BARRIERS IN IMPLEMENTING THE CIRCULAR ECONOMY MODEL IN APPAREL WASTE MANAGEMENT IN SRI LANKA

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Abstract. The apparel industry is one of Sri Lanka's major export-oriented sectors, generating a substantial amount of pre-consumer apparel waste. Currently, landfilling and incineration are the dominant waste management methods, posing significant environmental, social, and economic challenges. This "take, make, use, discard" approach follows the linear economy model. To address its limitations, the Circular Economy (CE) model has gained momentum over the past few decades. However, while some research has explored CE adoption in Sri Lanka's apparel industry, no studies have critically analysed the barriers to its implementation. Given that CE remains a relatively novel concept in the country, addressing these barriers is essential. This study aims to identify the challenges and barriers in implementing the CE model in Sri Lanka's apparel industry. A qualitative research approach was employed, involving four in-depth case studies of large-scale apparel manufacturing organisations. Primary data were collected through twelve semi-structured interviews and validated by four industry experts. Thematic content analysis was conducted manually to analyse the data. The findings identified 39 barriers categorised under seven key pillars as economic, environmental, social, legal, market, organisational and market.

Keywords. Apparel Industry, Barriers, Circular Economy, Pre-Consumer Apparel Waste, Sri Lanka

1. Introduction

Sri Lanka's export earnings from apparel in 2024 reached USD 4.7 billion, recording a year-on-year growth of nearly 5% (Joint Apparel Association Forum Sri Lanka, 2024). According to the Ministry of Industry and Entrepreneurship Development (2021), the Apparel sector's contribution to Gross Domestic Product (GDP) stands at approximately 7%. As an industry-expanding strategy, the apparel sector has developed strong partnerships with famous brands, notably Nike, Victoria's Secret, and Marks & Spencer (Goger, 2013). Nevertheless, the apparel sector contributes significantly to worldwide production and consumption, it is also responsible for generating a considerable amount of waste. The apparel sector in Sri Lanka generates tens of thousands of tons of textile waste annually (Dias, 2024). According to the source of generation, apparel waste can be divided into two categories: post-consumer waste and pre-consumer waste (Tomovska et al., 2016). Pre-consumer apparel waste can be described as waste generated from the manufacturing processes. The apparel supply chain is divided between developed countries and developing countries that have outsourced the apparel production process, which means that the former generates post-consumer waste, while the latter generates more pre-consumer waste (Tomovska et al., 2016). Therefore, Sri Lanka generates high pre-consumer apparel waste as an industrialised country. Gunasekara et al. (2018) also asserted that the management process of apparel waste in Sri Lanka has become a major challenge in modern culture. The primary challenge is not the generation of apparel waste but rather its management and treatment. The apparel sector's present waste management techniques, such as incineration and landfilling, have a tremendous impact on the economy, society, and the environment. This "take, make, use, discard" model is known as the Linear Economy (LE) model. To address the limitations of the LE model, the Circular Economy (CE) model gained momentum during the last few decades.

According to Geng et al. (2012), the model of CE has developed as a viable solution to address these issues and move in the direction of an environmentally friendly strategy. According to the Ellen MacArthur Foundation (2019), CE is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoring, shifts towards the

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use of renewable energy, and eliminates the use of toxic chemicals that impede reuse. Further, the CE model aims for the elimination of waste through the effective design of materials, products, systems, and, within its business models. A substantial body of research has focused on CE adoption and implementation in the apparel sector. Considering the apparel sector in Sri Lanka, a few studies published in the last five years explain that CE is a relatively new concept in the country. Mahendrarajah and Thayaparan (2020) conducted a literature review on the applicability of CE in the apparel sector, its benefits, and the challenges of adopting. Edirisinghe et al. (2022) conducted a study to examine the properties of waste, treatment options, and disposal techniques of apparel waste. Furthermore, Edirisinghe et al. (2023) surveyed to examine the production of fabric waste in the apparel manufacturing sector of Sri Lanka. Moreover, Edirisinghe et al. (2024) studied a comprehensive approach to identifying the environmental impact of the product lifecycle in the textile industry, with a specific focus on recognising the potential of CE to mitigate environmental impacts. Regarding CE adoption and implementation of apparel and textile waste, two studies can be found: Sulochani et al. (2020) evaluated best practices in waste and water management in the Sri Lankan textile sector using CE as a theoretical framework, and Jayakodi and Thayaparan (2021) conducted a study introducing an approach for effective pre-consumer apparel waste management practices through the CE model. However, none of these studies have focused on empirically identifying the barriers to implementing CE in pre-consumer apparel waste management. Subsequently, a prevailing research gap was identified as a research avenue to carry out this study in the Sri Lankan context. Identifying barriers to pre-consumer apparel waste management is essential for developing effective strategies to enhance resource efficiency and effective CE implementation apparel sector in Sri Lanka. Further, it helps uncover systemic challenges, enabling policymakers and businesses to design targeted interventions for waste reduction. For industry professionals, understanding these barriers facilitates the adoption of CE practices, improving operational efficiency and compliance with evolving environmental regulations. Therefore, this study aims to critically identify the barriers to implementing the CE model in pre-consumer apparel waste management in Sri Lanka.

2. Literature Review

2.1. APPAREL INDUSTRY AND PRE-CONSUMER APPAREL WASTE GENERATION

Global apparel production is vast, and as a result, a massive amount of apparel materials gets wasted (Swami et al., 2016). The change in the apparel industry with fast fashion and on-time production has led to an increase in the number of fashion seasons and new fashion collections for each season at a low price, which has been identified as the underlined reason for waste generation (Johansson, 2010). The apparel sector in Sri Lanka is also shown to generate an enormous amount of pre-consumer apparel waste (Gunasekara et al., 2018). According to Jordeva et al. (2015), pre-consumer apparel waste can be divided into textile waste, which includes synthetic fibre, cotton fibre, cotton mixtures, and mixed raw content; packing waste, which includes cardboard boxes, containers, bailing, and other waste; and impurities, which include cardboard and paper, buttons and reels, metal components, as well as other types of waste. According to Jayakodi and Thayaparan (2021), fabric and polymer are categorised as textile waste; buttons, metal parts, labels, tags, and trims fall under impurities; cardboard boxes, polythene, and paper are classified as packing waste; and thread cones, fabric cones, broken machinery, and empty chemical cones are identified as other wastes in Sri Lanka. Sarkar et al. (2018) explained that fabric scraps and trimmings, along with defective goods, are produced during the manufacturing process at several stages, such as material cutting and sampling, and along manufacturing. Table 1 indicates the classification of the pre-consumer apparel waste based on the literature findings.

Table 1: Types of Pre-Consumer Apparel Waste

Textile waste	Impurities	Packing waste	Other
Fabric Polymer	Buttons Metal parts Labels Tags and trims	Cardboard boxes Polythene Paper	Thread cones (Plastic and cardboard) Fabric cones (Plastic and cardboard) Broken machinery Empty chemical containers

Larney & Aardt (2010) explained that waste is generated throughout the entire apparel production process. Pre-consumer apparel waste generation poses significant challenges for the apparel sector and increases environmental, social, and financial problems (Sarkar et al., 2018). Additionally, the disposal of apparel waste through landfilling and incineration has gained popularity while also contributing to global warming (Mulla, 2019). Globally, only 20% of apparel waste is accumulated for reuse or recycling (Koszewska, 2018). According to available research, Sri Lanka's main disposal options are landfilling and incineration, with some clothing waste also being reused and recycled (Dissanayake et al., 2018). Although 8,000 to 19,000 tonnes of clothing waste are burned annually in Sri Lanka, only 25% of the material is expected to be recycled or reused (Jayasinghe et al., 2010). The problem has become even more challenging due to the lack of suitable waste management solutions to handle the enormous amounts of pre-consumer apparel waste generated daily (Dissanayake et al., 2018).

2.2. CIRCULAR ECONOMY IN PRE-CONSUMER APPAREL WASTE MANAGEMENT

The LE model is based on the "take, make, use, discard" principle (Sariatli, 2017). This principle serves as an example of how the LE is used in apparel waste management in an effort to maximise short-term earnings and correspond to fast fashion expectations. The LE model's leading illustration of the burden on the environment brought on by high consumption is the fashion industry (Kirchherr, 2018). Landfilling is one approach that eliminates the residual energy of a product after it has been disposed of, and LE is connected to various needless resource losses (Ellen MacArthur Foundation, 2019). Incorporating a waste management system that is environmentally friendly is crucial, according to the author, given the aforementioned shortcomings of the current pre-consumer apparel waste management procedure. Due to the emphasis on preventing waste from ending up in landfills, procedures and embedded adaptability incorporate loops of feedback (Seadon, 2010).

The idea of CE is seen as a solution for balancing goals for environmental conservation and economic growth due to the numerous difficulties and underlying constraints of LE (Lieder & Rashid, 2016). The apparel industry has been recognised as one of the best avenues to implement CE since it represents one of the highest-earning industries in the world, having an estimated market worth of 0.82 trillion euros. However, the industry strongly adheres to the LE model because of its low-cost goods and quick-fashion trends (Barla et al., 2017). Therefore, circularity is designed to serve long-term sustainable development, being the ultimate aim in terms of the environment, the economy, and society. Furthermore, CE has become widely accepted, business model innovation will be just as important as technological advancement in both the Business-to-Customer (B2C) and Business-to-Business (B2B) segments (Rizos et al., 2018). To improve manufacturing performance in terms of sustainability, CE practices and technology are crucial (Šebo et al., 2021). Due to its unexpected results in numerous businesses in Sri Lanka, the zero-waste idea, or the notion of CE, has drawn more attention. Although some CE principles are being applied on an ad hoc basis. For instance, the construction sector in Sri Lanka currently has extremely limited awareness and comprehension of these concepts (Wijewansha et al., 2021). This suggests that the CE is a relatively new concept in Sri Lanka,

and this situation is particularly true for the apparel industry, where there is limited awareness and understanding of its principles.

2.3. INSIGHTS FROM GLOBAL CONTEXT ON BARRIERS IN IMPLEMENTING CIRCULAR ECONOMY PRE-CONSUMER APPAREL WASTE MANAGEMENT

The adoption of CE practices in the apparel sector faces a range of interrelated challenges. A lack of awareness and understanding of CE principles among industry stakeholders is identified as a primary barrier (Ghani & al Hamad, 2024; Zoumpalova et al., 2023). This knowledge gap is further exacerbated by low literacy levels and limited exposure to sustainable business models (Farrukh & Sajjad, 2024). The absence of robust policies, regulatory incentives, and supporting infrastructure also hinders progress (Ghani & al Hamad, 2024; Zoumpalova et al., 2023). Moreover, a lack of communication and collaboration across the value chain limits opportunities for joint innovation and capacity building. Market immaturity, including limited demand for recycled materials and unfamiliarity with circular products, adds another layer of complexity (Ghani & al Hamad, 2024; Sharma et al., 2025). Further resistance to change is often driven by deeply rooted norms, centralised decision-making, and a focus on short-term economic gains over long-term sustainability goals (Farrukh & Sajjad, 2024). Further to the authors, these issues are particularly evident in contexts like Pakistan’s textile industry, where manufacturers prioritise profit maximisation and cost-cutting, even when aware of CE benefits. High operational and material costs, combined with technical limitations such as inefficient recycling processes and performance concerns with recycled inputs, further discourage CE adoption (Farrukh & Sajjad, 2024; Ghani & al Hamad, 2024). Financial constraints both internal and macroeconomic are also critical, especially for startups and organisations operating in resource-scarce regions (Zoumpalova et al., 2023). To overcome these barriers, scholars suggest a multifaceted approach including financial support mechanisms, regulatory reforms, knowledge sharing, consumer engagement, and investment in innovation and technology (Farrukh & Sajjad, 2024). Most of the identified barriers to CE implementation are specific to countries such as India, Pakistan, the Czech Republic, and Sweden and largely represent high-level, systemic challenges. However, there is limited understanding of how these barriers manifest in the Sri Lankan context, particularly within the apparel sector's pre-consumer waste management.

3. Methodology

The nature of the research problem determines the choice of an appropriate research approach (Creswell, 2014). The qualitative method places a strong emphasis on interpretation and description, which can lead to the development of new theories or concepts to assess organisational processes (Hancock et al., 2009). Given the qualitative nature of the data required for this study, a qualitative research approach was selected, as it provides deep insights into real-life contexts, preserves the intended meaning, and enables a comprehensive understanding of the research findings, an aspect that is challenging to achieve through quantitative methods. A case study is an empirical investigation that explores a contemporary phenomenon within its real-world context, particularly when the boundaries between the phenomenon and its context are not clearly defined (Yin, 2019). Therefore, the case study approach is suitable for research topics requiring an in-depth understanding of organisational and social processes, allowing for the collection of rich contextual information (Cassell & Symon, 2004). Accordingly, 4 major apparel companies were selected to provide diverse perspectives, enhance the findings, and contribute to a more comprehensive understanding of the subject matter. Three selection criteria were considered when selecting apparel manufacturing facilities as 1) engaged in the export market and collaborating with international brands, 2) employing more than 1000 workers, and 3) having a production capacity exceeding 10,000 items per month. In each case, three semi-structured interviews were conducted with corporate executives and waste management professionals responsible for overseeing waste treatment at the facility with more than 3 years

of experience. The experts were selected for the study using the purposive sampling technique. Additionally, a validity expert form was conducted to validate the findings of the study. Four pioneer experts in the field were selected for this, covering academia and industry, using purposive sampling. Finally, the gathered data was analysed through thematic and manual content analysis.

4. Data Analysis and Discussion

4.1. SEMI-STRUCTURED INTERVIEWS

Table 2: Demographic Details of the Respondents of the Semi-Structured Interviews

Case	Type of Business	Product Type	Respondent Code	Experience	Designation
Case A	Export	Casual wear, Activewear	A 1	7 years	Assistant Manager - Environmental Sustainability
			A 2	3 years	Executive Compliance and Sustainability
			A 3		Assistant - Housekeeping and Waste Management
Case B	Export	Casual wear	B 1	6 years	Senior Manager - Head of Facilities Management
			B 2	4 years	Senior Executive - Facilities Engineering
			B 3		Staff - Waste Management
Case C	Export	Activewear, Lingerie Wear	C 1	11 years	Senior Manager - Corporate Environment Sustainability
			C 2	4 years	Assistant Manager - Waste Handling
			C 3		Assistant - Housekeeping and Waste Management
Case D	Export	Casual wear	D 1	5 years	Senior Manager Corporate Environment Sustainability
			D 2	3 years	Executive Compliance and Sustainability
			D 3		Assistant – Facilities Management

4.1.2 Analysis and discussion

Lack of funding allocation for the automation projects is a crucial barrier that has been stated by B2. For the implementation of CE, it needs a considerable amount of investment, which has a long-term economic return (Liu & Bai, 2014). High cost of recycling is one of the economic barriers which have been faced by all four factories (Ghani & Al Hamad, 2024). D1 has commented that the lack of recycling facilities within the country has been identified as the major reason for this. A1 has commented that through lean manufacturing, a lot of waste generation can be reduced. However, a lack of employee engagement towards the lean manufacturing process is a major barrier that has been identified. Further, he stated that "employees are more concerned about the production process and target completion rather than lean manufacturing aspects". C1 also mentioned that due to a lack of engagement, immense contribution needs to be implemented, and it is an extra burden on employees, confirming with the literature findings (Zoumpalova et al., 2023).

B1 stated that the application of theoretical lean manufacturing tools to the practical situation is lacking or not practical. B2 also confirmed this by explaining that "it can occur conflicts between the operation team and the Business Continuous Improvement (BCI) team, and due to the practicality issues, that occurred within the organisation. Because sometimes the solutions of the BCI team are not practical". Further, B2 commented that the same barrier occurs while implementing planned reduction projects. Generally, the factories have been located all around the country, and some of them have been located in rural areas. This has become a barrier for the CE. The respondent A2 stated that some of the suppliers who fulfil the organisational quality requirements reject the transport of materials to the rural areas due to high transportation costs. Purchasing the materials from only registered suppliers is another barrier. Respondent B2 commented that for some clothing styles, suitable suppliers are recommended by the brands, and the organisation has no authority to select the suppliers from the list, which has already been registered. In such an incident, the organisation selects the suppliers who have a lower price scale without considering sustainability or circularity requirements. Lack of awareness regarding the reusing and recycling opportunities of the waste is another organisational barrier that has been stated by respondents. Respondent B1 stated that the lack of well-established internal policies for reuse and recycling can be identified as a significant barrier towards the implementation of CE.

Most of the respondents commented that emissions have occurred due to the long transportation of the waste material, and transportation is also identified as another environmental barrier. B2 has commented that due to the changes in the properties of the materials, it is hard to reuse some materials. When considering the recycling practices, respondent C2 has commented that it is hard to recycle the blended materials. When comparing the statements of respondent A1 and C1, A1 stated that "blended materials have become a major problem for recycling". As an example, some fabric materials comprised 95% polyester and 5% spandex". C1 also confirmed that "it is hard to recycle the blended materials. Especially dark-coloured and printed materials". When evaluating these two statements, it has been revealed that blended, printed and dark-coloured materials are hard to recycle. Fabric that comprises a variety of fibres and colours will cause challenges in the sorting process and reduce the quality of recycled materials; they are considered limiting factors in textile recycling (Ghani & Al Hamad, 2024; Zoumpalova et al., 2023). Evaluating the statement of C1, it reveals that environmental pollution occurs due to the emissions and fuel usage for the recycled machinery, though recycling is essential towards the CE. The machinery, which is used to treat the waste, consumes more energy and creates pollution (Kumar et al., 2019). In addition to that, most of the respondents commented that the unavailability of advanced technologies regarding apparel waste management is identified as a major barrier. The unavailability of a method that includes all the details of the raw materials, finished goods, and waste items that can track all details is a barrier. Further, B1 argues that such a system can identify the reuse and recycling opportunities of the materials. Use of machinery with outdated technologies for the cutting and sewing processes is identified as another technological barrier. Respondent D2 argues that reduction is not possible through those outdated technologies. Further, respondent A2 commented that "the marker efficiency strategy cannot be efficiently implemented for some styles. Because of that reason, it cannot achieve the reduction targets and generate high wastages". Most of the respondents illustrated that the unavailability of the machinery which recycles the fabric is one of the crucial barriers towards the CE. Due to the lack of fully cost-effective recycling technologies and the existence of cheap fabrics in the market, interest in textile waste recycling is limited (Zamani et al., 2014).

Respondent A1 commented that most of the time, brands are the ones who nominate the suppliers. Therefore, sometimes select the suppliers without considering the sustainability criteria. Further respondents A2, B1, D1, and D2 have commented that lack of local suppliers who fulfil the requirements available in the market. Respondent A2 has further stated that "lack

of local suppliers who fulfil the organisational, legal, and brand level requirements. As an example, most of the suppliers do not fulfil the requirement of EPL and SWML licence, which is issued by the Central Environment Authority (CEA) regarding the waste handling". Most of the design process of a product is done by the brands. Further, they select the materials for a certain design. This has become a crucial barrier for circularity. Respondent A1 has commented that brands have certain restrictions for manufacturers regarding material reductions, which are considered a barrier for CE. The minimum order quantity of the suppliers has become a critical barrier for waste reduction and reuse. C1 has commented that "MOQ of the suppliers has become a huge issue. As an example, for one colour the length of the minimum fabric roll is approximately 10,000m, and for the button 1500-3000 per colour or shape. Most of the time, these fabrics or buttons cannot reuse for another style. Because manufacturers produce their products based on customer requests. These requests can be changed from time to time due to the fast-fashion concept. It is hard to get the materials from the requested amounts". Further, he has elaborated that this has become a huge barrier for the reduction targets as well. Moreover, the respondent commented that "generally, fabric and button manufacturers produce in larger quantities. Because that is the way that they can earn a profit. Because of this, it is hard to reduce the purchasing of materials which are more than required. As an example, most of the thread cone suppliers in foreign countries do the same". D1 has commented that sudden order changes of the customer or brands, and based on the lack of flexibility of the suppliers to change the order from the organisation, have become a major barrier. Most of the respondents from all four cases lack reusing and recycling vendors in the market is also critical, which all four organisations have equally faced.

Lack of employee awareness regarding the different waste management approaches and tools has been identified as a barrier, which has been stated by B1 and D1. Further lack of skills of the machine operators regarding the machine operating method, also highlighted as a barrier. These two barriers can be demonstrated as skill and knowledge level barriers (Sharma et al., 2025; Zoumpalova et al., 2023). Lack of free minds of employees for innovations regarding waste management has been identified as a social barrier for CE. Further to the respondent, "lack of customer willingness towards the recycled products due to high cost, aesthetic appearance and quality has become a social barrier for CE". Kirchherr et al. (2018) identified lack of consumer awareness and interest acts as a major barrier towards the CE implementation. It has been difficult to maintain the strategies of CE due to a lack of demand and low customer acceptance of remanufactured products (Kumar et al., 2019). Respondent B1 has commented that high rules and regulations within the BoI plants have become a major barrier for waste collectors. As an example, their documentation procedure is lengthy. For this reason, most of the vendors deviated from collecting the waste. Further, most of the respondents from all four cases commented that the organisation pays money to obtain the licence for waste management. Charges and taxes specified by the government are another barrier (Altun, 2012). After the analysis of the data, the identified barriers were grouped based on the economic, social and environmental. However, due to the extensivity of the barriers identified, a few more categories were identified as organisational, market, legal and technological. After the classification of the barriers, it was verified that both the barriers and their respective categories were verified by the experts. The summary of the identified barriers with their respective categories is depicted in Figure 1.

4.2 EXPERT VALIDATION FORUM

To validate the analysed data, expert interviews were conducted with four professionals from the waste management field. The interviewees included a chartered sustainability manager, a deputy general manager in compliance and sustainability, and a general sustainability manager, with 8, 14, and 12 years of experience in the apparel industry, respectively. Additionally, a researcher with 20 years of experience in sustainability and CE practices within the apparel

sector was also interviewed. Table 3 illustrates the agreed-upon and revised barriers and barrier categories through the expert validation. The first question asked of the expert group was their opinion on the barrier category name and its adequacy. All the experts agreed with the identified barrier categories, which were generated from the nature of the barriers. Subsequently, it was verified that the barriers under each barrier category were verified, which is depicted in Table 3.

Table 3: Results of the Expert Validation

Barrier Category	**Expert Code**			
	E1	**E2**	**E3**	**E4**
1. Economic	Agreed	Agreed	Agreed	Agreed
2. Environmental	Agreed	Agreed	Agreed	Agreed
3. Social	Agreed	Agreed	Agreed	Lack of public awareness of recycled materials
4. Organisational			Unavailability of a proper plan to manage the total waste that has been collected within the organisation.	
5. Technological	Agreed	Agreed	Agreed	Lack of technologies within the country to recycle the blended materials.
6. Market	Agreed	Agreed	high cost of the waste management vendors.	Agreed
7. Legal	Lengthy, time-consuming and a lack of continuous monitoring in the environmental license issuing and renewing process.	Cost of the environmental license renewal process.	Lack of rules and regulations on CE.	Lack of national-level research on CE

4.3 SUMMARY OF THE IDENTIFIED BARRIERS

Figure 1: Summary of the Identified Barriers

Figure 1 presents the summarised findings of the study. A total of 44 identified barriers were categorised into seven clusters: environmental, social, economic, market, technological, organisational, and legal. The clustering was carried out by the authors following the semi-structured interviews. These barrier categories and their respective items were then validated through an expert forum, ensuring the accuracy and reliability of the study's final outcomes.

5. Conclusion and Recommendations

Pre-consumer apparel management has emerged as a significant concern, although the apparel sector has been acknowledged as one of the main contributors to the country's economy. Landfilling and incineration have become prominent methods of treating the pre-consumer apparel waste, which has created environmental, economic, and societal concerns. Therefore, the application of the CE model in ensuring the proper handling of pre-consumer apparel waste has great potential. As a relatively new concept to Sri Lanka, barriers to adopting CE in pre-consumer apparel waste management are crucial. Hence, this study was enabled to identify 44 barriers, which include a lack of technological infrastructure, complex legal issues, reluctance to change within organisations, and commercial difficulties. Further identified barriers were

categorised into seven categories as environmental, economic, social, organisational, technological, legal and market-related barriers. Therefore, this lays a background for apparel manufacturing organisations to find suitable strategies to minimise or eliminate the identified barriers for effective CE implementation. Furthermore, policymakers, business professionals, and stakeholders can use the research's findings as helpful insights to create focused plans, policies, and initiatives which tackle the identified barriers. As a limitation of the study, the concept awareness of the experts was identified. Finally, the apparel sector may move toward a CE by working together, encouraging sustainable waste management techniques, and gaining long-term benefits for both the environment and the economy. As a future research avenue, the identification of strategies to eliminate or mitigate is imperative through an empirical study.

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