

## SUSTAINABLE

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### DEVELOPMENT OF SUSTAINABLE FASHION

The overgrowth of the fashion industry in the past decades, dominated by a linear model, has led to many problems, making sustainable fashion a focus of both industry and academic attention. Sustainable fashion is a macro and multi-faceted subject, with technology being one of the key drivers in many of the approaches and practices towards sustainable fashion. This report discusses the current landscape and future of technology in sustainable fashion around a number of interrelated and inclusive themes. Due to limitation of themes and descriptive research, some of findings lack quantitative evidence and therefore the impact of technology on sustainable fashion may be deviated or omitted in some degree. It is also worth noting that other drivers and players within and outside the fashion industry simultaneously influence the development and application of technology during the fulfillment of sustainable fashion.

## EXECUTIVE SUMMARY

### Process Model

DEFINE MACRO TOPIC  
Overview of Sustainable Fashion

TARGET MAIN THEMES  
Waste, New Materials and Forms, Business Model

OVERVIEW OF CURRENT LANDSCAPE  
Academic and Industrial

CONSUMER AND MARKET  
Market trend in Sustainable Fashion

DIRECTIONS AND LIMITATIONS  
Indicate potential direction

OPPORTUNITIES AND CHALLENGES  
Align technical issues with market trends

## Introduction

Sustainability in fashion can be analyzed from three interrelated perspectives: **economic, social, and environmental**, each comprising different subfactors (Elkington, 2000). Currently, fashion scholars and practitioners are not only concerned with economic performance, but social and environmental aspects are also receiving more attention than ever before in the past decade (McKinsey, 2022; Mukendi et al., 2020). While sustainable fashion (SF) has become a major area of academic research and business practice, it still lacks a clear-cut definition (Henninger, 2018). In this paper, SF is defined as **all movements aimed at making fashion-related subjects more sustainable**, including but not limited to waste reduction, animal welfare, and human rights, etc (Mukendi et al., 2020).

**Technology** is a critical driver that enables sustainable fashion to thrive and develop, with multiple advanced technologies being applied throughout the fashion industry (Pater et al., 2014). Some of the technologies have proved to make fashion more sustainable, such as blockchain, which improves supply chain transparency, and 3D knitting, which reduces material waste (Scaturro, 2008).

This paper aims to review technologies applied in three important themes of sustainable fashion, which are **waste, sustainable business model and new material and form of fashion** (metaverse) (Figure 1.1). It will then suggest the potential direction for technological application and development in these areas.



## 2.1 Waste

THREE THEMES FOR SUSTAINABLE FASHION

The theme of waste in sustainable fashion has been highlighted a serious issue in various sustainable fashion theories, thus warranting considerable attention in this report.

Shown in Figure 2.1.1, the textile and fashion industry involves a long and complex supply chain, where different forms of waste are produced, including textile, energy, water, etc (Shrivaniyaghadam et al., 2020; Jaccoutt et al., 2010). Textile waste, in particular, has emerged as a major global concern, with the whole fashion industry generating over 92 million tonnes of textile waste annually (Nimmi et al., 2020). Waste is generated at every stage of the textile and fashion value chain from production to consumption, and generally, it can be classified into two categories, namely pre-consumer waste and post-consumer waste (Shrivaniyaghadam et al., 2020).



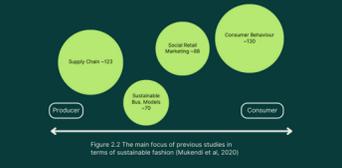
## Overview of Current Landscape

TECHNICAL APPROACH FOR SUSTAINABLE FASHION

Sustainable fashion refers to every phase of fashion pipeline and all three dimensions of sustainability, which is influenced by multiple drivers, such as technology and policy, as well as players, such as retailers, policymakers, consumers, etc (Henninger et al., 2017). Previous research has introduced various models and theories to explore sustainable fashion (diagram 2.1), which encompass different scopes and different angles of approach.

Researcher	Perspectives and Contributions	Reference
Fair Fashion	Accountability, Sustainability, Open and Creative (2016)	Chen and Goodwin (2016)
Global Fashion	Environmental and Social Sustainability	Jeppiaharan (2010, 2011)
Green Fashion	Full process of production, from fibre to fashion	Jeppiaharan (2010, 2011)
Eco Fashion	Full process of production, from fibre to fashion	Jeppiaharan (2010, 2011)
Slow Fashion	Reduce the volume of production, slow down the pace of production	Jeppiaharan (2010, 2011)
Conscious Fashion	Reduce the volume of production, slow down the pace of production	Jeppiaharan (2010, 2011)

Figure 2.1 Overview of Sustainable Fashion (Author's own, 2023)



## 3.2 Opportunities and Challenges

Align Sustainability with Marketing

Sustainability satisfies the psychological needs of ethical consumers and is already a widely adopted competitive advantage. It can also be aligned with marketing (Wener and Carmali, 2006; Kasser, 2009).

Reduce Costs in Sustainable Material Sourcing

In mass production, polyester, polyamide, or synthetic cellulosic fiber is less costly than virgin materials (McKinsey, 2023). Replacing valuable animal materials, such as animal leather and fur, with sustainable artificial materials can also reduce costs (Shannonfabrics, 2019). If a brand were to pass on a green fiber premium to customers, it would lead to a 2% to 12% increase in retail prices. However, products from sustainable brands are much more expensive than non-sustainable peers (McKinsey, 2023).

Extend in Consumer Journey and Customer Engagement

Circular business models such as upcycle and repair extend the customer journey in the post-consumption stage, creating new customer touchpoints and improving customer engagement. Thus increasing customer lifetime value (PLV, 2019; Elf et al., 2021). Swap and rental also leads to a wider range of audiences, such as those with lower incomes and ages (BoF, 2022).

## PRE CONSUMER WASTE

Wastes are generated in every process of garment production, and thousands of tonnes of fabric are wasted before garments reach the consumer (EAC, 2019). Cutting is the process that generates the majority of pre-consumer waste, of which up to 15% fabrics could be recycled (AATCC, 2019; Burns, 2019). The application of digital technology, e.g., computer pattern making, has reduced pre-consumer waste to a large extent (Ghosharyay et al., 2022).



Figure 2.1.2 Textile Scrap in Cutting Room (Source: Medium.com)

## POST CONSUMER WASTE

Globaly, around 56 million tonnes of garments are purchased each year, and this is expected to rise to 93 million tonnes by 2020 and 100 million tonnes by 2050 (BBC, 2020). The main source of waste is clothing that consumers discard, which often ends up in landfills. By 2050, it is estimated that more than 500 million tonnes of clothing will be dumped into landfills (Figure 2.1.3)(BBC, 2020). The decomposition can take years and release harmful pollutants into the environment. In particular, fast fashion model and cheap textile products with a short life span have led to an increase in the quantity of post-consumer textile waste causing serious environmental impacts (Stancu et al., 2021).

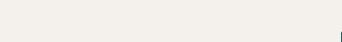


Figure 2.1.3 Textiles End Up in Landfills (Source: SustainFashion)

## Recycle

is an important part of the fashion industry's circular transformation towards Zero Waste (Z). It is defined as a process of materials being shredded or pulled apart into small fractions or fibres, called shoddy or mungo (DEFRA, 2006). Current recycling technologies could be classified into four ways shown below, each with its own positives and negatives.

Mechanical	Thermo-mechanical
<ul style="list-style-type: none"> <li>Make use of physical forces such as cutting and grinding to convert textiles into waste fibres</li> <li>Commercially proven, low energy and cost-efficient</li> <li>Challenge: quality degradation of recycled fibres with a fibre-length reduction of up to 30-40%</li> </ul>	<ul style="list-style-type: none"> <li>Mix use of combination of pressure and heat to melt synthetic textiles and recover polymers</li> <li>Less quality degradation than mechanical recycling technologies, low energy usage and can be used on non-textile</li> <li>Limitation: Can not be used on natural fibres</li> </ul>
Chemical	Thermal-Chemical
<ul style="list-style-type: none"> <li>Involves multiple distinct technologies, which use chemical solvents to break down fibres to the polymer or monomer level</li> <li>Allows returning to almost virgin-quality fibres</li> <li>Requires more energy than mechanical recycling</li> </ul>	<ul style="list-style-type: none"> <li>Make use of gasification to produce which uses chemical solvents to break down fibres to the polymer or monomer level</li> <li>Compatible with all forms of fabric</li> <li>Researching to almost virgin-quality fibres</li> <li>Can not be used in closed-loop recycling</li> </ul>



Figure 2.1.4 Mechanisms of possible textile waste recycling routes (Source: Damayanti, 2021)



Figure 2.1.5 Pinesse Leather from Pineapple Leaf Fibre (Source: Vogue, 2022)



Figure 2.2.1 Louis Vuitton PFP-ink Bag (Source: Vogue, 2022)



Figure 2.2.2 Metaverse NFT Rewards in Game APP (Source: Vogue, 2022)

## 2.2 Sustainable Materials and New Forms of Fashion

THREE THEMES OF SUSTAINABLE FASHION

Technology aids the development of sustainable materials and products

artificial materials could solve social and environmental issues in fashion industry (Fletcher, 2013). Pinesse (Figure 2.2.1), a plant-based leather, is claimed to be an alternative to traditional animal leather and non-biodegradable PU leather, making the product more eco-friendly while ensuring animal welfare (Higgs, 2016). Since its commercial launch in 2015, Pinesse has been used by more than 500 manufacturers, including several luxury and fast-fashion Hugo Boss (BoF, 2018; Nike, 2022).



Figure 2.2.1 Pinesse Leather from Pineapple Leaf Fibre (Source: Vogue, 2022)

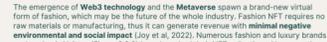


Figure 2.2.2 Louis Vuitton PFP-ink Bag (Source: Vogue, 2022)

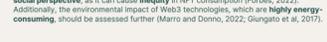


Figure 2.2.3 Metaverse NFT Rewards in Game APP (Source: Vogue, 2022)

## 2.3 Circular Business Model

THREE THEMES OF SUSTAINABLE FASHION

The application of advanced algorithms and data processing technologies in the fashion industry, such as AI and big data, has enabled more accurate forecasting of consumer demand, allowing suppliers and brands to supply on demand, thus avoiding overproduction and reducing waste (Wong and Guo, 2010; Thomassy and Zeng, 2019; Ren et al., 2018). As a result, some of the environmental and social problems are alleviated and the sustainability of the existing growth-oriented fashion business model is enhanced (BoF, 2020). Nevertheless, the current linear fashion model needs to be transformed into a circular model, as it can significantly reduce waste and solve other sustainable problems in the fashion industry. Figure 2.3.1 shows the environmental improvement of circular fashion. Besides technology, other players influence the circular transformation as well, the Textiles 2030 initiative (Figure 2.3.2), a voluntary agreement launched by industrial NOOs, endeavors to guide businesses toward circularization.

Sustainable fashion derives from a wide range of circular business models, including BT (reuse/repair), CT (swap), and CT (buyback), etc.

Digital platforms using circular business models are emerging in the fashion industry, while more and more brands are experimenting with circular business models (EAC, 2019; BoF, 2020). Retail and resale services enable consumers with less disposable income to purchase luxury fashion, while repair services can extend the life cycle of products, resulting in improved resource and reduced waste (Jain et al., 2022; BoF, 2020). However, the circular business model is currently facing a number of barriers and is therefore not always beneficial to the economy and the environment (EMF, 2021). New applications and developments in technology may address some of these barriers.



Figure 2.3.1 CO2 Reduction compared to Linear Model (Source: Circular business review (EMF, 2021), p.30)

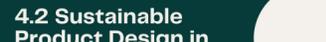


Figure 2.3.2 Textiles 2030 (Source: Textiles 2030)

An agreement to accelerate the UK fashion and textiles industry towards a circular economy (Source: Textiles 2030)

## 3.1 Market and Consumer Analysis

FASHION SHOWED THE FASTEST GROWTH YOY IN CONSUMING SECTION

Figure 3.1.1 Fashion industry grows faster (Source: Deloitte Global Powers of Retailing 2023)



THE FASHION INDUSTRY RETURNS TO GROWTH, WITH SUSTAINABLE NICHE AND CIRCULAR FASHION BUSINESS MODELS TAKING AN INCREASING SHARE OF



Consumer shift changed lifestyles and increased sustainable consumption offer more space for sustainable fashion to develop. Sustainability creates value but quality still ranks top (Mintel, 2018). 57% of consumers consider sustainability important when buying fashion items (Mintel, 2022).

Repairing broken items instead of buying brand new has been a strong trend in the UK, 52% of consumers say they intend to repair (Passport, 2022).

75% consumers recycle items, compared to 56% globally (Passport, 2022).



Figure 3.1.2 The growth of sustainable fashion (Statista, 2022)

85% of UK consumers are willing to buy secondhand fashion, and 53% of them have ever purchased secondhand (Statista, 2022).

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## Market & Consumer

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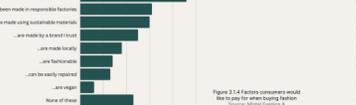
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