Supply Chain & Logistics Research Journal
Vol. 1, Issue 1, 2026

Vol. 1, Issue 1, pp. 31-44, 2026

Sustainable Supply Chain Management: Balancing Cost-Effectiveness and Environmental Performance in India's Manufacturing Sector

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Abstract

Sustainable supply chain management is now a strategic focus of manufacturers that are trying to minimize the environmental effects without compromising on cost competitiveness, service availability and growth. It is this challenge that is especially relevant in India, where growth of manufacturing, export-focus, energy-intensive manufacturing, regulatory reform, and growing environmental reporting requirements are transforming supply-chain choices. This article surveys the ways in which Indian manufacturing companies can reconcile affordability and environmental sustainability by managing their supply chain sustainably. The synthesis of existing literature on sustainable supply chains, Indian manufacturing empirical studies, and recent policy initiatives in energy efficiency, carbon markets, and value-chain environmental, social and governance disclosure is synthesised using a structured desk-study approach. The review concludes that environmental enhancement and cost cut are not necessarily conflicting. Green procurement and eco-design, process and energy efficiency, logistics optimization, waste reduction, remanufacturing, material recovery, supplier development, and digital visibility have joint operational and environmental benefits that can be achieved selectively and with management commitment. Nonetheless, many sustainability initiatives encompass initial expenses, functionality needs, supplier limitations, unpredictable payback and coordination overhead. These are best achieved when companies consider total cost of ownership, as opposed to just purchase price, consider interventions by material environmental impact, make suppliers part of improvement programmes, and use data to quantify both the financial and ecological outcomes. Strategic relevance of supply-chain decarbonization and traceability is further enhanced by regulatory mechanisms like the India Perform, Achieve and Trade scheme, the emerging carbon-market architecture, the extended producer responsibility, and Business Responsibility and Sustainability Reporting.

Key words: *Sustainable supply chain management; green supply chain management; India; manufacturing; cost-effectiveness; environmental performance*

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Article History

Received: 24 June 2026 | Revised: 24 July 2026 | Accepted: 22 August 2026

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1. Introduction

Supply chains in manufacturing are now also being requested to achieve three simultaneous outcomes namely; competitive cost, dependability in terms of operational performance and reduced environmental impact. Traditionally, the procurement and operations decisions tended to focus on unit cost, productivity, quality and delivery, whereas the environmental implications were seen as compliance or corporate social responsibility issues. Sustainable supply chain management (SSCM) defies such a distinction by embedding economic, environmental, and social aspects in the process of sourcing, production, logistics, product design, recovery, and supplier relationships (Carter & Rogers, 2008; Seuring and Muller, 2008).

The cost-environmental performance balance is of particular concern in India, where manufacture is the core of the industrial development, and a great number of activities are energy-, material-, and logistic-intensive. The companies experience intense price rivalry and mounting customer, regulatory, shareholder and global value-chain pressure. Indian data demonstrates that GSCM can enhance the environmental performance and the operational performance, but there are inconsistencies in the direct economic benefits of practices and sectors (Vijayvargy et al., 2017; Das, 2018; Khan et al., 2022).

It is not whether or not firms should be more sustainable but how to incorporate sustainability without unmanageable cost burdens. Other programs produce immediate savings in terms of reduced energy consumption, waste, material waste and transport inefficiency. Some of them need capital investment, certification of suppliers, cleaner technologies, redesign, or systems of traceability with longer payback periods. The sustainable supply chain strategy should then differentiate between short-term win-win and long-term investments and actions that rely on regulatory or market incentives (Srivastava, 2007; Golicic & Smith, 2013).

This subtle opinion is supported by Indian evidence. Mitra and Datta (2014) have discovered that adoption of green supply chain practices by the Indian manufacturing firms was linked to improvement in performance and Luthra et al. (2016) reported that regulation, internal management, and competitiveness were also important factors that led to adoption of GSCM practices in the automobile industry. Subsequent research revealed that operational, environmental, and low-carbon performance can be affected by eco-design, customer cooperation, investment recovery, internal environmental management, green logistics, and leadership commitment (Vijayvargy et al., 2017; Khan et al., 2022; Gupta et al., 2025).

The policy environment too is evolving at a high rate. The Perform, Achieve and Trade (PAT) system in India is based on energy-intensity goals and tradable energy-saving certificates to enhance cost-effective energy efficiency in energy-intensive industries. According to the Bureau of Energy Efficiency, the scheme has assisted over a thousand listed consumers and has already provided significant energy savings, with the emerging Carbon Credit Trading Scheme that is to slowly transition several of the high-emitting industrial sectors to greenhouse-gas intensity targets (Bureau of Energy Efficiency [BEE], 2026; Press Information Bureau [PIB], 2024). These policies enhance the economic argument of decarbonization as the inefficient utilization of resources poses more and more regulatory and financial risks.

The arena of environmental disclosure is not only growing in individual companies but also in value chain. The BRSR Core framework of the Securities and Exchange Board of India established value-chain disclosure of ESG measures on large listed companies on a staged basis, which raised the demand on manufacturers to gather environmental information of their upstream and downstream partners (Securities and Exchange Board of India [SEBI], 2023, 2025). This change turns sustainability into a factory-management problem, instead of a supply-chain governance need that encompasses suppliers, logistics partners, customers, and recovery partners.

It is against this backdrop that the article discusses the application of sustainable supply chain management to ensure a balance between cost-effectiveness and environmental performance in the manufacturing

industry in India. It examines sustainable procurement, collaboration with suppliers, eco-design, energy and resource efficiency, low-carbon logistics, circularity, reverse logistics, digital technologies, performance measurement, regulation, and barriers to implementation. The main point is that sustainability can be discussed as the productivity and strategic capability agenda and not as an independent environmental programme since the best long-term results are achieved when environmental enhancement is included in the decision-making processes regarding costs, quality, innovation, and supply-chain resiliency (Pagell & Wu, 2009; Sarkis et al., 2011).

2. Literature Review

2.1 Sustainable Supply Chain Management and the Triple Bottom Line

SSCM goes beyond traditional supply chain management in that it specifically incorporates economic, environmental and social goals within interorganizational processes. The conceptualised notions of sustainability used by Carter and Rogers (2008) and Seuring and Müller (2008) are the strategic and open integration of the environment, social, and economic objectives in the coordination of business processes and the management of material, information, and capital streams as well as the collaboration between supply-chain companies respectively. This view changes the point of focus of an individual factory and moves to the broader network which produces, delivers and recovers value.

Greenhouse-gas emissions, resource circularity, hazardous substances, waste, packaging, pollution, water consumption, land impact, and the energy consumption are all part of the environmental aspect of SSCM. Economic dimension entails overall cost, profitability, productivity, quality, lead time, inventory, asset utilization, market access and risk. The strategic issue is to find interventions that enhance either of the two dimensions or create acceptable trade-offs in the long run. It is becoming clear that the supposed necessity of environmental improvement to decrease competitiveness is equally being debunked by research, and that operational efficiency and innovation can generate shared value when sustainability is part of core management systems (Golicic et al., 2013; Dubey et al., 2017).

This relationship is theoretically explained by the natural-resource based view. According to Hart (1995), capabilities, which are associated with pollution prevention, product stewardship, and sustainable development, may turn out to be sources of competitive advantage. The sustainability of the supply chain takes these abilities further than the firm boundaries since in most cases environmental performance is affected by the technologies used by the suppliers, material selection, transport systems, and end-of-life systems. Companies which build joint environmental competencies are thus able to mitigate risk and enhance efficiency in a manner that is hard to copy (Sarkis et al., 2011; Pagell and Wu, 2009).

2.2 Green Procurement and Supplier Environmental Management

A significant portion of the manufacturing environmental impact is determined by procurement choices as they can affect material composition, embedded energy, processes with suppliers, packaging, transportation distance and waste. Green procurement involves the incorporation of environmental requirements in the selection of suppliers, contracting, evaluation, and development. Common ones are supplier environmental audit, restricted-substance specifications, environmental management certification, life-cycle requirements, recycled-content specifications and joint improvement programmes (Zhu et al., 2008; Srivastava, 2007).

This is a special challenge to Indian manufacturers since the supply bases can consist of many small and medium enterprises that have an uneven environmental capability. Vijayvargy et al. (2017) discovered that environmental practices were not uniformly employed by the firm size and that environmental evaluation of suppliers was a field that needed enhancement. This indicates that even big manufacturers cannot meet ambitious environmental goals by purchasing rules alone; they might have to make investments in training suppliers, supporting processes, data standards, and longer relationships.

Green procurement relies on cost-effectiveness in its pricing based on the total cost of ownership as opposed to the lowest price offered. A more expensive purchase of a material or supplier might result in less energy consumption, less scrap, less defects, easier recycling, less compliance risk, or less disposal cost. On the other hand, the environmental specifications which are not closely correlated with material effects may add administrative load without adding any significant value. Strategic sourcing must thus be integrated with environmental requirements and quality, risk, and life-cycle cost, capacity, and delivery performance (Carter and Rogers, 2008; Das, 2018).

2.3 Eco-Design and Sustainable Product Development

Eco-design is more environmentally friendly at the product-development level where it takes into account material intensity, energy consumption, durability, repairability, recyclability, packaging and end-of-life recovery. Design decisions not only influence a lot of the downstream environmental impact of a product, but also the manufacturing complexity, the number of components, the logistics efficiency, and the cost of the materials. Early incorporation of environmental criteria can thus prevent the costly re-design and enable resource productivity and customer value (Srivastava, 2007; Sarkis et al., 2011).

Green product and process design is an area of sustainable manufacturing that has been found to contribute significantly to manufacturing in India based on empirical evidence. Gupta et al. (2025) have discovered that green product and product design had a strong impact on management performance that subsequently facilitated low-carbon performance and sustainable manufacturing. Previous evidence also demonstrates that eco-design may also play a role in operational performance of Indian manufacturers (Vijayvargy et al., 2021). The findings underpin the contention that environmental design capability is best considered as a manufacturing and innovation competence as opposed to being a compliance requirement.

The most economic value of eco-design is where redesign minimizes the use of materials, eases assembly, decreases packaging, increases product life or increases recovery value. Nonetheless, the cost can also heighten with sustainability features in cases where there is a shortage of alternative material, certification is costly, or new tooling is required in production. To help firms in determining the kinds of designs to implement to minimize total system cost and enhance their environmental performance, firms must employ life-cycle costing and value engineering (Golicic & Smith, 2013; Pagell & Wu, 2009).

2.4 Energy Efficiency and Low-Carbon Manufacturing

One of the most apparent places where environmental and economic goals can intersect is in terms of energy efficiency. The decreasing energy intensity minimizes both the operating cost and greenhouse-gas emissions. Opportunities, among others, are efficient motors, boilers, furnaces, compressed-air systems, waste-heat recovery, process optimization, electrification, renewable electricity, predictive maintenance, and energy-management systems. The PAT scheme in India formalizes this logic by establishing sector-specific energy-saving thresholds and establishing tradable certificates on confirmed savings (BEE, 2026; PIB, 2024).

In the case of low-carbon supply chain studies on Indian manufacturing, it has been demonstrated that there are relationships between carbon governance, low-carbon purchasing, product and process design, manufacturing, and logistics. Empirical results have shown that low-carbon process and product design and lower-carbon manufacturing and logistics enhance environmental sustainability, but short-run economic relationships are not necessarily found to be statistically significant (Dubey et al., 2019). This supports the importance of decarbonization being viewed on a longer investment horizon and the necessity to differentiate direct operating savings and the larger risk, compliance, and market benefits.

The new Carbon Credit Trading Scheme enhances the strategic worth of checked emissions information and operational decarbonization. Various industries with high energy consumption will slowly shift their PAT to greenhouse-gas intensity compliance mechanisms, implying that in the coming years the emissions

performance can more and more influence direct financial requirements and opportunities (BEE, 2026). Manufacturing companies are thus encouraged to combine energy, carbon, cost, and production data as opposed to report them using different reporting systems.

2.5 Green Logistics and Transportation Efficiency

Logistics influences the cost and the environmental performance in terms of transport mode, transport distance, load factor, routing, warehousing energy, packaging and reverse flows. Green logistics policies comprise route optimization, increased use of vehicles, modal, consolidated shipment, energy efficient warehouses, reusable packaging, electric or alternative-fuel vehicles and better network design. Most of these interventions cut down the fuel cost and emissions in cases where operational conditions favor their application (Srivastava, 2007; Dekker et al., 2012).

In the case of Indian producers, the problem of logistics sustainability is determined by the long domestic routes, roadways, fragmented freight markets, port and rail connection, and the disproportional use of cleaner vehicles. The low cost interventions often start with utilization and planning instead of costly technology: cut down on the empty runs, better order consolidation, redesign packaging, more vehicle fill, and better delivery planning may reduce the emissions as well as the freight expense. More capital-intensive solutions like fleet electrification would demand route appropriateness, charging availability, usage analysis, and overall-cost assessment (Dekker et al., 2012; Evangelista et al., 2018).

The design of supply-chain, also counts. Local sourcing is not necessarily green because local suppliers can be close enough to cut transportation emissions and lead time, yet local manufacturers might use inefficient production technologies, or raw materials might need further refinement. The comparison of total emissions and total cost should not be based on sourcing, production, storage, and transportation distance however, but on life-cycle analysis and network analysis (Seuring and Muller, 2008; Golicic and Smith, 2013).

2.6 Circular Economy, Reverse Logistics, and Waste Valorization

Circular supply chains seek to preserve the value of products, components, and materials by reusing, repairing, remanufacturing, recycling, and recovering. Reverse logistics is a core competency as goods and materials should move back to the users, collection, sorting, processing and manufacturing sites. Close-loop supply chains may decrease the demand of virgin material and costs of disposal and generate recovered-material revenue, albeit at the cost of reliable return volumes, quality control, market demand and economical recovery operations (Guide & Van Wassenhove, 2009; Govindan & Soleimani, 2017).

The manufacturing scenario in India is getting shaped by the long-term producer responsibility policies of plastic, electronic, batteries and other waste materials. Such mechanisms transfer the responsibility of end-of-life to producers and establish incentives to traceability, collection systems, recyclable design, and official recovery networks. Cost-wise, compliance may result in the introduction of new operating expenses, although the firms can mitigate long-term cost by design to reduce recycling, increased recycled content, supplier collaboration, and investment recovery practices (Srivastava, 2007; Vijayvargy et al., 2021).

Particularly, investment recovery is important as it converts obsolete materials, scrap, excess inventory and recovered products into economic value. Empirical studies of Indian companies have shown investment recovery to be a significant predictor of environmental performance, demonstrating how waste reduction and asset recovery can help in achieving sustainability and financial results (Vijayvargy et al., 2021). Circularity will though work best in combination with procurement, product design, production planning and market strategy as opposed to being handled as a waste-disposal operation.

2.7 Digital Technologies and Sustainability Visibility

Digital technologies have the potential to enhance SSCM by increasing the visibility of resource flows and supplier performance. Measurement of energy, waste, carbon, inventory, transport and compliance could be

enhanced with the use of enterprise systems, sensors, energy platforms, analytics, traceability tools and supplier portals. The improved information assists companies in discovering hotspots, evaluating options, and focusing on interventions (Kamble et al., 2021; Bag et al., 2021).

Digitalization quality relies on data quality and utilization by the managers. Gathering sustainability information of a fragmented supplier base may also be costly, particularly when it comes to small suppliers who may not have standardized systems. The growing value-chain ESG disclosure demands in India put additional pressure on traceable and verifiable information, yet companies cannot afford to establish reporting frameworks that do not enhance the decision-making process (SEBI, 2023, 2025). The design of digital tools should thus be grounded on certain management inquiries like carbon hotspots, supplier risk, recovery rates, or energy-intensity variance.

The analytics can also enhance the balance between costs and the environment by detecting the changes in operations that leave no waste and not less service. To illustrate, predictive maintenance can minimize the energy loss and unexpected downtime of equipment, demand analytics can minimize the amount of wasted inventory, and route optimization can minimize the number of kilometers traveled. The digital sustainability capability is thus most robust when associated with operational excellence as opposed to being a separate technology programme (Bag et al., 2021; Gupta et al., 2025).

2.8 Drivers and Barriers in Indian Manufacturing

The regulation, competitive pressure, top-management support, customer expectations, organizational capability, and environmental commitment are always found to be significant drivers of adoption in Indian GSCM studies. Regulatory factors are identified as one of the most influential factors in the automobile industry by Luthra et al. (2016) and top-management performance as the key to converting the green practices into the low-carbon and sustainable manufacturing results, as noted by Gupta et al. (2025). These results show that momentum is generated by the outside force, but the quality of implementation is decided by the inside leadership.

High initial cost, uncertainty of payback, supplier ability, poor information sharing, lack of expertise, change resistance, poor waste and logistics infrastructure and inability to measure environmental outcomes are the barriers. Sustainability can be particularly challenging to smaller businesses due to financial and technical limitations, despite its long-term effects on the business (Vijayvargy et al., 2017; Vadukiya and Mundra, 2024). These obstacles justify why the pressure of policy can lead to inequalities of implementation alone.

The relationship between cost and environment is thus contingent. Environmental practices with Payback Rapid payback Environmental practices that reduce the intensity of materials, energy, or waste can be applied, whereas more advanced technology, certification, or redesign may only be possible at longer horizons. Portfolio strategies that are integrated with strategic investments and supplier-development programmes should be adopted by organizations in order to incorporate quick-win efficiency projects. It also demands that finance teams put into consideration avoided risk, future carbon cost, regulatory compliance, and reputational value instead of determining sustainability projects by evaluating them based on immediate direct savings (Das, 2018; Gupta et al., 2025).

3. Methodology

This article incorporated a designed desk-based literature review to explore the manner in which sustainable supply chain management can reconcile the notions of cost-effectiveness and environmental performance in the manufacturing sector of India. The review combined peer-reviewed literature on sustainable and green supply chain management, Indian manufacturing research, circular economy, low-carbon operations, green logistics, supplier management, and digital technologies. To ensure that the existing policy and reporting

trends on industrial sustainability are covered, institutional sources, such as the Bureau of Energy Efficiency, The Securities and Exchange Board of India, and other government sources, were included.

The search strategy was a combination of the following terms: sustainable supply chain management, green supply chain management, Indian manufacturing, cost performance, environmental performance, green procurement, eco-design, low-carbon supply chain, circular economy, reverse logistics, energy efficiency, BRSR, and PAT. Conceptual and review works were included as foundational literature, where they presented key theoretical concepts, and empirical Indian research and more recent sources from 2022-2026 were given preference to capture the most up-to-date state of implementation and policy adjustments.

Sources were also considered when they specifically discussed the connection between supply-chain sustainability practices and environmental, operational, or economic performance, or when they described an India-specific regulatory or capability problem. The synthesis was structured on eight themes, namely: green procurement, eco-design, energy and carbon efficiency, logistics, circularity, digitalization, drivers and barriers, and performance integration. The analysis did not assume trade-offs and complementarities between cost and environmental outcomes and instead focused on evidence that those practices are likely to increase sustainability.

It is an interpretive review and not a meta-analysis. The various sectors, sample sizes, constructs, time periods, and definitions of economic and environmental performance studied use imply that a single pooled effect cannot be used. Instead, it aims at finding common mechanisms, conditions of implementation and management strategies applicable to Indian manufacturing. The review has a limitation of inconsistent evidence across industries, as well as the fact that most empirical research is based on perceptions of managers, as opposed to audited performance data, to which the limitation is also acknowledged in the literature on the Indian GSCM (Vijayvargy et al., 2021; Gupta et al., 2025).

4. Findings and Discussion

4.1 Cost-Effectiveness and Environmental Performance Are Often Complementary

Literature demonstrates that the connection between cost and environmental performance is complimentary rather than the conventional trade-off story. Operating cost and environmental impact can be minimized by practices which minimize energy, material consumption, defects, transport kilometers, packaging, or waste. In a meta-analysis of environmentally sustainable supply chain practices, Golicic and Smith (2013) revealed evidence of positive correlations with performance, although Indian research indicates that GSCM can be used to enhance operational and environmental performance (Mitra and Datta, 2014; Vijayvargy et al., 2021).

Nevertheless, economic gains are indirect or lagging. Vijayvargy et al. (2021) discovered that certain dimensions of GSCM influenced environmental and operational performance more explicitly than direct economic performance, whereas Dubey et al. (2019) revealed that the environmental benefits of low-carbon practices were not significantly linked to the economic performance. This implies that avoided costs, risk reduction, productivity, quality, and future compliance exposure should be measured by firms instead of necessarily having all sustainability projects produce accounting profit in the short term.

4.2 TCOO is More Proper Than the Purchase price.

One result is that sustainable sourcing must be based on a change of purchase-price management to total-cost-of-ownership logic. Low-cost inputs may create hidden costs by being high scrap, inefficient in energy use, defective, unsafe to handle, disposal, regulatory, or unstable supply. An expensive material on the other hand could enhance process yield, product durability, recyclability or transport efficiency. The life-cycle cost and environmental impact must thus be included in the supplier evaluation in green procurement decisions (Carter and Rogers, 2008; Zhu et al., 2008).

This change is particularly significant in the Indian manufacturing where procurement departments tend to be pressurized by aggressive cost targets and suppliers are intensely price-driven. Unless energy, waste, quality, or recovering values are factored in the procurement incentive, sustainability criteria will continue to take the back seat. Trade-offs can be better assessed by cross-functional sourcing teams comprising procurement, engineering, operations, finance, and sustainability and finding suppliers who develop lower total system cost (Das, 2018; Khan et al., 2022).

4.3 Supplier Development Is More Effective Than Compliance-Only Approaches

Standards and capability development should be integrated in supplier environmental management. Certification, emissions information, recycled content or restricted-substance compliance can be mandated to large manufacturers, yet most smaller suppliers do not have the systems to deliver on these expectations. Compliance-only approaches may minimize supplier access or change cost without enhancing processes (Vijayvargy et al., 2017).

Supplier development may deliver better long-term outcomes with joint energy audit, lean-and-green projects, technical training, using shared measurement templates, quality improvement, and financing efficient equipment. This kind of cooperation is consistent with the theory of SSCM that focuses more on interorganizational cooperation as opposed to unilateral pressure (Seuring & Muller, 2008; Pagell and Wu, 2009). This capability will probably be central to value-chain sustainability at reasonable cost to Indian manufacturers that have large networks of suppliers that are MSMEs.

4.4 Energy Efficiency Offers the Clearest Win-Win Opportunity

One of the most powerful spheres of the simultaneous economic and environmental benefits is revealed in energy efficiency. By increasing the efficiency of processes, utilizing waste heat, minimizing compressed-air losses, optimizing motors and furnaces, and using structured energy management, energy-intensive industries can lower their costs and emissions. The PAT scheme in India is specifically modeled on the basis of cost-effective energy-intensity improvement and has provided large-scale proven energy savings among specified consumers (PIB, 2024; BEE, 2026).

To the manufacturers, this means that priorities should be put on projects based on their potential energy saving, capital requirement, payback, operational risk and carbon impact. More strategic decarbonization investments can be put in place with quick-payback efficiency measures. The shift of some industrial sectors to a carbon-intensity compliance regime under the Carbon Credit Trading Scheme also implies that energy efficiency will have an increasing impact on the operating cost and carbon-market exposure (BEE, 2026).

4.5 Eco-Design Reduces Downstream Cost When Integrated Early

When sustainability is considered during the initial stages of engineering, eco-design is able to decrease the environmental impact without raising the final cost of the product. The material mass reduction, simplification of product architecture, component standardization, greater durability, and recyclability can reduce procurement costs, assembly costs, standardization of components, warranty costs, and end-of-life costs. This integrated design approach is supported by Indian evidence stating that green product and product design as a powerful sustainability driver (Gupta et al., 2025).

On the contrary, it is costly to add environmental features after the completion of product development. Companies must thus incorporate the life-cycle criteria in stage-gate development, value engineering, and design reviews. Quality, manufacturability and cost are to be taken into consideration with environmental metrics. This transforms sustainability into a downstream compliance check as an innovation parameter (Srivastava, 2007; Sarkis et al., 2011).

4.6 Green Logistics Should Begin with Utilization and Network Efficiency

Green logistics programs are commonly linked with expensive technology, yet the review indicates that efficiency of operations should be achieved initially. Logistics cost and emissions can be reduced through better load factors, shipment consolidation, shipment route optimization, empty movement reduction, redesign packaging, and warehouse energy management. These are typically less capital-intensive than replacing the fleet, and can be scaled with digital planning (Dekker et al., 2012).

Electrification and alternative fuels can generate some additional environmental benefits, but their cost-effectiveness varies with route length, usage, access to charging, duty cycle in a vehicle, and the price of energy. Indian manufacturers are thus advised to partition logistics lanes and choose technologies that operate at competitive total cost, where the operating conditions are favorable. Portfolio approach may involve optimization of traditional transport and specific implementation of cleaner technologies (Evangelista et al., 2018).

4.7 Circularity Converts Waste Cost into Resource Value

Another good opportunity to balance cost and environmental goals is offered by circular supply-chain practices. The manufacture of scrap, packaging, obsolete inventory, used products and production by-products may be transformed into inputs or recovery revenue instead of disposal liabilities. Remanufacturing, investment recovery, and recycling decrease the need of virgin material and may result in a reduction of the cost of waste-management (Guide & Van Wassenhove, 2009; Govindan and Soleimani, 2017).

Empirical data in India have been especially conducive to investment recovery which has been cited as one of the significant sources of environmental performance (Vijayvargy et al., 2021). The requirement of extended producer responsibility is making the concepts of circular design and reverse logistics more significant since end-of-life responsibility is becoming significant to the producer. Companies that reformulate products and packaging to be easier to recycle can decrease compliance cost in the long run and enhance material security.

4.8 Digital Visibility Enables More Precise Sustainability Decisions

When firms are unable to separate where the environmental impact and costs are incurred, sustainability programmes are likely to fail. Digital systems enhance the transparency of energy, emissions, supplier performance, waste, inventory, and logistics. This allows hotspot analysis and avoids the possibility of an even distribution of resources among activities with a very unequal environmental impact (Bag et al., 2021).

The BRSR Core value-chain model adds even greater significance to the traceable sustainability data among big listed companies and their important suppliers and customers (SEBI, 2023, 2025). The manufacturers are thus advised to come up with standard data definitions, collection where possible, automatic collection and supplier reporting protocols and verification controls. The goal must be decision-useful data and not as much information as possible: managers must have sufficient accuracy to compare suppliers, monitor intensity, find exceptions, and quantify improvement.

4.9 Leadership and Cross-Functional Governance Determine Implementation Quality

Top-management commitment is a key requirement to sustainable supply-chain performance that is constantly identified in the review. Sustainability projects tend to be cross-functional and may entail conflicting goals between procurement, production, finance, logistics, marketing and suppliers. In the absence of senior sponsorship, the cost pressures may prevail over environmental criteria or environmental programmes may be disconnected with the operational decisions (Luthra et al., 2016; Gupta et al., 2025).

Cross-functional governance is therefore required. The manufacturers are advised to establish explicit energy ownership, supplier environmental performance, logistics emission, waste recovery and product

sustainability in their operation reviews. The involvement in finance is especially crucial since sustainability projects require plausible business cases that acknowledge the cash savings, cost avoidance, working capital, future regulatory exposure, and strategic value instead of direct revenue alone (Das, 2018).

4.10 Regulation Is Shifting Sustainability from Voluntary to Strategic

The cost of environmental inaction is rising in India due to the sustainability policy landscape. PAT and carbon-market development, extended producer responsibility and BRSR-related value-chain disclosure enhances the financial relevance of resource efficiency and environmental performance. Regulation has already been noted as a substantial force of the implementation of GSCM in the Indian automobile manufacturing, and the existing policy trends reinforce this force (Luthra et al., 2016; PIB, 2024).

Regulation must however be considered as a minimum requirement as opposed to the whole business case. When the compliance becomes mandatory, firms will have to spend on capital expenditure in a rush, have fewer suppliers, and have poor data systems. Premature integration enables organizations to learn, develop supplier capability and realize efficiency savings before the requirements become more constrained. Proactive sustainability can thus minimize transition cost and enhance access to customers which set global value-chain requirements.

4.11 SMEs Require Different Sustainability Pathways

Small and medium-sized manufacturers experience varying economic constraints to big firms. They can be unstaffed with committed sustainability personnel, resources to invest in efficient technologies, supplier bargaining power, or complex data systems. Standardized requirements may thus lead to unequal implementation overheads. The Indian evidence indicates that the adoption of GSCM is not uniform among firms of different sizes and that the environmental capability of suppliers is not even (Vijayvargy et al., 2017).

The cost-effective SME routes must focus on shared services, cluster-based energy audits, standard reporting templates, access to green finance, shared recycling systems, and technical support by a major customer or industry associations. Big manufacturers have the opportunity to enhance their own scope-three and value-chain performance by assisting small suppliers to become better than merely ignore them. This practice is in favor of environmental betterment.

4.12 Performance Measurement Must Integrate Financial and Environmental Indicators

Sustainable performance of supply-chain must be quantified with matched economic and environmental indicators. They may be energy cost per unit, energy intensity, freight cost and emissions per tonne-kilometer, scrap cost and waste intensity, material yield and rate of recycled content, supplier cost performance and environmental compliance, or recovery revenue and landfill diversion. Measures are aided by pairing to allow managers to detect initiatives that enhance both dimensions, and to allow trade-offs to become explicit (Carter and Rogers, 2008; Golicic and Smith, 2013).

Where necessary, there should also be a normalization of environmental indicators to production activity. An increase in absolute emissions can be experienced as a company expands although efficiency of a process increases, but intensity measures can show the performance behind the scene. Meanwhile, companies are advised to watch the absolute effects when regulatory or climate targets require an overall reduction. A balanced dashboard must thus be a combination of cost, operational, intensity, and absolute environmental measures in conjunction with leading indicators like supplier coverage and progress of project implementation (Gupta et al., 2025).

5. Conclusion and Recommendations

5.1 Conclusion

This review confirms the fact that sustainable supply chain management has the potential to promote both cost-efficiency and environmental performance across the manufacturing industry in India, though the connection depends on the nature of the practice, implementing potential, and time horizon. Direct win-win benefits are often given by energy efficiency, waste reduction, optimization of logistics, improvement of material yield and investment recovery. Other initiatives that might need initial investment, such as supplier transformation, advanced traceability, eco-design, cleaner technologies, and a circular infrastructure, can generate long-term value by reducing resource exposure, regulatory readiness, resilience, and accessing the market (Golicic & Smith, 2013; Vijayvargy et al., 2021).

The facts have further revealed that the issue of environmental sustainability is also becoming a supply-chain governance problem and not a factory problem. Environmental outcomes are influenced by supplier capability, logistics choices, product design, consumer needs, end-of-life systems and value-chain reporting. The PAT and carbon-market systems, extended producer responsibility, and BRSR value-chain disclosure model are supporting this move and increasing the significance of data, traceability, and cross-organizational cooperation in India (BEE, 2026; SEBI, 2023, 2025).

The main management implications of this are that manufacturers need to consider sustainability as a productivity, innovation, and risk-management agenda. The life-cycle and total-cost logic should be considered in one when it comes to cost and environmental objectives. Sustainability is economically plausible when it is integrated in sourcing, engineering, operations, logistics, finance and supplier relationships as opposed to being treated as a special reporting process (Carter and Rogers, 2008; Pagell and Wu, 2009).

5.2 Recommendations

First, Indian manufacturers must pinpoint the environmental hotspots in their end-to-end supply chains and focus interventions based on materiality, cost, and operational value. The ranking should prioritize energy, material loss, transport, packaging, water, and waste as well as high-impact suppliers to ensure that investment is made in activities that have the greatest environmental and economic leverage (Srivastava, 2007; Gupta et al., 2025).

Second, procurement needs to embrace total-cost-of-ownership models that include quality, energy, waste, logistics, compliance, and recovery impacts. The supplier scorecards must integrate the cost, delivery, quality, and environmental measures but the measures must be decision relevant. Structured development support should be provided to critical suppliers instead of compliance requests (Vijayvargy et al., 2017).

Third, companies need to speed up energy-efficiency initiatives and combine energy information with production and finance. The scaled measurement of the quick-payback efficiency should be measured, whereas the more significant decarbonization investments must be measured in terms of future carbon-market and energy-price conditions. PAT and the new Carbon Credit Trading Scheme must be seen as strategic indicators and not just a regulatory liability (PIB, 2024; BEE, 2026).

Fourth, the product development should be incorporated with sustainability. The material efficiency, repairability, recycled material, packaging, logistic footprint, and end-of-life recovery of the product should be considered by the design teams at the earliest design phase. The environmentally preferable designs must not be unnecessarily expensive, and this should be prevented by life-cycle costing and value engineering (Sarkis et al., 2011; Gupta et al., 2025).

Fifth, the efficiency principle that should be introduced to logistics sustainability is the consolidation, route planning, load improvement, packaging optimization, and warehouse energy management. The introduction of cleaner vehicles and alternative fuel should be done in a selective manner with route economics and infrastructure considerations supporting competitive total cost (Dekker et al., 2012).

Sixth, manufacturers are to create circular supply chains by means of reverse logistics, investment recovery, product take-back, reuse, remanufacturing, and recycled-material partnerships. Procurement and design should be linked to the circularity programmes in such a way that the quality specifications of the recovered materials and their economic outlets are stable (Guide and Van Wassenhove, 2009; Govindan and Soleimani, 2017).

Seventh, companies need to define value-chain sustainability data architecture. The importance of common definitions, supplier templates, traceability controls, automated measurement, and verification procedures will only grow due to the increased BRSR Core and customer reporting requirements. The process of data collection must be made in a way that enhances the quality of operational decisions and external disclosure (SEBI, 2023, 2025).

Eighth, the large manufacturers are expected to facilitate sustainability capacity of MSME suppliers based suppliers regarding training, audits, digital tools, technical assistance, and financing. This will minimise the risk of environmental requirements locking out smaller domestic suppliers or just push costs upwards without ameliorating processes (Vijayvargy et al., 2017; Vadukiya and Mundra, 2024).

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