Sustainable Manufacturing and Environmental Pollution Programme

DECARBONISING THE TEXTILE SECTOR IN BANGLADESH

Insights from the SMEP Programme's Fakir Knitwear Project

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UK International Development
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1.

Summary

Led by Primark and Panta Rei, with support from Fakir Knitwear, Grundfos, and H&M, this SMEP Programme collaboration demonstrates how integrating advanced wastewater treatment and reuse technologies, such as ultrafiltration and reverse osmosis, can significantly reduce greenhouse gas emissions, by reducing water and chemical usage in the textile sector. **By reusing 50 per cent of wastewater and reducing softening agents**, the project will potentially achieve **GHG emission reductions of 30.3 kgCO_2e and 17.8 kgCO_2e per cubic meter (m^3) of treated water, compared to untreated and secondary-treated scenarios, respectively. Scaling similar systems to 25 per cent of wastewater treated across the industry** could help Bangladesh to **conserve over 43 million m^3 of groundwater annually and cut GHG emissions by 1.5 to 2.6 million tonnes CO_2e, contributing 4–7 per cent toward Bangladesh's 2030** Nationally Determined Contributions (NDC) targets. To enable scale-up across the industry, the study recommends implementing financial incentives and establishing multilateral partnerships for infrastructure deployment, and embedding circular economy frameworks into national policy alongside robust monitoring and verification systems. The study also emphasises having supportive trade mechanisms (considering both tariff and non-tariff measures) to facilitate technology transfer from developed to developing countries.

↓ Image 1. Wastewater treatment facility at Fakir Knitwear, Dhaka, where SMEP, Primark, Fakir Group, and H&M collaborate to reuse wastewater, cutting chemicals, conserving groundwater, and reducing GHG emissions.

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2.

Technical aspects of Wastewater Treatment in the textile industry

Due to globalisation of textile value chains and technological advancement, fast fashion provides consumers across the world with a constant source of new styles at affordable prices (European Parliament, 2020). Unfortunately, how we make clothes now is primarily linear, based on a "take-make-dispose" system. Globally, just 0.3 per cent of the materials used to produce textiles come from recycling, and almost none of this involves recycling old clothes back into new ones (Circle Economy, 2024).

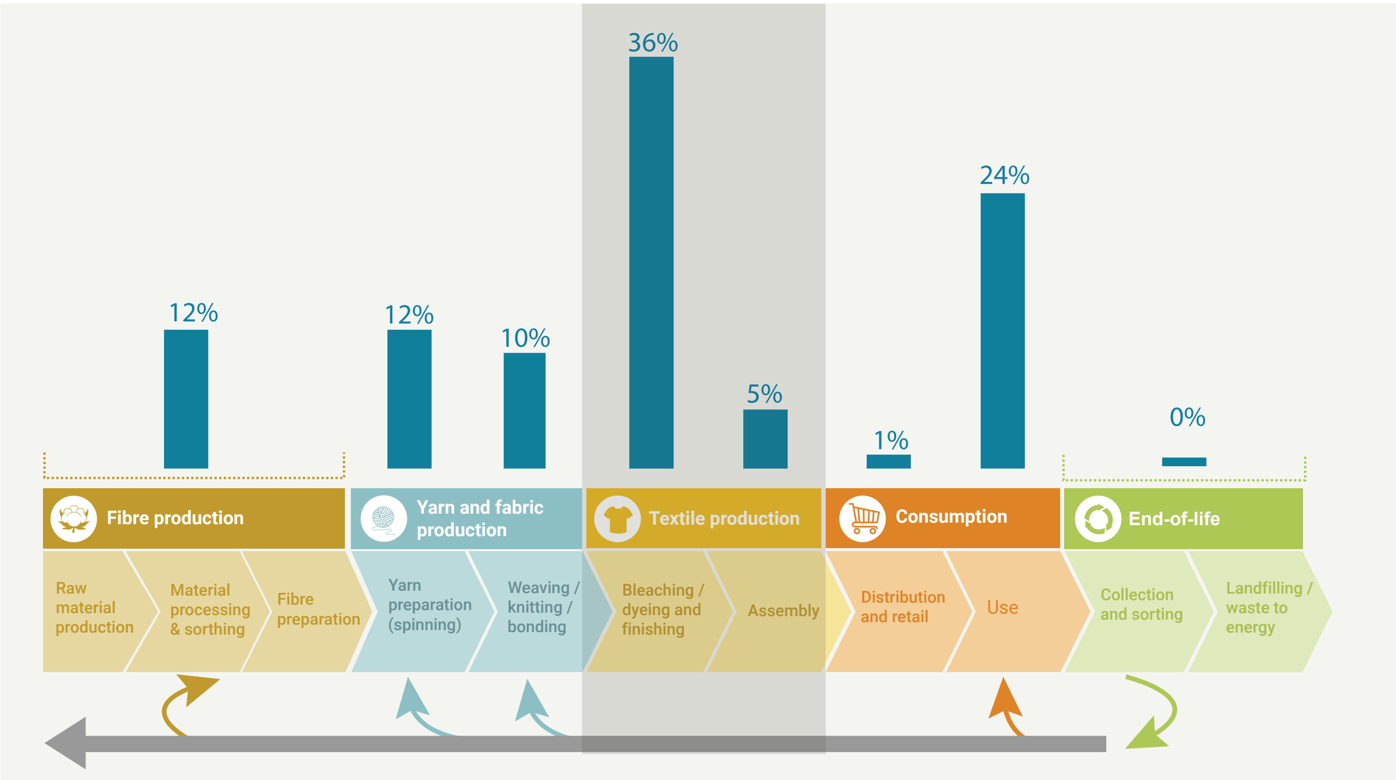
The textile sector is highly material-intensive, consuming around 109 million tonnes of fibres in 2020. The majority of these were synthetic fibres such as polyester (64 per cent), followed by cotton (24 per cent) (Quantis, 2018). In addition to raw materials, the industry requires substantial amounts of land, water, and chemicals, and contributes significantly to environmental pollution. It is estimated to account for around 20 per cent of global clean water pollution from dyeing and finishing processes, 3.5 per cent of global water scarcity, and 5 per cent of nutrient overload that disrupts marine and freshwater ecosystems. The sector is also responsible for nearly 3.5 per cent of global greenhouse gas emissions (Circle Economy, 2024; European Parliament, 2020).

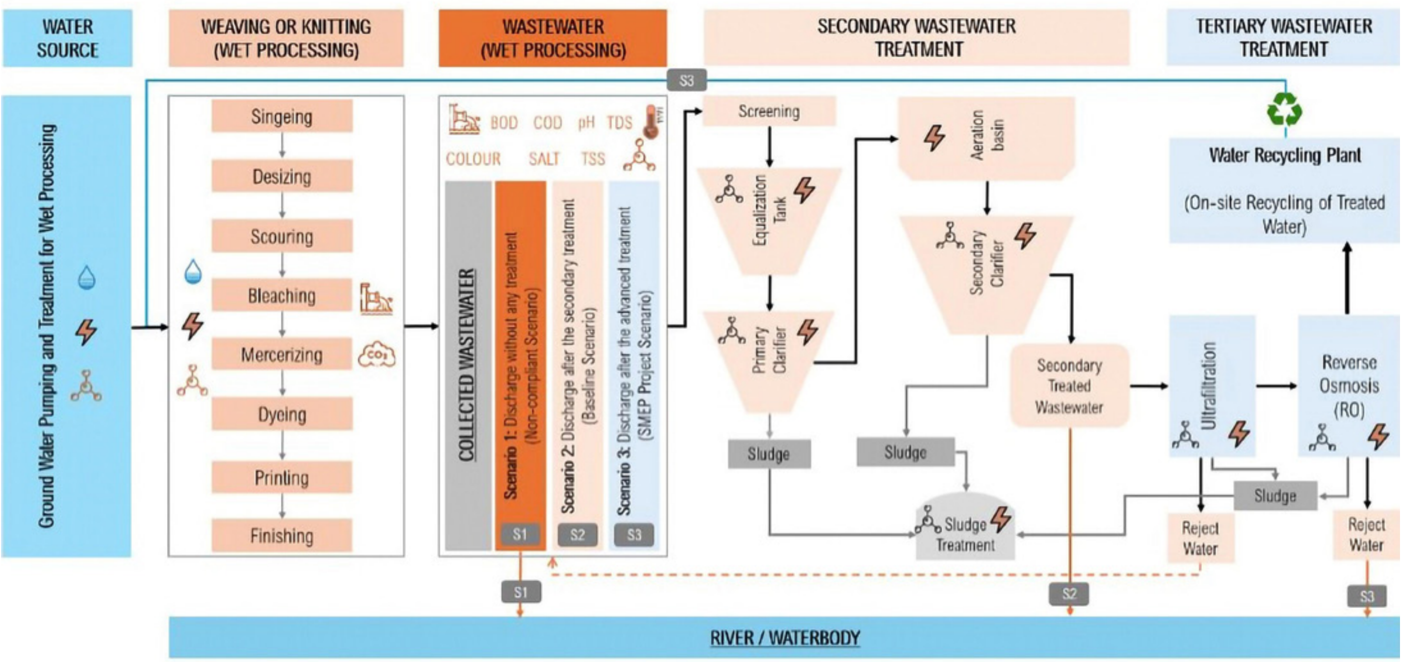
According to the European Environmental Agency 2023 report (EEA, 2023), the clothing of an average person in Europe in 2020 would represent about 400 square meters (m2) of land, 9 cubic meters (m^3) of fresh water and around 391kg of raw materials. The carbon footprint of fast fashion consumption is 11 times higher (2.50 $kgCO_2e$ for one wear jeans) than that of traditional fashion (Li, et al., 2024).

Comparing different phases of the value chain (including, production, logistics, consumption, and discarding processes), the manufacturing stage in textiles production would have the highest climate impact (41 per cent), followed by the use phase (25 per cent) as shown in Figure 1.

↓ Figure 1. **Climate impact across the global apparel value chain**

Source: UNEP (2022).





Potential Opportunities for the Reduction of Resource Use and GHG Emissions:

	Reduction of water demand by recycling of treated wastewater for on-side application and improving water efficiency in the wet processing		Reduction of chemical demands by optimising chemical uses and recovery of chemicals through advanced chemical recovery options
	Reduction of energy demand by improving energy efficiency and sourcing of on-site renewable energy (e.g. solar PVs, bioenergy from sludge)		Recovery of heat from the weaving and knitting process and from the wastewater through heat exchangers (e.g. Shell-and Tube or Plate)

↑ Figure 2. **Potential opportunities for the reduction of material use and GHG emissions**

Source: Adapted from Panda, et al., 2021 and Azanaw, et al., 2022

Instead of a linear fast fashion, circular design and manufacturing of textile and apparel- focus on more durable, repairable, reusable, and recyclable clothing, which would reduce the material inputs, create less pollution and result less GHG emissions. A detailed emission reduction opportunities mainly at the manufacturing phase is presented in Figure 2.

This technical brief examines the potential greenhouse gas (GHG) emissions reductions through water circularity and improving the water quality of industrial wastewater treatment in Bangladesh, one of the Sustainable Manufacturing and Environmental Pollution Programme (SMEP) projects funded by the UK Foreign, Commonwealth and Development Office (UK-FCDO) and partnership with the UN Trade and Development (UNCTAD). The scope of the GHG emissions reduction is part of the SMEP's reporting requirement of the International Climate Finance (ICF) KPI 6. The key assumptions of the GHG emissions are listed in Annex A3.

2.1. Sectoral GHG Emissions Reduction Opportunities

The GHG emissions in the textile manufacturing process mainly relate to energy use for processing textiles, and the resources (e.g., water) and chemicals used. Depending on the manufacturing countries, water used in the process is sourced from the local utilities, surface water (e.g., rivers), or groundwater.

The wastewater generated after wet processing in the textile industry is characterised by different pollutants depending on the processing stage (Panda, et al., 2021). Sizing/desizing generates high biological oxygen demand (BOD),[1] chemical oxygen demand (COD),[2] and surfactants. Scouring wastewater is alkaline, containing fats and oils. Bleaching contributes oxidizing agents and salts. Dyeing produces wastewater with colour, salts, heavy metals, and dye residues. Printing produces wastewater including thickeners, binders, and pigments, while finishing adds silicones and softeners to the effluent. Thus, various chemicals are used for treating the wastewater in a typical activated sludge wastewater treatment (WWT) plant.

1 Biochemical oxygen demand is a measure of the amount of dissolved oxygen consumed by microorganisms while decomposing organic matter in a water sample under aerobic conditions.

2 Chemical Oxygen Demand (COD) is a measure of the amount of oxygen required to chemically oxidize the organic compounds present in a water sample.

↑ Image 2. Untreated (left) and treated (right) wastewater samples from a textile manufacturing process, demonstrating the impact of advanced treatment on water quality and potential GHG emissions reduction.

The GHG emissions reduction consider both direct and indirect emissions related to advanced WWT. The direct emissions of the cased considered (Fakir Knitwear) include the emissions from the on-site biological treatment processes (mainly using the electricity to operate equipment) and sludge management, including landfills and on-site combustion of fossil fuels, such as diesel/ gas-powered electricity generation to run the factory and WWT (Scope 1). The indirect emission of Scope 2 emissions is likely to be the use of purchased electricity, heat, or steam consumed by treatment plants (US-EPA, 2025). There would be other indirect emissions, such as producing and transporting chemicals used in the treatment process and off-site sludge disposal (Scope 3 emissions). Regarding the secondary treatment phase, aeration[3] is one of the most critical and energy-intensive processes, consuming up to 50–60 per cent of the overall energy required by a WWT plant (Mendoza, 2023).

The circular economy opportunities and GHG emissions reduction benefits at the textile manufacturing stage could be achieved mainly by:

i. Reduction of energy demand by improving energy efficiency and sourcing of on-site renewable energy (e.g. solar PVs, bioenergy from sludge using Anaerobic Digestion);

ii. Recovery of heat from the weaving and knitting process and from the wastewater through heat exchangers (e.g. Shell-and-Tube or Plate heat exchangers);

iii. Reduction of water demand by recycling and reusing of treated wastewater for on-site application and improving water efficiency in the wet processing; and

iv. Reduction of chemicals demand by optimising uses and recovery through advanced chemical recovery options.

The realization of those strategies requires access to products and services which may not be all available in domestic markets. Therefore, enabling trade policy is essential when related products and components need to be imported.

3 Aeration is important in wastewater treatment to supply oxygen needed for the breakdown of organic matter, thereby reducing Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). If untreated, high COD and BOD levels can deplete oxygen in receiving water bodies, contributing to eutrophication and harming aquatic life.

← Image 3. Workers in the textile industry at Fakir Knitwear, Bangladesh.

3.

Fakir Knitwear's GHG Emission Reduction in Bangladesh
Case study

3.1. Textile industry in Bangladesh

Bangladesh, through commitments made in the Paris Agreement (2016), seeks a 5 per cent reduction (12 million tons CO_2e) in greenhouse gas emissions below the 'business-as-usual' level by 2030 as reflected in the country's Nationally Determined Contributions (NDCs). To achieve the emissions reduction targets, Bangladesh aims to achieve 40 per cent renewable energy by 2041, while reducing primary energy consumption per unit of GDP by 15 per cent by 2021 and 21 per cent by 2030 (MEFCC, 2021).

As the second-largest apparel exporter globally (after China) Bangladesh's textile industry accounts for 84 per cent of the nation's exports and contributes approximately 12 per cent to the country's GDP, while employing over 4 million people.[4] At the same time, the textile and apparel sectors are responsible for about 8.2 per cent of national electricity consumption (Khatun and Bari, 2024) and withdrawal of an estimated 1,500 billion litres of water annually for industrial processes (IFC, 2018). Additionally, these sectors contribute approximately 12.4 per cent and 15.4 per cent of the country's greenhouse gas (GHG) emissions, respectively (Light Castle, 2024).[5]

Bangladesh has also committed to achieving the Sustainable Development Goals (SDGs), particularly: ensuring access to safe water and sanitation for all (SDG 6); promoting clean and renewable energy through a just transition (SDG 7); advancing sustainable consumption and production via resource efficiency (SDG 12); and supporting climate mitigation and adaptation (SDG 13). As part of its commitment to a just transition for decarbonising the energy and industrial sectors, and to future-proof Bangladesh's position in the global supply chain, the industry is working to increase the number of LEED-certified factories (targeting 3,500 factories by 2030), promote green exports and sustainability standards, and expand renewable energy installations across manufacturing and industrial zones (ILO, 2023).

4 For more information about key statistics and trends in the textile industry in Bangladesh, visit: https://wifitalents.com/bangladesh-textile-industry-statistics/.

5 For more information about sustainability and emission reduction strategies in Bangladesh's garment industry, visit: https://lightcastlepartners.com/insights/2024/11/green-rmg-bangladesh/.

3.2. Fakir Knitwear's background and facts

The Fakir Knitwear Project in Bangladesh aims to promote water reuse in garment factories and demonstrate a business case for scaling up improved wastewater recycling in brands' supply chains. Panta Rei is deploying advanced wastewater treatment and water recovery systems through ultrafiltration and reverse osmosis (RO), at Fakir Knitwear. Simultaneously, Grundfos is enhancing the efficiency of four water pumps at the site. In parallel, the consortium is supporting the Primark-funded Energy Resources Integration (ERI) resource efficiency program, which aims to reduce water usage, improve energy efficiency, and lower the chemical content in wastewater. These combined efforts seek to limit pollution and offset the additional energy demands associated with the project's water treatment processes.

Table 1. Key details of the Fakir Knitwear factory in Bangladesh

Factory	Fakir Knitwear
Location	Bangladesh
Leading retail brands	Primark; H&M
Treatment technology	Ultrafiltration; reverse osmosis (RO)
Treatment provider	Grundfos; Panta Rei in collaboration with WaterAid
Annual water use	432,000 m^3

3.3. The baseline scenario for wastewater treatment and discharge

The industrial wastewater treatment in Bangladesh is regulated under various regulatory policies (including Bangladesh Environment Conservation Act, Rules, National Water and Environmental policies, Sector-specific Standards and Guidelines), developed and implemented the Department of Environment (DoE), Ministry of Environment, Forest and Climate Change, the Government of Bangladesh. The GHG emissions reductions from the wastewater treatment have been considered under three scenarios, aligning and meeting the local regulatory requirements (as shown in Figure 2):

i. Scenario 1 (S1): Discharge without any treatment (Non-compliant Scenario),

ii. Scenario 2 (S2): Discharge after the secondary treatment (Baseline Scenario), and

iii. Scenario 3 (S3): Discharge after the advanced treatment (SMEP Project Scenario).

In the non-compliant scenario, wastewater is discharged without any treatment, mainly by factories that are non-compliant with local regulations, leading to severe environmental pollution. In the context of Fakir Knitwear, under the worst-case scenarios, all of the wastewater from the existing effluent treatment plant would have been released as discharge into the Meghna River, which flows past Dhaka city into the Bay of Bengal.

Under the baseline scenario (complaint under the local regulations, listed in Annex A1), wastewater is discharged after secondary treatment, which is often the standard required by local regulatory bodies. The secondary treatment considerably reduces organic matter and suspended solids, though some pollutants may remain (acceptable limits shown in Annex A2a and A2b) while discharged into the Meghna River.

Conversely, the SMEP Project scenario utilises advanced treatment, producing very high-quality water suitable for recycling and reuse, thereby minimising environmental impact and promoting water conservation beyond current standards. Treated wastewater is then discharged to the river (under ZDHC regulations - NEP 2018).

3.4. Potential GHG emissions reduction

SMEP Programme's Fakir Knitwear Project

↑ Image 4. Haze over Dhaka's skyline, seen from the Buriganga River in March 2024, highlighting industrial pollution that SMEP Programme projects aim to mitigate.

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Fakir Knitwear is one of the established textile factories in Bangladesh, with no further expansion plan. The annual water consumption and the generated wastewater of the factory are 432,000 m^3, which is expected to remain the same in the next 7 years (duration of the SMEP Project). Thus, during the entire SMEP program of 7 years, Panta Rei (6 years of RO in operation) will treat around 2,592,000 m^3 of wastewater. Thus, the core water-related emissions at Fakir Knitwear have been considered as emissions from (a) wastewater discharge, (b) groundwater pumping and (c) groundwater softening. The reduction of emissions during the SMEP project is shown in Table 2.

This recirculation of treated wastewater back into production halves the demand for the electricity from groundwater pumping for factory use. The carbon intensity of Bangladesh's grid-level electricity is 0.61 $kgCO_2/kWh$; therefore, any reduction in electricity demand from decreased groundwater pumping results in emissions savings at a rate of 0.61 $kgCO_2$ for each kilowatt-hour of electricity saved. In addition, Panta Rei's treated wastewater offsets the need for softening agents (with an emission factor of ~0.58 tCO_2e per year) for the groundwater treatment (naturally very hard, requiring lime or other softening agents) before the wet processing.

Thus, the SMEP project at Fakir Knitwear would save a total of 1,296,000 m^3 of water withdrawal from the ground (SMEP Program 2024-2031), along with the savings from not requiring the softening agents for the groundwater treatment, resulting in a total GHG reduction of 46,202 tCO_2e (baseline S2) and 78,521 tCO_2e (non-compliant S1). This accounts for around 18 $kgCO_2e/m^3$ of water (baseline scenario) to 30 $kgCO_2e/m^3$ of water (non-compliant scenario) of GHG reduction opportunity using advanced WWT.

↓ *Note: Estimated by the authors, considering a 5 per cent efficiency loss, as per IPCC standards.*

Table 2. Estimated emissions savings at Fakir Knitwear through SMEP-supported wastewater recovery (tCO_2e)

	2024–25	2025–26	2026–27	2027–28	2028–29	2029–30	2030–31	Total
Non-compliant scenario (S1)	—	14104	14104	14104	14104	14104	14104	84621
Baseline scenario (S2)	—	8434	8434	8434	8434	8434	8434	50601
SMEP-supported scenario (S3)	—	328	328	328	328	328	328	1967
Emission savings vs. (S1)*	—	13087	13087	13087	13087	13087	13087	78521
Emission savings vs. (S2)*	—	7700	7700	7700	7700	7700	7700	46202

3.5. The sectoral implications of the GHG reductions

As a global hub of textile and readymade garments manufacturing, Bangladesh hosts around 1,430 textile mills and 240 dying, printing and finishing mills (BIDA, 2024). To contextualise the sectoral relevance on a national scale, textile mills were expected to produce around **349 million m^3 of wastewater in 2021** (Hossain, et al., 2018).

In a scenario where only 25 per cent of the wastewater from textile mills becomes treated by an advanced WWT, similar to Fakir Knitwear, that would avoid GHG emissions in the order of 1,555,218 tonnes (S2) to 2,643,116 tonnes (S1) each year, **representing 4 per cent to 7 per cent of NDC's emissions reduction targets by 2030**. This would also **save around 43,625,000 m^3 of precious groundwater**, which is critical for water insecure countries like Bangladesh (UNCTAD, 2025).

In addition to water reuse and avoided emission reductions, the pilot project also offers economic benefits by saving electricity and softening chemicals, as well as environmental benefits by reducing pollution and bio-/chemical oxygen demand. However, limitations such as high upfront costs, technical complexity, and shortages of skilled labour, particularly in the Global South, need to be considered some trade-offs, including increased sludge production, to minimise hindrances to implementation and sectoral uptake of the technology.

Further GHG emissions reductions (and other benefits) can be achieved by adopting additional practices in future treatment systems built for the sector. Biological treatment, such as with anaerobic digesters, constructed wetlands, and activated sludge (aerobic digestion), may lower the impact of pollution and emissions from wastewater and sludge production by reducing the organic matter and nutrient load. Low operational costs and potential for use of byproducts (as an energy source or additional income stream) make these methods suitable in this context, and manufacturers could share the nontrivial setup cost. In cases where heavy and toxic metals or residual inorganics would be discarded by a textile manufacturer after the filtration and biological treatments, chemical treatment methods like precipitation or coagulation and flocculation can enhance the treatment system. Chemical treatments may be selectively used where the cost is justifiable, such as to prevent toxic dyes, non-biodegradable organics, or heavy metals from disrupting filtration and biological treatments. Targeted precipitation or coagulation can also help stabilise reverse osmosis concentrate or sludge, ensuring safer disposal and enhancing the overall efficiency and sustainability of the treatment system.

Given the environmental benefits (reduction of pollution and GHG emissions) of the textile manufacturing of the SMEP's pilot project, the case study offers an excellent opportunity for regional and global relevance to replicate similar approaches to other top textile-producing countries, particularly in the Global South. Moreover, considering the total expenditure (US$ $1.53 m) of advanced WWT of the Panta Rei technology, it provides around 30.3kg/US$ (S2) and 51.5kg/US$ (S1) emissions reduction efficiency per US$ spent in the wastewater treatment technology.

3.6. Co-benefits and trade-offs

Advanced WWT technologies offer numerous environmental, social, and economic co-benefits while reducing GHG emissions. Environmentally, it produces cleaner water bodies by removing pollutants such as heavy metals, microplastics, and excess nutrients. This enables subsequent usage in applications such as regenerative agriculture. Advanced treatment also facilitates water reuse in industrial operations, conserving groundwater resources. Moreover, shifting to renewable energy reduces harmful air emissions, while anaerobic digestion turns waste into valuable resources like biogas and biofertilisers.

Socially, decarbonisation can reduce utility costs for industries and households through energy efficiency and renewable energy use. It also enhances public health by cutting air and water pollution and stimulates green job creation in the engineering and agriculture sectors. These social gains are especially relevant in regions facing employment and health disparities.

Economically, benefits include lower operational costs, improved industrial competitiveness, and new revenue streams from carbon credits and resource recovery. These drivers can stimulate technological innovation and create markets for sustainable products and services, positioning industries for long-term viability in a low-carbon economy.

However, several trade-offs must be addressed. High upfront costs, technical complexity, and skilled labour shortages, particularly in the Global South, can hinder implementation. Regulatory gaps and competition for finite resources may also pose barriers. Addressing these challenges requires coordinated policy, financing mechanisms, and capacity-building to ensure inclusive and effective transitions.

↓ Image 5. Industrial wastewater treatment generates substantial amounts of sludge. This enables subsequent usage in applications such as agriculture.

4.

Policy implications
Sectoral and national

4.1. Linkages to sectoral decarbonisation and national relevance

Textile sector plays a significant role in Bangladesh's national decarbonisation strategies. Bangladesh NDCs in 2022 (MEFCC, 2022) put a sector-specific action plan for industrial energy efficiency, including textiles and leather (because it covers 24 per cent of GHG emissions from manufacturing sub-sectors). If the SMEP-supported initiative was to be scaled to treat only 25 per cent of the total wastewater generated in the Bangladesh textile industry, this would save annually around 4 per cent to 7 per cent of the NDC's emissions reduction targets by 2030 and save around 43,625,000 m^3 of precious groundwater in Bangladesh.

Considering the various opportunities outlined in the SMEP project at Fakir Knitwear case study, particularly through reducing the sectoral energy demand by halving the ground water demand through reuse of treated wastewater and by halving the demand for softening agents and avoiding their applications in the groundwater treatment, the SMEP Panta Rei project at Fakir Knitwear in Bangladesh shows a significant sectoral and national decarbonisation benefits as well as economic benefits.

A list of 12 national and sectoral regulatory policies, strategies and action plans in Bangladesh were rated (from high, medium, low and not relevant categories) against the quantified and non-quantified SMEP project's benefits. It shows that SMEP Project's outcomes are highly supporting and aligning with all 12 national and sectoral policies and strategies as shown in Annex A4.

4.2. Potential for replications, partnerships and financial mechanisms

The project is highly relevant for regional and global contexts, since the majority of the textiles producing countries (Top 10) are from Asia (China, Bangladesh, Vietnam, India, Pakistan etc.), Europe (Germany, Turkey, Italy, Spain, etc.) and the USA.[6] Countries like Bangladesh, India, Pakistan, and China face significant water pollution and emissions challenges.

The replication of similar project widely to transform the textile sector in Bangladesh and other countries (mainly in South Asia), would require financial support and partnerships between various actors in the textile sector, including, labours, manufacturers, regulatory bodies, buyers/retail brands, global agencies including aid and financial institutions.

Different financial and governance mechanisms should be considered to uptake similar initiatives in Bangladesh and other countries, including international climate and development financial mechanisms, national, governmental and institutional mechanisms. Also, the sectoral transformation requires technology transfer, technical support and capacity building to ensure appropriate implementation planning and maximising the decarbonisation goals.

Securing finance is undoubtedly one of the biggest challenges for scaling up such a business. Despite various constraints, there are several initiatives that could be beneficial for the relevant stakeholders in accessing necessary funds and financial support. Table 3 shows the potential options for sectoral, national and international financial and governance mechanisms to the uptake of the SMEP project in Bangladesh and other countries.

6 For more information about the top textile manufacturing countries in 2024, visit: https://www.royaleuropetextile.com/top-10-textile-manufacturing-countries-in-the-world-fy-2024-update/.

Table 3. Potential sectoral, national and international financial and governance mechanisms

Type of initiatives	Mechanisms/Funds	Scope/Applicability
International Climate and Development Financing Mechanisms	Green Climate Fund (GCF)	GCF is highly relevant to the textile sector, and it has already funded textile and RMG energy efficiency projects in Bangladesh. It could support wastewater treatment, circular economy, and emissions reductions.
	Global Environment Facility (GEF)	Potential for wastewater quality improvement, sludge management, and clean production.
	NAMA Facility	Suitable for replicating ETP and RO-based interventions at industrial clusters.
	Climate Investment Funds (CIF)	Supports scaled-up financing for low-carbon and climate-resilient development. Could support wastewater reuse and renewable-powered ETPs.
	UNDP/UNIDO Programmes	Technical support and funding for the green industry and clean technology.
National Financial Mechanisms	Bangladesh Bank Green Transformation Fund (GTF)	Offers low-cost finance for green infrastructure, including water treatment and energy efficiency in export-oriented industries.
	Infrastructure Development Company Limited (IDCOL)	Public-private financing agency supporting renewable energy and green infrastructure projects (co-finance mechanism).
	Export Promotion Bureau (EPB) Green Incentives	Potential incentives for exporters with green credentials (e.g., LEED-certified, water-efficient).
Governance & Institutional Mechanisms	Public-Private Partnerships (PPPs)	Reduces capital burden on individual SMEs; useful in industrial clusters.
	Green Industrial Zones / Eco-Industrial Parks	Promotes circular infrastructure and cost-sharing models.
	Environmental Compliance Bonds / Performance-based Incentives	Can link to ICF/SMEP metrics, e.g., GHG reductions per m^3 treated water.
Voluntary and Private-Sector Mechanisms	Sustainability-Linked Loans (SLLs)	International brands may support suppliers with SLLs for upgrading ETPs.
	Green Bonds or Blue Bonds	Could be issued by local banks, with textile sector as a focus.
	Brand-Supplier Sustainability Programs	A powerful mechanism for scaling green practices via supply chain mandates.
Technical and Capacity Building Mechanisms	Climate Technology Centre and Network (CTCN)	Support technology roadmaps for textile wastewater reuse.
	International Climate Finance KPI Frameworks (e.g., ICF KPI 6)	Ensures future project proposals are results-based and aligned with donor expectations.

↑ *Source: Compiled by authors.*

5.

Key policy recommendations for GHG mitigation in the textile sector

Although the project has been demonstrated only in one factory in Bangladesh, it has surely confirmed its merit and consideration for scaling up a similar program in Bangladesh and replicating it in other textile manufacturing countries. The following key policy considerations may support the uptake of the SMEP wastewater reuse project in the textile industry:

GOVERNMENTS

Integrating the circular economy principles (e.g. wastewater reuse, sludge-to-energy) into national industrial, water, and climate policies to support achieving GHG reduction targets aligning with the Nationally Determined Contributions (NDCs). Performance-based green subsidies, tax incentives, trade facilitation for key components and environmental compliance bonds for factories would enable the wider adoption of the advanced WWT in the textile industry.

Accelerate green industrial zones, which enable co-finance and co-investment in the infrastructure of advanced WWT and renewable energy pooling in industrial clusters to reduce the cost burdens.

Develop a national digital dashboard for monitoring and certifying pollution and emissions reduction targets linked to the performance-based subsidies.

PRIVATE COMPANIES AND INDUSTRIES

Including brands & technology providers

Encourage and enable public-private partnerships (PPPs) for co-investment models with the technology providers. Ensure wastewater treatment and GHG reduction as part of supplier sustainability scorecards and procurement criteria.

Support technology adoption and innovation by collaborating with international and local technology providers to share knowledge, build local capacity and find affordable solutions.

Enable the ecosystem to share knowledge and technologies and build local capacities to support South-South partnerships and North-South collaboration for technology transfer.

INTERNATIONAL AGENCIES AND DONORS

Leverage climate and green funds to support sectoral and regional replication of wastewater reuse and energy efficiency in textiles and support demonstration projects to validate locally adapted circular wastewater treatment technologies.

Facilitate multi-stakeholder platforms involving governments, industry, financial institutions, and NGOs to support circular economy initiatives and capacity building for institutional and technical readiness and facilitated technology transfer while ensuring transparency, replicability and accountability, maintaining expected sustainability standards and monitoring mechanisms.

References

Azanaw, A., Birlie, B., Teshome, B., & Jemberie, M. (2022). *Textile effluent treatment methods and eco-friendly resolution of textile wastewater*. Case Studies in Chemical and Environmental Engineering, 6, 100230.

Circle Economy (2024). *The Circularity Gap Report: Textile.* The Circle Economy Foundation: news. Available at: https://www.circle-economy.com/news/just-0-3-of-materials-used-by-the-global-textile-industry-come-from-recycled-sources-with-almost-no-textile-to-textile-recycling/.

European Environmental Agency (EEA) (2023). *ETC CE Report 2023/8: Consumption and the environment in Europe's circular economy*. European Environmental Agency. Available at: https://www.eionet.europa.eu/etcs/etc-ce/products/etc-ce-report-2023-8-consumption-and-the-environment-in-europe2019s-circular-economy/.

European Parliament (2020). *The impact of textile production and waste on the environment (infographics).* Available at: https://www.europarl.europa.eu/topics/en/article/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographics#:~:text=Textile%20production%20is%20estimated%20to,up%20in%20the%20food%20chain/.

Hossain, L., Sarker, S.K., and Khan, M.S. (2018). *Evaluation of present and future wastewater impacts of textile dyeing industries in Bangladesh.* Environmental Development, 26, pp. 23–33. Available at: https://doi.org/10.1016/j.envdev.2018.03.005/.

International Finance Corporation (IFC) (2023). *Bangladesh's textile sector weaves a clean, sustainable future.* International Finance Corporation. Available at: https://www.ifc.org/en/stories/2010/clean-sustainable-bangladesh-textile/.

International Labour Organization (ILO) (2023). *A just transition in the textile and garment sector in Bangladesh: Technical stakeholder workshop*. Organized by the International Labour Organization on 31 October 2022, Intercontinental Hotel, Dhaka. Available at: https://www.ilo.org/media/240086/download/.

Khatun, F., and Bari, E. (2024). *Prospect of renewable energy transition in Bangladesh's RMG industry.* Centre for Policy Dialogue (CPD). Available at: https://cpd.org.bd/resources/2024/05/Prospect-of-Renewable-Energy-Transition-in-Bangladeshs-RMG-Industry.pdf/.

Li, Z., Zhou, Y., Zhao, M., Guan, D., and Yang, Z. (2024). *The carbon footprint of fast fashion consumption and mitigation strategies: A case study of jeans.* Science of The Total Environment, 924, 171508. Available at: https://doi.org/10.1016/j.scitotenv.2024.171508/.

LightCastle Partners (2024). *Defining 'green' for the context of the RMG sector in Bangladesh.* LightCastle Partners. Available at: https://lightcastlepartners.com/insights/2024/11/green-rmg-bangladesh/.

Mendoza, E. (2023). *How does the aeration process in wastewater treatment work to consume organics?* Fehr Graham Engineering and Environment. Available at: https://www.fehrgraham.com/about-us/blog/how-does-the-aeration-process-in-wastewater-treatment-work-to-consume-organics-fg/.

Ministry of Environment, Forest and Climate Change (MEFCC) (2021). *Nationally determined contributions (NDCs) 2021: Bangladesh.* Government of the People's Republic of Bangladesh. Available at: https://unfccc.int/sites/default/files/NDC/2022-06/NDC_submission_20210826revised.pdf/.

Ministry of Environment, Forest and Climate Change (MEFCC) (2022). *Roadmap and action plan for implementing Bangladesh NDC: Transport, power and industry sectors.* Government of the People's Republic of Bangladesh. Available at: https://unfccc.int/sites/default/files/NDC/2022-06/NDC_submission_20210826revised.pdf/.

Panda, S.K.B.C., Sen, K., and Mukhopadhyay, S. (2021). *Sustainable pretreatments in textile wet processing.* Journal of Cleaner Production, 329, 129725. Available at: https://doi.org/10.1016/j.jclepro.2021.129725/.

Qu, S., Hu, Y., Wei, R., Yu, K., Liu, Z., Zhou, Q., Wang, C. and Zhang, L. (2024). *Carbon footprint drivers in China's municipal wastewater treatment plants and mitigation opportunities through electricity and chemical efficiency.* Engineering. Available at: https://doi.org/10.1016/j.eng.2024.01.021/.

Quantis (2018). *Measuring fashion: Environmental impact of the global apparel and footwear industries.* Quantis. Available at: https://quantis.com/measuring-fashion-report-2018/.

United Nations Environment Programme (UNEP) (2020). *Sustainability and circularity in the textile value chain: Global stocktaking.* United Nations Environment Programme. Available at: https://circulareconomy.europa.eu/platform/sites/default/files/2023-12/Full%20Report%20-%20UNEP%20Sustainability%20and%20Circularity%20in%20the%20Textile%20Value%20Chain%20A%20Global%20Roadmap_0.pdf/.

United Nations Trade and Development (UNCTAD) (2025). *Liquid asset: Rethinking water use in global manufacturing powerhouses.* UN Trade and Development (UNCTAD). Available at: https://unctad.org/news/liquid-asset-rethinking-water-use-global-manufacturing-powerhouses/.

United States Environmental Protection Agency (US-EPA) (2025). *Scope 1 and Scope 2 inventory guidance*. United States Environmental Protection Agency. Available at: https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance/.

Annex A1

The regulations related to the water quality and wastewater treatment in Bangladesh

Relevant regulations	Key requirements	Sources
Bangladesh Environment Conservation Act (BECA), 1995 and 2010 **Environment Conservation Rules (ECR), 1997**	BECA serves as the foundational environmental legislation in Bangladesh, aiming to conserve the environment, improve environmental standards, and control pollution. BECA mandates that industries, including textiles, must obtain Environmental Clearance Certificates (ECC) and adhere to environmental standards set by the Department of Environment (DoE). The ECR 2010 include the mandatory sludge management and installation of an effluent treatment plant for industries.	DoE (1995)
National Water Policy (NWP), 1999	The NWP provides a framework for the development and management of water resources, emphasising efficient and equitable water use. It encourages the textile industry to adopt water-saving technologies and practices to minimise water pollution.	GoB (1999)
Bangladesh Standards and Guidelines for Sludge Management, 2015	Depending on the origin, the wastewater sludge is categorised as A (municipal sludge), B (from CETP) and C (from CETP with hazardous nature), which required to follow specific management options and meeting the environmental standards (e.g. substances, heavy metals, etc.), such as, aerobic digestion, composting and agricultural use for category A sludge, controlled landfill, thermal incineration land application (e.g. filling materials) and recycling in brick, cement or asphalt making for category B and only controlled landfill and thermal incineration for category C.	DoE (2015)
National Environmental Policy-NEP, 2018	The NEP aims to integrate environmental considerations into all development activities, promoting sustainable practices across sectors. The policy supports initiatives like cleaner production and zero discharge of hazardous chemicals (ZDHC) in the textile sector.	MEFCC (2018)
The Environmental Conservation Rules (ECR), 2023 SPECIFIC STANDARDS FOR TEXTILE WASTEWATER DISCHARGE	The ECR rules set the maximum limits of wastewater quality before discharge. The maximum limit for colour is set to 150 Hazen (Pt-Co), for COD it is 200 mg/L., and the temperature of the wastewater cannot be more than 5 °C above the temperature of the water body where it will be discharged.	DoE (2023)

Annex A2

Textile wastewater quality standards in Bangladesh

The Environmental Conservation Rules (ECR), 2023

Table A2a. Potential sectoral, national and international financial and governance mechanisms

Parameter	Unit	Maximum limit
pH	—	6-9
Color	Hazen (Pt-Co)	150
Temperature	°C	Maximum 5 °C above the temperature of the water body
Suspended Solids (SS)	mg/L	100
(BOD5 at 20 °C)	mg/L	30
COD	mg/L	200
Total Dissolved Solid (TDS)	mg/L	2100
Oil & Grease	mg/L	10

Table A2b. Maximum limits for some dyes & pigment components (ECR, 2023)

Parameter	Unit	Maximum limit
Chromium (Cr)	mg/L	0.5
Sulfide (S)	mg/L	2.0
Phenol Compounds	mg/L	1.0
Lead (Pb)	mg/L	0.1
Cadmium (Cd)	mg/L	0.02
Cobalt (Co)	mg/L	0.5
Nickel (Ni)	mg/L	1.0

Annex A3

Technical assumptions and boundaries

The methane emissions from wastewater were quantified by considering the IPCC guidelines.[7] For the ground water softening, a dose of 54.1 g/kg of textile for Soda Ash (Sodium Carbonate) assumed for groundwater softening.

NOTES AND ASSUMPTIONS

- The emission reduction potentials have been considered from:
    - water reuse and electrical efficiency.
    - avoided dumping and incineration of textiles.
- Incineration of textile waste calculated based on 2006 IPCC guidelines, Vol 5, Chapters 2 and 5.
- Organic loads of wastewater for the projects is unknown, sourced from IPCC guidelines.
- The amount of organic matter removed as sludge is conservatively assumed to be 30 per cent.
- For textiles, COD is assumed to be similar to that for organic chemicals due to the application and working with dyes.
- A working year is assumed to have 260 working days, each of which is 8 hours long. Relevant for hourly/daily wastewater generation volumes.
- Approximately 119 litters of wastewater is generated per kg of fabric.
- Average energy consumption across 15 factories in Bangladesh estimated at 2.58 kWh/kg of fabric.
- Panta Rei expect to use a maximum of 44,790 kWh per month for their operations.
- A 95 per cent additionality parameter was applied as per KPI 6 guidelines.
- Bangladesh Environment Conservation Act (BECA), 1995 and BECA (2010)

7 Based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, Chapter 6 (Wastewater treatment and discharge). Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf/.

Annex A4

Relevance of SMEP projects to Bangladesh's national and sectoral policies, strategies, and action plans

Relevant regulations	1	2	3	4	5	6	7	8	9	10	11	12
Reduction of GHG emissions	Medium	Medium	Medium	Low	High	High	High	High	High	High	Medium	Medium
Reuse of industrial wastewater	Medium	High	High	Medium	High	High	Medium	Low	Medium	High	Low	Medium
Reduction of groundwater demand	Medium	Medium	High	Low	High	High	Medium	Medium	Medium	High	Medium	Medium
Reduction of chemical demands for groundwater treatment	Low	Medium	Medium	High	Medium	High	Low	High	Medium	Medium	Low	High
Potentials for heat recovery	High	High	Medium	Medium	High	High	Medium	Low	Medium	Medium	Low	High
Potentials for chemicals (e.g. Salt) recovery	Low	Medium	Medium	High	Medium	High	Low	High	Medium	High	Medium	High
Bioenergy from sludge	Medium	Medium	Low	High	Medium	Medium	Low	Medium	High	High	Medium	High

1. Bangladesh Environment Conservation Act (BECA), 1995 and 2010
2. Environment Conservation Rules (ECR), 1997
3. National Water Policy (NWP), 1999
4. Bangladesh Standards and Guidelines for Sludge Management, 2015
5. National Environmental Policy (NEP), 2018
6. The Environmental Conservation Rules (ECR), 2023
7. Nationally Determined Contributions (NDCs), 2022
8. Energy Efficiency Action Plan
9. Bangladesh Climate Change Strategy and Action Plan (BCCSAP)
10. Circular Economy Roadmap/Initiatives
11. National Industrial Policy, 2016
12. DoE Guidelines on Sludge and Chemical Management, 2015

Low   Medium   High

Sustainable
Manufacturing and
Environmental
Pollution
Programme

UK International
Development
Partnership | Progress | Prosperity