

Review Article

# Strategies to Adopt Circular Economy Practices in the Fashion Industry

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**Abstract** - *The fashion industry is a major contributor to global waste and pollution, with fast fashion and a focus on disposability leading to overconsumption and environmental degradation. The circular economy offers a potential solution to these issues by extracting maximum value from resources before recovering and regenerating products and materials. In this paper, we explore strategies that the fashion industry can adopt to move towards a circular economy. These strategies include incorporating closed-loop design, resource efficiency, sustainable production, implementing take-back and recycling programs, and shifting towards rental and sharing models. We also discuss the role of consumers and producers in driving a shift towards a circular economy in the fashion industry. Through an examination of best practices and case studies, this paper highlights the potential for the fashion industry to not only become more sustainable but also more profitable and efficient.*

**Keywords** - *Circular economy, Sustainability, Fashion, Pollution, Clothing.*

## 1. Introduction

The fashion industry is a significant contributor to waste and pollution, both during production and through the disposal of clothing and other textiles. The industry consumes substantial resources to meet the growing demand keeping pace with fast-changing fashion trends, which significantly contribute to social, economic, and, most importantly, environmental issues.

The industry has a noticeable impact on sustainability, including through the use of hazardous chemicals and the consumption of water, energy, and other natural resources, as it involves numerous processes such as spinning, weaving, dyeing, and finishing. According to estimates, the industry produces around 92 million tons of waste every year (Beall 2020), and an average person disposes of up to 70 pounds of textiles annually (Tula 2021). A significant portion of this waste ends up in landfills, where it can take decades to decompose, or is incinerated, making the fashion industry the second largest contributor to air pollution. It accounts for more than 1.2 billion tons of greenhouse gas emissions (Change 2018), and it is estimated that by the year 2050, the industry will have already used about 25% of the world's carbon budget (Pandey 2018).

In addition to the environmental impacts, continued reliance on fast fashion and disposable clothing has contributed to social and economic problems. Many fashion companies produce cheap, low-quality clothing in large quantities, leading to overconsumption and excess textile

waste. This has also led to the overexploitation of labor and increased child labor practices (Yousefi 2020). The fashion industry is highly competitive, with many companies vying for consumer attention. This can lead to pressure to constantly introduce new styles and products, which can be unsustainable in the long term.

Consumers have become increasingly concerned about the impacts of their purchases and are looking for more sustainable options. This creates an urgent need to tackle the environmental, social, and economic problems created by the fashion industry's negligence through circular economy approaches. The circular economy model has gained attention in recent years as it promotes the continual use of resources rather than the traditional linear model of take-make-dispose. In this economic model, resources are kept in use as long as feasible through sustainable practices such as repair, reuse, refurbishment, and recycling (figure 1).

## 2. Methodology

This study employed a systematic literature review (SLR) as a research approach to collect, synthesize, and appraise the findings of all available evidence on the topic to provide a comprehensive overview of the current state of knowledge on this topic (Snyder 2019). This process involved using a systematic and transparent approach to identify, evaluate, and synthesize all relevant studies to minimize bias and ensure the reliability and validity of the review.



An online search was conducted on various databases such as Google scholar, Scopus, and JSTOR to discern the most relevant literature published in English within the last 10 years on this topic. This led to the discovery of numerous relevant journal papers, articles, and published reports strongly linked to the circular fashion concept. Relevant keywords (Circular economy, Sustainability, Fashion, Pollution, Clothing, Textile) were utilized within the databases with different combinations, which generated an array of apt results.

The articles retrieved were thoroughly analyzed based on topics of circular fashion: the definition, general background of the industry, the need for circular practices in fashion, and strategies to implement circular fashion principles in the textile industry.

The discussion centers around four main themes-resource efficiency, which focuses on best practices for sustainable production and waste minimization; circular design, which encourages the better long-lasting design of clothing to extend the product life cycle; and end-of-life circularity, which includes approaches such as recycling, reuse, resale, and repurpose.

### **3. Sustainable Production and Resource efficiency**

Resource efficiency is an essential aspect of a circular economy because it helps to reduce the amount of materials and energy used to create products and provide services (Bocken et al. 2016). This, in turn, can help mitigate the environmental impact of these activities, as well as decrease costs for companies and consumers. It particularly focuses on the efficient and safe use of raw materials and other resources to facilitate circularity along the product life cycle. This strategy contains three broad steps: renewable and sustainable materials, waste mitigation, and minimization of resource consumption.

#### **3.1. Waste Mitigation: Lean Production and Just-in-Time**

Apart from end-of-life waste, a lot of textile waste is created before and during the production process. This includes the material wasted during the cutting process, which is approximately 15% of the fabric used in garment manufacturing (Enes and Kipöz 2020). Further, huge amounts of waste are created when stocks that are unsold in the market are discarded due to seasonal changes.

To manage this waste, zero-waste designs can be created, which ensure that the fabric is fully utilized during production by simplifying designs (Claxton and Kent 2020). In the past zero-waste fashion has been a niche market. However, a circular economy approach can help bring it to light and encourage designers to develop more zero-waste designs (Moorhouse and Moorhouse 2017).

A step towards zero waste is also adopting a lean production process. One of the key principles of lean production is eliminating waste, which can take many forms in the fashion industry, such as excess inventory, long lead times, and overproduction. By identifying and eliminating these forms of waste, lean production can help reduce costs, increase efficiency, and improve the responsiveness of the production process to changes in demand (Shalini 2011). By minimizing waste and maximizing efficiency, lean production can help reduce the use of resources such as water, energy, and materials and thus help reduce pollution and emissions.

Additionally, the industry can move towards a demand-driven business model to reduce the waste created due to unsold stocks. For example, Zara's model has an efficient and sustainable production process based on accurately predicting product demand. Their clever supply-chain strategy includes producing small quantities and restocking when required (Pal and Gander 2018). This is an example of a Just-in-time (JIT) model, which greatly focuses on reducing waste and promoting sustainability within the production process. A benefit of JIT is that it can help to improve efficiency and responsiveness. By only producing what is needed, JIT can help companies to reduce lead times, which can be especially beneficial in the fast-paced fashion industry where styles and trends change quickly (Tsolova 2017). Additionally, by having a better understanding of demand, JIT can help companies to better plan and schedule production, which can help to reduce the overall time, costs, and waste associated with production.

#### **3.2. Sustainable Materials**

Traditional textile production methods are often resource-intensive and can significantly negatively impact the environment. For example, cotton is one of the most pesticide-intensive crops, and conventionally grown cotton uses around 16% of the world's insecticides (Andsager 2019).

Using renewable and sustainable raw materials can help substantially reduce textile production's environmental impact by conserving resources, reducing the use of synthetic chemicals, and promoting sustainable agricultural practices. Examples of sustainable raw materials include organic cotton, hemp, and bamboo. Organic cotton, when grown without the use of synthetic pesticides or fertilizers, can help to reduce water consumption and the use of toxic chemicals. While materials such as organic polyester can help minimize energy and consumption of fossil fuel resources such as petroleum (EEA 2019). Thus, using ecologically responsible natural fibers can considerably reduce the environmental impact associated with the raw material stage of production.

Hazardous chemicals are currently being used in the production of textiles during processes such as bleaching, dyeing, and printing, which poses a serious health risk to humans and animals, as well as the environment. Replacing these toxic chemicals with bio-based inputs is one strategy that can mitigate the danger of using such chemicals (Muthu and Gardetti 2016). Additionally, the industry can innovate using biomimicry for the sustainable functionalization of textiles without using toxic solutions to alleviate the harmful impact of the textile industry (Weerasinghe et al. 2019).

### **3.3. Minimization of Resource Consumption**

The fashion industry currently consumes around 93 billion cubic meters of water annually- 4 percent of all freshwater extracted globally (Ellen MacArthur Foundation 2021). This number is estimated to double by 2030 if no action is taken (GFA 2019). Reduction of water consumption in the industry can be achieved through various methods. Companies can work with each other to reduce or remove water usage from dyeing, stone-washing, and finishing processes. For example, innovations such as 'Air dye technologies' can be adopted, replacing water with air in the dyeing process (Kant 2012). Further, companies can provide customers with clear instructions on cleaning processes to reduce water wastage from washing machine usage.

The industry must also prioritise energy conservation and transition from non-renewable energy to renewable energy sources to bring about environmental and socio-economic benefits. Some measures, such as the utilization of energy-efficient equipment and processes, switching from thermal energy to renewable energy, and wastewater recovery, are already in place (Çay 2018). However, making advancements to reduce dependence on unsustainable processes is still important. This the industry must keep innovating and come up with solutions.

## **4. Circular Design**

When discussing the fashion industry, various stakeholders are involved in it, some being manufacturers, suppliers, businesses, producers, and consumers. However, a very important stakeholder to consider is the designers. The design stage is a very important part of the circular fashion concept because more than 80 percent of the environmental impact of a garment is decided during this production stage (European Commission 2014). Normally, designers are pushed to create designs that are in sync with the fast-fashion concept and can meet consumers' growing demand with the objective of profit maximization, which leads to excess waste creation.

Designing for circularity in fashion refers to the concept of creating a closed-loop system in which clothing and textiles are designed, produced, used, and then recycled or repurposed rather than discarded as waste. This can include

using sustainable materials, designing for longevity and repairability, and implementing recycling and repurposing systems for used clothing. The goal is to lessen the fashion industry's environmental impact, thus moving away from a linear "take-make-waste" model.

### **4.1. Design for Customization and Personalization**

Customization enables consumers to buy clothing with a unique fit and look. Designing for customization includes providing a platform for consumers to design their clothing, allowing them to get exactly what they want and keep their clothing for longer. Each client receives personalized service during the customization process, and by actively participating in the customization process, the consumer transforms into a co-designer, strengthening their affinity with the product (Piller and Müller 2004). This process becomes even easier with the development of modern technology. Designs can be worked on with consumers using computer-aided design (CAD) through 3D digital models or virtual prototyping, allowing customers to make changes and adjustments to the design before producing or purchasing it, minimizing the waste that goes into designing a new product (Mardjetko 2021). Correct fit and customized features can persuade consumers to engage in sustainable consumption habits.

Moreover, customization can also include designing clothing with detachable or interchangeable parts, using modular construction techniques, and incorporating features that allow for easy adjustments. By designing for customization, the clothing can be more personal and satisfying for the consumer and ultimately reduce the need for new clothing to be produced. This strategy refers to the concept of creating clothing and textiles that can be easily adapted, modified, or repurposed to meet the exact requirements and preferences of the user to extend the product's life.

### **4.2. Design for Composting**

This idea encourages designing products that can be easily broken down into nutrient-rich organic matter, which can then be used as a soil amendment for agriculture. One way to achieve design for composting in a circular fashion is to use biodegradable and plant-based materials. These materials can be broken down by microorganisms in a composting system, returning valuable nutrients to the soil.

Composting may not be possible as few materials are fully biodegradable (Niinimäki 2017). However, with recent advancements, it is possible to incorporate this design into some components, such as using bio-inspired polymers, natural dyes, and biomaterials (Dissanayake and Sinha 2015). For instance, Spinnova, a Finnish company, has developed a fiber used to manufacture their clothes that is fully biodegradable and returns to nature quickly (Spinnova).

It is important to consider the entire life cycle of a product, from its design and production to its use and disposal. Designing for composting in a circular fashion requires a holistic approach, considering the whole lifecycle of a product and identifying opportunities for reducing its environmental impact and recovering valuable resources.

#### **4.3. Design for Longevity and Repairability**

Designing for longevity in fashion refers to creating clothing and textiles built to last, which can encourage consumers to keep their clothing for longer periods (Urbinati et al. 2017).

This can include using high-quality, durable materials, designing for repairability and adaptability, and creating timeless, versatile styles that do not quickly go out of fashion (Manshoven et al., 2019). This reduces the need for consumers to replace their clothes with new ones continuously and encourages long-lasting use of existing garments.

Additionally, clothing can be designed to be easy to care for, so they can be used for longer without showing signs of wear and tear. This can be done by using natural fibers that are biodegradable and less chemically treated, designing clothes that are easy to repair, and providing repair and care instructions to the customers.

These strategies will not only mitigate the industry's environmental impact but will also inspire consumer loyalty and satisfaction for businesses. This is because the designs will encourage consumers to develop an emotional attachment to their multi-functionality and trans-seasonal nature, increasing profits for businesses in the long run (Niinimäki 2017).

#### **4.4. Design for Disassembly and Reassembly**

This approach refers to the concept of designing clothing and textiles in a way that makes them easy to take apart, sort, and recycle at the end of their life. Currently, clothes must be physically deconstructed by removing the stitching or cutting along the seam. Due to the time and expense associated with hand disassembly, many usable articles of clothing are abandoned without further processing (Dissanayake and Sinha, 2015).

This can include using modular construction techniques, such as snap fasteners, Velcro, and zippers, that allow for easy separation of different materials and designing for ease of removal of non-essential parts (Abuzied et al. 2020).

Additionally, designing for disassembly can also include using materials that are easy to recycle and have a high recycling rate, such as natural fibers, and providing clear labels that indicate the materials used in the garment and their recyclability.

This strategy is essential in a circular fashion, as it allows for easy separation of different materials and makes it possible to recycle and remanufacture the materials in new clothing. It also allows for a better understanding of the materials used in the clothing and can help identify which materials are more sustainable and which are not. By designing for disassembly, the clothing can be easily broken down into its different components, which can be recycled or repurposed, thus extending the life of the clothing and reducing its environmental impact.

### **5. After usage Circularity (The 5 R's)**

End-of-life circularity refers to the concept of designing products and systems with the intent that they can be reused, recycled, resold or rented, or repurposed at the end of their useful life, as described below. This is in contrast to the traditional linear economy, where resources are extracted, used, and then disposed of. By designing for end-of-life circularity, the goal is to reduce and divert waste from landfills and minimize the depletion of natural resources (Bocken et al. 2016).

#### **5.1. Recycle**

The traditional linear economy model of fast fashion, in which clothes are produced quickly and cheaply, often with a short lifespan, has led to significant amounts of textile waste. Recycling can help to close the resource loop. Recycling can take many forms in the fashion industry:

##### **5.1.1. Textile Recycling**

One example is textile recycling, which involves collecting and processing used clothing and textiles to be used as raw materials for new products. This can include everything from repurposing old clothing into new designs to breaking down textiles into fibers for use in insulation or other industrial applications.

For instance, solvent technologies are considered an efficient way of recycling textiles, as they can effectively separate a wide range of fibers, including natural fibers such as cotton and wool, as well as synthetic fibers like polyester and nylon (Damayanti et al. 2021). One example of a solvent technology used in textile recycling is the "wet-cleaning" process, which combines solvents, water, and detergent to dissolve adhesives and other contaminants. Another example is the "dry-cleaning" process, which uses solvents such as perchloroethylene or tetrachloroethylene to dissolve adhesives and other contaminants. The fibers are then separated, cleaned, and dried before they can be used as raw materials for new products.

Solvent technologies are a promising method for textile recycling, as they can effectively separate a wide range of fibers and produce high-quality raw materials for new products. However, as with any process, a careful evaluation of the environmental and health risks must be considered.

5.1.2. Chemical Recycling

Another approach is chemical recycling, which uses chemical processes to break down plastics and other synthetic materials into their component molecules. This allows the raw materials to be used to make new products, such as fibers, yarns, and plastics. Chemical recycling can help to reduce the amount of textile waste and conserve natural resources by keeping synthetic fibers in use for a longer period of time.

One example of chemical recycling in textiles is using solvents to dissolve synthetic fibers, such as polyester, and extract the polymer, which can then be used to produce new fibers. This process, known as "depolymerization," is considered one of the most promising methods of chemical recycling for textiles (Paben 2017).

Another example is the use of pyrolysis, which is a thermal process that breaks down plastics and other synthetic materials into their component molecules. The resulting "oil" can be used as a feedstock for producing new plastics or chemicals (Özsin and Pütün, 2022). There are also emerging technologies like enzymatic recycling and mechanical recycling that can be used to recycle textiles.

5.1.3. Closed-loop Recycling

The fashion industry can also implement closed-loop recycling, where materials are collected and processed within the same company and used to produce new products. This approach allows companies to keep resources in use for as long as possible, reducing the need for new resources and minimizing waste (BOF 2021). Some companies have implemented in-house recycling programs, collecting and processing used textiles from their own operations, such as cutting room scraps and using them as raw materials for new products. Closed-loop recycling within companies allows them to have more control over the recycling process and ensure the quality of the final products while also increasing brand loyalty and customer engagement.

Overall, recycling is a key strategy for the fashion industry to adopt as part of a circular economy. It not only helps to minimize waste and preserve natural resources, but it can also be a cost-effective and profitable approach.

5.2. Resale and Rent

This refers to the practice of buying, selling, and renting used clothing and accessories rather than producing new items.

Renting and sharing is one practice that allows customers to borrow clothing and accessories for a certain period of time rather than buying them outright, allowing multiple people to use the same item. It can help to promote sustainable consumption by making it easier for consumers to access affordable, pre-owned fashion (Chen et al. 2021).

Another very popular innovative approach is 'take-back initiatives'. Take-back initiatives in circular fashion refer to programs where brands or retailers take back used clothing and accessories from customers with the goal of either recycling or reselling the items. They can be in the form of a physical store or a mail-in program, where customers can return their used clothing for a discount or reward. These programs allow for garments to be reused, resold, repurposed, or recycled, reducing the need for new resources and reducing the fashion industry's environmental impact (Hvass and Pedersen 2021). They create an opportunity for brands to build customer loyalty and trust by demonstrating their commitment to sustainability.

This approach helps extend the garments' lifecycle and reduce waste and pollution associated with the production of new clothing.

5.3. Reuse and Repurpose

Reuse is a key strategy that involves keeping resources in use for as long as possible by finding new uses for them, while repurposing involves finding new uses for existing products and materials.

One approach to reuse in the fashion industry is implementing "repair and alteration" services, where customers can bring their clothes to be repaired, altered, or customized. This can extend the life of clothing and reduce the need for new products. Another example is the use of "creative reuse", which is the process of using old clothing and textiles in new ways, such as turning old t-shirts into rugs, scarves, or even furniture (Sharan 2012).

"Upcycling" is a way to repurpose textiles, transforming used clothing and textiles into new products without losing the quality of the original materials. This can include anything from turning old denim into bags or old t-shirts into cleaning cloths (Davies 2021).

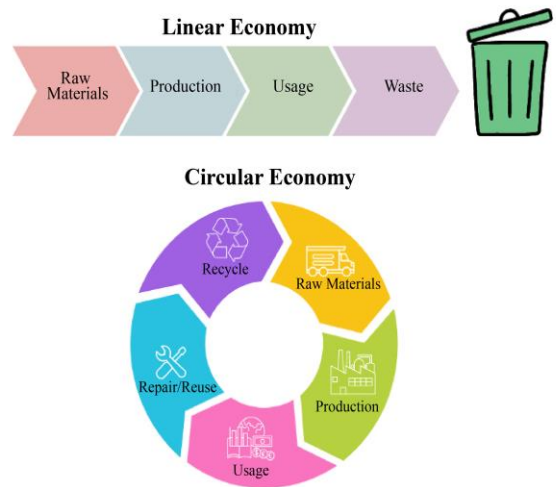


Fig. 1 Key differences between linear economy and circular economy

Repurposing can also be done using textile waste as raw materials for other industries. Examples include using textile scraps to make insulation, padding, or car parts (Davis, 2022). Another approach is repurposing textile waste into energy through processes such as incineration or gasification, which can generate heat and electricity. This can be done environmentally friendly, using state-of-the-art technologies such as advanced combustion and gasification systems, which can control emissions and maximize energy efficiency (Athanasopoulos and Zabaniotou 2022).

## 6. Conclusion

This paper offers a comprehensive literature analysis of the circular economy model in the fashion sector, which is among the most polluting in the world. This research substantially enriches the topic by developing an understanding of circular fashion and assembling a framework for circular fashion strategies. The fashion/textile industry has great promise and potential to adapt to the circular economy model. The three key strategies discussed in this paper revolve around resource efficiency, circular design, and end-of-life circularity to

provide a holistic overview of the topic. The ultimate goal is to create a closed-loop system in which clothing and textiles are designed, produced, used, and then recycled or repurposed rather than discarded as waste.

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