A Cross-Industry Analysis of Sustainable Practices and Trends of Circular Economy Dynamics on Production Technology in Bangladesh

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Abstract. The concept of a circular economy is gaining fame worldwide as a sustainable alternative to the traditional linear economy mode. This can also be characterised by a 'take-make-dispose' approach. This research explores the implementation and dynamics of the circular economy across several industries in Bangladesh. Here, we have analyzed diverse sectors such as textiles, electronics, and agriculture. After analyzing, this study identifies each industry's unique challenges and opportunities in transitioning towards more sustainable practices. The study was done by doing qualitative interviews and data analysis. In the end, the research will highlight innovative strategies companies employ to maximise resource efficiency which will eventually minimize environmental impact. The findings reveal a growing trend of sustainability-driven business models. This not only supports economic growth but also contributes to environmental conservation. An in-depth overview of the circular economy's potential to transform industrial practices in Bangladesh is provided through this study. The policymakers, business leaders, and stakeholders aiming to create sustainable development can get valuable insights from this study. This analysis can be taken as a guide for future research and practical applications within the scope of environmental and economic sustainability in emerging economies.

1. Introduction

The circular economy (CE) has came to the light as a transformative concept for achieving sustainable development goals. CE mainly emphasizes on resource efficiency and waste reduction. The shift from a linear 'take-make-dispose' model to a circular one has attracted substantial attention globally. This happened mainly because of its potential to mitigate environmental impacts and build economic resilience [1,2,3,4,5]. Countries across Europe and North America are integrating circular principles into their industrial practices. This integration has demonstrated significant progress in the manufacturing and consumer goods sectors. Despite the global momentum, the adoption of circular economy practices in Bangladesh still needs to be revised [6].

In Bangladesh, the dominant economic model is still heavily linear. The current situation of Bangladeshi industries can be characterized by limited recycling and high levels of waste. This approach strains the country's limited resources. As a result, it is bringing significant environmental challenges. The minimized interest in the circular economy in foreign contexts provides a crucial backdrop for examining its potential applicability and benefits within the Bangladeshi context.

This study aims to go deeper into the trends and practices of prominent four Bangladeshi companies, such as Walton, SMEC, DBL, and Beximco. This study is about understanding the current sustainable circular economy principles into their operations. Also this study suggests, what circular practices companies can integrate into their operation. These companies represent a cross-section of industries including electronics, construction, and textiles. Each of these companies contributes significantly to the national economy. By analyzing these companies, this research seeks to uncover the current state of circular economy practices in Bangladesh. Also this research identifies industry-specific challenges and opportunities.

The research questions guiding this study are multifaceted:
1) What is the current trend of circular economy practices in Bangladesh?
2) This question aims to establish a baseline understanding of how far Bangladeshi companies have adopted circular principles.
3) Which industry is performing better in terms of integrating circular economy practices? This question seeks to recognize leading sectors and derive lessons that could be applied across other industries.

By employing a mixed-methods approach, combining quantitative data analysis with qualitative insights from industry experts and stakeholders this study answers to these questions. These methodology allows for a detailed examination of the operational, economic, and environmental aspects of circular economy practices within these industries. And also gives a clear understanding of the overall situation of the country.

Understanding the dynamics of the circular economy in Bangladesh is important for the economic benefits. Also it undeniably brings environmental benefits by aligning the country with global sustainability goals. It is important for Bangladesh to consider alternative models that support not only economic development but also gaining environmental goals. Because nations worldwide are working to reduce their ecological footprints while promoting sustainable growth.

2. Literature Review
The Circular Economy (CE) practices in Bangladesh are mostly taken as recycling within a few industries like textiles and Plastics. Key challenges includes wider CE adoption for example - technological limitations, insufficient policy support, and low public awareness and participation. Implementing CE could lead to significant environmental benefits like reduced pollution and better waste management, as well as economic advantages through resource savings and job creation [6].
The ship demolition industry is significant to Bangladesh's economy, providing materials like steel and iron which are critical for local industries. This sector reduces the need for expensive imports and supports many local jobs. Deep Neural Networks (DNN) to enhance efficiency in estimating recoverable materials from ship demolition, aiming to reduce time and increase profitability. Despite economic benefits, the industry faces criticism for environmental damage and poor labor conditions. The study by Ahasan et al. [7] discusses the balance between economic benefits and environmental and social responsibilities.

Again understanding and leveraging the identified drivers can facilitate strategic planning and operational improvements. Also advocating for strategic investments in technology and processes that align with circular economy principles are important to achieve sustainability targets [8].
There is very little work done in the circular economy sector of Bangladesh while most of the circular economy research is done in western countries. Hence, the objective of this study is to fill up the gap in the research field of Bangladesh.

3. Methodology

The methodology for this study involves a combination of semi-structured interviews, secondary source data extraction, and data analysis using a Multi-Criteria Decision Tool. Interviews were held with key executives from the four leading Bangladeshi companies. The companies are Walton, SMEC, DBL, and Beximco. These interviews are designed to be flexible, allowing for open-ended questions and enabling the respondents to share their experiences, challenges, and insights freely. We have selected these industries due to their significant contributions to the national economy. The concept of Circular Economy (CE) is still not common in Bangladesh as this is a developing country and most industries maintain only the conventional way of production. Only a few leading companies integrate the concept of sustainability (not CE) into their operation process. Other small and medium enterprises (SMEs) do not even consider the positive side of sustainable production let alone implementing CE. We have interviewed four different industries from three different sector (Engineering & Consulting, Textile, Electronic & Manufacturing). We had approached other companies as well. But most of those companies were hesitant to share information fearing breach of confidentiality. Two interviewees (totaling eight interviewees) per each company were chosen based on their direct involvement in different initiatives within their organizations. Separate questionnaires were used for each industry though substantial questions were similar.

The Multi-Criteria Decision Tool (MCDT) was applied to assess and compare the circular economy performance across the selected industries. The criteria were selected preliminarily based on the keywords from the annual reports published by the companies. And later, we eliminated multiple keywords and selected material efficiency, production process optimization, policy compliance and consumer engagement – these four keywords based on the response from the interview. The MCDT analysis involved assigning numerical scores based on the interview responses and secondary data analysis, which later allowed us to do a comparative evaluation of CE adoption across companies.

4. Findings

The methodology After conducting the semi structured interviews, findings were tabulated in a concise format. Table 1 contains the key findings after conducting the questionnaire survey with SMEC.

Table 1. Key Findings From SMEC

Practice	Current Approach	Gradually Adapting New Approach	Circular Economy Opportunity
Design Strategy	Traditional methods		Eco-friendly design, consider lifecycle impacts
Building Materials	Primarily virgin materials	Utilize demolition debris in new construction	
Life Cycle Assessment	Limited use	Integrate LCA tool for all projects to optimize resource efficiency and environmental impact	
Cost Focus	Prioritize immediate economic gains		Balance cost with long-term environmental and resource savings

These key findings help us to understand SMEC's different strategy. Their current strategy, gradually adopting strategy and the opportunities before them are covered in these key findings. However, we can see that SMEC still have not taken much initiative in CE sector. They mainly follow the traditional way of doing construction. However, it might be considered that some of their information might be confidential. Hence, not shared in the interview.

Then, Table 2 depicts the key findings after conducting the questionnaire survey with Walton.

Table 2. Key Findings From Walton

Material	Waste Stream	Circular Economy Practice	Outcome
Aluminum	100%	Melts and reuses aluminum for LED bulb parts	Reduced reliance on virgin aluminum, energy savings
Packaging and shield material	Sheet metal safety guards	Recycles materials, reduces landfill waste	Resource recovery, promotes a closed-loop system
Plastic	100%	Recycles for various applications	Eliminates plastic waste, creates new products from recycled material
Dining system	Waste	Biogas plant for electricity production	Generates renewable energy from organic waste, reduces reliance on fossil fuels
Burnable materials		Incineration boiler	Energy recovery from waste, avoids landfill disposal
Copper	100%	Makes Walton cable	Reduced copper mining need, minimizes environmental impact
Metal plate wastage		Makes lift counterweight	Utilizes waste material for new application, avoids additional production
Machine making section		Makes their machines	Increases self-reliance, reduces external resource dependence

Walton is a leading electronics and appliance manufacturing company in Bangladesh. The key focus of this company is reducing waste and integrate sustainability into its operation. In the above table a brief overview of Walton's working process has been presented based on the information we got from interview. Apart from this material recycling, Walton has implemented innovative waste management practices. Their organic waste from dining system is converted into biogas. This biogas generates renewable energy and reduces the reliance on fossil fuel.

This company has a vertically integrated supply chain. Whenever a part of a machine breaks down, they try to use that part from an obsolete machine. They also repair and upgrade the parts and machines to make best use of all of their resources.

Findings after conducting the questionnaire survey with DBL are presented in Table 3.

Table 3. Key Findings from DBL

Key Finding Category	Description
Material Innovation	DBL innovates by creating special yarns from "cut clips" and raw cotton combined with recycled materials such as PET bottles.
Recycled Materials	They use recycled polyester from PET bottles, along with other recycled materials, in their production processes. This includes producing poly-cotton yarns and cotton-poly-terry products, showcasing a commitment to reusing materials .
Collaborations	DBL collaborates with global brands like Puma, H&M, and Zara, and has specific projects with Coca-Cola to recycle PET bottles into apparel. These collaborations ensure compliance with international circular economy standards despite the lack of local legislation .
Compliance and Motivation	Though there are no local laws on the circular economy in Bangladesh, DBL follows international standards due to requirements from their partnerships with top global brands. This is crucial for maintaining their business relationships and market presence.
Specific Projects	Their "Switch 2 Circular Economy" project is notable for its innovative approach to converting PET bottles into wearable dresses. This involves multiple stages of material transformation from waste to fashion .
Resource Efficiency	DBL has achieved significant resource savings in the usage of recycled cotton, that results in significant reduction in water, energy and carbon emission.
Waste Reduction	They focus on reducing waste throughout their production processes, contributing to substantial savings in resources and minimizing environmental impact. This includes the use of materials like cotton nappy mélange and creating special yarns that incorporate up to 30% recycled materials mixed with virgin fibers.

DBL has always been committed to sustainable fashion industry. By using organic cotton, recycled polyester, and other sustainable fabrics they reduce the environmental impact of raw material extraction. They also implemented zero-waste manufacturing by implementing cutting-edge technologies to minimize the fabric waste during production. They also repurpose waste into new products like turning fabric scraps into insulation materials.

They also utilize solar, wind and other renewable energy sources to power their manufacturing facilities. DBL offers high quality and long lasting clothing option to reduce the frequency of replacement.

Finally, key findings after conducting the questionnaire survey with Beximco are presented in Table 4. Beximco is dedicated to reduce the waste of textile industry. BEXIMCO has initiated programs to collect and recycle old garments from consumers, transforming them into new fibers or products. BEXIMCO employs advanced technologies and lean manufacturing techniques to minimize fabric waste during production.

Table 4. Key Findings from Beximco

Key Finding Category	Description
Material Recycling	Beximco recycles pre-consumer waste such as knit polos and denim, buying from suppliers who sort these materials.
Organic Materials	They use 100% organic cotton in their products, which supports sustainable agriculture and reduces environmental impact.
Water Management	Beximco reuses 30% of their ETP water and has reduced their water usage by 70% through the ZDHC process.
Innovative Processes	Adoption of the ZDHC (Zero Discharge of Hazardous Chemicals) process to minimize water use and reduce pollution.
Sustainable Manufacturing	Beximco emphasizes the use of recycled raw materials and aims to integrate sustainable practices across its operations, including digitalizing design to reduce sample waste and using eco-friendly processes to cut water usage

Across the four industries analyzed in the sectors of electronics, construction, and textile - we can clearly see a divergence in the CE adoption in these four companies as shown in Figure 1. Some of these companies are significantly ahead in sustainable practices. The electronics sector (Walton) showed a highly integrated approach in material recycling. They have achieved 100% reuse of aluminum, recycles plastic and copper. They have also incorporated waste-to-energy solutions such as biogas solution. However, despite these efforts, Walton is facing thee challenge of scaling up closed loop production due to the high initial costs of recycling infrastructure. In contrast, the construction industry (SMEC) remains in the early stages of CE adoption. They rely heavily on traditional building methods. This is due to the limited budget of the projects and corruption in this sectors which doesn't allow them to explore modern methods. Due to these reasons, SMEC has to prioritize immediate economic gains over long-term sustainability. Which indicates a significant gap in circularity compared to other industries. On the other hand, the textile sector (DBL) can be seen as a leader in CE implementation which is driven by global sustainability regulations from brands like H&M, Puma, and Coca-Cola. They have also successfully integrated recycled PET bottles into polyester fabrics and have achieved zero-waste manufacturing. However, their CE adoption is mainly externally motivated rather than driven by national policy. This shows that the companies can integrate CE policies well into their processes if they are motivated by the government initiatives. Similarly, we can see that Beximco achieved sustainability milestone by utilizing 100% organic cotton, implementing Zero Discharge of Hazardous Chemicals (ZDHC) water management to reduce water usage by 70%, and digitalizing designs to minimize material waste. Despite the progress, the companies are struggling in implementing CE initiatives due to high resource consumption and an absence of local CE initiatives. It is noticeable that consumer engagement and design for longevity is significantly underdeveloped. Only Walton prioritize repairability, product take-back program or extended product lifespan. To create a clear momentum towards circularity in textiles and construction there is a strong need for policy interventions and industry collaboration to accelerate CE adoption Bangladesh.

Between the first two interviews, a multi criteria decision analysis was carried out. The findings from the analysis are presented in Figure 2 and Figure 3. The criteria were initially set by the result of the annual reports of these companies. The four main criteria were later identified by validating the key words in the interview. The weightage we got was based on our survey, interview, and the secondary

data source that found from those companies. There was an scale of importance for comparison. The scale of importance is shown in Table 5.
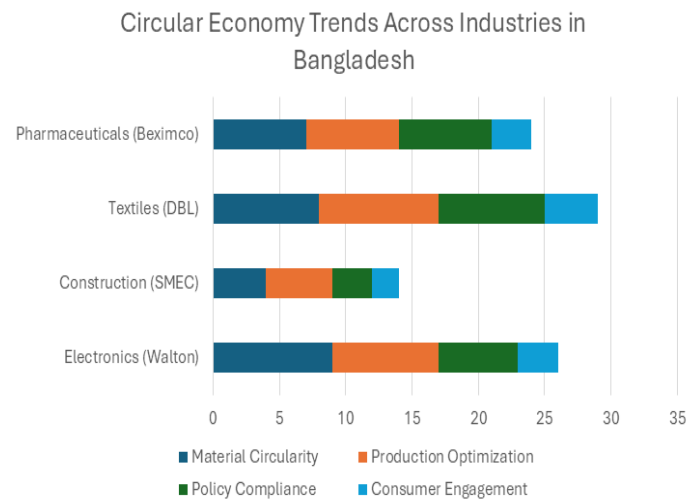

Figure 1. Comparative analysis of circular economy adoption across four industries in Bangladesh
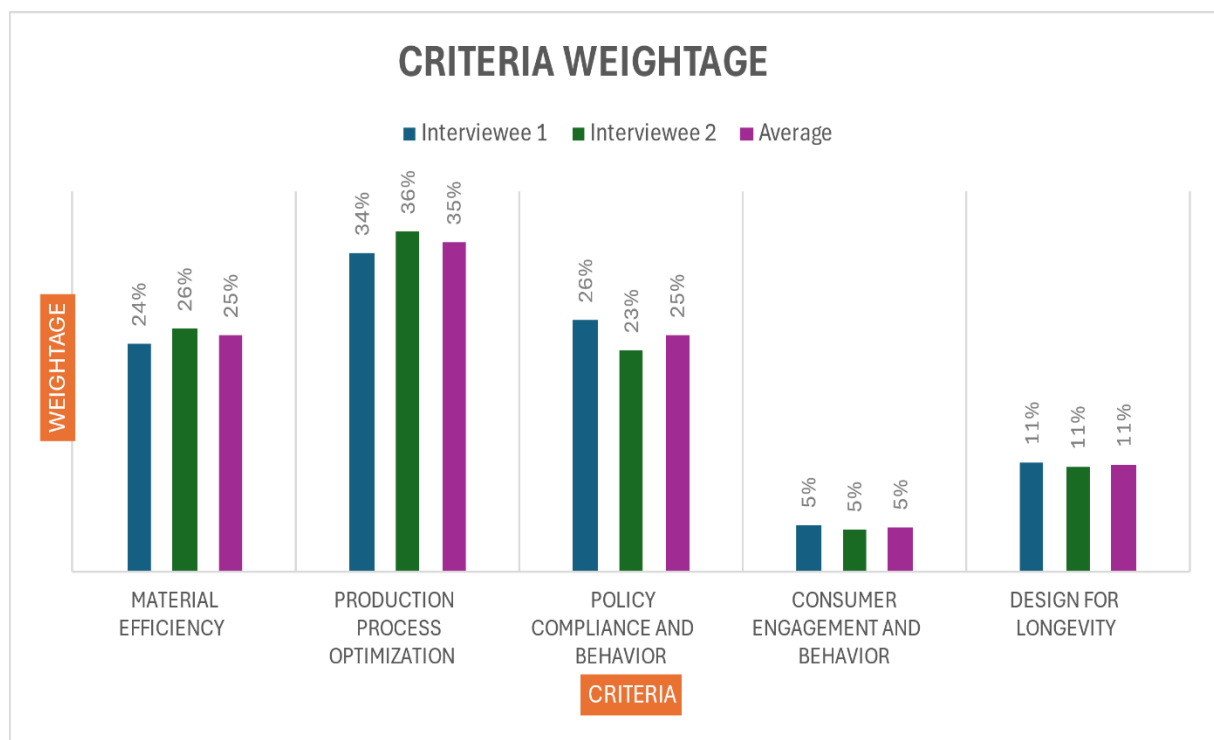

Figure 2. Multi Criteria Analysis on Criteria Weightage

Table 5 *:* The example scale for comparison [9]).

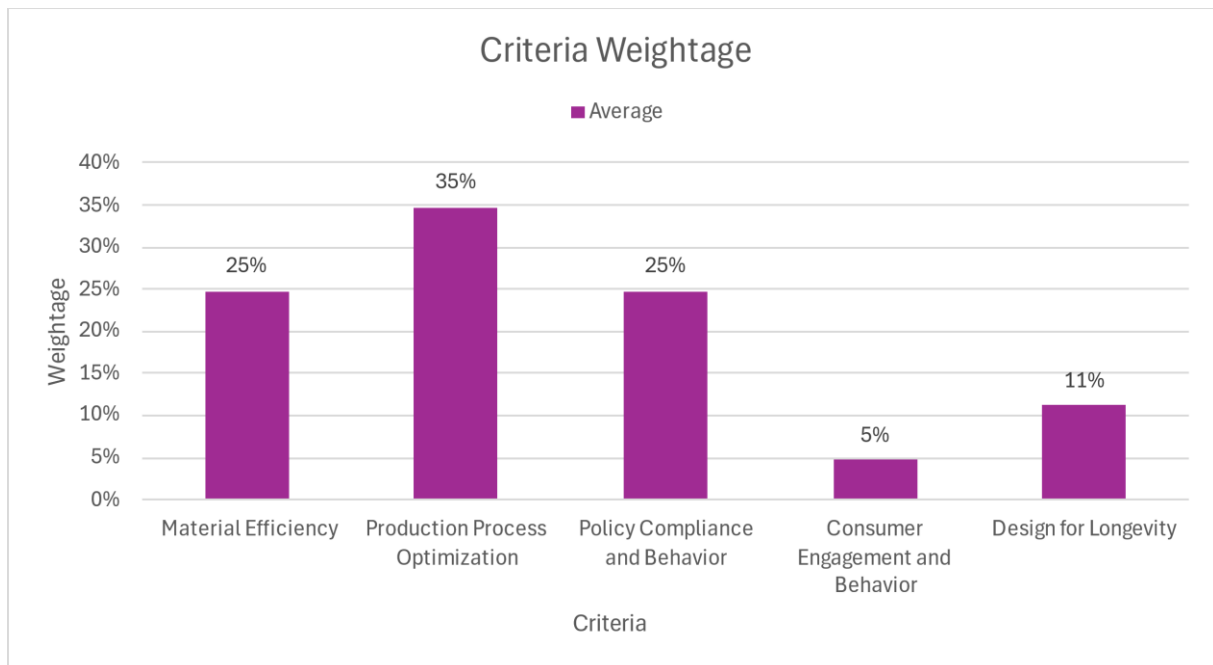| Scale	Degree of preference
1	Equal importance
3	Moderate importance of one factor over another
5	Strong or essential importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Values for inverse comparison

Figure 3. Multi Criteria Decision Analysis in Summary

A frequency index was used here to rank causes of delay based on frequency of occurrence. The occurrence is identified by the participants. Here, Frequency Index is (F.I.) % = Sa (n/N) * 100/5 [10]. Here, a is the constant expressing weighting given to each response (ranges from 1 for rarely up to 5 for always), n is the frequency of the responses, and N is total number of responses. Again, for severity index a formula is used to rank causes of delay based on severity as indicated by the participants. Severity Index is (S.I.) % = Sa (n/N) * 100/5 [10] Here, a is the constant expressing weighting given to each response (ranges from 1 for little up to 5 for severe), n is the frequency of the responses, and N is total number of responses. Again, the importance index of each cause is calculated as a function of both frequency and severity indices [10]. Importance Index is (IMP.I.)% = [(F.I.) % * (S.I.) %]/100

The MCD analysis shows that on average Material efficiency which is use of recyclable material, and sustainable cotton is 25% important. Production process optimization, mainly greenhouse gas production control is the most important criterion for all companies. Policy compliance is 25% important. Consumer engagement and behavior is the least concerning for them which is 5% only. And design for longevity is moderately important, which is only 11%. But for companies to implement

circular economy design for longevity and policy compliance and behavior should be more important. As policy comes from the government. If government makes rules and regulations about circular economy and the company adhere to those rules and regulations then there will not be much need for taking other measurements. On the other hand, if we consider design for longevity means the dresses will last longer. Hence the consumer will not have to buy dresses frequently. So, there will be a minimum amount of wastages.

5. Conclusion

This research has shown that though Bangladesh is not fully aware of the circular economy practices, and there is a lot of challenges in the ways of adopting circular economy, Bangladesh still has the potential for adopting circular economy. This study is the first cross industrial analysis in Bangladesh which finds that key challenges include a lack of advanced technology, insufficient government policies. Low public awareness is another key challenge. Despite these obstacles, there's a clear opportunity for Bangladesh to improve its resource efficiency and reduce environmental impacts. These will eventually lead to economic benefits and better sustainability in the long run. Research in this sector will provide deeper insights and help dive deeper and help build effective strategies for embracing circular economy principles. This adoption usually helps a country to align with the sustainability development goals and enhance the economic resilience. However, this study has a clear limitation. The first limitation is small sample size. We tried approaching multiple factories with the concept of our research. However, most of those industries had limited knowledge about sustainability let alone CE. Hence, we only had to consider these few industries that had a minimum knowledge about the concept of sustainability and CE. In future further research may be conducted tin small and medium enterprises (SMEs) and policy oriented framework.

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