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Abstract

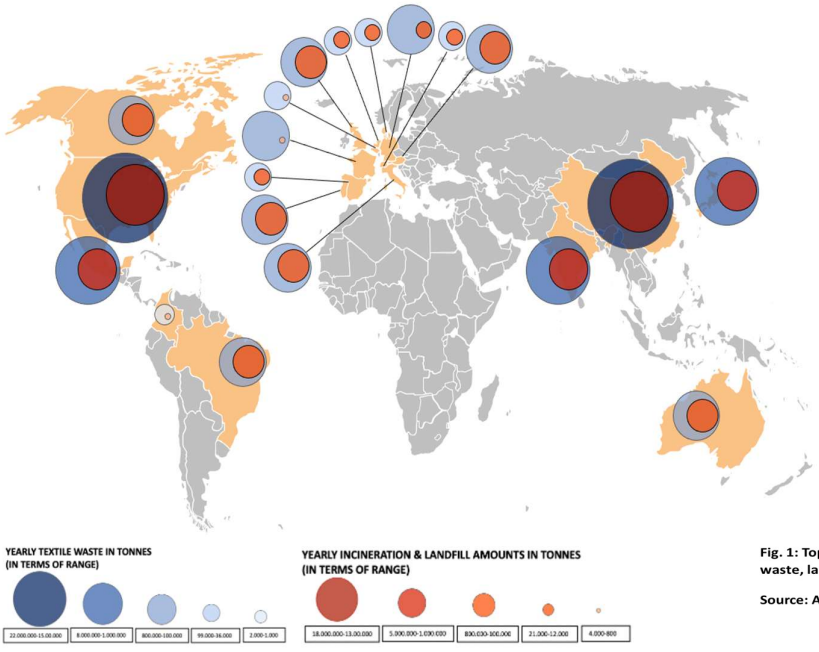
Apparel is one of the most polluting industries in the world, and its production and consumption are dispersed across the global North and South. This global fragmentation of production and consumption, coordinated by lead firms such as apparel brands and retailers, creates challenges for achieving a green transition. This research-based policy note explains these challenges, focusing on pre-consumer textile waste in the context of apparel manufacturing in Bangladesh. Previous studies on the apparel circular economy have focused on textile recycling technology, efficiency, process innovation and climate change mitigation, challenges stemming from the void in circular ecosystem policies, cooperation and shared commitment between local and global actors, and traceability technology to track wellbeing, human rights, and component's life cycle (for GHG emissions) have not been discussed. While previous studies have tended to focus on fashion brands' perspective and post-consumer circularity, they have downplayed the supplier perspective, in particular pre-consumer textile waste circularity. Our note aims to combine both perspectives, highlighting the dynamics and challenges associated with the pre-consumer textile-waste circular economy transition. We argue that achieving a circular economy requires reconfiguration of existing national business systems, institutions, and industry ecosystems as well as cooperation between institutions, global value chain actors, and technological innovations. Component-level circularity, therefore, should be designed in consistent with the firm-level, industry ecosystem-level level, and institutional policy-level dynamics including the consideration of political economy, and normative and cognitive transformations. Thus, the circular economy transition should be viewed from the system-level perspective in relation to innovation, capability upgrading, and the changing dynamics of global actors. We propose a three-dimensional matrix that can be used to assess the status of a country's circular economy transition and identify appropriate climate action strategies for the fashion industry in Bangladesh and around the world.

Introduction

The green transition is increasingly important in the agendas of national governments, multinational corporations (MNCs), and supply chain actors due to regulations and directives from the European Union and the United Nations. The circular economy is an effective operational model for firms and industries to attain environmental and economic efficiency (Morseletto 2022; Boje and Rana, 2021).

The circular economy is based on several key principles, including using renewable energy and resources, moving from goods to services, and keeping products, components, and materials at their highest utility and value through circular flows and smart design. Adopting a circular economy model allows MNEs to work with their suppliers and other organizations, which are socially embedded, to reduce, re-use, and recycle production and consumption wastes by closing loops in global production and consumption value chains with an aim to maintain planetary balance and societal wellbeing. Properly implemented, it has the potential to reduce CO2 emissions, toxic material use, and water consumption, and close production and consumption loops for waste valorization and resource conservation, increasing both economic efficiency and environmental efficiency while encouraging innovation and driving growth (Zhang et al., 2020).

Achieving a circular economy requires reconfiguring existing national business systems, institutions, and industry eco-systems, as well as the nature of cooperation between institutions, global value chain actors, and technological innovators (Rana and Allen, 2024; Jensen and Whitfield 2022; Matson, 2022; Rana and Allen, 2021a). However, reconfiguring a national system is not so easy. In many global value chains, including that of the apparel industry, production and consumption is dispersed across the global North and South. Apparel brands and retailers are predominantly based in the United States, Europe, and Japan, while most textile and apparel suppliers are located in Asia, Africa, and Latin America. Existing research on green transition in this sector has focused on circular economy modeling (Barford and Ahmad, 2021; Rana and Tajuddin, 2021), material recycling (Mäkelä, Rissanenb, and Sixta, 2022), waste management technologies (Zhang et al. 2022) and reducing environmental impact (Morseletto 2022; Johansson 2023; Sandin and Peters, 2018). There remains a lack of research on the challenges for the circular economy transition posed by this global fragmentation of production and consumption coordinated by lead firms. This research note explains these challenges from the context of apparel supplier countries. We aim to inspire a new research agenda and highlight the antecedents for policy development required for a circular economy transition in the global fashion industry in supplier countries such as Bangladesh.



LOCATION	YEARLY TEXTILE WASTE IN TONNES (ROUNDED)	INCINERATION & LANDFILL IN TONNES (ROUNDED)
China	22.000.000	17.000.000
US	16.000.000	14.000.000
India	8.000.000	4.000.000
Mexico	4.380.000	4.000.000
Japan	2.00.000	1.000.000
Australia	780.000	700.000
Canada	480.000	400.000
UK	350.000	245.000
Austria	222.000	185.000
France	205.000	3.000
Portugal	200.000	14.000
Brazil	170.000	102.000
Italy	143.000	100.000
Germany	124.000	15.000
Netherlands	95.000	13.000
Belgium	84.000	900
Spain	40.000	20.000
Switzerland	36.000	18.000
Denmark	4.000	1.500
Colombia	1.300	1.200

Fig. 1: Top 20 countries with post-consumer textile waste, landfill & incineration by 2020.

Source: Authors developed based on various databases.

Apparel is one of the most polluting industries in the world, with pre-consumer and post-consumer waste rates of approximately 20–29% and 87%, respectively (Chen et al., 2021; Savage, 2022). Globally, annual purchases of apparel exceed 60 million tons, and are expected to reach 100 million tons by 2030 (Nature-Editorial, 2022). Producing these mountains of clothing uses water anywhere from 20 trillion to 200 trillion litres every year, discharges 190,000 tons of microplastics, and emits 1.2 billion tons of greenhouse gases (GHGs) annually (Chen et al., 2021; Nature-Editorial, 2022; Sahimaa, et al., 2023). Much of the apparel produced ends up in landfills, in incinerators, or as unsold goods (Figure 1).

Based on our analysis, Figure 1 depicts the top twenty countries in post-consumer waste, incineration, and landfill amounts, and shows that China, US, Japan, Australia, Canada, UK, and Austria have had the highest amount of apparel incineration and landfill in the years leading up to 2020. Some emerging economies such as India, Pakistan, and Malaysia import second-hand and unsold clothes from Western countries for recycling into fiber and yarn, which is then sold back to the apparel suppliers of Western brands for making garments. This is one of the reasons waste volumes appear high for these countries, although other emerging economies, such as Mexico and Brazil, do also consume large amounts of apparel. The apparel waste of some European countries, on the other hand, appears lower because these countries export used and unsold clothes to other countries. For instance, Nordic countries, the UK, and the Netherlands export to Germany, Hungary, Poland, Bulgaria and Croatia, where some volume is recycled but the remaining is re-exported (or donated) to African countries. This not only damages African countries' local apparel industries but also pollutes the environment through landfill and dumping at sea (Greenpeace 2022).

Due to fast fashion trends, post-consumer apparel accounts for the largest amount of waste produced. Blaming the global fashion industry, inadequate policy, and the slow commercialization of new technologies, past studies have called for further research and policy work on circularity in the global fashion industry (Nature-Editorial, 2022; Sahimaa, et al., 2023; Niinimäki et al., 2020; Savage, 2022). These studies emphasize the need for global brands and national institutions to adopt initiatives focused on post-consumer textile recycling, the production of textiles with long lifetimes, and science-based global institutional policies. Some policy-driven projects have been initiated by EU and UN organisations such as UNIDO that runs the Switch2CE project in Bangladesh, Morocco, and Egypt. However, pre-consumer apparel waste in the global value chain was overlooked in the circular economy transition analysis.

Apparel consumers generally do not receive incentives to return used clothes for recycling. While a few global brands do provide recycling incentives, they are not available in all countries where the brands are sold. Even fewer brands offer repair services, and again, most only offer these in selected stores and countries. Thus, recent EU policy initiatives focused on creating a more circular global fashion industry are very important in creating incentives for recycling, reusing, and repairing, and the development of recycling infrastructure. Reconfiguring industry eco-system, garment designs, and business models can accelerate the circular economy transition; but workers' health, safety, wellbeing, and GHG emission transparency are critical issues, for which traceability of the global value chain remains a challenge (Eppinger, 2022; Rinaldi, 2022).

The European Green Deal and its Circular Economy Action Plan 2023, together with the "EU strategy for sustainable and circular textiles," suggest a minimum decrease of 55% in GHG emission by 2030 as compared to the levels recorded in 1990 (European Union, 2023). The EU

corporate sustainability due diligence 2023 initiative, meanwhile, aims for greater transparency and governance on human rights, living wage, and labour wellbeing across global value chains ("Corporate sustainability due diligence", 2023; Filho et al., 2023). A digital passport is expected to be introduced for greater transparency in the textile life cycle, but it is not clear how data on human rights and worker wellbeing will be collected, verified, and processed across global value chains.

Given the policy dynamics in the global North, as discussed, we analyse the pre-consumer textile waste produced in the global South and explain the context of apparel manufacturing in Bangladesh in order to highlight the key challenges affecting the transition to circularity in supplier countries. Bangladesh is the world's second-largest apparel exporter. A number of apparel brands and retailers, in collaboration with donor-funded projects, are pushing for the development of a policy framework in Bangladesh, supporting circularity among suppliers. Apparel brands are concerned about achieving the GHG reduction targets set for 2030 and are eager to reduce dependency on Chinese apparel suppliers. For instance, Nordic-based apparel retailers H&M and Bestseller have committed to investing 1.3 billion USD in offshore wind energy projects in Bangladesh to offset CO2 emissions by their suppliers. They are also working towards circular economy transitions in apparel supplier countries in collaboration with the United Nations Industrial Development Organisation (UNIDO), Global Fashion Agenda, Reverse Resources, European Investment Bank, Chatham House, Circle Economy Foundation, and the local garment industry association in Bangladesh, BGMEA (Hendriks, 2023).

As estimated, Bangladesh's apparel industry produces 577,000 tons of textile waste annually, almost half of which is cotton fabric (Textile Focus, 2021). This includes pre-consumer waste, which is largely composed of offcuts of various sizes with various colors, and leftover fabric. Fully reusing or recycling pre-consumer textile waste in Bangladesh could reduce the country's textile imports by 15 percent and thus save manufacturers 500 million USD (Textile Focus, 2021). However, our field study reveals that there are three types of challenges to implementing circularity in Bangladesh's apparel industry: (i) lack of circular ecosystem policies; (ii) low level of shared commitment and cooperation among firms (i.e. suppliers of different sizes), national institutions, and global actors; and (iii) the need for efficient and low-cost circular and traceability technologies. We discuss each of these below.

Circular Ecosystem Policies in Bangladesh

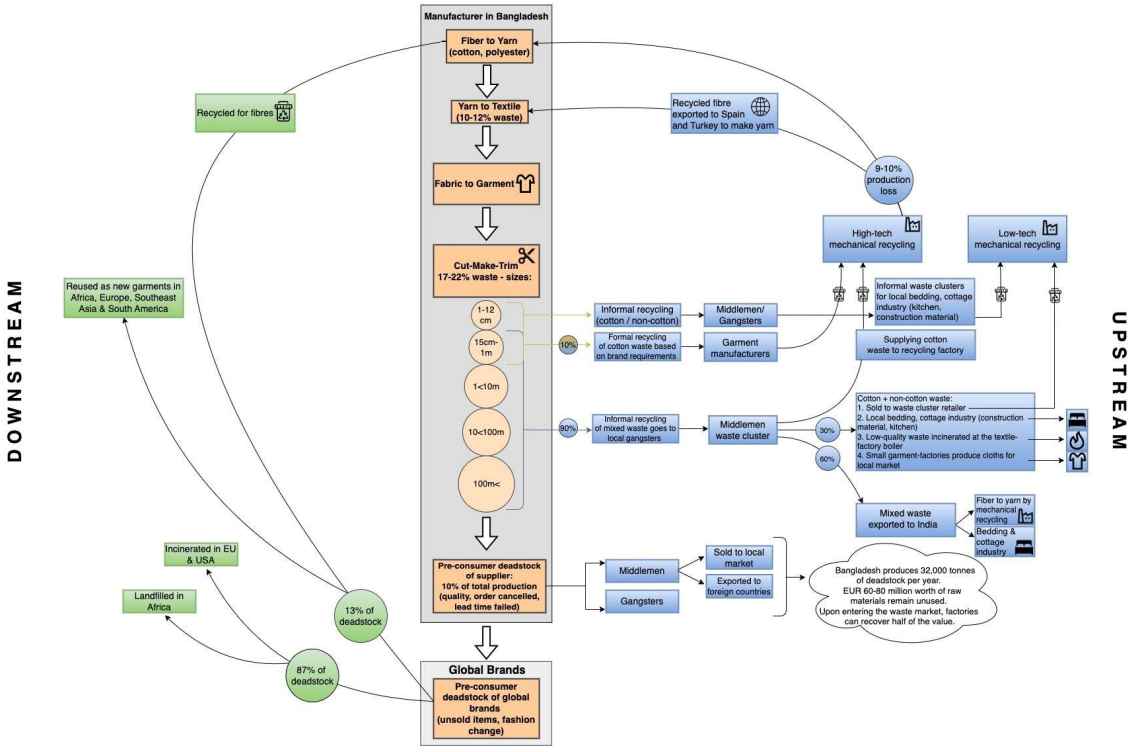
Policies that incentivize the value chain actors for normative change and cognitive development are the key to circular economy transition. Bangladeshi government policies allow apparel manufacturers to import yarn and fabrics duty-free; these are then used to produce garments for export. The cost of production thus includes the cost of waste, including the benefit of duty-free, affecting export price. However, there are no government policies encouraging textile waste recycling for capturing higher value, or motivating suppliers of different sizes (i.e. large, SMEs, micro) to become actively involved in waste processing and recylcing. Taking advantage of the recycling system in India, 60 percent of Bangladesh's pre-consumer textile waste is exported to India, where it is recycled to make fibres, home textiles, and industrial products. Figure 2 draws on our fieldwork; and shows the map of pre-consumer waste flow and value creation in upstream value chain in Bangladesh, marked in blue color.

Activity-flow in the map (marked in green color) in downstream value chain does not take place in Bangladesh but in the global North, and connects it to some other countries in the global South (Fig. 2). However, if this is linked with Bangladeshi apparel industry through policy initiatives, it can add further value to national economy by processing post-consumer waste and pre-consumer deadstock of global brands; 87% of which are normally incinerated and landfilled in the global North (See, Fig. 2).

The recycling ecosystem that deals with the remaining 40% of Bangladesh's pre-consumer textile waste is complex, as shown in Figure 2. In 2023, between 100 and 200 large garment factories sent at least 10% of their cotton textile waste to recycling facilities in Bangladesh, because some global buyers require their suppliers to recycle waste: H&M, for example, requires its suppliers to recycle 25% of their waste, while Bestseller aims for 30% of pre-consumer waste to be recycled by 2025. The intermediary firm 'Reverse Resources' records the input-output data on these flows for traceability purposes. Traceable cotton waste is recycled in Bangladesh to produce fibres which are either consumed locally or exported to Turkey, Spain, and other garment manufacturing countries.

Large apparel suppliers in Bangladesh tend to be vertically integrated, internalizing value-adding activities, which grants them more control over production processes and more rents, and attracts more orders from global apparel brands and retailers. This pattern tends to be repeated in pre-consumer textile waste recycling, where large suppliers are creating their own waste recycling plants to be competitive. Until January 2024, 24 pre-consumer textile recyling plants have been set up in Bangladesh, 90 percent of which are owned by large garment suppliers. Credibility of tracing (i.e., of waste recycling) thus, could be an issue unless additive tracing technology is used where data can not be tempered.

Fig. 2: Pre-consumer textile-waste recycling map, based on Bangladesh and its link to apparel global-value-chains, partially covering up-and downstream value-chains.



Small and medium suppliers, which make up 85 percent of the 3,500 garment factories in Bangladesh, typically sell their textile waste to informal handlers, making it difficult to trace. 30 percent of Bangladesh's textile waste enters the local informal sector, which adds little value to this material. Smaller-sized mixed fabrics waste is recycled into fibres and used to produce mattresses, cushions, filling for automobile seats, blankets, handicrafts, and kitchen textiles. To date, most suppliers and global initiatives have focused on recycling pre-consumer textile waste into yarn, overlooking more diverse uses and higher value addition for this material due to policy gaps. For instance, chemical processing of smaller-sized pre-consumer textile waste (i.e.12cm<) can generate Carboxymethyl cellulose, which can be used to make high-value added cellulose gum (sodium carboxymethyl cellulose), useful for various applications in the textile industry such as sizing, printing, and dyeing (Haleem et al., 2014). Larger-sized fabrics waste (10m>) is reused (i.e. upcycled) by micro-factories to make garments (Fig. 2). While this adds greater value with no CO_2 emissions or water use, it also does not receive attention from global brands or local policymakers.

Approximately 90% of the textile waste trade in Bangladesh is controlled by informal handlers, with implicit support from the local politicians, which is a lucrative illegal business. This is the key challenge to formalise textile waste recycling. Customs rules allow apparel suppliers (i.e. factories) to declare up to 29% of their textile waste against every export order, claiming to have incinerated it. However, in reality, the factories sell it to the informal handlers, who then sell it to middlemen; eventually, it ends up in waste-retail clusters. The actual waste produced by apparel factories varies from 10 to 29% depending on the product type. For example, an interview with a case company representative reveals that an apparel factory which consumes an estimated 1,000 tons of cotton knit fabric monthly will net these informal handlers BDT 3 million (USD 30,000) in annual profit. Factory owners receive similar amounts of illegal cash earnings through tax avoidance. In return, these informal handlers operate protection rackets, promising to protect companies from union leaders.

The transition to a formal and traceable textile waste recycling system in Bangladesh is thus impeded by a lack of financial incentives for informal waste-handlers, recyclers, and factory owners to add value by stimulating recycling, and by the lack of a consistent tax and duty system allowing waste recycling and reuse to be declared against export orders. Small and micro firms upcycling the textile waste to add higher value are also out of policy incentives.

Post-consumer textile waste recycling is completely absent in Bangladesh, as a 126% import duty is imposed on textile waste (including second-hand clothes and unsold garments from the Global North). India has allowed the import of post-consumer textile waste for over two decades and encouraged research and innovation of fibre technology to boost both pre- and post-consumer textile circularity. These government policies have made India an "expander" in textile recycling, while Bangladesh remains a "beginner" (see our proposed three-dimensional matrix in Figure 3). However, in both countries, there is minimal regard for the human rights, safety, and mental and physical well-being of recycling laborers in the informal sector and in small and medium recycling factories, which requires policy attention (Adger et al., 2022).

Cooperation and Shared Commitment

In Bangladesh, there is a lack of cooperation both between local actors, such as firms and the government (i.e., between firms of different sizes, including small businesses involved in pre-consumer textile waste value chains), and between suppliers and global actors. This challenge is typical of garment supplying countries (Wetterberg, Barrie, and Schröder, 2022). In Bangladesh, large suppliers and textile factories have significant representation and power on boards in both garments and textile associations. As a result, green transition strategies and initiatives undertaken by donor-funded projects, global brands, and transnational institutions tend to prioritize large firms' perspectives and voices. The interests and needs of small holders/firms in both the formal and informal economies are, thus, overlooked in fragmented business systems such as Bangladesh's. Policy incentives and norms tend not to encourage collaboration for value co-creation between large and small firms in fragmented business systems with institutional voids, which is the case with Bangladesh's apparel industry (Rana and Allen, 2021b; Jabbur et al., 2020).

While recycling aims to reduce GHG emissions, most apparel manufacturing countries use non-renewable energy. Up to 50% of the energy used by large LEED (Leadership in Energy and Environmental Design)-certified factories is the internalized solar energy, but the remaining factories depend on the country's national energy grid, which is powered by 98% non-renewable energy. There is no collective initiative among suppliers to use green energy. Most global brands tend not to treat their suppliers' green transition as a shared commitment, particularly with regard to providing finance; instead, they use governance and knowledge-sharing to motivate suppliers to make the green transition. An exception to this pattern is Bestseller and H&M's collective investiment, undertaken with a local company, in an offshore wind power plant project in Bangladesh.

The Bangladeshi government has no specific policy on finance or research and development relating to the circular economy transition and circular technology innovation (Biermann et al., 2022). The International Finance Corporation and the European Investment Bank aim to offer financing for green transition, but their collaboration with micro, small and medium enterprises appears to be non-existent. Red tape and the politicization of financial institutions are typical in Bangladesh, which means that suppliers are poorly coordinated with financial institutions when it comes to green transitions. Although Bangladesh Bank offers loans for energy transitions at a 4.5% interest rate (which commercial banks execute at 6%, after adding a margin for their own profit), commercial banks prefer their own sustainable financing at 9% to offset higher loan-recovery costs due to weak law enforcement in Bangladesh. Nevertheless, the banks tend to offer the green financing with the same 6% interest to politically influential owners of large factories. In such a case, political connections protect bank executives' jobs in case of non-recovery. Institutional voids or dysfunctionality in institutional systems in financing the green transition of micro-small & medium enterprises is, thus, a crucial challenge in the Global South (Rana and Allen, 2024).

Circular Technology and Traceability

Technology is pivotal for circularity, particularly in design, components, recycling and data-sharing. While generative design based on artificial intelligence (AI) and 3D modelling allow for the

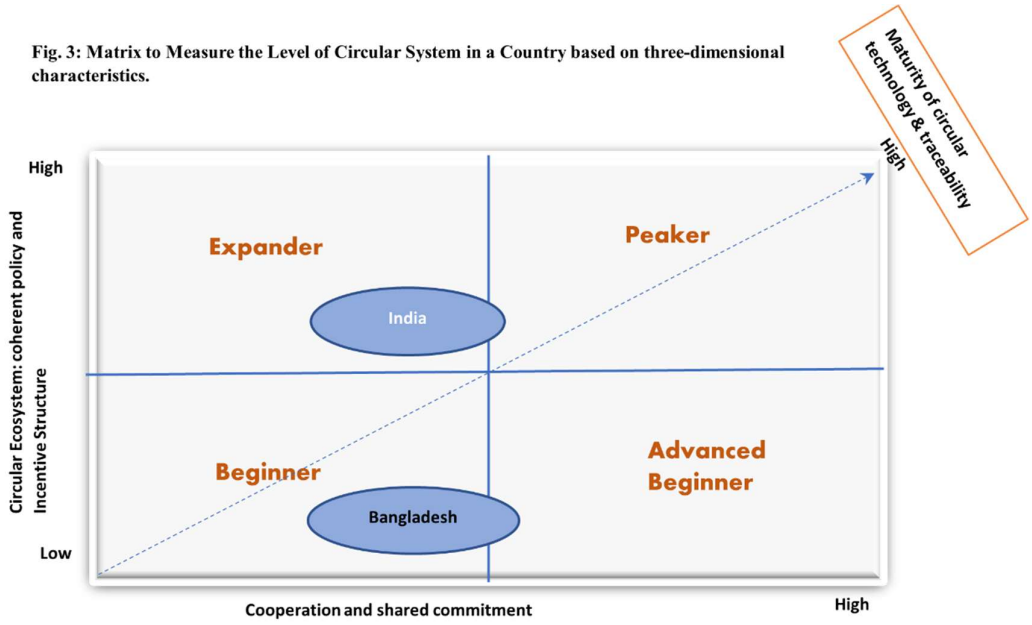
development of more eco-friendly designs, the replacement of natural fibres with man-made fibres does not always lower emissions (Simpkins, 2021). With existing technologies on the market, it is difficult to mechanically separate and recycle fibers in pre-consumer fabrics and post-consumer garments. Because mechanical sorting-system uses more labourers, often with low health-safety and wellbeing condition, while more energy is used in mechanical recycling compared to chemical recylcing, fibre production incurs losses of 9–10%. Only 20–40% of recycled fibres can be reused for quality febrics; they must be mixed with new fibers to produce quality fabrics due to their reduced strength and shorter length.

Recent technological innovations use chemical processes to recycle polymers or cellulose from pre- and post-consumer textile waste into renewed fibres (e.g. Renewcell, the company that is backed by H&M and the EU) (Zhang, Boriskina and Tao, 2023). This process uses minimal energy and produces no microfibre discharge. Unlike cotton, polymers can be broken down into monomers that can then be reconstructed into new polymers (Savage, 2022). Post-consumer textile waste is likely to be recycled where it is produced. For example, waste from Europe is likely to be recycled there or in Turkey, which has a large textile industry, to reduce transport costs. Meanwhile, pre- and post-consumer textile waste from Asia will likely be recycled there, providing opportunities for local firms to enter this new regenerative cellulose production segment of the textile industry. However, these technologies are still in the early phase of commercialization, with existing and start-up firms still struggling to raise the financial capital required to recycle textile waste on a large scale and to create the infrastructure required to produce sufficient raw material for large-scale production. Furthermore, most of these technologies are not yet available for licensing to other firms.

Thus, there are significant obstacles for firms in the Global South to access and commercialize these frontier technologies. Incentives and low-cost finance need to be made available to local firms to replace their mechanical recycling technology with chemical recycling. Accessing the new chemical recycling technologies requires licensing, strategic alliances, or joint venture agreements with the foreign firms that hold the patents. Furthermore, firms developing new technologies in regenerative cellulose production are focused on sustainability and thus are seeking to set up their pulp production factories in countries that have low-cost renewable energy. Bangladesh is behind other countries such as India and Vietnam in renewable energy production.

Traceability in global supply chains requires the tracking of information on manufacturing, fibre origin, regenerated component life, CO_2 emissions, water consumption, and labor wellbeing across the apparel life cycle. New technologies in “forensic fiber identification” and additive tracing, such as FibreTrace®, near-field-communication with circular-identification, and near-infrared-imaging-spectroscopy, show promise but have yet to mature (Crowley and Rademan, 2022). Hard data on apparel lifecycles can be recorded and processed using blockchain and AI, based on real-time data of fibers lifecycle, and wellbeing can be objectively measured using the real-time biometric information of workers; but robust models and systems for data gathering and management are needed to capture and process information on wellbeing and fiber traceability across global value chains, which are yet to be developed.

Transitioning to circularity: a three-dimensional strategy matrix



The circularity of a country's apparel and textile economy can be positioned on a three-dimensional matrix, presented below in Figure 3, to evaluate the current state of the industry and support the development of a consistent policy for climate action.

The vertical axis in Figure 3 represents circular ecosystem policies and incentive structures, along with institutional readiness, for companies and intermediaries involved in the textile circular value chain (Rana and Allen, 2024). The horizontal axis represents the level of cooperation and shared commitment between apparel suppliers, global apparel buyers, recyclers, state institutions, third-party global actors, and transnational institutions such as NGOs. The third dimension represents the maturity of circular technology and traceability.

Based on our field study and analysis as well as the Chatham House Earth Map (2024), Bangladesh is in the "beginner" quadrant. For comparison, India is positioned in the "expander" quadrant, as it has a higher level of government policy support, textile technology and innovation, and more cooperation between businesses in both pre-consumer and post-consumer textile recycling. Countries in the 'peaker' position have high levels of government policy support for circularity; strong collaboration and shared commitment between buyers (including foreign brands), suppliers, and the national institutions in which they are embedded; circularity companies; and sophisticated technologies and traceability systems. Countries in the 'advanced beginner' quadrant have a low level of government policy support but have buyers, suppliers, and global institutions which incentivize cooperation and shared commitment, thus encouraging circularity. Bangladesh is likely to move into the "advanced beginner" quadrant unless state policies are initiated to incentivise the speed of green transition.

The role of global brands and multilateral institutions will affect the two dimensions in green transition of suppliers in global value chains, i.e. "cooperation and shared commitment" and "maturity of technology". However, state institutions need to pay attention to developing policy incentives to encourage investment in circular economy as well as research and innovation related to textile recycling to affect the third dimension. Policy incentive should encourage suppliers and informal sector actors involved in pre-consumer textile handling, recycling or reusing. Circular economy transition means development of a new form of economic system; thus old routines, habits, norms and thinking need to be replaced by offering a compatible incentive structure and policy regulation. Apparel value chain actors, state, and global brands need to share resources; they should complement each other to develop a functioning circular ecosystem. This requires rebuilding institutions through collective efforts and shared commitment.

As brands continue to push suppliers to reduce production cost, informal trading of pre-consumer textile waste by suppliers is considered to be an incentive to offset the cost pressure from brands. This means brands and suppliers need to come to an understanding to share profitability reasonable to both parties. Exploiting suppliers in the name of free market would not be a sustainable mode of transaction in the long run.

Global brands tend to create demand for fashion and over-consumption, control the market and technology (i.e. through patents and designs), gain higher financial returns from the value creation process, and hold relatively higher power in global value chains (Rana and Allen, 2021a). It is, therefore, expected that they should take more responsibility for climate action in institutional voids in which their supply chains are embedded. Global brands should develop strategies to track and support the development of the thousands of micro-enterprises reusing (i.e. upcycling) their pre-consumer textile wastes to add value in Bangladesh; without this effort, green industrialisation will continue to exclude low- and middle-income economies (Jensen & Whitfield, 2022, Rana and Allen, 2021a).

Over half a million workers are involved in this extended value chain centered on the processing and use of pre-consumer waste in Bangladesh, and the wellbeing and job satisfaction of these workers cannot be ignored (Wang, 2022). However, to date these workers and businesses have not been recognized in national policy or in the corporate strategies of global fashion brands. The European Union’s 2022 textile strategy and corporate sustainability due diligence directive (includes human rights), which is concerned with reducing resource use and promoting recycling and wellbeing, can only succeed if policies consider the recycling of both pre-consumer *and* post-consumer-based waste along the textile industry's global value chains (Interreg Europe, 2022).

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This article does not contain any studies with human participants performed by any of the authors.

Data availability:

The datasets generated during and/or analysed during the current study are not publicly available due to personal identification of the stakeholders interviewed, but are available from the corresponding author on reasonable request.