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Chapter

Sustainability Initiatives in the Fashion Industry

Jennifer Xiaopei Wu and Li Li

Abstract

A heightened awareness toward the fashion industry's environmental impact has emerged in recent years, stirred by mounting evidence of intensified global clothing consumption and driven by the increased accessibility and affordability of clothing. In the last 3 years, the release of several comprehensive reports years detailing the extent of the fashion industry's environmental impact, as well as the founding of several fashion industry-targeted sustainability campaigns (e.g., the "2020 Commitment" of the Global Fashion Agenda), has not only helped draw a great deal of attention to the issues but has also triggered an evident wave of intention toward a concrete, quantifiable action. With the abundance of information surrounding the subject of sustainability in the fashion industry, this chapter intends to provide an overview of (1) the most concerning environmental impacts caused by the fashion industry, (2) current leading collective sustainability campaigns mobilizing the fashion industry, (3) current available benchmarks and tools for measuring environmental impact of the textile life cycle, and (4) examples of how companies in the fashion industry are executing sustainability initiatives in their products or processes. Finally, the chapter will conclude with some of the current challenges and future opportunities in sustainability confronting the fashion industry.

Keywords: fashion industry, Textiles and Apparel, sustainability, environmental impact, sustainability initiatives

1. Introduction

The taxing impact the fashion industry has had on the environment is by no means a new revelation—having accumulated a great deal of evidence over the years. However, unlike in the past when "sustainability" seemed more like an ideal adopted by individual, niche grassroot organizations, it is now considered a core value globally across the fashion industry. The fashion industry's recent wave of intentional action toward sustainability is in part motivated by several comprehensive and revealing industry sustainability reports released in the last 3 years [1–3], but moreover it is a collective response to the recent fashion industry-specific sustainability campaigns such as the "2020 Commitment," spearheaded in the last 2 years by several sustainability-driven coalitions (e.g., the Global Fashion Agenda and the Waste and Resources Action Programme UK), which have rallied formal commitments from a significant portion of the fashion industry toward concrete, quantifiable action for sustainability by 2020.
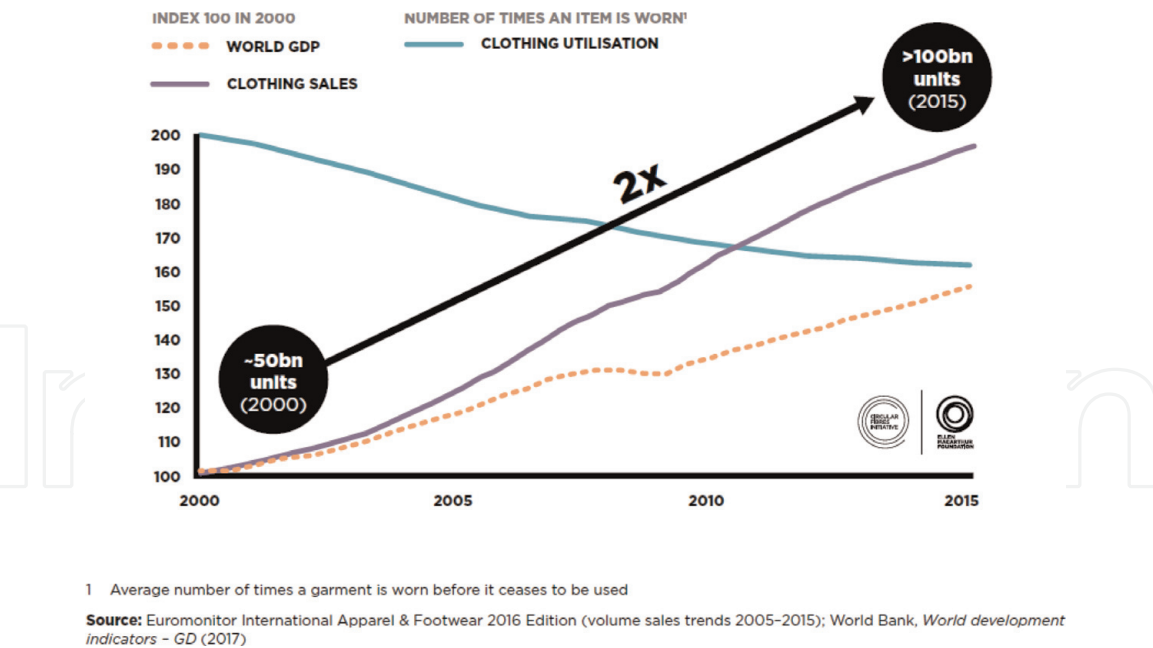
INDEX 100 IN 2000
····· **WORLD GDP**
— **CLOTHING SALES**

NUMBER OF TIMES AN ITEM IS WORN¹
— **CLOTHING UTILISATION**

1 Average number of times a garment is worn before it ceases to be used

Source: Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015); World Bank, *World development indicators – GD* (2017)

Figure 1.
Growth of clothing sales and decline in clothing utilization since 2000. Source: World bank, [4].

The heightened concern toward the fashion industry's environmental impact is also stirred by evidence of intensified global clothing consumption—which according to data from the World Bank [4] has doubled from around 50 billion units of clothing sales in 2000 to over 100 billion units in 2015 (see **Figure 1**). This dramatic increase in clothing consumption has been fueled by fast fashion, an increasingly bargain-driven consumer, increased accessibility via an expanding online shopping landscape, and more buying power from a growing middle class, especially in emerging economies such as China (projected to surpass the United States "as the largest fashion market in the world" in 2019, according to McKinsey FashionScope [5]). Unfortunately, the increased accessibility and affordability of clothing simultaneously propagated not only a culture of excessive consumption but also a quicker disposal of clothing, as exemplified by an approximately 20% decrease in the average number of times a garment is worn before it is abandoned as shown in **Figure 1**.

Given the abundance of information surrounding the subject of sustainability in the fashion industry from many sources, there is an opportunity for a collated overview on the subject. Therefore, the purpose of this article is to provide an overview of (1) the most concerning environmental impacts caused by the fashion industry, (2) current leading collective sustainability campaigns mobilizing the fashion industry, (3) current available benchmarks and tools for measuring environmental impact of the textile life cycle, and (4) examples of how companies in the fashion industry are executing sustainability initiatives in their products or processes. Finally, the article will conclude with some of the current challenges and future opportunities in sustainability confronting the fashion industry.

2. The environmental impact of the textile life cycle

In any given industry, each stage of the product life cycle poses an impact on the environment—by consuming environmental inputs (e.g., water for harvesting raw materials, fossil fuels to power manufacturing equipment, etc.) and releasing environmental outputs (e.g., carbon dioxide emissions from burning fossil fuels, landfill waste after product is disposed, etc.). For the fashion industry, the environmental
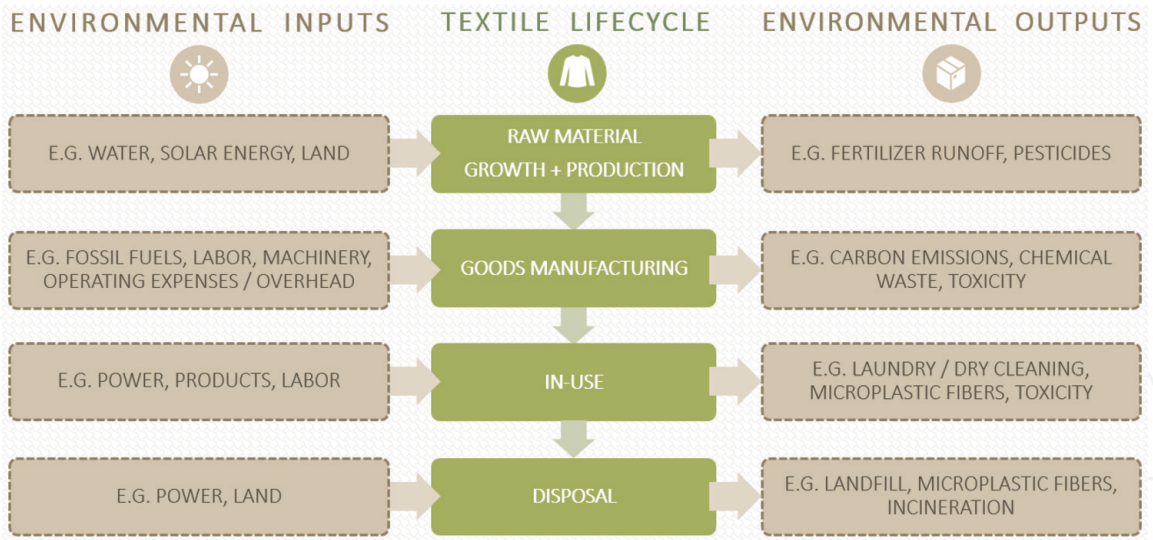
Figure 2.
Environmental impact (inputs and outputs) of the textile life cycle.

inputs and outputs of the textile product life cycle is reflected in **Figure 2**. (It is worthwhile to note that the term "life cycle" used is misleading in that the above chain of processes does not form a "cycle," but is instead linear sequence of events, with a definite beginning and end. A true cyclical life cycle would be indicative of recycling or reuse, feeding the end waste back into the system to be used again).

As shown, the inputs and outputs of the fashion industry's "textile product life cycle" pose impact on the environment, but it is the size of the impact which is staggering. This is partly due to the immense scale of the fashion industry, which has been evaluated to be a USD 1.3 trillion dollar industry [6], and the world's third largest manufacturing industry, after automotive and technology [7]. But also, according to a report by the Ellen MacArthur Foundation, data confirms that the greenhouse gas emissions produced by textile production exceeds that of international aviation and maritime shipping combined. If it continues down this path, it is projected that by 2050 it could account for 1/4 of the worlds' carbon emissions [1]. To put it into perspective further, the annual carbon footprint of the fashion industry's product life cycle (3.3 billion tons CO_2 emissions) is almost equivalent to that of 28 countries in the EU (3.5 billion tons) [7].

However, greenhouse gas emissions are not the only harmful environmental outputs from the fashion industry; it is just one of the numerous other inputs and outputs which have strenuous environmental implications, as exemplified in **Figure 2**. The below provides a summary, along with examples, highlighting some of the leading concerns (note that there are indeed many others; however, for the purpose of this condensed article, we will focus on the following):

• *Heavy consumption of depleting natural resources:*

   ○ For example, water consumption for cotton crops

   ○ For example, coal/natural gas (nonrenewable) energy to power manufacturing facilities

• *Polluting waste outputs (e.g., chemicals, pesticides, carbon emissions, etc.):*

   ○ For example, fertilizer/pesticide runoff from cotton crops

○ Dyes/chemical waste from garment factories (e.g., for dyeing and washing processes)

- *Microplastic pollution (e.g., from synthetic fiber shedding):*

  ○ For example, shedding of polyester fibers (considered microplastics) in the laundry process: a domestic wash load can release around 700,000 fibers and, as they are unable to be completely filtered out by waste water treatment plants, end up infiltrating and accumulating in marine ecosystems [8]. This issue is exacerbated by the drastic increase in the annual consumption of polyester fibers in the fashion industry, which has grown exponentially, from 8.3 million tons in 2000, to 21.3 million tons in 2016 [6].

This section provided a condensed overview of the extent of the fashion industry's impact on the environment and highlighted the most concerning forms of impact. However, it is worth noting that the abundance of published data and literature on the environmental impact of the fashion industry is truly inundating and could easily extend beyond the scope of this section. The following section will present some of the current collective global sustainability campaigns which are striving to alleviate the environmental impact of the fashion industry in the future.

3. Collective global sustainability campaigns in the fashion industry

The intensified evidence of the fashion industry's impact on the environment in the last decade prompted the founding of several global sustainability campaigns within the last 3 years. These campaigns, spearheaded by sustainability-driven coalitions, are mobilizing companies across the fashion industry, collectively toward adopting sustainable materials and practices throughout their design, development, and supply chains, and have already garnered formal commitments from key players in the fashion industry which represent a sizable portion of the market. Two predominant global campaigns, initiated in 2018, are summarized below:

- *The "2020 Circular Fashion System Commitment," introduced by the Global Fashion Agenda*

  ○ *Mission/action points:*

    The Global Fashion Agenda is a leadership forum engaging the fashion industry toward sustainability [9]. Its "2020 Circular Fashion System Commitment" is a call on the fashion industry to commit toward a "circular fashion system," by taking concrete action on one or more of the following points:

    1. Implementing design strategies for *cyclability*

    2. Increasing the volume of *used* garments and footwear *collected*

    3. Increasing the volume of *used* garments and footwear *resold*

    4. Increasing the share of garments and footwear made from *recycled post-consumer textile fibers*

     ○ Industry commitment (as of May 2018):

          1. Ninety-four companies signed on (represents 12.5% of the global fashion market), including ASOS, H&M, Nike, Inditex, Kering, and Target.

• *The "Sustainable Clothing Action Plan (SCAP) 2020 Commitment,"
introduced by the Waste and Resources Action Programme (WRAP)*

     ○ *Mission/action points:*

The SCAP (spearheaded by WRAP) is a collaborative framework and voluntary commitment for organizations to deliver industry-led targets of a 15% *reduction* in *carbon*, *water*, and *waste* in the clothing industry by [10]:

1. Reinventing how clothes are *designed* and *produced*

2. Rethinking how we value clothing by *extending life* of clothes

3. Redefining what is possible through *reuse* and *recycling*

• Industry commitment (as of March 2019):

• Eighty companies signed on (represents 58.5% of the UK's retail sales volume), including ASOS, Marks and Spencer, Ted Baker, and others.

The action points of both these campaigns show an emphasis on cyclability—not just of materials but also practices—and reshaping the product life cycle toward circularity [10] (see **Figure 3**). The number of companies committed to these campaigns so far is a promising sign that sustainability is gradually becoming an integral factor in the fashion industry. Aside from the global sustainability campaigns such as above, another industry resource supporting companies toward sustainability is the various benchmarks and tools developed to help the fashion industry gauge the environmental
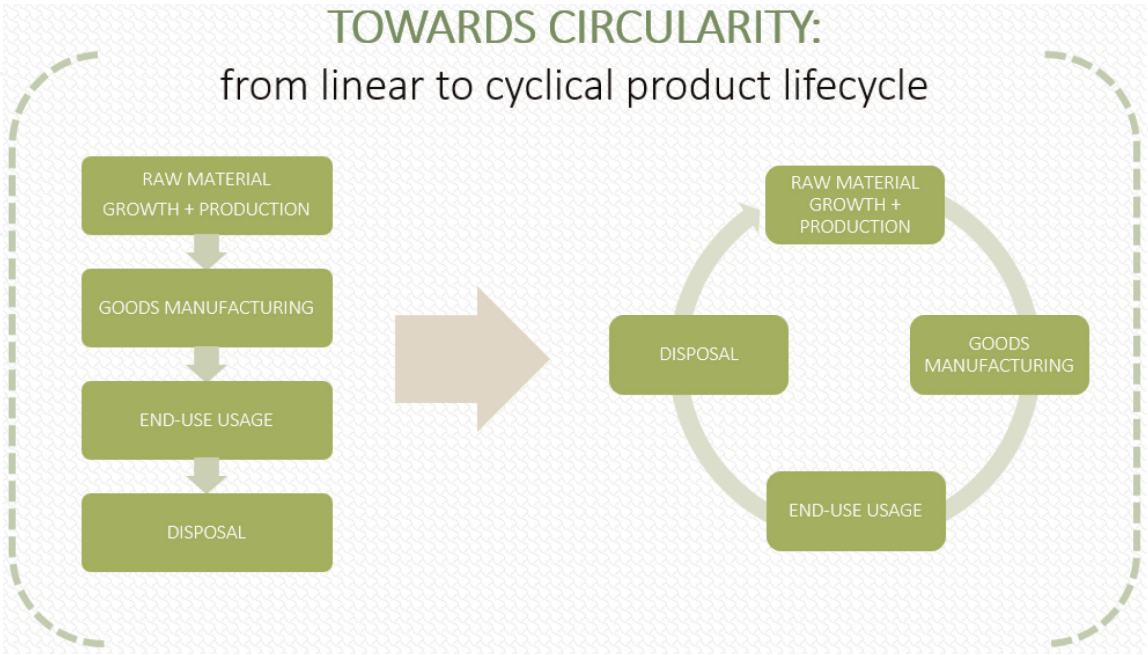

Figure 3.
A diagrammatic expression of the goal of "circularity" in the textile product life cycle.

impact of certain materials or processes and therefore help steer decisions accordingly. The following section will explore some of these tools and benchmarks.

4. Measuring environmental impact: benchmark and tools for the fashion industry

For companies in the fashion industry to become more cognizant and proactive about minimizing the environmental impact of their product life cycles, they would need to rely on a definitive benchmarks and tools to gauge the environmental impact of their decisions regarding product or processes. However, measuring environmental impact of such decisions can be very convoluted, as results tend to be conflicting depending on which angle it is viewed from. Here are some examples of the conflicting nature of environmental impact measures:

On the one hand, for example:

- A polyester shirt has more than double the carbon footprint of a cotton shirt (5.5 kg CO_2 emissions vs. 2.1 kg CO_2 emissions) [11].

But on the other hand:

- The processing for cotton produces a water footprint 20 times larger than that of polyester (see **Figure 4**).

- One kilogram of cotton—equivalent to the weight of a shirt and pair of jeans— can take as much as 10,000–20,000 liters of water to produce [10].

- For an organic cotton tote to make up for the environmental impact (water use, energy use, etc.) of a classic plastic bag, it would need to be used 20,000 times [12].

The following is an outline of three established benchmarks and tools, designed to enable the fashion industry (and other industries), to measure the environmental impact of certain decisions regarding their material use or processes employed:

- *Higg Index, developed by the Sustainable Apparel Coalition:*

  It is described as "a suite of tools" that enables the measure and score of a company or product's "sustainability performance" at "every stage in their sustainability journey," aiming to provide a "holistic overview" that "empowers businesses to make meaningful improvements that protect the well-being of factory workers, local communities, and the environment" [13]. It encompasses the following tools:

  ○ *Product tools:*

    1. *Higg Materials Sustainability Index (MSI)*: "the apparel industry's most trusted tool to accurately measure the environmental sustainability impacts of materials," by scoring materials based on their environmental impact from fiber to fabric across five environmental impact parameters (global warming, water pollution, water scarcity, resource depletion, and chemicals) (see **Figure 5** for a sample screenshot of the Higg MSI interface)
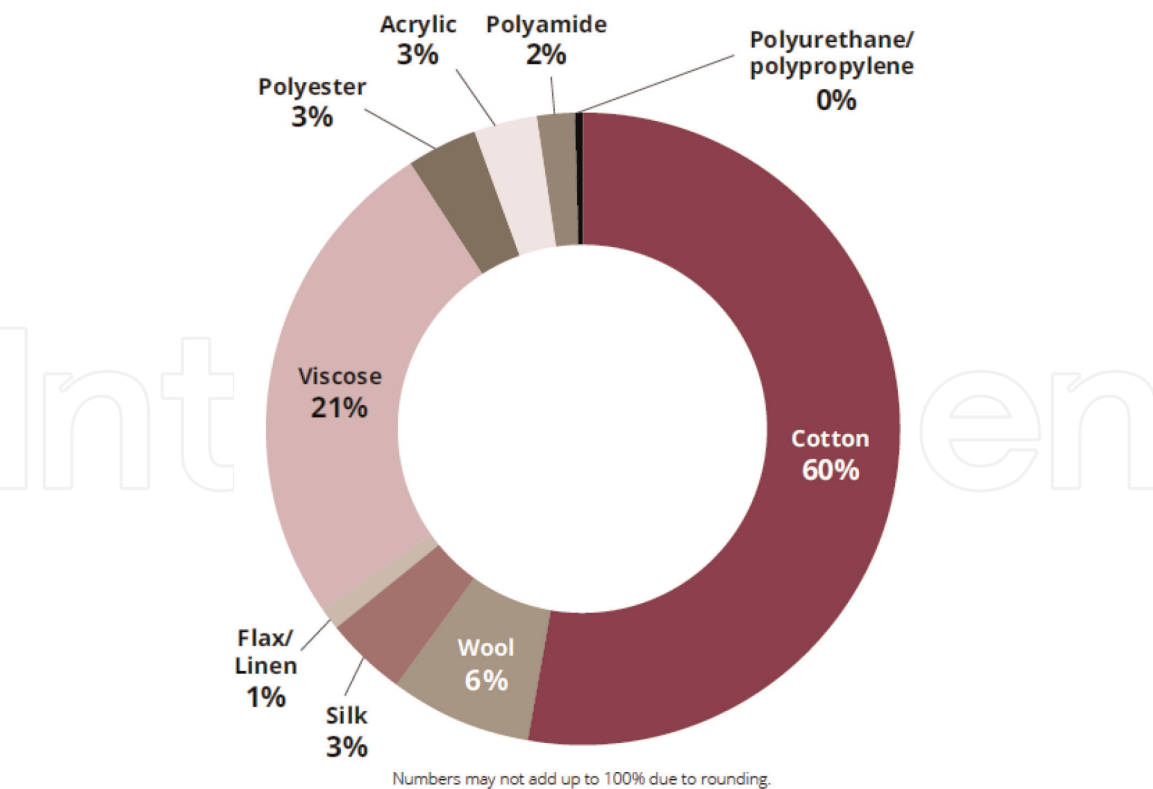
Figure 4.
Water footprint for the total processing phase of each fiber type for the UK (m3) in 2016. Source: Waste and resources action programme [14].
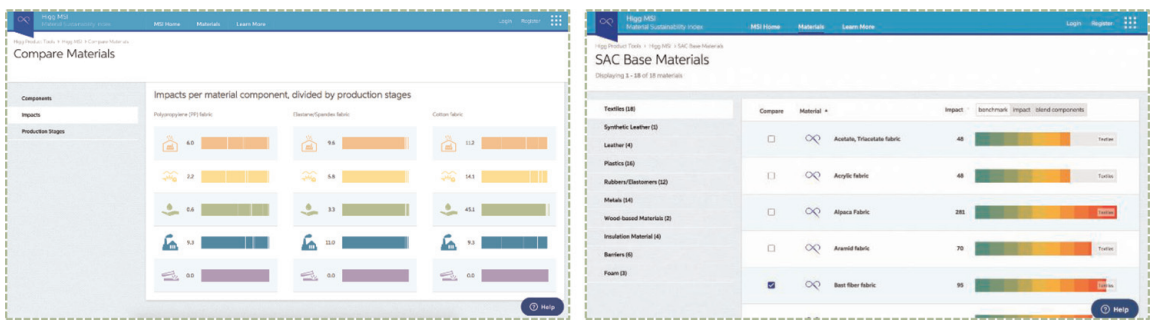

Figure 5.
Sample screenshots of the Higg Materials Sustainability Index (MSI) tool. Source: Sustainable apparel coalition [13].

2. *Higg Design and Development Module (DDM)*: "guides designers to combine their chosen materials for maximum positive impact, to select the most sustainable manufacturing techniques, and to consider the complete life-cycle of the product"

3. *Higg Product Module (PM)*: will measure the environmental impact a product (apparel, footwear, and textile products) generates through-out its life cycle when produced at industrial scale and be able to cross compare products with one another as well as which life cycle stages or production processes contribute the most impact (expected to launch in 2019)

   ◦ *Facility tools:*

   1. *Higg Facility Environmental Module (FEM)*: measures the environmental impact of individual factories based on assessing factors such as

environmental management systems, energy use and greenhouse gas emissions, water use, wastewater, emissions to air (if applicable), waste management, and chemical use and management

2. *Higg Facility Social and Labor Module (FSLM)*: measures the social impact of individual factories based on assessing factors such as recruitment and hiring, working hours, wages and benefits, employee treatment, employee involvement, health and safety, termination, management systems, facility workforce standards and those of value chain partners, external engagement on social and labor issues with other facilities or organizations, and community engagement

  ○ *Brand and retail tools:*

1. *Higg Brand and Retail Module (BRM)*: enables brands and retailers of all sizes to measure the environmental and social and labor impacts of their operations across a product's life cycle (from materials sourcing through its end of use). The environmental impacts measured include greenhouse gas (GHG) emissions, energy use, water use, water pollution, deforestation, hazardous chemicals, and animal welfare. The social and labor impacts measured include child labor, discrimination, forced labor, sexual harassment and gender-based violence in the workplace, non-compliance with minimum wage laws, bribery and corruption, working time, occupational health and safety, and responsible sourcing.

• *MADE-BY Environmental Benchmark for Fibers, developed by MADE-BY in cooperation with Brown and Wilmanns Environmental, LLC:*

It ranks 28th in the most commonly used fibers in the garment industry into 5 classes (Class A–E), based on the following measures: greenhouse gas emissions, human toxicity, eco-toxicity, energy, water, and land [15] (see **Figure 6**).

• *Corporate Fiber and Materials Benchmark (CFMB) (formerly the Preferred Fiber and Materials Benchmark (PFMB)), launched by the Textile Exchange:*

Launched in 2015, it is a leading industry-led, voluntary self-assessment tool which enables companies to systematically measure, manage, and integrate a preferred fiber and materials strategy into four key areas of mainstream business operations: corporate strategy, supply chain, consumption, and consumer engagement [16] (see **Figure 7** for flowchart of this framework laid out). It also provides feedback on progress and performance in comparison to peers and the overall industry. As of 2018, 111 companies have partaken in the program (an increase of 106% since 2015).

As can be seen from the three examples above, there is a wide selection of benchmarks and tools for measuring environmental impact available to the fashion industry; however, there are some limitations to consider. For one, the wide selection can also be problematic as each of the different initiatives above accounts for slightly different factors or weighs them slightly differently; therefore the result obtained from one tool might not be consistent with that obtained from another. For example, based on the Higg Materials Sustainability Index, natural fibers like
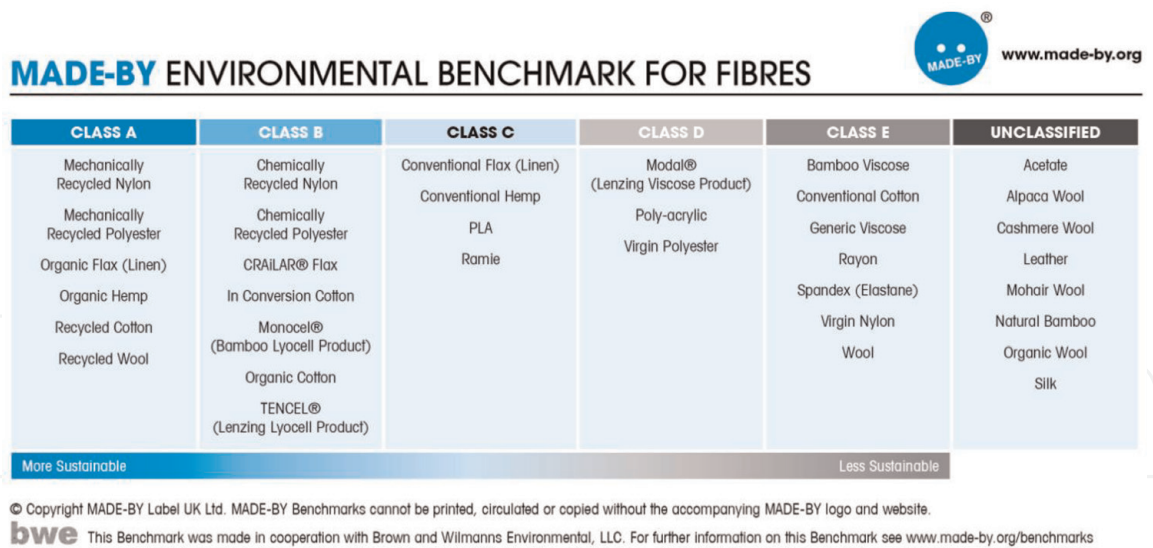
MADE-BY ENVIRONMENTAL BENCHMARK FOR FIBRES

MADE-BY ® www.made-by.org

CLASS A	CLASS B	CLASS C	CLASS D	CLASS E	UNCLASSIFIED
Mechanically Recycled Nylon	Chemically Recycled Nylon	Conventional Flax (Linen)	Modal® (Lenzing Viscose Product)	Bamboo Viscose	Acetate
Mechanically Recycled Polyester	Chemically Recycled Polyester	Conventional Hemp	Poly-acrylic	Conventional Cotton	Alpaca Wool
Organic Flax (Linen)	CRAiLAR® Flax	PLA	Virgin Polyester	Generic Viscose	Cashmere Wool
Organic Hemp	In Conversion Cotton	Ramie		Rayon	Leather
Recycled Cotton	Monocel® (Bamboo Lyocell Product)			Spandex (Elastane)	Mohair Wool
Recycled Wool	Organic Cotton			Virgin Nylon	Natural Bamboo
	TENCEL® (Lenzing Lyocell Product)			Wool	Organic Wool
					Silk
More Sustainable				Less Sustainable	

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bwe This Benchmark was made in cooperation with Brown and Wilmanns Environmental, LLC. For further information on this Benchmark see www.made-by.org/benchmarks

Figure 6.
The MADE-BY environmental benchmark fiber classification chart. Source: Common objective [15].

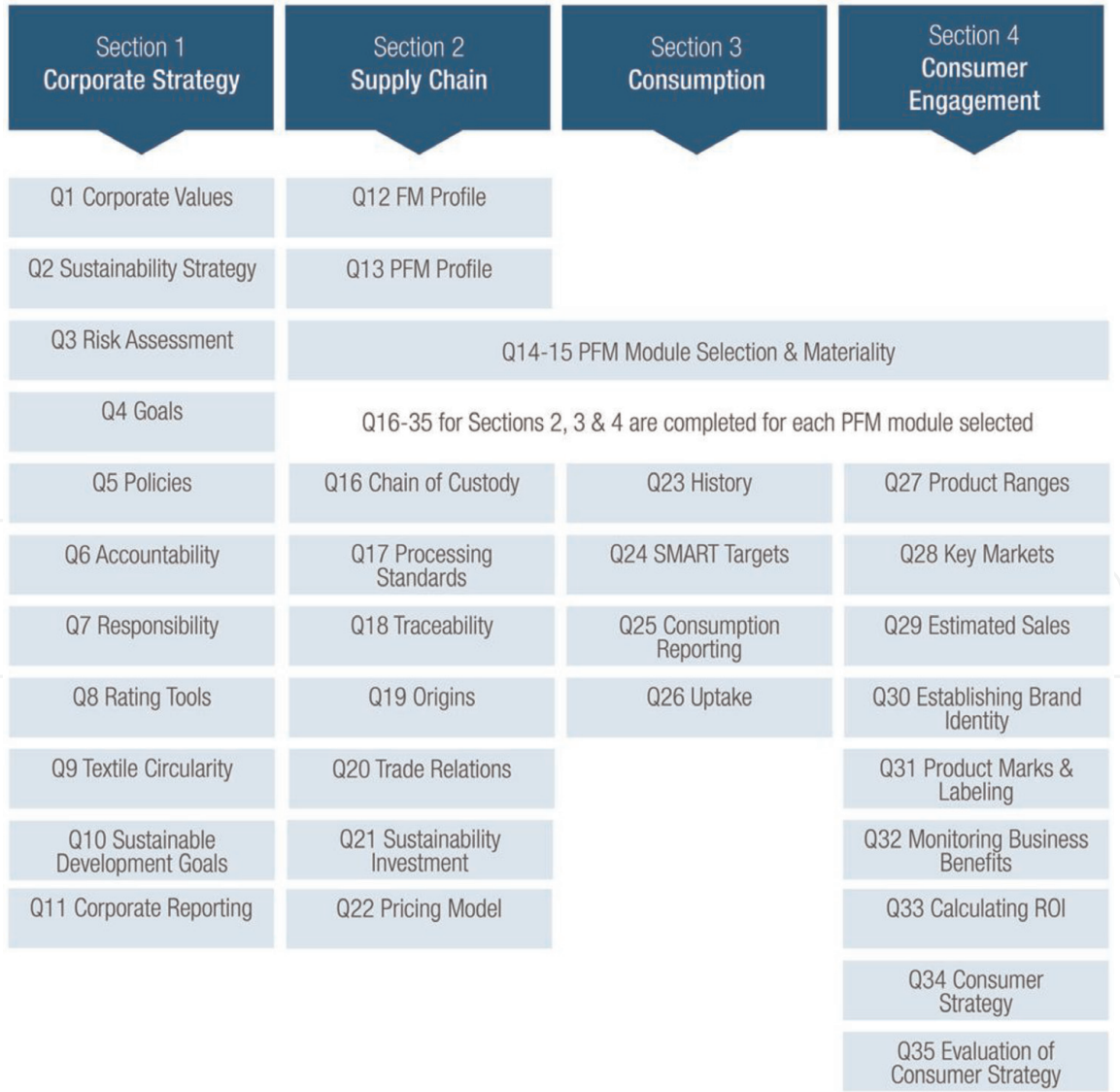| Section 1 Corporate Strategy	Section 2 Supply Chain	Section 3 Consumption	Section 4 Consumer Engagement
Q1 Corporate Values	Q12 FM Profile		
Q2 Sustainability Strategy	Q13 PFM Profile		
Q3 Risk Assessment	Q14-15 PFM Module Selection & Materiality		
Q4 Goals	Q16-35 for Sections 2, 3 & 4 are completed for each PFM module selected		
Q5 Policies	Q16 Chain of Custody	Q23 History	Q27 Product Ranges
Q6 Accountability	Q17 Processing Standards	Q24 SMART Targets	Q28 Key Markets
Q7 Responsibility	Q18 Traceability	Q25 Consumption Reporting	Q29 Estimated Sales
Q8 Rating Tools	Q19 Origins	Q26 Uptake	Q30 Establishing Brand Identity
Q9 Textile Circularity	Q20 Trade Relations		Q31 Product Marks & Labeling
Q10 Sustainable Development Goals	Q21 Sustainability Investment		Q32 Monitoring Business Benefits
Q11 Corporate Reporting	Q22 Pricing Model		Q33 Calculating ROI
			Q34 Consumer Strategy
			Q35 Evaluation of Consumer Strategy

Figure 7.
Flowchart showing the framework of the textile exchange's corporate fiber and materials benchmark (CFMB). Source: Textile exchange, [16].

silk, cotton, and wool are assigned higher environmental impact scores (i.e., more damaging to environment) of 128, 98, and 82, respectively, while fossil-fuel-derived fibers like nylon, acrylic, and polyester have lower impact scores at 60, 52, and 44 [7]. This is because the Higg Index puts greater emphasis on fiber production, which is indeed more taxing on the environmental for natural fibers such as silk, cotton, and wool, as their procurement imposes a greater strain on natural resources (such as water, land, or animal welfare). Yet, in contrast, according to the MADE-BY Environmental Benchmark (**Figure 6**), fossil-fuel-based virgin nylon fibers and natural wool fibers are both ranked under the same Class E (the "least sustainable" category). Hence the availability of multiple benchmarks and tools could prove to be more incumbering than helpful when it comes to definitively measuring environmental impact.

Another limitation of these benchmarks and tools is that they do not sufficiently weigh in, or even overlook, the impact of the in-use phase of the textile product life cycle. The in-use phase here refers to the period when the textile product is being used for what it was made for. So, for a garment, that would mean the period from when it is purchased by a customer until it is no longer used or disposed of, which mostly involves its wearing and laundering. The research of Laitala et al. reveals that energy and water consumption during the laundering process varies greatly depending on fiber content of the garments [17]. Firstly, (see **Figure 8**) the research presents data which indicates that wool- and silk-based garments are 3–6 times more likely to be dry-cleaned than cotton- or synthetic-based garments and furthermore that dry cleaning uses 3–6 times (depending on the type of dry-cleaning
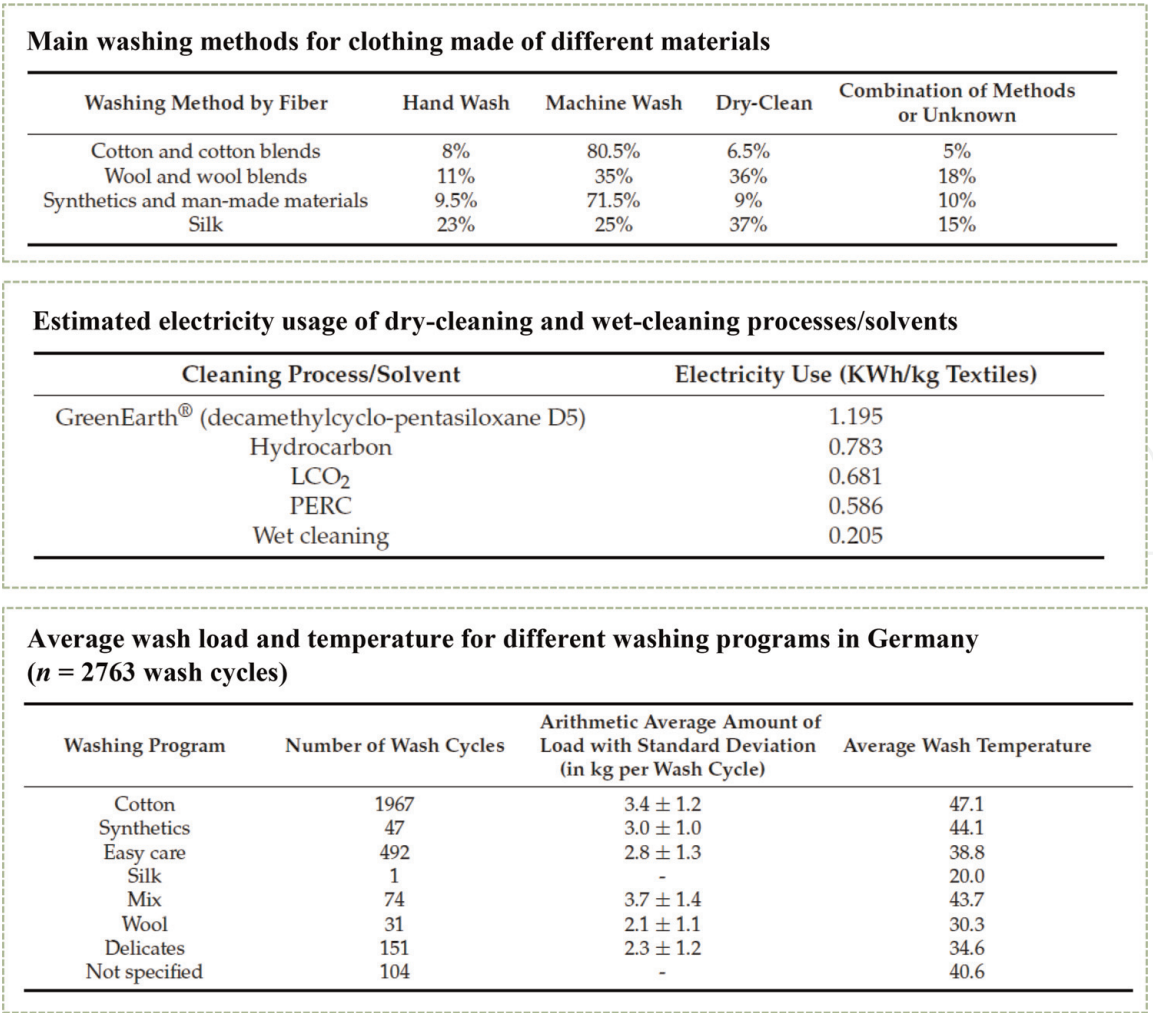
Main washing methods for clothing made of different materials

Washing Method by Fiber	Hand Wash	Machine Wash	Dry-Clean	Combination of Methods or Unknown
Cotton and cotton blends	8%	80.5%	6.5%	5%
Wool and wool blends	11%	35%	36%	18%
Synthetics and man-made materials	9.5%	71.5%	9%	10%
Silk	23%	25%	37%	15%

Estimated electricity usage of dry-cleaning and wet-cleaning processes/solvents

Cleaning Process/Solvent	Electricity Use (KWh/kg Textiles)
GreenEarth® (decamethylcyclo-pentasiloxane D5)	1.195
Hydrocarbon	0.783
LCO_2	0.681
PERC	0.586
Wet cleaning	0.205

Average wash load and temperature for different washing programs in Germany (n = 2763 wash cycles)

Washing Program	Number of Wash Cycles	Arithmetic Average Amount of Load with Standard Deviation (in kg per Wash Cycle)	Average Wash Temperature
Cotton	1967	3.4 ± 1.2	47.1
Synthetics	47	3.0 ± 1.0	44.1
Easy care	492	2.8 ± 1.3	38.8
Silk	1	-	20.0
Mix	74	3.7 ± 1.4	43.7
Wool	31	2.1 ± 1.1	30.3
Delicates	151	2.3 ± 1.2	34.6
Not specified	104	-	40.6

Figure 8.
Data on laundry requirements based on fiber content. Source: Laitala et al. [17].

process) more electricity than wet washing methods (which is the predominant laundering method for cotton- or synthetic-based garments). However, their research also shows that on average, the water temperature of the wash setting for cotton-based garments is about 17°C higher than that for wool-based garments. With polyester and other nonbiodegradable polymer fibers (e.g., acrylic and nylon), there is the developing concern regarding the shedding of fibers (microplastic) during the washing process which, being unable to be completely filtered out by standard waste water treatment plants, end up infiltrating and accumulating in marine ecosystems.

Another aspect which deserves more consideration by the benchmarks and tools is human ecology and not just environmental ecology. For example, there are man-made fibers derived from plants, such as polylactic acid (PLA) derived from corn, which are environmentally biodegradable, but not necessarily human biocompatible [18]. Therefore, the potential negative side effects or toxicity on human ecology is a factor which deserves equal attention in impact measures.

These limitations in the current benchmarks and tools are a clear reminder that measuring environmental impact of product or processes in the fashion industry is multifaceted and convoluted. Currently there is no prevailing, overriding benchmark or tool that provides a definite unanimous measure of environmental impact, so it is up to companies to adopt a holistic approach when developing a strategy toward sustainability.

5. Sustainability initiatives in the fashion industry

Having reviewed several sustainability campaigns and environmental impact measure benchmarks and tools relevant to the fashion industry today, this section will now proceed to provide insight into how companies and various players in the industry have responded, i.e., the kinds of strategic initiatives being taken toward sustainability. The sustainability initiatives will be categorized into two types: (1) front-end approach and (2) back-end approach.

5.1 Front-end approach

Within the context of this article, this refers to the integration of sustainable initiatives at the beginning stages (front-end) of the textile product life cycle, such as in the raw material sourcing and design and development processes. So, for example, a front-end sustainable initiative could be the decision to use "low environmental impact*" textile fibers as the raw materials for the textile goods being produced. A front-end sustainable initiative could also be manifested in the design and development process, for example, by utilizing digital tools to minimize the need for physical prototype samples or by training designers to adopt an eco-conscious mindset into their creations. (*Note that we are using the term "low environmental impact" textile fibers as opposed to "sustainable" or "eco-friendly" or "green" textile fibers because the latter terms can be misleading as there are no completely "sustainable/eco-friendly/green" fibers; all materials pose some impact. Furthermore, as discussed in the previous section, it is difficult to resolutely confirm the impact of a certain material, as there are many facets of environmental impact. Therefore "low environment impact" is a more accurate representation of what is possible to strive for in sustainable materials).

An industry example of a front-end approach to sustainability is the adoption of regenerated cellulosic fibers, such as Lyocell and Seacell, by various fashion companies particularly in lingerie and activewear [19]. With cotton, albeit a natural

cellulosic fiber, bearing a hefty water footprint in the harvesting process, and with petrochemical-based synthetic fibers such as polyester and nylon bearing a hefty carbon footprint in the manufacturing process [20], regenerated cellulosic fibers can prove advantageous. They have the benefit of being biodegradable and derived from natural renewable resources (i.e., Lyocell is derived from wood pulp and Seacell is derived from seaweed) via a closed-loop manufacturing process, thereby consuming far less water and energy than traditional cotton, polyester, and nylon. Both Lyocell and Seacell also naturally carry antibacterial and fast-drying properties, which is why they are ideal for lingerie and activewear product.

A limitation of a front-end approach in tackling environmental impact is that it is still feeding more product in the fashion pipeline which will eventually end up at the end of the textile life cycle as waste by-product (even if it is biodegradable by-product) which needs to be managed accordingly. Therefore, in the following section, we will look at an approach which tackles the by-product end of the textile product life cycle.

5.2 Back-end approach

Within the context of this article, this is referring to sustainability initiatives which aim to minimize the environmental impact of the product and processes at the end of the textile product life cycle, e.g., at disposal. A prime example of this is exemplified in the now widespread initiatives of post-consumer textile recycling.
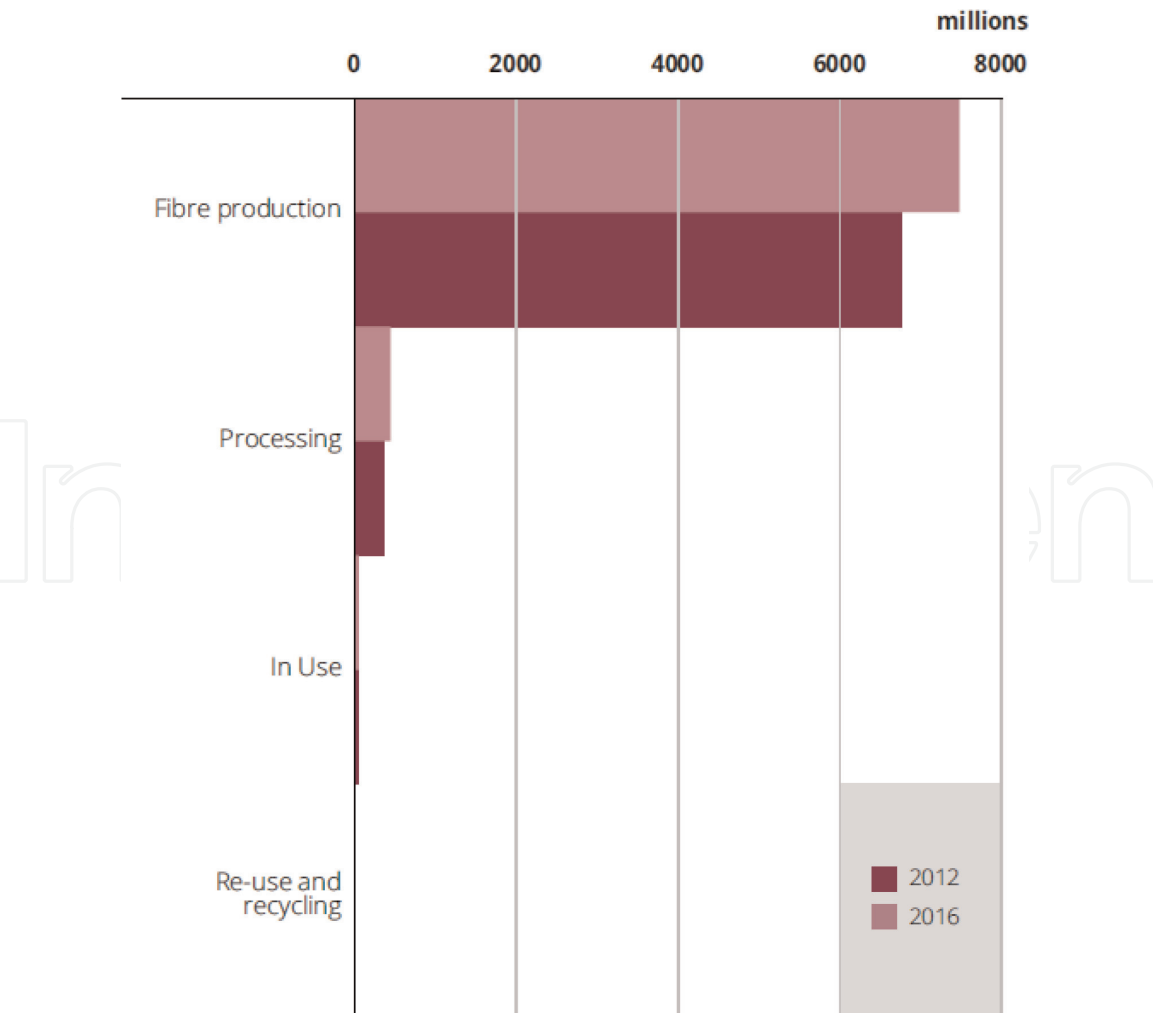
Figure 9.
Water footprint of clothing in the UK (m3) in 2012 and 2016, comparing life cycle stages. Source: Waste and resources action programme [14].

The reason recycled textiles have become so prevalent as a strategy to minimize environmental impact is not only because of the exponential supply of textile waste driven by intensified clothing consumption but more strategically because research has shown that the fiber production stage (extraction and processing) of the textile product life cycle has the greatest environmental impact in terms of water and carbon footprint, as shown in **Figures 9–10** [14]. Therefore, by recycling post-consumer textile waste back into the textile supply chain enables bypassing the heavy environmental toll of the fiber production stage.

There has been a great deal of research invested into textile recycling, from both the industry and academia. One notable advancement in textile recycling is exemplified by Garment-to-Garment (G2G) Recycle System, a closed-loop garment recycling retail concept supported by technology which enables the recycling of blended post-consumer garments, developed by HKRITA, in partnership with H&M and Novetex [21]. The Garment-to-Garment (G2G) Recycle System brings garment recycling to the retail level, therefore paving the way for garment recycling to be more accessible to the everyday consumer.

There are also several notable recycling initiatives which, instead of relying solely on post-consumer textile products, are derived from various kinds of post-consumer plastic waste. REPREVE is one example of this. Produced by the company Unifi, REPREVE is a brand of polyester fibers made from recycled post-consumer plastic waste (e.g., plastic bottles) [22]. The ability to convert various forms of
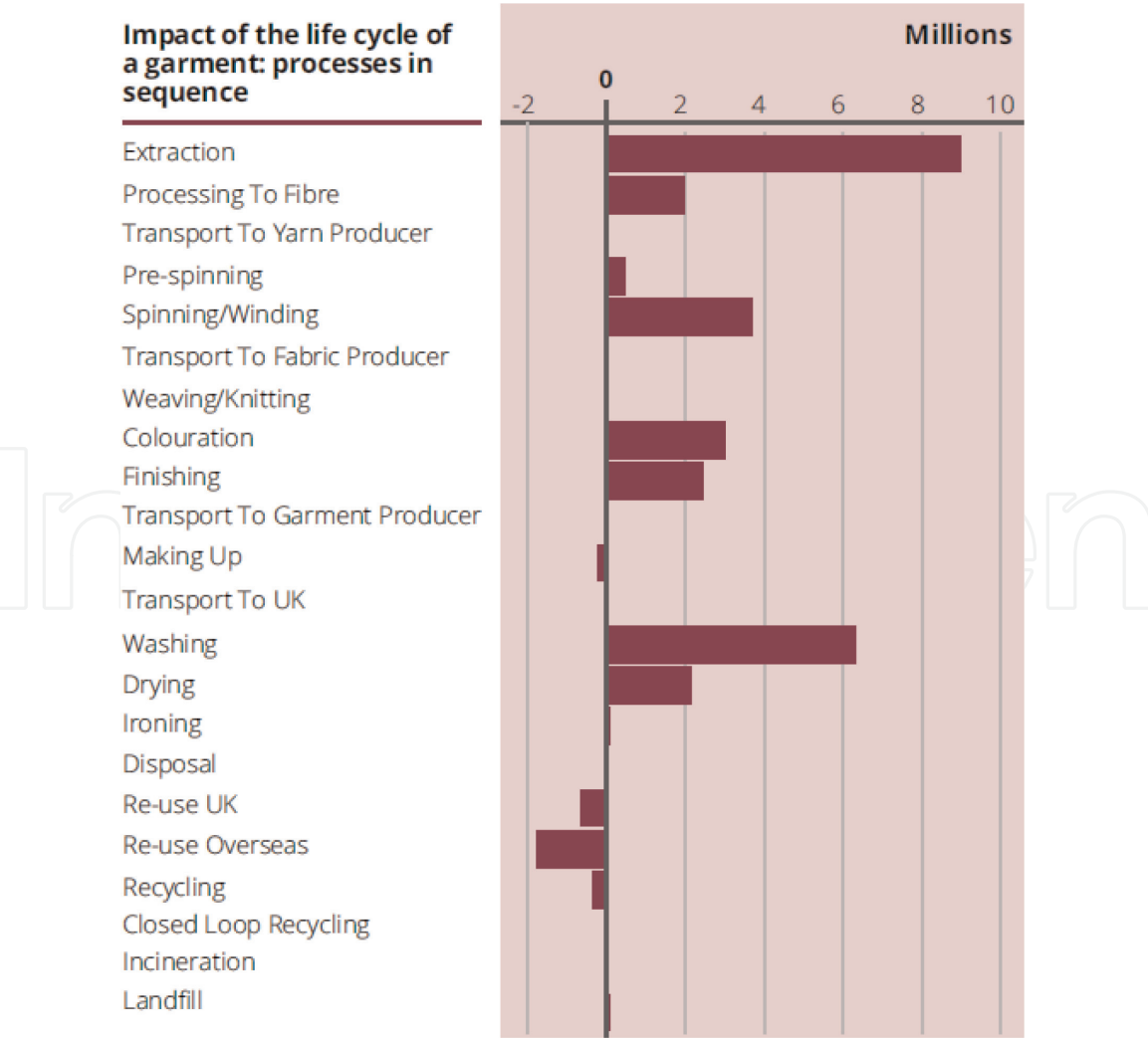

Figure 10.
Carbon footprint of clothing in the UK (t CO_2e) in 2016, by process. Source: Waste and resources action programme [14].

plastic waste into usable polyester textile fibers has the benefit of resourcefulness. Even though the conversion from post-consumer plastic waste to fiber requires energy and water input for the manufacturing process, according to Unifi, it is reportedly much less than that required for virgin polyester (energy consumption is 45% less, water consumption is almost 20% less, and over 30% less greenhouse gas emissions).

Over the past decade, there have been many encouraging advancements which have expanded back-end approach sustainability initiatives such as textile recycling. However, there remain limitations in the current textile recycling technologies. For example, due to the need for comprehensive shredding in breaking down post-consumer textile waste, the tensile strength of recycled cotton yarns is less than that of virgin cotton [23]. Furthermore, as recycled yarns are composed of a mixture of fibers which may have undergone different dyeing and finishing processes in their last life, even after cleaning and bleaching processes, they may not be able to achieve the same hand-feel and color vibrancy possible with virgin fibers, therefore limiting its design versatility. These are some examples of limitations which could be preventing a greater adoption of textile recycling in the industry.

6. Conclusion

This article has attempted to provide a current and overarching view on the most concerning environmental impacts of the fashion industry today, the leading global sustainability campaigns and benchmarks and tools established to help empower the fashion industry toward concrete action and, last but not least, examples of sustainability initiatives being implemented in the industry. The fashion industry's large-scale wave of movement toward sustainability is evident; however, there remain questions and challenges to be addressed, one being how successful the "2020 commitment" goals will be, with 2020 just around the corner, and considering how potentially disruptive any kind of change is in an industry which is built on long-established processes and practices and adheres to an inflexible, tight calendar. Furthermore, as discussed in this article, the array of benchmarks and tools available for measuring environmental impact can result in a convoluted process and conflicting, inconclusive information. Such challenges may deter a company from successfully achieving concrete changes toward sustainability.

Even if companies are able to navigate through the intricacies in evaluating environmental impact of a textile product or process, it is important to remember that the textile product life cycle is never impact-free (at least not in the foreseeable future), as it relies on the environment to provide various inputs and outputs. With this reality in mind, companies may find that making small but carefully holistically considered steps in the right direction can be much more effective than larger uninformed leaps when it comes to sustainability.

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References

[1] Ellen MacArthur Foundation. A new textiles economy: Redesigning fashion's future. 2017. Available from: https://www.ellenmacarthurfoundation.org/publications

[2] Lehmann M, Tärneberg S, Tochtermann T, Chalmer C, Eder-Hansen J, Seara JF et al. Pulse of the fashion industry report 2018. 2018. Global Fashion Agenda and The Boston Consulting Group. Available from: https://www.globalfashionagenda.com/initiatives/pulse/#

[3] Textile Exchange. 2018 Preferred Fiber and Materials benchmark insights report. 2018a. Textile Exchange. Available from: https://textileexchange.org/downloads/2018-preferred-fiber-materials-benchmark-insights-report/

[4] World Bank. Euromonitor international apparel and footwear 2016 edition (volume sales trends 2005–2015). 2017. World development Indicators—GD

[5] The Business of Fashion and McKinsey and Company. The State of Fashion 2019. 2019. The Business of Fashion and McKinsey and Company. Available from: https://www.businessoffashion.com/articles/intelligence/the-state-of-fashion-2019

[6] The Economist (Producer). Fashion's toxic threads. [Video]. 2018. Available from: https://www.youtube.com/watch?v=Ko_BZhIpI1Q

[7] UK Parliamentary Environmental Audit Committee. Fixing fashion: clothing consumption and sustainability. 2019. UK Parliament House of Commons. Available from: https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/1952/report-files/195202.htm

[8] Napper IE, Thompson RC. Release of synthetic microplastic plastic fibres from domestic washing machines: Effects of fabric type and washing conditions. Marine Pollution Bulletin. 2016;**112**(1):39-45. DOI: 10.1016/j.marpolbul.2016.09.025

[9] Global Fashion Agenda. 2020 Commitment. 2018. Available from: https://www.globalfashionagenda.com/commitment/

[10] Waste and Resources Action Programme. Sustainable clothing action plan (SCAP). 2018. Available from: http://www.wrap.org.uk/sustainable-textiles/scap

[11] Kirchain R, Olivetti E, Miller TR, Greene S. Sustainable apparel materials. 2015. Cambridge, MA: Materials Systems Laboratory, Massachusetts Institute of Technology. Available from: https://globalcompostproject.org/wp-content/uploads/2015/10/Sustainable ApparelMaterials.pdf

[12] Schlanger Z. Your Cotton Tote is pretty much the worst replacement for a plastic bag. QUARTZ. 2019. Available from. https://qz.com/1585027/when-it-comes-to-climate-change-cotton-totes-might-be-worse-than-plastic

[13] Sustainable Apparel Coalition. The Higg Index. 2019. Sustainable Apparel Coalition. Available from: https://apparelcoalition.org/the-higg-index/

[14] Waste and Resources Action Programme. Valuing Our Clothes: The Cost of UK Fashion. 2017. Available from: http://www.wrap.org.uk/sustainable-textiles/valuing-our-clothes

[15] Common Objective. Made-By Environmental Benchmark for Fibres. 2018. Common Objective, Available from: https://www.commonobjective.

co/article/made-by-environmental-benchmark-for-fibres

[16] Textile Exchange. Corporate Fiber and Materials Benchmark. 2018b. Textile Exchange. Available from: https://textileexchange.org/pfm-benchmark/

[17] Laitala K, Klepp IG, Henry B. Does use matter? Comparison of environmental impacts of clothing based on fiber type. Sustainability. 2018;**10**(7):6-8. DOI: 10.3390/su10072524. ISSN 2071-1050; CODEN: SUSTDE

[18] Ramot Y, Haim-Zada M, Domb AJ, Nyska A. Biocompatibility and safety of PLA and its copolymers. Advanced Drug Delivery Reviews. 2016;**107**: 153-162. DOI: 10.1016/j.addr.2016. 03.012

[19] Barnes O. Sustainable Yarn. Textiles and Knitwear Team WGSN Materials, WGSN Reports. 2018. WGSN. Available from: https://www-wgsn-com.ezproxy. lb.polyu.edu.hk/content/board_viewer/ #/80459/page/1

[20] Dissanayake G, Perera S. New approaches to sustainable fibres. In: Muthu SS, Gardetti M, editors. Sustainable Fibres for Fashion Industry: Volume 2. Springer Singapore: Singapore; 2016. pp. 1-12

[21] The Hong Kong Research Institute of Textiles and Apparel (HKRITA). Inaugural Deployment of HKRITA's Award-Winning Textile Recycling Technologies Helps Close the Loop for the Fashion Industry [Press release]. 2018. Retrieved from: http://www. hkrita.com/marketing/PressRelease/ 20180903_HKRITA_Media_event_on_ Textile)Recycling_Eng.pdf

[22] Unifi Inc. REPREVE. 2019. Available from: https://repreve.com/

[23] Ütebay B, Çelik P, Çay A. Effects of cotton textile waste properties on

recycled fibre quality. Journal of Cleaner Production. 2019;**222**:29-35. DOI: 10.1016/j.jclepro.2019.03.033