



The Narrative of Circular Economy and Sustainability -A Critical Analysis of Fashion Industry

Ruchi Gautam¹

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Abstract

Purpose Amidst growing environmental concerns, the fashion industry faces a pivotal moment marked by its substantial ecological footprint. This study delves into the intersection of circular economy (CE) and sustainable development (SD) within the fashion industry, emphasizing the urgent need for change. The research aims to identify implementation challenges while highlighting the timeliness of shifting towards sustainable fashion practices.

Methodology This research employs a comprehensive methodology, incorporating both a systematic literature review (SLR) followed by real-world case studies. An extensive search was conducted across pertinent journals from 2010 to 2022 using Scopus, with keywords related to circular economy, sustainable development, and the fashion industry. Furthermore, eight secondary case studies were purposively selected and analysed.

Findings Circular economy principles offer a promising avenue for advancing fashion sustainability. However, hurdles persist, including complex supply chains, mixed fabric recycling, inadequate infrastructure, and the lack of industry standards. Overcoming these challenges necessitates systemic changes, collaborative efforts, and technological investments. Nevertheless, embracing circularity presents valuable opportunities for enhancing resource efficiency and cultivating a socially and environmentally conscious fashion industry.

Significance This study highlights the pressing need for a profound transformation within the fashion industry to mitigate its environmental impact. By adopting circular economy principles, the industry can significantly contribute to the United Nations Sustainable Development Goals. Achieving this, however, requires substantial shifts in business models and industry practices.

Originality The research stands out for its comprehensive approach, integrating a systematic literature review with real-world case studies. By analysing a diverse array of journals and cases spanning nearly a decade, it offers a comprehensive understanding of the current state of circular economy adoption within the fashion sector.

Keywords Circular Economy · Fashion Industry · Sustainable Development Goals (SDGs) · Sustainability

✉ Ruchi Gautam
rgautam.jrsu@gmail.com

¹ Jharkhand Raksha Shakti University, Ranchi, India

Introduction

The global consumption of natural resources has reached unsustainable levels, placing immense stress on the Earth's ecosystems. The United Nations (UN) reports that mining and processing activities alone account for more than 90% of global biodiversity loss and over 50% of CO₂ emissions [1]. Striking a balance between the growth in resource usage, population, and income presents a formidable challenge. The imperative to transition towards a circular economy is evident as we confront these pressing global issues.

In response to the rise in global wealth, we are witnessing a simultaneous and alarming trend—escalated consumption leading to environmental degradation. Conventional consumption patterns follow a linear take-make-dispose model that has prevailed in industrialized nations for decades. This linear approach exerts unsustainable pressure on our finite planetary resources, underscoring the urgent need for a rapid shift towards a global circular economy [2].

Circular economy (CE) can be viewed as a strategic approach to address and overcome the modern obstacles of sustainable development. In a circular economy framework, the emphasis is on designing, producing, and utilizing products with resource preservation and sustainability at the forefront [3]. Waste is virtually eliminated, and carbon emissions significantly reduced. Products are designed to serve for as long as possible through repair, recycling, and thoughtful redesign, enabling them to be reused repeatedly. [3].

The fashion industry operates as a complex network, interweaving stakeholders, supply chains, and cyclical processes. The creation and production of clothing entail iterative steps guided by design briefs, market research, and creative inspiration. These steps culminate in promotion, marketing, and wholesale orders, which precede production, distribution, and consumption. Crucially, feedback loops sustain the perpetual flow of information and material supply. To advance environmental sustainability, practices such as recycling, reusing, and employing less harmful raw materials assume pivotal roles within the fashion industry.

Environmental sustainability within the fashion industry encompasses various practices, including recycling or repurposing used apparel and textiles and embracing less harmful raw materials [4]. Metrics such as water consumption, carbon emissions, waste production, and pollution levels serve as significant indicators of humanity's encroachment beyond the planet's safe boundaries, where the prospect of reversing damage becomes increasingly remote.

The textile sector occupies a unique and substantial position within India, standing as one of the country's oldest industries and contributing 14% to its overall industrial manufacturing output. Yet, this industry distinguishes itself with extensive water consumption, particularly during its wet processing stages, demanding a substantial water supply. Alarming assessments by the World Bank [5] underscore the textile industry's role in contributing to approximately 17–20% of contemporary water contamination in India. The sector's reliance on water is unmistakable, consuming between 50 and 100 L per kilogram of fabrics, predominantly during dyeing and finishing processes. Tragically, these processes introduce over 72 hazardous synthetic compounds into water, with 30 combinations proving recalcitrant and challenging to eliminate. Moreover, India discards over 1 million tonnes of textiles annually, perpetuating significant waste accumulation.

On a global scale, the fashion industry exacts a substantial environmental toll. It consumes a staggering 93 billion cubic meters of water annually, a volume equivalent to the essential water requirements of five million individuals, and contributes to roughly 20% of

the world's wastewater (*UN Launches Drive to Highlight Environmental Cost of Staying Fashionable*, 2021). Furthermore, 87% of the fibre input required for garment production is wasted through incineration or landfills. Alarmingly, the fashion industry accounts for 10% of global carbon emissions, surpassing the combined emissions from international aviation and maritime transportation.

The fashion industry's colossal impact on climate change is undeniable. According to research by McKinsey, in 2018 alone, the sector was responsible for emitting approximately 2.1 billion metric tons of greenhouse gases (GHGs), constituting approximately 4% of the global total. To place this into perspective, the fashion industry annually emits GHGs equivalent to the collective economies of France, Germany, and the United Kingdom. This underscores the industry's substantial carbon footprint and the imperative for adopting sustainable practices.

Projections indicate that greenhouse gas emissions stemming from the fashion industry will surge by over 50% by 2030. Furthermore, assuming current demographic and lifestyle patterns remain unchanged, global garment consumption is set to ascend from 62 million metric tonnes in 2019 to an anticipated 102 million tonnes within the next decade. Notably, the industry contributes to ocean pollution, releasing over 50 billion plastic bottles' worth of plastic microfibers annually, weighing more than half a million tons. These microfibers pose a perilous threat to both human and environmental health as they infiltrate the food chain and prove challenging to extract from water sources.

All stakeholders across the fashion industry's value chain play a pivotal role in driving decarbonization initiatives. By acting collectively, they possess the potential to engender meaningful and lasting transformation, effectively addressing the environmental challenges confronting the fashion industry, particularly about water usage and climate impact [6].

Considering the presented facts, it becomes unequivocally clear that the fashion industry demands a comprehensive overhaul to confront its profound environmental impact. As a major contributor to global pollution, the industry grapples with numerous environmental challenges that obstruct progress toward attaining the Sustainable Development Goals (SDGs) outlined by the United Nations.

The fashion industry faces intricate challenges as it strives to transition towards a circular economy, a crucial shift necessary to address pressing environmental and social concerns while upholding its overall performance and profitability. Additionally, the limited availability of research on circular fashion poses a significant obstacle to the successful adoption of circular economy practices within the industry [7–10].

Transitioning to a circular economy is not without its hurdles. Ten significant challenges, as elucidated by Abdelmeguid et al. [10], include poor material and energy efficiency, suboptimal circular design, technological complexities, regulatory constraints, internal resistance, financial constraints, a shortage of expertise, leadership issues, limited external collaborations, and the need to influence consumer behavior. These challenges emphasize the multifaceted nature of the transition, necessitating coordinated efforts to overcome them and foster a more sustainable and circular economic model.

A report by McKinsey suggests that the industry can resolve challenges in two major segments of their value chain: the heavy resource demands and difficult labour issues in the production process, and the excessive waste associated with disposing of unfashionable or worn-out garments¹. It also mentions the development of standards and practices for designing garments that can be easily reused or recycled [11].

The significance of this research topic cannot be overstated. The fashion industry's environmental impact is a matter of global concern, and addressing it is imperative for sustainable development. This research holds immense importance as it has the potential to

offer practical solutions for transforming the fashion industry into a more sustainable and circular sector. By addressing these knowledge gaps, it contributes to global sustainability efforts and aligns with the United Nations' Sustainable Development Goals (SDGs).

Existing literature provides valuable insights, but it often lacks a holistic examination of circular economy adoption within the fashion industry. This study aims to bridge this gap by combining rigorous academic research with real-world examples, offering a comprehensive perspective. The novelty of this research lies in its comprehensive approach to understanding the application of circular economy principles in the fashion industry. This approach not only bridges the gap in the existing literature but also offers a new perspective for future research. It provides a foundation for future research to build upon, particularly in developing strategies to overcome the identified challenges.

The beneficiaries of this study encompass a wide range of stakeholders, including policymakers, fashion industry professionals, environmental advocates, and researchers. By shedding light on the potential of circular economy principles, it equips these stakeholders with actionable knowledge to drive transformative change. The urgent need to address the environmental impact of the fashion industry and the potential of circular economy principles to drive change justify the undertaking of this study.

Research Questions:

1. Relationship and Contribution of Circular Economy to Sustainable Development (SD) in fashion industry.
2. Challenges of Applying Circular Economy Principles in the Fashion Industry.

Circular Economy and Sustainable Development in the Fashion Industry

Over the past few years, there has been an increasing focus on the idea of a circular economy among individuals, industries, governments, and academia, [12, 13]. Significantly, research has demonstrated that the circular economy can effectively contribute to achieving the Sustainable Development Goals (SDGs) [14, 15]. More specifically, firms' adoption of sustainable practices, revision of their business models, and consistent reporting are essential factors in supporting this transition toward sustainability [16].

The fashion industry functions as a complex network of stakeholders, supply chains, and cyclical processes. Designing and producing clothing involves iterative steps guided by design briefs, market research, and creative inspiration. Promotion, marketing, and wholesale orders precede production, distribution, and consumption. Feedback loops ensure a continuous flow of information and material supply. To promote environmental sustainability, practices like recycling, reusing, and using less harmful raw materials are crucial in the fashion business.

The surge in demand from fashion consumers and the prevalence of fast fashion trends have led to a significant increase in apparel production and consumption [17]. This surge results in the generation of substantial waste at every stage of the manufacturing process, encompassing spinning, knitting/weaving, dyeing, apparel production, and finishing, as noted by Koszewska [7]. Several studies have approximated that in 2014, the global textiles industry produced around 92 million tons of waste, with only a small fraction being reused or recycled, and a significant portion ending up in landfills or being incinerated

[18, 19]. The extensive generation of textile waste can be attributed to the significant demand and varying consumption patterns of contemporary consumers when it comes to fast fashion, as observed in studies by Niinimäki et al. [19] and Ütebay et al. [20].

The practice of reusing and recycling textiles can be viewed as a path to achieving socio-economic advantages and contributing to the growth of a country's economy, as pointed out by Cuc and Vidovic (2014). In fact, there is a growing momentum in promoting a "circular economy," as outlined by the Ellen MacArthur Foundation (2017), where materials are continually reused and recycled within the economic system. This concept is gaining momentum and is being embraced through commitments made by policymakers, businesses, and members of civil society (Fig. 1).

Economic Significance of the Fashion Industry The fashion industry's economic significance is undeniable, with a global valuation of approximately USD 2.4 trillion and employment of around 75 million people across its value chain [21]. It ranks as the third-largest manufacturing industry globally. The fashion industry, with a market worth of 1.3 trillion dollars and employing over 300 million people worldwide [22, 23] holds significant economic importance and serves as a substantial contributor to global GDP. It operates in a fiercely competitive market, largely characterized by the presence of global brands. Despite facing a severe financial crisis in the past decade, the fashion industry has exhibited rapid growth and undergone substantial transformations [24].

Market analyses conducted by prominent international consultancy firms such as McKinsey, Deloitte Group, and BCG highlight the dynamic and highly competitive nature of today's fashion industry, characterized by abrupt changes and increasing uncertainty [24].

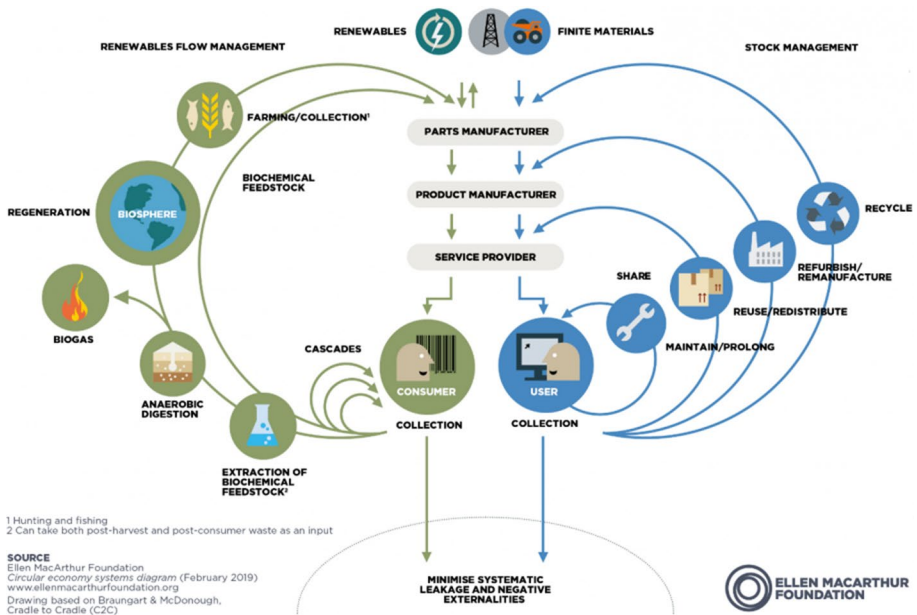


Fig. 1 (Adapted from Ellen MacArthur Foundation system diagram, 2019). This figure illustrates the continuous flow of technical and biological materials through a circular economy

Linear Fashion System and its Consequences The current fashion system operates in a linear manner, with a significant portion of garments made from non-renewable resources and disposed of quickly, leading to environmental pollution and resource depletion [25]. The current global economic model is predominantly linear, characterized by a "take, make, and dispose" approach. This model, apart from causing environmental pollution, also leads to substantial waste generation and inefficient resource utilization [26].

In the fashion industry, as per Ellen MacArthur Foundation, 2017, this linear model is evident in three primary stages: "take" (involving the eLESLIExtraction of raw materials), "make" (comprising garment production), and "waste" (encompassing the wearing and eventual disposal of clothing) (*Press Release: Global Commitment 2019*, n.d.)The prevalent fast fashion business model, which dominates the industry, involves the extensive consumption of natural resources to manufacture inexpensive clothing by low-wage workers. These garments are worn briefly by consumers and then discarded [27].Consequently, as clothing production has escalated, the frequency of garment usage has declined (European Environmental European Environment Agency, 2019, Ellen MacArthur Foundation, 2019).This pattern results in a significant waste output, as various estimates suggest [19], and contributes to a critical sustainability crisis from both social and environmental perspectives [28].

Closed-Loop Processes and Sustainable Production Closed-loop processes involve recycling and reusing materials throughout the manufacturing process. Sustainable production focuses on designing and producing goods with minimal environmental impact, considering social equity and economic viability [29].

In such scenarios, many textile companies opt for technical cycle circularity strategies like reuse, repair, remanufacture, and recycling. These approaches are selected to achieve goals such as extending product lifespans, preserving materials and textiles within the production cycle, and reducing waste [30].

Textile recycling is seen as a crucial step toward achieving sustainability in the industry. In response to the growing awareness that the fashion industry needs to address its impact on raw resources, especially with the increasing global population, fashion brands have begun integrating textile-to-textile recycling into their product manufacturing processes [31]. Furthermore, reusing products instead of discarding them in landfills contributes to environmental conservation and aligns with the principles of the circular economy, as supported by research from Fortuna and Diyamandoglu [32].

Systems-Thinking Approach Over the last few decades, a variety of theories, frameworks, and strategies have been formulated to encourage systemic thinking and modelling with the overarching goal of advancing sustainability. Among these, several theories are particularly pertinent to resource recovery systems. These include the cradle-to-cradle concept proposed by McDonough and Braungart [33], the performance economy articulated by Stahel [34], industrial ecology as elucidated by Graedel [35], and the notion of industrial symbiosis introduced by Chertow [36]. Implementing circular business models and sustainable production practices requires a systems-thinking approach, involving collaboration among various stakeholders, including policymakers, designers, and recyclers [37].

Standardization and Certification Standardized definitions and measurements of circularity are currently lacking in the fashion industry, hindering progress assessment and comparisons between companies. Industry standards and certifications, as highlighted by Franco [38], can motivate circular practices and enhance transparency. Auditing and

certification are pivotal, with third-party audits and certifications ensuring supplier compliance, as advocated by Pui-Yan Ho and Choi 2012. Certification bodies like Higg, CDP, and Cradle to Cradle are instrumental, with authors emphasizing the importance of supplier adherence to sustainability standards and codes of conduct [39, 40].

Additionally, the textile industry has embraced a range of certifications and standards to promote responsible production and consumption. These include ISO 9001 (2015) for quality management systems, Global Organic Textile Standard (GOTS) for organic and sustainable textile production, Fair Trade ensuring equitable and safe working conditions, ECO PASSPORT by OEKO-TEX certifying chemical safety in manufacturing, SA8000 for fair and safe workplaces, WRAP promoting lawful and ethical manufacturing, Blue sign emphasizing resource efficiency and safety, Zero Discharge of Hazardous Chemicals (ZDHC) reducing toxic substance release, Responsible Care fostering chemical industry sustainability, and REACH limiting hazardous chemical use and enhancing safety. Collectively, these certifications contribute to a more sustainable and ethical textile industry [41].

Transitioning to Circular Economy in Fashion Circular economy principles aim to move away from the traditional linear "take, make, dispose" model to a regenerative system. It focuses on waste reduction, prolonged product and material use, and natural system regeneration. The concept of a circular economy offers a promising solution to address waste management challenges in the textile industry ("Front matter. [42]. Circular economy principles, such as material reduction, reuse, recycling, and recovery, play a crucial role in sustaining environmental quality and addressing climate change concerns, as highlighted by Kirchherr et al. [43]. The adoption of these principles in apparel processing factories is gaining prominence to mitigate the negative impacts of carbon emissions and fast fashion, as stated by Saha et al. [44]. Over the past decade, the concept of a circular economy has emerged as a comprehensive framework, representing a departure from the conventional linear economic model characterized by a "take-make-dispose" approach [45]. Instead, it aspires to advance global sustainability by intentionally slowing, narrowing, or even closing the loops concerning materials and energy [46]. Consequently, the circular economy represents a novel sustainability paradigm that explicitly emphasizes economic dimensions while concurrently safeguarding environmental and social interests [47].

Social Impact and Labor Conditions The fashion industry's labour conditions significantly impact workers worldwide. Circular economy practices can empower garment workers by ensuring fair wages, safe working conditions, and worker rights. Brands that prioritize worker well-being contribute to a more sustainable industry. Transparency in supply chains is essential to monitor and improve labour conditions.

Innovation and Technology Designers benefit from software tools that facilitate circular fashion. These tools optimize material use, reduce waste, and visualize closed-loop processes. By integrating circularity into design, we can create more sustainable products. Blockchain technology enhances transparency by tracking a garment's entire lifecycle. Consumers can verify authenticity, ethical sourcing, and recycling efforts. Implementing blockchain solutions can strengthen trust and accountability.

Fashion Industry Coalitions and Supplier Engagement Collaborations among brands, NGOs, and industry associations drive circularity. Initiatives like Fashion Revolution and the Ellen MacArthur Foundation's Make Fashion Circular foster collective action. Together, we can accelerate positive change.

Brands collaborating with suppliers scale circular practices. Supplier partnerships are essential for industry-wide adoption. Engaging suppliers in circular initiatives ensures a holistic approach to sustainability.

Impact on Climate Change Human impact on the planet currently outpaces its regenerative capacity by approximately 50%, with carbon emissions being a major contributor [48]. The fashion industry's carbon footprint is substantial, with the potential to consume up to 25% of the world's carbon budget by 2050 [4]. The fashion industry witnesses a staggering loss of over 10 million tonnes of textiles and clothing each year, leading to landfill waste [49]. This alarming statistic underscores the pressing need for fashion brands and retailers to prioritize addressing these issues.

The fashion industry has a significant impact on climate change. According to research, in 2018, the sector was responsible for approximately 2.1 billion metric tons of greenhouse gas (GHG) emissions, accounting for approximately 4 percent of the global total. To put this into perspective, the fashion industry emits an equivalent amount of GHGs annually as the combined economies of France, Germany, and the United Kingdom [50].

Projected Increase in Emissions Fashion sector accounts for roughly 10% of global carbon emissions and a staggering 20% of water wastage [51]. On a global scale, the fashion industry stands as one of the leading contributors to water consumption and water pollution [52]. Interestingly, only 1% of the materials employed in clothing production are currently recycled, despite the potential for recycling up to 95% of these materials [46]. It is projected that greenhouse gas emissions from the fashion industry will increase by over 50% by 2030. Moreover, assuming current demographic and lifestyle trends remain unchanged, global garment consumption is expected to rise from 62 million metric tonnes in 2019 to 102 million tonnes in a decade. The industry also contributes to ocean pollution, with over 50 billion plastic bottles' worth of plastic microfibers, weighing more than half a million tons, being released annually. These microfibers pose a threat to both humans and other species as they enter the food chain and cannot be easily removed from water.

Urgency for Sustainable Practices The urgency for implementing sustainable practices within the fashion industry is evident. The 2020 McKinsey report titled "Fashion on Climate" emphasizes that all stakeholders across the fashion industry's value chain have a crucial role in driving decarbonization efforts. By collectively acting, they can bring about meaningful and lasting change to address the environmental challenges in the fashion industry, particularly concerning water usage and climate impact [6]. Narratives that advocate for the adoption of a circular economy can communicate anticipated future outcomes [53]. These anticipated outcomes are often prominently reflected in the mission statements of businesses [54].

Environmental Challenges and Sustainable Development Goals (SDGs)

Study by researchers has revealed that despite its increasing prominence, the textile industry confronts a multitude of challenges. These challenges encompass environmental pollution, noise pollution, adverse effects on human health, and constraints on resources [55, 56].

Given the facts presented, it becomes evident that the fashion industry needs a thorough redesign to tackle its significant environmental impact. As a major contributor to global pollution, the industry confronts numerous environmental challenges that impede progress

towards achieving the Sustainable Development Goals (SDGs) established by the United Nations. A study by Schroeder et al. [57] recognizes the circular economy as a potent tool that can be harnessed to advance the Sustainable Development Goals (SDGs). The transition to a new production model that places greater value on resources aligns with and contributes to the attainment of numerous SDG targets.

Sandin and Peters [55], in their comprehensive review of 41 publications, have recently examined the environmental advantages associated with textile reuse and recycling. One prominent finding from their review is that, in general, both reuse and recycling practices lead to a reduction in environmental impacts, primarily due to the decreased demand for primary resources. Additionally, the concept of a circular economy serves to advance the United Nations Sustainable Development Goals (SDGs), a comprehensive set of 17 objectives [58, 59].

Circular Economy as a Solution

Circular economy strategies, including reduce, reuse, and recycle, offer an alternative to the linear model. Reduction focuses on minimizing waste across production and consumption stages, while reuse involves designing products for multiple uses. Recycling aims to decrease the need for new manufacturing [60]. The concept of a circular economy has swiftly evolved into a sustainability model and an economy with the ability to regenerate itself [61]. Circular fashion strategies, as emphasized by Berberyan et al. [62] entail providing affordable, high-quality, and customized clothing to bridge the gap between consumer attitudes and behaviours, encouraging sustainable product consumption. The circular fashion approach plays a vital role in supporting sustainable apparel businesses as they grapple with the substantial waste generated by today's textile and apparel industries [63]. According to McHattie and Ballie [64], by fostering circularity in the production process, it promotes the reuse of cutting waste and extends the lifespan of resources. The circular economy's principles, encompassing practices like reduction, reuse, and recycling, have the transformative capacity to convert waste into new products, thus valorising and repurposing it [65, 66]. This approach ensures that waste is reused, remanufactured, or recycled within the circular economy, mitigating its detrimental impacts on society, the economy, and the environment [67]. Incorporating discarded textile remnants into circular fashion production significantly contributes to preserving ecological and economic sustainability. The global surge in consciousness surrounding ethical responsibilities towards the environment, the economy, and society has spurred the integration of sustainable practices within supply chain networks [68].

Design for Longevity principle emphasizes creating durable, timeless, and easy-to-repair clothes. It involves considering the quality of materials, construction, and workmanship, ensuring good fit, and communicating clearly about the care instructions¹. It's estimated that doubling the lifetime of a garment can reduce its environmental impact by 49%¹. [69].

Recycling involves breaking down used or discarded garments into raw materials, which can then be repurposed to create new products². On the other hand, upcycling transforms existing garments into fashionable new pieces without altering their original composition³. Each upcycled garment retains some of its history, fabric, and character while being given a second chance [70].

Using renewable and less harmful materials is a crucial aspect of a circular economy. Alternative materials like organic cotton, hemp, or recycled polyester have the potential to reduce the fashion industry's environmental footprint⁴. These sustainable fabrics are often

biodegradable, meaning they can break down naturally without causing harm to ecosystems. They also require fewer pesticides and chemicals during cultivation, reducing water pollution and minimizing health risks for workers [71]. In the fast fashion industry, sustainability efforts are evident across multiple stages of the value chain. In the realm of circular fashion, circular design principles, championed by Dokter et al. [72] and Enes and Kipöz [73], take centre stage during the product design phase, emphasizing sustainable materials, waste reduction, and innovation. Brands align their strategies with the Ellen MacArthur Foundation's principles (2017) [74], aiming to create products with recycled materials, repairable attributes, and recyclable designs. Dan and Østergaard [75] emphasize the importance of training designers in circularity. Moving into virgin raw material extraction and textile production, fashion brands like H&M and VFC, as highlighted by Hansen and Schaltegger [76], prioritize responsible sourcing practices, sustainable cotton, and recycled fibres. Innovations include converting waste materials into new fibres. Research by Moazzem et al. [77] confirms the environmental benefits of using recycled and organic materials in textile production. In the product manufacturing phase, typically outsourced by major fashion retailers, circularity policies govern supplier practices. These policies, addressing restricted chemicals, waste reduction, water efficiency, and sustainable materials, align with findings from Wen et al. [78]. Various solutions, including water conservation technologies and innovative manufacturing processes, are deployed.

Packaging reduction is a critical focus, with companies like H&M adopting Circular Product Development Guidelines and Circular Packaging Strategies to minimize plastic use [79]. Collaboration with organizations like the Ellen MacArthur Foundation and the Sustainable Apparel Coalition is widespread (Inditex, H&M, Gap, PVH), emphasizing the importance of cross-sector partnerships [80]. Customer engagement is a pivotal aspect, with companies educating consumers on circular fashion and promoting garment durability through care guides [81]. Hvass and Pedersen [82] state that post-consumer garment collection and recycling initiatives are increasingly common, with brands like VFC and PVH encouraging customers to return used clothing for recycling. Transparency and traceability are crucial, as companies adopt tools like the Higg Index and blockchain technology to provide information on materials, supply chains, and environmental impacts [83].

Benefits and Challenges of Circular Business Models

Circular business models have the potential to increase profitability, market share, customer loyalty, and product quality while reducing waste and pollution in the fashion industry [84]. Circularity in fashion, a closed-loop system is a solution which reuses and transforms products [85], protecting the environment and sustaining profitability [86]. It considers the full product life cycle and all stakeholders [87], aligning with the concept of a 'restorative or regenerative' industrial system [51].

However, adopting these models necessitates systemic changes [43]. It is essential to recognize that for a shift towards a circular economy to occur successfully, Circular Business Models (CBMs) must not only be implemented but also possess the capacity to capture market share from the presently dominant linear business models [88, 89]. According to a report from the European Environment Agency (2019), the lack of scalability of CBMs has been identified as a primary impediment to the slow transition to a circular economy in Europe's textile industry. Other research studies have also pinpointed the limited scalability of CBMs as a factor contributing to the sluggish adoption (e.g., [38, 89]), even when there is anticipated high demand for such circular models [38]. Transitioning to a circular

economy in fashion is a multifaceted challenge [10]. The fashion industry faces several challenges in transitioning to a circular economy, including the complexity of materials, recycling difficulties, lack of infrastructure, and the need for industry standards [90, 91]. Kumar et al. [92] identified 15 supply chain challenges, with a shortage of skilled workers being critical. Tura et al. [93] categorized challenges into seven areas, including environmental and technological factors, stressing the need for context-specific analysis.

Hina et al. [94] classified challenges as internal (e.g., product design) and external (e.g., supply chain complexities). García-Quevedo et al. [95] highlighted the importance of resources and regulations, especially for SMEs. Bertassini et al. [96] emphasized addressing soft aspects (culture and values) and hard aspects (capabilities) when implementing circular economy models. Organizations must also consider product factors (price, quality) and consumer-related factors (habits, values), achieving a balance. These insights illustrate the complexity of transitioning to a circular fashion economy. Nevertheless, a notable challenge frequently raised by fashion companies and manufacturers is the limited availability of sustainable sourcing materials and clothing options [97].

Linder and Williander's [98] comparative study between Circular Economy Business Models (CEBM) and Linear Business Models (LBM) brought attention to the higher financial risks associated with CEBM. This heightened financial risk stems from the increased costs involved in remanufacturing and refurbishing designs within a circular economy framework. The complexities and additional expenses incurred in the process of reusing and extending the lifecycle of products contribute to this elevated financial risk. This finding underscores the need for careful financial planning and strategic considerations when transitioning from a linear to a circular business model.

The existing literature highlights that financial and cost barriers are significant obstacles to the implementation of Circular Economy Business Models (CEBM), requiring substantial investments in technology, employee training, and restructuring, with uncertainties about returns and revenue models posing challenges [99–104].

Shifting Consumer Preferences

Contemporary consumers prefer sustainable clothing options [68]. Recently, there has been a significant surge in interest among consumers in the concept of "slow fashion," mainly because it aligns with ethical and sustainable production principles [105]. Slow apparel promotes the idea of producing high-quality garments that are designed to last, using environmentally friendly materials and fair labour practices [106]. The environmental considerations associated with apparel play a pivotal role in influencing consumer purchasing patterns [107] and encourage them to invest more in eco-friendly clothing [106]. In response to this growing demand, textile and apparel companies are actively exploring ways to mitigate the environmental impact of their products. They are increasingly adopting eco-conscious practices to enhance their appeal to consumers while safeguarding their profit margins [108].

Interesting research by Bain & Company in 2022, identifies five distinct fashion consumer personas, varying along a spectrum of sustainability concern and behaviour. Sustainability Champions are highly concerned and actively purchase sustainable apparel. Indifferent Consumers show little interest in sustainability. Positive Attitudes with Low Behaviour group expresses willingness but struggles to act sustainably, while Idealist Consumers are deeply concerned but seldom make sustainable fashion choices, indicating a noticeable gap between their intentions and actions." [108].

Circular Economy Strategies and the Sustainable Development Goals (SDGs): Circular economy strategies can contribute significantly to various SDGs within the fashion industry

Goal 3: Good Health and Well-being: Circular practices can reduce health risks associated with textile dyeing wastewater and improve working conditions for garment workers [109, 110]. For instance, sustainable dyeing practices can significantly reduce the industry's environmental footprint and enhance product sustainability [111]. Biodegradation methods using enzymes and microorganisms have shown promise in treating textile effluents, offering cost-effective and efficient solutions [112].

Goal 7: Affordable and Clean Energy: Circular measures, such as energy-efficient manufacturing and renewable energy adoption, can reduce the fashion industry's dependence on fossil fuels [113, 114]. The industry can transition to renewable energy sources and implement energy-efficient practices in manufacturing processes [6, 115].

Goal 12: Responsible Consumption and Production: Circular strategies, including closed-loop supply chains and product design for circularity, promote responsible consumption and production, reducing waste and pollution [116, 117]. SDG 12, which pertains to responsible production and consumption, is underscored as particularly crucial for the textiles and fashion industries [118]. The fashion industry can adopt circular business models that increase the use of clothes, clothes made from safe and renewable materials, and old clothes used to make new ones. [119].

Goal 14: Life Below Water: Circular economy methods can help reduce marine plastic pollution by minimizing plastic waste reaching the ocean from the fashion industry [120]. The fashion industry can adopt practices to catch microplastics before they end up in washing machine wastewater, and limit plastics in products [121].

Goal 15: Life on Land: Circular strategies can lessen the fashion industry's impact on land use, water consumption, and pollution, contributing to environmental preservation [80, 122]. Producing new garments requires significant amounts of water and energy [123]. By extending the life of existing clothing and using recycled materials, circular fashion reduces the demand for new production, thereby conserving water and energy resources.

Research Methodologies

Method

It started with **PRISMA Literature Review Analysis**: I started my investigation by conducting a comprehensive literature review using the PRISMA method. This involved identifying relevant studies, selecting the most pertinent ones, critically appraising their content, and synthesizing the findings to gain a broad understanding of sustainability and circular economy practices in the fashion industry.

Identification of Key Themes The analysis of literature has identified several key themes. The first is the environmental impact of the fashion industry, which is significant due to its substantial carbon emissions and water consumption. This leads to the second theme, the urgent need for sustainable practices within the industry. The third theme is the economic significance of the fashion industry, which makes a major contribution to economies worldwide. However, the current linear fashion system has detrimental consequences,

leading to the fourth theme, the need for a transition to a circular economy. This transition is not without challenges, which brings us to the fifth theme, the importance of a systems-thinking approach and stakeholder collaboration. The sixth theme is the role of industry standards and certifications in promoting circular practices. Lastly, the research highlights the link between circular economy strategies and several Sustainable Development Goals (SDGs), indicating the potential of the circular economy in contributing to global sustainability efforts.

Case Study Analysis Armed with the insights from the literature review, I then proceeded to analyse the sustainability practices of different fashion brands (Eileen Fisher, H&M, Levi's, Nova Fashion, Zara, Omnes, The North Face, Patagonia). This allowed me to see how the theoretical concepts identified in the literature review were applied in practice. The selection criteria were based on the following factors:

Diversity: To capture a range of practices and experiences, fashion companies with varying levels of adoption of circular economy principles were included. This allowed for the examination of both early adopters and those in the process of transitioning to circular practices.

Industry Influence: Some of the selected companies are well-known leaders in the fashion industry, while others are emerging players. This mix ensures a comprehensive view of circular economy practices across the sector.

Availability of Data: Cases were chosen based on the availability of publicly accessible data, including annual reports, sustainability reports, and official publications. This ensured that a substantial amount of information was accessible for analysis.

Insights into Real-World Implementation of Circular Economy Practices Finally, I synthesized the findings from the case studies to gain insights into the real-world implementation of circular economy practices in the fashion industry. I discussed the effectiveness of different circular economy practices, the challenges in implementing these practices, and potential solutions.

Research Type This research employs an exploratory and descriptive research design. The systematic literature review aims to explore and synthesize existing knowledge regarding the relationship between circular economy principles and sustainability in the fashion industry. Concurrently, the case studies provide descriptive insights into real-world applications and the challenges encountered by diverse fashion companies in their efforts to adopt circular economy practices.

Sampling Technique For the systematic literature review, a purposive sampling technique was employed. The selection criteria focused on articles published within the timeframe of 2010 to 2022, with specific emphasis on circular economy, sustainable development, and the fashion industry. The inclusion of papers meeting these criteria ensures both relevance and the high quality of the literature considered for analysis. For the case study component of this research, a purposive sampling technique was employed to select relevant fashion companies for in-depth analysis.

Cases under study 1. Eileen Fisher 2. H&M 3. Levi's 4. Nova Fashion 5. Omnes 6. Zara 7. The North Face 8. Patagonia.

The selected case studies offer a spectrum of perspectives within the fashion industry, encompassing both fast-fashion and sustainable brands. They vary in their circular economy practices, sustainability commitments, and responses to environmental challenges. This diversity allows for a comprehensive analysis of how different brands address the research objectives.

Rationale for Case Study Selection The selection of these case studies was driven by the need to provide a well-rounded analysis of circular economy practices in the fashion industry. By including a diverse set of cases, this research aims to capture the various approaches, challenges, and successes in adopting circular principles. These cases were chosen based on their significance in the industry, global representation, and the availability of reliable data sources.

The case study analysis supplements the systematic literature review by offering real-world insights and practical examples of circular economy implementation. It allows for a deeper exploration of the challenges faced by fashion companies and the strategies employed to promote sustainability. By adopting a purposeful sampling approach and utilizing reputable data sources, this research ensures the robustness and validity of the case study findings, contributing to a comprehensive understanding of the research topic.

Data Collection

For the systematic literature review, data collection followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method. Relevant research papers were identified through keyword searches in reputable databases, including Scopus and Google Scholar. These selected papers served as a robust information source on the adoption and implementation of circular economy principles in the fashion industry.

Systematic Literature Review Process

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method guided data collection for the systematic literature review (**Fig. 2**) [124].

Initial data collection involved keyword searches in Scopus. The keywords included were "circular economy," "sustainable development," and "fashion industry" in a linear combination.

The inclusion/exclusion criteria were strictly defined to ensure the relevance and quality of selected papers. Only articles published in English were considered for our study. The criteria focused on articles published between 2010 and 2022, directly related to circular economy principles and sustainability within the fashion industry. After an initial screening, duplicate articles were removed from the dataset to prevent redundancy.

Data for the case studies were sourced from credible outlets such as industry reports, official publications, and company websites. These case studies offer valuable insights into the real-world experiences of various fashion companies in embracing circular economy practices.

Screened Studies

In the initial screening phase from 1450, a total of 1440 records were identified for potential inclusion in the study. After a meticulous review of the titles and/or abstracts of these records

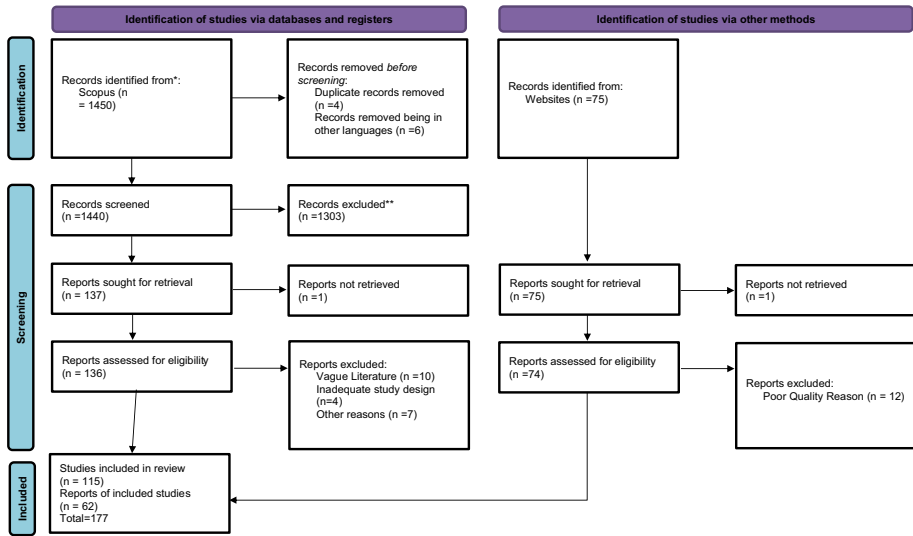


Fig 2 Systematic Review of Litertature using PRISMA

to assess their relevance to the research objective, 1303 records were deemed not directly related and were consequently excluded from further consideration.

This process led to the identification of 137 records that were subsequently retrieved and assessed for eligibility. However, among these 137 records, 22 were excluded for various reasons and 115 were included for our research.

Finally, during the review of websites as potential sources, 75 websites were identified. These websites were subsequently assessed for eligibility. However, 13 of them were excluded at this stage due to concerns about their legitimacy and the accuracy of the facts and figures they presented and 62 were used.

Consequently, after this meticulous screening process, a total of 117 studies and reports were included in the study for further analysis and examination. This rigorous screening ensured the selection of relevant and credible sources for the research.

Findings

In this study, the discussion section is divided into two parts: one based on the literature review and the other based on the analysis of case studies

In the first part of the discussion, the focus is on synthesizing and interpreting the findings from the systematic literature review. This includes an analysis of existing scholarly literature related to circular economy principles and their relationship to sustainability in the fashion industry. The researchers discuss key themes, trends, and insights from the literature, highlighting the current state of knowledge in the field.

In the second part of the discussion, the emphasis shifts to the analysis of the case studies conducted in the research. The researchers present and interpret the findings from the real-world applications of circular economy initiatives in the fashion industry. This part of

the Discussion aims to provide a deeper understanding of the on-ground implementation of circular economy practices in the fashion sector.

Section A: Analysis of Literature Review

Rising Awareness and Economic Significance of Circular Economy

The SLR highlights the increasing awareness of the circular economy concept among various stakeholders, including individuals, industries, governments, and academia [12, 13]. It also underscores the economic significance of the fashion industry, revealing its global valuation and its role as a major contributor to employment and GDP [21].

Environmental Impact and Urgency for Sustainable Practices in the Fashion Industry

The SLR acknowledges the significant environmental impact of the fashion industry and emphasizes the urgency of implementing sustainable practices within the industry, given its substantial carbon emissions and water consumption [6, 7, 17].

Linear Fashion System, Consequences, and Transition to Circular Economy

Farrer and Fraser [25] have brought attention to the linear fashion system's detrimental consequences, which involve the wasteful extraction of non-renewable resources and the rapid disposal of garments, leading to environmental pollution and resource depletion. The SLR also highlights the necessity of transitioning from the linear fashion system to a circular economy [46].

Systems-Thinking Approach and Standardization

The SLR recognizes the need for a systems-thinking approach to address sustainability challenges in the fashion industry [33–36]. It also highlights the importance of industry standards and certifications in promoting circular practices and enhancing transparency [40, 125].

Contribution to Sustainable Development Goals (SDGs) and Impact on SDGs.

The SLR emphasizes the role of the circular economy in contributing to the achievement of the Sustainable Development Goals (SDGs) and establishes a link between circular economy strategies and several SDGs [14, 57, 59, 116, 126].

Focus on Sustainable Practices

Kristoffersen et al. [16] have highlighted that firms' adoption of sustainable practices, revisions of their business models, and consistent reporting are pivotal factors in supporting the transition to sustainability.

Impact of Circular Economy on Sustainable Development Goals

The SLR establishes a link between circular economy strategies and several Sustainable Development Goals (SDGs), including those related to health, clean energy, responsible consumption and production, life below water, and life on land [57, 59]. This connection reinforces the relevance of circular practices in advancing the global sustainability agenda.

Overall, the SLR provides a comprehensive overview of the fashion industry's current state, its environmental and economic significance, and the urgent need for a transition to circular economy practices. It also highlights the potential for circularity to contribute to the achievement of SDGs and the importance of collaboration and standardization in driving this transformation.

Section B. Case Analysis

Eileen Fisher

Eileen Fisher, a renowned women's clothing brand, is committed to sustainability and ethical practices [127]. Eileen Fisher and her team have been leading the charge in sustainability through their focus on circular practices. In their Vision 2020 strategy, they divided their goals into eight key areas, spanning materials, chemistry, carbon, and water on the environmental front, while also addressing conscious business practices, fair wages and benefits, worker voice, and worker and community happiness on the social side. Among these areas, significant strides have been made, particularly in materials, where notable progress has been achieved [128]. They focus on creating durable pieces using eco-friendly materials like organic cotton, linen, and Tencel. Additionally, they incorporate recycled fibres like polyester and nylon, supporting circularity. The groundbreaking "Renew" program promotes a circular economy by refurbishing and recycling old clothing [129]. The brand's design strategy is based on simplicity and sustainability [130]. They also launched the Renew program, which has collected a total of two million garments since its inception in 2009. In 2021, Eileen Fisher predominantly used three fibres by volume: cotton, Tencel™ Lyocell, and linen. An impressive 98% of their cotton products were either organic or recycled, and the same held true for 98% of their linen products. The company actively supports farmers transitioning to organic crops and ensures that materials are produced without violating human rights standards. [131]. One fact starts to become clear as more firms attempt to lessen the significant environmental effect of the fashion and apparel industry: there isn't a one-size-fits-all solution. Eileen Fisher's "Renew" program has been a significant step towards waste reduction by refurbishing and recycling old clothing [129]. The use of eco-friendly materials like organic cotton, linen, and Tencel has not only reduced their environmental footprint but also set a precedent for other brands [132]. The brand plans to build transparent supply chains and increase the number of clothes it takes back and resells by at least 15%3. What sets them apart is the Higg Brand and Retail Module (BRM) tool they use which is all-encompassing evaluation instrument designed to thoroughly assess the sustainability effects throughout a company's full value chain. [130]. They also aim to reduce greenhouse gas emissions created during production and shipping by 25% by 2025 compared to 2017 [133]. Eileen Fisher's commitment to sustainable fashion, including recycling and ethical labour practices, has revolutionized the industry and earned her the CFDA's Positive Change Award. The brand's continuous efforts towards sustainability include carbon sequestration, recycling plastic for clothing, adopting responsible dyes, and reducing air shipments [134].

H&M Conscious Collection

H&M's Conscious Collection features garments made from eco-friendly and recycled materials [135]. They reduce environmental impact and carbon footprint by using recycled materials. The company encourages responsible consumption and garment recycling [136]. H&M has made commitments to responsible denim production, including incorporating lower-impact materials like reconstituted cotton, and significantly reducing water use [137]. However, H&M's fast fashion model raises concerns about its environmental impact due to the amount of clothing it produces and the resources required to create and transport those garments [137]. Critics suggest H&M needs systemic changes to address fast fashion's issues [138]. H&M's use of recycled materials has been a key factor in reducing their environmental impact and carbon footprint [135]. Their efforts to encourage responsible consumption and garment recycling have been commendable, but the effectiveness of these initiatives in terms of numbers is yet to be determined.

Zara

Zara's fast-fashion model encourages overconsumption and waste [139]. Garments are designed for short-term trends, contributing to the linear fashion model. Their "Closing the Loop" program focuses on garment collection but faces challenges in textile recycling [140, 141]. Zara has publicized a list of environmental commitments, which span to 2030 and include everything from water conservation to reducing waste in landfills [12].

It recently released its first women's collection made of recycled poly-cotton textile waste by partnering with Cric. This move is commendable as it helps bring clothing made from blended textile waste to the mass market [142]. The manufacturing procedure for the recycled carbon emissions capsule that LanzaTech, a biotechnology company, and Inditex's Zara jointly created, has been made public. The designs incorporate fabric that is made from carbon emissions. LanzaTech's patented CarbonSmart technology helps the retailer prevent the emissions from being released into the atmosphere [143]. This collaboration comes after Inditex, the parent company of Zara, made an investment in Cric last year, with the goal of advancing large-scale solutions for circularity in fashion. It marks the first time Inditex has invested in this manner through its Sustainability Innovation Hub (SIH), which is focused on enhancing technological innovation and promoting product circularity within the industry [142].

While well-known brands like Zara are developing lines using recycled textiles, this movement has not yet reached the scale needed for a global impact. The fashion industry still struggles with the problem of old clothes being collected but not properly disposed of, contributing to the global textile waste mountain. For recycling to work on a large scale, the quality of recycled materials matters. High-quality and fast fashion rarely go hand in hand. Zara aims to change this by offering premium clothing through its Massimo Dutti line, but fashion recycling is still in its infancy [144]. Additionally, Zara falls behind truly sustainable brands. [145]. Their Join Life program isn't doing enough to make meaningful change, and they continue to promote mass consumerism inherent in fast fashion [146]. While Zara's efforts are commendable, addressing these criticisms is essential for a more sustainable future in fashion. Zara's "Closing the Loop" program and their recent collection made of recycled poly-cotton textile waste

are significant steps towards waste reduction [140, 141]. However, the challenges they faced in implementing these practices and the exact amount of waste reduction achieved would require more detailed data and analysis.

Fashion Nova

Fashion Nova's fast fashion leads to overproduction and waste [147]. They lack transparency in their supply chain and have faced labour practice accusations [148]. Unfortunately, Fashion Nova's environmental rating is 'Very Poor' [149]. The brand doesn't publish sufficient relevant information about its environmental policies [148]. Most of the fabrics it uses are either natural without relevant certifications (such as cotton or linen) or synthetic petroleum-based fibres (like polyester and nylon). Only a tiny proportion of its materials are environmentally friendly [150]. Fashion Nova's labour rating is also 'Very Poor'. None of its supply chain is certified by labour standards ensuring worker health, safety, or living wages. [151] There's no evidence of payment of a living wage in its supply chain. In 2019, Fashion Nova's Los Angeles workers were widely underpaid. The brand doesn't disclose policies to protect suppliers and workers from the impacts of COVID-19 [150]. Critics argue for a shift towards mindful and ethical production [149]. Despite the criticisms regarding sustainability and ethical practices, Fashion Nova has made some efforts towards improving their practices. However, the specifics of these initiatives and their impact on the brand's environmental and labor practices are not clearly documented and would require further investigation [147].

Omnes

It is a sustainable clothing brand that is committed to creating fashion that doesn't cost the earth. The brand believes in improving the ways the fashion industry works, which could make a truly positive difference to the future of our planet [152]. OMNES means 'all', and the brand stands for everyone, emphasizing that we are all in this together when it comes to sustainability [152]. They aim to create garments that will last, made from responsibly grown and sourced materials (OMNES—Sustainability Rating—Good on You 2022). From the design stage to the production of garments, they prioritize natural, recycled, and dead-stock materials [153]. They have partnered with the climate organization Earthly since 2020 to measure the carbon impact of their operations, and offset it through investing in nature-based projects that remove carbon, restore biodiversity, and support the communities most impacted by climate change. They have gone beyond climate neutrality by removing at least 110% of their carbon footprint [154]. Additionally, Omnes's commitment to sustainability extends to their regenerative cellulosic fibre, with 95% sourced from low-risk forest product suppliers. Notably, 77% of their regenerated cellulosic fibre is Tencel™ Lyocell, a fibre produced through a closed-loop process that recovers and reuses 99% of the solvent, contributing to a greener economy.

OMNES has made a commitment to sustainability and has implemented practices to reduce its environmental impact. However, like all brands, it faces the challenge of balancing sustainability with affordability, fashion trends, and consumer demand¹. Despite these challenges, OMNES is making strides in the right direction and serves as an example for other brands in the fashion industry.

North Face

Reputable outdoor apparel and gear company The North Face has advanced sustainability and circular economy initiatives. Their dedication to ecological accountability is in line with the Sustainable Development Goals (SDGs). Reducing environmental impact is the goal of The North Face's circular design range. The corporation breaks down the equipment after you return it, and each of the twenty styles is built from that equipment. Next, they upcycle the materials to create an entirely new product. In addition, their Renewed program reduces gear waste by giving well-worn favorites a second chance at life through cleaning, maintenance, and resale. 100% of The North Face's premium materials, which include nylon, polyester, and cotton, are expected to be responsibly sourced, recycled, or produced via regenerative farming by 2025.

To lessen their reliance on fossil fuels, they are actively employing recycled synthetic materials. By fall 2022, more than 85% of their polyester and 75% of their nylon will be composed of recycled materials. Moving away from virgin synthetics, the firm also experiments with bio-based materials generated partially from living stuff. Their dedication includes the use of regenerative materials from farms that prioritize carbon sequestration and the restoration of soil health. Science-based goals have been set by The North Face to reduce greenhouse gas emissions across their supply chain and operations. In order to lower Scope 1 and 2 emissions in half by 2030, they are actively reducing emissions and collaborating with suppliers. Their efforts benefit the industry as a whole, going beyond their individual operations. By 2025, the company is determined to do away with single-use plastic packaging. They're also reducing other forms of packaging (both plastic and paper) and ensuring new materials used are more recyclable.

North Face's circular design collection and Renewed program have contributed to waste reduction and changed customer behaviour towards sustainability [155]. Their future goals, such as ensuring that 100% of their top materials are either recycled, responsibly sourced, or regeneratively grown by 2025, are expected to further reduce their environmental footprint.

Levi's

Levi's aims to lead in transparency and impact by embracing a circular future. They focus on three pillars: climate, consumption, and community. Their goal is to create products with their next use in mind, shifting away from the concept of "end of life" to "end of use." They're working toward a circular economy where materials are used and reused safely. By 2025, they plan to introduce or increase resale and upcycling initiatives to extend the life of their products. This commitment aligns with the Ellen MacArthur Foundation's Make Fashion Circular Framework. In terms of sustainable denim innovation, in July 2020, they introduced the Well Thread 502 jean, its most eco-friendly denim to date. This jean is crafted from organic cotton and Circulose®, an innovative material partially derived from recycled jeans, developed by Renewcell (*Levi's Collaborates With Renewcell to Create Their Most Sustainable Jean Ever | Knowledge Hub | Circle Economy Foundation* 2020). Levi's actively aligns with the UN SDGs, and this collaboration exemplifies the kind of multi-stakeholder partnerships that are encouraged under SDG 17. Their purpose is to deliver profits through principles while making a positive impact on the world. Beyond their own operations, they emphasize the need for collective action and lasting impact within supply chains. Levi's "Buy Better, Wear Longer" campaign encourages conscious choices [156]. They offer garment recycling and focus on sustainable materials [157].

Levi's integrates circular economy principles into their practices [158]. Levi's introduction of resale and upcycling initiatives has been a significant step towards reducing waste generation (*Circular Economy—Levi Strauss & Co* 2022). Their most sustainable jean ever, made with organic cotton and Circulose®, is a testament to their commitment to circular economy practices and actively contributing to SDGs 12, 13, 15 and 17.

Patagonia

Patagonia leads in sustainability with recycled materials [159]. They promote repair, reuse, and environmental causes [160]. In 2005, Patagonia launched the Common Threads Garment Recycling Program. The idea was to create a line of clothing that never ended up in a landfill. They aimed to return, recycle, and reuse every single polyester fiber. The program started with Capilene® baselayers, which were collected from customers and recycled to make like-new polyester. However, challenges related to supply and economics led to its discontinuation.

Patagonia drew inspiration from the concept of Cradle to Cradle, which set the foundation for a circular economy [161]. The goal was to design products using renewable energy, efficient water usage, and socially equitable practices. These products would then be recycled and reused repeatedly. It continues to prioritize circular principles and serves as a role model for sustainable fashion [162]. Patagonia is a global leader in sustainability, with its drive to preserve the planet's ecosystems running through the entire business. They use recycled materials, actively promote repair and reuse through their Worn Wear program, and engage in environmental advocacy. Their climate goals include being carbon-neutral by 2025 and sourcing 100% of their energy from renewables [163]. Despite occasional criticism about high price points, Patagonia exemplifies how circularity can positively impact both the environment and consumer behaviour. Patagonia's circularity strategy has also led to extending the life of clothing by nine months, reducing carbon, waste, and water footprints by approximately 20–30% each [164]. They have resold more than 120,000 repurposed items, significantly cutting down on waste and emissions. These efforts contribute to several SDGs, including Goal 12: Responsible Consumption and Production, Goal 13: Climate Action, and Goal 15: Life on Land [165]. Patagonia's dedication to circularity and sustainability sets a strong example for the industry.

Discussion

The literature review and case studies stress on the potential of circular economy principles in driving sustainability within the fashion industry. The transition from a linear to a circular model, as advocated by researchers such as Arauzo-Carod et al. [12], D'Adamo et al. [13], and others, is not just a theoretical proposition but is being actively pursued by leading fashion brands like Eileen Fisher, H&M, Patagonia, and Levi's [127]. For H&M, the future of fashion is both 'circular' and digital. (2020). These brands serve as practical examples of the successful integration of circularity into their operational models, thereby contributing to several SDGs. For instance, by adopting responsible manufacturing and consumption practices, these brands are directly contributing to SDG 12 (Responsible Consumption and Production). Similarly, by reducing waste generation and environmental impact, they are making strides towards SDG 13 (Climate Action) and SDG 14 (Life Below Water), given the significant pollution caused by the fashion industry [20, 166].

The initiatives by Omnes demonstrate a practical application of circular economy principles in the fashion industry, contributing to SDGs such as Responsible Consumption and Production (SDG 12) and Climate Action (SDG 13). It's evident from these, that organizations exemplify different facets of circularity. While some organizations lead the way, systemic shifts are necessary to achieve true sustainability in the fashion industry.

It is also important to acknowledge the challenges in implementing these circular economy principles, as noted by Arauzo-Carod et al. [12] and others. Overcoming these challenges will require industry-wide collaboration, transparency, and a shift towards more durable and responsible practices [91, 167–169].

The fashion industry is at a critical crossroad where sustainability and circular economy practices are no longer optional but imperative. The case studies of various brands illustrate that significant progress can be made when brands prioritize environmental and social responsibility, transparency, and innovative circular solutions. To drive meaningful change, the fashion industry needs to collaborate with stakeholders, invest in research and development for circular technologies, and implement systemic changes that challenge the prevailing fast-fashion business model. Consumers also play a pivotal role in driving the transformation towards a more sustainable fashion industry. Mindful consumption, opting for high-quality and durable pieces, supporting brands with transparent and ethical practices, and actively participating in recycling and take-back initiatives are essential steps that individuals can take.

By collectively embracing circular economy principles and sustainable practices, the fashion industry has the potential to achieve a significant positive impact on the environment, society, and the economy. It is through collective efforts, collaboration, and conscious consumer choices that the vision of a circular and sustainable fashion industry can become a reality, creating a brighter and more responsible future for fashion and the planet.

Conclusion

In conclusion, the industry's current linear model of "take, make, dispose" leads to considerable waste generation, water consumption, and chemical pollution. However, the adoption of circular economy principles presents a promising solution to these sustainability challenges. Notably, leading brands exemplify successful integration of these principles, yet significant challenges remain, particularly for fast-fashion behemoths. Genuine systemic transformation, characterized by collaboration and heightened consumer awareness, is imperative for ushering in a sustainable future for fashion and the planet.

Designing for longevity, recycling and upcycling, and the use of sustainable materials are key circular strategies that help mitigate the industry's environmental impact. These strategies not only align with the Sustainable Development Goals (SDGs) but also resonate with shifting consumer preferences towards more sustainable clothing options. However, transitioning to a circular economy in the fashion industry is not without its challenges. It requires systemic changes, including modifications in business models, consumer behaviour, and regulatory frameworks. Despite these challenges, the potential benefits of a circular economy for the fashion industry are immense. As the industry continues to evolve, it is crucial for all stakeholders—from designers and manufacturers to retailers and consumers—to play their part in this transition towards a more sustainable and circular fashion industry. By doing so, the fashion industry can continue to thrive economically while also safeguarding our planet for future generations.

Recommendations

Implications for Practitioners

Practitioners in the fashion industry can draw inspiration from the case study findings to implement circular practices within their organizations. Lessons learnt from brands like Eileen Fisher, H&M, Levi's, and Patagonia can guide real-world strategies for sustainability.

Suggestions for Future Research

Future research in this area could delve deeper into the scalability of circular practices across different fashion brands and explore consumer behaviours in response to sustainability initiatives. Additionally, studying the long-term impact of circularity on the fashion industry's sustainability goals would be beneficial.

Limitations of this study

Despite the rigor of the research methodology, there are few limitations to this study. The selected case studies may not fully represent the diversity of the fashion industry, potentially limiting the generalizability of the findings. The research's reliance on secondary data sources may present challenges in terms of data accuracy and completeness. Despite these limitations, the study provides valuable insights into the role of circular economy in achieving sustainability in the fashion industry.

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Declarations

Ethics Approval and Consent to Participate Yes.

Consent for Publication Yes.

Competing Interests The authors declare no conflict of Interest.

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