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Sustainability and Circular Economy in Textile and Apparel Industry in Bangladesh

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Abstract

The textile sector is one of the most important and fifth largest industrial sectors in the world. Textile sector has created Job opportunity for Millions of workers around the world. The apparel industry plays a great role in economy, employment, investment and revenue all around the world. Textile recycling is a procedure that transforms old or unwanted textiles into new products. This helps to decrease the amount of textile wastage and save assets. Over the last few decades the rate of both pre- and post-consumer textile waste generation has increased significantly. Textile recycling involves reprocessing post-industrial or post-consumer textiles into new products, the term recycling refers to the conversion of textile waste into something approximating the same value. Textile recycling generally includes mechanical and/or chemical processes that turn textile fabrics back into their fiber components to then be remanufactured into fabrics. Post-consumer waste results in lower-quality recycled fiber due to degradation during wear, therefore, only pre-consumer waste is typically recycled mechanically. A circular economy can assist by the development of right choices in the design of products, selection of resources, production, retailing and consumption phases and ultimately in the end of life of the products. Worldwide, 75% of textile waste is landfilled, while 25% is recycled or reused. Landfilling of textile waste is a prevalent option that is deemed unsustainable. Promoting an enhanced diversion of textile waste from landfills demands optimized reuse and recycling technologies various textile reuse and recycling technologies are available and progressively innovated to favor blended fabrics. This Paper highlights the process of mechanical and chemical recycling of Textiles. Benefits of circular economy and how to overcome the Challenges of Circular Economy. Also, will presents the sustainability and efficiency of the Bangladeshi textile industry.

Keywords: Textile sustainability; Fibre recycling and reuse; circular economy; Textile recycling technologies; Challenges of Circular Economy.

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1. Introduction

At present, Textile recycling is becoming more effective and cost saving technology. Without Textiles it is impossible to imagine a world. Textile sector very essential for our everyday life and Global economy. Textile and Fashion design effects the selection of materials and the planning of production and supply procedure. Textile production has numerous methods that vary in means of changing production to make it less harmful to the environment.

Population growing, development of living standards, an increasing assortment of textile materials, and the decreasing life cycle time of textile products added to global fibre consumption that produces a significant amount of post-industrial and post-consumer fibre waste. Globalization has made the apparel industry produce more clothing at lower costs, and many consumers have adjusted a 'fast fashion' tendency that considers clothing to be a disposable product. Fast fashion categorized by mass production, variety, agility, and affordability has taken about a surge of apparel consumption. Global fibre production per person has increased from 8.3 kilograms in 1975 to 14.6 kilograms per person in 2022. The latest report – which includes materials produced for the fashion, textile, and apparel industry as well as for other industries – shows that global fibre production increased from around 112 million tonnes in 2021 to a record 116 million tonnes in 2022. This is expected to grow to 147 million tonnes in 2030 if business continues as usual. The percentage of natural fibres produced via programs with sustainability elements slightly increased in 2022, including cotton (25% in 2021 to 27% in 2022) and wool (3% in 2021 to 4.3% in 2022). However, the production of virgin fossil-based synthetic fibres also rose from 63 million tonnes to 67 million tonnes. Polyester continues to be the most widely produced fibre globally, making up 54% of production in 2022. After years of growth, the combined share of all recycled fibres slightly decreased from around 8.5% in 2021 to 7.9% in 2022. This was mainly due to a decrease in the market share of recycled polyester – 99% of which was made from plastic bottles – from 15% in 2021 down to 14% in 2022. Reasons for this decrease include the growing competition for PET bottles as feedstock along with the systematic challenges in scaling textile-to-textile recycling. Less than 1% of the global fibre market came from pre- and post-consumer recycled textiles in 2022 [1].

2. Material and Method

2.1. Textile Production

Clothing and textiles added 6% to the world exports of manufactured goods in 2017 (Figure 1); China and the European Union (EU) are the two leading regions for clothing and textile exports. The worldwide volume production of textile fibres in 1975 was about 23.9 million metric tons (MMT), in 2017 it reached 98.5 MMT Reference [2], and it increased further to about 111 MMT in 2019 [3]. For many years, cotton fibre demand dominated polyester; however, in 2002, polyester demand exceeded cotton fibre and has continued to grow at a faster rate than cotton fibre.

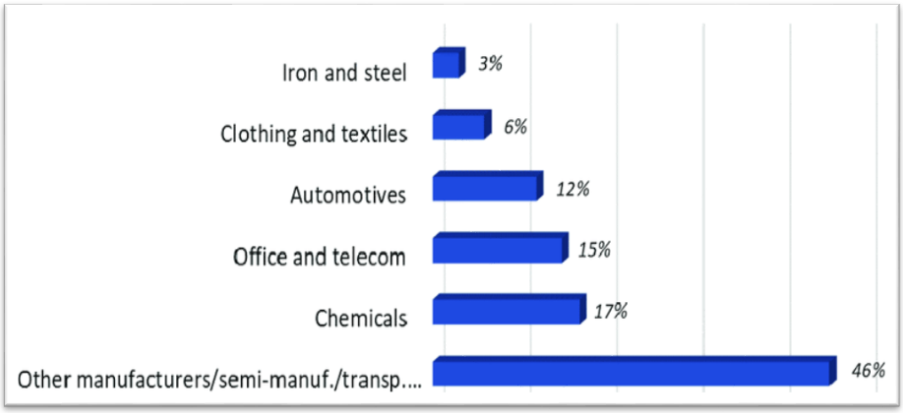

Figure 1: Percentage share of world exports of manufactured goods in 2017

Global textile consumption is estimated to expand at an annual average rate of 4% and reach 87 million tons by 2020. This growth is likely to fuel the demand for textile fibres. During 2008, many major fibre manufacturers had to restructure, or shut down their operations to remain solvent. Consolidation of facilities and closure of less profitable units were seen in the west European countries. Capacity declined by 0.9% in the US and by 2.8% for EU. Other Asian countries saw a decline of 3-4% during 2008-09. Following a 7-year decline, global demand for textile fibres has recovered after 2008, during the recovery period; past recession. Demand increased by 4% during 2009, and 5% during 2010. An increase in the fibre consumption can be attributed to a 9% increase in the consumption of cotton. During 2009, global consumption of cellulosic fibres also increased by 11%. For making woven and knitwear apparels, cellulosic, and cotton fibres prove to be good competitors with woollen fibres. Woollen fibres are the smallest of all the major fibres consumed in the world. Unlike other fibres, woollen fibre consumption did not meet with a decline during 2008, while at recession. On the contrary, consumption of woollen fibres fell by 10% during 2009 and by 1% during 2010. Icac reports that during 2009-10, global cotton production declined by 7% resulting from a decline of production in us, and china, the world's two biggest cotton producing countries. Polyester industry is currently experiencing over capacity due to immense investments in china in the recent few years. But the shocking increase in the prices of cotton, and cotton yarn forced the apparel manufacturers to seek for options, and consequently choose polyester fibres. Thus, the Over Capacity of Polyester Fibres Were Absorbed By the Garment Industry. A Shortage In Acrylonitrile Caused A Decline In The Production Of Acrylic Fibres, Despite Its Strong Demand [4].

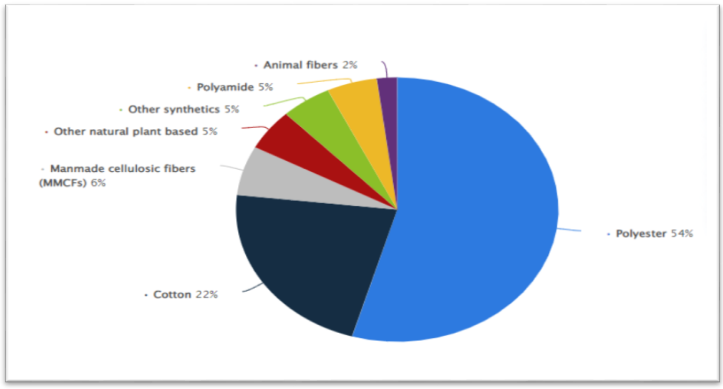

Figure 2: Distribution of textile fibers production worldwide in 2022

The raw materials for textiles should be made renewable, or easily recyclable with little or no concerns to the environment. The best approach can be to use big data material informatics (Jose and Ramakrishna 2018; Tebyetekerwa and his colleagues. 2019) to search for options of replacement. Concerns about the small, untraceable fiber plastics can be solved by using biodegradable fibers. Also, efforts and policies should be made to ensure all staple fibers are made from biodegradable materials, and filaments that can be easily collected from the environment can either be made degradable or biodegradable [5].

2.2. *Textile Waste Generation and Management in Leading Economies*

Textile waste is considered as discarded or unwanted material from the production and use of fiber, textile, and clothing, which can be considered into three types, pre-consumer, post-consumer, and industrial textile waste .The pre-consumer textile waste is viewed as 'clean waste', as a by-product during the manufacturing process of fibrous materials. The post-consumer textile waste consists of discarded garments or household textiles (sheets, towels, and pillowcases) that are worn-out, damaged, and outgrown of no value to consumers after their service life [5]. Industrial textile waste is deemed as 'dirty waste' generated from commercial and industrial textile applications. The expansion of the clothing and textile industry and the consumer's fast fashion trend have caused a rapid global increase in textile wastes. The increased consumption of fashion textiles generates a growing amount of waste. As fashion textiles, are almost 100% recyclable, nothing in the textile and apparel industry should be wasted in an ideal scenario. Furthermore, more than 60% of all recovered clothes could be reused, 35% could be converted into wipers and fibre recycling, and only 5% would need to be discarded [6]. However, in the real world, a significant portion of textile waste is disposed of in landfills. As a result, it is critical to comprehend the challenges that leading economies face when it comes to textile production and waste management. In terms of textile exports, the leading economies considered in this study are China, The European Union, The United States, and Canada [7].

China has the largest economy in clothing and textiles exports globally, yet the industry faces unprecedented crises [8]. The country's dominance as a textile provider across the globe is challenged by the loss of competitive advantages in terms of low labour costs as wages are rising. China attempts to maintain its dynamic advantage in labour-intensive textile products by inspiring the relocation of Chinese textile production bases to poorer Chinese provinces and neighbouring least developed countries (LDCs). Simultaneously, China's global competitiveness was upgraded through technological advancement, implementing sound policies to develop capital-intensive textile goods, launching niche products and international brands [9]. The Chinese textile industry sector has experienced consistent economic growth over the last decade and is primarily focused on the production of apparel made of synthetic fabrics. Furthermore, China produces approximately 31% of the global ratio of synthetic fibers required by the modern textile industry and produces nearly 65% of the world's clothing. When China started imposing strict environmental standards on textile production, China's cloth products became more competitive in the United States (US) market [10].

In the US, the majority of textile waste in the MSW stream is discarded apparel. However, other sources were identified such as furniture, carpets, tires, footwear, as well as other non-durable goods such as towels, sheets, and pillowcases [10]. Textile waste generation and the fraction of textile waste in MSW is increasing with time. In 2010, an estimated 13.2 MT of textile waste were generated, which is equivalent to 5.3% of total MSW

stream. While in 2015 and 2017, the generated textile waste increased to 16.1 MT and 16.9 MT, accounting to 6.1% and 6.3% of the total MSW generation, respectively [11].

Approximately 85% of all textiles in the US end up in landfills, and only 15% is donated or recycled .The United States Environmental Protection Agency (USEPA) estimated that textile waste occupies nearly 5% of landfill space. Among the leading economies in the textile industry, the US has the highest share of landfilling textile waste, amounting to 29.3 kg/ca in 2016 and the estimated cost of textile waste sent to landfills is $45/ton. Since landfilling keeps the largest share in textile waste management [12].

US, promoting recycling technologies to many textile industries is crucial. Composting is not a common method of managing textile waste. Nevertheless, incineration and recycling are gaining popularity in textile waste management.

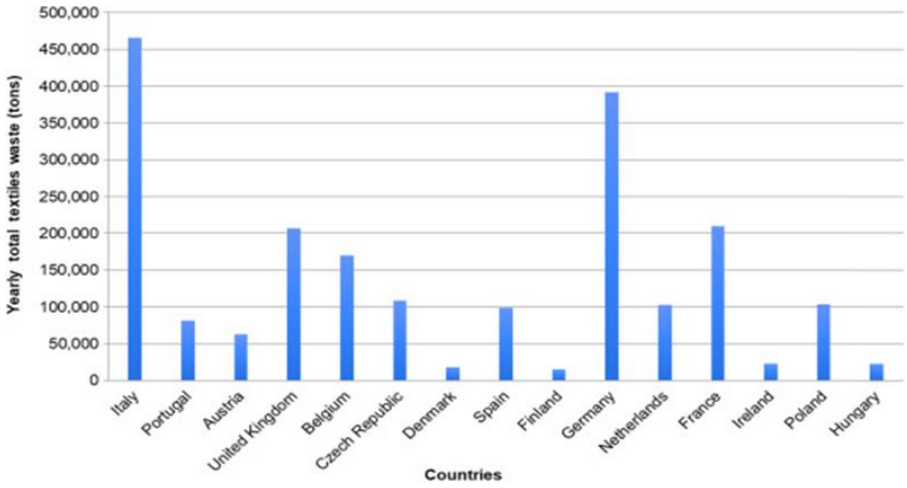

Figure 3: Textile waste management and environmental concerns

In Canada, an estimated 500,000 tons of apparel waste is disposed of annually. The average Canadian discards between 30 and 55 pounds of textiles annually. Almost 95% of those clothes could be reused or recycled. Globally, textile waste has increased dramatically due to the rise in clothing consumption and production. In Ontario, approximately 1.2 million people dispose their unwanted clothes into the waste bin at a rate of roughly 45,000 tons annually. In the Metro Vancouver Regional District, an estimated 30,000 tons of textile waste are annually landfilled, accounting for 5% of the annual total waste volume in 2016. In Toronto, a survey was conducted to determine if participants donated and/or disposed of their unwanted clothing. According to the findings, 17% of participants consider “disposal” to be the most convenient (10%) and fastest (7%) method of getting rid of unwanted textile waste. In Manitoba, textile and carpet waste materials are under the Canadian Council of Ministers of the Environment (CCME) National Action Plan for EPR of the Waste Management Task Group. Unwanted clothing items that could be donated are usually dropped off at city drop-off bins or collected by non-profit charitable organizations and municipal programs. Due to their poor condition, some donated textiles are frequently discarded in landfills [13].

3. Textile Reuse and Recycling

Textile recycling is typically classified as mechanical or chemical recycling. Mechanical recycling degrades waste into a decoration, construction, agricultural, and gardening use. Chemical recycling involves a process where polymers are depolymerized (polyester) or dissolved (cotton and viscose). Chemical recycling can produce fibres of equal quality compared to virgin materials The sorted textile waste could be chemically treated to extract resources such as protein-based fibres to produce wood panel adhesives; and cellulosic fibres for bioethanol production For mono-fibre materials such as acrylic, pure cotton, and wool Mechanical recycling processes is best suited due to their fibre yield usually include shredding waste textiles into small fractions, carding to release the fibres, bleaching, and then re-spinning those fibres into new yarns.. Mechanical recycling shortens the staple fibre length, compromising the strength and softness of recycled fibres. As a result, fabrics that include mechanically recycled fibres can generally only use 20 to 30% of recycled fibres before the quality of the fabric is reduced. Chemical recycling refers to the process of using chemical methods to disassemble textiles back to their basic chemical components. Most chemical recycling technologies are in the start-up research and development phase [14].

Textile reuse and recycling are more sustainable than incineration and landfilling, but reuse is more advantageous than recycling. For this, designing a textile product by prolonging the service life quality could promote reuse. In adding, it is important to promote consumer consciousness to foster an environmentally friendly consumption behaviour on textile products.

Leading economies should manage their textile waste in a closed-loop circular approach, mainly when exporting textile waste to developing countries is being banned. Various streams of textile recycling technologies are available and continue to innovate new ideas with biotechnology advancement. Applying holistic technologies, and not relying upon a single technology, to manage a complex textile waste is considered essential.

Normally, textile reuse and recycling could reduce environmental impact because it could potentially reduce virgin textile fibre production and avoid processes further downstream in the textile product life cycle. Moreover, textile reuse and recycling are more sustainable when compared to incineration and landfilling. However, reuse is considered more useful than recycling, mainly when sufficiently extending the reusing phase. Textile reuse includes various means for extending the useful service life of textile products from the first owner to another. This is commonly practiced by renting, trading, swapping, borrowing, and inheriting, facilitated by second-hand stores, garage sales, online and flea markets, and charities. On the other hand, textile recycling refers to reprocessing pre-consumer and post-consumer textile waste for use in new textile or non-textile products [15].

The textile recycling route can be classified based on the nature of the processes involved or the level of disassembly of the recovered materials. Fabric recycling contains in recovering and reusing of a fabric into new products. In the meantime, fibre recycling involves disassembling of fabric but preserving the original fibres. Polymer/oligomer recycling consists of disassembling of fibres while preserving the polymers or oligomers. Moreover, monomer recycling consists of disassembling of polymers or oligomers, while preserving the monomers [16].Moreover, textile recycling can be classified into upcycling, downcycling, closed-loop, and

open-loop recycling. If the product made from recycled material is of higher quality or value than the original product, it is termed ‘upcycling’; the opposite of this is known as ‘downcycling’. Closed-loop recycling involves recycling of a material from a product and reusing it in a more or less identical product. In contrast, open-loop recycling consists of recycling of a material from a product and reusing it in another product. Figure 4 shows the classification of various forms of reuse and recycling. The closed-loop recycling approach recovers the raw material used to produce a polymer product and then reprocess it into the same product of equivalent quality as that from the virgin material [17].

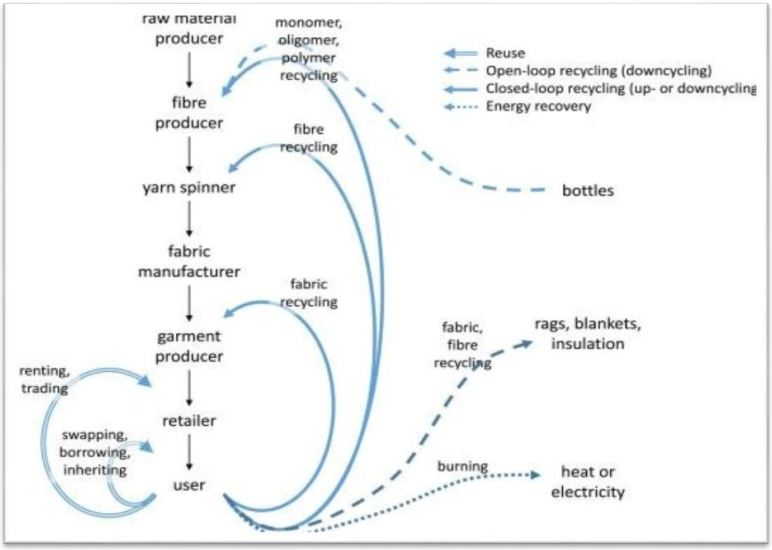

Figure 4: Classification of various forms of reuse and recycling

Furthermore, recycling technologies for fibres can be typically divided into primary, secondary, tertiary, and quaternary approaches. Primary approaches involve recycling industrial scraps. Secondary recycling involves the mechanical processing of a post-consumer product. Tertiary recycling involves pyrolysis and hydrolysis, converting plastic waste into chemicals, monomers, or fuels. Quaternary recycling refers to burning the fibrous solid waste and utilizing the heat generated [18].

3.1. The sustainability and efficiency of the Bangladeshi textile industry

The textile industry in Bangladesh is currently in a very inefficient and unsustainable state. The industry is distinguished by considerable environmental effects, low productivity, and high amounts of waste generation. Most important are environmental effects which is including water pollution, air pollution, water consumption etc. The textile industry in Bangladesh is known to discharge untreated or partially treated wastewater into nearby water bodies, such as rivers or lakes. This wastewater often contains toxic chemicals, dyes, and heavy metals, leading to severe water pollution and ecological damage. Harmful emissions, such as volatile organic compounds (VOCs), particulate matter, and greenhouse gases, are released into the atmosphere, affecting air quality and public health. Waste generation is another big problem in textile industry of Bangladesh, like textile waste, chemical waste, and packaging waste. Another one is low productivity, like insufficient product processes and lake of skill development. The textile industry in Bangladesh often relies on outdated machinery, inefficient technologies, and manual labour-intensive processes [19].

This results in lower productivity levels, increased energy consumption, and wastage of resources there are some other reasons too, like inefficiency and unsustainable behaviour in the Bangladeshi textile industry are poor production processes and low levels of productivity that are experienced in the nation (Matuoviová, 2020). In addition, the majority of SMEs are unable to generate sufficient revenue to cover their operating costs, leading to widespread bankruptcy and closure. Additionally, the industry is quite susceptible to shifts in the state of the global economy, which has a negative impact on debt levels and unemployment rates. The government has launched a number of initiatives to solve these problems and assist the growth and sustainability of the textile sector in Bangladesh (Sikder, 2019). These include the creation of a textile policy, the support of environmentally friendly production methods, and the creation of cutting-edge infrastructure for the textile industry. The government's actions are anticipated 12 to increase productivity and sustainability in the textile sector in Bangladesh. To guarantee a well-coordinated and efficient response, it is essential that other stakeholders join in on these efforts [20].

4. Circular Economy Model

In a circular economy, manufacturers design products to be reusable. For example, electrical devices are designed in such a way that they are easier to repair. Products and raw materials are also reused as much as possible. For example, by recycling plastic into pellets for making New plastic products. The circular economy keeps resources — such as products, materials, and energy — in the economic system for as long as possible and at the “highest value” possible. Products gain value as they’re manufactured, through the input of materials, labor and energy.

A circular economy is fundamentally different from a linear economy. To put it simply, in a linear economy we mine raw materials that we process into a product that is thrown away after use. In a circular economy, we close the cycles of all these raw materials. It is estimated that a circular economy path adopted by India could bring in annual benefits of 40 lakh crores or approximately US$ 624 billion in 2050. The greenhouse emission would reduce by 44%. The recent agreement of Adani Group with French Total Energy group to convert 25% into green energy [21].

A sustainable circular economy involves designing and promoting products that last and can be reused, repaired and remanufactured. This retains the functional value of products, rather than just recovering the energy or materials they contain and continuously making products.

4.1 Overcoming challenges of the circular economy

Overcoming the initial opposition from producers and customers, as shown in the survey, is one way to overcome the difficulties of implementing a circular economy in the Bangladeshi textile industry. It might be necessary for them to comprehend a circular economy and how it can help those (Bressanelli and his colleagues, 2019). The producers and consumers of textiles, who are most impacted by the current system, may also be resistant to change (Oliveira and his colleagues, 2020). To address these difficulties, institutional frameworks and policies supporting the circular economy must be developed. This was backed up by the survey's high answer rate of 55% regarding this particular question These may involve activities that increase producer, consumer, and stakeholder knowledge of the advantages of a circular economy (Bressanelli and his colleagues,

2018). They can also contain clauses that encourage manufacturers to use more environmentally friendly methods and guarantee that consumers recycle their textiles properly. Understanding how circular economy ideas might be used to this sector can improve cooperation among stakeholders in the Bangladeshi textile industry (Eberhardt and his colleagues, 2019). For instance, principles like boosting green chemistry, reusing resources, and decreasing waste from production and consumption can be applied to the manufacturing of textiles (Brendzel-Skowera, 2021). Additionally, textile items and packaging can benefit from the ideas of waste reduction, recycling, and energy conservation [22].

4.2. Factors that make implementation of circular economy in Bangladesh's Textile Industry Difficult

The requirement for new infrastructure is the largest obstacle to adopting a Circular Economy in Bangladesh's textile industry. This comprises both the institutional and physical infrastructure, such as manufacturing and waste management facilities, as well as educational and training programs. More education is required regarding the advantages of the circular economy and the steps that must be taken to put it into practice (Kazancoglu and his colleagues, 2021). This restricts the adoption of these practices by Bangladeshi textile makers. Government, business, and civil society must work together to provide the required infrastructure in order to overcome these obstacles. This will necessitate both public and corporate sector funding, as well as expenditures in education and training programs (Saha and his colleagues, 2021). It will also call for the creation of best practices, such as minimizing trash production and utilizing cutting-edge technology to enhance recycling procedures (Masum, 2016). Bangladesh's textile industry has the potential to become a leader in the Circular Economy with the correct infrastructure in place [23].

Actions need to be done on implementation of circular economy in Bangladesh's textile industry.

4.3. There are various aspects that need to be done to implement a circular economy. These are

4.3.1 Developing Comprehensive policy Structure

The production of textiles is one of the industries that contributes the most to global pollution. The manufacture of textile fibres consumes significant quantities of water and energy and releases significant quantities of greenhouse gases and other pollutants. Twenty percent of those who responded to the survey provided their opinion that a policy framework ought to be put into place. The textile sector is responsible for producing a significant amount of waste, the management of which can be challenging and expensive. It is vital to build a comprehensive policy framework for implementing the Circular Economy in the textile industry of Bangladesh in order to address these issues.

4.3.2. Increasing Consumer awareness of Circular Economy importance

The framework is in place to incorporate regulations that assist the development of new textile technologies, encourage the use of recycled textile materials, and advance sustainable production methods (Sharma and his colleagues, 2021). By offering money and technical support, it should also aid in the development of novel textile technologies (Marios and his colleagues, 2018). Finally, the government should support environmentally friendly production methods by educating and advising textile manufacturers (Marios and his colleagues, 2018). The textile industry in Bangladesh might benefit from these regulations by developing a circular economy,

which would lessen the negative environmental effects of waste management and textile production. Additionally, they would promote the economic growth of the nation by generating jobs in the sector [24].

4.3.3. Creating incentives for producers to adopt the Circular Economy

In the textile sector of Bangladesh, there are a few different strategies to provide producers with incentives to join the circular economy. According to Fischer and Pascucci (2017), one method is to offer monetary incentives, such as tax breaks or subsidies, to businesses that implement more environmentally friendly manufacturing 30 practices.

China, India, and Pakistan are some of the other countries that have encouraged their textile companies to participate in the circular economy by providing financial incentives. China has put in place several regulations in the textile industry to encourage the growth of the circular economy. These policies include the development of environmentally friendly supply chains, the establishment of a recycling system that is applicable to the entire sector, and the adoption of a system that assigns responsibility for production to producers. The textile sector in India has also benefited from India's implementation of several laws that encourage the growth of the circular economy. These policies include the creation of a database for the management of electronic waste, the encouragement of waste segregation at the point of generation, and the provision of financial incentives for manufacturers to adopt environmentally friendly industrial practices. To encourage textile manufacturers in Pakistan to participate in the circular economy, Pakistan has established a number of financial incentives. The creation of a producer responsibility system, the establishment of a fund for environmentally friendly infrastructure, and the execution of a waste management plan are all examples of these types of incentives [25].

5. Conclusion

The global rise in population, industrial growth, and improved living standards have caused a global fibre consumption that generates an alarming amount of unwanted textiles. Economic and environmental sustainability should be incorporated into the long-term textile waste management program. Though the application of EPR policy in textile waste is still limited, it is considered essential in promoting a circular economy system. EPR makes the producers responsible for the overall textile waste management from the collection to the disposal at the end of the product's life cycle. Besides EPR, there is a holistic approach involving major stakeholders (industry, government, private agencies, and consumers) who must work in unity to promote a dynamic circular system. The emerging economies in Textile manufacturing should take the lead in shifting from a linear economy to a circular economy. Textile reuse and recycling are more sustainable than incineration and landfilling, but reuse is more beneficial than recycling. For this, designing a textile product by prolonging the service life quality could promote reuse. In addition, it is essential to promote consumer awareness to foster an environmentally friendly consumption behaviour on textile products. Leading economies should manage their textile waste in a closed-loop circular approach, mainly when exporting textile waste to developing countries is being outlawed. Various streams of textile recycling technologies are available and continue to innovate new ideas with biotechnology advancement. Applying holistic technologies, and not relying upon a single technology, to manage a complex textile waste is deemed essential.

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7.Conflict of Interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

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