IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, November 2025
Impact Factor: 7.67

A Review of Environmental, Economic, and Technological Challenges in Green FMCG Logistics

Bhavya Kala HV[1] and Dr. Sapna Rathore[2]
[1]Research Scholar, Department of Commerce
[2]Research Guide, Department of Commerce
Vikrant University, Gwalior (M.P.)

Abstract: *Green logistics has become increasingly significant in the Fast-Moving Consumer Goods sector due to rising environmental concerns and stakeholder pressure. This review explores major environmental, economic, and technological challenges hindering the integration of green technologies in FMCG logistics. Through analysis of existing literature, the study identifies barriers and opportunities, and proposes future research directions. The integration of green technology in Fast-Moving Consumer Goods logistics presents both significant opportunities and complex challenges. This review explores environmental, economic, and technological barriers affecting sustainable logistics practices. Environmental challenges include high carbon emissions, waste generation, and inadequate green infrastructure. Economic challenges involve high implementation costs, uncertain returns on investment, and budget constraints. Technological challenges encompass integration with existing systems, workforce skill gaps, and data security concerns. Despite these obstacles, green logistics offers potential benefits such as operational efficiency, regulatory compliance, brand enhancement, and long-term cost savings. The study highlights strategies and future directions for effective green technology adoption in FMCG supply chains.*

Keywords: Green Logistics, Sustainable Transportation, Environmental Challenges

I. INTRODUCTION

The FMCG industry relies on efficient logistics to handle high product turnover at low cost. However, traditional logistics practices contribute significantly to carbon emissions, energy consumption, and waste generation (Srivastava, 2007). Green logistics aims to minimize environmental impact through sustainable technologies, cleaner processes, and optimized supply chains (Mangla et al., 2018). Despite benefits, adoption faces multifaceted challenges that require systematic investigation.

The Fast-Moving Consumer Goods sector is one of the most dynamic and competitive industries worldwide, characterized by high-volume production, rapid product turnover, and a complex supply chain network that spans sourcing, manufacturing, warehousing, and distribution (Mangla et al., 2018). The logistics function within FMCG operations plays a critical role in ensuring timely delivery, cost efficiency, and customer satisfaction. However, traditional logistics practices in this sector heavily rely on fossil fuel-based transportation, extensive packaging, and energy-intensive warehousing, contributing significantly to environmental degradation, carbon emissions, and resource depletion (Srivastava, 2007; McKinnon et al., 2015). As global awareness of climate change and environmental sustainability increases, FMCG companies are under mounting pressure from regulators, consumers, and investors to adopt greener logistics practices.

Green logistics, defined as the design and management of supply chains with reduced environmental impact, has emerged as a strategic necessity rather than a mere corporate social responsibility initiative (Dekker et al., 2012). It encompasses a wide range of practices, including sustainable transportation, energy-efficient warehousing, eco-friendly packaging, reverse logistics, and integration of renewable energy technologies. Despite the potential benefits, the

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 2, November 2025 Impact Factor: 7.67

adoption of green logistics in FMCG supply chains remains inconsistent and slow due to multiple interrelated challenges spanning environmental, economic, and technological domains (Govindan et al., 2014). These challenges hinder large-scale implementation and require systematic investigation to identify feasible strategies and policy interventions.

From an environmental perspective, the FMCG sector contributes significantly to global greenhouse gas emissions. Transport operations alone account for a major share of carbon footprints due to the frequent and rapid movement of goods across regions (European Environment Agency, 2020). Packaging waste, especially from single-use plastics, further exacerbates environmental pressure. While regulations increasingly mandate reductions in emissions and waste, many FMCG companies face difficulties in meeting these standards due to inadequate infrastructure and technological support (Geueke et al., 2018). The limited availability of electric vehicle charging stations, renewable energy-powered warehouses, and energy-efficient cold chains poses practical constraints on adopting greener logistics solutions. Moreover, integrating circular economy principles, such as material recovery and recycling, is challenging in high-volume FMCG operations, where speed and cost-efficiency are prioritized (Mangla et al., 2018).

Economic challenges also play a significant role in slowing the transition toward green logistics. The upfront costs of adopting eco-friendly technologies including electric or hybrid transportation fleets, solar-powered warehouses, and IoT-enabled logistics monitoring systems are substantial (Dekker et al., 2012). Small and medium-sized FMCG firms, in particular, struggle to justify these investments due to budget constraints and uncertain returns on investment (Kramer & Haigh, 2009). Even large firms may be hesitant because the financial benefits of reduced fuel consumption, lower waste disposal costs, and improved brand image often accrue over a long period, rather than immediately. In addition, fluctuating energy prices and inconsistent government incentives in different regions create further financial unpredictability, making long-term planning for sustainable logistics more complex (Govindan et al., 2014).

Technological barriers present another critical dimension of challenge. Implementing green logistics solutions requires advanced technologies such as route optimization algorithms, predictive analytics for demand forecasting, blockchain for traceability, and IoT-based asset tracking (Wang & Sarkis, 2017). However, integration with existing legacy systems is often problematic due to interoperability issues and a lack of standardized platforms (Brettel et al., 2012). Moreover, the workforce in many FMCG companies lacks the necessary skills to operate and maintain sophisticated green technologies effectively. Training programs and knowledge transfer initiatives are essential but add to operational costs and implementation time. Data security and privacy concerns also pose a significant challenge, as increased digitalization exposes logistics data to potential cyberattacks, further slowing the adoption of innovative solutions (Zhang et al., 2020).

Despite these challenges, the opportunities for green logistics adoption in the FMCG sector are substantial. Efficient logistics planning, such as route optimization, load consolidation, and adoption of renewable energy sources, can reduce fuel consumption and operating costs over time (Hofmann & Rutschmann, 2017). Moreover, the integration of sustainable practices enhances corporate image and brand equity, attracting environmentally conscious consumers. With growing consumer awareness of sustainability, FMCG companies that prioritize green logistics can gain a competitive advantage in increasingly environmentally sensitive markets (Chen, 2013). Government incentives, such as tax benefits, grants, and subsidies, further support the financial feasibility of adopting green technologies (Porter & van der Linde, 1995).

The complexity of FMCG logistics, coupled with environmental, economic, and technological constraints, necessitates a comprehensive review of existing literature to identify the barriers and potential enablers for green technology integration. Several studies have explored individual aspects, such as carbon footprint reduction (McKinnon et al., 2015), supply chain sustainability (Srivastava, 2007), and technological innovation adoption (Wang & Sarkis, 2017). However, few studies systematically combine environmental, economic, and technological challenges in a holistic framework that is specific to FMCG logistics. A thorough understanding of these interconnected challenges is essential for managers, policymakers, and researchers to design scalable, effective, and sustainable logistics strategies.

Furthermore, the global nature of FMCG supply chains adds another layer of complexity. Companies often operate across multiple countries with differing environmental regulations, economic conditions, and technological readiness levels. This necessitates flexible, adaptable, and locally responsive green logistics solutions (Mangla et al., 2018).

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 2, November 2025 Impact Factor: 7.67

Collaboration among supply chain partners, including suppliers, distributors, logistics service providers, and government agencies, is crucial for overcoming barriers and leveraging opportunities in green logistics. Coordination mechanisms, shared investments, and knowledge exchange can help reduce costs, mitigate risks, and improve the overall environmental performance of FMCG supply chains.

Green technology adoption in FMCG logistics presents a multidimensional challenge, encompassing environmental regulations, high costs, technological integration issues, and workforce limitations. Nevertheless, the sector also stands to gain from enhanced operational efficiency, reduced environmental impact, improved brand image, and alignment with sustainability goals. A systematic review of environmental, economic, and technological challenges, supported by case studies and empirical data, is critical to advancing the practical implementation of green logistics in FMCG operations. This study seeks to bridge gaps in current literature and provide insights for sustainable, cost-effective, and technologically feasible logistics practices in the FMCG sector.

ENVIRONMENTAL CHALLENGES

1. High Carbon Emissions and Regulatory Pressure

The FMCG sector is a large contributor to greenhouse gas emissions due to freight transportation and packaging waste (McKinnon et al., 2015). Stricter environmental regulations demand rapid decarbonization, increasing compliance burden for logistics providers (European Environment Agency, 2020). The FMCG sector significantly contributes to global carbon emissions due to high-frequency transportation, extensive packaging, and energy-intensive warehousing operations (McKinnon et al., 2015).

Road freight, air transport, and cold chain logistics collectively account for a substantial portion of greenhouse gas emissions, impacting both climate change and air quality (European Environment Agency, 2020). Regulatory frameworks at national and international levels, including carbon taxation, emission caps, and mandatory reporting, are increasingly stringent, pressuring FMCG companies to reduce their environmental footprint (Geueke et al., 2018).

Non-compliance can result in legal penalties, reputational damage, and increased operational costs. These regulatory pressures, combined with growing consumer demand for sustainable products, necessitate urgent adoption of eco-friendly logistics practices such as electric or hybrid vehicles, route optimization, energy-efficient warehousing, and sustainable packaging (Mangla et al., 2018). Consequently, balancing operational efficiency with environmental compliance remains a core challenge for FMCG logistics management.

2. Limited Availability of Green Infrastructure

The lack of charging stations for electric vehicles, sustainable warehousing, and renewable energy systems limits the feasibility of sustainable logistics solutions (Geueke et al., 2018). Inadequate infrastructure increases dependency on fossil fuel–based systems.

One of the major barriers to implementing green logistics in FMCG operations is the limited availability of green infrastructure. Sustainable logistics solutions, such as electric vehicles, solar-powered warehouses, energy-efficient cold storage, and renewable energy-based distribution centers, require substantial infrastructure support (Geueke et al., 2018). In many regions, charging stations for EVs are sparse, and renewable energy supply is inconsistent, limiting the feasibility of transitioning from fossil fuel-based systems (Mangla et al., 2018). Additionally, reverse logistics for recycling or reusing packaging materials often lacks organized collection and processing facilities, increasing operational complexity (McKinnon et al., 2015). The high cost of constructing eco-friendly warehouses and retrofitting existing facilities further constrains adoption, particularly for small and medium-sized FMCG firms (Govindan et al., 2014). Addressing these limitations requires coordinated efforts from governments, industry stakeholders, and technology providers to expand infrastructure availability, promote standardization, and provide incentives for sustainable investments.

ECONOMIC CHALLENGES

1. High Implementation and Operational Costs

Green technologies such as EV fleets, solar-powered warehouses, and advanced emission monitoring require substantial initial investment (Dekker et al., 2012). Smaller FMCG firms often lack financial capacity to adopt such

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 2, November 2025 Impact Factor: 7.67

technologies, making cost a major barrier (Govindan et al., 2014). One of the primary barriers to adopting green logistics in FMCG operations is the high implementation and operational costs associated with sustainable technologies. Integrating eco-friendly solutions, such as electric or hybrid vehicle fleets, renewable energy-powered warehouses, and advanced tracking systems, requires substantial upfront capital investment (Dekker, Bloemhof, & Mallidis, 2012).

These costs include procurement, installation, system integration, and employee training, which are often beyond the financial capacity of small and medium-sized FMCG firms (Govindan et al., 2014). Operational costs, such as maintenance of electric vehicles, software updates for IoT-enabled monitoring systems, and energy management of solar-powered storage facilities, further add to financial burden (Mangla et al., 2018). Additionally, uncertain returns on investment and long payback periods discourage firms from committing to large-scale green technology adoption (Kramer & Haigh, 2009). Consequently, high costs remain a significant constraint in scaling sustainable logistics solutions in the FMCG sector.

2. Uncertain Return on Investment

Investments in green logistics do not always lead to immediate tangible financial returns. ROI timelines can be long, discouraging decision-makers from committing resources (Kramer & Haigh, 2009). This impedes large-scale green technology adoption. One of the primary economic challenges in adopting green technologies in FMCG logistics is the uncertain return on investment. Implementing eco-friendly solutions such as electric vehicle fleets, renewable energy-powered warehouses, and IoT-enabled logistics tracking systems requires substantial upfront capital (Dekker et al., 2012). However, the financial benefits of these investments, including reduced fuel costs, lower emissions penalties, and enhanced brand reputation, are often realized over a longer period rather than immediately (Kramer & Haigh, 2009). This delayed ROI creates hesitation among FMCG firms, particularly small and medium enterprises, in committing resources to sustainable logistics initiatives (Govindan et al., 2014). Moreover, fluctuating energy prices, inconsistent government incentives, and regional regulatory differences further complicate the prediction of financial returns. Addressing this uncertainty requires comprehensive cost-benefit analyses, supportive policies, and strategic investment planning to make green logistics economically viable and attractive to stakeholders.

TECHNOLOGICAL CHALLENGES

1. Integration and Interoperability Issues

Green technologies often lack standardized platforms, causing difficulties in integrating them into existing logistics systems (Brettel et al., 2012). For example, IoT sensor networks may not synchronize with legacy logistics software. One of the primary technological challenges in implementing green logistics in FMCG supply chains is the integration and interoperability of new systems with existing infrastructure. FMCG companies often operate with legacy logistics software, which is not designed to accommodate modern green technologies such as IoT-enabled asset tracking, blockchain-based traceability, or AI-driven route optimization (Brettel et al., 2012).

The lack of standardized protocols and platform compatibility creates operational inefficiencies, delays, and higher implementation costs. Additionally, integrating diverse technologies across multiple stakeholders suppliers, distributors, and third-party logistics providers complicates data sharing and synchronization, reducing the effectiveness of sustainability initiatives (Wang & Sarkis, 2017). Interoperability issues also impact real-time monitoring, predictive maintenance, and decision automation, which are critical for optimizing resource utilization and minimizing environmental impact. Addressing these challenges requires standardization efforts, middleware solutions, and strategic collaboration among stakeholders to ensure seamless technology integration in FMCG logistics networks (Dekker et al., 2012).

2. Skilled Workforce Deficit

Implementing advanced technologies like AI-based routing, blockchain for traceability, and predictive analytics requires specialized skills (Wang & Sarkis, 2017). A shortage of trained professionals limits effective deployment. A major technological challenge in implementing green logistics in FMCG supply chains is the shortage of a skilled workforce capable of operating and maintaining advanced sustainable technologies. Green logistics relies on digital

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 2, November 2025 Impact Factor: 7.67

tools such as IoT-enabled asset tracking, predictive analytics for demand forecasting, blockchain for supply chain transparency, and AI-driven route optimization (Wang & Sarkis, 2017).

Many FMCG firms, especially in developing regions, face difficulties due to employees lacking technical expertise or formal training in these technologies (Brettel et al., 2012). This skills gap delays the adoption of green initiatives, increases reliance on external consultants, and raises operational costs. Additionally, insufficient knowledge about environmental compliance, renewable energy management, and circular economy practices limits the effective utilization of green technologies (Mangla et al., 2018). Addressing workforce skill deficits through targeted training programs, workshops, and knowledge-sharing initiatives is essential for sustainable logistics transformation and long-term operational efficiency.

DATA SECURITY AND PRIVACY CONCERNS

With increased reliance on digital technologies, logistics data become more vulnerable to cyberattacks and privacy breaches (Zhang et al., 2020). Companies are cautious about technology adoption due to potential security risks. The adoption of green technologies in FMCG logistics increasingly relies on digital solutions such as IoT-enabled fleet tracking, AI-based route optimization, cloud-based warehouse management, and blockchain for supply chain traceability (Wang & Sarkis, 2017). While these innovations enhance operational efficiency and sustainability, they also expose logistics systems to data security and privacy risks. Sensitive information, including supplier contracts, inventory levels, customer data, and transport routes, may be vulnerable to cyberattacks, data breaches, and ransomware attacks (Zhang et al., 2020).

Moreover, the integration of multiple digital platforms with legacy systems can create interoperability gaps, increasing vulnerability to unauthorized access (Brettel et al., 2012). Compliance with data protection regulations such as GDPR or local privacy laws adds another layer of complexity. Addressing these risks requires robust cybersecurity measures, encryption protocols, employee training, and regular audits, ensuring both secure operations and stakeholder trust while promoting sustainable logistics practices (Geueke et al., 2018).

OPPORTUNITIES FOR GREEN TECHNOLOGY ADOPTION

1. Enhanced Operational Efficiency

Green technologies such as route optimization, load consolidation, and electric fleets can significantly reduce fuel consumption and operating costs over time (Hofmann & Rutschmann, 2017). Enhanced operational efficiency is one of the most significant benefits of integrating green technologies into FMCG logistics. Sustainable practices such as route optimization, load consolidation, energy-efficient warehousing, and adoption of electric or hybrid fleets reduce fuel consumption, minimize idle time, and lower overall operational costs (Hofmann & Rutschmann, 2017).

The use of advanced technologies, including IoT-enabled asset tracking, predictive analytics for demand forecasting, and automated inventory management, allows real-time monitoring and decision-making, improving supply chain responsiveness and reducing delays (Wang & Sarkis, 2017). Moreover, energy-efficient cold chain solutions and renewable-powered warehouses not only reduce environmental impact but also enhance productivity by ensuring optimal storage conditions and lowering energy expenditure (Dekker et al., 2012). Studies have shown that firms adopting green logistics practices experience measurable gains in efficiency while maintaining service quality, demonstrating that environmental sustainability and operational performance can be mutually reinforcing (McKinnon et al., 2015).

2. Competitive Advantage and Brand Value

Consumers increasingly value sustainability. FMCG firms that integrate green logistics can enhance brand reputation and capture environmentally conscious market segments (Chen, 2013). Integrating green technology in FMCG logistics not only enhances operational efficiency but also strengthens competitive advantage and brand value. Consumers increasingly prefer companies demonstrating environmental responsibility, making sustainable logistics a differentiating factor in a highly competitive market (Chen, 2013). By adopting eco-friendly transportation, energy-efficient warehousing, and sustainable packaging, FMCG companies can reduce their environmental footprint while signaling corporate commitment to sustainability.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 2, November 2025 Impact Factor: 7.67

This proactive approach fosters consumer trust, loyalty, and positive brand perception, which can translate into increased market share (Porter & van der Linde, 1995). Furthermore, companies that lead in green logistics often attract environmentally conscious investors and partners, enhancing long-term financial stability and market positioning (Mangla et al., 2018). In addition, sustainable practices can generate cost savings through optimized resource utilization and energy efficiency, reinforcing both operational and strategic competitiveness (Hofmann & Rutschmann, 2017).

POLICY SUPPORT AND INCENTIVES

Governments worldwide offer incentives for adopting green technologies, including tax credits, subsidies, and grants, which can offset initial investment challenges (Porter & van der Linde, 1995). Government policies and incentives play a crucial role in promoting green technology adoption in FMCG logistics. Regulatory frameworks, such as emission standards, waste management laws, and energy efficiency mandates, compel companies to integrate sustainable practices (European Environment Agency, 2020).

In addition to regulations, financial incentives including tax credits, grants, subsidies, and low-interest loans help offset the high initial costs associated with green logistics technologies, such as electric fleets, renewable energy-powered warehouses, and IoT-enabled monitoring systems (Porter & van der Linde, 1995; Govindan et al., 2014). Policy support also extends to research and development initiatives, public-private partnerships, and infrastructure development, such as EV charging networks and sustainable transport corridors, which facilitate operational feasibility for FMCG firms (Mangla et al., 2018). Effective policy implementation encourages innovation, reduces financial risk, and accelerates the transition toward environmentally sustainable supply chains, creating both economic and ecological benefits.

SUMMARY OF CHALLENGES AND OPPORTUNITIES

Category	Challenges	Opportunities
Environmental	High emissions, regulatory compliance, lack of green infrastructure	Reduced ecological footprint, alignment with global sustainability goals
Economic	High costs, uncertain ROI, budget constraints	Long-term cost savings, subsidies, market differentiation
Technological	Integration issues, skilled workforce deficit, data security concerns	Efficiency gains, innovation in logistics processes, digital transformation

II. CONCLUSION

Green technology integration in FMCG logistics offers substantial environmental and economic benefits but is impeded by significant barriers. Environmental regulations, cost considerations, and technological limitations are core challenges. However, with strategic investment, workforce training, standardization efforts, and supportive policies, FMCG logistics can transition toward sustainability. Future research should focus on empirical studies and case analyses to evaluate best practices and scalable models.

REFERENCES

[1]. Chen, Y. (2013). Green supply chain practices and firm performance: Evidence from the Chinese manufacturing industry. *Journal of Cleaner Production*.

[2]. Dekker, R., Bloemhof, J., & Mallidis, I. (2012). Operations Research for green logistics — An overview of aspects, issues, contributions and challenges. *European Journal of Operational Research*.

[3]. European Environment Agency. (2020). Greenhouse gas emissions from transport.

[4]. Geueke, B., Groh, K., & Muncke, J. (2018). Circular economy and its risks and benefits for sustainability. *Current Opinion in Green and Sustainable Chemistry*.

[5]. Govindan, K., Azevedo, S.G., Carvalho, H., & Cruz-Machado, V. (2014). Impact of supply chain sustainability on operational performance: A case study approach. *International Journal of Production Economics*.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, November 2025
Impact Factor: 7.67

[6]. Hofmann, E., & Rutschmann, M. (2017). Assessment of logistics asset performance for sustainable supply chain management. *Journal of Business Logistics*.

[7]. Kramer, M.R., & Haigh, M. (2009). The role of scale in creating green growth. *Harvard Business Review*.

[8]. Mangla, S.K., et al. (2018). Supply chain challenges in FMCG industry for sustainability implementation. *Journal of Retailing and Consumer Services*.

[9]. McKinnon, A.C., Browne, M., Whiteing, A., & Piecyk, M. (2015). Green Logistics: Improving the environmental sustainability of logistics. *Kogan Page*.

[10]. Porter, M.E., & van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*.

[11]. Srivastava, S.K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews*.

[12]. Wang, X., & Sarkis, J. (2017). Technological challenges in sustainable supply chain management: The role of innovation and information systems. *International Journal of Logistics Management*.

[13]. Zhang, X., et al. (2020). Cybersecurity risks in digital logistics and supply chains. *Journal of Information Security*.