International Labour Organization

ILO Working Paper 53

February / 2022

Taking climate action

Measuring carbon emissions in the garment sector in Asia

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ISBN: 9789220353233 (print)
ISBN: 9789220353240 (web-pdf)
ISBN: 9789220353257 (epub)
ISBN: 9789220353264 (mobi)
ISBN: 9789220365847 (html)
ISSN: 2708-3446

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Authorization for publication: Mr Graeme Buckley, Director for ILO DWT for East and South-East Asia and the Pacific

ILO Working Papers can be found at: www.ilo.org/global/publications/working-papers

Suggested citation:
Sharpe, S., Dominish, E., Martinez Fernandez, M. 2022. *Taking climate action: Measuring carbon emissions in the garment sector in Asia*, ILO Working Paper 53 (Geneva, ILO).

Abstract

This paper examines carbon emissions across the garment sector as counted using the two prominent methodologies for calculating emissions – the life cycle assessment (LCA) and carbon accounting in line with the Greenhouse Gas Protocol. The purpose of this paper is to provide insight into where and why the carbon intensity of textiles and garments varies across the supply chain and where activities to decarbonize the sector should be prioritized.

About the authors

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The paper also draws on valuable points raised during the S*trategies on Reducing and Utilizing CO2 for Cost Effective Business Roundtable* hosted by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Sustainable Business Network[1].

[1] https://www.ilo.org/asia/events/WCMS_781625/lang--en/index.htm

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Acronyms

CO_2e	Carbon dioxide equivalent
GHG	greenhouse gas
Higg MSI	Higg Material Sustainability Index
kWh	kilowatt hour
LCA	life cycle assessment
LCI	life cycle inventory
M&S	Marks & Spencer
NDC	nationally defined contribution
SAC	Sustainable Apparel Coalition
SBTs	science-based targets
SBTi	Science Based Targets initiative
UNFCCC	United Nations Framework Convention on Climate Change
WALDB	World Apparel and Footwear Life Cycle Assessment Database
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Executive Summary

The textile and garment sector accounts for a significant proportion of global carbon emissions, estimates range between 6 and 8 per cent of total global carbon emissions, or some 1.7 billion tonnes in carbon emissions per year. The Paris Agreement sets out to limit global warming to less than 2 degrees above pre-industrial levels, with the preferable target of limiting warming to 1.5 degrees. The emission reductions associated with achieving this goal are significant – to reach this target, global emissions will need to decline by about 45 per cent (on 2010 levels) by 2030 and be at net zero by 2050.

Garment sector stakeholders came together in 2018 to commit to climate action through the United Nations Framework Convention on Climate Change (UNFCCC) Fashion Industry Charter for Climate Action. Signatories to the Charter commit to 30 per cent greenhouse gas (GHG) emission reductions by 2030 (from a 2015 baseline) and net-zero emissions by 2050.

This is a significant challenge – realizing this 30 per cent reduction in the sector's emissions would require a reduction of more than half a billion tonnes of carbon dioxide across the sector per year by 2030. Meeting this challenge will require system-level changes in the production and consumption of textiles and garments, and will likely have significant impacts on how and where garments are produced and the employment associated with this production.

This paper provides an explainer on how and where carbon emissions accrue across the textile and garment sector supply chain as a precursor to identifying where in the supply chain action should be most targeted. The findings show that emissions occur all along the value chain, but are most significant in the yarn and fabric production phase, which is also consistent with other environmental impacts such as water consumption and chemicals use.

Energy use is the major contributor to GHG emissions in the textile and garment sector. High energy demand comes from the wet processing stages (dyeing and finishing), where energy is used to create steam to heat water and also for drying fabrics. The carbon intensity of the energy sources used in production centres (coal or natural gas) translates to high emissions intensity for textile production. Energy can also account for a significant portion of costs within energy-intensive parts of the value chain, such as textile mills and garment factories; so there is an economic and as well an environmental driver to reduce emissions in the sector.

The paper examines carbon emissions across the garment sector as counted using the two prominent methodologies for calculating emissions, with the purpose to provide insight into where and why the carbon intensity of textiles and garments varies across the supply chain and where activities to decarbonize the sector should be prioritized. The two standardized approaches to measuring GHG emissions are through life cycle assessment (LCA) and carbon accounting in line with the Greenhouse Gas Protocol.

This paper highlights the carbon emission implications of:

- using different fabrics and textiles (specifically natural versus man-made);
- the carbon intensity of energy sources in production centres;
- the overall volume of production; and
- the length and intensity of the use phase (including washing and wearing behaviours of consumers).

The scale and pace of system-wide change in garment manufacturing required to meet targets for climate action means that there will also be significant impacts on the world of work in these components of the supply chain. Reducing carbon emission will require changes to business models alongside technological

and process innovations. To achieve these changes will require investments in human and financial capital over a sustained amount of time to ensure a just transition takes place.

Introduction

The Paris Agreement sets out to limit global warming to less than 2 degrees above pre-industrial levels, with the preferable target of 1.5 degrees. The emission reductions associated with achieving these targets are significant – to reach them, global emissions will need to decline by about 45 per cent (of 2010 levels) by 2030 and be at net zero by 2050 (IPCC 2018).

Garment stakeholders came together in 2018 to commit to climate action, forging the United Nations Framework Convention on Climate Change (UNFCCC) Fashion Industry Charter for Climate Action. The Charter is an industry-wide commitment to support the goals of the Paris Agreement, launched in December 2018 at the 24th Conference of the Parties in Katowice, Poland (UNFCCC 2018). Signatories to the Charter commit to 30 per cent greenhouse gas (GHG) emission reductions by 2030 (from a 2015 baseline) and net-zero emissions by 2050.

This is a significant challenge – globally the garment and textile sector accounts for 6–8 per cent of emissions (Niinimaki 2020), or some 1.7 billion tonnes of carbon emissions per year. A 30 per cent cut means emissions reduction of some half a billion tonnes of carbon dioxide per year by 2030, and this ambitious goal raises some immediate questions: How will the sector achieve these targets? What incentives, support and policies need to be in place? What effects will these emission reductions and the resulting changes in production and consumption systems have on employment and the world of work?

For the ILO, the implications for the world of work are clear. As discussed at the Governing Body in November 2020, climate change will significantly impact jobs and livelihoods and challenge our ability to achieve sustainable development (ILO 2020). The transition to a low-carbon, environmentally sustainable economy and society will provide demand for new employment and skills, and allow for the achievement of poverty eradication and social justice. However, in certain circumstances, geographies, communities and sectors, it will have negative impacts on employment and labour markets. As industrial activities move away from carbon-intensive production, employment and economic activity will also need to change, and industrial change at this scale is rarely smooth. A low-carbon transition that is also just – leaving no-one behind – will require the ongoing engagement of stakeholders, and the development and implementation of specific policies to support employment creation and skill development, sustainable enterprise development, social protection, rights at work and social dialogue (ILO 2020).

Specifically, the ILO Governing Body provided ILO with a mandate for action to:

a) promote further discussion, research, knowledge and understanding of the implications of climate change for the world of work, focusing on all relevant sectors;

b) advance the application of the ILO Guidelines for a Just Transition towards Environmentally Sustainable Economies and Societies for All, with a focus on assisting governments, workers' organizations and employers' organizations in the development of policies through social dialogue to implement their climate change commitments, including through the Climate Action for Jobs Initiative;

c) promote collaboration between the ILO, its constituents and relevant international institutions addressing climate change and related key environmental issues, such as deforestation, desertification, rising sea levels and biodiversity loss, adaptation and reduction of emissions, as well as implementing the Decade of Action towards achieving the 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 8, with a view to advancing a just transition for all;

d) continue to pursue carbon neutrality at the ILO, in line with the United Nations target to reach carbon neutrality by 2020; and

e) report back to the Governing Body on the implementation of the above-mentioned points.

This paper contributes to this effort in the garment sector. To address decarbonization, we first need to understand where and how emissions are generated. This paper provides an overview of how emissions are calculated across the sector, highlighting implications and limitations. The paper concludes with the implications of this pattern of emissions and the decarbonization needs across the sector.

The ILO Just Transition Toolkit for the Textiles and Garment Sector

This paper has been produced as part of the Just Transition Toolkit of the Decent Work in the Garment Supply Chains in Asia project. The Just Transition Toolkit focuses on enhancing the environmental sustainability of the garment supply chain. The Toolkit is built from inputs from constituents, including a mix of knowledge creation, knowledge diffusion and capacity-building activities for key sector actors with the aim of developing an evidence base for how environmental sustainability and the adoption of more sustainable practices in the textile and garment supply chain enhance decent work in the sector. The Toolkit consists of reports, briefs, highlights, videos, and infographics that provide specific advice for industry stakeholders to address gaps and weaknesses in national environmental regulation on country-specific levels, relevant guidance and support to help manufacturers understand and apply environment and decent work principles, and information on eco-innovation and greener production in the garment industry.

Throughout this paper we use the term "textile and garment sector", as we are specifically interested in garment production and therefore in the textiles manufactured as inputs into these garments. Textiles are manufactured for other purposes including furniture, automotive accessories and household decoration, and while the environmental impacts of the production of these textiles might be similar to textiles produced for garments, these textiles are not the focus of our work in this project.

The Decent Work in the Garment Supply Chains in Asia project is a regional project with coverage of all countries across the Asian region, but activities and evidence are drawn from four target countries: Bangladesh, Cambodia, Indonesia and Viet Nam.

Method

This paper is based on desk-top review of existing carbon emissions accounting reports and methodologies. Understanding how carbon emissions accrue over the highly globalized and complex supply chains of the textile and garment sector is also a complex and resource-intensive activity. There are a few foundational studies that have accomplished this measurement of emissions across the sector (each with some limitations). In reviewing these studies with a specific focus on the geography of emissions in Asia, the paper highlights where the impacts of decarbonization will be felt; where and in what supply chain activities employment impacts will accrue; and where should be the focus of just transition planning.

Structure of this paper

This paper is divided into four sections. Section 1 includes this introduction and method section, and also the following background context on the wider environmental impacts of the textile and garment sector. Section 2 examines in detail the carbon emissions in the sector and identifies which activities in the supply chain are the most carbon-intensive. Section 3 summarizes the two main methodologies for greenhouse gas (GHG) accounting – life cycle assessment and GHG accounting. Section 4 presents conclusions and implications of this work for the Decent Work in the Garment Supply Chains in Asia project and the wider textile and garment sector.

Background context – environmental impacts of the textile and garment supply chain

Asia accounts for some 60 per cent of global exports of garments, textiles and footwear. The industry has rapidly grown over the past two decades, employing more than 40 million workers, the majority in many countries being women (Sharpe 2017). Environmental impacts are concentrated at certain points in the supply chain, particularly in four areas:

a) the weaving, dyeing and finishing processes in textile manufacturing;

b) energy use throughout the supply chain, but concentrated in textile manufacturing and to a lesser extent in garment assembly;

c) textile waste associated with garment assembly; and

d) the transport emissions throughout the supply chain as materials and then final products are shipped globally.

The most significant impacts however are within the first two areas, with the main impacts being on use intensity of water resources, chemical use (including toxic chemicals), waste water discharges and lack of treatment processes, as well as energy use and the carbon intensity of electricity.

Textile manufacturing is very water- and chemical-intensive. The growth and sustainability of the sector is highly dependent on how resources are managed. The textile industry in general has an enormous water footprint ranging from agricultural water consumption for cotton farming, to water consumption in textile printing, dyeing and finishing. The sector is one of the largest users of fresh water in the world, consuming an estimated 79 billion cubic meters of fresh water annually across the entire value chain (United Kingdom 2019). As textile production is located in some countries that already have insecure water suppliers, water crises are forecast in a number of textile producing countries.

The sector is also responsible for severe water pollution by discharging large volumes of wastewater containing hazardous substances into rivers and water courses without appropriate treatment. It is reported that 20 per cent of industrial water pollution globally is attributable to the dyeing and treatment of textiles (EMF 2017).

The carbon footprint from the sector is also significant as will be further examined in this paper. As noted above, the sector accounts for 6–8 per cent of total global emissions (Niinimaki 2020). In 2015 this equated to emissions of 1.7 billion tonnes of carbon dioxide (United Kingdom 2019), which is more than all international flights and maritime shipping combined (Sumner 2019). The numbers are not surprising given the fact that over 60 per cent of textiles are used in the apparel industry, and a large proportion of apparel manufacturing occurs in China and India. India in particular relies heavily on hard coal and natural gas for electricity and heat production, sharply increasing the carbon footprint of each apparel product. Encouraging energy efficiency and switching to renewable energy sources, such as solar, hydro or wind power, can significantly change emissions and improve the sustainability of textile production.

Moreover, the increase of fast fashion has stimulated demand for fast, cheap and low-quality goods. Both the growing volume of garment production and how these garments are used and disposed of that have resulted in increasing climate change impacts stemming from the garment sector. Between 2005 to 2016, the climate impact of various production stages in the apparel sector increased by 35 per cent and is projected to continue to increase under a business-as-usual scenario (Quantis 2018).

▶ 1 Carbon emissions in the textile and garment sector

1.1. Distribution of emissions across the value chain

It is challenging to quantify the distribution of carbon emissions across the value chain, as it is dependent on the specific product and materials, as well as the emissions intensity of the country of production (WRI 2019). The following section summarizes the findings from studies that have analysed carbon emissions in the sector. It is important to note that the studies vary in method, scope and location, so there is a lack of consensus among results.

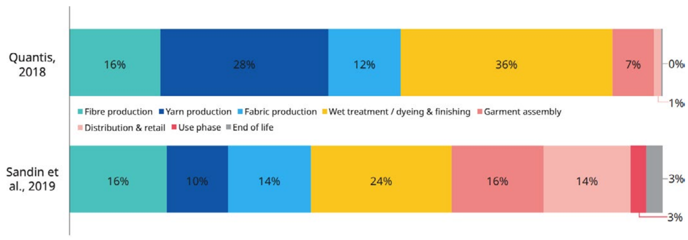
However, the overall findings highlight that it is the production of yarn and textiles and the use phase that have the largest share of emissions, with a smaller share of emissions in the production of raw materials, assembly, distribution and disposal.

1.1.1. Textile and garment production

We are aware of only one study that has attempted to measure emissions across the garment sector globally. The 2018 study by Quantis found the largest share of emissions are from the dyeing and finishing processes (36 per cent), followed by yarn preparation (28 per cent), fibre production (15 per cent) and fabric preparation (12 per cent). This study found that assembly was only responsible for 7 per cent of emissions, and distribution and disposal at end-of-life for negligible amounts (Quantis 2018). That study did not include the use phase or transport to the customer because of the difficulty of analysing the variability in consumer behaviour (Quantis 2018).

These results are consistent with a Swedish study based on emissions from six types of garments, which found wet treatment (dyeing and finishing processes) accounted for the largest portion of emissions (23.5 per cent), followed by fibre production (16.3 per cent), confectioning (cutting and sewing) (15.6 per cent) and fabric production (14.1 per cent) (Sandin et al. 2019). A comparison of the results of these two studies is presented in figure 2. The Swedish study assumed best available technologies were used in the textile manufacturing processes, which is not the case in reality and likely leads to unaccounted emissions in the garment production process.

▶ **Figure 1. Comparison of the distribution of emissions in the garment sector value chain between two key studies**



Studies focused on particular factories, brands or garments also found similar results. For example, a 2019 study of a sewing assembly line for men's shirts in China found that fabrics are the main source of carbon emissions (Zhang and Chen 2019). Another study from China on the impacts of a cotton T shirt production also found that the largest contributors to carbon emissions in the life cycle was the dyeing process (35 per cent); however, this study also found significant emissions in the garment assembly stage (32 per cent) (Zhang et al. 2015). H&M (2019) found that fabric production (which in this study included yarn production and dyeing/finishing) was by far the largest source of emissions (48 per cent), followed by the use phase (13 per cent), garment assembly (12 per cent) and raw materials (11 per cent).

The high share of emissions in these stages are a direct result of the high energy demand of these processes and the reliance on fossil fuels for energy in countries of production. Wet textile processing, commonly used for dyeing, is a highly energy intensive process and typically involves the direct use of coal or natural gas onsite for the production of steam. For example, a study of a cotton mill in Turkey found that the largest energy consumption was natural gas for steam generation (46 per cent), almost all of which is used for heating water for the wet processing, and the second-largest energy use was for drying (30 per cent) (Alkaya and Demirer 2014). A study from Bangladesh found significant energy use in the wet processing unit, which uses both steam and heat energy, and in the weaving machines (looms), which consume 50–60 per cent of the energy at the weaving plant (Hasan et al. 2019). In the production of cotton T-shirts in China, emissions in the dyeing phase were mainly attributed to the use of coal burned onsite to produce steam, and emissions in the garment assembly stage were indirect emissions from electricity consumption at the factory (Zhang et al. 2015).

Although not the focus of this review, studies have found that for footwear, the manufacturing phase has the largest impact on carbon emissions, accounting for 63–68 per cent, followed by the production of raw materials, accounting for 20–29 per cent (Cheah et al. 2013; Quantis 2018).

1.1.2. Consumer use phase

It is less common for studies to assess the contribution of the “use phase” by consumers of textiles and garments to the carbon emissions over a garment’s life cycle. Calculating emissions from the use phase is challenging, as there is a lack of data on behaviours such as the frequency of washing, washing temperature, detergent types and drying methods, which vary greatly between cultures (Yasin et al. 2016).

Some studies suggest the use phase may be the largest contributor to emissions in the value chain. A study undertaken for the UK brand Marks & Spencer (M&S) found that the use phase had the largest consumption of energy across the life cycle, responsible for 81 per cent of energy use for men’s cotton briefs and 76 per cent for polyester trousers. Washing and drying were the major energy consumers, and therefore sources of emissions. In both examples, product manufacture was responsible for 13 per cent and retail operations 4 per cent, and cotton fibre production was responsible for only 3 per cent compared to 7 per cent for polyester (Environmental Resources Management 2002).

Levi Strauss & Co also found that the use phase had the largest share of emissions (34 per cent), higher than fabric production (31 per cent) and cotton cultivation (10 per cent) (Levi Strauss & Co. 2018).

A study in China also found significant emissions in the use phase, assessing it as the third-highest contributor to emissions. However, this study was based on washing habits in China that are less energy intensive than in other major economies, so emissions are likely to be higher in other countries (Zhang et al. 2015).

1.1.3. Distribution and end-of-life

The studies discussed above all found that transport is not a significant consumer of energy, with estimates of 1–6 per cent of the value chain. However, the M&S study notes that transport by a consumer from the store uses more energy than all other transport in the value chain (Environmental Resources Management 2002), and this was not accounted for in the Quantis study. The Swedish study on six garments found a significant share of emissions from transport in the use phase, accounting for just over 10 per cent of emissions (Sandin et al. 2019).

Disposal was also found to have an insignificant impact on emissions, with estimates between 0 and 2.8 per cent across the studies reviewed. However, life cycle assessment (LCA) has been used in several studies to investigate the environmental impacts of clothing sharing, reuse and recycling.

For example, a study in Finland found that increasing the collection of discarded textiles for reuse and recycling can create an environmental benefit by offsetting virgin textile production. However, there are uncertainties whether recycled fibres can replace virgin fibres, and whether the reuse and resale of textiles reduces demand for new production or adds to overall demand and consumption (Dahlbo et al. 2017). The M&S study showed the environmental benefit of clothing reuse. It found that processing and distribution of second-hand clothing consumes 1.7 kilowatt hours (kWh) of energy per kg, and each kg of clothing displaced by second-hand clothing could save 65 kWh for cotton and 90 kWh for polyester (Environmental Resources Management 2002). A study of clothing libraries in Sweden found that in some scenarios the transportation emissions can surpass the environmental benefits of reduced production of new clothing. The key variables to ensure an environmental benefit are extending the lifespan of the garment and low impact transportation (Zamani, Sandin and Peters 2017).

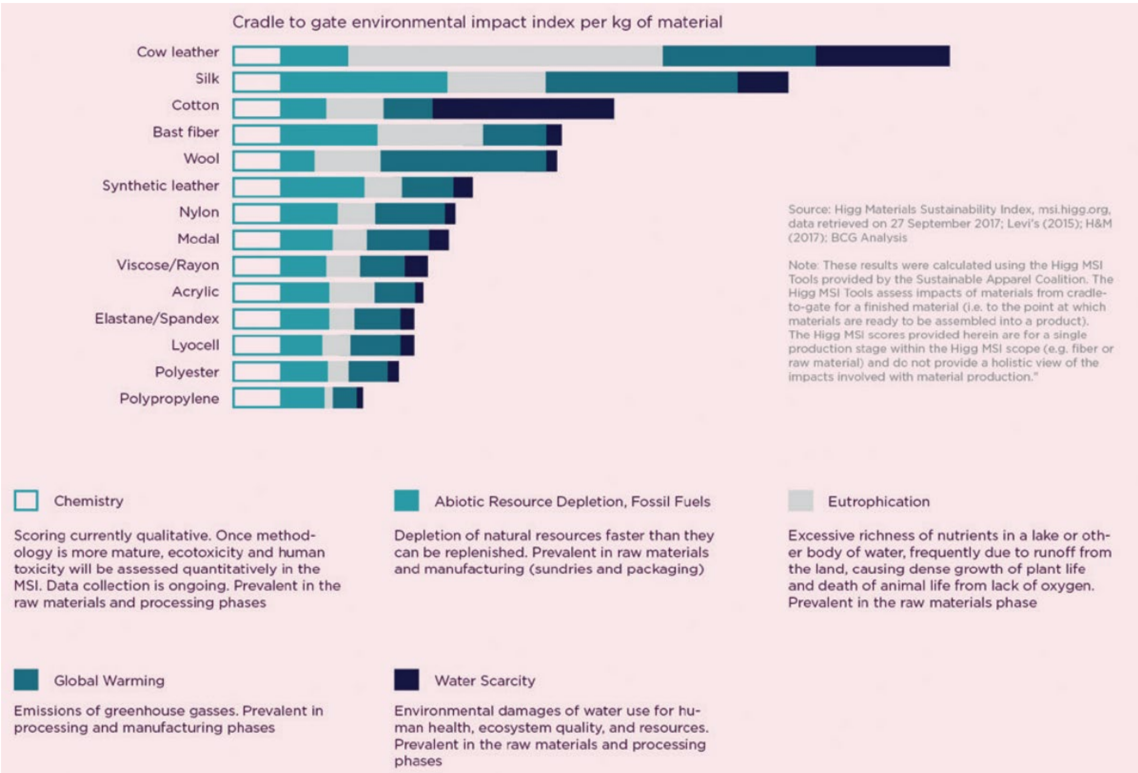
1.1.4. Variations between fibres

The type of fibre also has an impact on GHG emissions; however, there are limited published data. The Pulse of the Fashion Industry report undertook an analysis of textiles based on fibre type and found that leather, silk and wool had the highest emissions by kg of material; while polypropylene and acrylic fibres had the lowest emissions (Global Fashion Agenda and Boston Consulting Group 2017). In fact, these natural fibres have the highest environmental impact when we also include water use and pesticide use in the growing of raw materials (see figure 3). Synthetic fibres are not without impact, although carbon emissions are lower. Other issues with these synthetic fibres include being made of non-renewable resources, and being a source for growing levels of micro-plastic pollution.

The phase of the value chain that contributes most to GHG emissions can depend on the fibre type as well as the production process. A UK study found that laundry processes in the use phase has the highest energy consumption within the life cycle of a cotton T-shirt, whereas for a viscose garment, the material production phase has the highest energy consumption (Allwood et al. 2006). In a similar result to the Pulse of the Fashion Industry report, this study found that garments made from non-synthetic fibres used twice as much energy as those made from synthetic fibres.

The emissions associated with different fibres are also impacted by the type of garments these fibres are made into and the use of these garments. Fibres such as wool, silk and leather are more likely to be made into higher-quality and longer-lasting garments, with synthetic garments used more in fast fashion items.

▶ **Figure 2. Comparison of emissions by fibre type**



Source: Global Fashion Agenda and Boston Consulting Group 2017.

1.2. Geographic allocation of emissions

There are limited data on the geographic allocation of emissions from the textile and garment sectors. However, we can infer where significant emissions occur by looking at the centres for production and consumption of textiles and garments.

1.2.1. Emissions from production

In China, the largest global producer of textiles and garments, the apparel industry is the sixth-largest industry sector in terms of energy consumption (Zhang and Chen 2019). In Bangladesh, the textile and garments industry is the top export earner, generating 81 per cent of gross domestic income. The industrial sector accounts for 27 per cent of the country's total energy consumption, and the textile sector is approximately one-third of this (Hasan et al. 2019). In Turkey, another textile producing country, the sector is the third-most energy intensive sector after iron/steel and cement (Alkaya and Demirer 2014).

The energy sources in countries of production have a large impact on the emission intensity of textiles and garment production. For example, Bangladesh is heavily dependent on natural gas, with less than 2 per cent renewable energy (Hasan et al. 2019). A summary of the primary energy consumption by fuel type across five important countries in the value chain is given in table 1.

▶ **Table 1. Primary energy consumption in selected countries by fuel type in 2019 (%)**

Country	Share of fossil fuels	Oil	Natural gas	Coal	Hydroelectric	Renewables
Bangladesh	**99.4%**	20.8%	70.3%	8.2%	0.4%	0.2%
China	**85.1%**	19.7%	7.8%	57.6%	8.0%	4.7%
India	**91.0%**	30.1%	6.3%	54.7%	4.2%	3.5%
Indonesia	**93.9%**	38.0%	17.7%	38.2%	1.7%	4.4%
Viet Nam	**84.8%**	25.9%	8.6%	50.3%	14.2%	1.0%

In countries without large garment production centres, the emissions from the textile and garment sector are very low. For example, in the United Kingdom of Great Britain and Northern Ireland the textile and garment industry is estimated to be responsible for less than 1 per cent of total emissions (Allwood et al. 2006).

1.2.2. Emissions from consumption

Apart from emissions for transport to final consumer, which as noted above are not a very significant, GHG emissions are generally considered to be the responsibility of the country where the goods or services are produced. However, there are arguments that emissions should be allocated to the countries that consume these goods or services (Peters and Hertwich 2008).

Taking this approach, it is estimated that per capita emissions from clothing consumption were 1,450 kg CO2e per year in the United States of America, 1,210 kg CO2e in Europe and 41.8 kg CO2e in China (Quantis 2018). A study in Sweden estimated emissions from clothing consumption to be 330 kg CO2e per person per year, approximately 3 per cent of the carbon footprint per person (Sandin et al. 2019).

2 Approaches to measuring emissions

There are two standardized approaches to measuring greenhouse gas emissions across the garment sector:

a) life cycle assessment; and

b) Greenhouse Gas Protocol accounting.

Life cycle assessment (LCA) is used to measure carbon emissions (or energy use and other environmental impacts) for a product (such as an item of clothing) or a process (such a production line). These impacts can then be scaled up to understand environmental impacts of production and consumption of certain products and sectors. By contrast, the Greenhouse Gas (GHG) Protocol is used by companies and organizations to measure their corporate-level emissions, including their value chain and operations.

2.1. Life cycle assessment

LCA is a framework methodology for quantifying the environmental impacts of products, processes or services. LCA provides a standardized way to quantify the environmental performance of products, such as energy use, greenhouse gas emissions, water footprint and pollutants. LCA is used inter alia within industry for optimizing the eco-efficiency of production processes and supply chains, and for making material selection and procurement decisions.

The process for undertaking an LCA begins with defining the system boundary (that is, what will be included in the system) and the functional unit (that is, what unit the environmental impact will be measured for – for example, one T-shirt). The next phase is to develop a life cycle inventory (LCI) that describes the flows to and from nature in relation to the functional unit. Data are from primary surveys of companies or factories in conjunction with secondary data from LCI datasets. There are a large number of LCI databases specific to products or regions. A life cycle impact assessment can then be undertaken with existing models and LCA software to quantify environmental impacts based on the flows identified in the LCI phase.

Standards for LCA have been developed through the International Organization for Standardization (14040:2006, Life Cycle Assessment: Principles and Framework, and 14044:2006, Life Cycle Assessment: Requirements and Guidelines) and detailed methodological guidance for LCA is provided through organizations such as the Life Cycle Initiative hosted by UN Environment .

A typical LCA of a product can cover all life cycle stages from raw materials extraction or production, manufacturing, distribution, use and end-of-life. An LCA is referred to as “cradle-to-grave” if it includes the full product life cycle, or “cradle-to-gate” if it only quantifies emissions until the product leaves the factory. Environmental Product Declarations (ISO 14025) have been developed as a standardized method to communicate LCA results to consumers.

Greenhouse gas emissions are defined in LCA studies as those with “global warming potential” and are measured in kilograms of carbon dioxide equivalent (kg CO2e). This measurement is used to account for the different impacts of various greenhouse gases (such as methane and nitrous oxide) in a common unit, by calculating the amount of carbon dioxide that would have the equivalent global warming impact. For example, 1kg of methane can be expressed as 25kg CO2e.

2.1.1. LCA use in the textile and garment sector

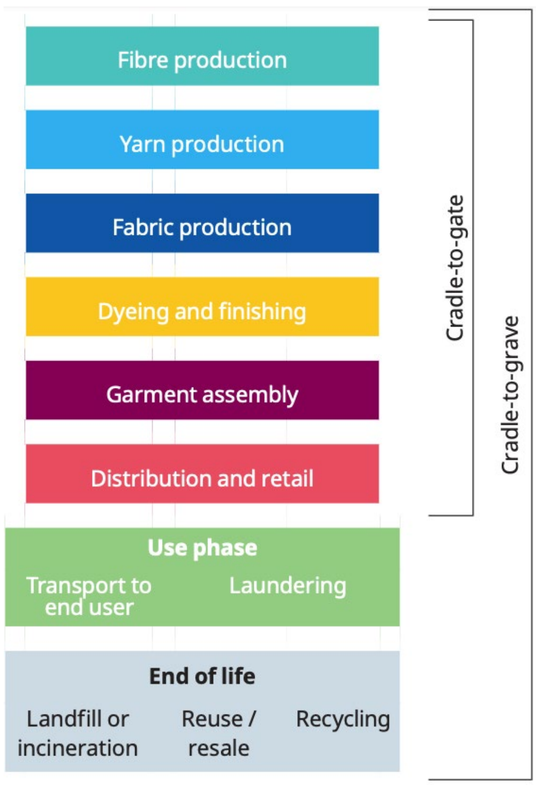
LCA has been used to quantify environmental impacts of the textile and garment sector, primarily by researchers and global fashion brands. LCA can be used to highlight the environmental impacts in a garment's life cycle, and to aid decision-making in the design process to use materials and processes with lower environmental impact.

It is also a useful tool to make comparisons between products to find which have the lowest environmental impacts; however, this is limited by the quality of the data and assumptions used, as most LCAs undertaken on textiles or garments are based on existing secondary LCI databases rather than on primary data (Zhang et al. 2015).

Most LCAs are focused on "cradle-to-gate" impacts of garments and do not account for the impacts of the use phase or at end-of-life (Chapman 2010; Zhang et al. 2015). For example, a cradle-to-gate LCA for a cotton garment would include the use of energy, water and materials and the production of emissions for cotton cultivation, cotton fibre production, textiles manufacturing (including spinning, knitting, dyeing) and garment assembly (cutting, sewing and packaging). The use phase would include data on the garment lifetime, use frequency, washing habits, and the energy, water and materials used in washing, drying and ironing. The end-of-life phase would include emissions from landfill or inputs and emissions from recycling.

An overview of a typical boundary for a "cradle-to-gate" LCA and a "cradle-to-grave" LCA for the textile and garment sector is given in figure 4.

▶ Figure 3. Typical boundaries for "cradle-to-gate" and "cradle-to-grave" LCAs for the textile and garment sector



Source: authors

2.2. Specific examples of LCA use in the sector

LCA has been used by researchers to understand the emissions in the sector at varying scales. For example, LCA has been used to show emissions in the life cycle of garment via a T-shirt in China (Zhang et al. 2015); to show the emissions in the production process in order to improve environmental performance through optimizing the assembly line (Zhang and Chen 2019); and to understand the potential of garment reuse and recycling through a clothing library in Sweden (Zamani, Sandin and Peters 2017).

LCA has also been used to look at the entire global apparel system, including fibre production, yarn preparation, fabric preparation, dyeing and finishing, assembly, distribution and end-of-life (Quantis 2018). A similar approach was used to evaluate the textile and garment sector in Sweden, but also included transport and laundry in the use phase (Sandin et al. 2019).

LCA has also been used by industry. For example, M&S commissioned a streamlined LCA (a simplified version) to determine the energy footprints for two M&S garments. This analysis was used to develop a software tool to allow the company to assess the life cycle energy consumption (Environmental Resources Management 2002).

2.2.1. LCA-based tools

The two most widely used tools that have been developed in order to simplify undertaking LCAs for the textile industry are the Higg Material Sustainability Index (Higg MSI) and the MADE-BY Fiber Benchmark (Laitala, Klepp and Henry 2018). Both of these tools focus on the sustainability of fibre types, focusing only on the materials but excluding the use phase.

The Higg MSI is a custom tool that is part of the Higg Index series of tools developed by the Sustainable Apparel Coalition (SAC), an alliance of more than 250 organizations, including brands, retailers, manufacturers and academics, governments and NGOs . The Higg MSI was developed for the textile industry to enable common methodology and procedures for LCA.

The MADE-BY Fiber Benchmark is a similar tool, but only includes raw materials before they are spun into yarn, excluding the phases of dyeing, knitting, weaving and finishing.

An analysis of these tools found that the type of fibre contributes to the environmental impacts of the use phase, as it impacts how long clothing lasts and how users take care of and use their clothing (Laitala, Klepp and Henry 2018). This review argues that LCA tools based only on material production impacts omit major environmental impacts in the use phase, such as GHG emissions from washing and the spread of microplastics from synthetic fibres.

The Higg MSI was used in the Pulse of the Fashion Industry report, and found that natural materials – particularly leather, silk and wool – had the highest emissions by kg of material (Global Fashion Agenda and Boston Consulting Group 2017). This report recommends preferencing plastic and man-made cellulosic fibres instead of natural materials. However, although natural materials have higher environmental impacts in the raw material production stage, this may not be the case once the lifespan and use of the garments is taken into consideration (Laitala, Klepp and Henry 2018).

A review of the Higg MSI against international LCA standards and guidelines found that there are a number of inconsistencies and improvements that could be implemented to ensure it provides robust, accurate and trustworthy results. This review concluded that in its current form the Higg MSI had limited capability to help stakeholders compare fabric types in order to select those with lower environmental impacts (Watson and Wiedemann 2019).

2.2.2. LCI databases

There are several databases that have been developed specifically for the textile and garment sector. These include:

- The World Apparel and Footwear Life Cycle Assessment Database (WALDB) founded by Quantis with a group of industry partners. The project is planning to develop more than 300 regionally-specific datasets for wool, cotton, leather, silk and man-made fibre supply chains for shirts, pullovers, trousers and shoes. The Sustainable Apparel Coalition (SAC) is a partner of the WALDB, and datasets from the WALDB are used in the SAC's Higg MSI.
- Cotton Incorporated, an association for American cotton producers and importers, commissioned the development of global LCIs for cotton fibre production and textile processing.

2.2.3. Limitations

LCA studies are designed to be very accurate, and are therefore complex and very resource-intensive, requiring a substantive investment of time and money for the company. They usually cannot be done in-house by fashion companies, which has limited the uptake of LCAs in the industry (FashionUnited 2017). As discussed above, a number of simplified tools have been developed to address this limitation, but these tools are still in development and have been criticized for not providing reliable data to the standard required for LCA.

2.3. Greenhouse Gas (GHG) Protocol

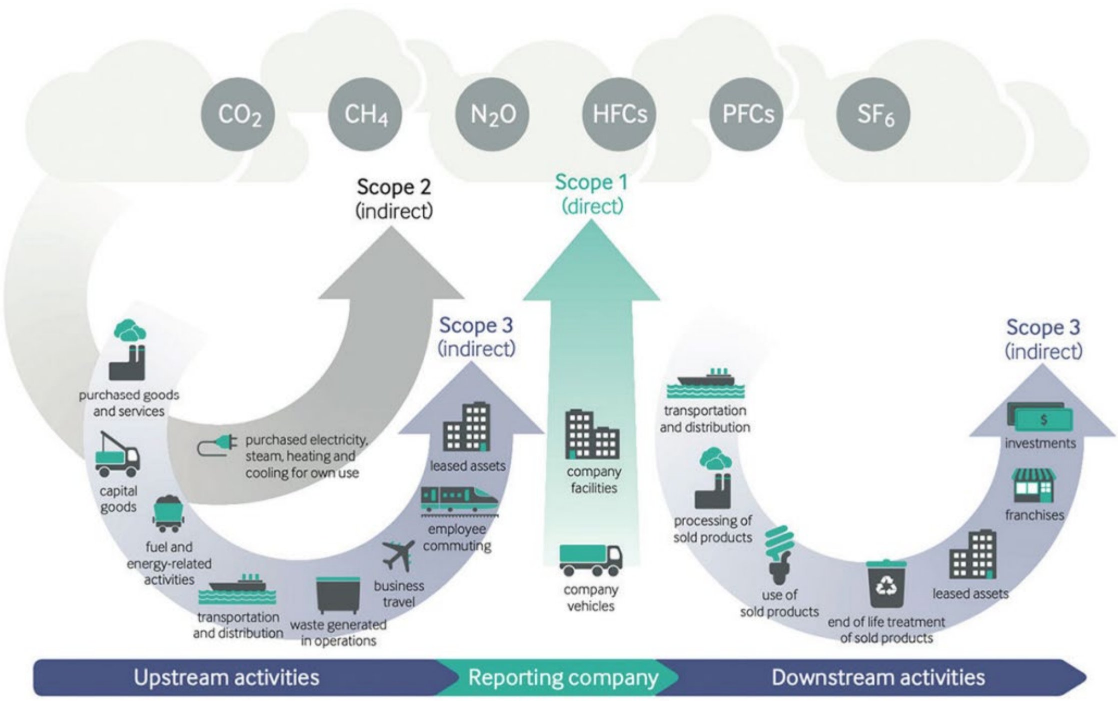
The GHG Protocol is a partnership of organizations that aims to develop internationally accepted standards, tools and guidance for GHG accounting. The GHG Protocol was established in the late 1990s by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), together with large corporate partners.

The Corporate Accounting and Reporting Standard (also referred to as the "Corporate Standard") is a standardized global framework for measuring GHG emissions. The Corporate Standard was released in 2001, and provides requirements and guidance for companies and organizations to prepare a corporate-level GHG emissions inventory. It is widely used as the basis for organizations to report emissions to voluntary GHG programmes, such as the CDP (formerly the Carbon Disclosure Project) and the Global Reporting Initiative, as well as national and regional industry initiatives (WBCSD and WRI 2004).

The standard defines emissions under three "scopes" for accounting and reporting (figure 5):

- Scope 1 – Direct GHG emissions: Direct emissions from sources that are owned or controlled by a company, including the burning of fuels for electricity, heat, steam or transport, or emissions from physical or chemical processes.
- Scope 2 – Electricity indirect GHG emissions: Indirect emissions from the generation of purchased electricity, steam, heating or cooling that are consumed by the company.
- Scope 3 – Other indirect GHG emissions: Indirect emissions that occur in the value chain of the company (upstream and downstream) as a consequence of the activities of the company (such as, purchased materials, goods and services).

▶ **Figure 4. Overview of GHG Protocol scopes and emissions across the value chain**



Source: Reproduced from WBSCD and WRI 2011a, figure 1.1.

The process for undertaking a GHG inventory using the GHG Protocol begins with setting an organizational boundary. In many cases this is simple, but if a company is a parent company for various operations, it needs to decide whether emissions are calculated based on equity in an operation, or on whether the parent company has financial and/or operational control.

The operational boundary then needs to be defined. All companies are required to account for Scope 1 and 2 emissions at a minimum, and need to determine whether to include Scope 3 emissions.

The GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (also referred to as the "Scope 3 Standard") provides further guidance on accounting for Scope 3 emissions (WBCSD and WRI 2011a). The criteria for which Scope 3 emissions should be included are outlined in table 2 below.

▶ **Table 2. Criteria for inclusion of Scope 3 emissions**

Criteria	Description
Size	They contribute significantly to the company's total anticipated Scope 3 emissions.
Influence	There are potential emissions reductions that could be undertaken or influenced by the company.
Risk	They contribute to the company's risk exposure (for example, climate change-related risks such as financial, regulatory, supply chain, product and customer, litigation, and reputational risks).
Stakeholders	They are deemed critical by key stakeholders (such as, customers, suppliers, investors, or civil society).
Outsourcing	They are outsourced activities previously performed in-house or activities outsourced by the reporting company that are typically performed in-house by other companies in the reporting company's sector.

Criteria	Description
Sector guidance	They have been identified as significant by sector-specific guidance.
Other	They meet any additional criteria for determining relevance developed by the company or industry sector.

Source: WBSCD and WRI 2011a, table 6.1.

The GHG Protocol has also developed the Product Life Cycle Accounting and Reporting Standard (referred to as the "Product Standard") which builds on the ISO LCA standards to provide requirements and guidance for consistently measuring and reporting GHG emissions associated with a product (WBCSD and WRI 2011b).

2.4. Greenhouse gas assessments in the textile and garment sector

The emissions by scope for upstream suppliers, including textile and garment manufacturers, is highly variable dependent on the type of company. For these upstream suppliers, Scope 1 and 2 emissions may be significant, and are generally a higher portion of total emissions than they are for brands and retailers.

For consumer-facing brands and retailers, Scope 3 emissions are typically the majority of total emissions. For example, C&A Corporation found that 96 per cent of emissions are Scope 3, including nearly 76 per cent of total emissions from purchased goods and services (C&A 2019). Data from H&M Group's 2019 sustainability report shows that Scope 3 emissions account for 99.6 per cent of total emissions, almost half of these from fabric production. Scope 3 emissions are more challenging to measure and manage, as brands or retailers may not have detailed data on emissions related to their upstream suppliers and therefore have limited influence over emissions reduction activities of these suppliers (WRI 2019).

Given the criteria in table 2, most brands and retailers are likely to include Scope 3 emissions from their upstream suppliers when undertaking a GHG inventory of their brand. This is because these emissions are a significant in terms of the company's emissions.

2.4.1. Science-based targets

The Science Based Targets initiative (SBTi) is a collaboration between the CDP, the United Nations Global Compact, WRI, and the World Wide Fund for Nature (WWF). The aim of the initiative is to encourage companies to set ambitious science-based targets (SBTs) for GHG emissions reduction, in line with the aims of the Paris Agreement to limit warming to a within 1.5°C or well-below 2°C pathway (Science Based Targets, n.d.-a).

SBTs are encouraged for signatories of the UN Fashion Industry Charter for Climate Action. The Charter, which has been signed by a large number of companies and supporting organizations, includes a commitment to reduce industry emissions by 30 per cent by 2030, from a baseline of no earlier than 2015. This commitment is based on reductions in Scope 1, 2 and 3 GHG emissions in line with the Greenhouse Gas Protocol Corporate Standard. The Charter sets a commitment to setting a decarbonization pathway for the industry based on the SBTi. As of May 2020, there are 14 textile and apparel companies that have approved SBTs, and a further 34 that have committed to setting targets (Science Based Targets, n.d.-b).

The SBTi has developed guidance for the apparel and footwear sector on appropriate target-setting methods and on best practices in target setting and emissions reduction. Given the significance of Scope 3 emissions and the barriers to addressing them, the SBTi provides specific guidance on measuring and reducing Scope 3 emissions (WRI 2019). This guidance includes the following criteria and recommendations:

- If a company's Scope 3 emissions are more than 40 per cent of total emissions, a target is required for Scope 3 emissions. Most brands and retailers will exceed this threshold and be required to set a Scope 3 target.
- If a Scope 3 target is required, companies must set one or more emission reduction targets and/or supplier or customer engagement targets that cover at least two-thirds of their Scope 3 emissions in line with the Scope 3 Standard.
- Targets must cover a minimum of five years and a maximum of 15 years from the date the target is submitted to the SBTi.
- Companies should engage their suppliers and recommend they use the SBTi guidance to set targets.
- Companies are encouraged to set targets for indirect emissions in the use phase (emissions generated by customers or end-users) if these are significant; however, these targets need to go beyond the target that covers two-thirds of Scope 3 emissions.

Company Scope 1, 2 and 3 targets need to meet a certain "level of ambition" through one of several methods, outlined in table 3 below. These methods differ as to whether targets are set as a percentage reduction in absolute emissions (the "absolute contraction" approach) or a reduction in emissions intensity based on physical or economic indicators (the "physical intensity" or "economic intensity" approaches). The SBTi guidance encourages the apparel sector to use the absolute contraction approach for Scope 1 and 2 emissions. The physical or economic intensity approaches can also be used, but the targets must not result in absolute emissions growth and must lead to linear annual intensity improvements equivalent to the absolute contraction targets.

Table 3. Target setting methods for reducing Scope 1,2 and 3 emissions

Method	Description	Examples of approved targets
Absolute contraction	Reduce absolute emissions consistent with level of decarbonization required to keep global warming at: • **2°C:** minimum 1.23% annual linear reduction (Scope 3 emissions only); • **Well below 2°C:** min. 2.5% annual linear reduction; • **1.5°C:** min. 4.2% annual linear reduction.	Levi Strauss & Co commits to reduce absolute Scope 1 and Scope 2 GHG emissions by 90% by 2025 (from a 2016 base year). Levi Strauss & Co. commits to reduce absolute Scope 3 emissions from purchased goods and services by 40% by 2025 (from a 2016 base year).
Physical intensity	Reduce emissions intensity per unit of physical production.	H&M Group commits to reduce Scope 3 GHG emissions from purchased raw materials, fabric, and garments by 59% per piece by 2030 (from a 2017 base year).
Physical intensity (Scope 3 emissions only)	Set targets that maintain Scope 3 emissions at base year level over the target period.	ASICS commits to reduce Scope 3 GHG emissions from purchased goods and services and end-of-life treatment of sold products by 55% per product manufactured by 2030 (from a 2015 base year).
Economic intensity	Reduce GHG emissions per unit of value added by at least 7% year-on-year.	Kering commits to reduce Scope 1, Scope 2 and Scope 3 emissions from upstream transportation and distribution, business air travel, and fuel- and energy-related emissions by 50% per unit of value added by 2025 (from a 2015 base year). Kering commits to reduce Scope 3 emissions from purchased goods and services by 40% per unit of value added by 2025 (from a 2015 base year).

Source: Adapted from WRI 2019.

Conclusion

This paper examined how and where carbon emissions accrue across the supply chain. The findings highlight that emissions occur all along the chain, but are most significant in the yarn and fabric production phase, which is consistent with other environmental impacts, such as water consumption and chemicals use. Although there are few studies that look at the use phase of garments (because of the challenges in calculating emissions based on behaviours such as washing, transport and use), the evidence that is available suggests that the consumer use phase contributes significantly to emissions in the value chain.

The implications for achieving carbon neutrality indicate energy use is the major contributor to GHG emissions in the textile and garment sector, although emissions also occur from non-energy sources such as land clearing for agriculture, chemical production and the raising of livestock for leather. High energy demand comes from the wet processing stages (dyeing and finishing), where energy is used to create steam to heat water and also for drying fabrics. The carbon intensity of the energy sources used in production centres (coal or natural gas) translates to high emissions intensity for textile production. Energy can also account for a significant portion of costs within energy-intensive parts of the value chain, such as textile mills and garment factories; so there is an economic and as well an environmental driver to reduce emissions in the sector.

The paper examines the two methodologies for calculating emissions across the sector, and provides insight into where and why the carbon intensity of textiles and garments varies across the supply chain and across production centres. It is challenging to quantify the distribution of carbon emissions across the value chain, as it is dependent on the specific product and materials, as well as the emissions intensity of the country of production (WRI 2019).

The two standardized approaches to measuring GHG emissions are through life cycle assessment (LCA) and carbon accounting in line with the Greenhouse Gas Protocol (GHG Protocol). LCA is particularly useful for measuring emissions from a particular product or process, then identifying opportunities for eco-efficiency in production processes and supply chains, and for making material selection and procurement decisions. However, LCAs are resource intensive and require specific technical skills to undertake, factors that have limited their uptake by the industry. Several tools have been developed in order to provide a simplified option, such as the Higg MSI, which measures fabric sustainability by fibre type, but these have been criticized for not providing reliable enough data to be used to make material selections. The Higg MSI, for example, does not account for the impact the fibre type has on emissions during the use phase.

The GHG Protocol is a standardized method for organizations to measure their emissions. The challenge for the textile and garment sector in measuring emissions with this approach is that for consumer-facing brands and retailers most emissions are indirect emissions, such as from purchased goods and services from upstream suppliers. These emissions are challenging to measure and manage, as brands or retailers may not have detailed data on emissions and limited influence over emissions reductions activities. The Science Based Targets initiative (SBTi) has developed specific guidance to help the sector in measuring and setting targets for these emissions in line with the GHG Protocol. However, so far there are only 14 companies with approved targets and 34 others that have committed to set targets.

The implications for decarbonization in the sector, and the ambition and timeline for this decarbonization to contribute to the Paris Agreement and commitments in the UNFCCC Fashion Industry Charter on Climate Action are clear. What is less clear are the adjustments that need to be made to working processes by manufacturers in Asia and to their supply chain in order to reduce emissions. As the analysis presented in this paper shows, it is in the production and manufacturing of fibres, textiles and garments that most carbon emissions accrue, and therefore it will be these processes and activities that need to decarbonize. Decarbonization activities will focus on switching to cleaner, more efficient energy sources – including renewable energy – as well as reducing the energy intensity of production (for processes using heat and steam).

Momentum from other areas in the supply chain will also impact on carbon emissions in production, and design decisions concerning textile composition and the quality and longevity of a garment will have a significant impact on how each garment and its use contribute to carbon emissions over a garment's lifetime.

There are brands and manufacturers already working to reduce their emissions (Scopes 1,2 and 3), and how these companies are managing this process needs to be better understood, so as to be replicated and scaled. Key questions that need to considered include:

- How do consumer-facing brands work with their supply chains to reduce Scope 3 emissions?
- How do brands and manufacturers use LCA information in decision-making for production?
- Who are the key intermediaries and what are the key tools that are used in these change processes?

Small- and medium-sized enterprises are a significant cohort of firms in the textile and garment production centres across Asia. These firms subcontract and supply to major brands but often not as the first supplier, but rather as two to three subcontracts away from these brands and their efforts to reduce Scope 3 emissions. How will these firms be reached and supported to reduce their emissions? How do we incorporate supply chain activities within national emission reduction efforts through NDCs[1] and within evolving national energy policies in countries where production is concentrated across Asia?

The scale and pace of systemwide change in textile and garment manufacturing that is required to meet targets for climate action mean that there will also be significant impacts on the world of work in these components of the supply chain. These impacts will include changes in the technological intensity of the sector, and therefore increased demand for financial capital and demand for new skills and knowledge. This, in turn, may potentially lead to less overall demand for labour in the production process. The geographical composition of the supply chain means that there will be "hot spots of impact" across the sector and across the Asia region. Further work is needed to analyse the impacts of decarbonization in these areas of the supply chain, and to ascertain the need for just transition planning to manage these changes.

[1] NDCs, or nationally defined contributions, are the emission reduction plans that individual countries commit to as their contributions to achieving the Paris Agreement.

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Acknowledgements

This paper has been prepared for the ILO's Decent Work in Garment Supply Chains in Asia project with the financial support of the Swedish Development Agency (Sida).

We would like to acknowledge reviewers from the Textile and Garment Eco-Innovation Research Network (TERN); David Williams, Laurel Anderson Hoffner and other colleagues of the Decent Work in Garment Supply Chains in Asia project; Fredy Guayacan of the ILO; Eric Roeder of UN ESCAP; and the ILO's GREEN JOBS programme for their valuable contributions, as well as John Maloy for his editing services.

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ISBN 9789220353233

9 789220 353233