MISTRA Dialogue

Investor Brief:

Sustainability in Textiles and Fashion

by

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Mistra Investor Briefs

The idea of 'Investor Briefs' arose from a meeting between two of Mistra's external asset managers and researchers from a Mistra-funded research programme. The aim of the Investor Brief is to provide a comprehensive, yet easily accessible, report on trends and key aspects as well as a tool kit that is useful for supporting sustainable investments and engagement. This Investor Brief, focused on fashion and textiles, is the second in a series in which the Mistra Dialogue initiative helps to connect investors and researchers, and catalyses the implementation of knowledge produced in the research programme Mistra Future Fashion.

Mistra, the Swedish Foundation for Strategic Environmental Research, funds academic and multi-stakeholder research with the aim of resolving important environmental problems and contributing to sustainable development. The determination to drive positive change is also key to Mistra in our role as an asset owner. Assets are entirely invested according to sustainability criteria and with a long-term perspective.

These dual roles as research funder and asset owner give Mistra a unique opportunity to provide a bridge between the finance sector and researchers that can provide for increased knowledge of asset management for sustainable development. The Mistra Dialogue initiative emphasises the ambition to refine and adapt the ideas, knowledge and results derived from Mistra-funded programmes to reach different target groups, with asset managers and investors as a key actor.

Mistra Investor Brief no. 1 (2019) *Plastics and Sustainable Investments – an information brief for investors*. Authors Tobias B Nielsen and Fredric Bauer. Based on results from STEPS – Sustainable Plastics and Transition Pathways.

Mistra Investor Brief no. 2 (2020) *Investor Brief: Sustainability in Textiles and Fashion*. Authors Åsa Östlund, Sandra Roos, Susanne Sweet, Emma Sjöström. Based on research results from Mistra Future Fashion.

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Preface

The ambition of this brief is to generate an understanding of how research-based results can serve as a guide for sustainable investment in the fashion and textile sectors. The brief has been developed based on discussions between researchers in the Mistra Future Fashion Research Programme and representatives from the Finance sector. A workshop with invited members of the financial sector was held at the Stockholm School of Economics in January 2020. This provided inputs on how best to provide important sustainability research findings for different financial analysts.

This Investor Brief was written at the first peak of the COVID-19 pandemic. The authors have not considered the impact of the economic and societal crises that this pandemic might have in the long run. It is likely that firm conclusions on how the crises has affected the textile and fashion industry, and textile and fashion use, will only be drawn in the next few years. That said, some effects that can already be seen, although these may be of a temporary nature. First, the apparel retailers whose only business model is in-store shopping are suffering the most; e-commerce, on the other hand, has increased dramatically. Broader society is changing (possibly also only temporarily) and many employees have been forced to work from home. Citizens are in a time shift where most people's lives are moving much more slowly. This, for some, has led to more conscious behaviour that could lead to a more sustainable way of living and consuming. This is our hope – that the pandemic period of lockdowns in many nations will lead to the paradigm shift that is required in order to live within the planetary boundaries.

We are grateful to the participants in the January workshop and the participants in discussions during the spring of 2020 who provided valuable inputs into and advice on the framing of this report. In addition, we would like to express a special thank you to Anna Strömberg, Swesif, for great support and feedback throughout the process of writing this report and for giving us the opportunity to present the report at a joint Swesif-Mistra seminar that will take place on 1 September 2020. Finally, we would like to thank Mistra (The Swedish Foundation for Strategic Environmental Research) for funding this report, and especially Åsa Moberg and Malin Lindgren at Mistra for spurring us on to pursue this project.

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Summary

This Investor Brief explains the key issues for, trends and challenges facing textiles and fashion, with a focus on environmental sustainability. The aim is to help investors align their activities – such as analyses, corporate evaluations and engagement – with the environmental goals of Agenda 2030 and the 1.5°C goal in the Paris Agreement. To this end, the report also contains a toolkit that can be used to assess the sustainability of investments and the success of engagement.

The content is based on the work of the Mistra Future Fashion research programme,[1] which involved eight years (2011–2019) of interdisciplinary research to clarify what sustainable fashion is and by what means sustainability can be achieved in the textiles, apparel and fashion industries. The research was based on a systems perspective that engaged researchers in design, materials, Life Cycle Assessment (LCA), business models, policy and user behaviour. Fifty industry partners also took an active part in the programme.

Major efforts are needed to achieve a sustainable textile industry

Mistra Future Fashion research found that the production of garments has the largest environmental impact from a life cycle perspective in terms of climate change, toxic pollutants and contribution to water scarcity. Reducing the impact of the production line will be of the outmost importance, by reducing both the number of items produced and the environmental impact of each item produced. In parallel, it will be crucial to develop recycling infrastructure and technologies.

To tackle and improve sustainability we will need to:

- avoid new production; and
- reduce the environmental impact of existing production.

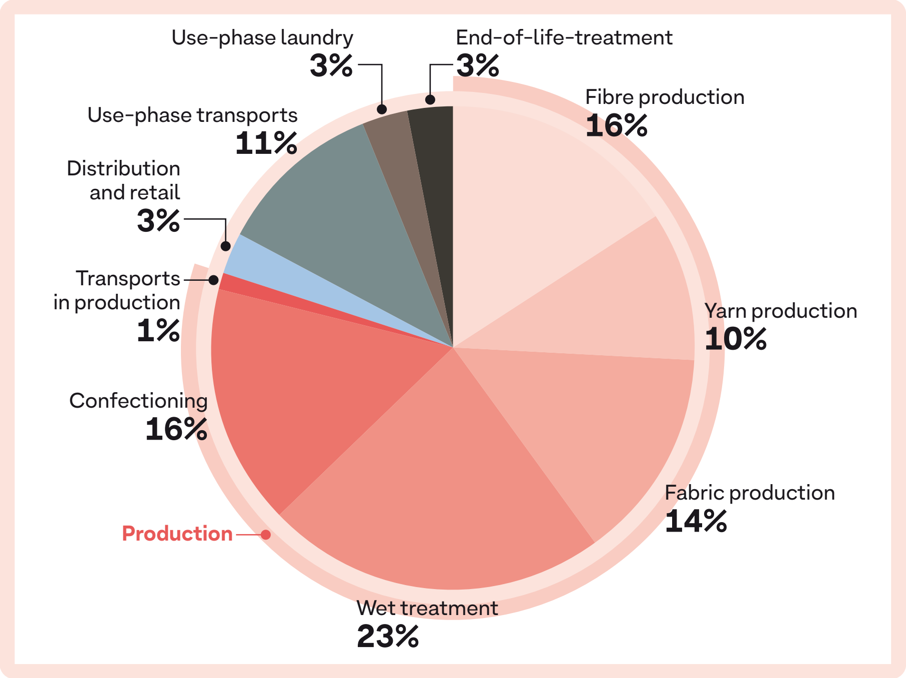
The global apparel industry accounted for 6.7% of the total global climate impact in 2016;[2] 63% of all fibres on the market are fossil-based synthetics (mostly polyester)[3].

1 *www.mistrafuturefashion.com*

2 Measuring Fashion, Quantis report 2018.

3 The Fiber Year, 2019. World Survey on Textile & Nonwovens. Speicher, Switzerland.

FIGURE 1: Climate impact of Swedish clothing consumption, contribution of life cycle phases.[4] The red sections of the chart comprise the production steps that make up the 80% of total climate impact.



80% of the total climate impact of Swedish clothing consumption is linked to its production (see Figure 1).[4] This is mainly due to the use of fossil fuel-based energy in the production processes.

Mistra Future Fashion recommendations for a textile industry that stays within planetary boundaries:

- **CLIMATE:** By 2030, reduce life cycle emissions of greenhouse gases from textile products by 50%. Be carbon neutral by 2050.
- **WATER:** By 2030, obtain information on the water sources of all major suppliers and recipients. By 2050, take steps to remain below the critical level of blue water withdrawal,[5] in cooperation with other local users.
- **POLLUTANTS:** Phase out all persistent organic pollutants (POP) from textile production by 2030. By 2050, have in place protocols on the responsible handling of chemicals; minimize the use of chemicals to prevent adverse impacts on the environment and human health[6]

4 Sandin, G., Roos, S., Spak, B., Zamani, B., Peters, G. Environmental assessment of Swedish clothing consumption. Mistra Future Fashion report 2019:05.

5 Blue water withdrawal as % of mean monthly river flow. For low-flow months, 25%; for intermediate flow months, 30%; for high-flow months, 55%, as recommended in Steffen, W., Richardson, K., Rockström, J., Cornell, S., Fetzer, I., Bennett, E., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C. A., Folke, C., Mace, G., Persson, L.M., Veerabhadran, R., Reyers, B., Sörlin, S., (2015) Planetary Boundaries: Guiding human development on a changing planet. Science 347 (80).

6 At the Johannesburg World Summit on Sustainable Development in 2002, the participating states agreed to the latter goal concerning chemicals (United Nations, 2002. Report of the World Summit on Sustainable Development, United Nations publications, New York).

Textile industry moves slowly towards a circular economy

Compared to sectors such as plastics, glass and metals, the textile industry has been very late with its transition to a circular economy. The textile industry globally uses only 3% recycled materials.[7]

Although there are many initiatives under way, there is currently no Extended Producer Responsibility (EPR) for the collection of textiles for reuse and recycling in most states. The 2018 amendment to the European Union (EU) Waste Framework Directive (see Appendix B) requires textiles to be collected separately from other waste. This directive should be implemented at the national level in all EU member states before 2025 (see section 3.4).[8] Under the Swedish Government's so-called January Agreement,[9] a suggested EPR for Textiles will be presented in December 2020.[10] The January Agreement also stipulates a new tax on harmful chemicals in clothes and shoes, as well as a tax on waste incineration (see section 3.4).

Circularity goals by 2025

EU:

- >55% (by weight) of municipal waste (not only textiles) to be prepared for reuse and the recycling.

Sweden (suggested targets from the Swedish Environmental Protection Agency)[11]

- The amount of textiles in Swedish household waste should be reduced by more than half from around 8 to 3 kg/capita/year).
- The majority (90%) of textiles should be reused or recycled, meaning that the total collected volume of discarded textiles will increase to over 85,000 tonnes/year.

7 Ellen MacArthur Foundation, A new textiles economy: Redesigning fashion's future, 2017.

8 Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on Waste

9 Socialdemokraterna. 2019. "Utkast till Sakpolitisk Överenskommelse Mellan Socialdemokraterna, Centerpartiet, Liberalerna Och Miljöpartiet de Gröna."

10 Ett producentansvar för textil, Dir.2019:96 *https://www.regeringen.se/4ae68c/contentassets/ed534990577740479348c54c724dad6d/ett-producentansvar-for-textil-dir.-201996*)

11 These targets will be revised in the Swedish EPR suggestion as to be presented December 2020.

Gamechangers: what investors should closely monitor

The four key areas below provide the greatest potential to achieve an environmentally sustainable textile and fashion industry.

New business models to prolong the life of garments

Business models that help to prevent new consumption would contribute both to the circular economy and to the environment. Examples of business models that prolong the lifetime of garments include increasing durability, renting/leasing, resale and 'upcycling' of second hand/pre-owned goods, mending/repair services and redesign.

New production technology

New resource-efficient technologies and technical innovations need to be developed and implemented, such as switching to renewable energy, optimisation of existing technologies to decrease energy demand, new technologies in the dyeing of textiles, and reduced water and chemicals use.

New material recycling technology

All materials on the market should ideally come from recycled or renewable sources. Design for recycling, as well as infrastructure for the collection and sorting of textiles, will be important instruments for increasing recycling rates. There is also a need for new recycling technologies. Pipeline inventions are likely to reach industrial scale in the near future.

Technology development for traceability

The development and standardisation of technologies and information systems to increase traceability will be needed to enable the measurement of impacts throughout the production chain. Traceable information tags, such as RFID tags, will increase sorting rate and accuracy. Tags for enhanced traceability will facilitate the fulfilment of certification obligations and directives, stock handling by the retailer, the visibility of pre-owned histories, and the provision of information from the production line.

✳ Investor toolkit

The Investor toolkit seeks to identify the key issues to consider and the critical questions for investors and financial analysts to ask when investigating environmental claims and analysing current and/or potential investments in firms along the textile value chain. The toolkit can serve as an input to engagement activities with portfolio companies, as decision support for new investments and as a checklist against greenwashing. Extensive supporting information is provided in the full report, Investor Brief: Sustainability in Textiles and Fashion, and in the list of suggested further reading in section 5.

Terminology that could signify greenwashing

A number of terms are commonly used in sustainability communications where vague definitions or a lack of applicability to the textile value chain raises a warning flag that the communicator is greenwashing. For more detail on the legislation surrounding these terms, use the guide from The Swedish Consumer Agency.[12]

TABLE 1: Terminology that could signify greenwashing.

Term	Comment
Circularity	Since there is no widely agreed definition , claims such as '100% circular materials by 2030' are very vague. In addition, circularity does not necessarily imply sustainability.
Sustainability	Since there is no widely agree definition , claims such as '100% sustainable materials by 2030' are very vague.
Recyclable	A much misused term. Most materials are recyclable in theory. To be recyclable in practice requires infrastructure (collecting and sorting), recycling technology and market demand for the recycled material.
Compostable	A much misused term. Most compostable materials are intended for an industrial composting process. To be compostable in practice requires infrastructure (collecting and sorting) and technology (there is no industrial composting plant in Sweden). Thus, this claim suffers from a lack of applicability in the textile value chain.
On-product labelling that does not make a statement related to the product	The Better Cotton Initiative (BCI) is in a laudable initiative that seeks to reduce the environmental impacts of cotton cultivation. However, it should be stressed that the existence of an on-product label does not mean that the product contains BCI cotton. It is only a statement that the company supports the production of BCI cotton. This makes the supply chain less transparent and increases the risk, for example, that the product will contain traces of pesticides. The BCI also permits genetically modified organisms (GMO) that are forbidden in several countries. This situation is different with the labelling of organic cotton, where organically grown cotton is used in any product that bears the label. In general, there is good reason to be cautious of labelling as there are many non-certified labels.

12 https://www.forummiljosmart.se/nyheter/se-upp-for-gronmalning/

The following questions are grouped around the four identified key areas for improvement. Each question has a response that outlines what should be included in a sustainable response.

New business models to prolong the life and use of garments

The greatest impact at the least cost can be achieved by avoiding the consumption (and thus production) of new items in the first place. This could be easily achieved by using products more efficiently. Examples of business models that prolong the life (number of uses) of garments include increased durability, renting/leasing, resale of second hand/pre-owned items, mending/repairing services and redesign. Even though the aim is an honest attempt to reduce environmental impact through the increased use of garments, however, this is not always the outcome (for more detail see section 2.1). Relevant questions to ask are:

Can the particular business model report an increased number of uses for the garment?

For example, 10 people using the garment once each in a rental model accounting for 10 uses in total is still a shorter use life than if the garment is used 20 times by one person. It is not the number of people using the garment that matters. It is the number of uses of each garment that reduces the production of new garments, thereby reducing environmental impact.

Is the product designed for its purpose? Is a significant part of the product offered designed to be redesigned to adapt to new trends or to fit a new customer?

Products with a long life need to be more durably made than fast fashion. To enable extended use of the goods, the choice of material should mirror the user phase. Polyester or polyester/cotton blends, for example, last longer following wash and wear than cotton. The durability of products (tear strength, pilling resistance etc.) can be tested in a laboratory using standardised methods.

Is there support for the consumer on how to repair the product?

To avoid a garment being discarded due to a lost button, broken zip, or similar, guidance on how to repair, and/or repair kits/services should be included or sold separately.

What is the displacement rate of the particular business model?

If customers buy second hand or rent a garment but also buy the same number of new garments, there is no reduction in environmental impact. The environmental gain of reuse and recycling originates from the avoided production of new garments, thereby avoiding environmental impact. The displacement rate is key to preventing environmental impact. Claims in the business model of reduced impact must always be followed by an estimate or assessment of the displacement rate.

Has consumer transport been considered and managed?

An increased number of users may mean that consumer transport also increases. Hence, there is a trade-off between increased resource consumption from consumer transport and reduced resource consumption from the reduced production of new garments. Consumer transport must be considered and managed to avoid problem shifting.

New production technology

The production of a garment has the highest environmental impact on the total life cycle of that garment. New production technologies, or updates of existing technologies, offer optimisation of existing technologies to reduce energy, water and chemical use by switching to renewable energy sources such as solar power, wind energy, hydropower or biofuels, alternative dyeing technologies, new waste-water treatment plants, and so on (for more detail see section 2.2). Investors are encouraged to take a holistic view of the product or service that a company offers.

For so-called green technologies, is a major environmental issue being addressed and will use of the technology lead to a significant reduction in the environmental burden? Are the environmental claims connected to the technology reasonable and verifiable?

The new production technology should address one or several of the significant environmental aspects. Reductions in the use of freshwater, hazardous chemicals or energy are important. The reduction should be quantified so that its significance can be stated, and supported by the information needed to verify the claims. In addition, using a life cycle perspective avoids improving part of a system (a process or an environmental aspect) in a way that negatively affects other parts of the system ('sub-optimisation').

What is the functionality of the technology? What is the output? For how long can it be used and what will happen to the materials afterwards?

The new technology should provide as durable and efficient a result as the technology it replaces. If the product or process fails to deliver what is expected, it will not be a feasible alternative to existing technologies. The materials treated with a process must not be degraded or altered so that the chances of a next loop in the circular economy are reduced. The concept of a 'functional unit' in Life Cycle Assessment (LCA)[13] can be used to evaluate 'how much function is provided in relation to the environmental burden' of a product or a process.

Identify the technologies built on for so-called 'lock-in' effects, such as investments in fossil energy technologies.[14]

It is important to consider how the technology supports a circular economy, and that the investments can be agile and used within several business models, using several types of resources/feedstocks in terms of material and energy. For instance, when investing in a technology for refining a particular resource, does it promote the production of such waste instead of minimising it?

Are complementary products, services or network infrastructure needed to enable the product or service to fulfil its function? What are the feedstock/input materials? Are these abundant in the longer run or is there a risk of shortage of supply?

The efficiency of a process is not just a question of the main material yield, but also linked to the amounts of energy and auxiliary materials used per product produced and the amount and type of waste and emissions generated. Processes based on a specific type of waste stream are sensitive in terms of feedstock abundancy. In addition, if the technology builds on collaboration between different tiers in the supply chain, on policy decisions that may change over time or on the actions (perceptions and acceptance) of consumers, this implies an increased risk compared to a 'stand-alone' technology.

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13 ISO 14040, Environmental management: life cycle assessment, principles and framework. International Organization for Standardization (ISO): Geneva, Switzerland, 2006.

14 Unruh, G.C. (2000) 'Understanding Carbon Lock-In.' *Energy Policy* 28(12), 817–30.

New material recycling technology

New material recycling technology can be classified as a ‘new production technology’, since the purpose of recycling is to produce recycled resources that can replace virgin resources (for more detail see section 2.3). Therefore, the above-mentioned points are also relevant in the case of material recycling technology. There are also other important issues to consider:

Is the waste hierarchy being followed?

Textiles that still possess qualities for reuse (second-hand) should not be considered for recycling. Only worn out goods should go to material recycling. Energy recycling, or incineration, should be avoided and landfill should not be used. For more on the waste hierarchy see Figure 9.

Is there a stable feedstock over time, or is the process flexible about incoming material? Are feedstocks from other industries such as plastics, packaging or paper considered to increase volumes?

Processes based on a specific type of waste stream are sensitive in terms of feedstock supply.

Can the material be recycled into another industry’s material stream with higher value?

To be locked into a model of recycling textiles to new textiles, so-called closed loop recycling, can lead to a downgrading of the material and opportunities of higher monetary and environmental value may be missed.

Can the recycled material replace virgin, non-recycled material?

To increase the market share of recycled material, it is important to use the benefits of existing markets. So-called drop-in solutions are attractive because existing technology can be used for the next or coming steps in the textile production chain, for example for spinning yarn, fabric making and the dyeing of materials.

Have the process conditions been optimised?

Every extra process step requires extra energy, which means costs and environmental impact, as well as the loss of process chemicals that are not recycled, which also has costs and environmental impact. Like the questions on ‘new production technology’ above, it is important to take the following into consideration:

- Is the energy input provided from renewable resources?
- Are the chemical balances of process chemicals optimised?
- Is there process optimisation for the highest possible yield at the lowest possible environmental cost?

Technology development for traceability

The development and standardisation of technologies and information systems for providing traceability is required to allow the measurement of impacts throughout the production chain. Only when impacts are made visible to customers can the vision of the 'polluter pays principle' be realized. Traceability can be achieved in the short run through certification and standards setting, and in the future will be supported by digital information tags connected to global information systems. Technologies for traceability need to be able to cope with the long and complex supply chains of the textile industry. The focus should be on implementation rates as it does not matter how well-designed an information system is if it is starved of data (for more detail see section 2.4). The most relevant questions are:

How are the main sustainability aspects identified? What data is required?

Transparency must be gained all through the production line in order to ensure a sustainable product from a life cycle perspective. Today's reporting formats contain a high degree of voluntary information and there is a risk that the most critical points are left out and that companies only report on the aspects where they perform well. Systems for traceability and transparency need to cover the content described above under 'new business models to prolong the lifetime of garments', 'new production technology' and 'new material recycling technology'.

Is the required information compatible with environmental reporting in other external, third party certified formats, such as GRI, the Higg Index or Fair Wear? Will improvements in the values of the real-life measurements lead to improvements in the scores on the NASDAQ, Sustainalytics, Morning Star and other indexes?

Willingness to report increases if the information requested is easily available and also being requested by other systems. In connection with the point above, where the coverage is analysed, comparison with an existing system may also be used to make rating instruments sharper.

Is hardware technology, such as NFC or RFID, part of the system? Is it fit for the purpose?

Ensure that any hardware (the digital tag) is compatible with the requirements of the system. Is the life of the hardware equal to the life of the garment? Can it be used together with smartphones? Are there any legal implications of use of the technology?

1 Introduction

This Investor Brief explains the key issues, trends and challenges facing textiles and fashion, with a focus on environmental sustainability. The aim is to align investor decisions with the environmental goals of Agenda 2030 and the 1.5°C goal of the Paris Agreement. The brief is designed to support investors' and financial analysts' Environmental, Social and Governance (ESG) analysis, corporate evaluation and engagement. It contains a toolkit that will be a useful aid to sustainable investment and engagement.

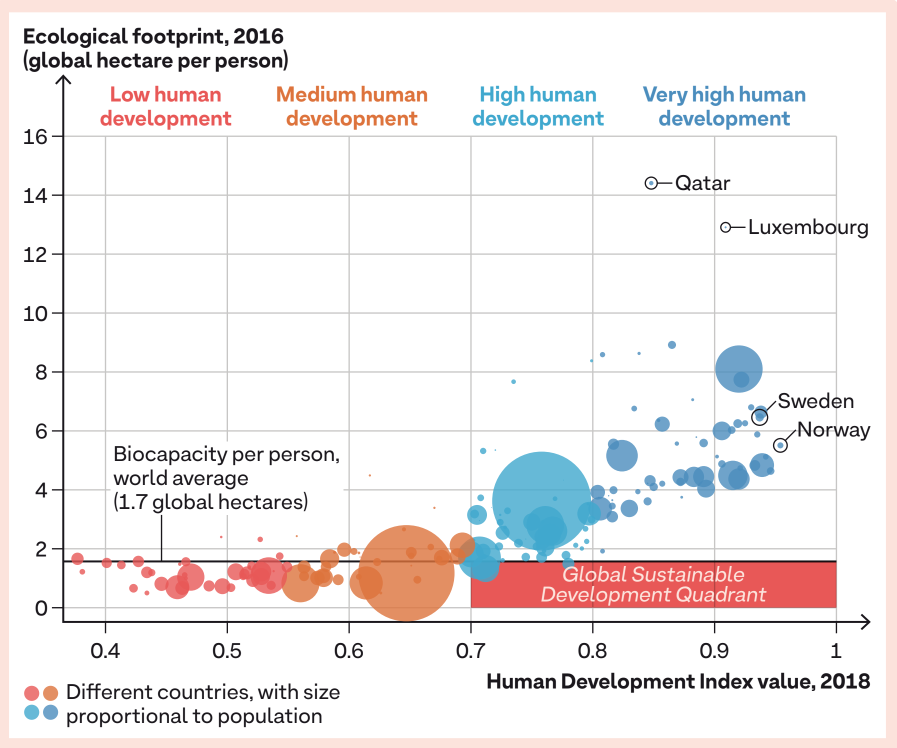
The content is based on the research programme Mistra Future Fashion, which undertook eight years (2011–2019) of interdisciplinary research to clarify what sustainable fashion is and the measures required to achieve sustainability in the textiles, apparel and fashion industries. This research was built up from a systems perspective, involving interdependency between design researchers, material scientists and Life Cycle Assessment (LCA) researchers, as well as research on business models, policy development and user behaviour. It also involved regular interaction with over 50 industry partners.

1.1 The textile and fashion market today and beyond

In 2016, the global apparel industry accounted for 6.7% of global climate impact; that is, 3,290 million tonnes CO_2 eq. of the total of 49,300 million tonnes CO_2 eq.,[2] or 442 kg CO_2 eq. per capita. In Sweden in 2017,[4] the total climate impact of textile consumption was 4.2 million tonnes CO_2 eq., of which apparel's share was roughly 3 million tonnes CO_2 eq. This corresponds to 297 kg CO_2 eq. per capita, or about 3% of the consumption-based carbon footprint of an average Swede. While this might appear low, this is mainly due to the green energy resources consumed in washing by consumers, and the figure only includes textile clothing consumption in Sweden. (Other sources are both textile and leather clothes , homeware textiles including furniture and technical textiles, see Appendix D). The 1.5°C goal of the Paris Agreement means that climate impact must be close to zero by 2050, which leaves little or no room for any net greenhouse gas (GHG) emissions arising from the production, transportation, laundering or waste management of textiles.

Putting exact numbers and drawing conclusions and comparisons on the climate impact of textile production, consumption and use present huge challenges, due to differences in scope and the range of possible methodological choices (see Appendix D). The above numbers were calculated to represent the cradle-to- gate, and cradle-to-grave climate emissions of the textiles used in garments. In these studies, the scope includes energy production and transport, meaning that not just textile site operations are included. Comparisons with the energy or transportation industry are not appropriate, since parts of these industries will overlap in the figures. Furthermore, it is easy to misinterpret textiles' share of total climate impact in different geographical areas. The consumption-based annual carbon footprint of the average Swede is 10 tonnes of CO_2 eq., which is around double the global average. Appendix D elaborates further on the topic of climate impact calculations and their interpretation.

FIGURE 2: An overview of 175 states' ecological footprints per capita plotted against their Human Development Index value. The red shaded area represents the *Global Sustainable Development Quadrant*, the area where states have both high levels of human development and globally sustainable resource demands. This has been calculated as <1.7 global hectares and an HDI score of over 0.7. Illustration adapted slightly from the 2019 Human Development Report.[16]



There are various approximations and estimates of future scenarios for the textiles and fashion industries, all of which are uncertain and contested.[15] Instead of discussing these, we intend to provide the reader with a qualified understanding of the boundaries of the planet's resources that also indicates what needs to be done and changed with regard to production and consumption. Figure 2 plots ecological footprint per capita against the Human Development Index (HDI), which tracks prosperity, level of education and life expectancy.[16,17] The ecological footprint per capita measures how big an area of biologically productive land and water a country requires, both domestically and abroad, to produce all the resources it consumes and to absorb the waste it generates.[18] There is data on 175 states.

On a scale of zero to one, the United Nations defines 0.7 as the threshold for a high level of development and 0.8 as very high development. Most European states are above 0.9 in this index. Using the Ecological Footprint and the HDI is a simple way to assess sustainable development. At current population levels (2019), the planet has just 1.6 global hectares (gha) of biologically productive surface area per person.[19] Measuring these two variables reveals that despite the increased adoption of the Sustainable Development Goals (SDGs) and other policies that strive to increase well-being without sacrificing the environment, very few states come close to achieving sustainable development.

It is also clear that the size of the footprint increases with the level of human development, and that nations with a currently low HDI score will seek to increase their level of development. Thus, the average per capita ecological footprint worldwide needs to fall significantly below this threshold if we want to accommodate larger human populations while also providing space for wild species to thrive.

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15 *https://www.vox.com/the-goods/2020/1/27/21080107/fashion-environment-facts-statistics-impact*

16 Human Development Report, UNDP, 2019.

17 Cumming, G.S, von Cramon-Taubadel, S. (2018) Linking economic growth pathways and environmental sustainability by understanding development as alternate social–ecological regimes. PNAS 115:38, 9533–9538.

18 Global Ecological Footprint Network database (*www.footprintnetwork.org/resources/data/*; accessed 17 July 2018).

19 *https://www.footprintnetwork.org/resources/glossary/* (in April 2020).

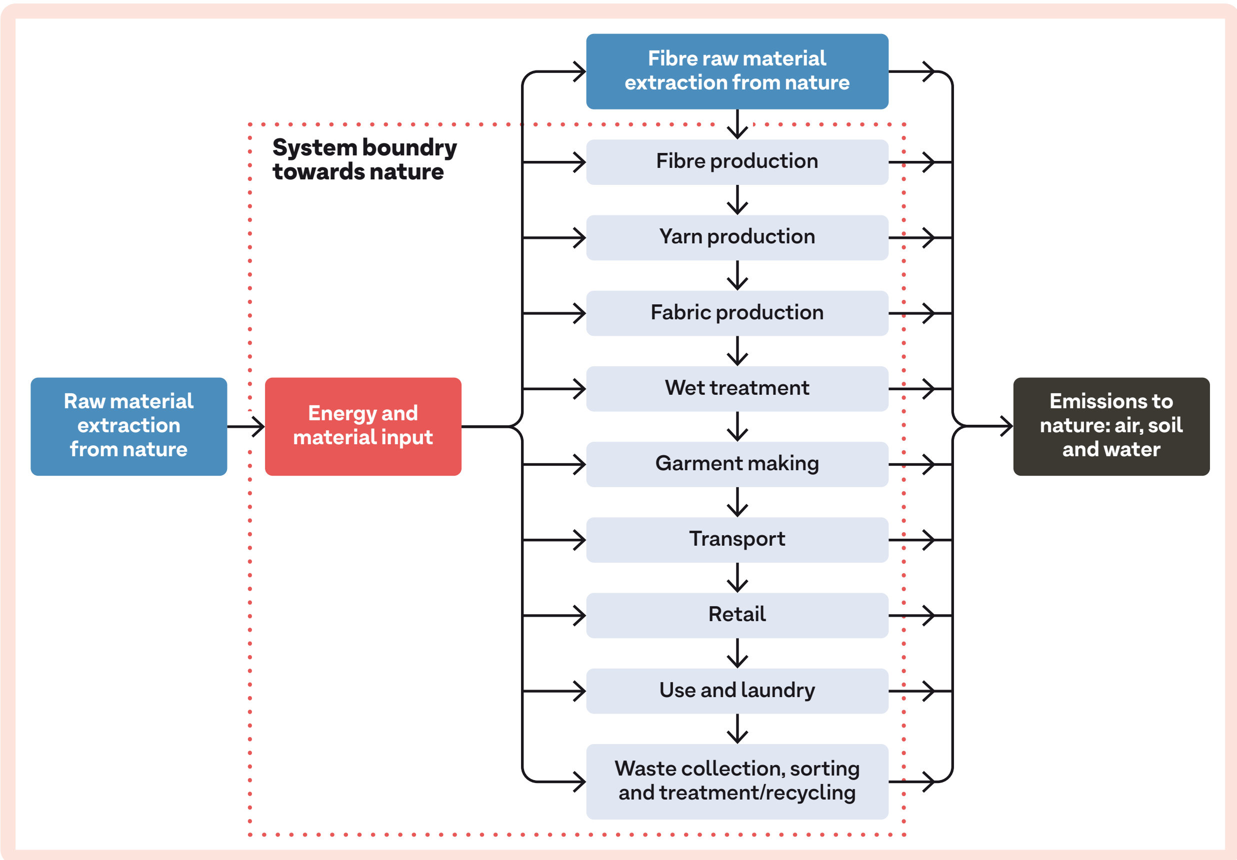
The Quantis report (2018) argues that:[2] 'we face urgent environmental and social challenges caused by climate change and resource depletion, the efficacy of solutions will depend on the creativity, innovation and boldness so characteristic of the fashion industry. It's time for players to change the trajectory'. The future direction of the EU is highlighted in a report published in March 2020. The European Commission's Circular Economy Action Plan: For a Cleaner and More Competitive Europe states that 'the EU needs to accelerate the transition towards a regenerative growth model that gives back to the planet more than it takes, advance towards keeping its resource consumption within planetary boundaries, and therefore strive to reduce its consumption footprint and double its circular material use rate in the coming decade'.[20]

Resource efficiency and the underlying sustainability issues are discussed in section 2, which provides guidance on our chosen key areas for improvement.

1.2 The structure of the textiles and fashion value chains

The textile value chain involves many different types of actor.[21] The types of processes involved vary from agriculture and animal farming to produce natural fibres, to chemical processing for regenerated and synthetic fibres, wet treatment for dyeing and finishing, and mechanical operations such as spinning, knitting and weaving for yarn and fabric production (see Figure 3) . Very often, the production process is carried out by sub-suppliers in each of these steps. Today, most of the production takes place in Asia. In each of these processes, environmental impact occurs as a result of energy, water and material inputs, and emissions to land, air and water.

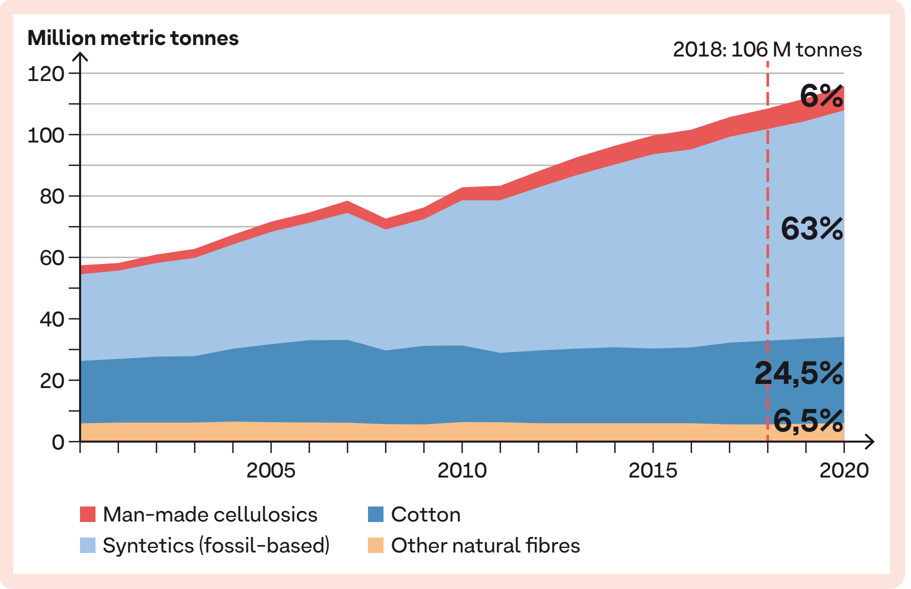
FIGURE 3: The textile value chain from an environmental perspective; the system starts with raw material extraction from nature (incl. fossil fuel extraction) and ends with emissions to nature.



20 Circular Economy Action Plan, the European Green Deal, European Union, 2020.

21 Roos, S. (2016) 'Advancing Life Cycle Assessment of Textile Products to Include Textile Chemicals. Inventory Data and Toxicity Impact Assessment.' PhD thesis, Chalmers University of Technology, Gothenburg, Sweden.

FIGURE 4: The global fibre market with its 4 main fibre categories. The annual growth in 2018 was 1.5% and it is expected that this rate will be maintained[3]. Illustration redrawn using data from The Fiber Year 2019[3] and Lenzing.



There is currently almost no garment production in Sweden. New regulations on textile collection and recycling, however, mean that non-textile companies are entering the textile industry, such as the pulping company Södra with its recycling of polycotton waste, OnceMore®,[22] and SYSAV in Malmö which has invested in textile waste sorting.[23] This means that traditional textile chain actors are likely to be replaced or accompanied by actors from other industries.

In 2018 the global fibre industry produced 106.5 million tonnes of fibres (see Figure 4), 63% of which was fossil-based synthetic fibres (plastics-based fibres, mostly polyester), 24.5% cotton, 6% man-made cellulosics (e.g. viscose and lyocell) and the remaining 6.5% other natural fibres such as wool, bast fibre, jute and silk.[3]

The production of cotton and synthetic fibres is known to have negative environmental impacts. With cotton, the use of pesticides and irrigation during cultivation contributes to emissions of toxic substances that cause damage to both human health and the ecosystem. Irrigation of cotton fields causes water stress due to the large water need. The use of synthetic fibres is questionable due to their (mostly) fossil-resource origin and the release of microplastics. To mitigate the environmental impacts of fibre production, there is an urgent need to improve the production of many of the established fibres and to find new, better fibre alternatives[24]. Furthermore, it will be essential to adopt a life cycle perspective when designers or buyers compare, promote or select fibres. To achieve best environmental practice, in addition to considering the impacts of fibre production, it is also important to consider the functional properties and durability of a fibre and how it fits into an environmentally appropriate product life cycle, including the entire production chain, the use phase, end-of-life management and the options for the next life cycle of the material. Selecting the right fibre for the right application is key to optimising the environmental performance of the product life cycle.

1.3 Social sustainability

One of the most publicly scrutinized areas of sustainability for the apparel and textile industries is their social impact. Globalisation and outsourcing have led to the location of textile production in low income countries, raising a number of social

22 https://oncemore.sodra.com/

23 https://www.sysav.se/Om-oss/pressrum/pressmeddelande/world-unique-plant-for-textile-sorting-in-malmo-2936412/

24 Sandin, G., Roos, S., Johansson, M. Environmental impact of textile fibers – what we know and what we don't know (Fiber Bible Part 2). Mistra Future Fashion report number 2019:03 part 2.

issues such as forced labour, child labour, low wages and insufficient workplace safety. Textile supply chains are typically a complicated network of suppliers and subcontractors, and production is often located far from the final market. The complexity of textile supply chains makes it difficult for clothing importers to track where and under what conditions garments are produced.

The Social LCA (SLCA) work of Mistra Future Fashion has sought to identify and assess the social challenges facing the textile industry, and the potential for interventions linked to achieving social sustainability targets. The social hotspots of textile imports to Sweden have been found to relate to significant social risks such as low wage levels, child labour and exposure to carcinogens in the workplace. The risk-level intensity was highest for indicators of low wages[25]. The same study also identified industrial sectors of concern. In addition to some of the main sectors of the production system itself, some unexpected sectors in the background/support systems were identified as important hotspots, such as commerce and business services.

There is currently an absence of models for impact pathways, such as human well-being or staff turnover rates, that reflect the actual damage or benefits of company-level activities on social end-points further down the cause-effect chain, that could support a scientifically verified social life cycle analysis. The SLCA work of Mistra Future Fashion has therefore been unable to assess the impact of *company-level interventions*. Relevant social cause-effect chains must be developed to enable measurement of the social benefits of interventions. This would help with assessments and to guide companies' work on achieving social sustainability targets. Nonetheless, a few certification schemes and tools for social assessment and certification have recently emerged on the market. One of the most used for labour standards is the Social Accountability Standard (SA8000). This standard is certifiable, covers workplace issues and is based on internationally recognized standards and regulations such as the Universal Declaration of Human Rights and ILO conventions, as well as domestic law. SA8000 applies a management systems approach to social performance and emphasises continual improvement.[26] Several social accountability knowledge providers are often used in the textiles, fashion and apparel industries. Fair Wear[27] works with brands to improve labour conditions in factories and carries out factory audits. The industry alliance the Sustainable Apparel Coalition (SAC) has members committed to measuring and improving environmental and social impacts. The SAC has developed its own tool, the Higg Index, to measure and score the sustainability performance of companies and products.

The value of these initiatives is hard to assess since their measurements and focus differ widely. Greater standardization is likely to develop over time to help create transparency and comparability, but for now they their impact is difficult to validate scientifically.

Even if the main focus of this report is environmental impact, identification and assessment of the social impacts of the textile industry is important for assessing sustainability and financial risk. A critical stance on claims of social sustainability is therefore strongly recommended.

1.4 The textile industry is slow in achieving a circular economy

Compared to sectors such as plastics, glass and metals, the textile industry has been very late in moving towards a circular economy. In most states, textiles stakeholders and industries do not yet have an Extended Producer Responsibility (EPR)

25 Zamani, B., Sandin, G., Svanström, M., Peters, G.M. (2018). Hotspot identification in the clothing industry using social life cycle assessment – opportunities and challenges of input-output modelling. *International Journal of Life Cycle Assessment* 23(3), 536–546.

26 https://sa-intl.org/programs/sa8000/

27 https://www.fairwear.org/

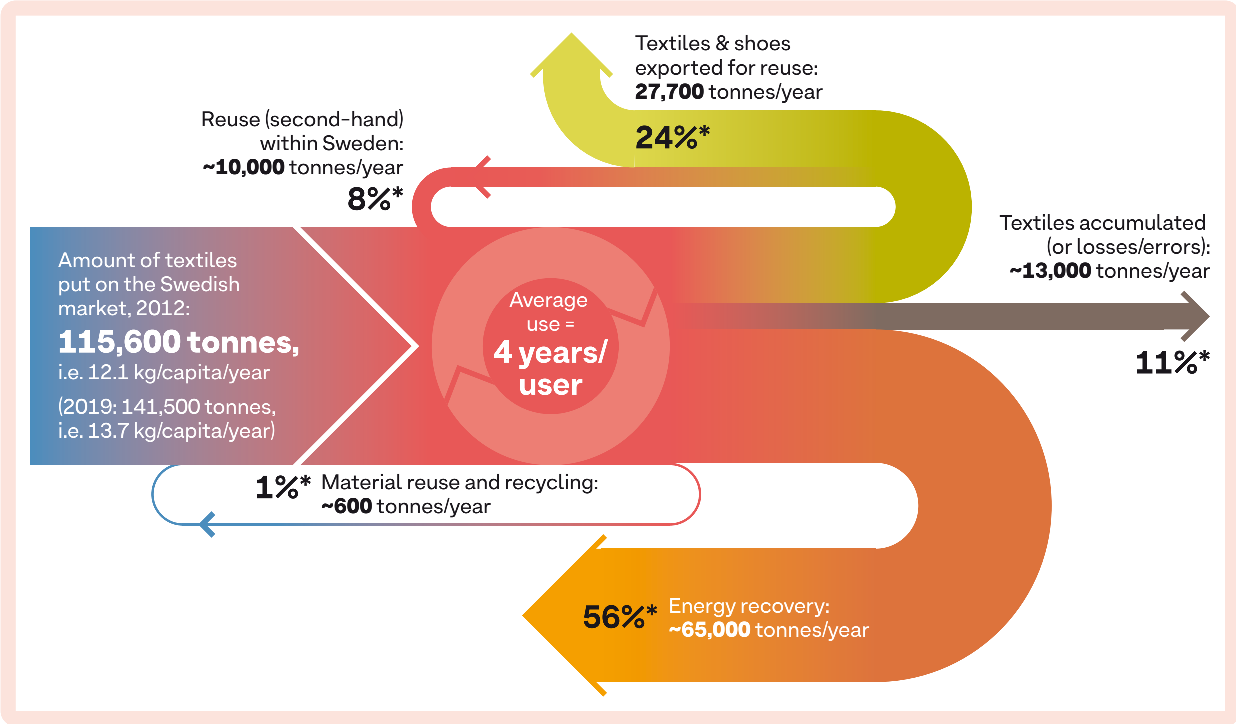


FIGURE 5: Textile fate flow chart; an overview of the fate of textiles in Sweden over time. The width of the arrows is in proportion to the volumes of textiles put on market in 2012, i.e. after the estimated average life of textiles of ~4 years. Data on end-of-life fates comes from studies run in 2014–2017.[31,32,33]

*Weight percentage of the Swedish net-import data on textiles from 2012, 115,600 tonnes. Swedish net imports ae assumed to be the same as textile production since domestic production is very small.

for the collection of textiles for reuse and recycling. The 2018 amendment to the Waste Framework Directive requires textiles to be collected separately from other waste. Separate collection should be in place at the national level in all EU member states by 2025.[8] Following the Swedish Government January agreement[9], an assignment in ongoing to present a suggested EPR for Textiles to the Swedish Government in December 2020[10] Moreover, this January Agreement also stipulates a new tax on harmful chemicals in clothes and shoes (excluding homeware textiles) and a tax on waste incineration (see sections 3.3 and 3.4).

The textiles sector now needs to prepare to align itself with the coming demands and new regulation. The fate of textiles on the Swedish market is shown in Figure 5, which is based on an average user lifetime for garments of around 4 years per user.[28,29] The available data on the end-of-life fate of Swedish textiles is from studies run by SMED in 2014–2017.[30,31,32] The data on textile fibres put on the Swedish market was taken from 2012.[33] Based on further data from 2016,[32] less than 1% of the total volume consumed four years earlier was recycled into new material. Energy recovery accounted for 56% (incineration) because most textiles end up in unsorted household waste.[31,32] A better option for this 65,000 tonnes would be to send part of it, such as the ~32,000 tonnes of pure cotton,[31] for materials recycling instead. An even better fate would be to reuse, as at least 32,000 tonnes that was in a reusable condition.[31] Only 8% of all textiles put on the market 2012 was found by a new user in Sweden,[32,33] while 24% was exported for reuse.[32] The residual volume of textiles, ~13,000 tonnes (based on the three studies with data from

28 Kirchain R., Olivetti E., Miller T. R. & Greene S. Sustainable Apparel Materials (Massachusetts Institute of Technology, 2015).

29 Geyer, R., Jambeck, J., Law, K. (2017) Production, use, and fate of all plastics ever made. Science Advances. 3(7), 1-5.

30 Hultén, J., Johansson, M., Dunsö, O., Jensen, C., (2016) Plockanalyser av textilier i hushållens restavfall, SMED Rapport nr 176 2016.

31 Belleza, E., Luukka, E., Svenska textilflöden -textilflöden från välgörenhet och utvalda verksamheter, SMED Rapport Nr 2 2018.

32 Elander, M., Miliute-Plepiene, J., Guban, P., Återanvändning av textil via utvalda marknadsplatser och appar. SMED Rapport Nr 11 2019.

33 Statistiska Centralbyrån and https://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Textil/

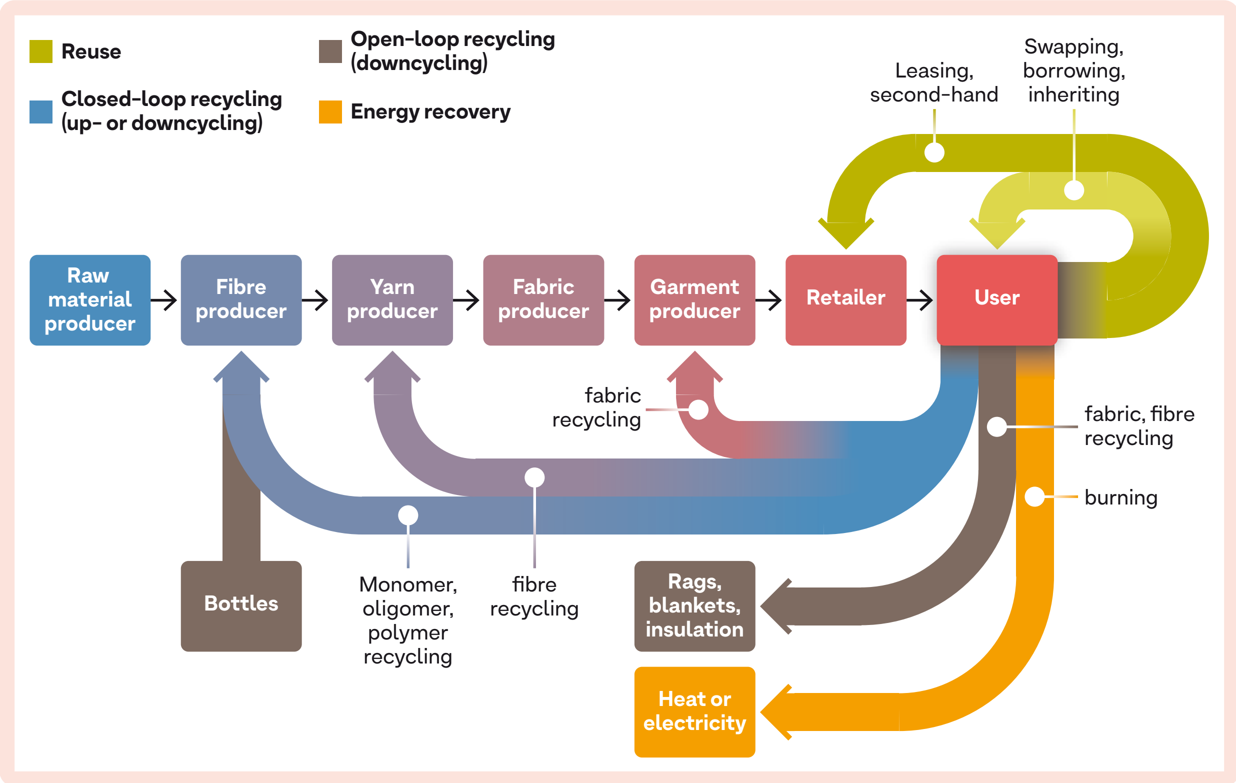


FIGURE 6: Examples of material reuse and recycling in the textile value chain. Redrawn from Sandin & Peters (2018)[36]

2014,[31] 2016,[32] and 2017[33]) may still be in wardrobes, or accounted as losses or errors in our estimates and methods.

Globally, the numbers were similar in 2015. Only 3% of recycled material was used in the textile industry,[7] of which just ~1% was recycled from textiles and ~2% came from the packaging value chain – mainly polyethylene terephthalate (PET) bottles. The EU's expectations for 2025 are clearly higher. By 2025, a minimum of 55% by weight of municipal waste (not just textiles) must be prepared for reuse and recycling. One of the major challenges for textiles is the lack of recycling infrastructure and technologies. The Swedish Environmental Protection Agency (EPA) has set clear targets for 2025 that the amount of textiles in household waste should be reduced by more than half from ~8kg/capita/year to 3 kg/capita/year, and that the majority (90%) must be reused or recycled.[11] This means that the total volume of discarded textiles collected will increase to over 85,000 tonnes/year. This will present significant challenges.

In addition, the European Union launched its action plan for a Circular Economy in 2015[34] to stimulate Europe's transition to a circular economy. A circular economy is the term for a society that produces no waste, but instead restores and regenerates products, components and materials to maintain their highest utility and value at all times. For a circular economy to be environmentally sustainable, efficient material recycling technologies are a prerequisite. Recycling technologies present both challenges and opportunities if planned from a systems perspective where one material loop does not have to be closed, but is instead allowed to flow into another loop.[35] Figure 6 shows some examples of material reuse and recycling in the textile value chain.[36] The material flows are divided into reuse of textile products, closed-loop recycling (textiles are turned into new textiles), open-loop

34 European Commission. (2015). Closing the loop: An EU action plan for the Circular Economy. Brussels, Belgium.

35 Roos, S., Sandin, G., Peters, G., Spak, B., Schwarz Bour, L., Perzon, E., Jönsson, C. (2019) White paper on textile recycling. Mistra Future Fashion Report series 2019:09

36 Sandin, G., & Peters, G. (2018). Environmental impact of textile reuse and recycling: a review. *Journal of Cleaner Production* 184(20), 353–365.

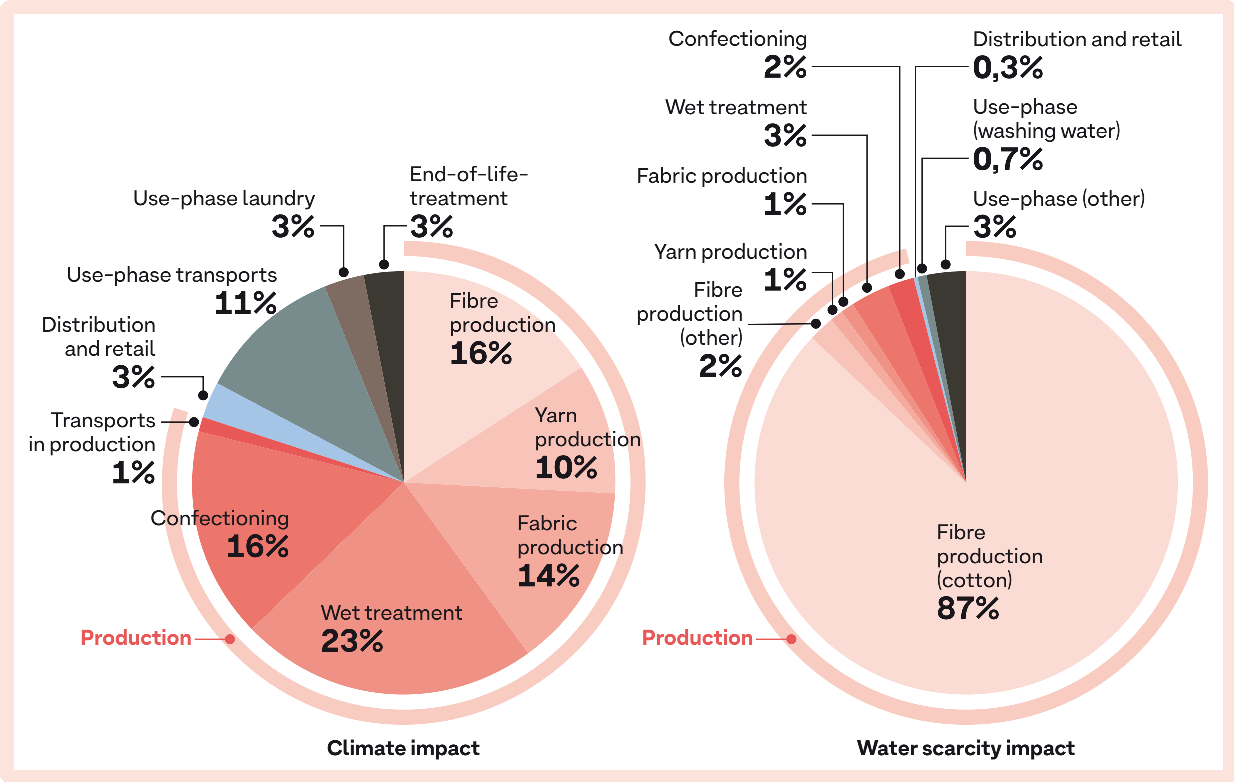


FIGURE 7: Climate impact (left) and water scarcity impact (right) of Swedish clothing consumption and the contribution of life-cycle phases based on LCA data.[4] The pink-red segments represent different steps within the production phase, which sum to 80% of the total climate impact and 96% of the total water scarcity impact.

recycling (non-textile material is turned into textiles / textiles are turned into low-grade products) and energy recovery.

A key finding from the Mistra Future Fashion research is that the production phase of garments accounts for the largest environmental impacts from a life-cycle perspective, in terms of climate change, toxic pollutants and contribution to water scarcity, among other things. In the Swedish case, ***the production phase accounts for close to 80% of the total climate impact of the full life cycle of garments***, from production to retail, use and end-of-life (see Figure 7).[4] For similar analysis of the average European life cycle, mostly due to higher share of fossil-based energy in the user phase, the use-phase laundry is ~10% and the total impact from production is ~70%. However, the 80% is mainly due to the consumption of fossil-based energy (coal, oil, natural gas) during production. Consumer transportation to and from the store accounts for 11%, whereas the user phase, including laundry, accounts for only 3%. In the category of water scarcity impact, the production phase accounts for 96% of the impact of the full life cycle of garments (see Figure 7).

Another key finding concerns the textile fibres themselves. The difference in environmental impact between fibre type is generally insignificant, as the main considerations are the energy source (fossil or renewable) and the use or non-use of environmental management systems.[25] ***Transparency throughout the production chain is therefore a more pressing issue than fibre content.*** Previous categorisations into 'good' and 'bad' fibres based on generic classifications of fibre type are too simplistic. There is however one exception: It is far less resource-intense to produce polyester than conventional or non-organic cotton and from a life cycle perspective, and the durability of polyester further improves its environmental profile. Conventional cotton fibres are grown with the unsustainable use of irrigation and pest control. Figure 7 clearly shows how cotton cultivation dominates in terms of water scarcity impact.

New sustainable fibres in old production processes challenges the output as sustainable products. The overarching issue to be addressed is the imbalance in the efforts required on production and use. There is generally a higher environmental impact for products with very short user phases. Furthermore, modern consumption habits generate massive textile overload in the market and ultimately huge problems with waste. This is the result of a linear economy in which 'take-make-use-dispose' represents a broken model right from start. In addition, many important decisions are made in the design of the garment and the selection of material properties, as well as by the purchaser function. ***Investors are therefore encouraged to explore the extent to which sustainability is integrated into the design and purchasing phases of textile and fashion companies.***

2 Time for action and direction

A small number of general, overarching aspects are building a framework for how sustainability in fashion and textiles will look in the future:

- The EU Circular Economy Package waste directive will take effect in 2025.[8] All EU member states should have textile collection, sorting and recycling in place by that date.
- Future resource demand should be for recyclable and renewable resources.
- In order to reduce climate impacts, and the social and environmental impacts of the production line, it must be transparent and measurable.

Given the fact that 80% of the total life cycle climate impact of textile use in Sweden[4] is derived from the production line, there are two ways to tackle and improve the sustainability impact: (a) avoid new production; and (b) reduce the environmental impact of production. To accompany these two actions, more holistic solutions are sought to achieve the SDGs.

By 2030:

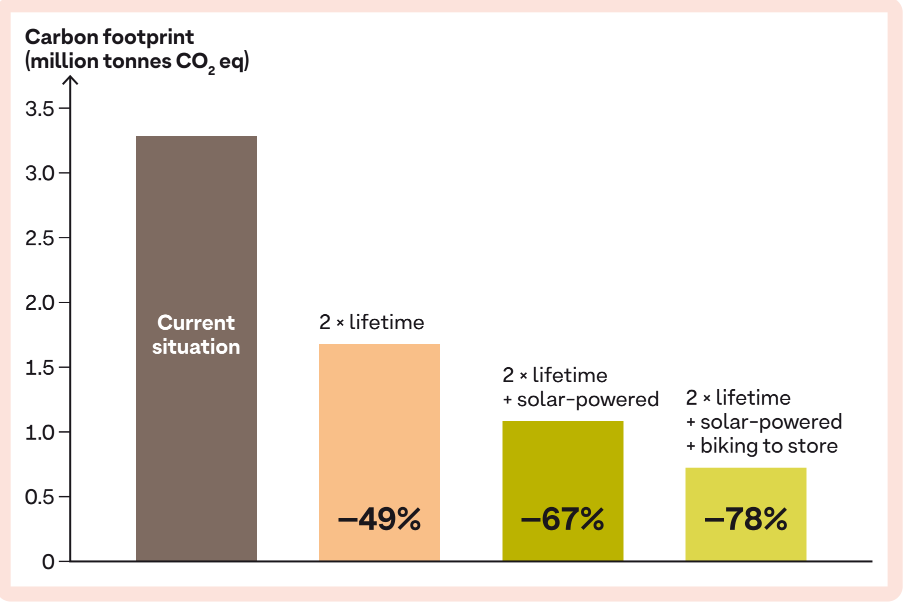
- reduce the life cycle emissions of greenhouse gases from textile products by 50%;
- have knowledge of all the main suppliers' and recipients' water sources, and of mean monthly river flows;
- have phased out all persistent organic pollutants (POP) from textile production.

and by 2050:

- be carbon-neutral;
- stay below critical blue water withdrawal in cooperation with other local users;
- have in place responsible handling of chemicals and minimize use of chemicals;
- ensure that chemicals are produced and used in ways that minimize the significantly adverse impacts on the environment and human health;
- pay living wages throughout the textile value chain to improve social conditions;
- achieve all the social goals of Agenda 2030.

Climate impact could be reduced quite easily by taking the systemic approach that is illustrated in simplified form in Figure 8, based on data from Sandin et al. (2019).[4] It illustrates a simplified approach to achieving the 2030 goal of a 50% reduction in greenhouse gas emissions compared to the current level. The first step is to double the lifetime of the garment by using your wardrobe for longer. The second step requires a move from fossil-based energy to solar power in the produc-

FIGURE 8: A stepwise illustration of how the carbon footprint can be reduced. Step 1 is to double the lifetime of the garment. Step 2 involves moving from fossil-based energy to solar power in the production line. Step 3 means the consumer avoiding use of fossil fuel-driven cars when buying garments (based on data from Sandin et al., 2019).[4]



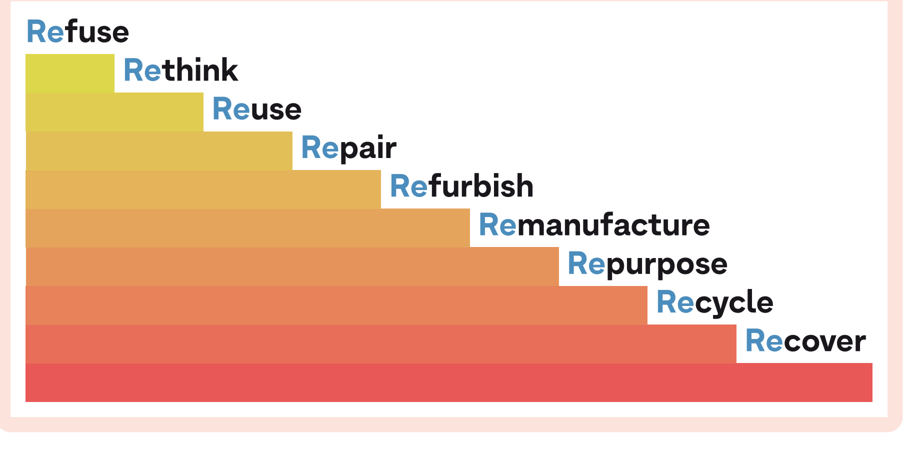
tion line. The third step means engaging with the consumer to avoid using a fossil fuel-powered car when buying the garment.

Other actions required to reduce environmental impact include water and/or energy saving technologies, process optimization and updated machinery.

The waste hierarchy is one principle that should be applied (see Figure 9).[37] Figure 9 presents a modified and extended waste hierarchy compared to that used in the Waste Framework Directive (Directive 2008/98/EC),[38] which has five steps: 'prevention', 'prepare for reuse', 'recycle', 'recover' and 'disposal'. The extended version visualises the many steps and ways to extend the lifetime of a product.

Sections 2.1 to 2.4 outline the key areas for improvement identified as of the utmost importance and as prerequisites for sustainable fashion production and use in a circular economy, based on the results of eight years of Mistra Future Fashion research.

FIGURE 9: The nine levels of circularity. The 9Rs is an extended version of the waste hierarchy adapted from Cramer, 2014[37]. It visualises the opportunities to extend the life of a product and avoid the disposal of materials.



37 Cramer, J. (2014) Milieu. Elementaire Deeltjes: 16 Amsterdam: Amsterdam University Press B.V.

38 European Commission. (2008). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. Official Journal of the European Union, L312, 3–30.

2.1 New business models to prolong the life of garments

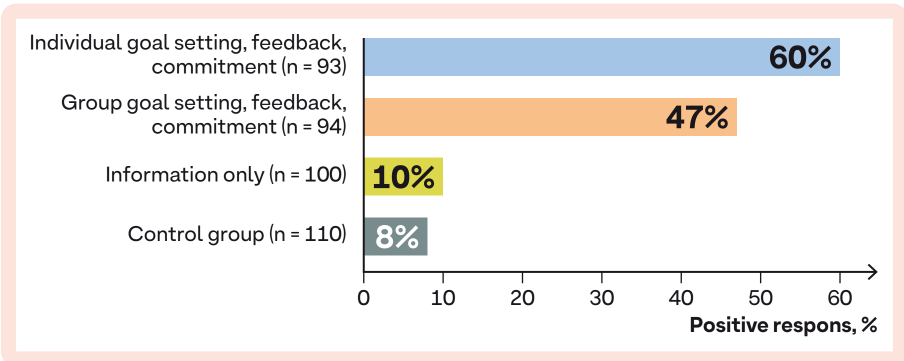
As the production of garments has the biggest climate impact by far on the total life cycle of a garment, business models that help to prevent new consumption would contribute both to the circular economy and to protecting the environment. One implication for investors is that new business models that prolong the lifetime of garments are the single most significant action to enhancing sustainability (see the recommended further reading in section 5). For instance, extending the lifetime of each garment so it can be used for twice as long would reduce the environmental burden by almost half. It is also important to follow the waste hierarchy (see Figure 9).

Examples of business models that prolong the lifetime of garments are: renting/leasing, sale of second hand/pre-owned items, and repairing and redesign services. Our study has shown a low awareness and likelihood of using new business models to prolong life.[39,40] However, there is increasing interest in second-hand shopping, especially by the generation aged 20 to 30, and private shopping using online marketplaces and apps is also increasing. (It increased by 32% between 2016 and 2017.)[33]

Studies show that in order to achieve a high response from the user/consumer to sustainable business models and reduce consumption, the user/consumer needs feedback on an individual level (see Figure 10).[41]

The lifetime of a garment can be calculated in various ways, from the number of uses to the hours of actual wear or the years of service. From an LCA perspective, the correct way to measure use life is linked to the function of the garment. Normally, garments have the technical function of keeping us warm, dry and covered, but garments also have an emotional aspect as they are also used to express our belonging to groups as well as our individuality, to mark festivities, and so on. In the first technical sense of measuring use it is often logical to use the number of times a garment is worn. In the seconds sense, a garment can still fulfil a function just by hanging in the wardrobe as the owner knows that he or she owns a suit, a dress or another garment for use on a special occasion.

FIGURE 10: The response on sustainable consumption depending on different consumer groups, showing the need of goal setting and feedback in order to improve towards a more sustainable consumption model (Joanes & Gwozdz, 2019[41]).



2.2 New production technology

The use of new sustainable fibres in old production processes counteracts the sustainability of the products. The overarching issue that needs to be addressed is the imbalance in the effort needed on production as opposed to use. In general, a product with a very short use phase has a high environmental impact. Investors are

39 Steensen Nielsen, K. & Gwozdz, W. (2018) Report on geographic differences in acceptance of alternative business models., Mistra Future Fashion report number: 2018:3.

40 Sweet, S. & Wu, A. (2019) Second-hand and leasing of clothing to facilitate textile reuse: identifying sources of value generation from the perspective of businesses and user. Mistra Future Fashion report number: 2019:13.

41 Joanes, T. & Gwozdz, W. (2019) Think Twice: a social marketing toolbox for reduced consumption. Mistra Future Fashion report number: 2019:12.

therefore encouraged to explore the extent to which sustainability is integrated into the design and purchasing phases of textiles and fashion companies.

Stepwise improvements in the production line

To take a systemic approach to improving the production line, a checklist of supply chain actions for textile related companies can be found in found in Roos et al 2020[42].

Fibre choice

A key finding concerning the choice of textile fibres is that the difference in environmental impact between fibre types is generally insignificant. There is however one exception: ***It is far less resource intense to produce polyester than conventional cotton from a life-cycle perspective, and the durability of polyester further improves its environmental profile. Conventional cotton fibres are grown using unsustainable levels of irrigation and pest control that are not in line with the goals of Agenda 2030***. In addition, innovations on new sustainable textile fibres are needed to become more resource efficient and convert the fossil-based market, which is currently around 63% of the textile fibre market (see Figure 4), to renewable resources and/or recycled options. Previous categorisations of 'good' and 'bad' fibres based on generic classifications of fibre types are too simplistic.

For all other fibres, be they virgin or recycled, and fossil- or bio-based, the impact is mainly connected to the amount and type of fossil-based or renewable energy resources used and the lack of environmental management systems in textile production processes (spinning, weaving and dyeing). With regard to preferred fibre choices, there is support available in the so-called Fibre Bibles 1[43] and 2,[25] and in the Preferred Fibre & Materials report (on microfibre-related issues, see section 3.4).[44]

Reduce energy use and/or switch to renewable energy sources

In order to diminish the climate impact and energy use of the production line, developments are recommended at various levels from innovations in the dyeing of textiles, to the optimisation of existing technologies to reduce energy use and/or switching to renewable energy sources (solar power, wind power or water power). Closed industrial systems will be required in order to avoid emissions.

Reduce water use

Water use in the textile industry

The wet treatment stage (dyeing and finishing) is the production step that has the largest single climate-related impact (see Figure 7) and gives rise to practically all the water pollution.[4] In contrast to other large industrial sectors, the textile industry causes direct pollution of the process water, which is mixed with chemicals and the products.[45]

Large amounts of hot water are used in other industrial processes, but usually as a cooling agent, meaning that it is not in direct contact with the products. A lot of

42 Roos, S., Larsson, M. and J.nsson C. (2019) Supply chain guidelines: vision and ecodesign action list, Mistra Future Fashion report number 2019:06.

43 Rex, D., Okcabol, S., Roos, S. (2019) Possible sustainable fibres on the market and their technical properties. Mistra Future Fashion report number: 2019:02 part 1.

44 Preferred Fiber & Materials – Market Report 2019, Textile Exchange 2020

45 SFA/Ecotextile News (2018) 'Podcast: Thought leadership, Linda Greer believes in radical transparency!' Sustainable Fashion Academy (SFA). Available at: *https://www.sustainablefashionacademy.org/podcasts/big-closets-small-planet/thought-leadership-linda-greer-believes-radical-transparency.!*

energy is needed to heat the water. Several innovations have been suggested involving dope dye/spin dye, digital printing and so-called right first time surveillance to reduce the rate of reworking. These are examples of mature technologies that are currently commercially available and have huge potential to reduce the environmental impacts.[46,47] There are also several developing technologies such as spray application and the use of supercritical carbon dioxide as a solvent in dyeing.[46,47] For European producers, the Industry Emissions Directive (IED) stipulates that best available techniques (BAT) processes must be used if a plant is to be granted an environmental permit. BAT processes are defined in the Best reference document for textiles. This is currently being revised, which could mean stricter requirements for European textile operators.[48]

Use of less toxic chemicals

Another major environmental issue in the textile industry concerns the use of durable water repellent (DWR) chemicals. Traditional fluorinated chemistry is being phased out as it has been shown to have unacceptable consequences for human health and the environment.[49] Silicon-based compounds had been seen as viable alternatives but new toxicity evaluations have shown them to be equally problematic.[50] The market is short of alternatives and there is an urgent need for innovative solutions.

Transparency and competences

Major areas of innovation in textile production technologies concern, for example, adaptation to renewable energy, reduced use of solvents and increased traceability. Although there are examples of innovative solutions in all steps in the production chain (from fibre production to yarn spinning, weaving/knitting, wet treatment, and cut and sew), it is at the wet treatment stage that most innovations are present[21]. ***Transparency and traceability to allow the measurement of impacts throughout the production chain is a more pressing issue than fibre content*** (see section 2.4).

Regardless of the level of technology, textile brands need to require their suppliers to measure and continuously improve their energy and water consumption, in compliance with Restricted Substances Lists (RSL), and to implement the use of wastewater treatment. Innovation does not necessarily lead to sustainability from a life cycle perspective. Investors should verify the competence of a company's textile processes and environmental management.

2.3 New materials recycling technology

To achieve a circular economy, the majority of the materials on the market should come from recycled or renewable sources. Modern consumption habits generate massive textile overload in the market and ultimately also problems with waste. This is the result of the existence of a linear economy model, in which 'take-make-use-dispose' represents an unsustainable design right from the start. Many important decisions are made in the design of a garment and the selection of material

46 Hasanbeigi, A., Price, L. (2015) A technical review of emerging technologies for energy and water efficiency and pollution reduction in the textile industry. J. Clean. Prod. 95, 30–44.

47 Johannesson, C., (2016) Emerging Textile Production Technologies Sustainability and feasibility assessment and process LCA of supercritical CO2 dyeing. PhD thesis, Chalmers University of Technology, Gothenburg, Sweden.

48 European Commission, 2003. Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for the Textiles Industry. European IPPC Bureau, Seville, Spain.

49 Jönsson, C., Posner, S., Roos, S., (2018) Sustainable Chemicals: A Model for Practical Substitution, in: Muthu, S.S. (Ed.), The Detox Fashion- Cleaning Up Fashion Sector. Springer Singapore.

50 Holmquist, H., Schellenberger, S., van der Veen, I., Peters, G.M., Leonards, P.E.G., Cousins, I., (2016). Properties, performance and associated hazards of state-of-the-art durable water repellent (DWR) chemistry for textile finishing. *Environ. Int.* 91, 251–264.

properties, as well as by the purchaser function. To ease the treatment of textiles at the disposal stage, investors are encouraged to explore the extent to which sustainability is integrated into the design and purchasing phases in textile and fashion companies.

Textile recycling technologies are currently lacking but a range of recent inventions seem likely to achieve industrial scale in the near future. (An up-to-date list of recycling options divided by fibre types is provided in 'Preferred fibre and materials: market report, 2019'.[44])

Infrastructure, collection and sorting

One of the biggest challenges to be resolved before 2025 is building up the infrastructure around collecting and sorting textiles for reuse and materials recycling. Figure 5 shows that as of 2015, more than half of all Swedish textiles (around 65,000 tonnes/year) was being incinerated or used for energy recovery.[31] Most of that volume should be collected and sorted separately by 2025 – in addition to the 37,000 tonnes already being sorted annually by non-profit organisations. New infrastructure will require several steps in order to be resource efficient and in line with the waste hierarchy and upcoming directives (see section 3 and Appendix B).

The various steps that need to be put in place for textiles disposal are:

Step 1: To separately collect both textile waste and textiles in a reusable condition, should be employed. This will be implemented and steered by the upcoming EPR at the national level.

Step 2: Increase the textile sorting capacity for reuse today. An almost threefold increase in total capacity in Sweden will be needed in the order of around 85,000 tonnes of textiles annually, based on the data in Figure 5 and the Swedish EPA. Sorting can be semi-automatic in order to sort for specific high-value brands providing these garments have automatically readable tags/labels. The actual judgement when sorting for reuse needs to be manual, however, as there is a relationship between better sorting for trends, brands and materials, and monetary returns.

Step 3: Automatic sorting of textile waste. Electronically readable tags (e.g. RFID tags) will be needed for high speed automatic sorting. Such tags have not yet been adopted by the majority of brands. The best available options are spectroscopic techniques such as Near Infrared (NIR) methods. There are various automatic sorting systems on the market and, although each methods has its limitations,[51] they are normally more accurate than manual sorting. A prerequisite for textile recycling is that the feedstock entering the recycling process is accurately characterised to enable adoption of the most suitable recycling technology.

The EU regulation on fibre labelling applies to textile products and to products and certain product components that are at least 80% textile fibre by mass (European Commission, 2011). Depending on the product, between 95 and 98% of the fibre content must be declared on the label. However, this is insufficient information to enable large-scale textile recycling, since the remaining fibre content could disrupt certain recycling processes. For example, even the existence of low levels of elastane prevents melt spinning of synthetic materials. In addition, the regulation does not require labelling to distinguish between fibres at a sufficiently specific level of detail. For example, it does not distinguish between Nylon 6 and Nylon 6.6, which is essential for certain recycling processes.

51 Englund, F., Wedin, H., Ribul, M., de la Motte, H., Östlund, Å. (2018) Textile tagging to enable automatic sorting and beyond. Mistra Future Fashion report 2018:1.

Recycling technologies

Materials recycling is already an established practice in many industries. Securing access to and the supply of feedstock has historically been the main driver. In the textile industry, recycling is much less mature and still the exception rather than the norm (see Appendix C).

There are various recycling methods[35]

- chemical recycling: suitable for post-consumer waste, both synthetic and natural fibre.
- mechanical recycling: the textile is torn into its fibre components, which can be re-spun into yarn. Suitable for pre-consumer waste (both synthetic and natural fibre), i.e. streams not exposed to wash, wear and UV, through which the polymers in the materials are degraded and weakened.
- thermomechanical recycling: the melting of synthetic fibres that can then be re-spun/reshaped into new materials.

TABLE 2: Recycling options, technologies and their outputs. For further reading on specific industrial processes or innovations see Roos et al., 2019[35] and the Preferred fibre & materials report, 2019.[44]

	Waste stream	Recycling process	Output
Textile to textile	100% polyester post-consumer garments	Chemical recycling via depolymerisation	Polyester yarn
	100% cotton fabric	Mechanical recycling by shredding to fibres	Short cotton fibres to mix with virgin cotton (15–20%)
	Wool and wool/acrylic fabrics	Mechanical recycling by shredding to fibres	'Shuddy' for non-woven, emergency blankets etc.
	100% cotton cutting waste	Chemical recycling to lyocell	Lyocell fibres
Non-textile to textile	100% Nylon 6 materials (fishing nets, carpets, pre-consumer hard plastic waste etc.)	Chemical recycling by depolymerisation	Nylon 6 yarn
	100% Nylon 6.6-materials (pre-consumer waste)	Thermomechanical	Nylon 6.6 yarn
	100% polyester materials (PET bottles and other food contact materials, pre-consumer waste etc.)	Thermomechanical or chemical recycling by depolymerisation	Polyester yarn
Textile to low-grade products	Mixed textile waste	Mechanical recycling by cutting into pieces	Industry wipes (single-use)
	Mixed textile waste	Mechanical recycling by shredding to fibres	Insulation, composites etc.
	Mixed textile waste	Energy recovery	Electricity and heat

Considerations for achieving increased value and opportunities for recycling

To establish large-scale textile recycling, the future should not be judged based on the current situation. There is great potential for environmental benefits to be derived from textile recycling if high recovery rates are achieved and high-quality products can be produced. We therefore recommend viewing textile waste not just as a resource that should be 'returned' to the textile value chain. ***Open-loop recycling that can exchange materials between textiles, plastics, composite and non-woven applications*** can increase the potential to be resource efficient, both economically and environmentally. Table 2 provides some examples of the use of recycled materials in textiles for the main fibre types: polyester, cotton and nylon. To ensure that fashion products are designed to be recyclable at their end-of-life, the ***current recommendations are to create monomaterial designs*** unless this shortens the life length of product and ***to avoid chemical treatments that might disrupt the recycling process or contain restricted chemicals***.

The environmental benefits of recycling largely depend on which virgin material is being replaced and how much of that material is replaced. There is strong support for claims that recycling is generally a preferable waste management option to incineration and landfill. Nonetheless, there are pitfalls.[35]

- in cases of low replacement rates, the impact of recycling processes such as sorting and transportation may be larger than the benefits of prevented production, causing a net increase of impact.
- depending on the recycling route and the kind of prevented production, problem shifting can occur as certain types of environmental impact may increase while others decrease. Östlund et al. (2015)[52] reveals that climate impact can increase if the recycling process is powered by fossil-based energy and the material replaced is made of a relatively climate-friendly fibre such as cotton .

There are also knowledge gaps where there is no data on replacement rates and a lack of studies on certain recycling routes and the recycling of certain materials. Moreover, some potentially important life cycle stages (such as collection and sorting) and impact categories (such as land-related impacts) are seldom considered.[36] This adds uncertainty to knowledge of the environmental consequences of textile recycling.

It is important to stress that to maximize the environmental benefit, ***the first step is for materials to be used and reused***, with recycling being the option once materials are discarded after prolonged use in alignment with the waste hierarchy. In this way, reuse and recycling are not competing strategies but both necessary and complementary in a circular economy.

2.4 Technology development for traceability

The development and standardisation of technology and information systems to enable traceability will be required to allow measurement of impacts throughout the production chain. To quote Peter Drucker in 1954: 'What gets measured gets managed'. Only when impacts are made visible to customers can the vision of the 'polluter pays principle' be realized. To facilitate recycling and its initial steps – the

52 Östlund, Å., Wedin, H., Bolin, L., Berlin, J., Jönsson, C., Posner, S., Smuk, L., Eriksson, M., Sandin, G. (2015) Textilåtervinning. Tekniska möjligheter och utmaningar. Naturvårdsverket Rapport 6685, Sweden.

collection and sorting of textiles – the textiles will need traceable information tags. This will increase the sorting rate and make it more accurate compared to manually sorted lines, which achieve only around 70% accuracy. Moreover, tags for traceability can facilitate stock handling at the retailer and provide pre-owned histories, as well as information from the production line.

In the short run, traceability can be achieved through certificates and standards. In the future, it will be supported by digital information tags connected to global information systems. Technologies for traceability need to be able to cope with the long and complex supply chains of the textiles industry. For example, if a digital tag is added at the garment making stage, this means that the upstream supply chain processes (fibre production, yarn spinning, weaving/knitting and wet treatment) must use another system for traceability.

Transparency has to be gained throughout the production process to ensure a sustainable product from a life cycle perspective. Today's reporting formats contain a high degree of voluntary reporting, and there is a risk that the most critical points will be left out or that companies will only report on the aspects on which they perform well. Systems for traceability and transparency need to cover the content described in sections 2.1 to 2.3.

A major focus must also be put on implementation rates, as it does not matter how well-designed an information system is if it is empty of data. Here, the development process of the Higg Index[53] can be used as a benchmark. It has made great efforts to engage the entire supply chain in the system and to get all stakeholders on board.

Finally, much of the hardware currently offered on the market demonstrates low levels of compatibility with requirements for application to textiles. For example, the life of the hardware, such as a digital information RFID tag, must be equal to the life of the garment and be able to withstand laundering.

53 SAC, 2020. Higg Index *https://apparelcoalition.org/the-higg-index/*

3 Legislation and voluntary initiatives

This section describes the current situation with regard to legislative and voluntary initiatives on the environmental aspects of the textile industry. These have arisen in recent years at both the EU and the national levels.

3.1 Overview of current legislation

The majority of the legislation addressing the environmental aspects of the textile industry is focused on chemicals. This reflects the large quantities of chemicals needed to produce textiles.[54] Furthermore, in contrast to most other sectors, the textile sector – and especially the dye houses in wet treatment processes – uses chemicals in open systems. These chemicals are mixed with incoming water and washed out using the wastewater from the processes. The direct pollution of process water with chemicals is a unique feature of the textile sector. Large amounts of water are also used in other industrial processes, usually as a coolant.[45] In the EU, emissions from textile manufacturing plants are regulated by the Industry Emissions Directive (IED)[55].

Appendix B provides an overview of the current legislation that applies to textile production. This legislation is fairly extensive and expanding at a steady rate. Keeping up to date and compliant with the legislation involves a significant workload for many companies. It is important to ensure that new and innovative start-ups are aware of and able to comply with all the legislation.

Market-based instruments (MBIs) operate mainly by creating economic incentives. Environmental MBIs such as taxes can support national budgets and act as a means of reducing reliance on income-based taxes. MBIs related to textiles include extended producer responsibility (EPR) and taxes or fees on specific products. The Authorization procedure in the REACH legislation is another example of an MBI. Green Public Procurement is an instrument used by the European Commission to promote environmentally friendly products and services and encourage eco-innovation, thereby contributing to sustainable development.[56]

54 Olsson, E., Posner, S., Roos, S., Wilson, K. (2009) *Kartläggning av kemikalieanvändning i kläder. Mölndal, Sweden.*

55 European Commission Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). Off. J. Eur. Union 2010, L334, 17–119.

56 European Commission Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Public procurement for a better environment; COM(2008).; European Commission, 2008

3.2 Movements related to new business models to prolong the lifetime of garments

The EU is developing a product policy framework within the Circular Economy Package,[57] of which the Product Environmental Footprint (PEF) initiative is one example.[58] On the issue of collaborative use through second-hand sales, leasing or clothing libraries, it is important to remember that there is a trade-off between a decreased environmental burden due to a possible greater number of uses (although this is not always the case) and an increased environmental burden linked to laundry and transportation. The market for pre-used items is growing slowly but surely. There is an increased interest among consumers in buying second-hand goods, and the entry of new, for-profit entrepreneurs provides new channels and business models for pre-used clothing.[59] A Swedish Public Radio investigation of second-hand sales by the five largest second-hand retailers in Sweden found that sales increased by 15% in 2019 and that retailers expect continued growth.[60] The increased availability of new business models such as rental and leasing as well as a growth in mending and re-manufacturing services means that continuing growth of the market can be expected. One policy suggestion is to reduce the tax on mending services. Sweden reduced the tax on smaller repairs in January 2017.[61] The tax was reduced from the 25% to 12% on apparel, among other products. Further policy developments to encourage new business models for prolonging life are expected in order to meet the targets in the EU circular economy directive.

3.3 Movements related to new material recycling technology

Several policy instruments have been investigated and evaluated. Extended Producer Responsibility (EPR) and Refunded Virgin Payments (RVP), a charge on virgin fibres, are two instruments that might stimulate fibre-to-fibre recycling.[62] In the 2019 January Agreement, the Swedish government stated that an EPR for textiles would be implemented by 2025.[9] The Swedish EPR draft will be presented on 10 December 2020.

Another part of the Circular Economy Package[57] states that all member states must collect textiles separately by 2025, and that more than 55% of all municipal waste (i.e. not just textiles) must be recycled into new material. This requirement will be increased to more than 60% by 2030 and to more than 65% by 2035. In addition, by 2035 no more than 10% of all waste will be allowed to go to landfill.

In addition, by 2024 EU member states must consider whether specific targets should be introduced with regard to reuse and recycling. The Swedish EPA suggested in 2015 that the volume of textiles in household waste in Sweden should be reduced by 60% by 2025.[63] This would mean a reduction of around 37,000 tonnes of textiles annually that is currently incinerated. This is of the same magnitude that Swedish non-profit organisations collected and sorted in 2016.[32]

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57 European Commission. 2018. 'Circular Economy Package.' 2018. *http://ec.europa.eu/environment/circular-economy/index_en.htm*.

58 European Commission. 2020. 'Product Environmental Footprint (PEF).' Single Market for Green Products Initiative. 2020. *https://ec.europa.eu/environment/eussd/smgp/index.htm*.

59 Sweet, S., Aflaki, R. & Stalder, M., (2019) The Swedish market for pre-owned apparel and its role in moving the fashion industry towards more sustainable practices. A Mistra Future Fashion Report 2019:13

60 *https://sverigesradio.se/sida/artikel.aspx?programid=83&artikel=7373979*

61 *https://www4.skatteverket.se/rattsligvagledning/edition/2018.1/355538.html*

62 Elander, M., Tojo, N., Tekie, H., Hennlock, M. (2017) Impact Assessment of Policies Promoting Fiber-to-Fiber Recycling of Textiles. Mistra Future Fashion Report Number: 2017:3.

63 Naturvårdsverket. 2016. 'Förslag Om Hantering Av Textilier – Redovisning Av Regeringsuppdrag.' Stockholm.

The Swedish EPA has also proposed that 90% of the volume of textiles separately collected should be prepared for reuse and recycling by 2025, in accordance with the waste hierarchy. This means that the activities of businesses based on manual and automatic sorting will have to more than double within a few years.

Incineration tax

In Sweden, there has been a tax on waste incineration of 75 SEK/tonne of waste since 1 April 2020. This may have an impact on textile waste handling for end-of-life textiles.

3.4 Movements related to new production technology

Tax on harmful chemicals

In the 2019 January Agreement, the Swedish government stated that a tax on harmful chemicals in clothing and shoes would be implemented during the current parliamentary term.[9] A proposal by the special investigation group was presented to the Ministry of Finance on 1 April 2020.[64] It is currently in the public consultation phase, which ends in October 2020. The proposed implementation date is 1 April 2021. In brief, the proposal is that clothes and shoes will be taxed at 40 SEK, but deductions of 95% can be applied if there is sufficient evidence that chemicals on a proscribed list were not used in their production. High-risk materials will be taxed by an additional amount, and 100% of this amount will be deducted where there is sufficient evidence of non-use. Second-hand garments are not included but new garments with recycled content are. The aim of the tax is to drive the substitution of harmful chemicals and thus to have an impact on the production of textiles.

Toxicity

Textile consumer products such as clothes, footwear and homeware textiles generally consist of several different materials. These textile materials, trims and prints, in turn, contain a wide range of chemical substances, not all of which are hazardous. Complex and non-transparent supply chains, accompanied by often limited chemical knowledge, make chemicals management and the substitution of hazardous chemicals in products and production processes a difficult challenge.[65] The lack of transparency by manufacturers on the content of textile input chemicals adds to the difficulty for textile brands to know what their end-products contain. As a consequence, it becomes more difficult for recyclers to get access to information about the chemical content of textile products.

The chemicals management practices that currently dominate among textile retailers are certification schemes such as Oeko-Tex[66] and BlueSign,[67] restricted substances lists (RSL) such as AAFA[68] and ZDHC[69], chemicals management tools such as AFIRM,[70] and multi-stakeholder initiatives such as the Swedish Chemicals Group.[71]

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64 *https://www.regeringskansliet.se/rattsliga-dokument/statens-offentliga-utredningar/2020/04/sou-202020/*

65 Roos, S., Posner, S., Jönsson, C., Olsson, E., Nilsson-Lindén, H., Schellenberger, S., Larsson, M., Hanning, A-C., Arvidsson, R. (2020) A Function-Based Approach for Life Cycle Management of Chemicals in the Textile Industry. Sustainability 12(3), 1273.

66 STANDARD 100 by OEKO-TEX®. Available online: *https://www.oeko-tex.com/en/our-standards/standard-100-by-oeko-tex* (accessed on 13 December 2019).

67 BLUESIGN®. Available online: *http://www.bluesign.com/*, accessed 13 December 2019.

68 AAFA Restricted Substance List. Available online: *https://www.aafaglobal.org/AAFA/Solutions_Pages/Restricted_Substance_List.aspx* (accessed on 13 December 2019).

69 Roadmap to Zero. Available online: *http://www.roadmaptozero.com/* (accessed on 13 December 2019).

70 AFIRM Supplier Chemistry Toolkit. Available online: *http://www.afirm-group.com/toolkit/* (accessed on 6 December 2019).

71 The Chemicals Group. Available online: *https://www.ri.se/en/what-we-do/networks/chemicals-group?refdom=www.swerea.se* (accessed on 13 December 2019).

Microfibres

Micro-sized particles of plastics, or so-called microplastics, are an environmental problem in marine and coastal waters. These oil-based microplastic particles attract contaminants that are normally not soluble in water. When the microplastics enter animals and plants in the aquatic environment, they bring contaminants with hazardous properties with them.[72]

There are ways to reduce microplastic shedding from textiles in the manufacturing of a garment. Research shows that[74] the risk of microplastics shedding from garments is reduced if:

- brushing is reduced;
- ultrasonic or laser cutting is applied in the manufacturing process; and
- microparticles on fabrics are removed at the production stage.

However, microplastics need not be hazardous in themselves as micro-sized particles cannot pass through cell walls. The chemical risks are contested within the scientific community. In a comparison of the possible toxic effects of microfibres containing textile additives with the possible toxic effects of microplastics where environmental pollutants had been sorbed on to the particle, the former contained far greater concentrations of toxins. More research is needed on the detrimental effects of micro-sized plastic particles. However, in the textiles field, the state-of-the-art knowledge indicates that it is probably more important to use low-toxicity textile additives than to work on mitigation measures for microfibre shedding.[73]

3.5 Technology development for traceability

The EU is developing a product policy framework for the circular economy,[57] for example through the Single Market for Green Products initiative in which the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF) have been established to measure environmental performance based on an LCA.[74] The Environmental Footprint initiative is currently in its transition phase (2019–2021), which aims to develop product- and sector-specific rules and investigate the possible adoption of policies.[58] Some states are have been forerunners. In 2022, the use of LCA-based[13] climate declarations will become a statutory requirement in the Swedish building sector.[75] France recently decided to investigate making climate impact labelling mandatory for apparel.[76]

3.6 Management systems and industry initiatives

Globally, the Sustainable Apparel Coalition (SAC) is the dominant initiative on sustainability in the textile field. Its membership represents over half of the global

72 Roos, S., Levenstam Arturin, O., Hanning, A-C. (2017) Microplastics Shedding from Polyester Fabrics. Mistra Future Fashion report series 2017:06.

73 Eriksson Andin, M. (2018) Microplastic Polyester Fiber as a Source and Vector of Toxic Substances: Risk Assessment and Evaluation of Toxicity.' Bachelor Thesis. University of Gothenburg, Sweden.

74 European Commission. 2013. 'Commission Recommendation of 9 April 2013 on the Use of Common Methods to Measure and Communicate the Life Cycle Environmental Performance of Products and Organisations (2013/179/EU).' Official Journal of the European Union L124 (1).

75 Regeringskansliet. 2019. 'Uppdrag Att Förbereda Införandet Av Krav På Redovisning Av En Klimatdeklaration Vid Uppförande Av Byggnader. Fi2+19/02439/BB.' Stockholm.

76 Ecotextile News. 2020. 'France Considers Labelled Apparel Ratings.' Ecotextile News, 2020. *https://www.ecotextile.com/2020021825710/fashion-retail-news/france-considers-environmental-ratings-on-apparel.html*.

turnover of the textiles sector.[77] The SAC is developing a set of tools, the Higg Index, to derive product scores based on LCA,[13] environmental and social compliance in the supply chain and brand performance.[53] SAC members will use the Higg Index to report their sustainability performance in a transparent and comparable way. The SAC is also involved in developing the product-specific rules for the EU Product Environmental Footprint (PEF)[58].

Another voluntary way of reporting environmental performance in a standardized way is by making Environmental Performance Declarations (EPD) according to ISO 14025.[78] The EPDs are also based on LCA,[13] and compatible with the PEF. Some textile brands are already reporting on the environmental performance of their products using EPDs.[79]

The United Nations Framework Convention on Climate Change Fashion Charter is another example of a voluntary commitment, where a 30% reduction target has been set for greenhouse gas (GHG) emissions by 2030 and a commitment has been made to devise and set a decarbonization pathway for the fashion industry drawing on methodologies from the Science-Based Targets Initiative (SBTi).[80]

The SBTi is an initiative for reporting and reducing GHG emissions.[81] The SBTi follows the GHG Protocol Corporate Standard,[82] which classifies a company's GHG emissions into three 'scopes'. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy or transport services. Scope 3 emissions are all the indirect emissions not included in scope 2 that occur, both upstream and downstream, in the value chain of the reporting company.[83]

Among the Swedish voluntary initiatives are the Swedish Textile Initiative for Textile Action (STICA),[84] and the Swedish Textile Water Initiative (STWI).[85] Several Swedish brands have also joined initiatives such as the Copenhagen Fashion Summit,[86] the Ellen MacArthur Foundation (EMF)[87] or Fashion for Good.[88]

VF Corporation, which owns brands such as Timberland and North Face, plans to offer green bonds to investors to fund sustainability-related projects.[89] VF plans to use the money in three key areas: to increase its sourcing of sustainable products and raw materials, to reduce the carbon footprint of its own operations and supply chain, and to offset unavoidable emissions.

Similarly, as discussed in section 1.3, there are many initiatives, labels and assessment tools in use in the apparel industry. Some of the more common ones are discussed above. Most of these do not address the sustainability of a whole system or the total impact of a product, but are specific to a single area, such as the organic farming of cotton or chemical use in dyeing. This demands a lot of specific knowl-

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77 SAC 2019. 'Sustainable Apparel Coalition (SAC).' 2019. *http://apparelcoalition.org/*

78 ISO. 2006. 'ISO 14025 – Environmental Labels and Declarations – Type III Environmental Declarations – Principles and Procedures.' Geneva, Switzerland: International Organization for Standardization – ISO.

79 The International EPD System. 2019. 'The International EPD® System.' 2019. *https://www.environdec.com/EPD-Search/?search_type=simple&Category=6193*.

80 UNFCCC. 2019. 'Fashion Industry Charter for Climate Action.' 2019. *https://unfccc.int/climate-action/sectoral-engagement/global-climate-action-in-fashion/about-the-fashion-industry-charter-for-climate-action*.

81 SBTi and WRI. 2019. 'Apparel and Footwear Sector. Science-Based Targets Guidance.' World Resources Institute (WRI) and Science Based Targets initiative (SBTi).

82 *https://ghgprotocol.org/about-us*

83 Machek, D., Heinz, C., Tojo, N. (N/A) Sustainable Supply Chain Management of Clothing Industry; Current Lack of Political Wills and Roles and Limitation of Multi-Stakeholder Initiatives. submitted work 2019.

84 *https://www.sustainablefashionacademy.org/STICA*

85 *https://stwi.se/sv/*

86 *https://www.copenhagenfashionsummit.com/*

87 *https://www.ellenmacarthurfoundation.org/*

88 *https://fashionforgood.com/*

89 Ecotextile News 2020. 'VF Corp Targets Industry First with Green Bonds.' Ecotextile News, 2020. *https://www.ecotextile.com/2020021825715/fashion-retail-news/vf-corp-targets-industry-first-with-green-bonds.html*.

edge on the part of an investor or financial analyst when reviewing or analysing companies or investment objectives. Unfortunately, there are few short cuts to reliable and verifiable information on sustainability impacts. Our advice is to look into the four areas highlighted as particularly interesting in this report and to be wary and critical when examining corporate information on these areas. Does the company use certification schemes? How transparent is the process of obtaining information? Ask questions about how data is collected and whether it has been verified by a third party. In addition, ask questions about what certifications and initiatives are being used, given the materials-related issues in the apparel industry. Are the initiatives used limited in scope but still used to brand the company as sustainable? A critical stance is strongly advised where broad claims of sustainability are being made.

4 Challenges

Circular business models and extended use of produced garments will be required to ensure that the planet's resources are used in the most efficient and sustainable way, and to minimize and hopefully eliminate waste.

Actions where investment can have an impact

- Extend the use of the garments produced through new business models.
- Switch from fossil-based to green energy all along the production line.
- Improved handling of textile waste: sorting, reuse and recycling.
- Joint action through multi-stakeholder initiatives and the like.

Policies are in the pipeline to prompt the development of new markets and business models, and allow consumer behaviour to be changed. With the aid of information flows and developments in digital technology, new consumer habits and demands are likely to arise. This will have an impact along with advances in sustainable production processes and techniques, which also assume less geographical dependence.

The use of fossil-based energy in the supply chain (i.e. for fibre processing, yarn spinning, weaving/knitting, dyeing, cutting and sewing) is the single most important issue for reducing the climate impacts of textiles. The impacts on water scarcity and the toxic effects of chemicals are in principle entirely caused by textile production processes, with the important exception of conventional cotton cultivation.

New textile fibres are needed that have lower environmental impacts but are comparable in quality and price to the substituted conventional fibres. In future (by 2025), goods collected from household waste will increase the feedstock going to fibres recycling. This will enable circularity, and hopefully involve more advanced design processes that incorporate sustainability impact procedures from the first design phase. These procedures are based on intended use and duration of use, which ensures optimum usage and follows eco-design guidelines.

We hope to see a future where new consumption habits lead to the increased availability of new services such as leasing, redesign and borrowing, which will encourage flourishing new businesses based on reuse, collection, sorting and recycling. This will mean increased availability of alternatives and enable more sustainable activities.

From a Swedish and European perspective, it is important to bear in mind that any national (or supranational) regulation of chemicals will be restricted to actions inside the area of jurisdiction. This will mean, for example, that European legislation can only regulate the chemical content of products produced in, imported into or used in the EU. The textile supply chain is global, however, and it is the rule rather than the exception for textile products and semi-finished products to be exported and imported between different areas of jurisdiction.[90]

In the absence of policy tools that can control the environmental impact of textile production processes, technologies to promote traceability in the supply chain can create manageability. Such technologies involve information systems, software and standards, as well as hardware. Multi-stakeholder initiatives (MSI) have emerged as a non-legislative governance measure to fill the governance gap in sustainable supply chain management (SSCM). Such MSIs include the above-mentioned Sustainable Apparel Coalition, the Sweden Textile Water Initiative, the Swedish Chemicals Group and Textile Exchange. MSI trends on harmonization and the domination of a small number of large brands in such MSIs, however, increase the risk of regulatory capture.[83]

Global norm development will be crucial to support progress on sustainability. For example, coalitions of investors have started initiatives to phase out fossil fuel-based investments and a similar initiative could possibly be taken by the financial community on issues in the textile sector.

90 Roos, S. (2015) Towards Sustainable Use of Chemicals in the Textile Industry: How Life Cycle Assessment Can Contribute. Licentiate thesis, Chalmers University of Technology, Gothenburg, Sweden.

5 Recommended further reading

All the reports and research articles in the Mistra Future Fashion research programme are available at *http://mistrafuturefashion.com/download-publications-on-sustainable-fashion/*

Recommended general reports:

Support for investors from Swedish Chemsec,
https://chemsec.org/business-and-investors/investors/

Framing stranded asset risks in an age of disruption (2018)
Material Economics and SEI.

EURATEX-Facts-Key-Figures-2020-LQ.pdf

Sections 5.1–5.4 provide references to reading pertaining to the specific research topics highlighted in this report.

5.1 Business models to prolong the life of garments

von Bahr, J., Nyblom, Å., Matschke Ekholm, H., Bauer, B. & Watson, D. (2019). *Policies supporting reuse, collective use and prolonged life-time of textiles*. A Mistra Future Fashion Report 2019:04.

Goldsworthy, K., Earley, R. & Politowicz, K. (2019). *Circular design speeds: prototyping fast and slow sustainable fashion concepts through interdisciplinary design research (2015–2018)*. A Mistra Future Fashion Report 2019:20.

Sendlhofer, T. (2019). *Organising Corporate Social Responsibility: the case of employee involvement at small and medium-sized enterprises*. Doctoral dissertation. Stockholm School of Economics.

Sweet, S. & Wu, A. (2019). *Second-hand and leasing of clothing to facilitate textile reuse – identifying sources of value generation from the perspective of businesses and user.* A Mistra Future Fashion Report 2019:13.

Sweet, S., Aflaki, R. & Stalder, M. (2019). *The Swedish market for pre-owned apparel and its role in moving the fashion industry towards more sustainable practices*. A Mistra Future Fashion Report 2019:01.

Watson, D., Gylling, A. C., & Thörn, P. (2017). *Business Models Extending Active Lifetime of Garments: Supporting Policy instruments*. A Mistra Future Fashion Report 2017:7.

Joanes, T. & Gwozdz, W. (2019). *Think twice – a social marketing toolbox for reduced consumption*. A Mistra Future Fashion Report 2019:12.

Steensen Nielssen, K. & Gwozdz, W. (2018). *Report on geographic differences in acceptance of alternative business models.* A Mistra Future Fashion Report 2018:3.

5.2 New production technology

Rex, D., Okcabol, S. and Roos, S. (2019) *Possible sustainable fibres on the market and their technical properties*, Mistra Future Fashion report 2019:02 part 1, ISBN: 978-91-88695-90-1.

Roos, S., Zamani, B., Sandin, G., Peters, G.M., Svanström, M. (2016) *A life cycle assessment (LCA)-based approach to guiding an industry sector towards sustainability: the case of the Swedish apparel sector, Journal of Cleaner Production*, 133(Oct.), 691–700.

Roos S, Sandin G, Zamani B, Peters G, Svanström M (2017). *Will clothing be sustainable? Clarifying sustainable fashion*. In: Muthu SS (ed.), 2017. *Handbook of Textiles and Clothing Sustainability*. Springer.

Roos, S., Larsson, M. and Jönsson C. (2019) *Supply chain guidelines: vision and ecodesign action list*, Mistra Future Fashion report 2019:06.

Sandin, G., Roos, S. & Johansson, M. (2019). *Environmental impact of textile fibers –what we know and what we don't know The fiber bible part 2*, Mistra Future Fashion report 2019:03, part 2.

Zamani, B., Sandin, G., Svanström, M., Peters, G.M. (2018). *Hotspot identification in the clothing industry using social life cycle assessment: opportunities and challenges of input-output modelling. International Journal of Life Cycle Assessment* 23(3), 536–546.

Zamani, B. (2016) *The challenges of fast fashion: environmental and social LCA of Swedish clothing consumption*. PhD thesis, Chalmers University of Technology, Gothenburg, Sweden.

5.3 New material recycling technology

Östlund, Å., Wedin, H., Bolin, L., Berlin, J., Jönsson, C., Posner, S., Smuk, L., Eriksson, M., Sandin, G. (2015) *Textilåtervinning. Tekniska möjligheter och utmaningar*. Naturvårdsverket Rapport 6685, Sweden.

Watson, D., Elander, M., Gylling, A., Andersson, T. (2017) *Stimulating Textile-to-Textile Recycling*. TemaNord 2017:569.

Palme, A. (2016) *Recycling of cotton textiles: Characterization, pretreatment, and purification*. PhD thesis, Chalmers University of Technology, Gothenburg, Sweden.

Roos, S., Sandin, G., Peters, G., Spak, B., Bour, S. L., Perzon, E., & Jönsson, C. (2019) *White paper on textile recycling*, Mistra Future Fashion report 2019:09.

Textile recovery in the U.S. -a roadmap to circularity. June 2020. Resource Recycling Systems.

5.4 Technology development for traceability

Englund, F., Wedin, H., Ribul, M., de la Motte, H., & Östlund, Å. *Textile tagging to enable automatic sorting and beyond*. Mistra Future Fashion report 2018:1.

Appendix A: Glossary of terms, standards and directives

Term	**Explanation**	**Comment**
Bio-based material or fuel	Claim that a material comes from a non-fossil source (renewable material).	Combustion of bio-based material or fuel does not result in a net addition of carbon to the atmosphere. Needs specification whether 100% of the material is from non-fossil sources or if only a part is bio-based. Bio-based is not equivalent to biodegradable.
Biodegradable material	Usually requires degradation in an industrial composting/digestion facility.	Often does not consider whether the material can easily be separated from the rest of the product or if there are available composting/digestion plants.
Circular economy	A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.	A concept with multiple definitions that may or may not include considerations of bio-based and/or recycled material input, non-toxic material flows, resource efficiency, social and economic sustainability issues and additional issues.[91]
Compostable material	Usually means degradation in an industrial composting facility.	These materials are normally not compostable to the extent that they can be degraded in a garden compost.
Environmental label	Environmental labels are voluntary and have been developed under the ISO 14020 series of standards.	
Environmental label Type I – Ecolabels	Type I environmental labels are third-party verified and defined by ISO 14024.	
Environmental label Type II – Self-declared environmental claims	The claimant can declare the environmental quality of their product, without set criteria, benchmarks or quality checks.	However, ISO 14021 states that this declaration should be verifiable and must not be misleading.
Environmental label Type III – Environmental declarations based on LCA	Third-party declarations verified under established programmes and defined by ISO 14025.	Prepared from LCA using predetermined criteria and set rules (product category rules).
Fossil	Non-renewable.	Combustion of fossil material or fuel results in a net addition of carbon to the atmosphere.

91 Kirchherr, J., Reike, D., Hekkert, M. (2017) Conceptualizing the Circular Economy: An Analysis of 114 Definitions. Resources, *Conservation and Recycling* 127, 221–32.

Term	Explanation	Comment
Green technology	Green tech or technology is an umbrella term that describes the use of technology and science to create products that are environmentally friendly.	The goal of green tech is to protect the environment and in some cases to repair damage done in the past.
Greenwash	Use of misleading claims on environmental performance.	For example, stating that a fashion company has improved its environmental performance by using recycled paper in its hang tags, which will have an insignificant effect.
GMO	Genetically modified organisms.	~75% of global cotton cultivation is GMO[92]
Lifetime	Active life of a product.	The lifetime of a garment is calculated in different ways from the number of uses to years in service etc.
Organic	Should follow the International Federation of Organic Agriculture Movements (IFOAM) guidelines.	Only applicable to agricultural products, which means e.g. that forest-based fibres cannot be labelled as organic.
Post-consumer recycled material	Materials recycled from collected used material	Normally unknown mixes of materials and qualities.
Pre-industrial recycled material	Materials recycled from industrial waste streams	Normally mono-material flows with well-known specifications.
Production	In a textile context usually a synonym for garment production (cut & sew).	'Produced in Europe' does not state where the fabrics and trims are produced.
Recyclable	Claim that a material can be recycled after use.	Often does not consider whether the material can easily be separated from the rest of the product, or whether there are available recycling plants or a market demand for the recycled material.
Recycled material	Claim that a material comes from a non-virgin source.	Needs specification whether 100% of the material is from non-virgin sources or if only a part is recycled.

92 *https://royalsociety.org/topics-policy/projects/gm-plants/what-gm-crops-are-currently-being-grown-and-where/*

Term	Explanation	Comment
Science-based targets (SBT)	The Science Based Targets initiative is a collaboration between CDP, the United Nations Global Compact (UNGC), World Resources Institute (WRI), and the World Wide Fund for Nature (WWF) and one of the We Mean Business Coalition commitments.	The problem lies in the name of this organization, and how to communicate activities linked to it. The 1.5-degree goal is based on science, but must always be translated into goals for a specific industry, which cannot be scientifically based. The choice of HOW to reach the 1.5-degree goal is ideological, including decisions about how to share the climate emission budget between industries and countries, or what negative effects on other sustainability factors that can be accepted[93]. Marketing claims such as "we have developed science-based targets" are therefore misleading and may also risk to substantiate the skepticism towards scientific information that already exists.
Scope 1 emissions	Defined in the GHG Protocol[94] as direct emissions from owned or controlled sources.	
Scope 2 emissions	Defined in the GHG Protocol as indirect emissions from the generation of purchased energy.	
Scope 3 emissions	Defined in the GHG Protocol as all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.	

93 Sandin, G., Peters, G.M. & Svanström, M. Using the planetary boundaries framework for setting impact-reduction targets in LCA contexts. Int J Life Cycle Assess 20, 1684–1700 (2015). *https://doi.org/10.1007/s11367-015-0984-6*

94 WRI (World Resources Institute) and WBCSD (World Business Council for Sustainable Development). 2004. The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard. Second Edition. Washington, DC: WRI and WBCSD.

Appendix B: Overview of current textile-related legislation

Current legislation	**Description**
REACH regulation (EC) 1907/2006	Restrictions in Annex XVII and information duty for SVHC. Continuously updated. European Commission Regulation (EC) No 1907/2006 of the European Parliament and the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/E. Off. J. Eur. Union 2006, L396, 0001–0851.
Stockholm Convention on Persistent Organic Pollutants (POPs)	There are 28 universally banned substances, some with textile relevance (PFOS, SCCP etc.). European Commission Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants. Off. J. Eur. Union 2019, L169, 45–77.
The Biocidal Product Regulation (BPR) Regulation (EU) 528/2012	The BPR regulates biocides. Only those on the positive/transition list of active substances are allowed. European Commission Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products. Off. J. Eur. Union 2012, 55.
Packaging Directive 94/62/EC	Restrictions on lead, cadmium, mercury and hexavalent chromium. European Commission European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste. Off. J. Eur. Union 1994, L365, 10–23.
Fibre labelling directive 1007/2011/EU	Requirement to label fibre content in textile products and to provide product care instructions. European Commission Regulation (EU) No 1007/2011 of the European Parliament and of the Council of 27 September 2011 on textile fibre names and related labelling and marking of the fibre composition of textile products. Off. J. Eur. Union 2011, L 272, 1–64.
RoHS Directive 2011/65/EU	Requires CE-mark and Technical Documentation for all products that 'generate, transmit and use electric current or magnetic fields whether or not their primary function', such as RFID tags, lights on shoes and garments etc. European Commission Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Off. J. Eur. Union 2011, L174, 88–110.
PPE Regulation 2016/425/EU	Personal protective equipment can be garments and shoes. Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC. Off. J. Eur. Union, L81, 51–98.
Waste Framework Directive 2008/98/EC	Stipulates the waste hierarchy. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, Off. J. Eur. Union L312, 3–30.
Waste Shipment Regulation 1013/2006/EU	Stipulates the conditions for the transport of waste. Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste, Off. J. Eur. Union L190, 1–98.

Coming legislation	Description
Amendments to REACH regulation (EC) 1907/2006	From 1 November 2020: CMR fast track for textiles (entry 68 in Annex XVII). Second-hand clothing is exempt. From 3 February 2021: Restriction on NPEO content in textile products (entry 46a in Annex XVII). Second-hand clothing is exempt.
Amendments to Waste Framework Directive	From 5 January 2021: Information duty on reporting SVHC substances in the SCIP database. Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, Off. J. Eur. Union L150, 109–140.

Initiatives	Description
Proposed national legislation in Sweden: A tax on harmful substances in clothes and shoes	Part of the January Agreement and planned for April 1st 2021. Does not include home textiles or PPE. The investigation was finalized at April 1st 2020 and is available at *https://www.regeringen.se/rattsliga-dokument/kommittedirektiv/2019/04/* dir.-201915/
Proposed national legislation in Sweden: EPR on textiles	Part of the January Agreement. Includes all types of textiles but excludes shoes. The investigation will be finalised in December 2020.
The European Circular Economy Package	The Circular Economy Package states that all member states must collect textiles separately by 2025. In addition, member states must consider by 2024 whether specific targets should be introduced with regard to reuse and recycling. In 2014, the Swedish EPA was asked by the government to investigate how textiles should be handled in a future system. The targets that were suggested in this work relate to collection as well as reuse and recycling, stating that by 2025 the volume of textiles in household waste shall be reduced by 65% compared to 2015. Also by 2025, 90% of the textile volume separately collected shall be prepared for reuse and recycling in alignment with the waste hierarchy. In the EPA report, the routes to reaching these goals were left open. In January 2019, however, the Swedish government stated, in the January Agreement, that an EPR for textiles will be implemented by 2025.
The European Green Deal	Under the European Green Deal, the EU makes a commitment to be climate neutral by 2050. Reliable, comparable and verifiable information plays an important part in enabling buyers to make more sustainable decisions and reduces the risk of 'greenwashing'. The Green Deal notes that an electronic product passport could provide information on a product's origin, composition, repair and dismantling possibilities, and on end of life handling. Communication from the Commission to the European Parliament, the European Council, the Council, the European economic and social committee and the committee of the regions – The European Green Deal. COM(2019)

Appendix C: Textile recycling myths(?)

Statement	**Conclusion**[35]
Recycling is better than incineration or landfill	**TRUE, BUT NOT ALWAYS:** The environmental benefits of recycling depend on which material is being replaced, how much of that material is replaced and how much environmental impact results from the recycling process.
Reuse is better than recycling	**TRUE:** The accumulated 'burden' in a textile material increases with each production step, just as the economic value does. The more production steps are replaced, the higher the environmental gain. For reuse, the burden of all production steps is replaced, which is not the case for recycling.
Recycling can make the textile industry sustainable	**FALSE:** This can never be true because the fibres account for only a minor part of the environmental impact.[4]
Large volumes of textiles end up in landfill if they are not recycled	**PARTLY TRUE, PARTLY FALSE:** In some countries textiles are incinerated with energy recovery and in some countries they are landfilled. In the EU, it is illegal to landfill combustible waste according to the Waste Framework Directive (European Commission, 2008). National permits are issued in some countries, however, but these are regarded as offences by the European Commission, which can mpose sanctions for violating EU legislation (European Commission, 2017). In countries with poor waste management systems, where all sorts of waste ends up in landfill, textiles are no exception.
When I take my clothes to the recycling bin they will become new clothes.	**FALSE (TODAY):** T to the authors' knowledge, there is currently no recycling of waste clothes collected in recycling bins back into new textiles. Some of the collected garments do get recycled, but for use as insulation, industrial wipes etc.
Collected textiles are burned/landfilled anyway	**PARTLY TRUE, PARTLY FALSE, EVENTUALLY TRUE:** Recycling is limited by the lack of recycling processes for handling the great variety of materials in terms of fibres, blends, dyes and finishes, as well as the availability of a market with a matching demand. Today, a relatively small proportion of collected materials are recycled, and a substantial share still goes to incineration or landfill. Eventually, after a second, third or more lives, textile material will always be so degraded or reduced due to losses in the system that no new product can be produced from it.
Textile waste has a negative environmental impact	**FALSE, INDIRECTLY TRUE:** Indirectly, activities that create a lot of waste mean that resources are not utilized optimally. Textiles are valuable materials that have gone through a number of refinement processes and have accumulated a value that is higher than the mere energy content. However, environmental impact means that there is a (measurable) change in the environment. Textile materials that are disposed into nature risk, for example, releasing hazardous chemicals or microplastics into the environment and in that way have an environmental impact. If the textile material is incinerated with energy recovery, landfilled in a controlled process or recycled, it does not come into contact with the environment. Combustion of fossil materials to create energy contributes to climate change in the same way as combustion of fossil fuels to create energy.

Statement	Conclusion[35]
Industrial wipes made from discarded textiles are reusable	**FALSE:** The multi-coloured wipes from discarded textiles are for single-use in the industry, while the wipes offered by laundries are homogeneous and branded.
Collected textiles ruin local textile production industries in Africa	**PROBABLY FALSE:** A difficult statement to verify or falsify but there are at least indications that in African markets where second hand textiles are not traded, local production has lost market share due to competition from cheap Asian textiles.[95]

95 Watson, D., & Palm, D. (2016). Exports of Nordic Used Textiles: Fate, benefits and impacts. Nordic Council of Ministers.

Appendix D: Diversity in climate impact measurements related to textiles

The table below lists some recent studies that attempt to quantify the total climate impact of the fashion, textile or clothing industry. The reports differ in scope: the fashion industry includes clothes and shoes but not homeware textiles or technical textiles; the textile industry includes all textiles but not leather products; and the clothing industry is more limited in scope. The scope is important to the results as consumption per capita varies in five of the reports between 9 and 31 kg per person per year, which obviously leads to differences in climate impact calculations. In addition, some exclude the use phase and only include the production of manufactured goods. For example, to compare data that only includes the use phase with the calculations of emissions that include international flights and maritime shipping, as the Ellen MacArthur Foundation (EMF) report does, is at least questionable.

The numbers below were calculated to represent the cradle-to-gate (C2G), cradle-to-grave or life cycle climate emissions of the textile materials used in garments. In these studies, the scope includes energy production and transport, etc., so not only textile site operations are included. Therefore, a comparison with e.g. the energy industry or the transportation industry is not easy as parts of these industries' emissions will overlap in the figures. Furthermore, it is easy to misinterpret textiles' share of total climate impact in different geographical areas. For Sweden, the consumption-based annual carbon footprint of an average Swede is 10 tonnes of CO_2 eq., which is about double the global average. It is also worth noting that global climate impact per year does not always correlate with Intergovernmental Panel on Climate Change figures when percentages are given.

The methodologies behind the figures also differ as the climate impact per kg of textiles varies between 17 and 39 kg CO_2-eq. (and in two cases raw fibre input is the basis for the calculations). With regard to all these calculations, transparency on the figures is needed to be able to interpret them correctly and to enable correct comparisons between products, countries and industry sectors.

	Eileen Fisher/ Dansk Mode & Tekstil	Ellen MacArthur Foundation[7]	Quantis[2]	Mistra Future Fashion[4]	Swedish EPA[42]	EEA[96]
Scope (which products are included)		Global, C2G, textile 2015	Global, C2G + EOL, apparel and footwear, 2016	Sweden, LC, clothing, 2017	Sweden, LC, clothing and home textiles, 2000–2017	EU, textile and leather including furniture and technical textiles, C2G
Consumption per capita		Globally 71 million tonnes (fibre), 7.4 billion → 9.6 kg per capita	31.21 kg Europe (fibres) 11.4 kg global (fibres)	10 kg Total for Sweden: 101,152 tonnes in 2017	14 kg	26 kg
Climate impact per kg textile		17 kg CO_2-eq./kg fibre	39 kg CO_2-eq./kg fibre	33kg CO_2-eq.	30 kg CO_2-eq.	25 kg CO_2-eq.
Ranking claims	Second after oil (myth)	More than those of all international flights and maritime shipping combined				Fifth of all household goods
Percentage		2% (Figure 3)	8.1% (between 5 and 10) 6.7% for apparel, 1.4% for footwear	3% for the average Swede**	4% for the average Swede**	
Sector climate impact per year*		1.2 Gton	4.0 Gton 442 kg CO_2-eq./capita 1,210 kg CO_2-eq./ capita in Europe	330 kg CO_2-eq. per Swede** Multiplied by 7.8 billion → 2.6 Gton (if everyone consumed like a Swede)	420 kg CO_2-eq. per Swede 2017**	654 kg CO_2-eq.per European production of clothing, footwear and household textiles
Global/national climate impact per year (IPCC 2018: 42+/- 3 Gton, 7.8 billions → 5.38 tonnes per capita)	-	60 Gton (based on 1.2 Gton being 2%)	49.3 Gton	** SEPA: 10 ton CO_2-eq. per Swede	** SEPA: 10 tonnes CO_2-eq. per Swede	

96 Manshoven, S., Christis, M., Vercalsteren, A., Arnold, M., Nicolau, M., Lafond, E., Fogh Mortensen, L., Coscieme, L. (2019) Textiles and the environment in a circular economy. Eionet Report - ETC/WMGE 2019/6.

	Eileen Fisher/ Dansk Mode & Tekstil	**Ellen MacArthur Foundation**[7]	**Quantis**[2]	**Mistra Future Fashion**[4]	**Swedish EPA**[42]	**EEA**[96]
Climate impact fibre level		Cotton: 4.7 Synthetics: 11.9	Not reported separately	Cotton: 2.2 (-0.9 – 9.3) Synthetics: 4.5 (1.7 – 5.4)	Not reported separately	Not reported separately
References and transparency	More hearsay	None, 'McKinsey analysis'	Not given to Ecotextile News on request	Yes	Some, but based on Mistra Future Fashion data	None (yet)
LCIA Method		Not reported	IMPACT 2002+ vQ2.2 (Jolliet et al. 2003, adapted by Quantis)	ILCD/PEF	ILCD/PEF	Multiregional input model based on Exiobase v.3.4 data (Stadler et al., 2018), using environmentally extended product-by-product tables.

This Investor Brief explains the key issues for, trends and challenges facing textiles and fashion, with a focus on environmental sustainability. The aim is to help investors align their activities – such as analyses, corporate evaluations and engagement – with the environmental goals of Agenda 2030 and the 1.5°C goal in the Paris Agreement. To this end, the report also contains a toolkit that can be used to assess the sustainability of investments and the success of engagement.

MISTRA
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