A REVIEW OF CIRCULAR ECONOMY IN WATER SECURITY AND SUSTAINABILITY: A CASE STUDY OF BANGLADESH TEXTILE AND GARMENTS INDUSTRY

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ABSTRACT

Bangladesh, the second-largest exporter of readymade apparel globally after China, has an intrinsic robust production capacity, quality and growth. The garment sector in Bangladesh comprises a significant portion, accounting for over 83% of the country's overall exports, with a value exceeding 33 billion USD in the year 2019. Furthermore, Bangladesh's apparel industry commands a market share of 6% in the global exports of apparel. However, the relatively 'cost-friendly' manufacturing processes poses a serious environmental threat. The textile and apparel industries in Bangladesh utilize 250-300 liters of water every kilogram of cloth which is approximately equal to the daily water use of two individuals. Over the past few decades, there has been a notable change in focus towards addressing sustainable production concerns, with a particular emphasis on water and energy. Circular Economy (CE) is a sustainable development concept that reduces, reuses, recycles, and recovers waste. CE evolved from the ‘take-make-waste’ approach of linear economy concept and takes into consideration of reducing waste and pollution, recirculating resources and regenarating nature. CE has been extensively studied in electrical, construction, automotive, and other areas. Nonetheless, because to the linear strategy that is currently in use and the imbalance in water supplies, CE has received rapid attention in the water sector. The comparatively newer concept of circular economy has the potential to be empolyed at the the textile and garment sector in Bangladesh in order to establish innovative pathways to efficiently utilize the limitied water resources. This study focuses on the integration of CE in the textile and garment sector in Bangladesh, and its challenges and opportunities in water security and sustainability.

Keywords: *Circular Economy, Water, Wastewater, Sustainability, Bangladesh*

1. INTRODUCTION

The majority of Bangladesh's exports consist of food items, chemicals, footwear, headgear, animal hides, textiles and readymade clothing, etc. (Observatory of Economic Complexity (OEC), n.d.). Among these items, Bangladesh's textile industry accounts for 13% of GDP and 84% of all export earnings. Millions of people's lives have improved, and the country's economy has grown as a result of Bangladesh's growing textile sector (Mamun, 2022). Bangladesh is currently the second-largest exporter of clothing in the world, behind China (Khairul Akter et al., 2022) and it has recovered its status as the second-largest clothing exporter in the world, despite some setbacks during the pandemic (Hassan, 2021; Oishee, 2021). The industry accounts for over 80% of the nation's export revenue, 10% of its GDP, and employs about 4 million people, the majority of whom are women (Better Work Bangladesh, 2019). The primary products of this industry include home textiles, denim, solid fabric, yarn-dyed fabric, cotton products of all sorts, 5 to 100 counts yarn for knitting and weaving, synthetic and filament yarn, and flax yarn (BTMA Annual Report 2022 - Bangladesh Textile Mills Association (BTMA), n.d.). After food, housing, and transportation, textiles are the category with the fourth-highest strain on the use of main raw materials and water, and the fifth-highest pressure on greenhouse gas emissions (European Environment Agency., n.d.). Water use and pollution from the textile sector are among the world's highest (Takahashi & Kumagai, 2006). Due to misuse and improper treatment, water scarcity and contamination of the environment have gotten worse, while the amount of water needed for industrial purposes worldwide is increasing at an alarming rate (Rather et al., 2018). From an environmental standpoint, according to Environmental Performance Index, Bangladesh is regarded as one of the most polluting nations in the world, coming in at position 177 out of 180. Approximately 28% of the country's deaths are due to air and water pollution (Bangladesh | Environmental Performance Index, n.d.). Despite being one of the largest global consumer goods industries, the textile sector is also the most polluting one (Koszewska, 2018; Siju et al., n.d.). Concerns about the environment include solid waste, non-renewable energy consumption, water and chemical use, and carbon emissions (Koszewska, 2018). Due to the conflict between these two trends, industrial producers are forced to use cleaner manufacturing techniques in order to conserve water and lessen pollution in the water. Local and regional water bodies are greatly impacted by the use of chemicals and additives in the textile industry (Manshoven et al., 2019).

The idea that an organization needs to consider all of the contexts in which it functions in order to be essentially sustainable over the long run has gained traction based on Elkington's triple bottom line (Elkington, 1998). This covers the social, ecological, and economic aspects of sustainability—also known as people, planet, and profit (Amini & Bienstock, 2014). A sustainable textile system should minimize any negative effects on the environment and society while respecting the planet's carrying capacity (Manshoven et al., 2019). Due to growing environmental concerns, textile companies are primarily motivated to implement circular economy practices to expand their enterprise's visibility and capitalize on their strong export potential (Partal et al., 2022). A systems-based strategy called the "circular economy" seeks to decrease waste and increase the lifespan of materials and goods. According to Ellen MacArthur Foundation, a circular textiles system can be defined as "restorative and regenerative by design and provides benefits for business, society and environment. A system in which clothes, fabrics and fibres are kept at their highest value during use, and re-enter the economy after use, never ending up as waste. In the near future, the main priorities are to improve working conditions and supply chain traceability while putting efficiency measures in place to cut down on the usage of energy, water, and chemicals.

1.1 State of the clothing and textile industry in Bangladesh

In general, Bangladesh's manufacturers can be divided into three categories: fully integrated manufacturing, which involves factories that import cotton and then proceed to import yarn and fabric to complete the remaining steps in the garment manufacturing process; factories that import fabric and assemble it into garments (a process also referred to as cut-make-trim) (Fernandez-Stark et al., 2011; International Labour Organization (ILO), 2021). The preliminary textile sector (PTS) meets about 85–90% of the yarn demand for knit RMG and 35–40% of the yarn requirement for woven RMG. According to Haider (2022) Bangladesh is dependent on other nations for the collection of raw materials and intermediate goods like fibre, yarn, and fabric because the country's export sector of the textile and apparel industry is larger than its domestic sector. In order to meet the demands of the apparel industry, the nation imports a significant amount of these goods each year. Furthermore, Bangladeshi clothing imports rely on international purchasing houses and businesses for the export and promotion of their finished goods. However, foreign consumers control the majority of the export-oriented production sector overall. The purchasing house networks, designs, and raw materials are directed and managed.

1.2 Bangladesh textile-garments industry water usage and wastewater scenario

The textile business relies heavily on water, which is used in both the supply chain and the industry's daily operations (Sagris et al., 2015). The textile sector significantly contributes to the internal water footprint of RMG products (Hossain & Khan, 2020). There are two distinct forms of water utilization in textile operations; 'Blue water' is consumed from groundwater or surface water during textile production, while 'Grey water' is considered polluted discharges. According to Hossain & Khan (2020), the yearly water footprint of the textile sector in Bangladesh was determined to be 1.8 billion cubic meters and the overall water footprint for the ready-made clothing product is determined to be 27.56 billion cubic meters in 2012–2016. Fabric cleaning requires one-third dying water (Hossain & Khan, 2020). If the water demand for the textile sector continues to follow the current "business as usual (BAU)" trajectory, it is projected that an additional 6,750 megalitres per day of water will be required by the year 2030. This is comparable to the yearly water requirements of a population of roughly 60 million individuals residing in Bangladesh (Sagris et al., 2015). The textile dyeing industry is a major contributor to groundwater depletion and severe water pollution to the environment (Mamun et al., 2022). The industrial clusters of the country, especially in Dhaka, Gazipur and Narayanganj region have been experiencing rapid depletion in the ground water level (Bangladesh Garment and Manufacturers & Exporters Association (BGMEA), 2020).

Vertically integrated factories under BGMEA (fabric knitting, dying, finishing, and fabric cut to sewing) have a larger water footprint due to water-intensive dyeing. These factories release most of their wastewater into the government sewer drain untreated (Bangladesh Garment and Manufacturers & Exporters Association (BGMEA), 2020). According to BGMEA, some of its member factories—particularly those that have earned the Leadership in Energy and Environmental Design (LEED) certification—had sewerage treatment plants (STPs) or are in the process of constructing STPs. However, they do not have a precise count of the number of factories that use STP.

1.3 Circular Economy (CE)

The current economy follows 'take-make-waste', also known as the linear approach (Chen et al., 2021a; What Is a Circular Economy? | Ellen MacArthur Foundation, n.d.). Pearce, Turner first presented the CE concept in their 1990 book "Economics of Natural Resources and the Environment. According to Ellen MacArthur Foundation, the circular economy works with an aim to never produce waste and regenerating nature. The products and materials are reused, recycled, refurbished, remanufactured by keeping them in circulation. The three principles of circular economy can be outlined as follows: (i) Eliminate waste and pollution, (ii) Circulate products and materials (at their highest value), and (iii) Regenerate nature. The goal of CE is to establish a greener economy that is defined by novel job opportunities and a new business model by promoting a more suitable and environmentally sound use of resources with a view to tackle climate change, minimize biodiversity loss, waste and pollution (Founding Partners of the Ellen MacArthur Foundation 2013 CIRCULAR ECONOMY TOWARDS THE Economic and Business Rationale for an Accelerated Transition, n.d.; Stahel, 2016). Waste is viewed as a resource in the context of the CE paradigm, and there is potential to manage wastewater sustainably (Kakwani & Kalbar, 2020).

1.4 Need for the review of CE in textile sector water usage

Water is used extensively in the manufacture of textiles, clothes, and their use and disposal, leaving fibre and chemical residues in water sources (Chen et al., 2021b). Sagris et al., (2015) estimate that an additional water supply of 6,788 MLD is required in 2030 to meet the sector's aspirations for the "business as usual" (BAU) water demand scenario. The absence of proper treatment for wastewater originating from the industrial sector is a significant contributor to the degradation of surface water quality in and around Dhaka (Sagris et al., 2015). It is estimated that the level of investment in new assets (water abstraction treatment and distribution plant as well as effluent treatment plant) to support growth in the textile sector will be in the order of $19 to $30 billion through to 2030 under a BAU water demand scenario (Sagris et al., 2015). However, the implementation of cleaner production measures will reduce the investment needed by the sector to provide water supply and pollution control. In addition, metering as well as simple and low-cost measures could reduce water use by up to 20% which will lower future infrastructure investment and operational expenditure by up to $6 billion. Installation of measures which reduce water use by 35%, would increase the total reduction in cost to $9 billion.

1.5 Research Objectives

Textile sector of Bangladesh depends mostly on natural resources, but the production method of the factories is unregulated. Implementing the relatively newer concept of circular economy in Bangladeshi textile sector has the potential to develop a system that is environmentally responsible yet profitable in terms of business. The aim of this study is to explore the scope and application of circular economy ideas to the textile and garments sector of Bangladesh as a means to reduce water usage in the industrial process, while enhancing water sustainability and security.

2. REVIEW METHODOLOGY

This study was developed by means of a review of seventy-two items, including book sections, journal articles, conference papers, theses, reports from international organizations, industry and other stakeholders, online web articles, newspapers, and interviews. The articles considered in this study were collected through a detailed bibliometric search on Google Scholar using the keywords 'Circular Economy', 'Textile and Garments Industry' and 'Water'. Based on the objective of the study, the articles were shortlisted and refined by manual screening. Aspects of Bangladesh's textile and garments industry, water use and its economic implications, the notion of CE, CE in the textile and garments sector, strategies for attaining water sustainability, the function of international organizations, and the difficulties in putting CE into practice in Bangladesh's textile and apparel sector were covered in the articles.

3. A CONCEPTUAL MODEL OF SUSTAINABLE WATER MANAGEMENT IN THE TEXTILE AND GARMENTS INDUSTRY USING CIRCULAR ECONOMY

System-level reform is necessary to convert the textiles sector into a circular economy (A New Textiles Economy: Redesigning Fashion's Future, 2017). The implementation of energy-intensive processes such as pumping and water purification, specifically softening, incurs water input expenses for textile mills, equivalent to approximately $12-40 per metric ton of fabric (Ecopsis, 2011). The cost of water alone makes it difficult to build a business case for industries to invest in water efficiency solutions (Sagris et al., 2015). Reduced water use can save energy and chemicals, making a stronger case (Best Practices for Textile Mills to Save Money and Reduce Pollution in Bangladesh, 2012). Textile trade associations indicated that their members would invest in resource efficiency initiatives if payback times were maximum ten years but preferable five years (Interview with Bangladesh Garment Manufacturers and Exporters Association Leadership Team, 2014; Interview with Bangladesh Textile Mills Association President, Mr Jahangir Alamin, 2014). From Table 1, it can be extracted that the cost and payback period is relatively beneficial for business operation.

Table 1: Typical costs and payback periods for water interventions in textile factories (Sagris et al., 2015)

Intervention	Cost	Payback
Metering, leak detection, maintenance, housekeeping	Small	1 month or less
Reuse cooling water	Small	1 month or less
Reuse process water from rinsing	Moderate	5 months
Improve washing ratio	Moderate / High	1 month or less

3.1 Water consumption data inventory

Data on water use and the efficacy of water efficiency initiatives are scarce from Bangladesh's textile industry (Resources | Bangladesh Water PaCT | Water Resources Management, n.d.). As this data could provide an invaluable foundation for detailed cost-benefit analyses of water efficiency interventions, the industry must take action and document water usage appropriately (Sagris et al., 2015). According to Mamun et al. (2022), water consumption should be monitored process-wise and machine-wise for each dyeing machine and addressed where water usage is high. Centre for Environmental and Resource Management (CERM), BUET (2017) recommended DoE to install flow meter at the inlet and outlet of every industry in order to determine and monitor the amount of reused/recycled treated water.

3.2 Centralised effluent treatment

Central Effluent Treatment Plants (CETPs) could provide more affordable options for treatment capacity, according to a high-level assessment of the textile industry's projected total costs of effluent treatment requirements up to 2030 (Sagris et al., 2015). As long as development expenditures are covered by a third party, textile trade associations have stated that the industry supports the idea of CETPs. Centralized ETPs have high capital investment and energy efficiency costs, but economies of scale may render them more efficient than decentralized systems. Table 2 exhibits that the treatment cost is much lower in centralised treatment facilities with respect to decentralised treatment.

Table 2: Comparison of future effluent treatment costs for the textile sector (Sagris et al., 2015)

Scenario	Description	Decentralized treatment ($bn)	Centralized treatment ($bn)	Cost ratio
0	Business as usual	14.46	7.3	1.98
1	Water use reduction by 20%	10.94	5.51	1.99
2	Water use reduction by 35%	8.3	4.17	1.99

3.3 Zero discharge

The Department of Environment (DoE), Bangladesh has mandated that various industries develop a 3R strategy (reduce, reuse, and recycle)/Zero Discharge (ZD) plan starting in early 2014 in an effort to reduce the use of natural resources, ensure sustainable waste management, and improve the carbon footprint of the production processes (Centre for Environmental and Resource Management (CERM) BUET, 2017). Zero discharge policies have the potential to cut return flows to the environment and reduce water abstractions by up to 75% from a water usage standpoint (Sagris et al., 2015). For the BAU scenario, Sagris et al. (2015) projected that the total capital and operating expenses for centrally located zero discharge interventions through 2030 will be approximately $31.3 billion. Compared to the BAU scenario, which includes decentralized effluent treatment, this is 20% more expensive. Table 3 illustrates the cost-benefit analysis of different scenarios incorporating BAU, water use reduction, and ZD. It is evident that 'water use reduction by 35%' scenario yields the most economically beneficial outcome, while 'ZD measures and water use reduction by 35%' decreases most water consumption.

Table 3: Cost-benefit analysis of future zero discharge scenarios and the effects of projected rises in energy prices on scenarios related to the textile industry (Sagris et al., 2015)

Scenario	Description	Projected total water costs to 2030 ($bn) – no energy price increase	Projected total water costs to 2030 ($bn) – annual 3% energy price increase	Reduced average water abstraction (MLD)
0	BAU	26.2	28.4	-
1	Water use reduction by 20%	20.4	22.1	1,641
2	Water use reduction by 35%	16.7	18.7	2,872
3	Zero discharge (ZD) measures on BAU scenario	31.3	35.1	6,154

4	ZD measures and water use reduction by 20%	25	28.1	6,564
5	ZD measures and water use reduction by 35%	20.3	22.8	6,872

Another concept, ‘Zero Liquid Discharge (ZLD)’ refers to a set of technological solutions that concentrate on recycling and recovering liquid end waste while reusing water (Ceballos, 2016). ZLD systems are in line with the concepts of the Circular Economy Strategy, which highlights the significance of cutting waste, repurposing resources, and recycling materials in order to lessen the negative environmental effects of economic activity (Waterman Engineers Australia, n.d.). Industries will be able to protect both their operations and the environment at a lower cost if the ETP-treated wastewater can be collected and treated in a centralized ZLD system (Centre for Environmental and Resource Management (CERM) BUET, 2017). However, every industry should make sure that their ETP is operating efficiently before introducing ZLD technology, as ZLD will not function as intended.

3.4 Recycle, reuse, recirculation of water and industrial interventions

The regeneration and reuse of water is an important instrument in the circular economy for minimizing consumption and protecting this priceless resource (Ceballos, 2016). Industries can lower operating costs, produce valuable byproducts, and improve their environmental reputation by recovering and reusing water (Waterman Engineers Australia, n.d.). According to Shirvanimoghaddam et al. (2020), the reduction of textile waste in industries should focus on the following for recycling and reusing water: the recycling and reuse of cooling water, condensate water, and the implementation of a bleach bath recovery system. Other sustainable measures can be implemented, such as utilizing cotton waste as an affordable and sustainable catalyst for wastewater treatment, pollution remediation, and the elimination of Bisphenol A (BPA) (Shirvanimoghaddam, Czech, Wiącek, et al., 2019; Shirvanimoghaddam, Czech, Wójcik, et al., 2019). Install steam traps and a condensate transfer pump to collect and reuse condensate from all sections for boiler feedwater, ensuring maximum condensate recovery (Mamun et al., 2022). Use of water-efficient machinery and equipment; for example, replace a dyeing machine with a high liquor ratio with one with a low liquor ratio should be implemented (Hussain & Wahab, 2018). Provision of i) salt recovery from spent alcohol (which is eventually drained to the ETP); ii) raising the treatment costs; and iii) employing acid to balance the high concentration of alkaline effluent for a potential water-saving approach should exist (Ozturk et al., 2016). The use of water-saving techniques such as enzymatic treatment, ultrasonic-assisted finishing, waterless dyeing in supercritical carbon dioxide, natural additives to improve processes, and dyes instead of synthetic ones can help address the water problem (Ebrahimi et al., 2011; Ebrahimi & Parvinzadeh Gashti, 2015; Gashti & Adibzadeh, 2014; Gashti & Gashti, 2013; Mirjalili et al., 2011; Muntaha & Khan, 2015; Parvinzadeh Gashti et al., 2014; Parvinzadeh, 2009; B. Zhang et al., 2014; Y. Q. Zhang et al., 2016). The recommended procedure for fabric washing is counter-current rinsing (Mamun et al., 2022). To prevent over washing, pretreatment washing of the dyed fabric should be carried out in accordance with the specifications.
Reuse of wastewater treated with effluent for car washing, toilet flushing, printing screens, and cleaning of empty chemical drums (Ozturk et al., 2016). According to Balachandran et al. and Rather et al. (2018), implementing a water conservation program may reduce water usage by up to 30% or more, and the cost savings can quickly cover the cost of the necessary supplies, which leads to a large reduction in effluent volume. Furthermore, reducing the amount of water used renders in lower processing and wastewater treatment costs (Rather et al., 2018). Implementing effective water treatment and water reuse facilities has the potential to significantly decrease the grey water footprint to approximately 1.26 billion cubic meters.

4. ECONOMICAL ASPECTS OF WATER USAGE IN TEXTILE AND GARMENTS INDUSTRY

It is estimated that the entire costs associated with water will account for between 2.4 to 3.7% of sector income by 2030 (Sagris et al., 2015). For an industry that considers water to be a resource that is free, this is a substantial expense. In most situations, the cost of water and wastewater may make up to 5% of the cost of manufacturing (Shaikh, 2009). According to Rather et al. (2018), the unconscious and unnecessary use of fresh, pure water also raises the price of finished textile fibres and textiles. From **Error! Reference source not found.**, it can be observed that the potential benefit per annum ($bn) i ncreases with the reduction of water consumption. On the other hand, an ETP's operating expenses range from Tk. 5.0 to 38.0 for every m3 of wastewater treated (Centre for Environmental and Resource Management (CERM) BUET, 2017). According to Peter John & Mishra (2023), investing in waste reduction, wastewater treatment, and green technologies improved profit while lowering associated expenses and minimizing environmental harm.

5. SOCIAL ASPECTS OF CIRCULAR ECONOMY IN TEXTILE AND GARMENTS INDUSTRY

5.1 Contribution of Sustainable Development Goals (SDG)

Bangladesh joined and ratified international social, economic, and environmental growth regulations, including the UN-led 17 sustainable development objectives, after independence in 1971 (Khairul Akter et al., 2022). A sustainable and circular system would help achieve several UN Sustainable Development Goals (SDGs) at the international level, such as Goal 6: Clean water and sanitation, Goal 7: Affordable and Clean Energy, Goal 12: Responsible Consumption and Production, and Goal 13: Climate Action (Manshoven et al., 2019). A 10-year Framework Program (10YFP) on Sustainable Consumption and Pattern (SCP) was accepted under this SDG umbrella, creating SDG 12, which aims to promote resource efficiency programs and SCP practices (Framework of Programmes on Sustainable Consumption and Production Patterns, n.d.). The SGD 12 entails 'ensuring sustainable consumption and production patterns', under which target 12.2 is 'By 2030, achieve the sustainable management and efficient use of natural resources', and target 12.5 include 'By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse' (United Nations Department of Economic and Social Affairs, n.d.). Business actions related to SDG 12 include developing circular economy models, addressing positive and negative social and environmental impacts, improving material and energy use efficiency and effectiveness, using resources more efficiently, leveraging renewable materials and clean technologies, tracking and reporting sustainability risks and performance, understanding waste generation and mitigating measures, etc (Bangladesh Garment and Manufacturers & Exporters Association (BGMEA), n.d.).

5.2 Contribution of International Brands and Organization

In recent years, there has been a growing demand placed upon worldwide companies and buyers by their customers, shareholders, and the public to enhance environmental and social compliance within their supply chains (Sagris et al., 2015). Textile trade associations recognize that in the next two to three years, buyers and brands will want better performance due to the developing concerns of energy and water. The Bangladesh Partnership for Cleaner Textiles (PaCT) project was initiated in 2013 by the International Financial Corporation (IFC) in collaboration with 13 garment firms (including H&M, Inditex, Levi Strauss & Co., Marks & Spencer, Tesco, PUMA, etc.) and other stakeholders with the aim to mitigate the negative environmental effects related to energy, water, emissions, and wastewater (BGMEA, 2020; Birner & Mahmood, 2014). Water conservation, recycling, and reuse are subject to stringent regulations under internationally recognized environmental standards like the Higg Facility Environmental Module (FEM), ISO 14001 for Environmental Management System, Business Environmental Performance Initiative (BEPI), or STeP (Sustainable Textile & Leather Production), to which Bangladeshi clothing factories comply with (BGMEA, 2020). The international fashion brand PUMA has joined the "Clean By Design" resource efficiency improvement programs, which are led by the IFC and involve the PaCT in Bangladesh. The programs' goal is to lower CO_2 emissions, water and energy consumption during the manufacturing process (How PUMA Makes the Factories in Its Supply Chain More Sustainable - PUMA CATch Up, n.d.). The Global Fashion Agenda (GFA), a major platform for industry collaboration on sustainability, is comprised of numerous partners, including some of the top fashion and textile firms globally (Manshoven et al., 2019). Its goal is to assist industry leaders in transforming the manufacturing, marketing, and consumption of fashion. In order to accomplish a long-term, scalable transition to a circular fashion system, BGMEA, Global Fashion Agenda (GFA), Reverse Resources, and Partnership for Green Growth (P4G) have joined forces to launch the "Circular Fashion Partnership (CFP)" initiative (BESTSELLER Participates in GFA's Circular Fashion Partnership in Bangladesh - Global Fashion Agenda, n.d.; BGMEA | Bangladesh Apparel Industry Moving Further into Circular Economy, n.d.).

6. WATER SUSTAINABILITY AND SECURITY: BANGLADESH SCENARIO

According to a study conducted by Bangladesh Garment and Manufacturers & Exporters Association (BGMEA), 15% of participating factories use recycled water in production or sanitation, while 23% harvest rainwater for gardening, car washing, or sanitation. Most participating factories use borewell water (91%), while 32% use municipal infrastructure. The report also states that within 2025, the water consumption reduction goal of 42% participating factories is 25% from 5% in 2020. Furthermore, according to ZDHC rules, factories discharge water from ETP after measuring pH, chemical and biochemical oxygen demand (CoD and BoD), total suspended and dissolved solids (TSS and TDS), temperature, color, and other parameters. Only 9% of factories dump treated water into rivers, while the rest into sewer pipes. In 2020, Fakir Knitwear reduced water consumption by 28.5 litres per kilogramme of cloth dying through process optimisation. BGMEA advocated for circular economy in Bangladesh's RMG industry (BGMEA, 2020). As the topic is vital, BGMEA, Global Fashion Agenda (GFA), and Reverse Resources initiated a trial intervention in 2020 with a few factories. Results from PaCT–1 show that 200+ factories under 13 global brands in Bangladesh are saving 22 billion litres/year and USD 16 million/year (Bangladesh Garment and Manufacturers & Exporters Association (BGMEA), 2020). Envoy Textile Ltd and Urmi Group have cut 25.7% water use to produce one kilogram of denim fabrics ("Low-Cost, Cleaner Production Processes Paying off | The Daily Star," 2021).

7. CHALLENGES AND OPPORTUNITIES IN IMPLEMENTING CE

Information regarding the present obstacles and future prospects of CE in the apparel sector is still lacking (Circular Economy in Bangladesh's Apparel Industry — Aalborg University's Research Portal, n.d.). According to Akhter 2023, the concept of CE is not well-understood by RMG specialists. The challenges comprised of inadequate infrastructure, financial constraints, inadequate skilled workforce, customer attitudes, and a lack of motivation and government regulation. Certain specific industrial zones have no co-ordination regarding CE practices, and furthermore, there exist shortages of central ETP. Moreover, the cost of CE technologies in factories is two to three times more than that of a traditional arrangement (Islam & Jabber, 2022). Additionally, it takes an extended period for businesses to break even on the cost of buying, setting up, and maintaining new machinery and plants. However, on the contrary, there are some limited but significant opportunities in implementing circular economy. Saha et al., (2021) outlined the opportunities as productivity, sustainability, cost savings, and improved company reputation, etc. Beyond these, there exists potential to incentivize foreign direct investment (FDI) in case of infrastructure and technological installation and support, and manufacturing process.

8. CONCLUSIONS

The concept of Circular Economy is still relatively new and is evolving with different scenarios and circumstances. This study aimed to employ CE concept in the perspective of water usage in Bangladesh's textile and garment industries. As the second largest exporter of ready-made garments and significant contributor to the textile industry, Bangladesh usages an ample amount of water (predominantly from groundwater source) for production and manufacturing. This natural resource is on the verge of being scarce and inaccessible due to over extraction, indiscriminate usage, pollution, and climate change. The industry's heavy water use, dye and fibre pollution threaten the environment and organisms. To counter these major environmental and economic issues, and to sustain Bangladesh's position in the global apparel ranking, an efficient industrial water management scheme is paramount. Thus, sustainability and circular economy in the garment and textile industry are urgently needed due to its wasteful and polluting linear economy as CE addresses to eradicate waste and pollution, rejuvenate products and materials, and regenerate nature. The application of CE in Bangladesh's textile and apparel sector faces several obstacles. The high expense of implementing new technologies and procedures is one challenge. Another challenge is that industry stakeholders are not aware of CE. Furthermore, there exist deficiency in government regulations in minimizing waste, reusing and recirculating water used in production. The move to circular textiles will require a change in behaviour throughout the whole system, from production and processing to transportation, consumption, and waste management. Addressing the complex water and environmental concerns requires technological intervention, multi-lateral cooperation, awareness, establishing and implementing policies. A comprehensive strategy including the industry's combined efforts, the incentives offered by the host government, the buyers, and most importantly, the end users' consciences, is needed to eliminate the obstacles to the realization of CE. However, if the challenges are tackled, CE can aid the industry to reduce water consumption, improve wastewater management, and reduce waste generation, while generate higher revenue in the long run.

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