



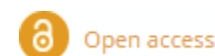
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# The challenge of “Depeche Mode” in the fashion industry – Does the industry have the capacity to become sustainable through circular economic principles, a scoping review

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## ABSTRACT

The fashion industry in its current linear business model of fast-fashion (“Depeche-Mode”) is one of today’s most unsustainable global businesses with textile production alone, significantly contributing to global greenhouse gas emissions. This scoping review utilises systematic techniques to collect data that evidences research on environmental impacts of the fashion and textile industry. This review collates information on how a fashion industry that utilises circular economic principles, could influence behaviour towards reduced carbon emissions, energy consumption and pollution. This scoping review provides examples of how transitioning to a fashion industry using circular economic principles has potential to make the industry more sustainable. A circular fashion economy, its various models for regenerative design, leasing, recycling and repurposing of clothing and textiles along with innovations and strategies towards a circular fashion economy are considered via best practice examples in the review. This scoping review indicates that the future of fashion becoming circular can enable a low impact value chain; however, significant independent research into the fashion industry is required as most research to date is being conducted by the fashion industry itself. It concludes, on balance, that the fashion industry when utilising circular economic principles is capable of sustainable change, but further investigation is needed to fully elucidate how the fashion industry can meet key emissions targets, therefore reducing climate impact and enhancing sustainability. This scoping review paves the way for further independent research questions to be developed to determine if a new industry model can reach a specified target level of decarbonisation.

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## PUBLIC INTEREST STATEMENT

This scoping review highlights research that has been undertaken over the last decade into the fashion industry’s efforts to become more sustainable by adopting circular economic principles. The review indicates that to date there is insufficient independent research being undertaken into the fashion industry’s objectives and actions for adaptation to a more sustainable economic model. In particular, more research needs to be undertaken when considering the fashion supply chain and the impact of re-use and recycling initiatives to close the loop on resource consumption. The review also explores some current best practice case studies that are being undertaken by fashion businesses and organisations. As the fashion industry attempts to move away from “fast-fashion” to a more sustainable model to achieve their climate change targets, more research should be conducted independently to evaluate the impact of actions undertaken.

## 1. Introduction

If the fashion industry were a country, it would be the 4<sup>th</sup> largest emitter of CO<sub>2</sub> in the world currently (Common Objective, 2018). The Ellen MacArthur Foundation reports that greenhouse gases (GHGs) from the fashion and textile industry amount to 1.2 billion tonnes annually (Ellen MacArthur Foundation, 2017). In 2018, the United Nations further substantiated these impacts and reinforced that statement indicating that the industry was responsible for 20% of global wastewater and 8.1% of all greenhouse gas emissions (UN, 2018). Should the fashion and textile industry continue with such a business as usual approach, alarmingly it will be responsible for the use of a quarter of the world’s carbon budget by 2050 (Ellen MacArthur Foundation, 2017) and yet when media coverage of major emitting industries brings attention to the public, any focus on the fashion industry and its impacts are largely immaterial. The Environmental Audit comments that “everything we wear has an embedded environmental cost in terms of energy, water, land, and chemicals used” (Environmental Audit Committee, pg 28, 2019) yet in general the public is unaware of the impact, the fashion industry is having on the environment. In August 2021, environmental activist Greta Thunberg critiqued the fashion industries commitment to sustainability: “Many are making it look as if the fashion industry are starting to take responsibility, by spending fantasy amounts on campaigns where they portray themselves as ‘sustainable’, ‘ethical’, ‘green’, ‘climate neutral’ and ‘fair’”, Thunberg wrote. “But let’s be clear: This is almost never anything but pure greenwashing. You cannot mass produce fashion or consume ‘sustainably’ as the world is shaped today. That is one of the many reasons why we will need a system change” (Thunberg in Vogue Scandinavia, 2021).

This impact of our clothing depends on multiple factors, the fibres that are used for the material and whether they were grown or made, the production methods used, how they are processed into yarn, dyed, printed and finally made into clothes (Niinimäki, et al., 2020). According to the Carbon Disclosure Project

(Carbon Disclosure Project (CDP), 2011), more than 50% of an average corporation’s carbon emissions are from its supply chain. With production and the consumption of clothing doubling since 2000 (WRAP, 2017) and on the current trajectory, the industry’s CO<sub>2</sub> emissions are projected to increase by more than 60% to nearly 2.8 billion tons per year by 2030 (UNFCCC, 2018). While there is an increasing trend for the fashion industry to describe their products as “sustainable”, products described with sustainability-related keywords still only made up less than 4% of the new products arriving on the US and UK market between January and September of 2020 (EDITED, 2020). Additionally, there is no clear definition for “sustainability” within the fashion industry leading to some claims of greenwashing by the industry and erosion of trust by consumers (Henninger, 2016). The fashion industry must change dramatically if it is to meet the challenge posed by a society that consumes their products that are facing significant impacts arising from climate change.

Circular economic principles can provide a pathway to decouple economic growth from environmental impact and have been identified as an important factor to reaching the UN Sustainable Development Goals (Independent Group of Scientists appointed by the Secretary-General, 2019). Any industry that utilises circular economic principles systemically has the capacity to benefit business, society and the environment. In contrast to the “take-make-waste” linear model, a circular economy is regenerative by design and aims to gradually decouple growth from the consumption of finite resources through closing the loop on resource usage predominantly by re-use and recycling processes. In such an industry, natural resources utilised would be regenerated, energy would be consumed from renewable sources, renewable resources would be utilised through re-use and recycling processes, and waste is eliminated as much as possible (Ellen MacArthur Foundation, 2019). For the fashion industry, sustainably sourced raw materials (fibres, water and energy) to create clothes is the first step in such a systematic approach. Re-use and recycling initiatives are also a key aspect of this approach to ensure clothes are utilised for as long as possible and that instead of generating clothing waste, clothes are broken down into fibres for recycling and reproduction. To date, a limited range of research studies have focused on either the environmental impact of the fashion and textile industry or an introductory concept to circular fashion economy. None has highlighted how the industry can become resilient to climate change through intrinsically linking circular economic principles and models to science-based targets. The aim of this scoping review, therefore, was to gain an insight into the requirements for transitioning to a fashion economy that utilises circular economic principles/models and ultimately how they stimulate the emergence of a potential new low carbon sustainable industry which could then allow for more targeted research into the industry, its impacts and the potential for the industry to change.

## **2. Methodology**

### ***Scoping review process***

Scoping reviews are utilised to ascertain the extent of relevant research literature on a specific topic. Such a review can then give clear indication of the volume of research literature and studies available as well as an overview of the topic without the need for detailed discussion. Scoping reviews are thus quite useful for examining emerging evidence when there is still uncertainty on the topic or it is perceived that there has not been significant research into the topic. This then permits the development of more specific research questions, which could be addressed by a more precise systematic review (Armstrong et al., 2011). Scoping reviews can report on the types of evidence that address and inform practice in the field and importantly in the way the research has been conducted (Pham, 2014) and whether there may be any biases in the research reported to date. Scoping reviews must be informed by an a priori protocol; systematic and include searching

for information in a wider fashion to find as much research as possible; transparent and reproducible and include steps to reduce error and increase reliability (such as the inclusion of multiple reviewers); and ensure data is extracted and presented in a structured way (Peters, 2015).

### **Review question**

Both SPIDER and PICO frameworks were used a guiding basis to formulate the research question (Cooke, 2012). The following overarching research question derived from the review title was *Can the fashion industry become sustainable via circular economic principles?* Arising from this question, the following aims drove the scoping review methodology:

- To explore findings on the carbon cost of the fashion and textile industry (production and consumption);
- To determine if the circular fashion economy and its models can reduce the carbon footprint of the fashion and textile industry (i.e. can the fashion industry keep clothing in circulation longer or close the loop using recycling and re-use processes); and
- Evaluate if the fashion industry has the capacity to adapt and become carbon neutral.

### **Review methodology**

A scoping review methodology was used for this study with cognisance paid to narrative and systematic review methodologies (Armstrong et al., 2011; Green et al., 2006; Munn, 2018; Peters, 2015; Pham, 2014; UCD, 2019, 2020). An analysis of the scientific evidence underpinning both the environmental impact and a circular fashion economy was conducted systematically through a review of articles published in the peer-reviewed scientific literature (i.e. systematic review inclusion and exclusion criteria methodologies were applied to obtain specific research that focused on answering the research question). A literature search was conducted using the database sources; Science Research, Science Direct, Scopus and Gov.Science, Web of Science, ResearchGate and Google Scholar search engines. The Boolean operators AND, OR and NOT were used to narrow or broaden the literature search. The combination of key terms searched “climate change and fashion” or “climate change and sustainable fashion” “circular economy and fashion” or “circular fashion and textiles” and “circular textiles economy” or “circular fashion economy” and “fashion and carbon footprint”. Over the course of this review, care was given to consider contextual variability and endeavour not to over-state effective and/or ineffective practices and solutions considered in the research literature.

As recommended by Levac (2010), a pilot exercise was undertaken. Half the records identified through database searching were extracted initially by the first author. Based on this preliminary exercise to guide the extraction process with the third author acting as a critical friend, the remaining extraction was then completed by the first author, with regular consultations with the third author. This initial review of the research arising from the search indicated that the research question had not already been answered nor were there any similar reviews asking the same question, the initial search also revealed little empirical research on the topic had been published prior to 2010. Research literature and secondary data that were recent and relevant were thus given priority limited to 2010 to 2021 (first quarter of 2021). Data were collected globally rather than a specific global region. Since each database searched provides different facilities for paper screening, papers were screened by limiting publication dates to 2010–2021, English language, publication status (fully publicised) and text availability (full-paper available) in the searched databases. Peer-reviewed

sources which contained verifiable information were prioritised.

Further literature searches were conducted with the above terms across, grey literature such as journals, magazines, newspaper articles, fashion websites and industry-specific blogs. However, these sources were not included in this review but used to interrogate and find further sources of relevant research, NGO or governmental publications. After limiting the publication date from 2010 to the first quarter of 2021, 120 documents were identified. Ninety-nine articles remained after removing duplication with further refinement and consideration of the aims bringing that total to just 51 research articles/reports and 10 best practice case studies that fit the criteria while also ensuring relevance to the three aims for inclusion in the presented tables (see results [Tables 1 to 7](#)). Explicitly, seven books and eleven articles written in a language other than English (i.e. French, Chinese, Spanish and German) were excluded. The first author conducted the search and was challenged by the third author (acting as a critical friend) regarding whether each study/report met the inclusion criteria. Disagreements were resolved via discussion with reference to the a priori eligibility criteria until consensus was achieved.

**Table 1.** Research articles documenting climate change impacts from the fashion industry ([Table view](#))

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
An Investigation of young fashion consumers' disposal habits.	Morgan and Birtwistle.	2009	Qualitative	Identifies how consumers use and dispose of fashion products approximating the disposal of clothing occurs after 7 to 10 wears.
The Lowest Cost at Any Price: The Impact of Fast Fashion on the Global Fashion Industry.	Lambert	2014	Mixed	Fast fashion industry provides low-cost, low-quality, trend-based clothing to consumers at unprecedented speeds.
The dirty side of the garment industry.	Anguelov	2015	Qualitative	An in-depth examination of fast fashion and its negative impact on environment identifies twenty percent of industrial water pollution is due to garment manufacturing
Sustainable Apparel Materials.	Kirchain and Olivetti	2015	Quantitative	An overview of the impact of four primary apparel materials: Cotton, Polyester, Leather, & Rubber
Carbon Footprint of Textile and Clothing Products.	Rana et al.,	2015	Quantitative	Key textile processing stages responsible for high greenhouse gas emissions have been identified, and various modern strategies to reduce the carbon footprint of textile industries.
Fast fashion: Business model overview and research opportunities.	Caro and Martinez-de-Albeniz.	2015	Mixed	Overview of the fast fashion model/examination of this business model/statistics relating to seasons.
Environmental impact of textile re-use and recycling—A review.	Sandin and Peters	2018	Mixed	Environmental impact—crude oil for production/Collaborative Consumption/Life Cycle Assessment/ Waste Management
The global environmental injustice of fast fashion.	Bick et al.,	2018	Mixed	The negative externalities at each step of the fast-fashion supply chain—5% waste in American landfill.
The price of fast fashion.	Nature Climate Change	2018	Qualitative	Overview of how consumption of fast fashion impacts the environment.

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
Footprint in the fashion and luxury industry.	Brenot et al.,	2019	Mixed	Details the water footprint in fashion and approx. Two thousand seven hundred litres of water to produce one cotton t-shirt.
Asymmetric impact of textile and clothing manufacturing on carbon-dioxide emissions.	Haseeb et al.,	2020	Quantitative	Analysis of the impact of textile and clothing manufacturing on carbon dioxide emission (CO <sub>2</sub> ) in top Asian economies./CO <sub>2</sub> per capita.
Examining globalisation, climate change and the fashion industry.	Hibberd	2020	Mixed	Exploration of impacts from fashion arising from globalisation, including environmental pollution in developing countries, as well as poverty-related impacts such as low wages, child labour, forced labour, unsafe working conditions, etc.
Fashion: an unrecognized contributor to climate change.	Hiller-Connell and LeHew	2020	Qualitative	An overview of complex environmental consequences associated with increased fibre, textile and clothing manufacturing, specifically highlighting the fashion industry contribution to climate change.
The need to decelerate fast fashion in a hot climate—A global sustainability perspective on the garment industry.	Peters et al.,	2021	Mixed	A robust discussion about the scale and temporal trends of fast fashion impacts focusing on key environmental indicators of energy consumption, climate, water and social indicators

### ***Inclusion and exclusion criteria***

The following hierarchy was used to help inform the selection of sources for inclusion

- In English;
- Academic peer-reviewed research articles from recognised journals;
- Textbooks/e-books that were relevant to the aims;
- Reports published by government and government-funded agencies; and
- Reports from non-governmental organisations that have linkages to the fashion industry.

Exclusions were made with the following criteria:

- Reports in a language other than English;
- Grey Literature (newspaper/magazine articles, journalism, industry-specific blogs);
- Articles reporting second-hand data only; and
- Studies where the full paper was unable to be retrieved.

It should be noted, however, that the narrative text was supplemented with grey literature at key points to emphasise how the fashion industries efforts to become more sustainable are portrayed in the media. While the review intended to include unpublished, academic literature, due to repository restrictions, dissertations

could not be retrieved from relevant sources. A decision was made to exclude theses; rather, a final hand search was conducted by author name for relevant publications in peer-reviewed journals that would have arisen from dissertations.

### **Presentation of results**

As research into the sustainability of the fashion industry is relatively new and novel, there was a noticeable variety in the types and methods of research conducted (quantitative, qualitative or mixed-methods) which made for challenges when comparing and contrasting findings. Consequently, it was considered an appropriate mechanism to present an overview of the research and how they were conducted to support the narrative through the inclusion of a series of tables built around key themes where the studies could be compared alongside relevant information on the year or study and the methods used for the research. [Tables 1 to 7](#) present the final 51 research articles/reports and 10 best practice case studies, which arose from the review process. They are designed to supplement the narrative and provide further information on each specific study that was ultimately included in the scoping review.

## **3. Results and discussion**

### ***Fashion industry climate change impacts***

The model of fast fashion (Depeche-Mode) became an emerging trend in the 1990s and by the mid-2000s it dominated the fashion industry. It is characterised by super-fast production, low-quality goods that are usually manufactured in countries that offer below minimum wages, little regulation, and the fewest protections for both workers and the environment (Lambert, 2014). This model has increased the number of fashion seasons from the traditional two main ones each year (spring/summer and autumn/winter) to as many as 50 to a 100 micro-seasons (Caro & Martínez-de-Albéniz, 2015). This leads to consumers having a wider variety of choice with greater frequency permitting consumers to use and dispose of fashion products with less wearing of the garment (Morgan & Birtwistle, 2009). The encouragement of this model, while being a boon for the fashion industry in permitting low-cost, low-quality and trend setting clothing to be produced at greater speed and greater profitability, it has led to reputational damage to the industry while also contributing significant environmental damage (Lambert, 2014). While globally economically beneficial the impact on the environment can be considered as disastrous (Anguelov, 2015) with increases in water consumption (Brenot, 2019) to produce crops associated with natural fabric production (Kirchain et al., 2015), increases in the use of hydrocarbons to produce artificial fabrics (Sandin & Peters, 2018) and resulting clothes waste production now accounting for increased landfill storage (Bick, 2018). The resulting carbon footprint of this fast fashion model has led the fashion industry to be one of the greatest contributors to global greenhouse gas (GHG) emissions, albeit quietly (Haseeb, 2020; Rana, 2015), while more noticeably polluting industries such as energy production, concrete production and transportation bear the brunt of public perceptions on polluting industries. [Tables 1 to 3](#) provide a range of research conducted on the environmental impacts of the fashion industry from research, government and NGO reporting.

**Table 2.** NGO reports documenting climate change impacts from the fashion industry ([Table view](#))

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
Climate Change:	Kering	201	Mixed	Outlines how the luxury sector is particularly

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
Implications and Strategies for the Luxury Fashion Sector.		5		sensitive to climate change as it relies on high-quality raw materials and materials that come from natural and agricultural systems that are limited.
Preferred Fiber Market Report.	Textile Exchange	2016	Mixed	The report provides updates on preferred fiber and materials development, growth, standards and innovative. Over 60% of materials are synthetic (combined).
A new textiles economy: Redesigning fashion’s future.	Ellen MacArthur Foundation	2017	Quantitative	An extensive report on clothing impacts and challenges/transition to the circular economy fashion industry greenhouse gas (GHG) emissions from textiles production totalled 1.2 billion tonnes of CO2 equivalent; industry could use more than 26% of the carbon budget associated with a 2°C pathway.
Fashion at the Cross Roads.	Greenpeace International	2017	Mixed	The report identifies and evaluates initiatives by companies that attempt to both slow the flow of materials and close the loop; the life cycle of clothing and textiles, including the way that such initiatives interact with each other.
Measuring Fashion 2018: Environmental Impact of the Global Apparel and Footwear Industries Study	Quantis	2018	Mixed	A comprehensive study of the environmental impacts across the industry’s entire value chain. Delivers insights into the efforts necessary to reduce climate impact by the industry in the vicinity of 50% by 2030/ Identifies clothing life cycle stages—impact categories across these stages to include Climate Change.
Mapping the Global Fashion Industry.	Common Objective	2018	Quantitative	Delivers insights to Impact on planet identifies If the industry were a country, fashion would be the 4th largest CO2 emitter in the world.
Destination Zero:7 Years of Detoxing the clothing industry.	Greenpeace International, Cobbing and Vicaire	2018	Mixed	The report outlines the use of hazardous chemicals in the manufacturing of clothes which were being released into waterways in countries.
The Future of Sustainability in the Fashion Industry.	Daheim et al.,	2019	Mixed	A reflection on the future perspectives and how much change does the industry have to undergo to achieve sustainability.
Fashion on Climate.	McKinsey and Global Fashion Agenda	2020	Mixed	This report presents an analysis of fashion industry’s GHG emissions and outlines areas where efforts to meet climate targets can be focused. Analysis of GHG emissions, their current and accelerated trajectories, and quantifying the gap to meeting the Paris targets, it offers insight into the industry’s potential for decarbonisation and presents recommendations for moving forward.

**Table 3.** Government commissioned reports documenting climate change impacts from the fashion industry ([Table view](#))

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
Valuing Our Clothes: the cost of UK fashion.	WRAP (UK)	2017	Mixed	A report looking at the environmental impact of the whole journey of clothing, from raw materials and manufacturing, to purchase, use and disposal. The report set the scene for collaborative change through the Sustainable Clothing Action Plan 2020 (SCAP), an industry-wide commitment, convened by WRAP and supported by UK governments.
Household Waste Characterisation Campaign Final Report.	Environmental Protection Agency (Ireland)	2018	Quantitative	10.3 % of Municipal Waste are Textile in Ireland equating to 80,000 tonnes a figure that has doubled in the last ten years from (2008–2018)
Textiles in Europe’s Circular Economy.	European Environment Agency (EU)	2020	Mixed	Report identifying EU consumers discard 11 kg of textiles per person per year and Textiles generates 15 to 35 tonnes of CO <sub>2</sub> ; The export of used clothes mainly to eastern European countries, Asia and Africa is significant and increasing.

When considering the fast fashion model production of clothing impacts on the natural environment and resources in a variety of mechanisms and the resulting challenges facing the industry as it transitions to the circular economy model, it is essential to note that GHG emissions from textile production totalled 1.2 billion tonnes of CO<sub>2</sub> equivalent. This demonstrates that the fashion industry is currently using more than 26% of the global carbon budget associated with the 2°C elevation target set by the Paris Agreement (Ellen MacArthur Foundation, 2017; Hiller-Connell & LeHew, 2020). This simple fact makes the fashion industry the fourth largest CO<sub>2</sub> emitter globally (Common Objective, 2018) while only accounting for 2% of the world’s GDP (Shirvanimoghaddam, 2020) and that in order to meet the Paris Agreement target the industry will need to radically overhaul itself to reduce its GHG emissions by at least 50% by 2030 (Quantis, 2018). While the relative contribution of this industry to the world’s GDP may be small, it is to be noted that the fast fashion industry contributes substantially to the local and national economy in many developing countries like Bangladesh and India (Fashion for Good and Circular Apparel Innovation Factory, 2020). The socio-economic impact of changes to the economic model of fast fashion is beyond the scope of this review; however, they should be considered in future research with a focus on lesser developed countries to ensure a just transition in climate change mitigation (Grimond and Warden, 2021).

The effort to reduce the fashion industry’s carbon footprint will need to counter the culture of fast fashion, which has grown exponentially while promoting irresponsible consumption patterns that have increased materials throughout the system leading to vast volumes of waste, most of which is incinerated, landfilled or exported to developing countries (European Environment Agency, 2020). Fast fashion brands are now producing almost twice the amount of clothing today compared with the year 2000 (Lehmann, 2018). According to the Fixing Fashion Report, the fast fashion business model is “encouraging over-consumption generating excessive waste” (Environmental Audit Committee, 2019 pg 6). The short lead times required to deliver such vast quantities at high speeds of new designs lend itself to poor garment quality and durability. Some garments are estimated to be discarded after just seven to ten wears (Morgan &

Birtwistle, 2009).

The fashion industry has both an extensive and multifaceted supply chain with many links across its value chain with globalisation of the industry often means that each step of producing a garment occurs in a different country, which aids transport and logistics, thus increasing the carbon footprint (Quantis, 2018). Each production step across the supply chain has an environmental impact due to usage of water, finite resources, soil and nutrients, chemicals and energy that contribute to climate change (Lambert, 2014). Despite a reported increase in efficiency of fashion production in the current century (Hibberd, 2020; Peters, 2021), across the full life cycle of clothing, the industry has an annual carbon footprint close to that of all 28 current EU states combined, 3.3 billion tonnes of CO<sub>2</sub> (Environmental Audit Committee, 2019).

The embodied carbon of a garment largely depends on the textile it is made from (Rana, 2015). Textiles (both natural and synthetic) generate 15 to 35 metric tonnes of CO<sub>2</sub> equivalent per tonne of textiles produced (European Environment Agency, 2020). Polyester, a synthetic material now accounts for over 60% of all textiles made (Textile Exchange, 2016). It may have less impact than a non-synthetic material like cotton but emits more greenhouse gases (per kilogram) as it requires significant quantities of non-renewable resources such as crude oil for production (Sandin & Peters, 2018). In 2015, the production of polyester for textiles resulted in the emissions of more than 706 billion kg of CO<sub>2</sub> equivalent (European Environment Agency, 2020). In addition to the greenhouse gas impact of synthetic fibers, there is also growing evidence that they contribute to an increase in microplastic pollution of the environment, both through water and air pathways (Duis & Coors, 2016). When washed, some garments release plastic microfibrils, of which around half a million tonnes every year contribute to ocean pollution—16 times more than plastic microbeads from cosmetics (Ellen MacArthur Foundation, 2017).

Cotton, albeit human-made from a natural material, contributes to the freshwater shortage globally due to the vast volumes required during farming and manufacturing. It can take approximately 2,700 litres of water to produce one cotton t-shirt (Brenot, 2019). While synthetic fabrics may use less land, they are energy-intensive and emit more greenhouse gases per kilogram. In 2015, a report by Rana (2015) stated that “polyester production for textiles released about 706 billion kg (1.5 trillion pounds) of greenhouse gases, the equivalent of 185 coal-fired power plants’ annual emissions” (Rana, 2015 pg 15). In comparison, the production of 1 kg of cotton has more significant impacts on land and water. The equivalent to the weight of a shirt and pair of jeans can take as much as 10,000 to 20,000 litres of water to produce. The Waste and Resources Action Programme (WRAP) further substantiates that a polyester t-shirt has more than double the carbon footprint of a cotton t-shirt 5.5 kg CO<sub>2</sub> to 2.1 kg CO<sub>2</sub> (WRAP, 2017). Additionally, the manufacturing of conventional cotton uses high levels of pesticides and hazardous chemicals, which then leach into waterways and surrounding areas impacting both the ecosystems and humans living in the area (Brenot, 2019). Greenpeace reports that agricultural practices associated with growing conventional cotton are putting long-term soil fertility at stake through soil degradation reducing its carbon sequestration capabilities (Cobbing & Vicaire, 2018).

Approximately 3,500 substances are used in textile production. Of these, 750 have been classified as hazardous for human health, and 440 are hazardous for the environment (European Environment Agency, 2020). Globally, 20% of industrial water pollution is due to garment manufacturing through chemical usage and dyeing process with most factories having no water filtration systems in place (Anguelov, 2015). Every year across the globe, we produce on average 100 to 120 billion garments, of which more than two-thirds of the textile goes to landfill at the end of their use (Ellen MacArthur Foundation, 2017; Shirvanimoghaddam,

2020). Approximately 15% of all fabric intended for clothing ends up on the cutting room floor (pre-consumer textile waste) due to poor design and production methods (Environmental Audit Committee, 2019). Europeans consume on average 26 kg of textiles per person of which 11 kg is wasted (ECAP, 2019) while in Ireland, 80000 tonnes of textiles are discarded in recycling and residual waste bins (Environmental Protection Agency, 2018). In 2014, North Americans were predicted to have used approximately 37 kg textiles per person (Carmichael, 2015). North Americans also generate approximately 16 million tons of textile waste each year (Shirvanimoghaddam, 2020). Textiles in America now occupy 5% of all landfill space (Bick, 2018). Lesser developed regions such as Africa, the Middle East or South Asia only consumed approximately 5 kg per person in 2014, whereas China had an average consumer demand of approximately 15 kg per person (Carmichael, 2015).

### **Considering a circular fashion economy**

Currently, the fast fashion model is linear nature with little or no incorporation of sustainability principles with the model beginning with crop production leading to fabric production followed by garment manufacture, distribution and consumption followed by discarding as a waste product (Patwa et al., 2020, Zamani, 2017). In order for fashion to become sustainable, it needs to move to a circular model. A circular fashion economy was inspired by the concept of circular economy, which involves moving away from our traditional linear model “take, make and dispose of” and towards a system whereby fibres/fabrics/garments are kept in use and retained at their highest value throughout the cycle (Niinimäki, 2017; Rathinamoorthy, 2019). Regenerative use of materials and resources, increased use of recycled fibres and designing clothes that are easy to recycle at end-of-life are all elements of a circular fashion economy (Ecopreneur, 2019). Dr Anna Brismar, the founder of Green Strategy (formerly Circular.Fashion), defines a circular fashion economy as “clothes, shoes or accessories that are designed, sourced, produced and provided with the intention to be used and circulate responsibly and effectively in society for as long as possible in their most valuable form, and hereafter return safely to the biosphere when no longer of human use” (Brismar, 2017).

The key principles of a circular fashion economy (Ellen MacArthur Foundation, 2017) concern the entire life cycle of a product, from design to sourcing and production, logistics transportation, storage, marketing and sale, as well as the consumer use and the product’s end of life: Circular Design; Circular Resources; Circular Business Models; and Circular Flow (Closing the Loop). A circular fashion system requires garments designed to circulate, which makes the design process crucial in determining the lifecycle of a fashion item (Guldmann & Huulgaard, 2020; Medkova & Fifield, 2016). Design impacts how clothing and textiles are produced, how long they will remain wearable and whether they can be repaired, reused or recycled and how they will re-enter the circle. [Tables 4 and 5](#) provide an overview of research into the circular fashion economy and expand on these key principles.

**Table 4.** Research articles focused on circular economic principles/fashion economy and circular models ([Table view](#))

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
The Life-cycle of the Fashion Garment and the Role of Australian Mass	Patwa et al.,	2021	Quantitative	Provides a global perspective of the linear textile economy and investigates its possible transformation into a new circular textiles economy.

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
Market Designers. Circular Design —Design for Circular Economy.	Medkova and Fifield	2016	Mixed	A thorough paper outlining strategies for Circular Product Design; explanation of circular design; New Business Models identified and explored.
Fashion in a circular economy', in Sustainability in Fashion: A Cradle to Upcycle Approach.	Niinimaki et al.,	2017	Quantitative	Study approaches; design for longevity, design for services, design for re-use in manufacture, design for material recovery and new business models for a circular economy.
Life cycle assessment of clothing libraries: can collaborative consumption reduce the environmental impact of fast fashion?	Zamani et al.,	2017	Mixed	Identifies life cycle assessment to explore the environmental performance of clothing libraries as one of the possible ways in which collaborative consumption can be implemented.
Consumer attitudes and communication in circular fashion.	Vehmas at al.,	2018	Mixed	Study outlining lengthening the life cycle of textiles by careful care, repairing or re-using garments and recycling material that is no longer reusable.
Circular Economy Challenges for the Textile and Clothing Industry.	Koszevska	2018	Mixed	Analysis of both impact of industry and Identifies challenges faced by the industry adopting CE models: new models.
Circular fashion.	Rathinamoorthy	2019	Mixed	This study identifies CE; Circular fashion; the linear economy; Principles of CF and outlines barriers in circular initiatives.
Qualification as corporate activism: How Swedish apparel retailers attach circular fashion qualities to take-back systems.	Corvellec and Stal	2019	Qualitative	This paper focuses on how Swedish apparel retailers qualify take-back systems for used clothes and textiles as steps toward creating circular fashion and able to develop circular material flows.
Barriers to circular business model innovation: A multiple-case study.	Guldmann and Huulgaard	2020	Mixed	The report explores the concept of CE and the adoption of CBM, which is a key element in the transition to a circular economy, further provides an overview of the barriers that hinder adoption of circular business models with a multiple-case study of the CBM innovation process.
Death by waste: Fashion and textile circular economy case.	Shirvanimoghoddam	2020	Mixed	This study states the value of the global fashion industry is 3000 Billion dollars that accounts for more than 2% of the world's Gross Domestic Product (GDP). The last two decades, not only the textile industry has doubled the production but also an average global annual consumption of

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
				textiles has doubled from 7 to 13 kg per person. More than two-thirds of the textile goes to landfill at the end of their use, and just around 15% is recycled.

**Table 5.** NGO and government reports focused on circular economic principles/fashion economy and circular models (Table view)

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
Environmental Profit and Loss Account.	Kering (for Stella McCartney Inc.)	2017	Mixed	The report outlining the future of sustainability at Stella McCartney includes embracing innovation and the circular economy.
Driving Circular Fashion and Textiles.	ECAP	2017	Mixed	Report on ECAP project of the same name with over of waste project that aimed to bring environmental and economic benefit to the clothing industry across design, production, consumption, public procurement, collection, recycling and reprocessing. Further states Europeans consume on average 26 kg of textiles per person per year and discard 11 kg per person.
The State of Fashion 2019.	Amed et al.,	2018	Mixed	Circular Value chain/nearshoring production One new strategy is to optimise the apparel production model, including elements such as nearshoring, automating new delivery models around customisation, and shifts toward sustainable, circular value chains. Nearshoring
Circular Design Toolbox. 2020 Circular Fashion System Commitment.	Global Fashion Agenda	2018	Qualitative	Report defining what a circular fashion system is; the circular design approaches; explores industry examples G Star Raw and cradle to cradle certification; sourcing circular materials and tools for implementing circular design.
The Future of Circular Fashion.	Fashion for Good and Accenture	2019	Mixed	Exploration and developed financial analysis for three circular business models: Rental —Subscription-Rental Re-commerce (Resale)
Sustainability Report.	Mud Jeans	2019	Mixed	Circular Approach/Life Cycle Assessment/Using 100% less water for dyeing; Supply Chain Overview; Net-Zero by 2030/ Reports 89% fewer chemicals and 65% less energy.
The State of Circular Innovations in the Indian Fashion and Textile Industries.	Fashion for Good and Circular Apparel Innovation Factory	2020	Mixed	This report highlights the challenges the Indian fashion/textile industry faces at a time when it is integral to India’s socioeconomic advancement. The sector employs over 45 million people, contributes 15% of India’s export earnings and 7% of the country’s industrial output. The Indian fashion sector supports dual roles as a consumer and manufacturer.

Circular Business Models (CBM) are closely bound to Circular Design considerations as detailed above. These models focus on long-lasting products offered as services, sharing platforms and enabling product access or performance, rather than its ownership (Medkova & Fifield, 2016). These new innovative business models aim to retain products, components or materials of the highest utility and value (Guldmann & Huulgaard, 2020). Additionally, re-commerce of used products is included, as the first user is not meant to be the last one (Ecopreneur, 2019).

Short-term subscription rental models are already emerging with steady growth within the industry. Fashion for Good reports that rental has grown more than 100% in the last 5 years (Fashion for Good/Accenture, 2019) and has been successful also in emerging markets like India (Fashion for Good and Circular Apparel Innovation Factory, 2020). Leasing and rental models can provide consumers with access to a variety of clothes while decreasing the demand for new clothing production, thus reducing the environmental impact. This re-use and resale model demonstrates a clear environmental value. Re-use extends the life cycle of a garment by an average of 2.2 years, potentially reducing its water/carbon/waste footprint by 73% (WRAP, 2017). A report by ThredUP indicated that resale had grown twenty-one times faster than traditional retail over the past 3 years. ThredUp further reports that the sector was worth \$24 billion in 2018 and could swell to \$51 billion by 2023 (ThredUp, 2018). Upcycling of products enables discarded objects or materials to be redesigned in such a way that it creates a product of higher quality or value (Marques, 2019). Repairing an item is the process of mending the clothing article. Garment repair is essential as it helps to prolong the life and usefulness of the garment (Vehmas, 2018).

In a fashion economy guided by circular economic principles, products are designed with the end of life in a mind and how they can reenter the cycle, thus closing the loop (Koszewska, 2018). Chemical recycling of post-consumer textiles is one solution offered for closing the loop; however, maintaining the quality of the fibres is currently not only a challenging but energy-intensive process. The closed-loop production system used by Lenzing uses chemical and heat recovery for the production of viscose and lyocell fibres to make sure the circular economy objective of recycling is in line with climate objectives (Ecopreneur, 2019). A study by Corvellec and Stål (2019) identifies Swedish retailers take-back systems for used clothes and textiles as steps towards closing the loop in a circular fashion.

In addition to improved environmental stewardship, circular economic principles and models can also provide social benefits such as increasing job opportunities and reducing poverty, which helps ensure a just transition towards sustainability (Independent Group of Scientists appointed by the Secretary-General, 2019). While the concept of “sustainable fashion” is mostly connected to environmental sustainability in the context of this review, social considerations such as fair wages also play an important role for consumers (Henninger, 2016). Adapting a circular economy model for the fashion industry can offer the opportunity to address both of these aspects simultaneously providing benefits to lesser developed regions especially. Nevertheless, research on the impact and adaptation of CBM in the fashion industry in emerging markets and lesser developed countries is scarce at the moment. While there are opportunities to adopt CBM and increase circularity in the fashion industry in these regions also (Fashion for Good, 2019), (Fashion for Good and Circular Apparel Innovation Factory, 2020), they need to be supported by more developed countries through provision of infrastructure and research, especially around the development of technological applications.

### ***Policy development***

The concept of Circular Economy in Europe has been strengthening since 2015, with the publication of the

report “Closing the Loop An Action Plan for the Circular Economy” (European Commission, 2015). Within this, the European Commission outlined the proposed amendments to the Waste Framework Directive 2008/98/EC (European Parliament and Council of the European Union, 2018) that requires for the first time Member States to set up separate waste collection for textiles and included a deadline for implementation, 1 January 2025. The package includes the use of measures to provide incentives for the application of the waste hierarchy, such as the extended producer responsibility (EPR), and introduces a change in the concept of waste that is being increasingly treated as a resource, with a significant impact on the fashion industry (Jacometti, 2019) (European Commission, 2020). Table 6 provides further information on the projects that have been undertaken in this area.

**Table 6.** Reports outlining developments in policy, legislation and commitments (Table view)

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
Closing the loop— An EU action plan for the Circular Economy.	European Commission	2015	Mixed	Report by EC outlining EU transition to CE for member states and the amended Waste Directive proposals to be implemented on by 2024.
Used Textile Collection in European Cities.	Watson	2018	Mixed	Report on ECAP project that aims to cut the environmental impact of clothing across the supply chain. Generating value for business through collaboration, measuring and sharing best practice and creating a circular approach to fashion across Europe. Reduce the carbon (save 1.6 million tonnes CO <sub>2</sub> ), water (save 588 million m <sup>3</sup> ) and waste footprints of clothing consumed in Europe
Circular Fashion Systems.	Global Fashion Agenda	2019	Mixed	Annual Report published by Global Fashion Agenda to keep track of signatories’ progress in implementing and reaching their targets for the 2020 Circular Fashion System. The role of design in a circular fashion system/Roadblocks to circular design/The role of garment collection schemes in a circular fashion system/The role of resale in a circular fashion system/Implementing Design Strategies for Cyclability
Circular Economy and Waste in the Fashion Industry.	Jacometti	2019	Mixed	This paper aims at analysing the existing EU measures that have an impact on the development of sustainable practices and the transition to a circular economy with particular emphasis on the fashion industry. The EU revised legislative framework on waste adopted within the Circular Economy Action Plan of 2015.
Fixing fashion: Clothing consumption and sustainability, clothing consumption and sustainability.	Environmental Audit Committee	2019	Mixed	<ul style="list-style-type: none"> <li>A report outlining the environmental cost of clothes; the social costs and new models for the industry. The committee further recommends 17 calls to actions for the UK Parliament to address the fashion industry.</li> </ul>
Circular Economy Action Plan.	European Commission	2020	Mixed	The plan outlined by the Commission prioritises seven sectors of which the textiles value chain is one, for

Study	Authorship	Year	Type of Study	Findings/Rationale for inclusion
A Waste Action Plan for a Circular Economy: Ireland’s National Waste Policy 2020–2025.	Government of Ireland	2020	Mixed	which the Commission has proposed to develop a “comprehensive strategy”. The Waste Action Plan for a Circular Economy sets out a range of aims and targets for the Irish State and the measures by which these will be achieved, including increased regulation and measures across various waste areas such as Circular Economy, Municipal Waste, Consumer Protection and Citizen Engagement, Plastics and Packaging, Construction and Demolition, Textiles, Green Public Procurement and Waste Enforcement.

Launched at 24th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP24) in Poland 2017, the Fashion Industry Charter for Climate Action attempts to address the issue through international coordination. The Charter aims to achieve net-zero emissions within the industry by 2050 and includes a thirty percent greenhouse gas reduction target for 2030 (UNFCCC, 2018). It includes a commitment to analyse and set a decarbonisation roadmap for the fashion industry drawing on methodologies from the Science-Based Targets Initiative. This target, which is one of the many goals enshrined in the Charter, is a clear demonstration that the fashion industry can urgently act on climate change. The industry charter specifies the following areas of work to be further developed by specific working groups:

- Decarbonisation pathway and GHG emission reductions;
- Raw material;
- Manufacturing/Energy;
- Logistics;
- Policy engagement;
- Leveraging existing tools and initiatives;
- Promoting broader climate action; and
- Brand/Retailer Owned or Operated Emission.

The European Clothing Action Plan (ECAP) is a 3-year program funded under the European Commission’s LIFE fund. The program has the overall aim of reducing clothing waste across Europe and embedding a circular economy approach into Europeans’ provision, access to and consumption of clothing (Watson, 2018). The ECAP Report (2019) outlines the programme aims:

- Divert over 90,000 tonnes of clothing waste from landfill and incineration;
- Reduce the carbon (save 1.6 million tonnes CO<sub>2</sub>), water (save 588 million m<sup>3</sup>) and waste footprints of clothing consumed in Europe;
- Ensure that fewer low-grade textiles go to incineration and landfill;

- Prevent waste across the clothing supply chain;
- Encourage innovation in resource-efficient design, recycling of textile fibres and service models; and
- Influence consumers to buy and use clothing for longer.

In a similar ethos to the charter, Cradle to Cradle is a certification program currently managed by the non-profit Cradle to Cradle Products Innovation Institute for organisations wanting to transition to the circular economy. This certification is the only third party able to certify the circularity of products (Franco, 2017; Niinimäki, 2017). It considers all aspects of the product, manufacturing, materials, chemicals, water and energy usage and assesses the following in its awarding process: material health; material utilisation; renewable energy; water stewardship; and social fairness.

A product being assessed receives a level of award in each category (bronze, silver, gold or platinum). This means that if a product has scored gold in material health, silver in material utilisation, and bronze and renewable energy and carbon management, the level awarded to the overall certification is bronze (i.e. the lowest score in any of the quality categories). In 2017, C&A launched the world’s first Gold level C2C certified T-shirt, made from 100% organic cotton and fully compostable at home (Daheim, 2019).

### ***Climate change stewardship best practice exemplars in the fashion industry***

A total of 10 case study examples emerged from the research as being at the forefront of positive stewardship in the fashion industry addressing climate change, unfortunately there were not more evidenced through the scoping review. [Table 7](#) provides an overview of each organisation's project and the key considerations that reflect a circular fashion ethos while striving for sustainability and a reduction in carbon emissions. The limited number of “exemplars” presented indicates further research is required from an industry perspective on how an organisation can reduce its carbon footprint through the value chain. The Kering’s environmental profit and loss methodology as applied by Stella McCartney (Stella McCartney, 2017) can provide a template the industry could replicate, allowing for baseline quantification of impacts and science-based targets to be established. Developing and applying such an industry standard that clearly defines sustainability measures and targets will increase consumer trust in fashion marketed under this standard and the perception of greenwashing can be avoided (Henninger, 2016).

**Table 7.** Fashion industry best practice examples of circular fashion models in action ([Table view](#))

Brand/Organisation	Year	Circular Principles and Models	Impact
Mud Jeans	2019	Circular Design Circular Flow	MUD Jeans are regarded as the first circular fashion brand with an aim to create a world without waste. They have pioneered “Lease A Jeans” where you lease a pair of jeans for a year. The lease includes a “Repair Service”, and after the year’s lease, the jeans can be kept, swapped for a new pair or simply returned. Through this approach, waste is prevented and ensures the return of their valuable material. Through recycling the pairs sent back and using an innovative water filtration system, MUD Jeans cuts their water usage by 78%. In their 2019 Sustainability Report Mud Jeans have set a goal to be carbon positive by 2021.

Brand/Organisation	Year	Circular Principles and Models	Impact
The Upcycle Movement (HaughtonHaughton).	2012	Circular Design; Upcycling Materials	The Upcycle Movement is a small Irish Design studio which specialises in transforming waste into worth with a focus on non-recyclable textiles. “Neo Collection” is the debut design range which gives wetsuits a new lease of life. These are turned into bags and accessories. Since the Upcycle Movement launched in 2018, c.1.157 tonnes of wetsuits, have been rescued by The Upcycle Movement. These would otherwise be landfilled or incinerated, the latter results in a release of highly toxic carbon monoxide fumes. Wetsuits are made of carbon chlorine compounds which are very harmful to the environment. Processing methods are consciously kept to a minimum to conserve energy such as open-air drying, and all wetsuits are dismantled by hand.
EcoAlf.	2019	Circular Design; Circular Resources; and Circular Flow	Ecoalf collects ocean waste and turns it into yarn to produce fabrics and products. They have re-used over 70,000,000 plastic bottles and 60 tonnes of fishing nets—seventy plastic bottles and with 135 grams of creating one meter of fabric. Thanks to the plastic bottles collection EcoAlf has saved a 20% in water, 50% in energy and over 60% in greenhouse emissions. By using recycled fishing nets, the brand has saved over 25% of natural resources, as well as 28% in greenhouse gas emissions.
Worn Again (Ellen MacArthur).	2017	Circular Design; Circular Resources; and Circular Flow	Worn Again Technologies was born from a vision to eradicate textile waste. A regenerative technology enables the circularity of PET and cellulosic raw materials, replacing the use of virgin resources. The process allows these materials to go back into manufacturing, moving away from a linear supply chain to a circular system, while providing long-term sustainable resource security.
Stella McCartney	2017	Circular Design; Circular Resources; and, Circular Model; Re-commerce.	Stella McCartney Real Real’s new business model gives new life to luxury goods through consignment by providing the largest selection of pre-owned luxury items transforming the way our clothes are produced, sold, shared and re-used. Also a leading member of the Cradle to Cradle Products Innovation Institute’s Fashion Positive initiative since 2014. The initiative aims to accelerate circular design through the development of circular materials.
ThredUp.	2018	Circular Model; Recommence.	ThredUp has now become the world’s largest second-hand clothing marketplace, allowing customers to sell their clothes via their site. Over 100,000 items across 35,000 brands are being resold per day.
G Star Raw (Global Fashion Agenda).	2018	Circular Design; Circular Resources; and Circular Flow.	Denim brand G-Star Raw developed the first-ever Cradle to Cradle (C2C) Gold-level certified denim. The capsule collection showcased a series of naturally dyed jeans with the dye deriving from plant waste. Impacts included 85% reduction in energy use, 98% of water is recycled the other 2% evaporates.

Brand/Organisation	Year	Circular Principles and Models	Impact
Carbon Lab	2019	Circular Design; Circular Resources; and Circular Flow.	A brand innovating their way towards regenerative clothing. They harness the power of science to create positive climate design; photosynthesis Coating sees garments covered with a living layer of photosynthetic microorganisms that rid the air of harmful CO <sub>2</sub> pollution through daily wear.
Adidas x Parley	2019	Circular Design; Circular Resources; and, Circular Flow.	Since 2019 Adidas and partner firm Parley, have produced 11 million pairs of shoes using recycled ocean plastic with a commitment to using only recycled polyester in every product by 2024. This objective towards circularity by attaining a “closed loop” or fully circular manufacturing model, where raw materials can be repurposed cyclically.
Girlfriend Collective	2019	Circular Design; Circular Resources; and, Circular Flow.	Girlfriend Collective use recycled materials to make all their activewear. Their fabrics are derived from recycled plastic bottles and through their Re-Girlfriend Programme, whereby clothing items reaching their end of life will be recycled into new clothing, closing the loop.

A mechanism introduced to keep garments in use for longer has been developed around the concept of renting fashion items. An example of this is the leasing of garments developed by MUD Jeans where you lease a pair of jeans for a year that includes a repair service and option to retain the jeans at the end of the year or they can be swapped for a new pair, or simply returned. Through this approach, the company has minimised waste through the recycling of jeans returned while also using an innovative water filtration system for cleaning the garments prior to reuse. Mud Jeans has set a goal to be carbon positive by 2021 (MUD Jeans, 2019). Similarly, other businesses are pioneering the reselling of garments to retain them in circulation and use for longer. ThredUp has become the world’s largest second-hand clothing marketplace, allowing customers to sell their clothes via their site. Over 100,000 items across 35,000 brands are being resold per day (ThredUp, 2018), while the designer Stella McCartney has developed a new business model, which allows for the reselling of luxury pre-owned garments and accessories (Stella McCartney, 2017).

The fashion industry is also now beginning to see adaptation in both repairing and reusing garments in order to keep them in use for longer (G Star Raw, 2018, Worn Again, 2018). Worn Again Technologies was born from a vision to eradicate textile waste. This team has developed a regenerative technology enabling the reuse of cellulosic raw materials, replacing the use for new resource production. The technology allows these materials to go back into manufacturing while moving towards a circular system and maintaining sustainable resource security. Similarly, there are moves to improve existing fashion waste management systems to transform fabric waste as a recyclable textile in its own right. The Upcycle Movement has rescued approximately 1.2 tonnes of wetsuits in the last year and recycling the wetsuit fabrics into new fashion accessories which would otherwise be landfilled or incinerated, further releasing GHG emissions. While wetsuits are made of carbon chlorine compounds that can be environmentally deleterious, the Upcycle Movement has developed processing methods, which conserve energy and do not release pollutants to the environment. In a similar fashion to the Upcycle Movement, EcoAlf goes one step further and uses existing waste as a mechanism to develop new fabrics for the fashion industry. Ecoalf collects ocean waste and turns

it into a range of fabrics suitable for the fashion industry. EcoAlf has recovered over 70 million plastic bottles and 60 tonnes of plastic fishing nets to develop these new fabrics. This has allowed EcoAlf to save 20% in water, 50% in energy and over 60% in GHG emissions. By using the collected and recycled plastics, the brand has saved over 25% of natural resources, as well as 28% in greenhouse gas emissions in comparison to creating new fabrics while also minimising waste and potential environmental pollution (EcoAlf, 2019).

#### 4. Conclusion

This scoping review has identified that a whole-system change is required in the fashion industry for any meaningful impact towards the reduction of carbon emissions. Simply injecting one principle of a circular fashion economy will not enable a pathway to carbon reductions, implementation of all circular principles must be the framework for such companies to align with and thus reduce emissions. The goals of the Paris Agreement translate to reaching climate neutrality in the second half of the twenty-first century. The fashion industry, as a significant global player, needs to take an active part in contributing to the realisation of these goals. Based on the Paris Agreement, the Fashion Industry Charter contains the vision for the industry to achieve net-zero emissions by 2050 and defines issues that will be addressed by signatories, ranging from decarbonisation of the production phase, regenerative materials, low-carbon logistics, working with the financing community and policy-makers to investigate scalable solutions using circular economic principles. The initial target by all signatories is to reduce greenhouse gas emissions by 30% by 2030 and have defined concrete measures in all companies and direct suppliers from 2025 (UNFCCC, 2018). However, this charter is not a mandatory requirement across the fashion industry as signatories must opt individually to align with the charter. A reoccurring theme though the industry is a lack of regulation, accountability and policy implementing strategies for change, which leaves room for greenwashing. This review re-asserts that all governments must play a critical role in seeding the adoption of circular economy concepts in their economies.

The scoping review has highlighted that to date a significant portion of research into the environmental impacts associated with the current model of the fashion industry as well as whether the industry can become sustainable has been conducted by the industry itself. There is also ambiguity as to what research is being funded by the fashion industry. The review has elucidated a lack of independent research into the fashion industry, and therefore this review can be considered to have an inherent internal bias and as such is a limiting factor of the review while also focusing researchers on the need for independent research. While the scoping process endeavoured to collate as much as possible peer-reviewed empirical and independent research into the environmental sustainability of the current model of the fashion industry and the proposed circular economy model, the majority of results presented in this review arise from the fashion industry itself or are funded by the industry. While aspects of the fashion industry are to be applauded for their efforts to research and highlight their environmental impacts and future prospects of sustainability, without a lack of independent research the industry does not have an independent peer counterpoint to consider the ramifications of its endeavours which is absolutely essential if the industry is to become accountable and meet its emissions/pollutant targets set via international climate change agreements.

Whilst there are limitations regarding science-based targets and lack of accountability throughout the industry, a fashion industry that adopts circular economic principles has the potential to provide social as well as environmental benefits at a global level. The shift towards a circular fashion economy will require

exceptional levels of collaboration across the value chain from businesses, governments, citizens and innovators who must collaborate on the implementation of new circular business models. Recycling, re-use, re-commerce and resource efficiency within circular business models offer huge scope to reduce emissions. A systemic approach to applying these strategies would move us towards achieving the UN Sustainable Development Goals and tip the balance in the battle against climate change.

This scoping review has identified that further independent research is needed on the types of circular fashion models in action and the potential impact these new models could have on reducing the carbon footprint and resource usage of the fashion industry. There is potential for a meta-analysis to be conducted of recent and current research into the use of circular economic principles and models by the fashion industry which could provide a more detailed analysis of common factors that the fashion industry must tackle in order to become more sustainable. The scoping review further indicates that there is a lack of significant science led independent research on the environmental impacts of the fashion industry processes including production, resource consumption and logistics/distribution. It is recommended that a future systematic review or meta-analysis be conducted in each of these areas to fully understand the impacts the fashion industry is having on the environment, in particular, how the circular supply chain within the fashion industry could have positive impacts on the environment. It is also recommended that all research funding should be declared and that should the fashion industry itself be funding research it is independently evaluated through a peer review process prior to publication.

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## References

- Adidas Group. (2019). *Adidas to produce more shoes using recycled plastic waste in 2019*. Press Release, January 21st 2019.
- Amed, I. (2018). *The State of Fashion 2019*. McKinsey & Company.
- Anguelov, N. (2015). *The Dirty Side of the Garment Industry: Fast Fashion and Its Negative Impact on Environment and Society*. CRC Press.
- Armstrong, R., Hall, B. J., Doyle, J., & Waters, E. (2011). ‘Scoping the scope’ of a Cochrane review. *J Public Health*, 33(1), 147–16. [Crossref](#)
- Bick, R. (2018). The global environmental injustice of fast fashion. *Journal of Environmental Health*, 17(1), 92. [Crossref](#)

- Brenot, A. (2019). *Water Footprint in Fashion and Luxury Industry* (pp. 95–113). Woodhead Publishing.
- Brismar, A. (2017). Definition of Circular Fashion. In *Green Strategy formerly Circular Fashion*. <https://www.greenstrategy.se/circular-fashion/key-principles-of-circular-fashion/>
- Carbon Disclosure Project (CDP). (2011). *Supply Chain Report 2011*.
- Carmichael, A. (2015). Man-Made Fibers Continue To Grow. In *Textile World, 2015 (FEB)*. Textile Industries Media Group LLC. <https://www.textileworld.com/textile-world/fiber-world/2015/02/man-made-fibers-continue-to-grow/>
- Caro, F., & Martínez-de-Albéniz, V. (2015). Fast Fashion: Business Model Overview and Research Opportunities. In *International Series in Operations Research and Management Science* (pp. 237–264). Springer. <https://link.springer.com/book/10.1007%2F978-1-4899-7562-1>
- Cobbing, M., & Vicaire, Y. (2018). *Destination Zero: 7 Years of Detoxing the clothing industry*. Greenpeace.
- Common Objective. (2018). *Mapping the Global Fashion Industry Key Findings Everything you need to know about the global fashion industry to achieve sustainable*. London, United Kingdom: Ethical Fashion Group.
- Cooke, A. (2012). Beyond pico the spider tool for qualitative evidence synthesis. *Qualitative Health Research*, 22(10), 1435–1443. [Crossref](#)
- Corvellec, H., & Stål, H. I. (2019). Qualification as corporate activism: how Swedish apparel retailers attach circular fashion qualities to take-back systems. *Scandinavian Journal of Management*, 35(3), 101046 Europe. [Crossref](#)
- Daheim, C. (2019). *The Future of Sustainability in the Fashion Industry*. C&A Foundation.
- Duis, K., & Coors, A. (2016). Microplastics in the aquatic and terrestrial environment: Sources (with a specific focus on personal care products), fate and effects. *Environmental Sciences Europe*, 28(1), 2. [Crossref](#)
- ECAP. (2019). *Driving Circular Fashion and Textiles*. WRAP UK.
- Ecopreneur. (2019). *Circular Fashion Advocacy: A Strategy towards a Circular Fashion Industry in Europe*.
- EDITED. (2020). *The Sustainability EDIT Retail Analysis 2020*. London, UK: EDITED. <https://insights.edited.com/sustainability>
- Ellen MacArthur Foundation. (2017). *A New Textiles Economy: Redesigning Fashion's Future*. Cowes, UK: The Ellen MacArthur Foundation.
- Ellen MacArthur Foundation. (2019). *Completing The Picture: How the Circular Economy tackles Climate Change*. Cowes, UK: The Ellen MacArthur Foundation.
- Environmental Audit Committee. (2019). *Fixing fashion: Clothing consumption and sustainability clothing consumption and sustainability*. HM Government, House of Commons.
- Environmental Protection Agency. (2018). *Household Waste Characterisation Campaign Final Report*.
- European Commission. (2015). *Closing the loop - An EU action plan for the Circular Economy*. Brussels, Belgium: The European Commission (EC).
- European Commission. (2020). *Circular Economy Action Plan for a cleaner and more competitive Europe*. Brussels, Belgium: The European Commission (EC).
- European Environment Agency. (2020). *Textiles in Europe's Circular Economy*. Copenhagen, Denmark: European Environmental Agency (EEA).
- European Union. (2018). Directive (EU) 2018/851 of the European parliament and of the council of 30 May 2018 amending directive 2008/98/EC on waste. *Official Journal of the European Union (PE/11/2018/REV/2)*, Brussels, Belgium. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018L0851>
- Fashion for Good and Circular Apparel Innovation Factory. (2020). *The State of Circular Innovation in the Indian Fashion and Textile Industries*. Netherlands: Accenture.
- Fashion for Good. (2019). *The Future of Circular Fashion*. The Netherlands: Accenture.
- Franco, M. A. (2017). Circular economy at the micro-level: A dynamic view of incumbents' struggles and challenges in the textile industry. *Journal of Cleaner Production*, 168 (2017), 833–845. [Crossref](#)
- Girlfriend Collective. (2019). *Recycle, Reuse, ReGirlfriend*. Press-Release, August 19th, 2019. Seattle, WA, USA: Girlfriend Collective.
- Global Fashion Agenda. (2019). *2 0 2 0 Circular Fashion System Commitment*.
- Global Fashion, Agenda. (2018). Spotlight On: G-Star RAW's circular ways are challenging denim conventions. *Global Fashion Agenda, Copen*, hagen, Denmark. Available at: <https://www.globalfashionagenda.com/spotlight-on-g-star-raws-circular-ways-are-challenging-denim-conventions/>
- Government of Ireland. (2020). *A Waste Action Plan for a Circular Economy: Ireland's National Waste Policy 2020-2025*. Government Publications.
- Green, B. N., Johnson, C. D., & Adams, A. (2006). Writing narrative literature reviews for peer-reviewed journals: Secrets of the trade. *Journal of Chiropractic Medicine*, 5(3), 101–117. [Crossref](#)

- Greenpeace International. (2017). *Fashion at the Cross-Roads*.
- Grimond, W., & Warden, J. (2021). *Fast Fashion Plastic Problem Sustainability and usage in online fashion*. The Royal Society for Arts, Manufacturers and Commerce (RSA), London, UK.
- Guldmann, E., & Huulgaard, R. D. (2020). Barriers to circular business model innovation: A multiple-case study. *Journal of Cleaner Production*, 243, (2020-01) 118–160. [Crossref](#)
- Haseeb, M. (2020). Asymmetric impact of textile and clothing manufacturing on carbon-dioxide emissions: evidence from top Asian economies. *Energy*, 196(117094), 1. [Crossref](#)
- Haughton, L. (2020). “*The Upcycle Movement, Statistics*” Sourced from CEO, Lynn Haughton (10th, June 2020). Dublin, Ireland: The Upcycle Movement Ltd.
- Henninger, C. E. (2016). What is sustainable fashion?. *Journal of Fashion Marketing and Management: An International Journal*, 20(4), 400–416. [Crossref](#)
- Hibberd, M. (2020). Examining globalisation, climate change and the fashion industry. In R. Nayak (Ed.), *Supply Chain Management and Logistics in the Global Fashion Sector: The Sustainability Challenge* (1st ed., pp. 33–48). Routledge.
- Hiller-Connell, K. Y., & LeHew, M. L. A. (2020). Fashion: An unrecognized contributor to climate change. In S. B. Marcketti & E. F. Karpova (Eds.), *The Dangers of Fashion: Towards Ethical and Sustainable Solutions* (pp. 71). Bloomsbury Visual Arts.
- Independent Group of Scientists appointed by the Secretary-General. (2019). *Global Sustainable Development Report 2019: The Future is Now – Science for Achieving Sustainable Development*. United Nations.
- Jacometti, V. (2019). Circular economy and waste in the fashion industry. *Journal of New Frontier Fashion Laws*, 8(4), 27. [Crossref](#)
- Kering. (2015). Climate change: implications and strategies for the luxury fashion sector. *BSR Working paper in collaboration with Kering BSR*, San Francisco, CA, USA.
- Kering. (2017). Stella McCartney 2016 Environmental Profit and Loss Account. London, UK: Stella McCartney Inc.
- Kirchain, R. et al., (2015). Sustainable Apparel Materials’. Cambridge, MA, USA.
- Koszevska, M. (2018). Circular economy - challenges for the textile and clothing industry. *Autex Research Journal*, 18(4), 337–347. Lodz, Poland. [Crossref](#)
- Lambert, M. (2014). *The Lowest Cost at Any Price: The Impact of Fast Fashion on the Global Fashion Industry*. Chicago, IL, USA: Lake Forest College Publications.
- Lehmann, M. (2018). *Pulse of the Fashion Industry 2018* (pp. 126). Boston Consulting Group in conjunction with Global Fashion Agenda.
- Levac, D. (2010). Scoping studies: Advancing the methodology. *Implementation Science*, 5(1), 69. [Crossref](#)
- Marques, A. D. (2019). From waste to fashion – A fashion upcycling contest. *Procedia CIRP*, 84 (2019), 1063–1068. [Crossref](#)
- McKinsey and Global Fashion Agenda. (2020). *Fashion on Climate – How the fashion industry can urgently act to reduce its greenhouse gas emissions*.
- Medkova, K., & Fifield, B. (2016). Circular Design - Design for Circular Economy. In *Lahti Cleantech Annual Review 2016* (pp. 32–47) (Willman, M., Editor). Lahti, Finland: Publication Series of Lahti University of Applied Sciences. [https://www.theseus.fi/bitstream/handle/10024/121322/LAMK\\_2016\\_24.pdf?sequence=2](https://www.theseus.fi/bitstream/handle/10024/121322/LAMK_2016_24.pdf?sequence=2)
- Monso, A.G., (2019). Innovative Business Models: The Case of Hybrid Organisations - Case Study EcoAlf. *FCJE*, Universitat Jaume I. Castellón de la Plana, Spain. Available at: [http://repositori.uji.es/xmlui/bitstream/handle/10234/186083/TFG\\_2019\\_Grifo\\_Monso\\_Angela.pdf?sequence=1&isAllowed=y](http://repositori.uji.es/xmlui/bitstream/handle/10234/186083/TFG_2019_Grifo_Monso_Angela.pdf?sequence=1&isAllowed=y)
- Morgan, L. R., & Birtwistle, G. (2009). “An investigation of young fashion consumers’ disposal habits’. *International Journal of Consumer Studies*, 33 (2), 190–198. [Crossref](#)
- Mud Jeans. (2019). *Sustainability Report 2019*. MUD Jeans, Nieuwegein, Netherlands.
- Mud, Jeans. (2019). ‘*Sustainability Report 2019*’. Mud Jeans, The Netherlands. Available at: <https://www.dropbox.com/s/aw4g1ui0105c2dc/MUD-Jeans-Sustainability-Report-20183.pdf?dl=0>
- Munn, Z. (2018). Systematic review or scoping review? guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, 18, 143 (2018). [Crossref](#)
- Nature Climate Change. (2018). *The Price of Fast Fashion* (Vol. 8, p. 1). Nature Publishing Group. (1).
- Niinimäki, K. (2017). *Fashion in a Circular Economy* (pp. 151–169). Palgrave Macmillan Publishing.
- Niinimäki, K. et al., (2020). The environmental price of fast fashion. *Nature Reviews Earth & Environment*, 1(4), 189–200. [Crossref](#)
- Patwa, N., et al., (2020). ‘Towards a circular economy: An emerging economies context’, *Journal of Business Research*, 122, 725–735.

- Patwa, N. (2021). Towards a circular economy: an emerging economies context. *Journal of Business Research*, 122 (2021), 725–735. [Crossref](#)
- Peters. (2021). The need to decelerate fast fashion in a hot climate - A global sustainability perspective on the garment industry. *Journal of Cleaner Production*, 295(126390), 1–10. [Crossref](#)
- Peters, M. D. (2015). Guidance for conducting systematic scoping reviews. *International Journal of Evidence-based Healthcare*, 13(3), 141–146. [Crossref](#)
- Pham, M. T. (2014). A scoping review of scoping reviews: Advancing the approach and enhancing the consistency. *Res Synth Methods*, 5(4), 371–385. [Crossref](#)
- Quantis. (2018). *Measuring Fashion 2018: Environmental Impact of the Global Apparel and Footwear Industries Study Full Report and Methodological Considerations*.
- Rana, S. (2015). Carbon Footprint of Textile and Clothing Products. In *Handbook of Sustainable Apparel Production*. (Chapter 7, pp 141-166) (Muthu, S.S., Editor). CRC Press, Routledge, Boca Raton, FL, USA.
- Rathinamoorthy, R. (2019). Circular Fashion. In Processing, Manufacture and Design - A volume in *The Textile Institute Book Series*. (Chapter 2, pp 13-48) (Muthu, S.S., Editor). Woodhead Publishing. [Crossref](#)
- Sandin, G., & Peters, G. M. (2018). Environmental impact of textile reuse and recycling – A review. *Journal of Cleaner Production*, 184 (2018), 353–365. [Crossref](#)
- Shirvanimoghaddam, K. (2020). Death by waste: fashion and textile circular economy case. *Science of the Total Environment*, 718 (2020), 137317. [Crossref](#)
- Stella McCartney. (2017). 2017 Environmental Profit and Loss Account. Stella McCartney Ltd, London, UK. Available at: <https://www.stellamccartney.com/on/demandware.static/-/Library-Sites-StellaMcCartneySharedLibrary/default/v10fa54905bdecf9d53f57900f8000b97231cfce6/report/EPL-Report-2017.pdf>
- Textile Exchange. (2016). *Preferred Fiber Market Report*.
- ThredUp. (2018). *Resale Report*. ThredUP.
- Thunberg, G. (2021). *The Wonders of Greta Thunberg*. Interview by T. Pattinson. Issue 1, Vogue Scandinavia, Stockholm, Sweden.
- UCD. (2019). *Library Guide – Narrative Literature Review*.
- UCD. (2020). *Library Guide and Manual - Systematic Review*.
- UN. (2018). *UN Partnership on Sustainable Fashion and the SDGs*.
- UNFCCC. (2018). *Fashion Industry Charter for Climate Action*. United Nations.
- Vehmas, K. (2018). Consumer attitudes and communication in circular fashion. *Journal of Fashion Marketing and Management*, 22(3), 286–300. [Crossref](#)
- Watson et al., (2018). Used Textile Collection in European Cities. *A study commissioned by Rijkswaterstaat under the European Clothing Action Plan (ECAP)*. PlanMiljø, Veksø, Denmark
- Worn Again, Technologies. (2018). “Worn Again Technologies breaks boundaries, raising £5 million, accelerating it to market, - Press Release. Worn Again Technologies, London, UK. Available at: <https://wornagain.co.uk/worn-again-press-release-july-2018/>
- WRAP. (2017). *Valuing Our Clothes: The Cost of UK Fashion*.
- Zamani, B. (2017). Life cycle assessment of clothing libraries: Can collaborative consumption reduce the environmental impact of fast fashion?. *Journal of Cleaner Production*, 162 (2017), 1368–1375. [Crossref](#)