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Exploring Production and Distribution Practices in the Textile Industry: A Green Supply Chain Implementation Analysis*

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Abstract

Purpose: The textile industry plays a crucial role in global economic growth; however, it also poses significant environmental challenges, including greenhouse gas emissions and hazardous waste generation. Therefore, the implementation of green production and distribution practices is essential to mitigate these negative impacts. Green production involves the use of environmentally friendly raw materials, waste reduction, and resource efficiency, while green distribution focuses on reducing carbon emissions in the supply chain and adopting eco-friendly packaging. This study explores the implementation of green production and distribution within Indonesia's textile industry, identifying key challenges such as high investment costs, limited waste management facilities, and insufficient government support. **Research design, data and methodology:** The research method used is a survey conducted and in-depth interviews among textile industries in Indonesia. In the field study, observations, surveys, and interviews related to green production and distribution were carried out. **Results:** Survey results indicate that "Reduce, Reuse, and Recycle (3R)" waste management practices are adopted by only 25% of the industry, while 30% of waste is still disposed of in landfills. Other obstacles include a lack of awareness regarding waste management and limited availability of recyclable materials. **Conclusion:** This study highlights the need for increased government support, technological innovation, and collaboration within the supply chain. Although implementing green production and distribution faces considerable challenges, it has the potential to provide significant benefits for environmental sustainability and the textile industry's long-term viability. This research can serve as a reference for developing environmentally friendly strategies in this sector.

Keywords: Green Distribution; Green Production; Green Supply Chain Management; Textile Industry; Waste Management

JEL Classification Code: L52, L61, L87, L91, O14

1. Introduction

The textile industry is a key sector in global economic growth. With the increasing market demand for textile products, production in this sector has expanded rapidly. However, this growth is often accompanied by significant environmental challenges. The textile industry is known as one of the largest contributors to greenhouse gas emissions

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and industrial waste, which negatively impact the environment. Therefore, the implementation of green production and distribution practices within this industry is crucial (Hole & Hole, 2020; Jäämaa & Kaipia, 2022).

Green production encompasses a range of activities aimed at minimizing the environmental impact of the production process. These include the use of environmentally friendly raw materials, waste reduction, efficient resource utilization, and the adoption of clean technologies. In the textile industry, green production is particularly important due to the high consumption of water, energy, and chemicals during production. When managed effectively, green production can help reduce water and air pollution and optimize energy and raw material use, thereby promoting environmental sustainability (Börjeson et al., 2015; Talay et al., 2022).

On the other hand, green distribution focuses on optimizing product distribution by considering environmental aspects, such as reducing carbon emissions in transportation and using eco-friendly packaging. Traditional textile distribution involves long and complex supply chains, often leading to a larger carbon footprint. By adopting green distribution practices, textile companies can reduce carbon emissions and improve distribution efficiency, for instance, by utilizing energy-efficient transportation, efficient inventory management, and recyclable packaging materials (Li et al., 2021; Nencková et al., 2020).

Research on green production and distribution in the textile industry is particularly relevant given the pressure from consumers, governments, and non-governmental organizations to adopt more sustainable practices. Consumers are increasingly aware of the environmental impact of the products they consume and tend to prefer products produced in an environmentally friendly manner. Furthermore, governments across the globe are tightening regulations on environmental standards for the textile industry, compelling companies to adapt to more sustainable production and distribution practices (Börjeson et al., 2015; Li et al., 2021).

Implementing green production and distribution can add value to companies. In addition to meeting regulatory and consumer demands, this approach can enhance operational efficiency and reduce long-term production costs. For example, by adopting more efficient and energy-saving production technologies, companies can lower utility costs and decrease waste. Similarly, more efficient distribution can reduce logistics costs and enhance product competitiveness in the global market (Li et al., 2021; Nencková et al., 2020).

Research in this area is vital to identify the challenges faced by the textile industry in implementing green production and distribution. For example, some textile companies resist adopting green practices due to high initial investment costs and limited access to eco-friendly technologies. By understanding these obstacles in-depth, research can offer practical solutions and effective strategies to encourage the adoption of sustainable practices in the textile sector.

Globally, the adoption of green production and distribution in the textile industry also contributes to achieving sustainable development goals. This research can support objectives such as climate action, responsible consumption and production, and access to clean water and sanitation. Therefore, research on this topic has broad implications, not only for the sustainability of the textile industry but also for global efforts to preserve the environment (Shirvanimoghaddam et al., 2020; Warasthe et al., 2022).

Research on green production and distribution in the textile industry can contribute to the literature on supply chain management and sustainability. Although studies on green supply chains have progressed, knowledge gaps remain, particularly in the context of the textile industry, which has unique characteristics and challenges. Hence, further research in this field can provide new insights and deepen our understanding of how green production and distribution strategies can be effectively implemented in the textile sector (Chen et al., 2024; Jia et al., 2020).

In the context of Indonesia, the textile industry is a driving force of the national economy with significant potential to adopt green production and distribution practices. Given the environmental challenges faced by Indonesia's textile industry, such as river pollution due to textile waste and high energy consumption, research in this field is crucial to drive the transformation of the Indonesian textile industry towards more sustainable practices. Therefore, the findings of this research are expected to serve as a reference for policymakers and industry players in formulating strategies and policies that support the development of an environmentally friendly and sustainable textile industry (Diabat et al., 2014; Raian et al., 2022).

In summary, the importance of research in green production and distribution within the textile industry lies in efforts to mitigate environmental impact, comply with regulations and consumer demands, improve operational efficiency, and support sustainable development goals. Therefore, comprehensive research on this topic is essential to promote the adoption of green production and distribution practices in the textile industry, both at the national and global levels. This study aims to explore green production and distribution practices in the Indonesian textile industry and the emerging challenges. The research is expected to provide a reference for the Indonesian textile industry in implementing green production and distribution, as well as in preventing and managing waste generated during production and distribution processes (Cai & Choi, 2020; Diabat et al., 2014).

2. Literature Review

2.1. Challenges and Opportunities in Managing Green Production and Distribution in the Global Textile Industry

The global textile industry significantly contributes to the world economy while also leaving a substantial ecological footprint. The primary environmental concern in this sector lies in the high consumption of natural resources, especially water, energy, and hazardous chemicals, during the production process. Activities such as dyeing, washing, and bleaching fabrics involve chemicals that can potentially pollute water and soil if not managed properly. Furthermore, textile production generates greenhouse gas emissions, contributing to climate change. Therefore, the management of green production and distribution is crucial in mitigating these adverse environmental impacts (Majumdar et al., 2022; Majumdar & Sinha, 2019).

Another pressing issue is the vast amount of waste produced by the textile industry. Each year, millions of tons of textile waste, including fabric scraps, threads, and discarded garments, are generated, with a significant portion ending up in landfills. Poorly managed textile waste can contaminate the environment, as many textiles contain synthetic materials and chemical dyes that are difficult to decompose. Additionally, most garments currently on the market are made from synthetic fibers, such as polyester, which take hundreds of years to break down naturally. Consequently, addressing this waste problem requires more environmentally friendly waste management approaches (Saccani et al., 2023; Vishwakarma et al., 2022).

The distribution of textile products, which involves complex global supply chains, presents another challenge in the implementation of green distribution practices. The distribution process, from raw material shipment to delivering finished goods to consumers, relies on various transportation modes that use fossil fuels and generate high carbon emissions. Additionally, the use of non-recyclable plastics and materials for packaging during shipping further contributes to waste. Therefore, efficient and eco-friendly distribution management is a critical challenge for textile industry players worldwide (Ali et al., 2024; Ruan et al., 2022).

In addition to these environmental issues, a significant challenge in green production management is the high investment cost required to transition to environmentally friendly technologies. Adopting energy-efficient machinery, installing wastewater treatment systems, and sourcing eco-friendly raw materials demand considerable capital. Many textile companies, particularly small and medium-sized enterprises (SMEs), struggle to secure the funds necessary for these changes. This difficulty is compounded by the uncertainty of short-term financial returns from green investments, making companies hesitant to adopt green production practices (Ewnetu & Gzate, 2023; Rashid et al., 2024).

The limitations of recycling technologies also pose a challenge in implementing the "Recycle" principle within the textile industry. Although many companies have started collecting used clothing for recycling, the process is often complicated and expensive. For instance, garments made from blended materials (e.g., cotton and polyester) are difficult to separate into reusable fibers. Moreover, recycled textile fibers typically yield products of lower quality than the original fibers, which diminishes their appeal to manufacturers. These technological constraints limit the textile industry's ability to fully incorporate recycling into its green production strategy (Caniato et al., 2012; Shirvanimoghaddam et al., 2020).

From a regulatory standpoint, many countries have introduced stricter policies concerning industrial waste management and carbon emissions, including those in the textile sector. However, consistent and fair enforcement across the global supply chain remains challenging. In many developing countries, where most textile factories are located, environmental regulations are either weak or not rigorously enforced. Additionally, varying environmental standards across countries make it difficult for companies with cross-border supply chains to comply with diverse requirements (Moretto et al., 2018; Talay et al., 2022).

Despite these challenges, there are also opportunities for the textile industry to innovate and enhance its sustainability practices. The implementation of the 3R principles (Reduce, Reuse, Recycle) within green production provides a clear direction for companies in managing their production. By adopting energy-efficient technologies and minimizing the use of hazardous chemicals, companies can reduce resource consumption and emissions. Additionally, the "Reuse" approach, such as repurposing fabric scraps and materials in the production process, can decrease waste and reduce production costs (Saccani et al., 2023).

In the field of distribution, opportunities arise through the use of digital technologies and data analytics to optimize supply chains. By implementing data-driven supply chain management systems, companies can reduce unnecessary shipping and optimize the use of more environmentally friendly transportation modes. Furthermore, initiatives such as using recyclable or biodegradable packaging materials can help minimize waste in the distribution process (Warasthe et al., 2022).

Consumer demand for more environmentally friendly textile products also creates new market opportunities for the industry. Consumers in many countries are increasingly aware of the environmental impact of the products they purchase and tend to choose sustainably produced goods. This shift can encourage textile companies to adopt green

labels and certifications for their products, which not only enhances the company's image but also attracts a broader market segment. Consequently, companies that successfully implement green production and distribution practices can leverage these opportunities to strengthen their competitiveness in the global market (Jia et al., 2020).

Material innovation presents another significant opportunity for the textile industry. Developing textile fibers from renewable sources, such as bamboo, hemp, or recycled fibres, offers a more environmentally friendly alternative to petroleum-based synthetic fibers. Additionally, new dyeing technologies that use less water and are free of harmful chemicals can help reduce the environmental impact of production. These innovations enable the textile industry to produce greener products and meet consumer demand for more ethical and sustainable products (Cai & Choi, 2020).

At the policy level, support from governments and international organizations also offers opportunities to accelerate the implementation of green production and distribution. Governments can provide financial incentives, such as subsidies, tax relief, or special financing programs, for companies adopting environmentally friendly technologies. Moreover, policies that promote the development of waste management and recycling infrastructure can assist textile companies in overcoming operational barriers to implementing green practices (Vishwakarma et al., 2022).

Industry cooperation and cross-sector collaboration play an essential role in developing innovative solutions for managing green production and distribution. For example, some large textile companies have begun partnering with technology firms to develop more effective recycling systems or collaborating with non-governmental organizations (NGOs) to enhance transparency and sustainability practices throughout their supply chains. Such collaborations can accelerate the adoption of green practices and have a more significant positive impact on the environment (Hole & Hole, 2020; Jäämaa & Kaipia, 2022).

Ultimately, the key to successful green production and distribution management in the textile industry lies in the sector's ability to adapt and innovate in response to changing circumstances. Despite the considerable challenges, various opportunities, such as rising consumer demand, policy support, and technological advancements, offer promising prospects for the textile industry to become more sustainable. Through a holistic and collaborative approach, the global textile industry can reduce its ecological footprint and contribute to the achievement of sustainable development goals (Li et al., 2021; Nencková et al., 2020).

2.2. Implementation of the 3R Principles (Reduce, Reuse, Recycle) and Their Benefits

The implementation of the 3R principles in green production and distribution is crucial for minimizing the environmental impact of industrial activities, particularly in the textile sector. The "3R" approach, consisting of reduce, reuse, and recycle, is a commonly embraced strategy for managing waste. Reduce means minimizing waste creation by purchasing fewer items and discarding less. Reuse refers utilizing materials multiple times to prolong their usability. Recycle means transforming materials back into raw components for new products via physical or chemical methods (Bai et al., 2022). The principal support to achieve sustainable development goals (SDG) as can be seen in Figure 1.

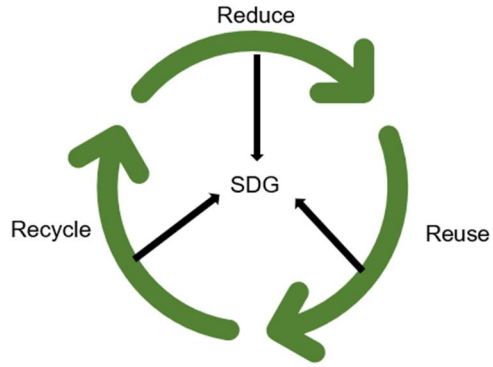

Figure 1: The 3R Principles Support to SDG

The "Reduce" principle emphasizes the reduction of resource and material usage during production processes. In the context of the textile industry, this means minimizing the consumption of water, energy, and chemicals that could potentially harm the environment. By adopting more efficient and energy-saving production technologies, textile companies can reduce waste and greenhouse gas emissions. This reduction not only contributes to environmental conservation but also lowers production costs in the long term, thereby enhancing product competitiveness in the global market (Warasthe et al., 2022).

The "Reuse" principle encourages the reutilization of materials and products that are still viable. In the textile industry, reuse can be implemented by recycling fabric scraps to create new products or designing products with a longer lifespan, thus reducing the need for new production. In the distribution phase, reusing packaging and containers for shipping can help decrease the consumption of new materials and packaging waste, thereby reducing the supply chain's carbon footprint. Consequently, reuse not only diminishes the volume of waste generated but also promotes a more sustainable use of resources (Stindt, 2017).

The "Recycle" principle focuses on processing materials and production waste into reusable materials. In the textile industry, recycling can be applied to fabric waste, fibers, and even water used in the dyeing process. By converting textile waste into raw materials for new products, the industry can

reduce its reliance on natural resources and mitigate negative environmental impacts. Recycling can also be applied to packaging materials used in product distribution, further supporting a sustainable supply chain. Therefore, adopting the 3R principles in green production and distribution becomes a key strategy in creating a more environmentally friendly, efficient, and sustainable textile industry (Hossan Chowdhury & Quaddus, 2021).

The application of the 3R principles (Reduce, Reuse, Recycle) in the textile industry offers significant benefits, both environmentally and economically. By reducing the use of resources and hazardous materials, the industry can curb greenhouse gas emissions and decrease water and soil pollution. Reusing raw materials and packaging not only minimizes waste but also lowers production and distribution costs. Meanwhile, recycling leftover materials and production waste enables the industry to reclaim existing materials, reducing its dependence on natural resources. Overall, the 3R implementation fosters a more efficient, sustainable, and eco-friendly textile supply chain while enhancing the company's image among increasingly sustainability-conscious consumers (Li et al., 2021).

2.3. Theoretical Framework for Research on Green Production and Distribution in the Textile Industry

The theoretical framework for this research is grounded in the concept of supply chain sustainability, with a specific focus on the implementation of green production and distribution practices within the textile industry. The textile sector is known for its significant environmental impact, primarily due to its high consumption of energy, water, and chemicals during production processes, as well as the carbon emissions associated with product distribution. Therefore, this study aims to explore how green production and distribution principles can be effectively implemented to mitigate these negative environmental effects (Ugarte et al., 2016).

The theory of Green Supply Chain Management (GSCM) serves as the primary foundation of this theoretical framework. GSCM integrates sustainability principles into all aspects of the supply chain, ranging from the selection of raw materials to waste management and product distribution. In the context of the textile industry, GSCM encompasses practices such as sourcing environmentally friendly materials, employing efficient production technologies, and adopting distribution systems that minimize carbon footprints. This concept forms the basis for understanding how the textile industry can transform its operations towards more sustainable practices (Ali et al., 2024).

The application of the 3R principles (Reduce, Reuse, Recycle) in green production is a key component of this framework. The "Reduce" principle emphasizes minimizing the use of raw materials, energy, and chemicals during production. This can be achieved through production efficiency, waste reduction, and the selection of materials with lower environmental impact. The "Reuse" principle focuses on repurposing materials and production waste to prevent excess consumption and reduce the need for new resources. Meanwhile, "Recycle" refers to the reprocessing of waste into reusable raw materials in production, thereby reducing environmental impact (Shirvanimoghaddam et al., 2020).

In addition to production, the concept of green distribution is another critical aspect of this theoretical framework. Green distribution optimizes the product distribution chain to reduce carbon emissions and the use of non-eco-friendly materials, such as plastic. This includes utilizing environmentally friendly transportation, efficient inventory management to minimize shipping trips, and choosing recyclable packaging materials. This approach is particularly relevant in the textile industry due to its complex supply chain, which involves multiple stakeholders, from raw material suppliers to end retailers (de Jesus Pacheco et al., 2023).

Furthermore, this framework incorporates the theory of institutional isomorphism, which explains how external pressures, such as government regulations, consumer demands, and industry standards, can drive textile companies to adopt green production and distribution practices. In some cases, companies may implement green practices in response to increasingly stringent environmental compliance requirements or to meet the expectations of environmentally conscious consumers. Therefore, institutional factors become key drivers in the adoption of green production and distribution (Li et al., 2021).

Apart from external pressures, the Resource-Based View (RBV) theory offers an internal perspective on the implementation of green production and distribution. According to RBV, companies that possess unique resources and specific capabilities in green technology, production efficiency, and waste management can gain a competitive advantage that supports their success in implementing green practices. In this context, investing in clean technologies and workforce training is crucial for building the necessary capabilities for green production and distribution (Kristoffersen et al., 2021; Moss et al., 2022).

Previous studies have shown that the implementation of green production and distribution affects not only environmental aspects but also a company's financial performance. The Triple Bottom Line (TBL) concept strengthens this theoretical framework by emphasizing that business sustainability is measured not only in terms of profit (financial gain) but also through social (people) and environmental (planet) aspects. In the textile industry, adopting green production and distribution practices can

provide long-term economic benefits, such as reduced production costs through energy and material efficiency, as well as enhanced brand image that attracts environmentally conscious consumers (Ahi & Searcy, 2015; Govindan et al., 2013; Majumdar et al., 2022).

Alongside the benefits, this theoretical framework also considers the obstacles and challenges in implementing green production and distribution. According to stakeholder theory, textile companies must balance various interests, including those of investors, consumers, government, and society. Challenges such as high initial costs for green technology investment, lack of technical knowledge, and insufficient recycling infrastructure often hinder companies from comprehensively implementing green practices (Govindan et al., 2013; Lerman et al., 2021).

Additionally, diffusion of innovation theory explains how the adoption of green production and distribution practices spreads among textile companies. According to this theory, innovations, such as the use of environmentally friendly materials or energy-efficient production technologies, are more likely to be adopted if they provide a competitive advantage and are positively received by the market. Therefore, companies that successfully adopt green practices have the potential to become pioneers that influence other companies within the textile supply chain (Pichlak & Szromek, 2021).

This theoretical framework integrates various concepts and theories, including Green Supply Chain Management, the 3R principles, institutional isomorphism, the Resource-Based View, the Triple Bottom Line, stakeholder theory, and diffusion of innovation theory. It provides a foundation for understanding how green production and distribution practices can be implemented in the textile industry, the factors influencing their success, and their impact on both the environment and corporate performance. Through this framework, the research aims to explore various strategies and solutions to support the transformation of the textile industry towards a greener and more sustainable supply chain.

3. Research Method

This study aims to evaluate the implementation of the 3R principles (Reduce, Reuse, Recycle) within the Indonesian textile industry using a survey-based approach. The case study focuses on examining how textile waste is managed across the textile supply chain in Indonesia. Data was collected on the types, quantities, and management methods of waste, as well as the distribution processes and policies adopted by the textile industry in line with the 3R principles. The research employs a structured survey divided into three main sections, guided by the 3R principles. The target population for this study includes textile factories in Indonesia, both those producing finished products and intermediate goods.

The population of this study is all textile and garment manufacturing companies operating on the island of Java, Indonesia, consisting of the provinces of Banten, DKI Jakarta, West Java, Central Java, DI Yogyakarta, and East Java. The sampling frame was taken from the Indonesian Textile Association database, data from the Ministry of Industry, and business directories. The sampling technique used was stratified random sampling. The primary respondents are supervisors or managers responsible for waste management at their respective factories.

The first section of the survey is designed to identify the types of waste generated by the textile industry and the disposal methods employed. Here, textile companies will be asked to document each category of waste produced and the corresponding disposal methods utilized. The second section of the survey aims to evaluate the waste management practices currently in place. Textile companies will be requested to provide information regarding recycling programs or projects they have implemented, annual waste management targets, and best practices already adopted within their facilities. This information is crucial to understanding the industry's level of readiness and commitment to the 3R principles, as well as the economic benefits derived from their implementation. The final section of the survey will assess the difficulties faced by suppliers in waste management and their needs to improve waste management practices. This includes technical, financial, and regulatory challenges that hinder the implementation of the 3R principles. Respondents will be asked to evaluate these factors and identify the resources or support required, such as new technologies, training, or government policies.

The study targets the textile industry throughout Indonesia, including regions with high concentrations of textile manufacturing, such as West Java, Central Java, and East Java. Out of the total textile industry population, 100 companies were contacted to obtain a representative sample, of which 33 responded positively to participate in the research. Data collection through the survey allows for a broader scope and efficiency in gathering and analyzing data. Following data collection, the next step involves validation and screening. Respondents are required to provide basic information about their factories and their contact details (name, phone number, and email) to ensure the data's credibility. Clear definitions and explanations of key survey questions are included to assist respondents in understanding and answering accurately.

The collected data will be analyzed to determine the volume and types of waste generated, disposal methods used, and the level of 3R implementation at each factory. Analysis

will be conducted for each waste category to identify waste management patterns at various stages of textile production. The evaluation of 3R practices will encompass the identification of reduction, reuse, and recycling levels successfully implemented by textile companies. Based on the survey results, an analysis of the primary challenges faced by the textile industry in implementing the 3R principles will be conducted. This analysis will aid in formulating policy recommendations and strategies to promote the effective adoption of the 3R principles, both at the company level and within government policies. In addition to quantitative data, respondents will also be asked to provide qualitative insights on best practices and challenges encountered in waste management. This qualitative analysis will complement the quantitative findings, offering a more comprehensive understanding of 3R practices.

To ensure data validity and reliability, the survey is supplemented with clear definitions and explanations for each question, minimizing potential bias in responses. The research is conducted with strict adherence to ethical considerations, including the confidentiality of respondent data. The information collected will be used solely for research purposes and will not be shared with third parties without consent. The results of this study are expected to serve as a foundation for developing waste management policies within the Indonesian textile industry and as a guide for companies to optimize the application of the 3R principles, thereby achieving sustainability and efficiency in production and distribution.

4. Results and Discussion

4.1. Global Issues in the Indonesian Textile Industry

The textile industry in Indonesia plays a vital role in the national economy, significantly contributing to its growth. However, behind this expansion and contribution lies a complex set of challenges related to the implementation of green production and distribution practices. These challenges are becoming increasingly urgent due to the growing global consumer demand for environmentally friendly products and the tightening government regulations regarding environmental impact management.

The first challenge faced by the textile industry is the high consumption of natural resources, particularly water and energy, during production processes. Processes such as fabric dyeing and washing require large amounts of water and generate wastewater containing hazardous chemicals. Many textile factories in Indonesia still rely on conventional technologies that are inefficient in terms of water and energy use, making it difficult for them to adopt the "Reduce" principle within the 3R framework. Furthermore, the lack of adequate wastewater treatment facilities leads many factories to discharge untreated wastewater directly into rivers, resulting in water pollution and adverse effects on surrounding ecosystems.

In addition to inefficient resource use, solid waste management practices in the textile industry also pose significant problems. Solid waste, including fabric scraps, yarn, cardboard, and packaging plastics, is often poorly managed and either discarded improperly or sold to informal collectors. The low recycling rate of textile waste in Indonesia indicates that the "Reuse" and "Recycle" principles are not being optimally implemented. This situation stems from several factors, such as the lack of awareness among producers about the importance of recycling, the limited availability of recycling technologies, and the high costs associated with responsible waste management.

Another obstacle to implementing green production is the substantial investment required to transition to environmentally friendly production technologies. Adopting green technologies, such as energy-efficient machinery and water recycling systems, necessitates a considerable initial investment. Many textile companies in Indonesia, especially small and medium-sized enterprises (SMEs), struggle to secure the necessary funds for these changes. Moreover, access to green technologies is limited, particularly for companies located in remote areas. As a result, many opt to continue using conventional production methods that are cheaper in the short term, despite their negative environmental impact.

In terms of distribution, one of the prevalent issues is the high carbon emissions resulting from logistics and transportation activities. The textile supply chain involves multiple stages, from raw material production and fabric processing to the distribution of final products to consumers, often requiring long-distance transportation. Most companies still rely on inefficient and environmentally unfriendly transportation methods, such as fossil fuel-powered vehicles. Additionally, textile product packaging often involves plastics and other non-biodegradable materials, adding to the solid waste management burden.

Regulatory factors also pose a significant barrier to the adoption of green production and distribution in the textile industry. Although the Indonesian government has established various regulations on waste management and energy efficiency, the implementation of these regulations in practice encounters several obstacles. Insufficient oversight and enforcement, coupled with a lack of incentives for companies adopting green practices, lead many businesses to hesitate in investing in environmentally friendly production and distribution. Moreover, the lack of coordination between various government agencies in

addressing environmental issues in the textile sector complicates efforts to achieve sustainability standards.

From a market perspective, the changing preferences of increasingly environmentally conscious global consumers add pressure on the Indonesian textile industry. Consumers now tend to favor products produced sustainably and with a low carbon footprint. However, many Indonesian textile producers are not yet equipped to meet this demand due to limited infrastructure and technologies for green production. Additionally, producers often face difficulties in obtaining international sustainability certifications, such as organic textile certification or other eco-friendly production standards, due to the complex and costly certification processes.

Another issue is the lack of knowledge and awareness among producers regarding green production and distribution practices. Many textile companies, particularly SMEs, do not fully comprehend the long-term benefits and importance of adopting environmentally friendly practices. They often perceive green production as an additional cost that reduces profitability. The lack of training, education, and technical support from the government or related organizations further exacerbates this issue, resulting in the slow adoption of green practices within the textile sector.

Furthermore, the complexity of the textile supply chain, involving multiple stakeholders, presents additional challenges in implementing green distribution. Effective sustainability practices require collaboration and coordination among raw material suppliers, manufacturers, distributors, and retailers. However, the lack of communication and transparency among supply chain actors makes it difficult to align green distribution practices across the entire supply chain. For example, even if some manufacturers implement eco-friendly distribution practices, their efforts may be ineffective if raw material suppliers or distributors continue using unsustainable methods.

Overall, the challenges of implementing green production and distribution in the Indonesian textile industry reflect the complexity and difficulty of integrating sustainability principles into business operations. Collaborative efforts between the government, industry, and society are required to overcome these obstacles. Research and innovation in green technology, the development of more effective regulations, as well as education and training for producers, are some steps that can promote the broader and deeper adoption of green practices within the textile industry.

The challenges faced by the Indonesian textile industry are similar to those encountered in other developing countries, such as Turkey. Water, energy, and chemical consumption, wastewater flow rates, exhaust emissions, and solid waste generation are all very high. This situation impacts the economic aspects of the textile industry, one of which is the increasingly long return on investment (Ozturk et al., 2016). Therefore, the implementation of sustainable production measures is necessary to produce extraordinary changes in the textile industry. The industry must consider the balance between the benefits gained from sustainable production and the costs incurred. To achieve this goal, the implementation of various sustainable production measures needs to be further studied. Economic returns will help the textile industry maintain its competitive position in the global textile market, which faces the pressing challenge of low-cost, high-quality, and environmentally friendly production. The implementation of sustainable production is expected to reduce water consumption, wastewater production, energy consumption, greenhouse gas emissions, and chemical consumption in textile companies (Alkaya & Demirer, 2014).

4.2. Types of Waste Generated by the Textile Industry in Indonesia

The textile industry in Indonesia is a major sector that produces various types of waste in large quantities. The waste originates from different stages of the production process, including raw material preparation, dyeing, washing, and the manufacturing of finished products. Below is a detailed explanation of the various types of waste generated by the textile industry in Indonesia, along with their general proportions:

a. Textile Waste

Textile waste, which includes fabric scraps, yarns, fibers, and offcuts, is one of the primary types of waste produced by the industry. This waste is generated during cutting and production processes, as well as from defective or surplus products. In Indonesia, the proportion of textile waste is relatively high, primarily due to inefficient production processes that result in a considerable number of offcuts. Used clothing and fabrics from the production process are often discarded, even though some of these materials can be recycled into new raw materials.

b. Paper Waste

Paper is used in the textile industry for various purposes, such as product packaging, labelling, and administrative documentation. Paper waste typically comes from packaging materials for raw materials and finished products, as well as from factory operations. Although its proportion is not as large as textile waste, paper waste is still significant. Most of this paper waste can be recycled, but the recycling rate in Indonesia remains low due to a lack of facilities and awareness of environmentally friendly waste management.

c. Chemical Waste

The textile industry in Indonesia uses a large amount of

chemicals in processes such as dyeing, washing, and fabric finishing. Chemical waste, including dyes, solvents, and other chemical substances, is a hazardous type of waste that requires specialized management. This waste constitutes a significant proportion of the total waste generated, particularly because many production processes still rely on conventional and inefficient technologies. Improper disposal of chemical waste can contaminate soil and water, posing a threat to human health and the environment.

d. Plastic Waste

Plastic is used in the textile industry for various purposes, including product packaging, raw material wrapping, and protective materials during production. Plastic waste, particularly single-use plastics, comprises a relatively large proportion of the industry's waste. Since plastic is not easily biodegradable, it presents environmental challenges if not managed properly. While some companies have attempted to recycle plastic waste, these efforts remain limited due to the lack of recycling facilities and strict waste management policies.

e. Hazardous Waste

Hazardous waste in the textile industry includes various chemical substances, used oils, and waste contaminated with toxic materials. Although hazardous waste represents a smaller proportion of the total waste, its environmental impact is substantial. In Indonesia, managing hazardous waste is often challenging due to the limited availability of hazardous waste processing facilities and a lack of awareness within the industry regarding safe waste management practices.

f. Oil Waste

Oil and lubricants are used in various machinery and equipment within textile production. Oil waste typically includes used oil and other contaminated lubricants. Although the proportion of oil waste in the textile industry is relatively small, it requires special handling due to its potential to contaminate the environment, particularly if spilled and absorbed into soil or waterways.

g. Leather Waste

In some textile factories that produce leather or synthetic products (such as polyurethane), leather waste can be generated in the form of leftover production scraps or defective products. The proportion of leather waste is smaller than that of textiles and paper. However, due to the material's non-biodegradable nature, managing leather waste poses a unique challenge. Recycling leather waste into new products, such as crafts or upholstery, is one potential solution, although it has not yet been widely implemented.

h. Metal Waste

Metal waste in the textile industry mainly originates from broken equipment and machinery, such as needles, machine components, and metal frames. Although it constitutes a relatively small proportion of the industry's total waste, proper management is crucial as metals can be recycled and reused. Some factories have started recycling metal as part of green production practices, although this needs to be further enhanced.

i. Glass Waste

Glass is used in the textile industry primarily for specific purposes, such as chemical storage or laboratory equipment. While glass waste represents a very small proportion, its management is important because broken glass can cause injuries and is not easily decomposed. Recycling glass waste into other materials or reusing it is one of the solutions that can be applied.

j. Wood Waste

Wood is utilized in the textile industry to make storage racks, pallets, and other production tools. Wood waste usually consists of splinters, offcuts, or unused wooden products. Although it forms a small proportion of the total industrial waste, wood waste can be reused for various purposes, such as producing alternative fuel or lightweight construction materials.

k. Rubber Waste

Rubber is used in certain textile products, especially in elastic parts of clothing and accessories. Rubber waste typically includes production scraps and defective products. Although its proportion is not large, managing rubber waste is challenging due to its non-biodegradable nature. Recycling rubber waste into new products, such as mats or cushions, is one potential approach, although it requires appropriate technology and infrastructure.

l. Ceramic Waste

The use of ceramics in the textile industry is quite limited, usually in laboratory equipment and certain machinery. Ceramic waste has a very small proportion and is rarely produced in large quantities. However, when generated, this waste is difficult to process due to the hardness and non-recyclable nature of the material. Therefore, its management requires special attention, particularly in terms of collection and safe disposal.

In summary, the Indonesian textile industry generates various types of waste with different proportions and characteristics (Table 1). Effective waste management requires a comprehensive approach that includes reducing material usage, recycling, and environmentally friendly waste processing. Although some efforts have been made,

the textile industry in Indonesia still faces significant challenges in optimally implementing green production and distribution practices.

Table 1: Waste Percentage by Type in the Indonesian Textile Industry

No.	Waste Type	Percentage (%)
1.	Textile	30
2.	Chemicals	20
3.	Paper	15
4.	Plastic	10
5.	Hazardous Waste	5
6.	Wood	5
7.	Leather	4
8.	Rubber	4
9.	Oil	3
10.	Metal	2
11.	Glass	1
12.	Ceramics	1

4.3. Disposal Methods in the Indonesian Textile Industry

The textile industry in Indonesia, being one of the most resource-intensive sectors, generates a significant amount of waste. Proper disposal methods are crucial to minimize the environmental impact of textile waste. Various disposal methods are employed by Indonesian textile manufacturers, each with different levels of implementation based on cost, feasibility, environmental concerns, and regulatory compliance. Below is an essay detailing these disposal methods and the estimated percentages of their usage in the industry.

a. Reduce, Reuse, Recycle (3R)

The “Reduce, Reuse, and Recycle” approach is a cornerstone of sustainable waste management and is being increasingly adopted in the Indonesian textile industry. Roughly 25% of textile manufacturers actively implement 3R practices to manage their waste. "Reduce" focuses on minimizing waste generation at the source by optimizing production processes and materials usage. "Reuse" involves repurposing excess materials, such as leftover fabric and threads, within the production cycle to avoid waste. "Recycle" entails processing waste into new materials or products. For example, fabric scraps are often recycled into new textiles or non-woven materials. The growing awareness of environmental issues and the economic benefits of resource optimization have driven the industry to gradually embrace 3R methods, but challenges such as technology costs and lack of infrastructure prevent widespread adoption.

b. Transported to Landfills

Despite efforts toward sustainability, the most common disposal method in the Indonesian textile industry remains transporting waste to landfills, accounting for approximately 30% of waste management practices. Textile waste, including rejected products, off-cuts, and other solid waste, is often disposed of in landfills due to its simplicity and relatively low cost. However, this method poses significant environmental concerns. Textile materials, particularly synthetic fibers, decompose very slowly in landfills, leading to long-term pollution. Moreover, chemicals from dyes and finishes can leach into soil and water sources. The high dependence on landfills reflects a need for more accessible and cost-effective waste management solutions that align with environmental goals.

c. Sold to Recycling Companies

Around 20% of textile waste in Indonesia is sold to recycling companies. This method involves partnering with recycling firms that can repurpose materials such as plastic, metal, fabric scraps, and cardboard into new products. Selling waste to recyclers not only diverts it from landfills but also provides a potential revenue stream for textile manufacturers. For example, plastic waste can be recycled into new packaging materials, while fabric scraps can be transformed into insulation or padding products. The practice of selling waste to recyclers is on the rise as more companies recognize the economic and environmental benefits of this approach. However, the extent of recycling is limited by the availability of recycling facilities and market demand for recycled products.

d. Returned to Upstream Supply Chain

Returning waste materials to the upstream supply chain accounts for about 5% of disposal practices in the Indonesian textile industry. This method involves sending back excess materials, such as dyes, chemicals, or unused fabrics, to suppliers for reuse in their processes. It is an effective way to ensure that materials are utilized efficiently within the supply chain. However, this practice is relatively underutilized due to logistical complexities and the limited capacity of suppliers to reprocess certain materials. Nonetheless, with increasing pressure to implement circular economy principles, more companies are exploring the potential of closing the loop within their supply chains.

e. Processed by Hazardous Waste Management Companies

Approximately 7% of textile waste, particularly hazardous waste such as chemical residues, dyes, solvents, and heavy metals, is managed by licensed hazardous waste management companies. These companies are equipped to handle toxic materials in compliance with environmental regulations, ensuring safe disposal without harming the

environment. This method is crucial for dealing with hazardous waste that cannot be recycled or treated internally. The relatively low percentage reflects the industry's struggle with the high costs and stringent regulations associated with hazardous waste processing. Improving access to affordable hazardous waste treatment facilities could increase the use of this disposal method.

f. Incineration

Incineration accounts for around 8% of textile waste disposal methods in Indonesia. This method involves burning waste at high temperatures, reducing its volume and generating energy. Incineration is particularly used for waste that cannot be recycled, such as contaminated fabrics and certain hazardous materials. While it offers a quick solution for waste reduction, incineration has drawbacks, including the release of harmful emissions if not properly controlled. The practice is often criticized for its environmental impact, but it remains an option for managing waste that is otherwise difficult to handle.

g. Collected by Government

Around 5% of textile waste is managed by government collection services. This typically involves municipal waste collection systems that gather waste from various industrial sites for centralized disposal. The government's role in waste collection is vital for small-scale textile manufacturers who may not have the resources to implement advanced waste management systems. However, this method often leads to waste ending up in landfills due to limited recycling or treatment capabilities within municipal waste management infrastructures.

The implementation of different waste disposal methods in the Indonesian textile industry varies significantly, with landfilling being the most prevalent (30%) due to its low cost and simplicity. In contrast, Reduce, Reuse, and Recycle (3R) methods, while environmentally beneficial, are adopted by only 25% of manufacturers, highlighting the need for more support and incentives to promote sustainable practices. The use of recycling companies (20%) shows potential for growth, given the economic benefits it provides. However, other methods like returning to the upstream supply chain (5%), processing by hazardous waste companies (7%), incineration (8%), and government collection (5%) indicate areas where improvement and investment could significantly enhance waste management in the industry (Figure 2).

By understanding the current distribution of disposal methods, stakeholders can better strategize to reduce reliance on environmentally harmful practices and encourage the adoption of more sustainable waste management solutions in Indonesia's textile sector.

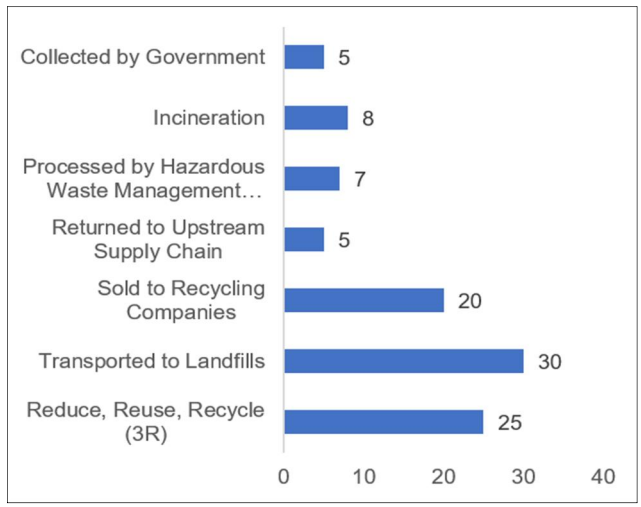

Figure 2: Disposal Methods in the Indonesian Textile Industry (%)

4.4. Challenges in Green Production and Distribution Practices in the Indonesian Textile Industry

The Indonesian textile industry faces a multitude of difficulties and challenges in implementing green production and distribution practices (Figure 3). As the industry seeks to transition toward more sustainable operations, several key factors act as obstacles that hinder the widespread adoption of environmentally friendly initiatives. Understanding these challenges is crucial for devising effective strategies to address the sustainability issues faced by the industry.

One of the most prominent challenges identified is the lack of a waste management system, which accounts for approximately 20% of the difficulties faced by companies. Many textile manufacturers in Indonesia have not yet established a proper waste management framework within their operations. This leads to inefficiencies in handling various types of waste, including textile scraps, chemicals, plastics, and other hazardous materials. The absence of an organized waste management system makes it challenging to implement recycling and disposal methods effectively, resulting in a high environmental impact.

Another significant barrier is the limited facilities available for green production and waste management, representing around 15% of the reported difficulties. Many textile companies, particularly small and medium enterprises (SMEs), lack access to advanced technologies and equipment necessary for green production. Facilities for recycling waste, processing hazardous materials, and adopting energy-efficient production methods are either unavailable or too costly for many manufacturers. This limitation hampers their ability to minimize resource consumption and waste generation, making it difficult for them to transition to more sustainable practices.

The lack of government support is another crucial issue that contributes to 15% of the challenges in adopting green production and distribution practices. While there are regulations governing waste management and environmental sustainability, their implementation is often inconsistent, and the support mechanisms for industries to comply with these regulations are limited. Without adequate incentives, subsidies, or guidance from the government, many textile manufacturers struggle to invest in sustainable practices. Enhanced government involvement could play a pivotal role in encouraging industries to adopt greener methods.

Limited financial budgets further complicate the industry's transition to green practices, making up 10% of the identified challenges. Implementing green production requires substantial investments in new technology, equipment, and training. Many textile companies operate on tight budgets, leaving little room for such investments. The financial constraint is particularly pronounced among smaller companies, which often lack access to affordable financing options for environmental initiatives. This limitation restricts their ability to improve their environmental performance and meet the growing demand for sustainable products.

The lack of waste management organizations accounts for another 10% of the difficulties faced by the industry. Proper waste management, especially for hazardous and non-recyclable materials, requires collaboration with specialized organizations. However, the availability of such organizations in Indonesia is limited, making it challenging for textile companies to manage their waste efficiently. Without adequate support from professional waste management services, companies often resort to less sustainable disposal methods, such as landfilling or incineration, which have negative environmental consequences.

Additionally, low law enforcement emerges as a critical issue, representing about 10% of the reported challenges. Although regulations for environmental protection and waste management exist, enforcement is often inconsistent and lacks the necessary rigor. This has led to a situation where many textile companies do not comply with environmental standards, either due to a lack of awareness or the perceived high cost of compliance. Strengthening law enforcement would be a vital step in ensuring that companies adopt sustainable practices and reduce their environmental footprint.

Lack of awareness about the importance of waste management and green production constitutes around 12% of the difficulties. Many textile manufacturers, especially smaller ones, are not fully aware of the long-term benefits of sustainable practices. They may view waste management and green production as an additional cost rather than an investment in their business's future viability. This mindset creates resistance to change and slows the adoption of environmentally friendly practices across the industry. Raising awareness and educating manufacturers about the benefits of sustainability can significantly impact their willingness to embrace green practices.

Another notable challenge is the lack of recyclable materials, which comprises 8% of the total difficulties. The textile industry often uses synthetic fibers and chemical-intensive processes that produce waste that is difficult to recycle. For example, fabrics blended with different types of fibers pose challenges for recycling due to the complexity of separating the materials. Moreover, the availability of recyclable raw materials is limited, which further complicates efforts to close the loop in textile production. Developing technologies and processes that enable the use of more recyclable materials is crucial for advancing green production practices.

The lack of support from waste management organizations also contributes to the industry's challenges. Textile manufacturers often struggle to find reliable partners to handle their waste responsibly. The limited number of waste management organizations in Indonesia means that companies have few options for processing and disposing of their waste sustainably. This lack of support hinders the industry's progress toward sustainable practices, as companies are forced to rely on less environmentally friendly disposal methods, such as landfills and incineration.

Inadequate government incentives and support mechanisms exacerbate the difficulties faced by the industry. While there is growing recognition of the need for sustainable production, many textile manufacturers do not receive sufficient support from the government in the form of subsidies, tax incentives, or grants. Without these support mechanisms, the costs of investing in green technologies and waste management systems can be prohibitive, especially for smaller companies. Enhanced government support is necessary to encourage widespread adoption of sustainable practices within the industry.

Furthermore, the high costs of adopting green technologies present a significant barrier. The initial investment required to upgrade facilities, implement waste management systems, and train staff in green practices can be substantial. This financial burden is often beyond the reach of many small and medium-sized textile manufacturers in Indonesia. Access to affordable financing options for environmental initiatives could help overcome this obstacle and promote the industry’s transition to more sustainable production methods.

The complexity of managing hazardous waste also presents a challenge. Textile manufacturing processes involve the use of various chemicals, dyes, and solvents that generate hazardous waste. Properly handling, storing, and disposing of these materials requires specialized knowledge, equipment, and collaboration with licensed hazardous waste management companies. The difficulty in managing hazardous waste contributes to the overall environmental

impact of the textile industry and underscores the need for more robust waste management infrastructure.

Addressing these challenges requires a multi-faceted approach that involves stakeholders across the industry, including manufacturers, government agencies, waste management organizations, and consumers. Collaborative efforts to raise awareness, enhance waste management infrastructure, and provide financial support can significantly impact the industry's progress toward green production and distribution.

Technological innovation is another potential solution to some of these challenges. Developing cost-effective, efficient technologies for recycling textile waste, processing hazardous materials, and using renewable energy sources can make green production more accessible to manufacturers. Investing in research and development is critical for creating sustainable practices that can be scaled across the industry.

Education and training programs are essential for increasing awareness and knowledge about green production practices among industry players. By providing manufacturers with the tools and information they need to implement sustainable practices, they are more likely to recognize the long-term benefits and adopt these methods in their operations.

In conclusion, the textile industry in Indonesia faces a range of challenges in adopting green production and distribution practices, including limited facilities, weak law enforcement, financial constraints, and a lack of awareness. Addressing these difficulties will require concerted efforts from all stakeholders, including the government, industry associations, and waste management organizations. By understanding these challenges and working together to overcome them, the Indonesian textile industry can move closer to achieving sustainable production and minimizing its environmental impact.

Figure 3: Challenges in Green Production and Distribution Practices in the Indonesian Textile Industry (%)

5. Conclusions

The textile industry plays a crucial role in global and national economic growth, including in Indonesia. However, this growth also poses significant environmental challenges, such as greenhouse gas emissions and the generation of hazardous waste. Therefore, the implementation of green production and distribution practices is essential to mitigate the industry's negative environmental impact. Green production involves the use of environmentally friendly raw materials, waste reduction, resource efficiency, and the adoption of clean technologies, while green distribution focuses on optimizing product distribution to reduce carbon emissions and promote the use of eco-friendly packaging.

This study emphasizes the importance of implementing the principles of the 3Rs (Reduce, Reuse, Recycle) and effective waste management in the textile industry. Based on the surveys and case studies conducted, it was found that the Indonesian textile industry faces various challenges in adopting green production and distribution practices, including limited facilities, inadequate waste management, and the high investment costs associated with environmentally friendly technologies. Furthermore, weak government regulations and a lack of awareness among producers exacerbate these issues, leading to slow progress in the adoption of green production and distribution.

The data indicates that only 25% of the industry adopts the "Reduce, Reuse, Recycle (3R)" method, while landfill disposal remains the most common waste management method (30%). This underscores the need for greater support and incentives to encourage sustainable practices. Additionally, the textile industry faces challenges in managing various types of waste, such as textile, chemical, plastic, and hazardous waste, all of which require specialized management methods and recycling technologies. Other difficulties include insufficient government support, a lack of awareness about the importance of waste management, and the limited availability of recyclable materials. High adoption costs for green technologies and the scarcity of waste management organizations further hinder textile companies from implementing green production and distribution practices.

Despite these challenges, this study identifies opportunities for the textile industry to enhance sustainable practices, such as adopting the 3R principles, utilizing energy-efficient technologies, engaging in sustainable supply chain collaboration, and using environmentally friendly materials. Increased government support, technological innovation, and education and training on green practices are urgently needed to address these challenges.

The adoption of green production and distribution in the Indonesian textile industry faces numerous obstacles but holds significant potential benefits for both companies and

the environment. A collaborative effort involving the government, industry stakeholders, and the community is necessary to accelerate the transition toward a more sustainable textile industry. The findings of this research are expected to serve as a guideline for policymakers and industry players in developing strategies and policies that support environmentally friendly production and distribution practices while optimizing waste management in the textile sector.

While this study provides a critical snapshot of the challenges in adopting 3R principles within the Indonesian textile sector, it opens several avenues for further investigation. Future research should employ a mixed-methods approach to delve deeper into the specific barriers. For instance, a qualitative, multiple-case study analysis of leading adopters versus laggards could provide rich, contextual insights into the decisive factors for successful implementation, moving beyond the correlational findings of a survey. This would help uncover the nuanced role of organizational culture, leadership styles, and internal innovation processes that survey data alone cannot fully capture. Furthermore, research could quantitatively model the financial implications—using life-cycle cost analysis (LCCA) or return on investment (ROI) models—of adopting specific green technologies (e.g., advanced water recycling systems, automated sorting for recycling). Demonstrating a clear business case with payback periods would be a powerful tool to overcome the cited barrier of high investment costs and persuade hesitant managers and investors.

The scope of inquiry should also be expanded beyond the factory gates to encompass the entire supply chain, which is crucial for a holistic transition to a circular economy. A pressing area for future study is the development and viability of reverse logistics networks specifically for post-consumer textile waste in Indonesia. Research could map the potential flows, identify key actors, and analyze the economic and environmental feasibility of establishing collection, sorting, and recycling hubs on Java. Additionally, exploring consumer behavior is paramount. Studies investigating Indonesian consumers' willingness to pay for products made with recycled materials or their participation in garment take-back schemes would provide essential demand-side data. This would help brands to minimize risk in their investments in circular initiatives and design effective consumer-facing campaigns, ultimately creating a pull mechanism that complements the push from regulatory and production-side efforts.

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