



## The Future Of Fashion Logistics: Sustainability, Innovation, And Circularity

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### Abstract

The textile industry plays a significant role in carbon emissions, particularly due to fast fashion, and is considered the second-largest polluter in the world. Apart from manufacturing and disposal, logistics in the fashion industry also plays an important role in contributing to greenhouse gas (GHG) emissions. This paper examines sustainable logistics in fashion, focusing on minimizing environmental impact while ensuring efficiency and ethical practices. It highlights key principles such as resource efficiency, circular economy practices, and responsible sourcing. The primary aspects of sustainable supply chain management, including green sourcing, optimized transportation, and effective inventory control, are discussed to reduce waste and carbon emissions. The role of eco-friendly packaging, energy-efficient warehousing, and reverse logistics in promoting reuse and recycling is also examined. Additionally, the paper emphasizes the integration of technologies such as IoT, artificial intelligence, and blockchain to enhance transparency and demand forecasting. Through key observations and emerging trends such as last-mile delivery, the paper provides operational strategies for building robust and sustainable fashion logistics systems.

**Keywords:** Carbon Emissions; Green Supply Chain Management; Sustainable Fashion Logistics

### 1. Introduction

Sustainability has become a critically important global concern, particularly within the textile industry, which is recognized as one of the largest contributors to environmental pollution. Textile waste is often identified as the second-largest polluter, with textile products contributing approximately 5% of global greenhouse gas emissions[1]. While much attention has been given to sustainable production practices, it is increasingly evident that sustainability cannot be achieved through production alone. Sustainable logistics plays a crucial role in ensuring the overall environmental performance of the textile and fashion industry. From packaging to transportation, every stage of logistics significantly influences the carbon footprint of a product. Proper packaging is essential to prevent product damage and avoid unnecessary waste, while efficient route planning and the use of eco-friendly transportation systems help reduce energy consumption and emissions. Therefore, integrating sustainable logistics practices alongside sustainable production is essential to achieving a truly environmentally responsible fashion system.

### 2. Methods

This paper is based on secondary data analysis, using existing literature for sustainable fashion logistics practices investigation. In particular, a narrative literature review was used as the research methodology, aimed at summarizing insights provided by existing literature. The data relevant to the topic of sustainable fashion logistics and practices were obtained from online databases and scholarly websites, including peer-reviewed articles, scientific papers, reports, sustainability frameworks, and other documents, related to the topic of the study. In particular, the following inclusion criteria were set up to select the literature sources used for data collection. Documents discussing the problem of sustainability in fashion and logistics industries. Literature covering various environmental, economic, and social aspects of supply chains. Sources of recent date to ensure current insight. Finally, the thematic analysis was performed to systematize and interpret the gathered information. Namely, concepts and findings presented in separate papers were categorized according to such thematic



categories as sustainable practices of logistics, supply chain transparency, technological measures, challenges and performance measures, etc. It should be noted that no primary data will be collected in the context of the study.

### 3. Concept Of Sustainable Fashion Logistics

Sustainable fashion logistics include such approaches as EV cargo that provide the different means of shipping and thus ensure the use of environmentally friendly approaches of delivery of goods. By using cleaner means of delivery, it becomes possible to reduce adverse impacts on the environment[2]. Moreover, it is worth noting that the use of eco-friendly fuels for ships, trucks, and planes is another way to make the process sustainable. For example, methanol can be used for ships because it can be biodegraded. Another way to make air transport sustainable includes the use of sustainable aviation fuels obtained from biowastes[3]. It is also necessary to take into account that proper routing and planning of the logistics processes play a major role in ensuring sustainability. Ineffective planning can result in inefficient use of energy. Such use can be represented not only by fuel but also by electric power used for transportation. It is also clear that with the right choice of routing, it is possible to significantly reduce the use of energy resources, decrease distances to be covered and make carbon footprint lower. Optimization of routes helps to significantly decrease the emission of greenhouse gases[2]. Moreover, the improper handling of returns, wrong deliveries, and changing addresses are the challenges that occur in fashion logistics and hamper sustainability. The improper handling of returns makes it impossible to reuse items. In other words, when returning process becomes ineffective, more items will become unfit to sell again due to failing to meet quality requirements[2], [4]. Furthermore, the process of returning itself increases energy expenses; hence, makes the logistics process less sustainable. To solve this problem, it becomes essential to optimize the returns process. Logistics strategies for in-store recycling programs might help reduce the carbon footprint and make the process more sustainable[3]. Besides, appropriate packaging of products, consolidation of loads and proper handling

of materials are necessary in order to ensure sustainability in fashion logistics[4]. Otherwise, damage caused to items during transportation leads to necessity to repeat all processes related to manufacturing of clothes. This procedure costs much and takes too much time. Clothes that are damaged during transportation can be simply thrown away. Automation is also one of the main features of sustainable logistics. Automated warehouses help to reduce energy expenses, avoid wasting resources, make rational use of space and contribute to increasing efficiency. Finally, it should be mentioned that the green packaging process provides for the use of recyclable materials only[3].

### 4. Importance Of Sustainable Logistics

Sustainable logistics is an important aspect in the modern-day supply chain management as it seeks to ensure low environmental impact alongside ethical practices and increased economic efficiency. In terms of environmental impact, sustainable logistics helps minimize the amount of waste produced, conserve natural resources, reduce the emissions of greenhouse gases, as well as encourage the usage of reusable and environmentally friendly packaging. Socially, sustainable logistics focuses on fair treatment of workers employed within logistics companies through offering fair wages, maintaining high health and safety standards, respecting human rights and other aspects associated with the workers' wellbeing. Economically, sustainable logistics ensures savings through efficient use of natural resources, operational efficiency, and improved risk management. Other benefits of embracing sustainable logistics include building the company's brand value, establishing consumer trust and creating competitive advantages in the international marketplace[6]. This type of logistics closely relates to CSR and ESG objectives. Sustainable logistics is becoming more popular due to various reasons including strict governmental regulations regarding sustainability practices, consumers' increasing preference for green brands and companies' commitment to achieving net-zero emissions[7]. The importance of sustainable logistics is further enhanced with the emergence of new technologies such as AI-based logistics optimization, usage of blockchain technology for transparency, IoT

enabled logistics tracking systems, reverse logistics systems, and product lifecycle assessment[8].

### **5. Sustainable Supply Chain Management**

The need for Sustainable Supply Chain Management (SSCM) in the fast fashion industry, producing a massive amount of synthetic and petroleum-based clothing products, contributing to excessive textile waste, and carbon emissions, is crucial in overcoming the environmental crisis. Moreover, the fragmentation of supply chains in developing countries adds complexity in implementing sustainability. On the other hand, eco-consumerism is putting pressure on brands to develop sustainable operations. The Patagonia brand has demonstrated sustainability practices in supply chain management by funding environmental projects and supporting NGOs and following globally recognized standards, such as OEKO-TEX, GOTS, and Fair Trade, and ensuring compliance in the suppliers' operations.

By embracing SSCM, organizations may achieve the following:

- Reducing negative impacts on the environment due to sourcing and manufacturing processes
- Ensuring corporate social responsibility through promoting social sustainability
- Embedding sustainability within the whole product lifecycle

Patagonia's sustainability is embedded in all organizational processes through four steps of systematic sustainability:

- Measuring environmental impact
- Reducing greenhouse gas emissions and resource consumption
- Moving towards renewable energy sources  
Capturing and offsetting carbon emissions

Moreover, the company promotes circular economy practices by working together with consumers on repair, reuse, and recycling efforts[5]. SSCM stresses on environmentally responsible practices at all stages of production and distribution. Green purchasing involves the process of eco-friendly raw materials sourcing to minimize the environment damage caused by dangerous inputs. Carbon dioxide emissions produced during distribution of goods

through transportation can be reduced. Also, needs efficient inventory management to lessen the waste and lead time[13].

### **6. Supply Chain Management In Logistics**

The use of Supply Chain Management (SCM) technologies proves crucial in achieving sustainability through materials' traceability, responsible sourcing, and collaboration of suppliers that guarantees compliance with ecological and ethical criteria. The use of predictive analytics makes possible avoiding waste generation, overproduction, and risks management. Supply chain sustainability is important due to the growing need of sustainability in consumers, investments, and government policies, helping protect the environment and society, as well as making businesses economically feasible. The key determinants of sustainability in supply chains include environmental (minimizing carbon footprints and applying eco-friendly material), economic (making the processes profitable and viable), and social sustainability (respecting ethical labor standards). However, there are several barriers, such as lack of transparency in the bottom tiers of supply chains, high initial costs, complex legal requirements, and unwillingness to sustainably operate. Therefore, taking certain actions to make a supply chain sustainable, for example, analyzing the tiers, evaluating suppliers, monitoring SCM technologies, and applying ecological sustainability practices can prove helpful[10].

### **7. Supplier Tier Visibility In Sustainable Fashion Logistics**

The supplier tier system, consisting of Tiers 1, 2, and 3 (where Tier 1 comprises direct suppliers, Tier 2 indirect suppliers, and Tier 3 raw material suppliers), is important for sustainable fashion logistics because environmental and social problems are more likely to arise further down the line. Visibility at all three tiers can help to pinpoint any problems related to carbon emissions, waste, and unethical labor, even if visibility is difficult to achieve due to a lack of transparency and information.[9].

### **8. Key Principles Of Sustainable Fashion Logistics**

Sustainable fashion logistics is adapted to follow the principles of integrating environmental



responsibility, circularity, resource efficiency, transparency, and ethical governance across the global supply chain. It highlights the decarbonization process through low-carbon transportation, energy-efficient operations in logistics, and usage of renewable energy, and promotes sustainable supply chain management. The key principle is to collaborate with the suppliers and stakeholders through transparency, adhering to standards, and joint sustainable goals. Circular logistics consisting of five R's: repair, recycle, resale, reverse logistics, resale, supports in the extension of product life and the reduction of waste. The central key factor is the thought of life cycle from material sourcing to end-of-life disposal, requires assessment of environmental impacts[12].

## 9. Core Components Of Sustainable Logistics

### 9.1.Packaging & Material Handling

The large and difficulty of modern distribution channels domineer the use of new innovative packaging. Packaging is seen crucial as it protects the product, but there is a need of environmental protection also. So ethical packaging is an unavoidable area of business in environmental concerns. LCA has been used for years to evaluate packaging sustainability. Packaging optimization can reduce the impact on the environment. It quotes the importance of avoiding chemicals, insoluble adhesives and labels reduce burden on environmental impact. The use of non-recyclable, multi-layered labels is also another issue. The packaging done with different geometric and alternative materials requires constructed adjustments. It may have the involvement in mechanical behavior, overall structural performance, and geometric difficulty[14].

### 9.2.Reverse Logistics

Reverse logistics helps in advancing the circular economy. The concept of effectiveness is based on defeating barriers such as low return on investments, strategic planning, deficiency, indigent supply chain visibility, and policy gaps. Regulating these changes through the adoption of technology, sustainable partnerships, and policy frameworks, strengthens economic, and increases social responsibility, environmentally friendly and escalate the efficiency of circular supply chain management[15]. It involves

the movement of goods from customers, back to sellers for reuse, returns, refurbishment, disposal, and recycling with the main aim of redeeming the product value, shrinking losses, and enhancing the customer satisfaction which is a key circular economy practice[16]. The technologies that can make sustainable logistics possible arise from the use of IoT solutions to facilitate real-time tracking and visibility within the supply chain; the application of AI and algorithms for demand forecasting and inventory management; and the use of automation aided by data systems. The above-mentioned technologies can assist in minimizing overproduction and enhancing traceability along the fashion supply chain[17].

## 10. Current Issues In Fashion Logistics

The contemporary fashion logistics system faces several challenges due to fast-changing trends and globalization. Rapid production cycles demand highly flexible systems, while trend-based inventory often results in overproduction and waste. Cost pressures can strain supplier relationships, potentially compromising product quality and labor ethics. Unethical practices like poor working conditions and low wages remain a concern, especially in complex supply chains. Fashion logistics also has significant environmental impacts, including carbon emissions and textile waste. Multi-tier supplier networks reduce transparency and complicate regulatory compliance. At the same time, reliance on technologies such as AI and real-time tracking is growing to boost efficiency and minimize waste. Balancing speed, cost, and sustainability continues to be a major challenge[11].

## 11. Metrics, Kpis, And Reporting Frameworks In Sustainable Logistics

**Carbon Footprint Measurement** The measurement of carbon footprint plays a vital role within sustainable logistics, which includes the calculation of the total greenhouse gas (GHG) emissions in terms of CO<sub>2</sub> equivalent (CO<sub>2</sub>e). Carbon footprint is usually divided into Scope 1, Scope 2, and Scope 3 according to the source of the emission. While Scope 1 is directly related to the source, Scope 2 includes indirect emissions that may appear during energy use, and Scope 3 covers all value chain emissions related to transportation, packaging, and returns, for



instance. Measuring these emissions helps in detecting the hotspots of emissions, the efficiency of emission reduction policies, and aligning the operations with the global goals of climate protection. Besides carbon footprint measurements, Environmental Key Performance Indicators (KPIs), based on such standards as ISO 14001, provide organizations with the means to measure their sustainability in various aspects, including, but not limited to, CO<sub>2</sub> emissions, energy use and energy efficiency (kWh/one product unit), fuel usage and efficiency (litres/km, delivery optimization, and fleet efficiency), packaging waste and material intensity, waste produced and recycling rate, and water consumption (in particular, in the logistics of textiles and fashion items). KPIs should be measurable, relevant, time bound, and actionable for an organization. Reporting Standards ISO 14001, Global Recycled Standard (GRS), and Higg Index add another layer of sustainability to logistics by providing organizations with structured environmental management systems, transparent tracking of recycled materials flow, and holistic assessment of both environmental and social impacts[18].

## **12. Future Trends In Sustainable Fashion Logistics**

Sustainable fashion logistics is undergoing a transformative shift driven by environmental concerns, technological advancements, and evolving consumer expectations. One of the most significant emerging trends is the adoption of green last-mile delivery systems, as rapid urbanisation and the growth of e-commerce have intensified delivery demand, leading to increased traffic congestion and greenhouse gas emissions. In response, governments are encouraging the transition to low-emission transport through incentives such as subsidies for electric vehicles and higher taxes on polluting vehicles, prompting companies to adopt electric delivery fleets, cargo bikes, drones, and smart delivery systems that reduce both environmental impact and operational costs. At the same time, automation and robotics are gaining importance in sustainable warehousing, with technologies such as robotic systems, automated sorting, and drone-

assisted logistics helping to manage high delivery volumes, improve efficiency, and minimise resource wastage; however, their adoption remains gradual due to continued consumer preference for humanised delivery experiences, indicating the need for a balance between technological efficiency and customer trust. Furthermore, consumer-driven demand is playing a crucial role in shaping sustainable logistics, as customers increasingly prefer eco-friendly delivery options but remain sensitive to cost, speed, and convenience, with satisfaction largely dependent on punctuality and reliability. Limited awareness of green logistics practices and policies further highlights the importance of transparency, education, and incentives to encourage sustainable behaviour. In addition to these primary trends, supporting developments such as green packaging innovations, policy-driven sustainability initiatives, and the growing use of data-driven logistics and optimisation models are reinforcing the transition toward more efficient and environmentally responsible supply chains. Overall, the future of sustainable fashion logistics will depend on the integration of green technologies, automation, and consumer-centric approaches, ensuring that sustainability aligns with economic feasibility and service quality[19].

## **13. Results And Discussion**

### **13.1. Results**

Sustainability in fashion logistics involves three main factors - environmental, economic, and social ones along the whole supply chain, with transportation, packaging, warehousing, and reverse logistics being the key areas contributing to environmental issues. In turn, transportation, especially last-mile delivery, is known for a high rate of emissions, while packaging is one of the causes of waste. Meanwhile, reverse logistics contributes to recycling and reusing clothes, although at a lower rate due to high costs and other issues. Finally, digital technologies, supplier transparency (especially in lower tiers), and consumers' preferences play a role in fashion logistics.

### **13.2. Discussion**

In general, these findings show that the minimization of carbon footprint in terms of transportation and



other logistics activities is a prerequisite to sustainability. Moreover, environmentally-friendly packaging along with waste minimization measures should be applied in order to avoid harm to the environment. While the possibility of implementing circular practices due to reverse logistics is present, its actual impact largely depends on solving operational problems. At the same time, the use of digital technologies can be beneficial when it comes to logistics operations but may prove to be unaffordable.

### Conclusion

Sustainable fashion logistics needs to be achieved through an integrative process considering environmental, financial, and socio-economic factors. Important aspects including transportation, packaging, reverse logistics, and innovative technologies have proven to be essential for decreasing environmental footprint and enhancing operational effectiveness. Although initiatives such as eco-friendly transport solutions, environmentally friendly packaging, and modern technologies provide substantial advantages, issues including high expenses, inadequate infrastructure, and complex logistics processes continue to present obstacles. The realization of sustainable practices can only be attained with the cooperation of relevant parties, enabling policies, technology adoption, and consumer involvement.

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