

## SUSTAINABILITY AND DIGITAL TECHNOLOGIES IN APPAREL DESIGN

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### **Abstract**

The fashion industry is undergoing a critical transformation as it confronts significant environmental and social challenges associated with its traditional linear model of production and consumption. As one of the most polluting sectors globally, it is responsible for substantial carbon emissions, water contamination, and the accumulation of vast amounts of textile waste – issues further intensified by the rise of fast fashion. In response, sustainable fashion has emerged as a comprehensive framework aimed at reducing environmental impact, promoting ethical labor practices, and advancing the principles of a circular economy.

This article examines the role of digital technologies as key enablers of this transition. Innovations such as 3D design and virtual prototyping minimize the need for physical samples, conserving materials and shortening design cycles. Digital textile printing and on-demand manufacturing combat overproduction and significantly reduce water and energy consumption. Artificial intelligence enhances trend forecasting and supply chain optimization, improving operational efficiency while minimizing waste. Blockchain technologies improve transparency and traceability across the supply chain, reinforcing ethical practices and counteracting product counterfeiting. Virtual try-ons and augmented reality enrich the consumer experience and reduce product returns, while 3D printing enables customized, low-waste production using sustainable materials.

Furthermore, the article discusses how circular economy principles – designing for durability, reuse, repair, and recyclability – are increasingly supported by digital innovations and Extended Producer Responsibility (EPR) frameworks. Although challenges remain, including high implementation costs, data integration complexities, and the need for specialized expertise, the integration of sustainability and digital technologies is emerging as a critical pathway toward a more responsible, transparent, and innovative fashion ecosystem.

**Keywords:** *fashion industry, textiles, clothing, sustainability, digital technologies*