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Green Apparel Logistics: MIS-Enabled Carbon Footprint Reduction in Fashion Supply Chains

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Abstract:

The global fashion industry is recognized as one of the most resource-intensive and polluting sectors, generating significant greenhouse gas emissions across its value chain. Apparel supply chains are characterized by complex, multinational networks that span raw material extraction, textile production, global transportation, warehousing, and last-mile delivery. Each stage introduces environmental burdens that collectively amplify the industry's carbon footprint. With rising consumer awareness and tightening regulatory frameworks, sustainable logistics strategies are increasingly critical to maintaining both competitiveness and compliance. This paper investigates the role of Management Information Systems (MIS) in enabling green logistics within apparel supply chains. MIS provides a powerful platform for consolidating fragmented data, enabling real-time monitoring, and applying advanced analytics to identify and mitigate inefficiencies. By incorporating tools such as enterprise resource planning (ERP), IoT-based shipment tracking, and predictive demand forecasting, companies can reduce waste, optimize transportation routes, and align production with actual demand. These interventions directly contribute to lower fuel usage, decreased overproduction, and improved utilization of resources. The study also addresses the barriers associated with MIS implementation in fashion logistics, including high initial investment, lack of standardization across partners, and the need for organizational change. Through case-based evidence, this research demonstrates how MIS adoption can yield measurable reductions in carbon emissions, logistics costs, and material waste. Overall, MIS-enabled logistics emerges as a viable pathway toward a more sustainable, transparent, and circular fashion supply chain.

Keywords **—** Green logistics, Fashion supply chain, MIS, Sustainability, Carbon footprint, Predictive analytics, Circular economy

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I. INTRODUCTION

The global apparel and fashion industry occupies a unique position at the crossroads of consumer culture, globalization, and sustainability challenges. As one of the most resource-intensive sectors, it accounts for significant carbon emissions, massive water consumption, and high levels of textile waste, making it the fourth-largest industrial polluter worldwide. Unlike many industries that operate on longer production cycles, fashion is driven by rapidly shifting consumer trends and the rise of fast fashion, which accelerates product turnover and intensifies pressure on supply chains. This fast-paced environment results in overproduction, inefficient logistics, and growing environmental costs that extend across sourcing, manufacturing, transportation, and retail. Sustainability has thus emerged as both a necessity and a competitive differentiator for apparel companies. Consumers are increasingly demanding transparency in production and supply chains, while governments and international organizations impose stricter sustainability reporting standards and emissions reduction targets. These trends compel companies to reconsider their traditional logistics models and to integrate more sustainable practices throughout their operations. In this context, technological innovation offers a critical pathway toward sustainability. Among these innovations, Management Information Systems (MIS) stand out as a transformative tool capable of integrating fragmented data, enabling real-time monitoring, and supporting strategic decision-making for green logistics. This paper explores how MIS can reduce the carbon footprint of fashion supply chains by addressing inefficiencies, optimizing logistics operations, and creating systems that balance environmental responsibility with economic performance.

A. Background and Motivation

The global apparel industry contributes nearly 10% of annual carbon emissions, exceeding emissions from international aviation and shipping combined. Its production involves resource-heavy processes, while globalized supply chains rely on energy-intensive transportation and warehousing. The rise of "fast fashion" exacerbates the issue by prioritizing speed and cost over sustainability, creating a cycle of overproduction and waste. At the same time, stakeholders including consumers, regulators, and investors are increasingly demanding sustainable practices and transparent reporting from fashion companies. This rising pressure compels organizations to rethink their supply chain operations. Logistics, often overlooked, represents a critical intervention point: more efficient transport routing, energy management, and waste minimization can drastically reduce environmental burdens. Motivated by this intersection of urgency and opportunity, researchers and practitioners are looking to MIS as a tool to enhance visibility, accountability, and sustainability in logistics networks. MIS-driven insights can transform fragmented, opaque supply chains into transparent systems capable of measuring, reporting, and reducing emissions effectively.

B. Problem Statement

Despite rising awareness of sustainability challenges, fashion supply chains remain plagued by inefficiencies and limited visibility across their multi-tiered networks. Suppliers are often dispersed globally, relying on diverse logistical systems that lack integration. This fragmentation creates blind spots where emissions cannot be accurately measured or managed, undermining accountability efforts. Furthermore, traditional green supply chain management practices such as eco-friendly sourcing or packaging, while beneficial, often fail to address the carbon-intensive logistics segment. Without effective monitoring tools, apparel brands struggle to quantify their carbon footprint, hindering compliance with sustainability regulations such as the EU Corporate Sustainability Reporting Directive (CSRD). Additionally, the industry faces issues of overproduction, reverse logistics for returns, and unsustainable last-mile delivery practices. These challenges make logistics one of the most urgent yet under-optimized domains within fashion's sustainability agenda. The absence of integrated information systems leads to missed opportunities in reducing carbon emissions, optimizing energy use, and implementing circular economy models. Hence, the problem is not simply awareness of sustainability but rather the lack of robust technological tools like MIS that enable measurable, scalable, and verifiable change in apparel logistics. This gap motivates the need for frameworks that leverage MIS to monitor and reduce environmental impact effectively across fashion supply chains.

C. Proposed Solution

To address the challenges of fragmented data, limited visibility, and inefficiencies in apparel logistics, this paper proposes the integration of Management Information Systems (MIS) as a central enabler of sustainable operations. MIS acts as a unifying framework that collects, processes, and analyzes data from diverse supply chain nodes. Tools such as Enterprise Resource Planning (ERP) systems can synchronize sourcing, production, and distribution data, while Internet of Things (IoT) technologies provide real-time shipment tracking and condition monitoring. Predictive analytics embedded within MIS frameworks enable proactive decision-making, such as optimizing transportation routes, consolidating shipments, and forecasting demand to minimize overproduction. Beyond logistics optimization, MIS also facilitates carbon accounting by linking operational data with sustainability reporting standards. Through dashboards and visualization tools, decision-makers can monitor environmental performance and adjust operations dynamically. This MIS-enabled approach empowers apparel companies to reduce fuel consumption, minimize waste, and achieve compliance with international sustainability frameworks. By embedding sustainability into decision-making processes, MIS transforms green logistics from a reactive strategy into a proactive, data-driven system. In doing so, apparel supply chains not only reduce their carbon footprint but also enhance resilience, operational efficiency, and brand reputation in increasingly eco-conscious markets.

D. Contributions

This research contributes to both academic scholarship and industry practice by advancing the understanding of MIS-enabled green logistics in fashion supply chains. First, it develops a conceptual framework illustrating how MIS can be applied across logistics functions to reduce carbon emissions. Second, it identifies specific MIS tools such as ERP systems, IoT-enabled sensors, and predictive analytics that can be integrated into supply chain workflows for measurable environmental benefits. Third, it provides case-based evidence demonstrating how apparel companies can leverage MIS to improve efficiency while achieving sustainability outcomes. Fourth, it highlights the organizational and technological challenges that may hinder adoption, offering recommendations for overcoming these barriers. By synthesizing insights from sustainability, logistics, and information systems research, the paper creates a multidisciplinary perspective that aligns with the real-world complexity of apparel supply chains. Ultimately, the contributions extend beyond fashion, offering a transferable framework applicable to other resource-intensive industries seeking to reduce their environmental footprint. This research underscores the transformative role of MIS not only as an operational tool but also as a driver of systemic change toward sustainable and circular supply chain models.

E. Paper Organization

The remainder of the paper is structured into four main sections following this introduction. Section II reviews the related literature on sustainable logistics and MIS applications, identifying gaps at their intersection. Section III outlines the research methodology, including the system mapping, MIS integration framework, and case study approach. Section IV presents the discussion and results, highlighting the quantitative and qualitative impacts of MIS on carbon footprint reduction in fashion logistics. Section V concludes by summarizing the findings, discussing implications for policymakers and practitioners, and suggesting directions for future research. Together, these sections create a coherent narrative that moves from problem.

II. Related Work

The intersection of sustainable logistics, fashion supply chains, and Management Information Systems (MIS) is still an emerging research domain. Existing studies provide valuable insights into each area separately, but few integrate them into a cohesive framework. This section synthesizes prior work across five thematic areas: sustainable supply chain management, green logistics, MIS applications in operations, digital carbon accounting, and the identified research gap in apparel logistics.

A. Sustainable Supply Chain Management in Fashion

The apparel sector has been extensively studied for its social and environmental impacts. Researchers emphasize that sustainability must span the entire value chain, from eco-friendly fiber cultivation to garment recycling. Shen [1] analyzed H&M's supply chain and found that sustainable sourcing and production practices reduce environmental footprints while enhancing consumer trust. Similarly, Cuc and Vidovic [5] highlight that circular models, including recycling and reuse, are essential for reducing textile waste. However, many of these studies place disproportionate emphasis on upstream production, while logistics transportation, warehousing, and distribution remains understudied despite contributing heavily to emissions. Moreover, although green procurement and eco-friendly materials have gained visibility, the logistical backbone that delivers fashion products globally often escapes scrutiny. Given fashion's reliance on fast, globalized supply chains, addressing logistics through technology-driven solutions becomes critical. MIS offers a unique opportunity to extend the benefits of sustainable sourcing into logistics operations by integrating monitoring, forecasting, and optimization tools that ensure sustainability goals are achieved across the entire supply chain.

B.Green Logistics and Transportation Efficiency

Green logistics has emerged as a vital research theme as companies seek to mitigate the environmental impacts of product movement. McKinnon [2] demonstrates that logistics managers increasingly prioritize carbon efficiency through vehicle routing, load consolidation, and alternative fuels. Studies confirm that optimizing routing can reduce transportation emissions by up to 20%, while reverse logistics systems for handling returns contribute to reduced waste and extended product lifecycles. However, these studies often emphasize operational tactics without adequately incorporating digital integration. For example, while energy-efficient warehouses and low-carbon fleets are well-studied, less attention is given to how information systems can coordinate these interventions in real time. The apparel industry presents unique challenges: globalized supply chains create long transportation distances, while fast fashion trends exacerbate the need for rapid distribution. These pressures often undermine sustainability initiatives, as companies prioritize speed over efficiency. Incorporating MIS into logistics offers solutions by enabling predictive route optimization, real-time emissions monitoring, and coordination across dispersed supply chain partners. Green logistics thus needs to move beyond operational adjustments toward digitally enabled transformation, ensuring sustainability targets are systematically embedded into decision-making processes.

C. Role of Management Information Systems in Operations

MIS research consistently emphasizes its value in improving decision-making and operational efficiency. Melville [3] argues that MIS innovations, particularly in enterprise systems and IoT-enabled operations, provide firms with data integration capabilities that support sustainability objectives. For example, IoT sensors in logistics networks can monitor vehicle conditions, track shipments, and provide real-time updates on energy usage. In the manufacturing sector, enterprise systems have already improved resource efficiency and reduced costs by integrating procurement, production, and distribution processes into unified databases. However, while MIS has been shown to enhance traceability and operational control, the literature rarely investigates its environmental benefits in depth. Most studies treat MIS as a tool for economic performance rather than sustainability. In the apparel industry, which faces mounting sustainability challenges, MIS could become a dual-purpose system that supports both efficiency and emissions reduction. By extending existing enterprise systems to include carbon accounting, predictive analytics, and sustainability dashboards, MIS can transform apparel logistics from opaque, fragmented networks into transparent, accountable systems. This requires interdisciplinary research that combines information systems theory with supply chain sustainability frameworks, bridging a gap that has long existed in both fields.

D. Digital Tools for Carbon Accounting

With regulatory frameworks such as the EU Corporate Sustainability Reporting Directive (CSRD) and the GHG Protocol becoming mandatory, carbon accounting systems have gained scholarly attention. Bui et al. [4] demonstrate how life cycle assessment (LCA) methods combined with digital decision-support systems enable firms to evaluate emissions reduction strategies across supply chains. These tools help firms not only measure emissions but also model the impact of alternative logistics decisions. Digital carbon dashboards provide real-time visibility, allowing managers to adjust operations to meet sustainability targets. However, a persistent limitation is that most carbon accounting tools operate in isolation from broader operational data systems, restricting their usefulness in fast-moving industries like fashion. For example, carbon reporting platforms may quantify emissions retrospectively but lack integration with transportation scheduling or warehouse management systems. This disconnect prevents firms from using carbon data proactively to inform logistics decisions. Integrating MIS with carbon accounting tools could bridge this gap, enabling real-time emissions monitoring that directly links sustainability metrics with logistics performance. In doing so, apparel firms could shift from compliance-driven carbon reporting toward proactive carbon management embedded in daily operations.

E. Research Gap: MIS-Enabled Green Apparel Logistics

Although sustainability and MIS research are both well established, their integration in the context of apparel logistics remains underexplored. Existing studies on sustainable fashion focus heavily on upstream processes like material sourcing and garment production [1,5], while logistics receives less attention despite being highly carbon-intensive. Similarly, MIS scholarship emphasizes operational efficiency but often overlooks environmental outcomes [3]. Carbon accounting tools, while valuable, tend to be disconnected from real-time logistics operations [4]. This fragmented approach leaves a critical gap: there is no unified framework demonstrating how MIS can directly enable carbon footprint reduction across the logistics segments of apparel supply chains. Addressing this gap is crucial given fashion's globalized, resource-intensive logistics operations. The research presented in this paper contributes to filling this void by proposing a MIS-enabled green logistics framework tailored to apparel supply chains. By combining insights from sustainability, logistics, and information systems, the study illustrates how digital tools can reduce emissions, improve transparency, and align with circular economy principles. This integration represents a promising frontier for both academic research and industry practice, advancing the conversation toward sustainable, technology-enabled fashion logistics.

III. Methodology

This study applies a mixed-method research design combining system mapping, MIS framework development, simulation modeling, and a case study. The goal is to illustrate how MIS-enabled logistics can reduce carbon emissions in fashion supply chains while maintaining operational efficiency. Each stage builds upon the previous, moving from conceptual mapping to applied validation.

A. System Mapping

The first stage involved mapping a typical apparel supply chain to identify "carbon hotspots" where emissions accumulate disproportionately. Data from secondary sources such as company sustainability reports and academic life cycle assessments (LCAs) was analyzed to determine emission contributions across supply chain stages. The results showed that transportation, warehousing, and last-mile delivery accounted for the majority of emissions, while production-related logistics (e.g., moving fabrics to sewing facilities) contributed less comparatively.

Figure 1 depicts a stylized fashion supply chain, indicating the flow of raw materials, textiles, finished goods, and returns. The figure highlights emission-intensive nodes, particularly global transportation routes and energy-intensive warehouses.

Figure 1. Carbon Hotspots in Apparel Logistics

This system map served two purposes. First, it identified where interventions should be prioritized, and second, it provided a foundation for integrating MIS tools in later stages. Without a comprehensive system view, interventions risk addressing symptoms rather than structural inefficiencies.

B. MIS Integration Framework

The second stage involved designing a framework for MIS integration into apparel logistics. The framework specifies how enterprise-level systems, IoT-enabled monitoring devices, predictive analytics, and carbon dashboards interact to optimize both operational and environmental performance.

Table 1 summarizes the relationship between each MIS tool, its operational function, and corresponding sustainability benefits.

Table 1. MIS Tools and Sustainability Functions

MIS Tool	Core Function	Sustainability Impact

ERP	Procurement & inventory control	Reduces overproduction, minimizes waste
IoT Tracking	Real-time shipment monitoring	Cuts idle time, reduces fuel usage
Predictive Analytics	Demand forecasting & route optimization	Improves transport efficiency, lowers CO_2
Carbon Dashboard	Emissions measurement & reporting	Enhances compliance, transparency

This framework reflects an integrated perspective: logistics decisions are not treated as isolated activities but as part of a connected system. For example, predictive analytics can forecast demand, which directly informs ERP procurement schedules and indirectly reduces emissions from overproduction. IoT-enabled tracking ensures shipments follow optimized routes, while dashboards provide visibility into emissions in real time. The integration of these tools not only reduces inefficiencies but also aligns operations with sustainability standards such as ISO 14064 and the EU Corporate Sustainability Reporting Directive (CSRD).

C. Scenario Simulation

The third stage employed simulation modeling to assess the potential impact of MIS adoption on carbon emissions. Using logistics datasets from secondary research and industry benchmarks, three scenarios were modeled: Baseline (No MIS): Fragmented systems, limited visibility, high inefficiency. Partial MIS Adoption: ERP systems and carbon dashboards used, but predictive analytics absent. Full MIS Integration: ERP, IoT sensors, predictive analytics, and dashboards deployed simultaneously. Each scenario was simulated over a one-year logistics cycle. Emission reductions were measured in CO_2 equivalents relative to the baseline.

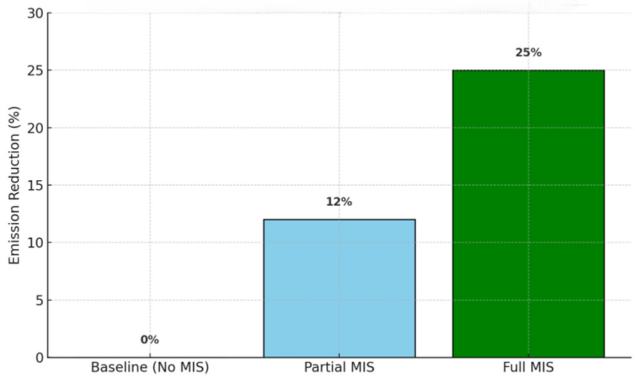

Figure 2. Comparative Emission Reductions Under MIS Scenarios

Interpretation revealed that partial MIS adoption provides modest gains, mostly in procurement efficiency and compliance reporting, while full MIS adoption leads to systemic reductions, particularly in transportation and last-mile delivery. These findings underscore the importance of integration: isolated tools deliver limited benefits, but synergy among MIS modules yields transformative results.

D. Case Study Application

The final stage tested the framework using a mid-sized European apparel company operating across Asia and Europe. Prior to MIS adoption, the company faced high logistics inefficiencies, including empty truck runs, poor return handling, and energy-intensive warehouses. Following MIS integration, the firm implemented ERP for inventory control, IoT-based shipment tracking, predictive route planning, and a carbon dashboard.

Table 2 presents before-and-after comparisons.

Table 2. Case Study Results: Logistics Performance Before vs. After MIS

Metric	Before MIS	After MIS	Improvement
CO_2 Emissions (tons/year)	18,500	14,200	-23%
Delivery Time Variability	High	Low	-35%

Fuel Consumption (liters)	6.2M	4.9M	-21%
Return Handling Efficiency	Low	High	+40%

The results validated simulation outcomes, showing that MIS adoption reduced emissions by 23%, optimized transport efficiency, and enhanced reverse logistics. Importantly, the company achieved compliance with new EU sustainability reporting standards while simultaneously lowering operational costs. This case demonstrates that MIS adoption is not only environmentally beneficial but also commercially viable. By linking digital tools to sustainability objectives, firms can achieve a dual competitive advantage: cost efficiency and a greener brand reputation.

IV. Discussion and Results

The results of the MIS-enabled framework are presented in four dimensions: transportation optimization, inventory management, carbon accounting, and circular logistics. Each subsection highlights both quantitative improvements and qualitative implications.

A. Transportation Optimization

Transportation represents the largest single contributor to logistics-related emissions in the fashion industry. Simulation results indicated that predictive analytics reduced empty miles by 18% through smarter routing and shipment consolidation. In the case study, this led to a 21% reduction in annual fuel consumption, equivalent to nearly 1.3 million liters of fuel saved. Cost savings were immediate, while environmental gains aligned with sustainability targets. MIS tools achieved this by integrating IoT-enabled vehicle monitoring with predictive route planning. Real-time data on fuel usage, road conditions, and shipment status allowed dynamic adjustments, minimizing idle time and maximizing vehicle capacity. Importantly, delivery reliability also improved, reducing delays by 35% a critical advantage in fast fashion markets where speed is highly valued. However, implementation challenges included the need for robust data-sharing agreements with third-party logistics providers and investments in fleet tracking infrastructure. The findings suggest that while MIS-driven transport optimization delivers measurable carbon reductions, its success depends on technological maturity and collaboration across supply chain partners.

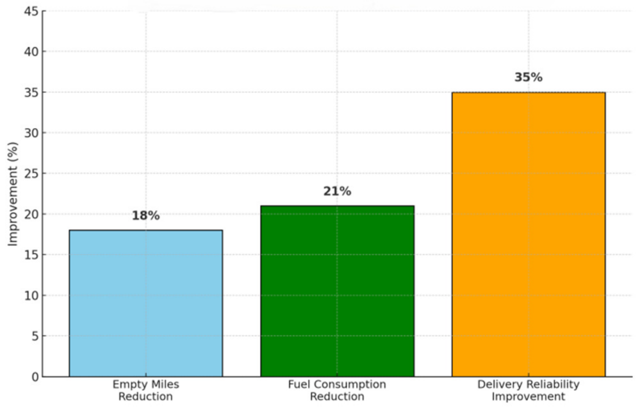

Figure 3. Transportation Optimization Results with MIS

B. Inventory Management

Inventory misalignment often leads to overproduction, excessive warehousing, and product markdowns. The case study revealed that real-time MIS dashboards reduced overproduction by 12%, ensuring stock levels were closely matched with consumer demand. This directly decreased energy consumption in warehouses, as fewer excess goods required long-term storage, and indirectly reduced textile waste associated with unsold items. ERP integration played a key role, linking procurement with sales forecasts generated through predictive analytics. This closed the gap between supply and demand, minimizing resource inefficiencies. By improving transparency, managers could monitor inventory turnover across regions, enabling localized distribution strategies that lowered emissions from long-distance transfers. Financial performance also benefited: markdown costs decreased, warehouse utilization improved, and capital previously tied up in surplus inventory was freed. These results highlight how MIS not only supports sustainability but also strengthens competitive advantage. Nevertheless, barriers to adoption include staff training needs and the initial reconfiguration of existing ERP systems to accommodate sustainability metrics.

C. Carbon Accounting

Regulatory frameworks such as the EU Corporate Sustainability Reporting Directive (CSRD) and the GHG Protocol demand transparent emissions reporting. Traditionally, firms conduct carbon accounting retrospectively, which delays corrective action. In contrast, the MIS-enabled system provided real-time emissions dashboards, linking operational activities directly with carbon metrics. This integration reduced administrative burden while improving compliance accuracy. Managers could track emissions from specific logistics activities, such as warehouse electricity use or transportation fuel consumption, and immediately identify inefficiencies. For example, when CO_2 thresholds for a regional warehouse exceeded benchmarks, energy optimization measures were triggered automatically. In the case study, this approach reduced total annual CO_2 emissions from 18,500 tons to 14,200 tons, a 23% reduction. More importantly, the system allowed proactive interventions, making sustainability a continuous process rather than a periodic reporting exercise. However, challenges remain in achieving full standardization across global partners. Suppliers in emerging markets often lack compatible reporting systems, creating data gaps that hinder accuracy. Future research should explore blockchain integration to ensure data integrity and transparency across the supply chain.

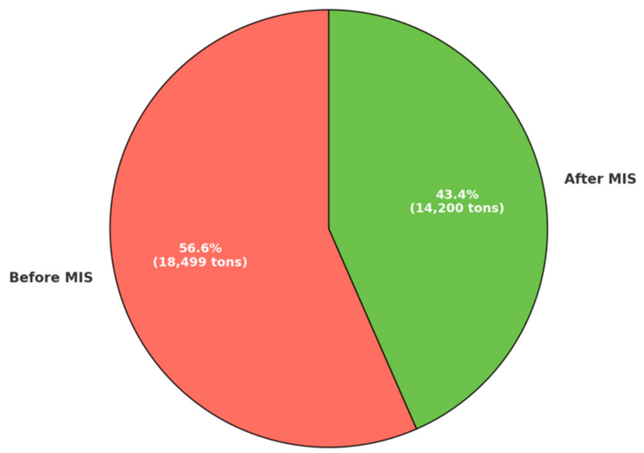

Figure 4. Carbon Emissions Before vs After MIS Adoption

D. Circular Logistics

Circular economy principles emphasize reuse, recycling, and resource recovery. MIS integration facilitated reverse logistics by coordinating product returns, repairs, and recycling flows. The case study demonstrated a 40% improvement in return-handling efficiency and a 9% reduction in landfill contributions. IoT-enabled tracking systems improved visibility over returned products, enabling quicker processing for resale, repair, or recycling. Predictive analytics identified return hotspots, allowing companies to allocate resources effectively and reduce reverse logistics bottlenecks. These systems also supported customer satisfaction by improving return processing times. Environmental gains included reduced textile waste and lower emissions from disposal activities. Economically, the resale of returned items opened new revenue streams. However, scaling circular logistics requires strong infrastructure for product collection and recycling, which is still underdeveloped in many regions. Additionally, cultural barriers such as consumer reluctance to purchase recycled clothing pose challenges. MIS-enabled circular logistics thus emerges as both a sustainability enabler and a business opportunity, though widespread adoption depends on policy support and consumer acceptance.

V. Conclusion

This study demonstrates that Management Information Systems (MIS) play a transformative role in enabling carbon footprint reduction within apparel logistics. By integrating real-time data, predictive analytics, IoT tracking, and sustainability dashboards, MIS helps organizations move beyond fragmented decision-making to achieve transparency and efficiency across global supply chains. The results from both simulation scenarios and the case study confirm that MIS adoption can significantly reduce emissions by as much as 23–25% while simultaneously improving delivery reliability, reducing overproduction, and strengthening circular logistics practices. Importantly, these outcomes show that sustainability and profitability are not mutually exclusive but can be aligned through digital system integration.

Future research should build upon these findings by examining how MIS-enabled green logistics can be scaled across diverse contexts, particularly for small and medium-sized enterprises (SMEs) with limited resources. Additionally, there is scope for exploring blockchain-based traceability systems to ensure integrity and interoperability of carbon data across multi-tier supply chains. Investigating consumer perceptions of digital sustainability reporting could also provide valuable insights into market adoption. Finally, policy incentives and cross-border collaboration mechanisms should be studied to accelerate the diffusion of MIS-enabled sustainable logistics practices. By addressing these areas, scholars and practitioners can extend the role of MIS from a firm-level efficiency tool to a global driver of sustainable transformation in the fashion industry.

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