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EDITED BY
Rajeev Pratap Singh,
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REVIEWED BY
Fabrizio Passarini,
University of Bologna, Italy
Barkha Vaish,
Banaras Hindu University, India

*CORRESPONDENCE
Patsy Perry,
p.perry@mmu.ac.uk
Arminda Paço,
apaco@ubi.pt

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An overview of the contribution of the textiles sector to climate change

Walter Leal Filho[1], Patsy Perry[2]*, Hilde Heim[2], Maria Alzira Pimenta Dinis[3], Haruna Moda[4], Eromose Ebhuoma[5] and Arminda Paço[6]*

[1]School of Science and the Environment, Manchester Metropolitan University, Hamburg University of Applied Sciences, Research and Transfer Centre "Sustainable Development and Climate Change Management", Hamburg, Germany, [2]Manchester Fashion Institute, Manchester Metropolitan University, Manchester, United Kingdom, [3]UFP Energy, Environment and Health Research Unit (FP-ENAS), University Fernando Pessoa (UFP), Porto, Portugal, [4]Department of Health Professions, Manchester Metropolitan University, Manchester, United Kingdom, [5]Department of Environmental Sciences, College of Agriculture and Environmental Sciences (CAES), University of South Africa (UNISA), Johannesburg, South Africa, [6]NECE-UBI (Research Centre for Business Sciences), Universidade da Beira Interior, Covilhã, Portugal

The textile industry is responsible for a significant amount of global CO2 emissions, exceeding those from several other sectors such as international aviation and shipping. This article outlines the reasons for the textile industry's contribution to climate change along with an overview of current trends. Finally, it outlines several measures to reduce its carbon footprint.

KEYWORDS

textiles, fashion, clothing industry, textiles and clothing, climate change, environmental impact, CO2 emissions

The ecological footprint of the textile sector

One of the most polluting industries is textiles and clothing; its detrimental ecological footprint is caused by high energy, water and chemical use, the generation of textile waste and microfibre shedding into the environment during laundering (Niinimäki et al., 2020). Due to lengthy supply chains and energy-intensive production methods, apparel and footwear industries generate 8–10% of global carbon emissions, superseding emissions from the aviation and shipping industries combined (European Parliament, 2021). Furthermore, it has been estimated that up to 20% of industrial wastewater pollution is caused by textile dyeing and finishing (Morlet et al., 2017).

Textile production occurs through geographically long and complex supply chains that include growers and processors of raw fibres, yarns and textiles, weavers, knitters, dyers and finishers, product manufacturers and distributors. While textiles have various end uses, from interiors and automotive fit-outs to geo-textiles, agri-textiles and hygienic textiles, the sector is essentially fashion driven, as most global fibre production (60%) is destined for clothing (Niinimäki et al., 2020). The production and manufacturing of natural and synthetic textiles continue to be the most ecologically damaging aspects of the

TABLE 1 Top 10 textile exporting countries 2020.

Country	Export value (US$ billion) in 2020	% Of global textile exports in 2020
China	276.0	35.6
Vietnam	38.9	5.03
Bangladesh	37.3	4.82
India	29.7	3.84
Turkey	28.5	3.69
Pakistan	14.9	1.93
Cambodia	12.4	1.60
Indonesia	11.9	1.54
South Korea	10.8	1.40
Chinese Taipei	8.17	1.06

(Source: OEC).

industry. Major textile production countries such as China, India and Bangladesh (see Table 1) still rely on coal. Logistical requirements of transporting goods globally at the various stages of production and distribution contribute to textiles' carbon footprint, alongside energy deployed in garment care such as washing, drying, pressing and dry-cleaning. Finally, the deterioration of textile waste in landfill and/or incineration causes hazardous chemicals and greenhouse gases (GHG) to be released into the environment (Juanga-Labayen et al., 2022). Textiles' ecological footprint has been exacerbated by the growth of fast fashion - cheaply manufactured, low quality clothing designed to be trendy and purchased frequently - which results in a waste of resources and greater textile waste as the clothing is more quickly discarded. Clothing production has doubled since 2000 and shows no sign of abatement due to globalisation, urbanisation and population growth which fuel demand for more clothing (Berg et al., 2021). Table 1 shows the top textile exporting countries in 2020.

The textile industry and climate change

Climate change is the result of increased greenhouse gas emissions, subsequent global warming and the response of the climate system to this warming (Masson-Delmotte et al., 2021). Due to its complex supply chain vis-à-vis transportation of fabrics and garment from production points, usually in developing countries (Chen et al., 2021) and energy-intensive production, the textile industry generates roughly 1.2 billion tonnes of CO_2 equivalent, or nearly 10% of world GHG emissions (UNFCCC, 2018). Due to the growing demand for clothing exacerbated by the proliferation of the fast fashion business model, a consistent throughput of natural resources is needed. It is projected that the fashion industry will account for approximately 25% of the world's carbon budget by 2050 (Ellen Mac Arthur Foundation, 2017). Greater consumption of natural resources to cater for the growth of fast fashion will result in both increased ecological degradation and the occurrence of climate change (Berg et al., 2021). Global fibre production almost doubled between 2010–2020 (from 58 million to 109 million tonnes) (Textile Exchange, 2021). Figure 1 illustrates the textile industry's massive contribution to GHG emissions, compared to global energy production, a red alert for the need to reduce textile production's impact on climate change globally.

Most textile and clothing production takes place in Global South countries such as India, China, and Bangladesh that rely heavily on fossil fuels for electricity supply, thereby increasing the carbon footprint of each clothing item produced. According to Peters et al.'s (2011) multi-regional ecologically extended input-output model to study the climatic impact of fast fashion, clothing and footwear consumption, there has been a 23% rise in GHG from 2000 to 2015. Because garments are worn for a shorter amount of time before they end up in landfill or are incinerated, carbon emissions have increased from both manufacturing as well as the production of materials used by the fashion industry.

The use of synthetic fibres has grown exponentially, and polyester has now surpassed cotton as the most widely used fashion fabric (Niinimäki et al., 2020). However, carbon emissions from synthetics are much higher than cotton because they are made from fossil fuels such as unrefined petroleum products, thereby contributing to climate change through carbon emissions. It is estimated that 5.5 kg CO_2e is emitted to produce one polyester t-shirt, compared 2.1 kg CO_2e for a cotton t-shirt (Kirchain et al., 2015).

The drive to produce more fabrics to meet the rising manufacturing demand of the fashion industry also contributes to deforestation. Rayon (a semi-synthetic fibre made from purified cellulose) and similar fabrics such as viscose and modal, are manufactured from wood pulp. The rayon/viscose industry is projected to expand in response to increasing demand (Mordor Intelligence, 2021), which will likely amplify the threat to forests globally. An estimated 30% of rayon and viscose utilised by the fashion industry are harvested from ancient and endangered forests (McCullogh, 2014). Deforestation, the second largest driver of GHG emissions globally, has accelerated the severity of extreme heat in temperate regions of North America and Europe (Stoy, 2018). A similar outcome may be at play in the developing South, albeit its contribution to the severity of extreme weather is yet to be scientifically ascertained.

As a result of fast fashion and shortening product life cycles, post-consumer textile waste contributes significantly to the increase of landfills and incineration (causing significant

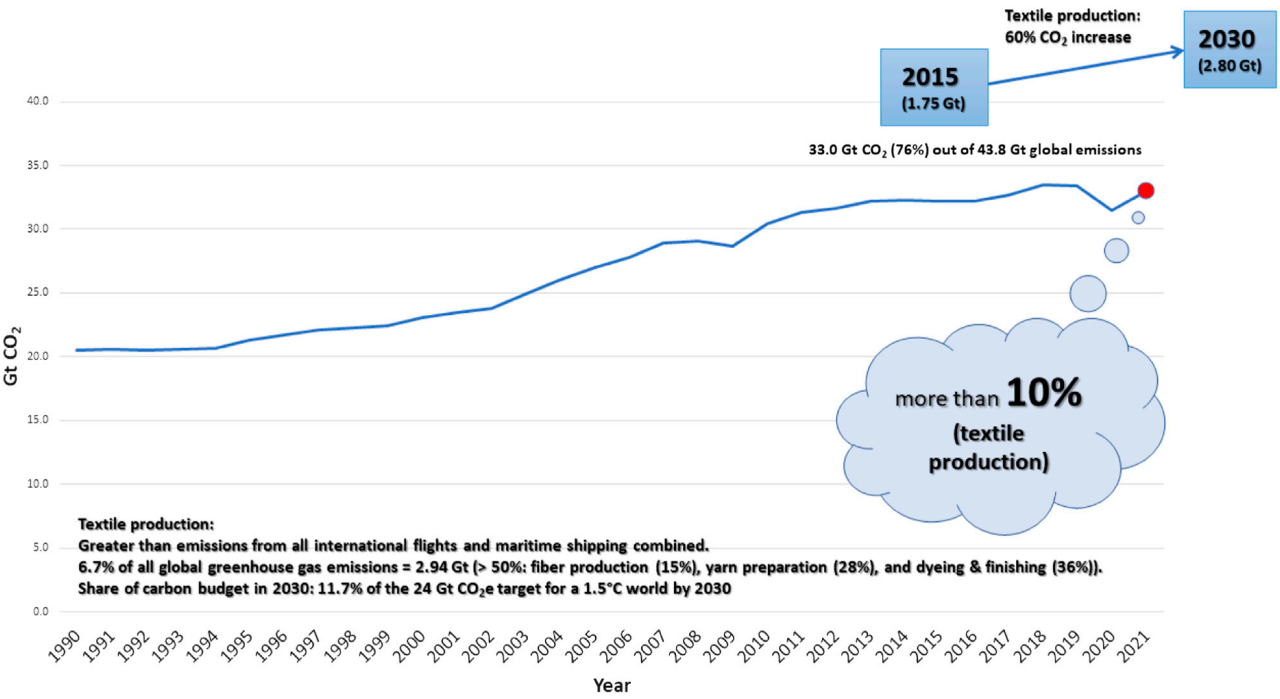

FIGURE 1
Textile contribution compared to global energy (coal, oil and gas = 76% of global emissions) related emissions (1990–2021). Authors' own figure based on data adapted from (Kerr and Landry, 2017; Quantis, 2018; C2ES, 2021; IEA, 2021; European Parliament, 2021).

TABLE 2 CO_2 emissions reduction targets of the top 10 textile and apparel exporting countries.

Country	Textile and apparel exports by value (US$ billions) in 2018	CO_2 emissions reduction targets	References
China	266.41	60–65% of 2005 level by 2030	Yang and Teng, (2018); Zhang et al., 2020
Germany	38.99	At least 65% by 2030 compared to 1990 emission levels	Black et al., 2021
Bangladesh	38.73	Unconditional 5% reduction in emissions below BAU by 2030	Boyd et al., 2015
Vietnam	37.93	Reduce carbon intensity by 15% by 2030 relative to 2014	Do and Burke, 2021
India	37.11	33–35% reduction in carbon intensity by 2030 compared to 2005	Mittal et al., 2018
Italy	36.57	Reduction of 33% by 2030	European-Parliament, 2021a
Turkey	27.56	21% reductions in emissions below BAU by 2030	Boyd et al., 2015
United States	27.14	2025 target of 26–28% reduction on 2005 baseline emissions	Boyd et al., 2015
Hong Kong	20.43	65–70% reduction by 2030	Kwok et al., 2020
Spain	20.20	Reducing non-ETS emissions by 26% by 2030 (compared with 2005)	European-Parliament, 2021b

(Source for Columns 1 and 2: Fibre2 Fashion, 2019).

emissions of toxic gases). Without a strategy of recovery and recycling, the consequences for the environment will worsen, bearing in mind the quantity of resources, water and energy that goes into the production of new textile products, that mainly become textile waste once disposed of by the consumer (McFall-Johnsen, 2020).

Future trends

To mitigate its contribution to GHG emissions and ultimately climate change, the fashion industry needs to move from a moderate decarbonisation trajectory to a more significantly aggressive one (Berg et al., 2021). Table 2 below shows the world's key textile and apparel exporting countries' targets for mitigating carbon emissions.

Large-scale systemic change is needed for the industry to align with the Paris Climate Change Agreement's goals to limit global warming to 1.5 °C above pre-Industrial Revolution levels (UNFCCC, 2018), but globalisation, the desire for economic growth and a lack of effective global policy hinder the development of a sustainable fashion system. Systemic change requires stakeholder collaboration, technology innovation, government policy and infrastructure support. Solutions range from technical advancements to regenerative models for farming to recycling innovations and biomaterials, as well as reuse and resale initiatives to support a circular economy. Sustainable solutions to recover, reuse and recycle used textiles are needed for transition from the current linear business model to a circular (closed loop) model to diminish the industry's ecological footprint (Jia et al., 2020; Berg et al., 2021). Decarbonisation could be achieved through phasing out coal and introducing renewable energy sources (Chen et al., 2021), using bio-based feedstocks, low-emission heat sources, sustainable production and transportation processes and an increase in the rate of recycling materials (Berg et al., 2021) and regeneration of natural systems (Jia et al., 2020).

Nearshoring and/or reshoring manufacture would shorten global supply chains and reduce emissions associated with logistics. Regenerative agriculture would support soil health and maintain balanced weather patterns. Digital product development systems featuring advanced 3D design and visualisation technologies would reduce transport costs and the need for physical production altogether in certain cases, such as garment sampling. Innovations in recycling and end of life processes include automation of sorting, safe chemical fibre separation and novel end uses for textile waste. Effort should also be placed around waste minimisation and investment assigned to pollution prevention technology, carbon footprint measurement and mitigation (Peters et al., 2015).

Government policies for manufacturing hubs will be critical in removing impediments to decarbonisation. Financial support through subsidies, incentives and lower loan rates, as well as infrastructure for renewable energy sources are required. New transformative policies and regulations include tighter supply chain obligations and incentives to support better business models (Villena & Gioia, 2020), as well as extended producer responsibility (EPR) legislation to fund the collection, sorting, and recycling of clothing at end of life (Bukhari et al., 2018). Stable retailer-supplier partnerships are needed to enable long-term investments and sharing the costs of investment into cleaner and greener production.

In respect of the evolution of aesthetic requirements, which is one of the engines of the fashion industry, it should be noted that consumers have began to demand products that are both functional and attractive. They are also paying increased attention to the environmental footprint of textiles. In this context, it is expected that textiles which are known to be—or are marketed as—environmentally friendly, may play a more prominent role in consumer choice.

Overall, the sector needs to shift away from its current focus on low costs, high volumes, and constant novelty to drive growth. The growth paradigm must be addressed and replaced with a degrowth, sufficiency or equilibrium models. Marketing messages which encourage consumption also need to change. Sustainable consumer behaviours could be supported through promoting a preference for sustainable materials, environmentally friendly garment washing and drying methods, garment recycling, rental and repair practices, reuse and sharing options (Niinimäki et al., 2020; Berg et al., 2021).

Author contributions

WLF conceived the paper and designed the approach used. All authors contributed to the manuscript, read, and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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