational challenges.

The analysis of sustainable product design and development stages suggests that most industries have moved beyond the ideation phase and are focusing on structured development processes. The "Design Stage" dominates across all sectors, with Chemicals & Plastics (25), Infrastructure, Steel & Cement (15), and Automobile & Transportation (14) leading. This indicates that these industries have recognized the importance of

incorporating sustainability principles into product design and are actively working towards integrating eco-friendly materials, energy-efficient production techniques, and circular economy principles. However, despite progress in design, the "Development & Trials" stage has lower engagement levels, with Chemicals & Plastics (10) and Pharmacy & Healthcare (8) leading, while Automobile & Transportation and Consumer Electronics & Capital Goods show relatively lower participation. This suggests that while sustainability-driven product concepts exist, the transition to large-scale production is still in progress and faces multiple operational and financial constraints.

The role of management perspectives in driving sustainable innovation is critical, as evidenced by the strong response in the "An Action Plan Is Demanded" category, particularly in Chemicals & Plastics (18) and Infrastructure, Steel & Cement (12). These findings indicate that while organizations recognize sustainability's significance, they still require clear execution plans and strategic frameworks to transition from conceptualization to implementation. Similarly, the "Understand Its Importance" category, which saw significant responses in Pharmacy & Healthcare and Infrastructure, Steel & Cement, suggests that industries are aware of sustainability's long-term benefits but may still be lacking the necessary expertise, regulatory clarity, or financial backing to fully implement sustainable strategies. The "Go Ahead Given for Trials" category, with moderate responses in Chemicals & Plastics (10) and Pharmacy & Healthcare (9), highlights sectors that are actively testing sustainable solutions, though challenges in scaling these initiatives persist.

The study also examined organizational interest in sustainability innovations, revealing that while enthusiasm for innovation is present, implementation hurdles remain a major challenge. The "All Well but Implementation Hurdles" category received the highest responses, particularly in Automobile & Transportation (15) and Infrastructure,

Steel & Cement, indicating that many businesses face barriers such as high initial investment costs, supply chain limitations, and technological constraints. The "Encouraged / Rewarded / Promoted" category, with strong engagement in Infrastructure, Steel & Cement and Chemicals & Plastics, reflects efforts to incentivize sustainability-focused innovation, suggesting that industries recognize the need to encourage sustainable initiatives within their workforce. However, the "Interested but No Initiatives" category, with moderate responses in Chemicals & Plastics and Pharmacy & Healthcare, highlights sectors where interest exists but has not yet translated into concrete sustainability projects, often due to unclear policy incentives or lack of leadership buy-in.

The findings further emphasize that while many companies have ideas for sustainability transitions, they require external support to turn them into actionable projects. The "Already Have Ideas but Need Encouragement & Support" category dominates across all sectors, particularly in Chemicals & Plastics (14), Infrastructure, Steel & Cement (12), and Pharmacy & Healthcare (12). This suggests that businesses are actively exploring sustainable innovations but need financial incentives, technical expertise, and strategic guidance to advance their initiatives. Similarly, the "Proposed to Initiate Like…" category, with strong responses in Chemicals & Plastics (10) and Infrastructure, Steel & Cement (7), reflects an increasing willingness to transition from conceptual planning to execution. However, the "Already Initiated Like…" category, with lower responses across all industries, suggests that very few companies have successfully implemented sustainability-driven innovations at scale.

One of the major barriers to sustainability innovation is the lack of structured policies to encourage and scale sustainable ideas. The study found that a significant number of respondents (10 from Chemicals & Plastics and 4 from Agriculture & Food Processing) reported the absence of formal policies supporting sustainability innovations.

The "Being Thought Of" category received moderate engagement, particularly in Infrastructure, Steel & Cement (6), suggesting that while some industries are considering policy frameworks, they have yet to implement structured sustainability governance models. Furthermore, the "Available but Not Effective/Attractive" and "Attractive but Not Implemented" categories highlight that even in industries where policies exist, they are often ineffective or lack proper enforcement.

The level of collaboration and knowledge-sharing among competitors also impacts sustainability-driven innovation. The study found that "No Discussion with Competitors" was a dominant response, particularly in Chemicals & Plastics (12) and Pharmacy & Healthcare (10), indicating that industries often view sustainability as a competitive advantage rather than a collective responsibility. While some sectors reported casual discussions and transactional business relationships with competitors, few have established formal collaboration mechanisms for sustainability-focused R&D and innovation sharing. This reluctance to collaborate could slow down industry-wide sustainability transitions, as businesses may struggle to implement sustainable solutions in isolation without cross-industry knowledge exchange.

Furthermore, industry attitudes towards trade competition in sustainability adoption highlight that while some sectors are willing to encourage and appreciate sustainability innovations (Chemicals & Plastics - 12, Pharmacy & Healthcare - 10), others remain hesitant or prefer a "copy & follow" approach rather than pioneering sustainability-driven transformations. This suggests that many companies are waiting for competitors to take the lead in sustainability innovations before committing significant resources themselves.

Financial constraints continue to be a major limiting factor in transitioning to sustainable business models. The study reveals that "Developmental Cost" emerged as

the most significant barrier to SBM adoption, with Infrastructure, Steel & Cement (13) and Chemicals & Plastics (10) leading the responses. Additionally, "Additional Resource Allocation" was another key concern, particularly in Consumer Electronics & Capital Goods (12) and Automobile & Transportation (12), highlighting the high costs associated with acquiring sustainable technologies, retraining workforces, and restructuring supply chains. These financial limitations restrict businesses from making long-term sustainability investments, even when they recognize the potential benefits.

Despite these challenges, many industries are making gradual progress toward setting long-term sustainability goals. The "Being Implemented" category received the highest responses across multiple industries, particularly in Consumer Electronics & Capital Goods (12) and Chemicals & Plastics (8), suggesting that certain sectors have already integrated sustainability-focused strategies into their long-term business models. However, the "Formed but Not Implemented" category (12 responses from Chemicals & Plastics and 8 from Infrastructure, Steel & Cement) indicates that while sustainability plans exist, execution remains a challenge due to financial or operational barriers.

5.4 Discussion of Analyzing Collaboration and Stakeholder Engagement

The role of collaboration and stakeholder engagement in driving Sustainable Business Model (SBM) adoption is critical, yet findings from this study reveal inconsistent levels of cooperation across industries. While certain sectors, such as Infrastructure, Steel & Cement, and Chemicals & Plastics, have initiated partnerships and sustainability-driven collaborations, many industries continue to operate in silos, limiting knowledge exchange and coordinated action. The lack of cross-sectoral collaboration, industry-government engagement, and inter-organizational partnerships hinders the

scalability of sustainability initiatives and slows down the transition toward SBMs in Indian manufacturing.

The study found that senior management in many sectors has begun engaging in sustainability discussions, but the extent of initiative implementation varies significantly. The "Yes, Well Initiated" category received the highest responses, particularly in Chemicals & Plastics (15) and Automobile & Transportation (15), followed by Consumer Electronics & Capital Goods (12) and Pharmacy & Healthcare (10). This suggests that certain industries recognize sustainability as a strategic priority and have incorporated it into leadership-level discussions and business planning. However, the "Aware but Not Initiated" category, with moderate responses in Chemicals & Plastics (6) and Infrastructure, Steel & Cement (4), indicates that awareness alone has not necessarily translated into tangible actions. Additionally, the "Management Not Aware" category received minimal responses, implying that sustainability awareness is present at the leadership level, but implementation remains a challenge.

Financial constraints also play a crucial role in collaboration-related challenges, particularly in sustainability research and development (R&D). The "Sufficient Budget for R&D" category was the most dominant, with Chemicals & Plastics (26), Infrastructure, Steel & Cement (15), and Automobile & Transportation (12) leading the responses. These findings suggest that some industries have allocated financial resources toward sustainability research, enabling them to invest in cleaner technologies, efficient supply chains, and circular economy initiatives. However, the "Insufficient Budget for R&D" category received notable responses, particularly in Pharmacy & Healthcare (6) and Infrastructure, Steel & Cement (5), indicating that certain sectors struggle to allocate adequate financial resources for sustainability-driven innovations. Additionally, the "Exploring Collaborations Openly" and "Initiated R&D and Collaboration Both"

categories highlight a growing interest in cross-industry partnerships, particularly in Pharmacy & Healthcare and Infrastructure, Steel & Cement, yet overall engagement remains moderate.

One of the biggest barriers to effective stakeholder engagement is the absence of well-defined policies for supporting innovative sustainability ideas. The study found that a significant number of sectors lack formal mechanisms to appreciate and escalate sustainability-driven innovations. The "No" category had strong responses, with Chemicals & Plastics (10) and Agriculture & Food Processing (4) leading, indicating that businesses in these industries lack structured policies to encourage sustainability innovations. The "Being Thought Off" category, with responses from Infrastructure, Steel & Cement (6), suggests that while policy development is being considered in some sectors, its execution remains unclear. Additionally, the "Available but Not Effective/Attractive" and "Attractive but Not Implemented" categories highlight that even in industries where policies exist, they either lack proper enforcement or fail to provide sufficient motivation for widespread adoption.

Inter-industry collaboration and competitive dynamics further influence the adoption of SBMs. The "No Discussion with Competitors" category received high responses, particularly in Chemicals & Plastics (12), Pharmacy & Healthcare (10), and Infrastructure, Steel & Cement (6). This indicates that many industries still perceive sustainability as a competitive differentiator rather than a collective responsibility. The lack of knowledge-sharing mechanisms among competitors restricts the development of industry-wide sustainability benchmarks and slows the diffusion of sustainable innovations. However, some industries, particularly those in Infrastructure, Steel & Cement and Textiles, reported moderate engagement in "Technical Knowledge Sharing & Collaboration Initiatives", suggesting that a few sectors recognize the value of

collaboration in driving industry-wide sustainability transformation. Nonetheless, formalized industry partnerships remain limited, with "Well Established Collaborations" receiving lower responses across all industries.

The study also explored how companies approach trade competition in sustainability adoption. The "Encourage & Appreciate" category was most prominent in Chemicals & Plastics (12) and Pharmacy & Healthcare (10), indicating that certain industries view sustainability initiatives from competitors positively and seek to learn from best practices. However, the "Copy & Follow" approach, which had high responses in Consumer Electronics & Capital Goods (9) and Automobile & Transportation (8), suggests that many industries prefer to adopt sustainability strategies only after observing their effectiveness elsewhere rather than proactively leading the transition. Moreover, competitive tensions were evident, with the "Jealousy" category receiving notable responses from Infrastructure, Steel & Cement (10) and Chemicals & Plastics (6), reflecting a reluctance among businesses to collaborate openly due to fear of losing market advantage.

Beyond inter-industry engagement, collaboration between businesses and external stakeholders such as regulatory bodies, policymakers, and suppliers remains inconsistent. The "Cooperation & Collaboration with Trade Competitors" category showed limited engagement across industries, with "No Discussion with Competitors" dominating. This suggests that many companies still lack structured platforms for sustainability-focused discussions with industry peers, policymakers, and regulatory authorities. While some businesses engage in casual discussions or transactional business relationships, few have established formal partnerships to co-develop sustainability solutions.

Despite these barriers, some industries have made notable progress in setting long-term sustainability goals and fostering external collaborations. The "Being

Implemented" category received strong responses across multiple industries, particularly in Consumer Electronics & Capital Goods (12) and Chemicals & Plastics (8), indicating that some companies have actively integrated sustainability goals into their long-term business models. However, the "Formed but Not Implemented" category (12 responses from Chemicals & Plastics and 8 from Infrastructure, Steel & Cement) reveals that while sustainability strategies exist, practical execution remains a challenge due to financial or operational constraints.

The discussion on sustainability issues such as Renewable Energy, Life Cycle Assessment (LCA), Greenhouse Gas (GHG) Emissions, and Waste Management further highlights the gap between discussions and real action. While the "Serious Steps Being Taken" category dominated across industries, particularly in Automobile & Transportation (14), Consumer Electronics & Capital Goods (8), and Pharmacy & Healthcare (7), indicating active engagement in sustainability measures, the "Only Discussion, No Action" and "Discussion but No Active Action" categories show that many industries are still in the planning phase rather than executing sustainability initiatives effectively.

5.5 Discussion of Examining Drivers and Barriers to Sustainability Innovations

Sustainability innovations are essential for transitioning to Sustainable Business Models (SBMs) in Indian manufacturing, but their adoption is hindered by multiple drivers and barriers. This study examined organizational, financial, and competitive factors influencing sustainability-driven innovations across key manufacturing sectors. Findings indicate that while awareness of sustainability innovations is increasing, industries continue to face operational, financial, and strategic obstacles that slow down the transition from awareness to execution.

One of the most significant barriers identified is managerial inefficiency and resistance to change, which emerged as a dominant challenge across industries. The "Managerial" category received the highest responses, particularly in Chemicals & Plastics (20), Infrastructure, Steel & Cement (15), and Pharmacy & Healthcare (11). This suggests that mid-level management plays a crucial role in either enabling or blocking sustainability transitions. Resistance to new business models, a lack of clarity in sustainability strategies, and the tendency to prioritize short-term financial gains over long-term environmental benefits contribute to slow adoption. The "CXOs" and "Management" categories also showed moderate responses, especially in Infrastructure, Steel & Cement and Chemicals & Plastics, indicating that top leadership buy-in is essential for driving sustainability innovations, but execution bottlenecks persist at the managerial level.

Financial constraints emerged as another major barrier to sustainability innovation. The "Developmental Cost" category dominated across sectors, particularly in Infrastructure, Steel & Cement (13), Chemicals & Plastics (10), and Pharmacy & Healthcare (13), highlighting that high initial investment requirements hinder many industries from adopting sustainable technologies. The "Additional Resource Allocation" category also had significant responses, with Consumer Electronics & Capital Goods and Automobile & Transportation (12 each) reporting the highest concerns, further emphasizing that businesses struggle to allocate the necessary funds, infrastructure, and skilled workforce for sustainability-driven initiatives. Despite an increasing interest in sustainability, many companies remain hesitant due to uncertainty over return on investment (ROI) and the high cost of transitioning to eco-friendly production models.

Mindset and cultural resistance also limit the adoption of sustainability innovations. The "Mindset & Current Practices" category, while receiving fewer

responses compared to financial barriers, was still noted as a key challenge, particularly in Chemicals & Plastics and Infrastructure, Steel & Cement (4 each). This suggests that deeply ingrained traditional business models and operational habits act as barriers to sustainability transitions. While financial incentives and regulatory pressures can push industries toward sustainable business models, changing organizational culture requires long-term commitment, leadership advocacy, and capacity-building programs.

Collaboration challenges further impact sustainability-driven innovations. The "Collaboration with Competitors" category had relatively low responses (mostly under 3 across all sectors), indicating that competitive dynamics do not play a primary role in inhibiting sustainability transitions. However, reluctance to engage in cross-industry partnerships means that businesses often struggle to share best practices and leverage collective resources for sustainability innovation. Industries that are willing to engage in joint R&D initiatives, co-develop green technologies, or participate in circular economy partnerships stand a better chance of overcoming financial and operational challenges associated with sustainability transitions.

Despite these barriers, some industries have started setting long-term sustainability goals, which could act as a key driver for innovation. The "Being Implemented" category dominated across multiple sectors, particularly in Consumer Electronics & Capital Goods (12) and Chemicals & Plastics (8), indicating that these industries are taking active steps to integrate sustainability into their long-term strategies. However, the "Formed but Not Implemented" category, with high responses in Chemicals & Plastics (12) and Infrastructure, Steel & Cement (8), shows that many industries have developed sustainability plans but struggle with execution due to financial and operational challenges.

Discussions on sustainability-related issues, such as Renewable Energy, Life Cycle Assessment (LCA), Greenhouse Gas (GHG) Emissions, and Waste Management, indicate that many industries are actively engaged in sustainability dialogues but are slow to implement concrete actions. The "Serious Steps Being Taken" category received the highest responses in Automobile & Transportation (14), Consumer Electronics & Capital Goods (8), and Pharmacy & Healthcare (7), showing that some industries are progressing toward tangible sustainability initiatives. However, the "Only Discussion, No Action" and "Discussion but No Active Action" categories had notable responses, particularly in Infrastructure, Steel & Cement and Chemicals & Plastics, reflecting that while sustainability conversations are taking place, the gap between planning and execution remains significant.

5.6 Response to Research Questions

1. What are the major challenges in creating sustainable business models (SBMs) across key manufacturing sectors in India?

The transition to sustainable business models (SBMs) in Indian manufacturing faces several persistent challenges, particularly concerning resource constraints, financial limitations, and resistance to change. The unavailability of sustainable raw materials remains a significant hurdle, especially in resource-intensive industries such as Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare. These sectors struggle to access alternative, eco-friendly resources, making sustainability transitions difficult and costly. High developmental costs further exacerbate the problem, preventing businesses from investing in greener production processes. Unlike multinational corporations in developed economies, many Indian firms lack access to

green financing mechanisms such as sustainability-linked loans, tax incentives, and investment grants, limiting their ability to fund sustainability initiatives.

Beyond financial constraints, a significant challenge in SBM adoption is the managerial reluctance to integrate sustainability into core business strategies. Many organizations view sustainability as a regulatory burden rather than a strategic opportunity, leading to hesitation in investing in long-term sustainable transformations. This resistance is especially prevalent in middle and senior management levels, where concerns about operational disruptions and uncertain financial returns discourage firms from prioritizing sustainability initiatives. The lack of regulatory clarity further complicates the process, as inconsistencies in environmental policies create uncertainty about compliance and industry-wide sustainability benchmarks.

Another critical challenge is the limited collaboration among industry stakeholders. While sustainability in global markets often involves joint initiatives between competitors, research institutions, and regulatory bodies, Indian manufacturers remain hesitant to engage in collective sustainability efforts. Many firms fear sharing knowledge with competitors, preventing the development of industry-wide sustainability frameworks. The lack of structured collaboration platforms means that individual businesses must navigate sustainability transitions in isolation, increasing costs and slowing progress.

2. How do the stages of awareness and readiness for circular economy and sustainable practices vary across sectors?

The level of awareness and readiness for circular economy adoption and sustainable practices varies significantly across different manufacturing sectors in India. While most sectors acknowledge the importance of sustainability, their preparedness for

implementation remains uneven. Certain industries, such as Chemicals & Plastics, Automobile & Transportation, and Pharmacy & Healthcare, demonstrate high levels of awareness and engagement, driven by increasing regulatory requirements and stakeholder expectations. These sectors have actively integrated sustainability discussions into their strategic planning and have begun taking steps toward developing circular economy-based initiatives.

Infrastructure, Steel & Cement, and Consumer Electronics & Capital Goods sectors, while moderately aware of sustainability concepts, remain largely in the planning stages rather than full-scale execution. Their readiness is hindered by high operational costs and supply chain inefficiencies, making sustainable transitions more complex. On the other hand, sectors like Textiles and Agriculture & Food Processing exhibit lower levels of awareness and engagement, with sustainability practices still at a nascent stage. These industries often lack structured sustainability programs, with minimal focus on circular economy integration and environmental responsibility.

Most industries have moved beyond basic awareness but remain in the early stages of implementation, focusing primarily on sustainable product design and planning. While many firms have conceptualized sustainability-driven business models, few have advanced to full-scale execution due to financial constraints and operational challenges. The gap between awareness and action highlights the need for sector-specific training programs, regulatory incentives, and financial support mechanisms to accelerate sustainability transitions in Indian manufacturing.

3. What strategies and innovations are being planned or implemented by Indian manufacturing sectors to transition to sustainable business models?

The strategies and innovations being implemented for the transition to sustainable business models in Indian manufacturing are diverse, reflecting the varying levels of sectoral preparedness. Many industries are focusing on incorporating circular economy principles into their operations by shifting from linear "take-make-dispose" models to more sustainable production and consumption cycles. Chemicals & Plastics, Infrastructure, Steel & Cement, and Automobile & Transportation sectors have been particularly proactive in integrating sustainable product design and development into their business strategies.

Sustainability-focused digital transformation is another area gaining traction, with industries exploring the use of IoT, AI, and blockchain technologies to optimize resource efficiency and reduce environmental impact. These technologies are being leveraged to improve predictive maintenance, reduce waste, and enhance the sustainability of supply chains. However, the adoption of Industry 4.0 technologies remains limited due to high costs and a lack of technical expertise, preventing widespread digital integration across sectors.

Financial sustainability strategies are also being explored, with companies looking into green bonds, ESG-linked financing, and sustainability-driven R&D investments to fund their transition. However, access to structured financial support remains a barrier, preventing many firms from implementing large-scale sustainability projects. While companies recognize the importance of sustainability-driven innovations, most remain in the early planning and development stages rather than full-scale execution. The transition to SBMs is progressing, but its pace is hindered by operational challenges, financial limitations, and regulatory uncertainties.

4. To what extent are Indian manufacturing companies collaborating with competitors and stakeholders to achieve sustainability goals?

Collaboration among Indian manufacturing companies to achieve sustainability goals remains limited, with most firms still reluctant to engage in cross-industry partnerships. Unlike international markets, where businesses frequently collaborate on sustainability research and development, Indian manufacturers often operate in isolation, fearing that sharing knowledge with competitors may result in a loss of market advantage. Competitive secrecy has restricted industry-wide knowledge-sharing initiatives, leading to slow and fragmented progress in SBM adoption.

While some industries have initiated discussions on sustainability, these interactions are often informal and lack structured collaboration mechanisms. Many firms engage in casual discussions or transactional relationships with competitors but refrain from joint sustainability projects or shared R&D investments. Industries such as Chemicals & Plastics and Pharmacy & Healthcare have shown particular reluctance to collaborate, with firms in these sectors citing concerns about competitive risk.

Government and policy-driven sustainability initiatives remain underdeveloped, limiting the potential for structured public-private partnerships. While some industries, particularly Infrastructure, Steel & Cement, have begun forming sustainability-driven collaborations, these remain isolated efforts rather than large-scale industry-wide transformations. Encouraging industry-wide sustainability consortia and integrating sustainability compliance into regulatory frameworks could help bridge this collaboration gap, fostering collective sustainability progress in Indian manufacturing.

5. What factors drive or hinder the successful implementation of sustainability-focused innovations in manufacturing?

The successful implementation of sustainability-focused innovations in Indian manufacturing is influenced by multiple driving and hindering factors. Among the key drivers is strong leadership commitment to sustainability, which has been instrumental in advancing SBM adoption in industries such as Chemicals & Plastics, Infrastructure, Steel & Cement, and Automobile & Transportation. Companies that prioritize sustainability at the executive level are more likely to invest in long-term sustainability initiatives, allocate resources for green innovations, and integrate sustainability into their corporate strategies.

Regulatory pressures and ESG compliance requirements also act as significant drivers, pushing firms to adopt sustainable practices. Companies operating in highly regulated industries, such as Pharmacy & Healthcare and Consumer Electronics & Capital Goods, are increasingly aligning with global sustainability standards to enhance their market competitiveness. The adoption of circular economy principles, waste-to-resource models, and sustainability-driven R&D investments has further contributed to the growing shift toward sustainable manufacturing.

However, financial constraints remain one of the most significant barriers to implementing sustainability-focused innovations. High developmental costs and limited access to sustainability financing prevent firms from making long-term investments in green technologies and energy-efficient production processes. Additionally, operational inefficiencies and supply chain complexities make it challenging for businesses to transition to sustainable business models.

Managerial resistance to change further hinders sustainability adoption. Many mid-level managers continue to prioritize short-term financial gains over long-term

sustainability goals, leading to slow adoption rates. Without strong executive buy-in and clear sustainability mandates, many firms struggle to implement SBM strategies effectively. The lack of industry-wide collaboration further exacerbates these challenges, limiting opportunities for collective learning and cost-sharing in sustainability initiatives.

Despite these challenges, sustainability-driven innovations continue to gain momentum, particularly in sectors that have embraced digital transformation, circular economy strategies, and regulatory-driven sustainability compliance. Addressing financial constraints, enhancing stakeholder collaboration, and integrating sustainability into corporate decision-making will be crucial in overcoming the barriers to SBM adoption and accelerating the transition to a more sustainable manufacturing ecosystem in India.

CHAPTER VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

This study comprehensively examined the barriers, awareness levels, strategic approaches, stakeholder collaboration, and innovation drivers influencing the adoption of Sustainable Business Models (SBMs) in key manufacturing sectors in India. The research highlights that while sustainability has gained significant attention, its implementation remains a challenge due to financial constraints, lack of managerial commitment, resource limitations, and sector-specific adoption gaps. The findings provide data-driven insights into the current state of sustainability adoption, sectoral differences, and the strategies required to facilitate a smoother transition toward SBMs.

The study identified resource unavailability and financial constraints as the most significant barriers to SBM adoption. Industries such as Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare reported the highest challenges, particularly in terms of high developmental costs, resistance to change, and inadequate sustainability-focused policies. Additionally, while concept clarity is not a major issue, operational execution remains weak, requiring targeted interventions in funding, training, and sustainability-focused leadership.

Despite these barriers, awareness of sustainability is increasing across sectors, with Automobile & Transportation, Chemicals & Plastics, and Pharmacy & Healthcare leading the way in sustainability preparedness. However, Textiles and Agriculture & Food Processing sectors remain relatively lagging in structured sustainability initiatives. The study found that while many organizations recognize the importance of sustainability, a significant gap exists between awareness and action, highlighting the

need for capacity-building programs, financial incentives, and stronger regulatory enforcement.

Strategies and innovations for SBM transition are at varying stages of development across industries. While many organizations have moved beyond initial discussions and are actively designing sustainable business models, full-scale implementation remains limited due to high costs and uncertain returns on investment. Circular economy principles, digital transformation, and green supply chain initiatives have gained momentum, but widespread adoption is still hindered by budgetary constraints and resistance to organizational change. The findings suggest that government-backed incentives, sustainability-driven R&D funding, and collaborative ecosystems could significantly accelerate the transition toward sustainable practices.

Stakeholder collaboration plays a pivotal role in shaping sustainability adoption. However, most industries continue to engage in informal or competitive interactions rather than structured collaborations. Knowledge-sharing and joint sustainability initiatives remain limited, particularly in Infrastructure, Steel & Cement, and Chemicals & Plastics sectors, where competitive secrecy prevents effective partnerships. Encouraging industry-wide sustainability alliances, forming policy-driven regulatory networks, and fostering public-private partnerships could bridge this collaboration gap and promote collective sustainability progress.

The study also analyzed the key drivers and barriers influencing sustainability-driven innovations. Managerial resistance, financial constraints, and limited resource allocation emerged as the biggest challenges, while leadership commitment, long-term sustainability planning, and industry-wide collaboration were identified as critical enablers. Although many organizations have formulated sustainability roadmaps, a lack of execution strategies and accountability frameworks continues to slow progress. The

study suggests that organizations must integrate sustainability into core business strategies rather than treating it as a peripheral initiative. Additionally, policy frameworks, financial support mechanisms, and skill development programs will be essential in removing sustainability adoption bottlenecks.

6.2 Implications

The findings of this study have significant implications for academia, business leaders, policymakers, and industry stakeholders aiming to facilitate the adoption of Sustainable Business Models (SBMs) in the Indian manufacturing sector. By identifying key barriers, assessing awareness levels, exploring strategic innovations, analyzing collaboration efforts, and examining sustainability drivers and challenges, this research provides actionable insights to support a structured transition towards sustainability.

From a theoretical perspective, this study expands the existing body of knowledge on SBMs by providing a sector-specific analysis of sustainability adoption in Indian manufacturing. While global research has widely explored sustainability frameworks, sectoral variations and region-specific constraints in India remain underexamined. This research contributes by highlighting differences in SBM readiness across industries, emphasizing the disparity between highly regulated sectors such as Pharmaceuticals and Chemicals & Plastics and those with minimal regulatory oversight, like Textiles and Agriculture & Food Processing. Additionally, the study underscores the gap between sustainability awareness and practical implementation, reinforcing the need to integrate behavioral and organizational change theories into sustainability research.

For business leaders and corporate decision-makers, the study provides crucial insights into embedding sustainability into strategic and operational frameworks. It emphasizes the need for businesses to shift from treating sustainability as a compliance

requirement to making it a core business strategy. Given that financial constraints and resource limitations were identified as significant barriers, companies must explore alternative financing models such as green bonds, sustainability-linked loans, and ESG investments to fund sustainability initiatives. Furthermore, capacity building and workforce training in circular economy principles, Industry 4.0 technologies, and green supply chain management will be essential to bridge existing skill gaps and enhance innovation. The study also highlights the importance of collaboration between management and operational teams to ensure that sustainability strategies move from planning to execution. By prioritizing sustainability-driven innovations such as waste-to-resource strategies, energy-efficient production systems, and green product development, companies can gain a competitive advantage and strengthen their brand reputation in both domestic and global markets.

The research also carries critical policy and regulatory implications. The study highlights inconsistencies in policy enforcement across sectors, suggesting that stricter regulatory monitoring is necessary to ensure widespread adoption of SBMs. Policymakers must introduce targeted financial support mechanisms such as tax incentives, subsidies, and sector-specific funding to help industries overcome the high costs of sustainability transitions. Additionally, public-private partnerships should be strengthened to foster collaboration between businesses, research institutions, and NGOs. This can facilitate technology transfer, promote knowledge sharing, and provide financial risk mitigation for companies adopting sustainable practices. Furthermore, investments in green infrastructure, such as renewable energy sources, sustainable industrial zones, and eco-friendly supply chains, will enable businesses to align with international sustainability standards. Expanding corporate ESG disclosure mandates and integrating

sustainability performance metrics into financial reporting will also drive greater accountability and transparency.

Collaboration among industries is another crucial area that requires improvement. The study reveals that while some industries have established sustainability-driven collaborations, most businesses hesitate to engage in knowledge-sharing with competitors. To overcome this challenge, industry-wide sustainability consortia should be established, enabling businesses to share best practices, pool resources, and collectively drive innovation. Strengthening supplier sustainability requirements and green procurement policies can also enhance environmental compliance across entire supply chains. Furthermore, open-source sustainability platforms and benchmarking frameworks should be developed to enable data-driven decision-making and collaborative problem-solving. National guidelines for circular economy adoption across industries can help standardize sustainable practices and ensure a unified approach to sustainability transitions.

Beyond corporate and policy-level implications, the study has broader societal and environmental consequences. Transitioning to SBMs can significantly reduce the environmental impact of industrial activities by addressing carbon emissions, waste generation, and resource inefficiencies. Additionally, companies that implement sustainable business models can influence consumer preferences towards eco-friendly products, shaping market demand for sustainable consumption. The adoption of sustainability-driven innovations is also expected to create new employment opportunities in green industries, particularly in areas such as sustainable manufacturing, renewable energy, and circular economy practices.

6.3 Recommendations for Future Research

Based on the findings of this study, several areas require further exploration to deepen the understanding of Sustainable Business Model (SBM) adoption in the Indian manufacturing sector. The following six recommendations highlight key areas where future research can contribute valuable insights:

1. Longitudinal Analysis of SBM Adoption

Future studies should adopt a longitudinal approach to track the progress of sustainability initiatives over time. This would provide insights into how businesses adapt to sustainability regulations, implement SBM strategies, and measure the long-term financial and environmental impacts. Such studies would also help assess whether current sustainability efforts lead to measurable improvements or require further policy and industry adjustments.

2. Sector-Specific SBM Implementation Strategies

While this research provided a broad analysis across multiple industries, future studies should focus on developing sector-specific SBM adoption frameworks. Industries such as automobiles, textiles, consumer electronics, and infrastructure have distinct challenges and opportunities related to sustainability. A more detailed sectoral analysis would help tailor strategies that address unique constraints and regulatory requirements, making SBM transitions more effective.

3. Financial Incentives and Economic Viability of SBMs

One of the most significant barriers identified in this study was financial constraints. Future research should explore the economic feasibility of SBMs and analyze financial incentives such as green bonds, ESG investments, and government subsidies that can facilitate sustainability transitions. Studies should also assess the return on investment (ROI) of sustainable business practices to encourage wider industry adoption.

4. Role of Digital Transformation in Sustainability

Industry 4.0 technologies, including IoT, AI, blockchain, and big data analytics, can optimize resource efficiency and drive sustainable manufacturing. Future research should examine how digital transformation can accelerate SBM adoption in India, focusing on the challenges of technology implementation, cost-effectiveness, and industry readiness for digital integration.

5. Policy Impact and Regulatory Effectiveness

Although India has introduced sustainability policies, their real-world effectiveness remains unclear. Future research should evaluate the impact of regulatory frameworks on SBM adoption, identifying gaps in enforcement, financial support, and policy implementation. Comparative studies with global best practices can help recommend policy improvements for better sustainability compliance.

6. Circular Economy and Waste-to-Resource Models

The circular economy is a crucial pillar of sustainability, yet its adoption remains limited in Indian manufacturing. Future research should explore practical implementation strategies for circular economy models, including waste-to-resource conversion, reverse logistics, and closed-loop production. Identifying best practices from global industries and assessing their applicability in the Indian context could support wider adoption.

6.4 Conclusion

This dissertation comprehensively examines the transition to Sustainable Business Models (SBMs) in the Indian manufacturing sector, focusing on the key barriers, awareness levels, strategic innovations, stakeholder collaboration, and the drivers and challenges influencing sustainability adoption. The findings highlight that while sustainability awareness is growing across industries, practical implementation remains

slow due to financial constraints, resource limitations, and resistance to change. The study underscores the need for sector-specific interventions, financial incentives, and regulatory support to facilitate a smoother transition towards sustainable practices.

One of the primary challenges identified is the lack of resource availability and financial support, particularly in sectors such as Chemicals & Plastics, Infrastructure, Steel & Cement, and Pharmacy & Healthcare. While many organizations recognize the long-term benefits of sustainability, they struggle with high developmental costs and limited access to green technologies. Additionally, managerial hesitancy and operational challenges hinder the full-scale execution of sustainability initiatives, reinforcing the need for stronger leadership commitment and structured policy support.

Despite these challenges, the research also highlights promising trends, including increased engagement in sustainable product design, circular economy initiatives, and Industry 4.0-driven innovations. However, these efforts remain fragmented, with industries still in the early stages of adopting structured SBM frameworks. The study also finds that collaboration among stakeholders, including industry competitors, policymakers, and regulatory bodies, remains limited. While some sectors have initiated partnerships, competitive tensions and a lack of standardized sustainability policies restrict knowledge sharing and joint sustainability initiatives.

To overcome these barriers, businesses must integrate sustainability into their core operations by fostering innovation, investing in research and development, and actively participating in collaborative sustainability networks. Policymakers need to provide financial incentives, regulatory clarity, and capacity-building programs to encourage wider adoption of SBMs across industries. Strengthening public-private partnerships, enhancing supply chain sustainability, and leveraging digital transformation will be crucial in accelerating India's sustainability transition.

Overall, this dissertation contributes to the growing discourse on sustainability in the Indian manufacturing sector by offering data-driven insights, strategic recommendations, and policy implications. While progress has been made, there remains a significant gap between awareness and implementation. Bridging this gap requires a multi-faceted approach involving industry-wide collaboration, targeted policy measures, and long-term investment in sustainable innovation. By addressing these challenges, Indian manufacturers can achieve global competitiveness while ensuring environmental and social responsibility in their business operations.

APPENDIX A

QUESTIONNAIRE

a) What are the major hurdles/problems in an Organization/Sector to imbibe an understanding and importance of Sustainable Business Models (SBMs) in your belief?

i) Concept Clarity
ii) Long Term Impact Understanding
ii) Unavailability of suitable resources
iv) Ignorance
iii) Other(s) Please Specify……

b) What is the level of awareness and understanding about the Circular Economy systems and processes in the Organization?

i) Not At All
ii) Nascent
iv) Mid Level
iv) Well Aware
v) Other(s) Please Specify……

c) Are Organizations in your sector/your organization working on Sustainable Product Design & Development and at which stage?

i) Thoughts only
ii) Initial Discussions
ii) Design Stage
iv) Development & Trials
iii) Other(s) Please Specify……

d) What are the thoughts of Management on Sustainable Product Design & Development?

i) Initial Thoughts only
ii) Understand its importance
ii) An action plan is demanded
iv) Go ahead given for Trials
iii) Other(s) Please Specify……

e) Name 4-5 Strategies discussed/planned/established for creating SBM in your organization.

i)……

ii)……..

iii)…….

iv)…….

v)……

f) What are the steps (In your own view) helpful to establish SBMs in your sector?

i)……

ii)……..

iii)…….

iv)…….

v)……

g) Barriers for Creation and implementation of SBMs are witnessed at which level?

i) Management ii) CXOs

ii) Managerial iv) Implementation Team

iii) Other(s) Please Specify……

h) Which type of Barrier is the most witnessed in your organization?

Mind Set & Current Practices ii) Additional Resource Allocation

Developmental Cost iv) Collaboration with Competitors

Other(s) Please Specify……..

i) Is there any thought process already initiated among senior management people to establish a Sustainable Business Model?

a) Yes but very early stage b) Yes well initiated

b) Management Not Aware d) Aware but not initiated

c) Other(s) Please Specify……..

j) Is Organization(s) Spending on R & D or exploring Collaboration with competitors?

i) Not at all
ii) Insufficient Budget for R & D
ii) Sufficient Budget for R & D
iv) Exploring Collaborations openly
iii) Initiated R & D and Collaboration both
vi) Other(s) Pls Specify……

k) Are Innovations and New Ideas are of interest to your organization and how they are dealt with in institutional framework?

i) Not of any Interest
ii) Interested but no Initiatives
ii) Appreciated & Initiatives taken
iv) Encouraged/Rewarded/Promoted
iii) All well but Implementation Hurdles
vi) Other(s) Pls Specify……

l) How can you bring Sustainable Business Model Innovation in your Organization/Sector?

i) No ideas as of now
ii) Already Have ideas but need encouragement & Support
iii) Proposed to initiate like……..
iv) Already Initiated like…….
v) Other(s) Please Specify……..

m) Any policy to appreciate and escalate an innovative & sustainable idea or business model brought on table by a team member is in place?

i) No
ii) Being Thought off
ii) Available but not Effective/Attractive
iv) Attractive but not Implemented

iii) Yes its attractive & Effective vi) Other(s) Please Specify…….

n) What are the Steps/Strategies you wish to implement in your organization to move towards sustainability?

i) ……..

ii) ……..

iii) ……..

iv) ……..

v) ……..

o) Is there a long term Sustainability Plan/Goals setup by the Organization?

i) Not At All ii) Being Thought off

ii) Under Formation iv) Formed but not Implemented

iii) Being Implemented vi) Other(s) Please Specify…….

p) Name the unsustainable Business practices currently being adopted in your organization you wish to change.

i) ……..

ii) ……..

iii) ……..

iv) ……..

v) ……..

q) Are there discussions about issues like designing out waste, shift towards renewable energy, elimination of toxic chemicals, product design innovations, R & D, Innovations, improving efficiencies, conserving climate changes, reducing GHG emissions, Carbon Footprint of Business, LCA of products, Talks beyond IR-PR-CSR, cooperation & collaboration?

i)	No	ii) Initial Thoughts only
ii)	Only Discussions, No Actions	iv) Discuss but No effective action
iii)	Serious steps being taken	vi) Other(s) Please Specify……

r) What is the policy of your organization regarding cooperation & collaboration with trade competitors:

i)	No discussion with Competitors	ii) Only Casual Discussion
ii)	Business Relations & transactions only	iv) Technical Knowledge Sharing & Collaborations initiatives
iv)	Well Established Collaborations	vi) Other(s) Please Specify……

s) How your organization dealt with trade competition:

i)	Encourage & Appreciate developments	ii) Try to reverse the
ii)	Jealousy	iv) Copy & Follow
iii)	Mutual Collaboration Approach	vi) Other(s) please specify

t) Any Suggestion(s)/Input(s)/Feedback/ Advise you may wish to provide for "Strategy Building in your Sector to create Sustainable Business Models!!

i)…….

ii)……

iii)……

iv)……

v)…….

u) In case you wish to make a mention of any case study(s) of creation of SBM please!!

i) ……

ii) ……
ii) ……

APPENDIX B

INFORMED CONSENT

Research Title:

Strategies for transition to sustainable business models (SBMs) in key manufacturing sectors in India.

Principal Investigator :

My name is Nitin Agarwal. I am a DBA learner at SSBM GENEVA. I am conducting a study and you are invited to participate.

Purpose of the Study:

You are invited to participate in a research study examining the challenges, awareness levels, and strategies for adopting Sustainable Business Models (SBMs) in key manufacturing sectors in India. This study aims to identify barriers to sustainability adoption, assess sectoral preparedness, explore ongoing innovations, and evaluate the role of collaboration in sustainable transitions. Your responses will contribute to a better understanding of the factors influencing sustainability implementation in the manufacturing industry.

Procedures:

If you agree to participate, you will be asked to complete a structured survey. The survey will include questions about your experiences, preferences, and perceptions regarding health insurance marketing strategies. It will take approximately 15–20 minutes to complete.

Confidentiality:

All information you provide will be kept confidential and used solely for academic purposes. Your responses will be anonymized to ensure that no personally identifiable

information is included in the study's results. The data will be securely stored and accessed only by the researcher and authorized personnel.

Potential Risks and Benefits:

There are no significant risks associated with participating in this study. Your participation will contribute to valuable insights into improving health insurance marketing strategies, which may ultimately benefit consumers and the industry.

Consent Statement:

By signing below, you confirm that you have read and understood the information provided above. You consent to participate in this study and allow the researcher to use your responses for academic purposes.

Participant's Name: _____

Participant's Signature: _____

Date: _____

Researcher’s Signature: _____

Date: _____

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