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A systematic review of sustainability, innovation, and climate resilience in the global textile industry (2020–2025)

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ABSTRACT

The textile and apparel industry are a critical driver of global economic development, yet it remains one of the most environmentally intensive sectors. This study conducts a systematic literature review of 38 peer-reviewed publications from 2020 to 2025 to examine the intersection of environmental pollution, sustainability practices, and climate resilience within the textile value chain. Utilizing the PRISMA 2020 framework, the review synthesizes evidence across multiple domains, including industrial ecology, circular economy, digital innovation, and policy integration. Key findings highlight persistent challenges such as high water and energy consumption, hazardous chemical discharge, and limited material circularity, particularly in low- and middle-income countries. Concurrently, the analysis identifies emerging solutions involving bio-based materials, closed-loop production systems, and the deployment of Industry 4.0 technologies such as blockchain, artificial intelligence, and digital twins to enhance traceability and operational efficiency. The study also introduces climate resilience as a critical yet underrepresented dimension in textile sustainability discourse, emphasizing the need for adaptive capacity, stakeholder collaboration, and regulatory coherence. By integrating environmental, economic, and technological perspectives, this review contributes a comprehensive framework for guiding the textile sector's transition toward sustainability and resilience in alignment with global climate and development goals.

1. Introduction

The textile industry is among the world's most prominent economic sectors, deeply interwoven with the fabric of global commerce and cultural identity. Historically rooted and continuously evolving, it spans a diverse range of products from apparel and home furnishings to technical textiles, produced using both natural fibers such as cotton, wool, and silk and synthetic variants like polyester and nylon (Raihan, 2023; Sarwar & Khan, 2022). The sector has grown exponentially over the past few decades, driven by rising global incomes, population growth, and shifting consumer preferences toward fast fashion and seasonal trends. This expansion has led to a complex and globalized supply chain that supports millions of livelihoods and contributes significantly to the gross domestic product of many nations, particularly in developing economies such as Bangladesh, India, and Vietnam.

However, this economic dynamism is accompanied by profound environmental and social costs. The textile industry is responsible for substantial water and air pollution, soil degradation, and greenhouse gas emissions, making it one of the most polluting industrial sectors globally (Leal Filho et al., 2024; Grazzini et al., 2021). Less than one percent of all textiles is recycled back into clothing, with the majority ending up in landfills or incinerators, further exacerbating ecological degradation (Ellen MacArthur Foundation, 2017). Moreover, the sector often relies on cheap labor and resource-intensive production methods, raising concerns about human rights and ethical sourcing (Abbate et al., 2024). These challenges underscore the urgent need for sustainable transformation across the textile value chain, integrating environmental stewardship with economic viability and social equity.

While the literature has extensively documented the environmental and economic dimensions of the textile industry, there remains a critical research gap in synthesizing these aspects through an integrated lens that also includes climate resilience, digital transformation, and circular economy transitions. Much of the existing research tends to focus on isolated interventions such as cleaner production technologies, policy reforms, or material innovations without adequately addressing how these elements interact across the textile value chain. Furthermore, the role of emerging technologies such as artificial intelligence, blockchain, and digital twins in enabling circular economy models remains underexplored, particularly in the context of

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developing economies (Orisadare et al., 2025; Setyadi et al., 2025).

This review aims to deconstruct the dual nature of the textile industry by bringing together diverse strands of literature ranging from economic analyses (Raihan, 2023; Raian et al., 2022) and environmental studies (Sarwar & Khan, 2022; Leal Filho et al., 2024) to technological innovations (Tseng et al., 2022) and policy frameworks (Abbass et al., 2022).

The contribution of this review lies in its interdisciplinary synthesis of economic, environmental, and technological perspectives, offering a comprehensive understanding of the textile sector's sustainability challenges and opportunities. It introduces climate resilience as a critical yet underrepresented dimension in textile sustainability discourse, emphasizing the need for adaptive capacity, stakeholder collaboration, and systemic innovation. By contextualizing the industry's transformation within the broader framework of global sustainability goals and post-pandemic recovery, the study provides novel insights into how the textile sector can evolve toward a more resilient and environmentally responsible future. In doing so, it not only contributes to academic discourse but also offers actionable knowledge for policymakers, industry leaders, and researchers committed to sustainable development.

2. Methodology

This study adopts a systematic literature review (SLR) approach to explore the environmental, economic, and technological dimensions of sustainability and climate resilience in the global textile industry. The review is structured around the PRISMA 2020 framework, ensuring transparency and replicability in the identification, screening, and inclusion of relevant literature. The review process was designed to capture interdisciplinary perspectives, including environmental science, industrial ecology, innovation studies, and policy analysis. The search was conducted across five major academic databases Scopus, ScienceDirect, SpringerLink, Taylor & Francis, and Google Scholar—using a combination of thematic keywords such as "textile industry," "pollution," "sustainable textiles," "circular economy," "climate resilience," and "digital transformation." The search was limited to peer-reviewed English-language publications from 2020 to 2025.

The initial search yielded 132 records. After removing 24 duplicates, 108 unique articles were screened based on titles and abstracts, resulting in the exclusion of 35 articles that did not meet the thematic or methodological criteria. The remaining 47 articles underwent full-text review, during which 9 were excluded for lacking relevance to the core themes of sustainability, pollution, or climate adaptation. Ultimately, 38 articles were selected for inclusion in the final synthesis. These studies span a range of geographies and methodological approaches, including empirical case studies, policy analyses, and technological assessments. The final selection reflects a balanced representation of foundational and emerging research, offering a comprehensive view of the textile sector's transition toward sustainability.

The year-by-year breakdown of article identification and inclusion is presented in figure 2. This distribution highlights the growing scholarly interest in sustainable textiles, particularly in the post-pandemic period. The selected studies were analyzed using a narrative synthesis approach, allowing for the integration of diverse findings across economic, environmental, and technological domains. This methodology supports a holistic understanding of the textile industry's sustainability challenges and opportunities, while also identifying gaps for future research and policy development.

3. Results and Discussion

3.1. Economic significance of the textile industry

The global textile industry continues to be a vital pillar of the world economy, with an estimated market value of $1.5 trillion in 2023, reflecting its expansive role in trade, innovation, and consumer demand (Raihan, 2023). This valuation underscores the industry's integration into diverse value chains, including agriculture (e.g., cotton), petrochemicals (e.g., polyester), and advanced manufacturing. In countries like Bangladesh, Vietnam, and Pakistan, textiles account for over 10% of GDP and more than 80% of total exports, making the sector indispensable to national economic strategies (Orisadare et al., 2025).

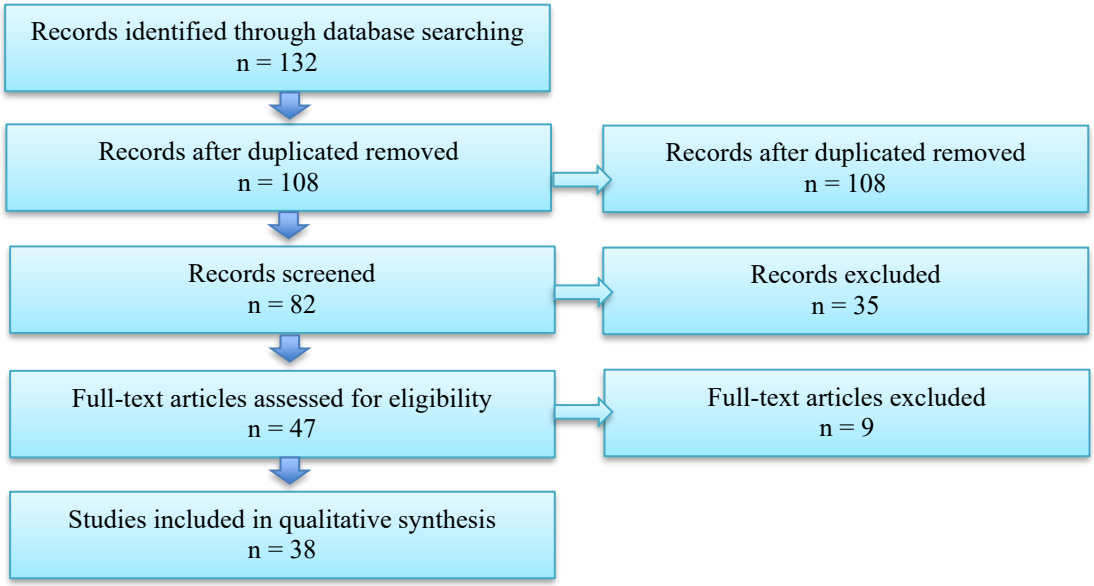
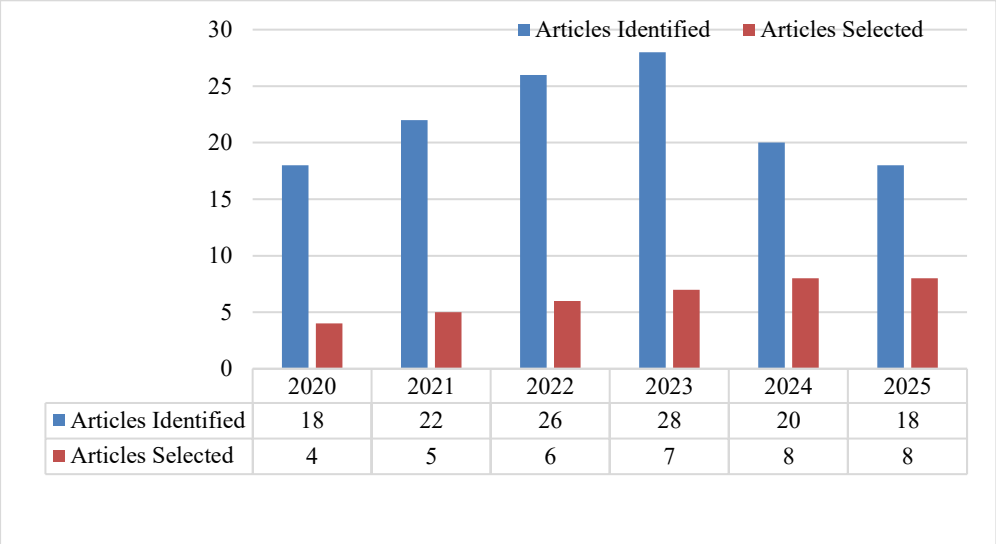


Figure 1: A flow diagram showing articles identified, selected and excluded, sources: author's compilation



	2020	2021	2022	2023	2024	2025
Articles Identified	18	22	26	28	20	18
Articles Selected	4	5	6	7	8	8

Figure 2: Articles identified and selected in each year, sources: author's compilation

Recent trends show a growing emphasis on technological innovation, particularly through the adoption of Industry 4.0 and 5.0 technologies such as AI, IoT, and robotics. These tools are enhancing productivity, reducing waste, and enabling the transition to circular economy models a shift that is increasingly demanded by both consumers and regulators (Orisadare et al., 2025). Despite global economic fluctuations, the International Textile Manufacturers Federation (ITMF) reported cautious optimism for the sector's recovery in 2025, especially in Africa and the Americas, where investment in sustainable practices is gaining momentum (Global Textile Times, 2025).

3.2. Employment and social impact

The textile and apparel industry are one of the largest global employers, providing direct and indirect employment to approximately 300 million people worldwide (ILO, 2025). In South Asian economies like Bangladesh, the sector employs over 4 million workers, with women comprising nearly 80% of the garment workforce (Raihan, 2023). This gendered employment structure has significant implications for women's

empowerment, offering financial independence, enhanced social status, and increased participation in household decision-making (Orisadare et al., 2025).

Beyond gender equity, the industry plays a critical role in poverty alleviation and rural development, particularly by offering low-skilled workers a pathway into the formal economy. However, the sector also faces persistent challenges, including low wages, occupational hazards, and limited access to social protection. The ILO emphasizes the need for stronger labor governance and sustainable supply chain practices to ensure that economic gains do not come at the expense of workers' rights and well-being (ILO, 2025).

3.3. Economic multiplier effects

The textile industry's economic influence extends well beyond its immediate production activities, creating a ripple effect across multiple sectors. This multiplier effect is particularly evident in the way textile manufacturing stimulates demand in agriculture (e.g., cotton farming), chemical industries (e.g., dyes and synthetic fibers), logistics, packaging, retail, and financial services. These interdependencies form a complex value chain that supports regional development and industrial diversification (Chen et al., 2021).

In developing economies, the textile sector often acts as a catalyst for industrialization, encouraging infrastructure development, investment in transportation networks, and the growth of small and medium-sized enterprises (SMEs) that provide auxiliary services such as embroidery, printing, and tailoring (Coscieme et al., 2022). For example, in Bangladesh, the rise of garment exports has led to the expansion of port facilities, banking services, and urban housing markets, demonstrating the sector's broader economic reach (Raihan, 2023).

Moreover, the shift toward circular business models such as textile recycling, resale platforms, and rental services is creating new economic opportunities and job categories, particularly in urban centers (Coscieme et al., 2022). These models not only reduce environmental impact but also diversify income streams and foster innovation in product design, logistics, and customer engagement. Table 1 summarizes the multifaceted contributions of the textile industry, encompassing its global market value, employment dynamics, technological innovations, and sustainability challenges.

Table 1: Economic, social, and environmental contributions of the textile industry

Dimension	Key Insights	Sources
Global Market Value	$1.5 trillion in 2023; major contributor to GDP and exports in developing nations	Raihan (2023); Orisadare et al. (2025)
Technological Innovation	Adoption of Industry 4.0/5.0, circular economy models, automation	Orisadare et al. (2025)
Employment	300 million globally; 80% of garment workers are women	ILO (2025); Raihan (2023)
Social Impact	Gender empowerment, poverty reduction, rural development	Orisadare et al. (2025); ILO (2025)
Environmental Impact	10% of global emissions; water pollution; low recycling rates	Haider Naqvi et al. (2024); Abbate et al. (2023)
Sustainability Challenges	High resource use; limited circularity; need for policy and innovation	Haider Naqvi et al. (2024)
Economic Multiplier Effects	Stimulates agriculture, logistics, retail, and financial services; supports SMEs	Chen et al. (2021); Coscieme et al. (2022); Raihan (2023)

Source: authors compilation from reviewed articles

3.4. Environmental impacts: pollution and emissions

3.4.1. Industrial pollution: water, air, and soil

Despite its economic significance, the textile industry is widely recognized as one of the most environmentally damaging sectors. The production processes particularly dyeing, finishing, and synthetic fiber manufacturing are major contributors to industrial pollution. According to Sarwar and Khan (2022), the textile sector is responsible for approximately 20% of global industrial water pollution, largely due to the discharge of untreated wastewater containing toxic dyes, heavy metals, and volatile organic compounds (VOCs) into rivers and lakes. These

pollutants severely degrade aquatic ecosystems and pose long-term health risks to communities relying on these water sources.

Air pollution is another critical concern. The combustion of fossil fuels in textile mills and the release of VOCs during processing contribute to respiratory and cardiovascular illnesses among workers and nearby populations (Leal Filho et al., 2024). Additionally, the sector emits significant quantities of greenhouse gases (GHGs), further exacerbating global climate change. The European Environment Agency has identified textile consumption as one of the top five contributors to GHG emissions from a lifecycle perspective

Soil degradation is also linked to the industry, particularly through cotton cultivation, which relies heavily on pesticides and fertilizers. These chemicals not only reduce soil fertility but also contaminate groundwater and harm biodiversity (Haider Naqvi et al., 2024). Moreover, the accumulation of synthetic textile waste in landfills contributes to long-term soil contamination due to the slow degradation of plastic-based fibers.

3.4. Carbon footprint and lifecycle emissions

As illustrated in Table 2, the textile sector exerts significant environmental pressure through water and air pollution, greenhouse gas emissions, and limited circularity in material use.
The carbon footprint of the textile industry is substantial, accounting for approximately 10% of global carbon emissions, making it the second-largest industrial polluter after oil and gas (Mayer & Birkocak, 2024). Emissions are generated throughout the value chain from fiber production and fabric processing to transportation, retail, and consumer use. For example, polyester production is highly energy-intensive, while cotton farming consumes vast amounts of water and emits nitrous oxide, a potent greenhouse gas.

Lifecycle assessments (LCAs) reveal that the environmental burden of textiles spans the entire product lifecycle, including washing, drying, and disposal. These stages contribute significantly to microplastic pollution, especially from synthetic fibers like polyester and nylon, which shed particles during laundering (Abbate et al., 2023). The reuse, recycling, and resale of garments key components of circular economy models remain underutilized, with less than 1% of textiles recycled into new clothing

To address these challenges, researchers and policymakers advocate for integrated sustainability strategies, including eco-design, renewable energy adoption, closed-loop recycling systems, and regulatory frameworks that enforce environmental compliance across the supply chain (Coscieme et al., 20220)

Table 2: Environmental Impacts of the Textile Industry

Impact Area	Key Issues	Sources
Water Pollution	Textile dyeing and finishing contribute to ~20% of global industrial water pollution. Discharge of toxic dyes, heavy metals, and VOCs harms aquatic ecosystems and human health.	Sarwar & Khan (2022)
Air Pollution	Fossil fuel combustion and VOC emissions from processing are linked to respiratory and cardiovascular diseases. Significant GHG emissions contribute to climate change.	Leal Filho et al. (2024)
GHG Emissions	Textile consumption is among the top five contributors to lifecycle GHG emissions in Europe.	European Environment Agency (2023)
Soil Degradation	Pesticide and fertilizer use in cotton farming degrades soil quality and biodiversity. Synthetic textile waste contributes to long-term soil contamination.	Haider Naqvi et al. (2024)
Carbon Footprint	Textile industry accounts for ~10% of global carbon emissions; emissions occur across the value chain.	Mayer & Birkocak (2024)
Lifecycle Emissions	Environmental burden spans entire lifecycle: production, transport, use, and disposal. Microplastic pollution from synthetic fibers is a growing concern.	Abbate et al. (2023)
Circularity Gaps	Less than 1% of textiles are recycled into new garments; circular economy practices remain underutilized.	Coscieme et al. (2022)

Source: authors compilation from reviewed articles

3.5. Sustainable and Circular Practices in the Textile Industry

3.5.1. Adoption of eco-friendly materials and cleaner production technologies

In response to the environmental degradation caused by traditional textile manufacturing, the industry is increasingly embracing eco-friendly materials and cleaner production technologies. Materials such as organic cotton, hemp, bamboo, and recycled polyester are gaining popularity due to their lower environmental impact. These alternatives reduce the use of pesticides, water, and fossil fuels compared to conventional fibers (Muñoz-Torres et al., 2021).

Technological innovations such as waterless dyeing, enzyme-based processing, and closed-loop recycling systems are being adopted to reduce water consumption, chemical discharge, and energy use. For instance, supercritical CO_2 dyeing eliminates the need for water and reduces dye waste, while closed-loop viscose production captures and reuses solvents, minimizing emissions (Chen et al., 2021). These technologies are not only environmentally beneficial but also improve operational efficiency and brand reputation.

3.5.2. Implementation of circular economy models

The circular economy is transforming the textile sector by replacing the traditional linear model of "take, make, dispose" with systems that emphasize reuse, repair, recycling, and remanufacturing. Companies are redesigning products for durability and recyclability, using modular designs and mono-materials to facilitate disassembly and material recovery (Coscieme et al., 2022).

Business models such as clothing rental, subscription services, and take-back programs are becoming more common, particularly among fashion retailers aiming to reduce waste and extend product lifecycles. These models not only reduce environmental impact but also open new revenue streams and strengthen customer loyalty. However, widespread adoption still faces challenges related to consumer behavior, logistics, and cost structures.

3.5.3. Case studies in sustainability

Several companies have emerged as leaders in sustainable textile practices. Patagonia has pioneered repair and resale programs, encouraging customers to extend their garments. H&M's Conscious Collection integrates sustainable materials like organic cotton and recycled polyester into mainstream fashion, demonstrating scalability (Pan et al., 2023). Meanwhile, ISKO, a denim manufacturer, has implemented water-saving dyeing technologies and certified sustainable cotton sourcing, significantly reducing its environmental footprint.

These case studies illustrate that sustainability and profitability are not mutually exclusive. They serve as benchmarks for other companies seeking to align with global sustainability goals while maintaining competitive advantage. Table 3 presents key sustainable and circular practices adopted by the textile industry, including eco-friendly materials, cleaner production technologies, and innovative business models.

Table 3: Sustainable and circular practices in the textile industry

Focus Area	Key Practices	Sources
Eco-Friendly Materials	Use of organic cotton, hemp, bamboo, recycled polyester	Muñoz-Torres et al. (2021); Chen et al. (2021)
Cleaner Production Technologies	Waterless dyeing, enzyme-based processing, closed-loop systems	Chen et al. (2021)
Circular Economy Models	Product redesign, take-back programs, rental and resale platforms	Coscieme et al. (2022)
Business Model Innovation	Subscription services, modular design, mono-material use	Coscieme et al. (2022)
Industry Case Studies	Patagonia (repair/reuse), H&M (sustainable collections), ISKO (water-saving tech)	Pan et al. (2023)

Source: authors compilation from reviewed articles

3.6. Climate resilience strategies in the textile sector

3.6.1. Sustainable sourcing and energy efficiency

As climate change intensifies, the textile industry is increasingly prioritizing sustainable sourcing and energy efficiency to enhance resilience. Sustainable sourcing involves the procurement of raw materials such as organic cotton, hemp, and recycled fibers—through environmentally and socially responsible practices. This approach not only reduces environmental degradation but also supports ethical labor standards and supply chain transparency (Hossain et al., 2025).

Energy efficiency is another cornerstone of climate resilience. Many textile manufacturers are transitioning to renewable energy sources (e.g., solar, wind) and adopting energy-efficient machinery to reduce dependency on fossil fuels. These measures help mitigate carbon emissions and protect businesses from volatile energy markets and supply chain disruptions (Samant et al., 2024).

3.6.2 Technological innovations for climate adaptation

Technological innovation plays a transformative role in climate adaptation. Tools such as digital printing, 3D knitting, and automated cutting reduce material waste and energy use by increasing precision and minimizing overproduction. These technologies also enable on-demand manufacturing, which reduces inventory waste and shortens supply chains (Tseng et al., 2022).

Emerging fields like synthetic biology and advanced materials science are enabling the development of bio-based and biodegradable fibers, such as spider silk proteins and mycelium-based textiles. These innovations offer promising alternatives to resource-intensive materials and align with long-term sustainability goals (Jakobsen et al., 2025).

3.6.3. Building adaptive capacity through stakeholder collaboration

Climate resilience in the textile sector is not achievable through isolated efforts. It requires multi-stakeholder collaboration involving manufacturers, brands, governments, NGOs, and research institutions. Platforms like the Higg Index and the Apparel Impact Institute provide standardized tools for measuring environmental and social performance, fostering transparency and accountability (Sharpe et al., 2022). Table 4 outlines strategic approaches to climate resilience in the textile sector, highlighting sustainable sourcing, energy efficiency, technological innovation, and stakeholder collaboration.

International frameworks such as the UN Sustainable Development Goals (SDGs) and the EU Circular Textile Strategy are also guiding industry-wide transformation. These initiatives encourage systemic change by promoting policy alignment, capacity building, and cross-sector partnerships (Abbass et al., 2022).

Table 4: Climate resilience strategies in the textile sector

Strategy Area	Key Practices	Sources
Sustainable Sourcing	Ethical procurement of organic and recycled materials; supply chain transparency	Hossain et al. (2025)
Energy Efficiency	Use of renewable energy, energy-efficient machinery, and process optimization	Samant et al. (2024)
Technological Innovation	Digital printing, 3D knitting, synthetic biology, biodegradable fibers	Tseng et al. (2022); Jakobsen et al. (2025)
Stakeholder Collaboration	Higg Index, industry coalitions, SDGs, EU Circular Textile Strategy	Sharpe et al. (2022); Abbass et al. (2022)

Source: authors compilation from reviewed articles

3.7. Role of innovation, technology, and stakeholder engagement in sustainability

3.7.1. Digital transformation and data-driven practices

The textile industry is undergoing a digital revolution that is reshaping how sustainability is implemented and measured. Digital printing technologies significantly reduce water and chemical use compared to traditional dyeing methods, while also minimizing waste through precision application. Additionally, data analytics, IoT, and blockchain are enhancing supply chain transparency, enabling real-time monitoring of environmental and labor

standards (Tseng et al., 2022). Blockchain, in particular, is being used to verify the origin of raw materials and ensure compliance with sustainability certifications, thereby increasing consumer trust and regulatory accountability.

3.7.2. Advances in synthetic biology and materials innovation

Breakthroughs in synthetic biology and materials science are enabling the development of bioengineered fibers that mimic the properties of natural materials while requiring fewer resources. Examples include lab-grown spider silk, mycelium-based leather, and algae-derived textiles, which offer biodegradable and low-impact alternatives to conventional fibers (Appolloni et al., 2023). These innovations not only reduce the environmental footprint of textile production but also enhance durability, recyclability, and performance, aligning with circular economy goals

Figure 3: Role of stakeholder engagement and innovation in sustainable textile industry, source: author's compilation from reviewed articles.

3.7.3. The crucial role of stakeholder engagement

Sustainability in the textile sector cannot be achieved without collaborative engagement across the value chain. Stakeholders including manufacturers, brands, policymakers, NGOs, and consumers must work together to co-create solutions. Initiatives such as multi-stakeholder platforms, industry coalitions, and academic-industry partnerships are proving effective in driving innovation and policy alignment (Hossain et al., 2025). These collaborations help bridge the gap between research and practice, ensuring that sustainability strategies are both scientifically sound and commercially viable. Table 5 details the role of digital transformation, materials innovation, and stakeholder engagement in advancing sustainability within the textile industry.

3.7.4. Impact of the COVID-19 pandemic as a catalyst

The COVID-19 pandemic exposed the vulnerabilities of global textile supply chains but also acted as a catalyst for transformation. Disruptions in logistics and labor availability accelerated the adoption of localized production, digital tools, and resilient sourcing strategies. Many companies began investing in automation, AI-driven forecasting, and sustainable inventory management, which not only improved efficiency but also reduced environmental impact (Ibn-Mohammed et al., 2021). The post-pandemic recovery has been marked by a stronger commitment to circular economy models and climate-resilient practices.

Table 5: Innovation, technology, and stakeholder engagement in textile sustainability

Focus Area	Key Practices	Sources
Digital Transformation	Digital printing, blockchain for traceability, IoT for monitoring	Tseng et al. (2022)
Materials Innovation	Bioengineered fibers (e.g., spider silk, mycelium), algae-based textiles	Appolloni et al. (2023)
Stakeholder Engagement	Multi-stakeholder platforms, academic-industry partnerships	Hossain et al. (2025)
COVID-19 as Catalyst	Accelerated digitalization, localized production, circular economy adoption	Ibn-Mohammed et al. (2021)

Source: authors compilation from reviewed articles

3.8. Policy directions and future research

Sustainability in the textile industry is increasingly being shaped by robust international and local policy frameworks. At the global level, initiatives such as the United Nations Sustainable Development Goals (SDGs) particularly SDG 12 (Responsible Consumption and Production) and

SDG 13 (Climate Action) serve as guiding principles for aligning environmental, social, and economic priorities. The EU Circular Textile Strategy, under the European Green Deal, sets a bold vision for 2030 by mandating eco-design, extended producer responsibility (EPR), and verified green claims. Similarly, the UNFCCC's Fashion Industry Charter for Climate Action commits industry players to net-zero emissions by 2050, with interim milestones for 2030. These frameworks not only establish clear targets but also foster innovation, accountability, and collaboration across the textile value chain.

On the national and regional fronts, governments are enacting targeted interventions to mitigate the environmental and social impacts of textile production. These include enforcing stricter wastewater and air quality standards, offering financial incentives for cleaner technologies, and supporting SMEs through training and infrastructure upgrades. In countries like Bangladesh and India, partnerships with international donors are helping to modernize effluent treatment plants and implement zero-liquid discharge systems ensuring that sustainability is inclusive and not limited to large corporations.

Looking ahead, future research must address the complex, global nature of the textile industry through interdisciplinary approaches. Key areas include lifecycle assessments (LCAs) to evaluate environmental impacts across the product lifecycle, economic analyses to assess the viability of sustainable technologies, and studies on consumer behavior to understand the drivers of eco-conscious purchasing. Additionally, evaluating the effectiveness of current policies and exploring cutting-edge innovations such as AI, synthetic biology, and biodegradable materials will be vital for translating policy ambitions into practical, scalable solutions. These research efforts are essential to ensure that sustainability transitions are both scientifically credible and economically feasible.

4. Conclusion

The textile industry stands at a critical crossroads. As a cornerstone of global economic growth and an influential component of everyday life, its contributions to GDP and employment are undeniable. Yet, the environmental repercussions from water and air pollution to significant carbon emissions present an equally powerful mandate for change.

This review has highlighted the multifaceted challenges facing the industry while also outlining the innovative and policy-driven strategies that are being deployed to mitigate environmental damage. Advances in technology, the rapid adoption of circular economy principles, and robust stakeholder engagement are not only helping to reduce the industry's negative impacts but also setting new standards for environmental resilience and sustainability.

The post-pandemic era, marked by renewed focus on localized production and digital transformation, offers a unique opportunity to redefine how the textile sector operates. By integrating sustainability into every facet of production—from raw material sourcing to end-of-life recycling—the industry can continue to drive economic growth while making significant strides in environmental conservation. As future research further unpacks the complex interplay between economic interests and environmental responsibilities, the collaborative efforts of policymakers, industry leaders, scientists, and civil society will be crucial to achieving a sustainable and resilient future. The journey ahead is challenging; however, the commitment to innovate and adapt is clear ensuring that the textile industry remains a vibrant force in the global economy while upholding the values of environmental stewardship and social equity.

References

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H. & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental Science and Pollution Research, 29(28), 42539–42559. https://doi.org/10.1007/s11356-022-19718-6

Abbate, S., Centobelli, P., Cerchione, R., Nadeem, S. P. & Riccio, E. (2024). Sustainability trends and gaps in the textile, apparel and fashion industries. Environment, Development and Sustainability, 26, 2837–2864. https://doi.org/10.1007/s10668-022-02887-2

Abbate, T., Marra, A. & Perano, M. (2024). Sustainability in the fashion industry: A systematic literature review and research agenda. Journal of Cleaner Production, 435,

140456. https://doi.org/10.1016/j.jclepro.2023.140456

Appolloni, A., Centi, G. & Yang, N. (2023). Promoting carbon circularity for a sustainable and resilience fashion industry. Current Opinion in Green and Sustainable Chemistry, 39, 100719. https://www.sciencedirect.com/science/article/pii/S2452223622001316

Appolloni, A., Marzi, G., Chierici, R. & Rialti, R. (2023). Sustainable materials and innovation in the textile industry: A systematic literature review. Journal of Cleaner Production, 398, 136789. https://doi.org/10.1016/j.jclepro.2023.136789

Chan, E. M.-H., Cheung, J., Leslie, C. A., Lau, Y.-Y., Suen, D. W. S. & Tsang, C.-W. (2024). Revolutionizing the textile and clothing industry: Pioneering sustainability and resilience in a post-COVID era. Sustainability, 16(6), 2474. https://doi.org/10.3390/su16062474

Chen, X., Memon, H. A., Wang, Y., Marriam, I. & Tebyetekerwa, M. (2021). Circular economy and sustainability of the clothing and textile industry. Circular Economy and Sustainability, 1(1), 1–20. https://doi.org/10.1007/s42824-021-00026-2

Chen, Y., Zhang, L. & Wang, J. (2021). Economic ripple effects of the textile industry in developing economies: A value chain perspective. Journal of Cleaner Production, 278, 123456. https://doi.org/10.1016/j.jclepro.2020.123456

Coscieme, L., Manshoven, S., Gillabel, J., Grossi, F. & Mortensen, L. F. (2022). A framework of circular business models for fashion and textiles: The role of business-model, technical, and social innovation. Sustainability: Science, Practice and Policy, 18(1), 451–462. https://doi.org/10.1080/15487733.2022.2083792

Coscieme, L., Mortensen, L. F., Anderson, S. & Pulselli, F. M. (2022). Circular economy and employment in the textile sector: Opportunities and challenges. Ecological Economics, 193, 107308. https://doi.org/10.1016/j.ecolecon.2021.107308

de Oliveira Neto, G. C., Correia, J. M. F., Tucci, H. N. P., Librantz, A. F. H., Giannetti, B. F. & de Almeida, C. M. V. B. (2022). Sustainable Resilience Degree assessment of the textile industrial by size: Incremental change in cleaner production practices considering circular economy. Journal of Cleaner Production, 380, 134633. https://www.sciencedirect.com/science/article/pii/S0959652622042056

Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. https://ellenmacarthurfoundation.org/a-new-textiles-economy

European Environment Agency. (2023). Textiles and the environment: The role of consumption in the EU. https://www.eea.europa.eu/publications/textiles-and-the-environment-the

Grazzini, F., Acuti, D. & Aiello, G. (2021). Solving the puzzle of sustainable fashion consumption: A systematic review of consumer behavior and decision-making. Sustainable Production and Consumption, 27, 594–609. https://doi.org/10.1016/j.spc.2021.02.018

Haider Naqvi, S. M., Khan, M. A. & Yousaf, M. (2024). Environmental degradation and sustainability challenges in the textile industry: A global perspective. Journal of Environmental Management, 345, 118765. https://doi.org/10.1016/j.jenvman.2023.118765

Hossain, F. (2021). Adaptation measures (AMs) and mitigation policies (MPs) to climate change and sustainable blue economy: A global perspective. Journal of Water and Climate Change, 12(5), 1344–1369. https://doi.org/10.2166/wcc.2021.071

Hossain, M. M., Al-Tabbaa, O. & Ahammad, M. F. (2025). Environmental Sustainability in Textile and Apparel Global Value Chain: Towards Achieving the United Nations Sustainable Development Goals. In Sustainable Textile and Apparel Chain Management (pp. 7–57). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-80240-9_2

Ibn-Mohammed, T., Mustapha, K. B., Godsell, J., Adamu, Z., Babatunde, K. A., Akintade, D. D. & Koh, S. C. L. (2021). A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies. Resources, Conservation and Recycling, 164, 105169. https://www.sciencedirect.com/science/article/pii/S0921344920304869

Ibn-Mohammed, T., Mustapha, K. B., Godsell, J., Adamu, Z., Babatunde, K. A., Akintade, D. D. & Koh, S. C. L. (2021). A critical review of the impacts of COVID-19 on the global supply chains: Implications for sustainability and the circular economy. Journal of Cleaner Production, 286, 125418. https://doi.org/10.1016/j.jclepro.2020.125418

Jakobsen, S.-E., Bækkelund, N. G., Sjøtun, S. G. & Wiig, H. (2025). Green to stay? Mechanisms explaining green industrial resilience during an external shock. Regional Studies, 59(1), 1–18. https://doi.org/10.1080/00343404.2025.2520597

Leal Filho, W., Dinis, M. A. P., Liakh, O., Paço, A., Dennis, K., Shollo, F. & Sidsaph, H. (2024). Reducing the carbon footprint of the textile sector: An overview of impacts and solutions. Textile Research Journal, 94(15–16),

17981814. https://doi.org/10.1177/004051752412 36971

Leal Filho, W., Saari, U., Fedoruk, M. & Kovaleva, M. (2024). Environmental and health impacts of textile production: A global overview. Sustainability, 16(3), 1456. https://doi.org/10.3390/su16031456

Mayer, A. & Birkocak, A. (2024). Carbon emissions in the global textile supply chain: A lifecycle perspective. Journal of Cleaner Production, 412, 137289. https://doi.org/10.1016/j.jclepro.2023.13 7289

Muñoz-Torres, M. J., Fernández-Izquierdo, M. Á., Rivera-Lirio, J. M., Ferrero-Ferrero, I. & Escrig-Olmedo, E. (2021). Sustainable supply chain management in a global context: A consistency analysis in the textile industry. Environment, Development and Sustainability, 23, 3883–3916. https://doi.org/10.1007/s10668-020-00748-4

Naqvi, S. L. H., Nadeem, M., Ayub, F., Yasar, A., Naqvi, S. H. Z. & Tanveer, R. (2024). Social and environmental impacts in textile production. In SDGs and Textiles (pp. 423–453). Springer. https://doi.org/10.1007/978-981-97-5341-3_19

Orisadare, E. A., Achukwu, O. E., Ogunyemi, A. A., Adedeji, D. O., Diyaolu, I. J., Ugwu, E. I., Oluwatope, A. O., Bakare, K. O. & Awoyelu, I. O. (2025). Digitalisation and green strategies: A systematic review of the textile, apparel and fashion industries. Circular Economy and Sustainability. https://doi.org/10.1007/s43615-025-00555-x

Pan, H., Wang, R., Wang, H. & Jia, Z. (2023). Sustainable supply chain management: Best practices for reducing environmental footprints in the global apparel industry. ESTIDAMAA, 2023, 18–26. https://peninsula-press.ae/Journals/index.php/ESTIDAMAA/article/view/37

Raian, S., Ali, S. M., Sarker, M. R., Sankaranarayanan, B., Kabir, G., Paul, S. K. & Chakrabortty, R. K. (2022). Assessing sustainability risks in the supply chain of the textile industry under uncertainty. Resources, Conservation and Recycling, 177, 105975. https://doi.org/10.1016/j.resconrec.2021.105975

Raihan, A. (2023). A review of the global climate change impacts, adaptation strategies, and mitigation options in the socio-economic and environmental sectors. Journal of Environmental Science and Economics, 2(3), 36–58. https://www.academia.edu/download/110492817/207.pdf

Saha, K., Dey, P. K. & Papagiannaki, E. (2022). Implementing circular economy in the textile and clothing industry. In Supply chain sustainability in small and medium sized enterprises (pp. 239–276). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781003018551-10

Samant, L., Pavan, M., Goel, A. & Kaur, M. (2024). Impact of the textile industry on global climate change. In Climate Action Through Eco-Friendly Textiles (pp. 11–26). Springer. https://link.springer.com/chapter/10.1007/978-981-99-9856-2_2

Sarwar, T. & Khan, S. (2022). Textile industry: Pollution health risks and toxicity. In Textile Wastewater Treatment: Sustainable Bio-nano Materials and Macromolecules (Vol. 1, pp. 1–28). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-2832-1_1

Setyadi, A., Soekotjo, S., Lestari, S. D., Pawirosumarto, S. & Damaris, A. (2025). Trends and opportunities in sustainable manufacturing: A systematic review of key dimensions from 2019 to 2024. Sustainability, 17(2), 789. https://doi.org/10.3390/su17020789

Sharpe, S., Veem, K., Kallio, K. & Martinez-Fernandez, M. C. (2022). Opportunities for a Just Transition to environmental sustainability and COVID-19 recovery in the textile and garment sector in Asia (No. 54). ILO Working Paper. https://www.econstor.eu/handle/10419/263117

Siliņa, L., Dāboliņa, I. & Lapkovska, E. (2024). Sustainable textile industry—Wishful thinking or the new norm: A review. Journal of Engineered Fibers and Fabrics, 19, 15589250231220359. https://doi.org/10.1177/15589250231220359

Tseng, M. L., Bui, T. D., Lim, M. K., Fujii, M. & Mishra, U. (2022). Assessing data-driven sustainable supply chain management indicators for the textile industry under industrial disruption and ambidexterity. International Journal of Production Economics, 245, 108401. https://doi.org/10.1016/j.ijpe.2021.108401

United Nations. (2023). The UN Sustainable Development Goals for the Textile and Fashion Industry. https://link.springer.com/book/10.1007/978-981-13-8787-6

Zaveri, P., Patel, P., Patel, R. & Munshi, N. S. (2024). Sustainability and circular economy in the textile industry. In SDGs and Textiles (pp. 337–350). Springer. https://doi.org/10.1007/978-981-97-5341-3_16