Comprehensive Overview of the Pakistan Textile Waste Industry

REVERSE RESOURCES

NATIONAL TEXTILE UNIVERSITY | FAISALABAD

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SMEP | Sustainable Manufacturing and Environmental Pollution Programme

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Executive Summary

The textile industry is a cornerstone of Pakistan's economy, contributing significantly to GDP and employment. However, it also generates substantial waste, both pre-consumer and post-consumer, posing social and environmental challenges. Pakistan has a long history of textile recycling, with Faisalabad serving as the primary hub for processing waste. The country is also a major importer of second-hand clothing, re-exporting a significant portion to different countries, including African markets. Despite this, the recycling sector remains largely informal, with limited technological advancements and policy support, leading to inefficiencies and lower-quality recycled materials.

Pre-consumer waste, such as spinning, weaving, and garment production waste, accounts for approximately 887 kilotons annually, with cotton-based materials dominating the waste stream. Imported textile waste, primarily second-hand clothing, adds another layer to the waste stream, with Pakistan importing 809 kilotons in 2023. The major portion is either re-exported or sold within the domestic market. However, there is also a stream of recycling of imported second-hand clothing that exists. Most recycling activities rely on mechanical methods. Bleaching is widely used to remove colors and blend fibers with virgin materials, making them suitable for open-end spinning. Colored fibers that are not bleached are typically channeled into low-value uses. Despite these established processes, the industry is largely informal. The sector faces challenges such as inefficient waste collection, contamination, and limited traceability, exacerbated by a fragmented and informal value chain. Additionally, high energy costs and outdated technology hinder the production of high-quality recycled yarn.

Strengthening the policy environment remains crucial, as the existing national regulations do not set firm recycling targets or adequately address traceability. Aligning domestic rules with international requirements, such as Extended Producer Responsibility, can help manufacturers manage end-of-life products more responsibly. Collaborative efforts, including public-private partnerships and funding for improved infrastructure, can foster advancements in technology and efficiency. Moving forward, organized collection systems, digital tracking of waste flows, and ongoing worker training can support higher rates of recycling. By taking these steps, Pakistan can position itself as a central hub of recycled materials, reduce waste leakage, and meet rising global demands for sustainable textile products.

1 Introduction

1.1 Overview of the Textile Industry in Pakistan

The textile industry in Pakistan holds a central position in the country's economy for decades. As one of the world's largest textile producers, Pakistan has a robust infrastructure in terms of cultivating cotton [1]. It stands as the 5th largest cotton producer globally and ranks 6th in Asia for textile exports [2]. Alongside this, the country's market for synthetic and blended textiles is also growing rapidly. Moreover, this sector contributes approximately 8.5% to the national GDP and accounts for nearly 55% of the country's total export earnings [3]. This sector is a vital source of livelihood for a substantial segment of Pakistan's population. It provides employment opportunities, with nearly half of Pakistan's industrial workforce engaged in textile-related activities [4, 5]. Pakistan's textile industry includes both large integrated units and small to medium-sized enterprises (SMEs), with a vertically integrated supply chain covering all stages, including ginning, spinning, weaving, processing, and finished garments. Each of these sectors plays a crucial role in the overall textile industry, contributing to the country's economic growth and export performance. Further, this industry caters to both domestic consumption and international markets. Pakistan's strategic location near major markets like China, Europe, and the Middle East enhances its export potential. The global textile industry is experiencing massive transformations because of sustainability concerns, technological advancement, and innovative fibers and fabrics [6]. Textile waste has become a major environmental concern, with millions of tons of discarded fabrics and garments ending up in landfills annually. Fast fashion makes cheap and trendy clothes quickly to meet customer demand, but it worsens the problem because most textile clothes are discarded after minimal use. This growing problem generates waste throughout the supply chain, both at pre- and post-consumer stages. Pakistan, as one of the largest textile exporters, faces similar challenges.

1 "Cotton Production by Country 2024." [Online]. Available: https://worldpopulationreview.com/country-rankings/cotton-production-by-country

2 "Top 10 Textile Manufacturing Countries in the World FY 2024 Update". [Online]. Available: https://www.royaleuropetextile.com/top-10-textile-manufacturing-countries-in-the-world-fy-2024-update/

3 "Economic Brief 2024," 2024. https://assets.kpmg.com/content/dam/kpmg/pk/pdf/2024/06/Economic-Brief2024.pdf

4 World Intellectual Property Organization (WIPO) (2024). Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship. Geneva: WIPO. 10.34667/tind.50062. https://www.wipo.int/web-publications/global-innovation-index-2024/assets/67729/2000%20Global%20Innovation%20Index%202024_WEB3lite.pdf

5 "The impact of reduced cotton production on rural economies and country's balance of payments," 2024. [Online]. Available: https://www.brecorder.com/news/40325955/the-impact-of-reduced-cotton-production-on-rural-economies-and-countrys-balance-of-payments

6 "Pakistan Textile Sector Report," 2023. VISCredit Rating Company Limited. [Online]. Available: https://docs.vis.com.pk/docs/TextileSectorReport.pdf

1.2 Importance of Textile Waste Management

The textile industry is one of the main sectors causing environmental damage around the world, which is heavily struggling with issues regarding the consumption of natural resources. The traditional "take, make, dispose" model has led to a rise in waste generation. Apart from generatingwaste, it is also responsible for 10% of greenhouse gas emissions globally, 20% of wastewater worldwide, and 9% of microplastic pollution in oceans annually [7], [8]. Every year, more than 92 million tonnes of clothing waste are produced, and it is expected that by 2030, this will rise to 134 million tonnes [9]. The Textile Exchange Materials Market Report 2024 reveals that only 7.7% of fibers are recycled, with 7% of that coming from PET bottles. Polyester holds the largest share at 12.5%, followed by wool at 6% and cotton at 1%, while textile-to-textile recycling remains below 1% [10].

Globally, more and more regulations are being introduced that directly or indirectly govern textile recycling, especially textile-to-textile recycling. The European Union is especially at the forefront of this, regulations like Waste Framework Directive (EU), Digital Product Passport (EU), Green Claims Directive (EU), Extended Producer Responsibility (EPR) for Textiles (EU), Waste Shipment Regulation (EU), Corporate Sustainability Due Diligence Directive, and the European Union's Eco-design for Sustainable Products Regulation (ESPR) play a crucial role in promoting textile recycling. These policies aim to promote sustainability and circularity in the textile sector worldwide.

By aligning with these global regulations, Pakistan can improve its product quality, attract investments in advanced recycling technologies, and create new revenue streams through high-demand recycled fibers. This proactive approach can strengthen Pakistan's reputation in sustainable textile production, open doors to premium markets, and create long-term trade opportunities in regions like the EU, US, Canada, Brazil, China, Japan, and Australia. Pakistan’s textile recycling industry is one of the oldest and largest in the region. However, it faces significant challenges, as it remains largely informal, with limited technological advancements, minimal policy support, and a lack of standardization. These factors contribute to inefficiencies, leading to substantial waste leakage across the value chain. As a result, recycled materials are often of lower quality, limiting their use in high-value apparel production.

This report aims to provide:

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7 S. R. Batool, S. Razzaq, and Y. Nawab, “Introduction - Circularity in Textiles,” S. R. Batool, S. Ahmad, Y. Nawab, and M. Hussain, Eds., Cham: Springer Nature Switzerland, 2023, pp. 1–17. doi: 10.1007/978-3-031-49479-6_1.

8 P. C. da Silva, G. C. de Oliveira Neto, J. M. F. Correia, and H. N. P. Tucci, “Evaluation of economic, environmental and operational performance of the adoption of cleaner production: Survey in large textile industries,” J Clean Prod, vol. 278, p. 123855, 2021.

9 E. P. John and U. Mishra, “A sustainable three-layer circular economic model with controllable waste, emission, and wastewater from the textile and fashion industry,” J Clean Prod, vol. 388, p. 135642, 2023

10 “Materials Market Report 2024 - Textile Exchange,” 2024. https://textileexchange.org/app/uploads/2024/09/Materials-Market-Report-2024.pdf

- An overview of textile waste management in Pakistan, including waste generation and recycling practices.
- Insights on promoting recycled production and boosting sales of recycled products in Pakistan's textile industry.
- Highlight challenges and opportunities in the recycling sector.
- Suggest practical solutions to improve sustainability and economic benefits.
- Offer a roadmap for stakeholders to adopt sustainable practices.

1.3 Methodology

In this study, both primary and secondary data were collected to explore the textile waste recycling industry of Pakistan.Primary data was collected through both formal and informal ways. Formally collected through structured surveys involving 40 participants, including recyclers, waste handlers, and municipal waste collectors. The surveys covered waste sourcing, handling practices, recycling activities, challenges, sales, and disposal. Additionally, field visits to recycling facilities and insights from national conferences (1st and 2nd National Conference on Recycling in Textiles) enriched the findings. Secondary data was gathered from ITC Trade maps, Pakistan Bureau of Statistics, Government Sources , and literature reviews. This mixed-methods approach provides a comprehensive analysis of key practices, challenges, and market dynamics in textile waste recycling. Due to the lack of documented data, a fragmented supply chain, and multiple business streams, this study relied heavily on primary data, which influenced its limitations. The detailed methodology is discussed in Annexures.

2 Textile and Clothing Waste in Pakistan: An Overview

Pakistan has a long history of reusing, repairing, recycling, and repurposing textiles, which has helped create informal ways of managing textile waste. In general, people have always focused on keeping and reusing old clothes, demonstrating the resourcefulness of local communities. In places like Sindh, people have been known for using leftover materials to make things like patchwork and embroidery, mixing practical use with cultural traditions. One example of patchwork is the quilt, called Rilli. It was originally made by stitching together old clothes into colorful patterns to create quilts and decorative items. The country has been managing textile waste for the past fifty years. Faisalabad is the main center for recycling textile waste, particularly post-industrial waste. Pakistan has also been one of the top importers of used clothing for many years.

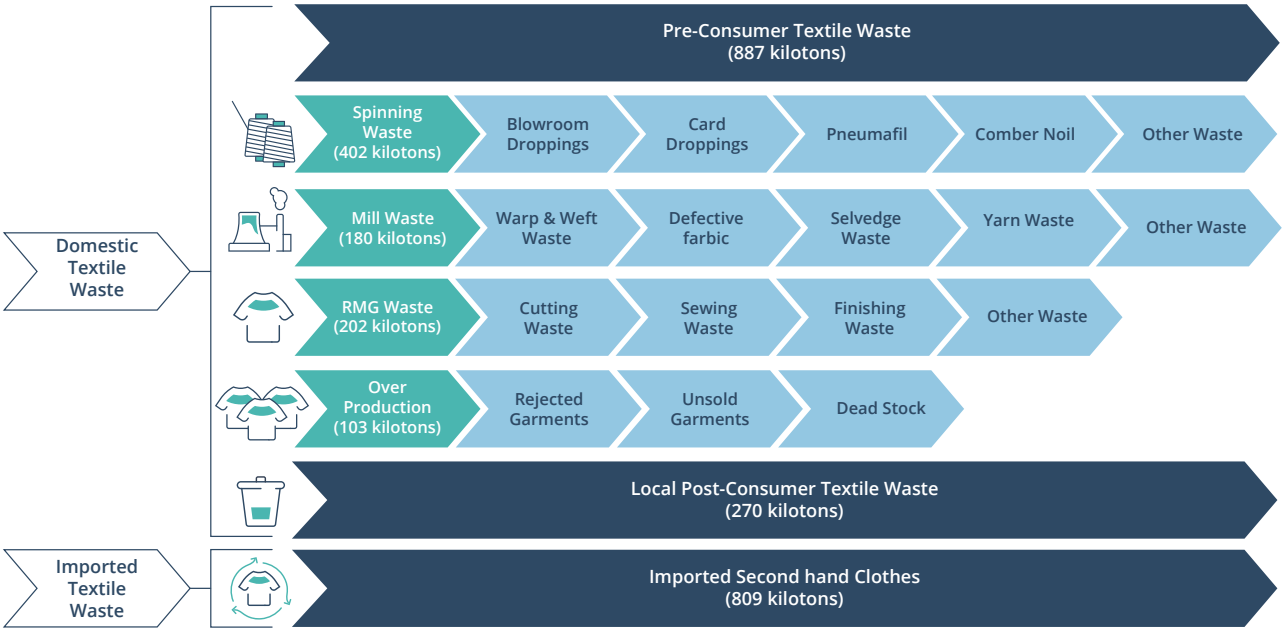


Figure 1. Types of Textile Waste Streams in Pakistan

Pakistan contributes to global textile waste through the production, consumption, and import of textile goods. There are two main waste streams of textiles in Pakistan, which include **Domestic Textile waste, and Imported Textile waste (See Figure 1)**. Domestic textile waste is further categorized into **Pre-Consumer Textile Waste and Post-Consumer Waste**, whereas **Imported Textile Waste** includes worn clothes (HS Code: 6309) clothing accessories, blankets, traveling rugs, and household linen.

2.1 Pre-Consumer Textile waste

Pre-consumer textile waste includes all post-industrial waste as well as any leftover/unsold materials or products such as fabric ends, unsold garments, deadstock, etc. Whereas **Post-industrial textile waste (PIW)** refers to the waste generated as a by-product of industrial processes such as spinning, weaving, textile wet processing, cutting, etc. This waste is a subset of

the pre-consumer waste. Pre-consumer textile waste accounts for approximately **887 kilotons** annually. Within post-industrial textile waste, spinning waste forms the largest share, followed by Ready-Made Garments (RMG) waste and mill waste. **Figure 2** shows a key diagram of the pre-consumer textile supply chain flow in Pakistan. It illustrates the different waste streams at each production stage, namely spinning, weaving/knitting and cut and sew. It is also visible how much yarns and fabrics are imported and exported to Pakistan.

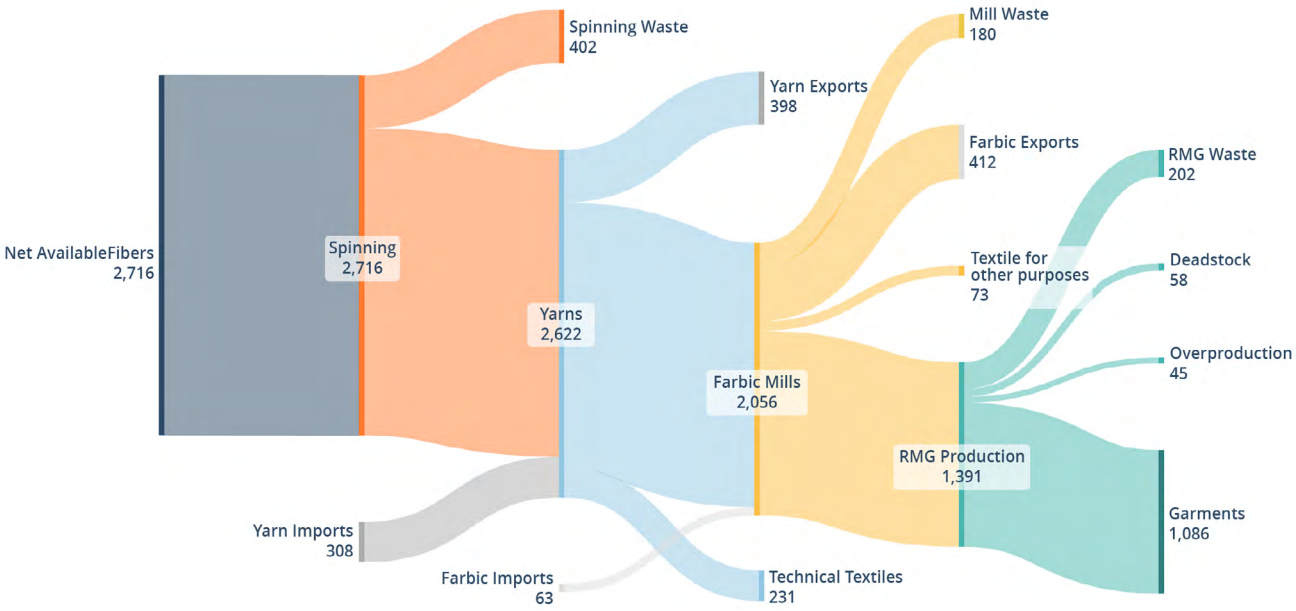


Figure 2. Supply chain flow and post-industrial waste in Pakistan (kilotons)

2.1.1 Spinning Waste

Spinning waste is generated during the yarn production process. The total yarn production in FY23 amounted to approximately **2700 kilotons**, of which around **1080 kilotons** was synthetic-blended yarn [11]. According to a study, the estimated waste generated in the spinning sector ranges between 12% to 18%. The average waste is approximately ~15%, accounting for approximately **~405 kilotons.** This waste comprises several types, including blow room waste, carding waste, comber noils, pneumafil waste, yarn waste, and sweep waste.

11 S. Touseef and S. Mirza, "Spinning Sector Study," 2024. https://www.pacra.com/view/storage/app/Spinning%20-%20PACRA%20Research%20-%20Sep%2724_1727947694.pdf

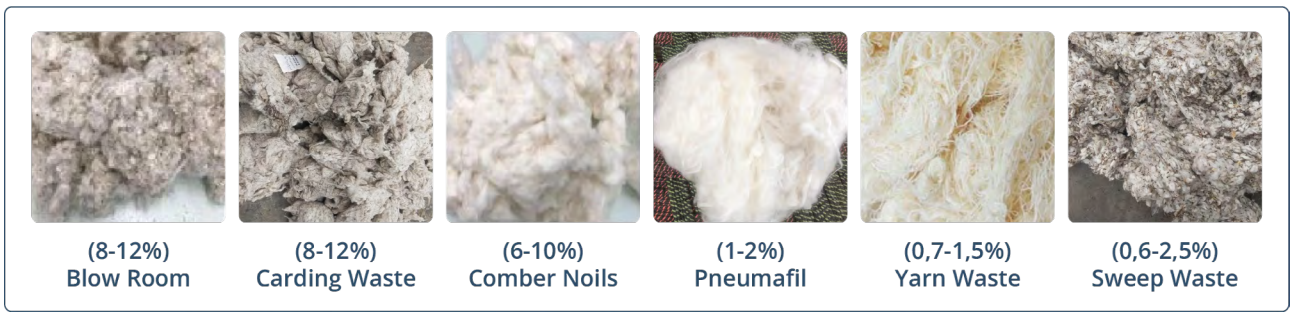


Figure 3. Types of Spinning Waste

2.1.2 Mill Waste

- **Weaving Waste:** Weaving is the process of converting yarn into fabric. The weaving sector is divided into organized and unorganized segments. There are approximately 125 large-scale and 625 small-scale weaving units. During FY23, the organized weaving segment contributed around **11.3% (~930 million square meters)** of the total fabric production, while the unorganized segment accounted for the remaining **88.7% (~7300 million square meters)**. Weaving waste is produced during fabric manufacturing and consists of various types, including warp waste, weft waste, selvedge waste, and fabric waste. The amount of weaving waste produced can vary depending on factors such as the type of fabric being produced, machine efficiency, and the skill of the operators. The estimated range of weaving waste is between **3% to 5.5%**. In FY23, the total fabric production in the country reached approximately **~8300 million square meters**. Of this, approximately **352 million square meters** (4.25% of total fabric production) were generated as waste during the weaving process. [12]
- **Wet Processing Waste:** Textile wet processing involves a series of chemical treatments that transform raw fabrics into finished products, making them ready for end use. During processing, wastage typically accounts for **2 to 6% (See Table 1)**. The waste generated during the processing can come from various sources, including rejected fabric due to defects such as dyeing patches, misprints, color streaks, or other imperfections.

Sr. No.	Process	Waste percentage
1	White Fabric	2 – 3 %
2	Dyed Fabric	3 - 6%
3	Printed Fabric	3 - 6%

Table 1. Overall wastage in processing

12 S.Tauseef and A. Wajih, "Weaving Sector Study," 2024. https://www.pacra.com/view/storage/app/Weaving%20-%20PACRA%20Research%20-%20Aug%2724_1724157028.pdf

2.1.3 Readymade Garment Waste

Pakistan's garment sector comprises approximately 5,000 apparel units, equipped with around 700,000 industrial and domestic stitching machines, producing both knitwear and woven garments [13]. RMG waste includes various types of waste generated throughout the production process, such as cut pieces, panels, fabric end rolls, off-cuts, threads, trimming, and labeling. These wastes are produced during the garment production process. The types and percentages of waste vary across different garment industries, with noticeable differences between the knitted garment, home textiles, and denim industries. Detailed estimates of waste percentages for different garment types as shown in **Table 2**. On average, the RMG industry generates approximately **201 Ktons of waste**.

Types of waste	Knitted Garment Industry Wastage%	Home Textiles Wastage%	Denim Industry Wastage%
Cutting waste	12 – 17.5	0 – 02	11 – 20
Stitching waste	05 – 12	0 – 01	0 – 5.5
Finishing waste	0 – 2.2	0 – 01	0 – 01

Table 2. Waste Percentage of RMG Waste

Textile Fiber Waste Composition

The Pakistani textile industry uses a wide range of fibers, including natural ones like cotton, jute, wool, and flax as well as synthetic fibers such as polyester and elastane, along with man-made cellulosic fibers like viscose. A significant portion of the garments are based on cotton and cotton rich blends.

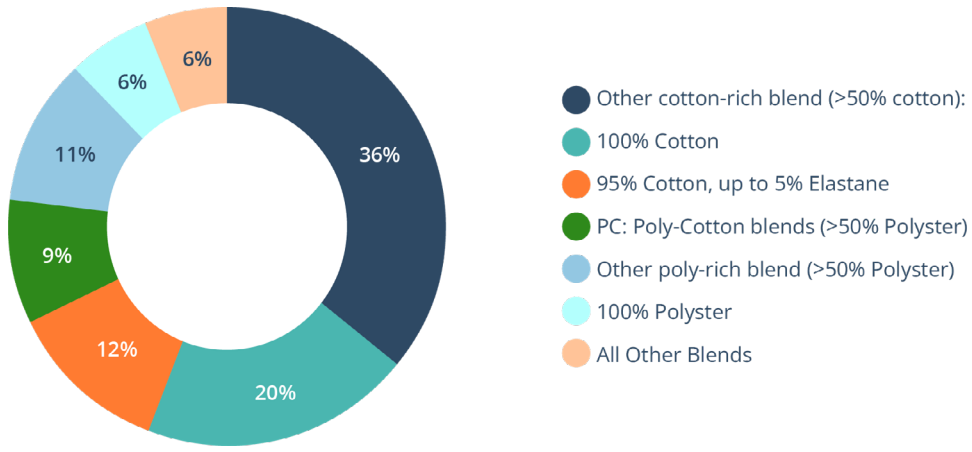


Figure 4. Estimated Composition of Textile Fiber Waste

13 S.Tauseef and S.F. Ahmad, "Composite & Garments," 2024. https://www.pacra.com/view/storage/app/Composite%20&%20Garments%20-%20PACRA%20Research%20-%20Jan%2725_1736248077.pdf

It is estimated that 68% of textile waste in Pakistan comprises cotton-based materials, including 100% cotton (20%), other cotton-rich blends (>50% cotton) (36%), and 95% cotton with up to 5% elastane (12%). This shows that cotton is mostly used fabric in Pakistan, especially in clothing, home textiles, etc. In FY23, Pakistan was the top third country exporting cotton waste (HS=5202) worth **59.29 million dollars**. Whereas polyester and synthetic fabrics make up around 26% of the waste, including polyester-rich blends (11%), poly-cotton blends (9%), and 100% polyester waste (6%). Polyester is getting more popular because it is cheap and durable. Many manufacturers prefer it for making clothes and sportswear. Apart from cotton and polyester-based textiles, there are various other blended fibers like wool, nylon, acrylic, and technical textiles that constitute 6 % of the total waste.

2.2 Local Post-Consumer Textile waste

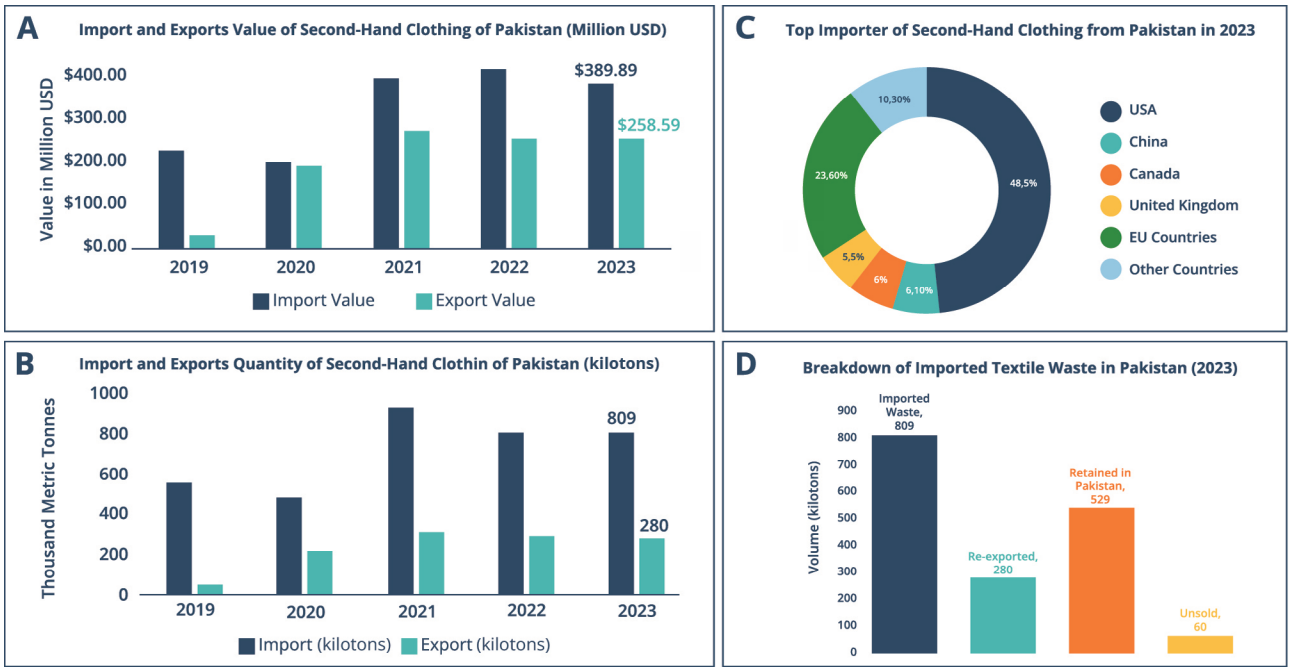
Post-consumer textile waste refers to textiles that consumers discard after extensive use, such as worn-out garments, bed linen, towels, or other household textile items. These items have been worn, used, and washed multiple times, making them reach their lifespan. There are two types, including reusable and non-reusable. Reusable items are typically resold in flea markets or donated to charities such as the Akhuwat Foundation and Edhi Centers, which distribute clothing to those in need, particularly during disasters like floods. In Pakistan, a growing network of vendors purchases textile waste and sells it to retailers, who make minor preparations before reselling it in local flea markets. Non-reusable items are repurposed into rags, cleaning mats, stuffing, and other applications by both households and local buyers. A small portion also enters municipal waste streams, a trend more prevalent in urban centers. Due to technological and logistical constraints, only a small fraction of post-consumer textile waste is recycled, primarily through downcycling. One key reason for the low recycling rate of local post-consumer waste is the prevalent usage pattern, where textiles are maximally utilized and repurposed rather than discarded or recycled. According to the study, approximately **270 kilotons** of post-consumer waste is generated locally each year [14].

2.3 Imported Textile waste

Pakistan is one of the top importers of second-hand clothing **(HS code: 6309)**. In 2023, the country imported approximately **809 kilotons** of used clothing, valued at **$390 million**, making it a key player in the global textile waste trade (see Figure **5A & B**). The United States was the

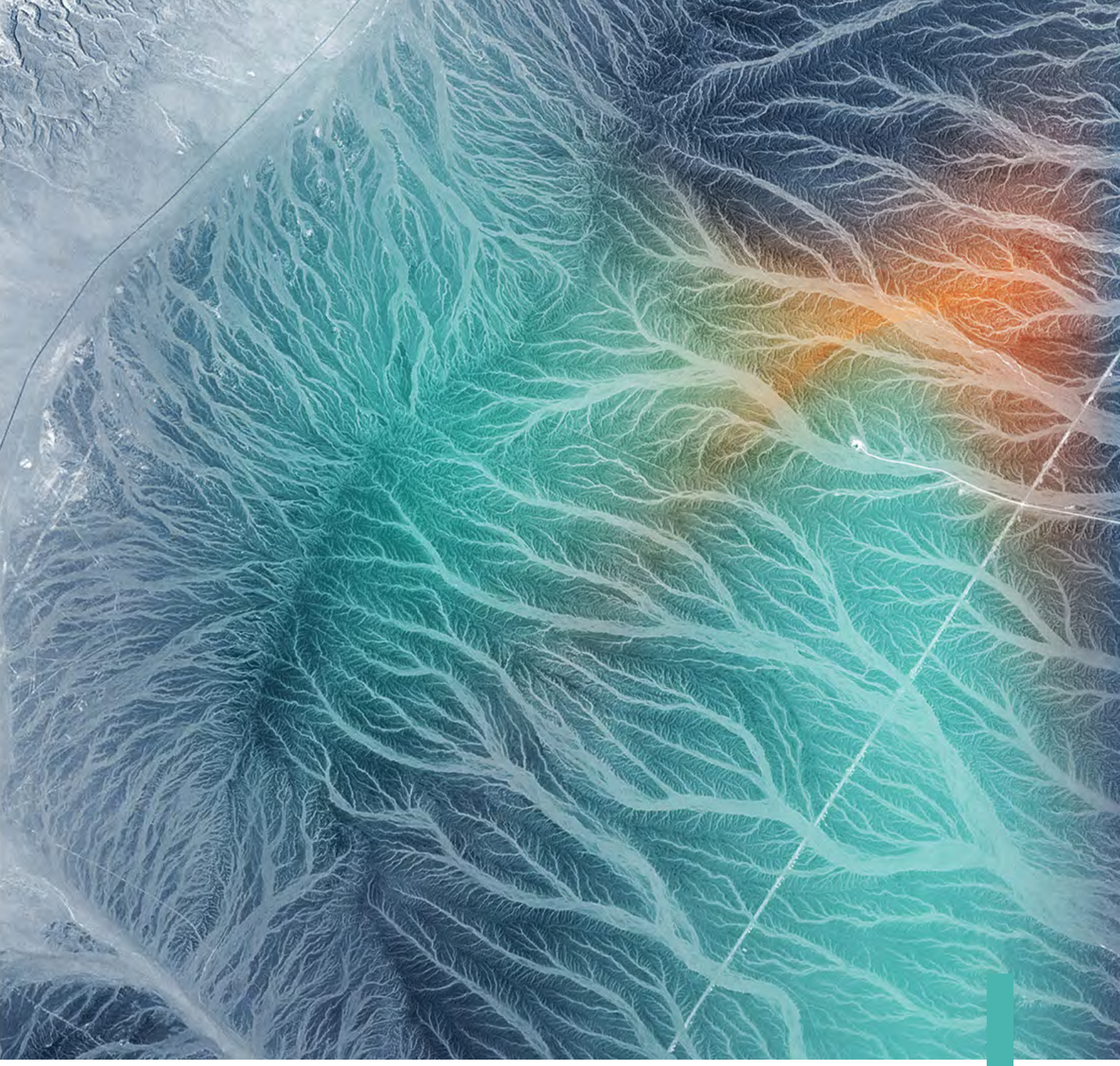
14 M. Shehzad, A. Bano, H. Kazmi, and J. Iqbal, "Current State of Textile Waste Management in Pakistan-A Case of Karachi, Pakistan," Pakistan Journal of Scientific & Industrial Research Series A: Physical Sciences, vol. 67, no. 2, pp. 164–172, 2024.

largest exporter, supplying around **$189 million** worth of used clothing to Pakistan. A significant portion of second-hand clothing around **280 kilotons** were re-exported to different countries, particularly in Africa. The top importers of used clothes from Pakistan in 2023 were Kenya, Mozambique, and Tanzania, with imports valued at $53 million, $39 million, and $33 million, respectively (see **Figure 5C**). The remaining 529 kilotons stayed in Pakistan, with approximately 60 kilotons (8-10%) remaining unsold (see **Figure 5D**) [15].



re 5. Overview of Imported & Exported Textile Waste

15 "International Trade Centre." [Online]. Available: https://www.trademap.org/



3 Mapping the Textile Waste Value Chain in Pakistan

3.1 Pre-Consumer Textile Waste Value Chain

In Pakistan, textile mills dispose of waste through a cost auction process, and it is primarily handled by independent waste handlers and recyclers. There are approximately 2,500 to 3,000 waste handlers in Pakistan both big and small. These waste handlers typically collect waste from mills, and take it to sorting hubs, where workers manually separate it based on material type, color, and quality. Usually recyclers prefer to purchase the sorted waste from traders, even at a high price. After sorting, the waste undergoes preprocessing such as washing, bleaching, and drying to prepare it for final use.

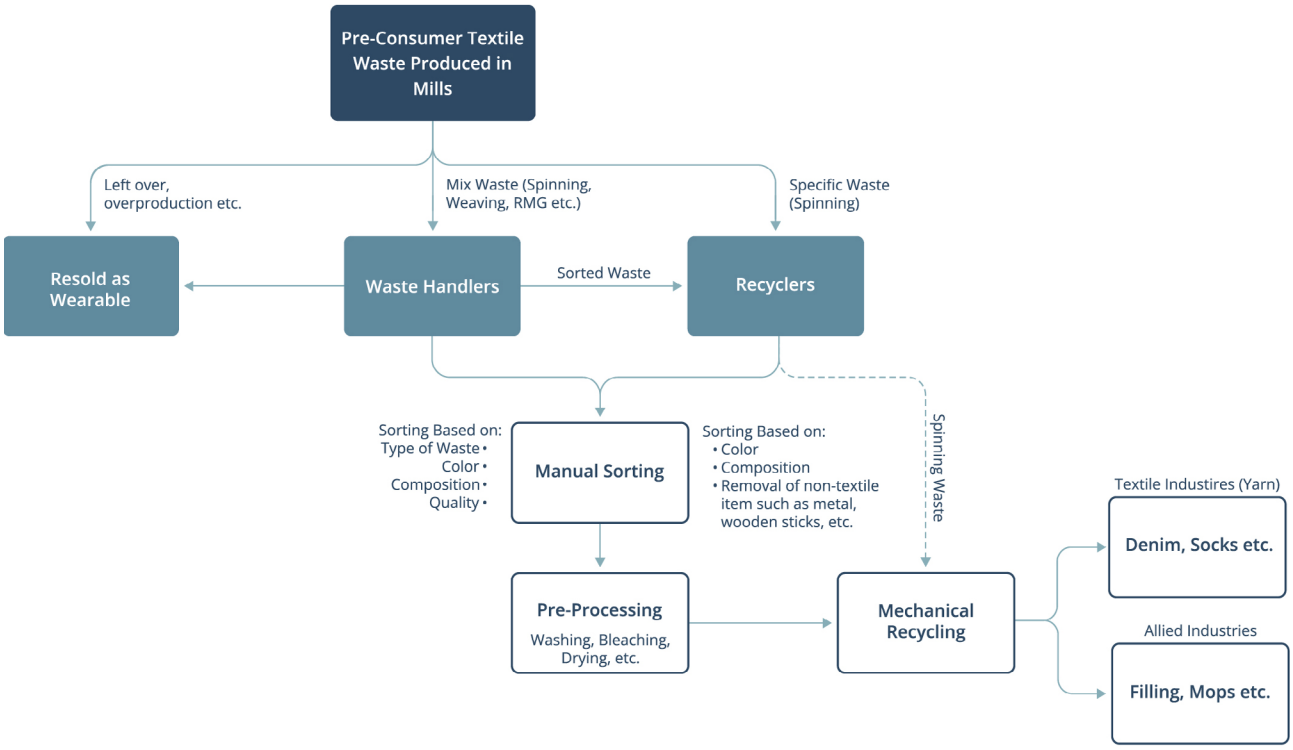


Figure 6. Pre-Consumer Textile Waste Value Chain

3.2 Local Post Consumer Textile Waste Value Chain

Domestic textile waste in Pakistan is managed through a decentralized system primarily driven by informal waste collectors, who gather discarded textiles from households and local sources as shown in **Figure 7**. These materials are transported to sorting hubs, where they are segregated based on quality, usability, and material type. Usable garments are repaired, cleaned, and resold in second-hand markets. Lower-grade textiles and materials unsuitable for resale are directed toward recycling facilities. In these facilities, waste textiles are processed into fibers, which are then used to manufacture products such as filling materials or low-grade yarns. In some cases,

unusable textile waste is diverted to industrial units as fuel for energy recovery, supporting local industries by utilizing waste as an alternative energy source.

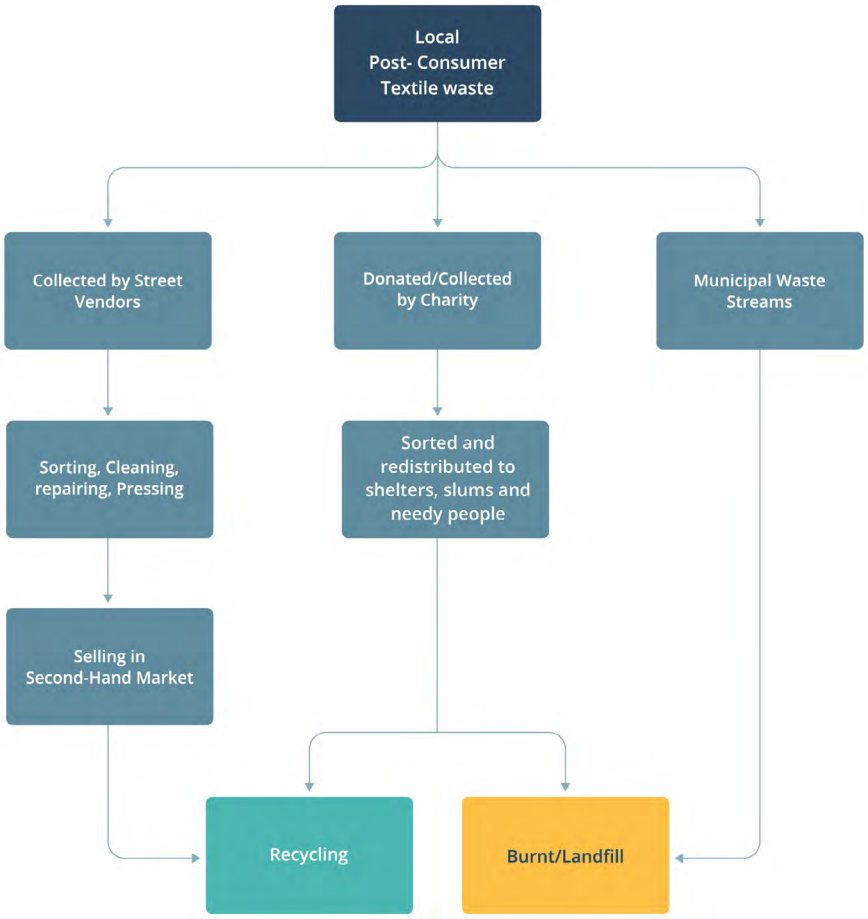


Figure 7. Domestic Post-Consumer Waste Collection Network and flow in the Pakistan

3.3 Imported Post Consumer Textile Waste Value Chain

For many years, Pakistan has been a major destination for imported textile waste (HS code 6309). Particularly Karachi has become a major hub for this industry. This imported textile waste enters via Karachi's seaport and is routed through key locations like the Karachi Export Processing Zone (KEPZ) and Sher-Shah market, with smaller-scale operations elsewhere. The first license in KEPZ was issued in 2004, and since then, 82 licenses have been granted, employing over 10,000 people, with about 50% of the workforce being female. At KEPZ, imported textile waste goes through several processing stages. The process begins with unloading containers of mixed-used clothing compressed into bales. These bales are then allocated to conveyor belts, where teams of specialized sorters manually sort the materials and categorize them into various categories, such as

T-shirts, jeans, blouses etc. This initial sorting process is followed by a series of rigorous quality checks, during which the used textiles are further segregated by quality, style, size, gender, and material type. Karachi acts as a gateway, distributing goods to second-tier markets in major cities (e.g., Lahore, Peshawar) and third-tier markets in smaller cities and districts (e.g., Bahawalpur, Gujranwala), with some reaching rural areas through a fourth tier. Figure 8 illustrates the value chain of imported textile waste streams.

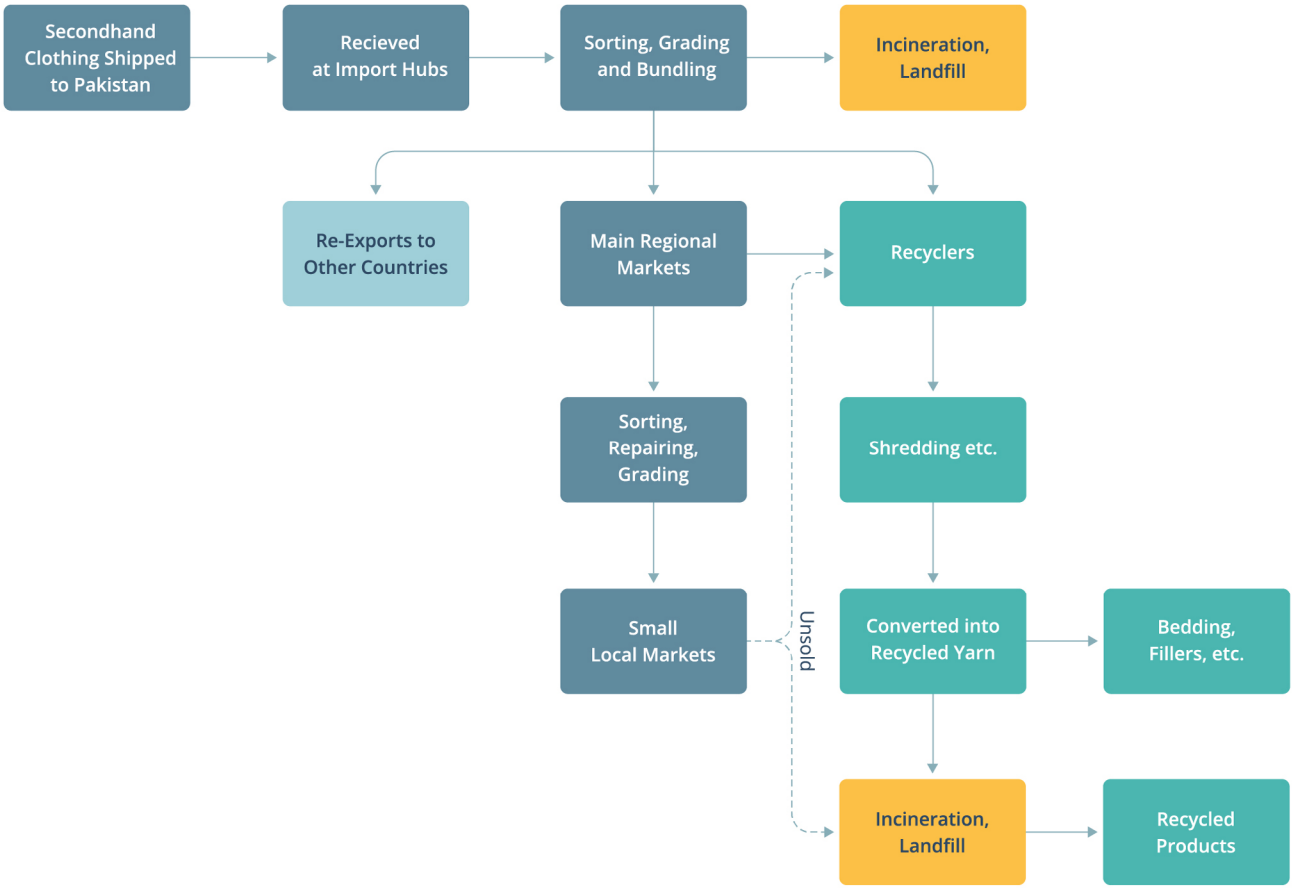


Figure 8. Value Chain for Imported waste stream

4 Recycling Infrastructure and Valorization of Textile Waste

The textile recycling sector in Pakistan is an important yet underdeveloped part of the overall textile economy. It includes both formal sectors and small-to-medium enterprises (SMEs) spread across different areas of the country. The industry mainly relies on mechanical recycling methods due to the current technology and infrastructure available.

4.1 Geographic Distribution of Recyclers

In Pakistan, the recycling industry is moderately developed, mainly focusing on pre-consumer textile waste. Faisalabad and Karachi are key cities in Pakistan where recycling and waste handling take place. Faisalabad has a strong textile manufacturing base, producing significant amounts of post-industrial waste. It is recognized as Pakistan's main hub for textile recycling, housing approximately **175 to 225** recycling units. Key locations are Satiana Industrial Association, Dajkot, Tata Bazar, and Ghulam Muhammad Abad (GM Abad), a small industrial estate in Faisalabad, where textile waste is processed and recycled. The Satiana region alone is home to nearly 100 textile recycling units, collectively providing employment to over 10,000-15,000 individuals depending on seasonal fluctuations. The majority of these workers are women, who play a significant role in sorting operations. Smaller clusters of recycling units are also found in other cities of Punjab, e.g., Lahore, Sheikhupura, Sahiwal, Jhang, Multan, Peshawar, Nankana, etc., collectively adding another 100 to 150 units. Punjab hosts the majority of recycling facilities, whereas Sindh & KPK accommodates an additional 100 to 150 units. Estimates suggest that between 350 and 450 recycling units in Pakistan engage in activities such as collection, sorting, pre-processing, and recycling.

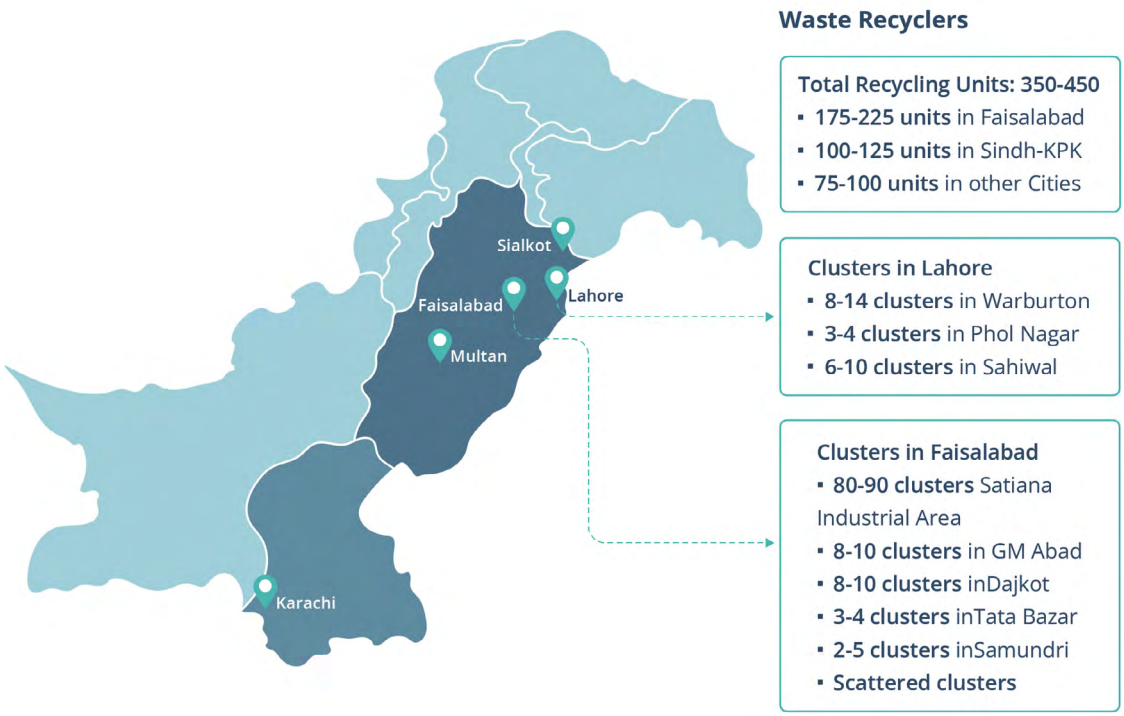


Figure 9. Geographical location of recyclers across Pakistan

4.2 Vertically Integration and Industry Strength in Pakistan's Textile Recycling Sector

The corporate sector in Pakistan is gradually recognizing the potential of textile recycling as both a business opportunity and a sustainability necessity. With growing awareness of circular economy principles and international pressure to adopt sustainable practices, several textile industries are investing in recycling initiatives. These companies are exploring methods to convert pre-consumer and post-consumer textile waste into valuable raw materials to make recycled yarns and fabrics. Additionally, the installation of open-end spinning systems is on the rise, driven by the need to recycle high-quality spinning waste. This technology also provides the flexibility to spin recycled fiber blends in various compositions. Many companies have already integrated open-end spinning into their systems, while others are in the process of adopting it, as it enables the efficient production of recycled fibers. This trend continues to gain momentum.

Many of these companies adhere to international standards such as the Global Recycled Standard (GRS) and similar certifications, enabling them to sell their products in global markets while maintaining transparency and credibility in their recycling processes. By controlling the chain of custody, they can efficiently recycle waste with high accuracy, ensuring better traceability, consistency, and quality in their recycled materials. However, while vertical integration offers many advantages, it also poses challenges for smaller players. These vertically integrated industries may disrupt the traditional waste handling ecosystem, where thousands of independent waste collectors, traders, and small-scale recyclers operate. This might trigger the shifting of local recyclers to shift or find other feedstocks, e.g., imported post-consumer waste etc.

4.3 Recycling Waste Stream

Textile recycling is defined as the process of recovering fiber, yarn, or fabric from used or unused clothing and other textile products. Ideally, recycled materials should maintain properties and functionality comparable to those of the original virgin materials. In Pakistan, this industry mainly focuses on mechanical recycling methods, reflecting the existing technological capabilities and infrastructure. Pakistan's textile recycling industry operates through two primary streams: bleaching for decolorization and direct recycling of colored fibers/mixed waste. The predominant method for processing textile waste involves bleaching to produce neutral fibers especially from pre-consumer waste, making them easier to blend with virgin cotton for high-quality textile production. Another key reason for decolorizing ready-made garment waste is that it is often mixed with spinning waste during the recycling process. This blending helps achieve higher-quality recycled fibers, ensuring better consistency and performance in the final textile products. This process enhances the value of recycled fibers, with bleached fibers commanding higher market prices, ranging from $0.8 to $1.60 per kilogram due to their widespread demand. In contrast, direct

recycling of colored fibers occurs on a smaller scale and is primarily used for low-value applications, such as canvas, cleaning materials, low-grade yarns, or stuffing. Colored fibers are further categorized into mono-color and mixed-color fibers—with post-consumer waste typically recycled as mixed-color fiber and utilized in low-value products. Due to limited demand, colored recycled fibers are priced significantly lower, around $0.3 to $0.5 per kilogram, making this method less profitable and less attractive for manufacturers.

The decolorization process involves segregation, bleaching, drying, and blends removal under UV light, ensuring high-quality fibers with a uniform composition, making them ideal for high-value applications. The price disparity between decolorized and colored fibers highlights the industry's strong preference for bleached fibers and market dynamics in Pakistan's textile recycling sector. Bleached fibers account for 85-90% of total recycled fiber production from pre-consumer waste, while the remaining 10-15% consists of mixed-colored fiber streams. These mixed-colored fibers are primarily used for low-value applications, as they are less versatile and harder to process into high-quality products.

Figure 10. Textile Waste Recycling streams in Pakistan

4.4 Valorization of Textile Waste

Valorization refers to the process of converting waste materials into higher-value products through reuse, recycling, and repurposing. In Pakistan, the valorization of textile waste is an established sector due to economic factors, high material value, market demand, and sustainability concerns. Given the country's strong position in textile manufacturing and second-hand clothing trade, optimizing waste utilization has become essential. There are two streams available: pre-consumer, and post-consumer waste, with varying degrees of recyclability and application potential. Textile waste, generated during production processes such as spinning, weaving, cutting, and dyeing, is highly recyclable due to its controlled composition and consistency. Mechanical recycling is the dominant method, where spinning, weaving, and cutting waste are blended to enhance fiber quality, strength, and length, improving performance in open-end spinning systems.

For monomaterial recycling, mill waste (100% cotton), denim (pre- and post-consumer), and wool are the most commonly valorized fibers. Denim recycling involves mechanically shredding and respinning it into new yarns. This allows the development of durable recycled products . Denim can be recycled in both its original color and bleached form, though imported post-consumer denim is mostly recycled without bleaching. Similarly, wool recycling follows a closed-loop system, where wool garments and production scraps are sorted by color, processed, and re-spun into high-quality fibers for new textiles. Pakistan recycles imported post-consumer wool, and both the recycled fibers and finished products are re-exported, primarily to European markets, which have a strong demand for recycled wool fibers.

Post-consumer waste, such as discarded clothing and household textiles, is more challenging to recycle due to contamination, fiber degradation, and mixed fiber content. Other than mono materials, Pakistan's recycling sector primarily focuses on downcycling post-consumer textiles into low-value industrial applications, such as filling, mops, cleaning materials, and coarser yarns for non-apparel use. The ecosystem of valorization of textile waste is very old, and it has successfully integrated the different type of waste, e.g., the waste of open-end spinning (recycled yarn) is mixed in different combinations with polyester and PCW recycled fiber to make filling materials for the floor mats, although it is considered waste, but its use case exists. Similarly, the canvas fabric is also made from recycled fiber.

Depending on the intended application, pre-consumer and post-consumer textile waste are either recycled and used separately or blended together. In some cases, even waste generated during the recycling process is further processed and repurposed to create various products. The high valorization of these materials is driven by their diverse range of applications, such as being used as filling materials, high-quality apparel, insulation, or non-woven fabrics. This approach maximizes resource efficiency and minimizes waste, contributing to a more sustainable textile industry. In nutshell, the valorization of textile waste in Pakistan is driven both culturally and economically.

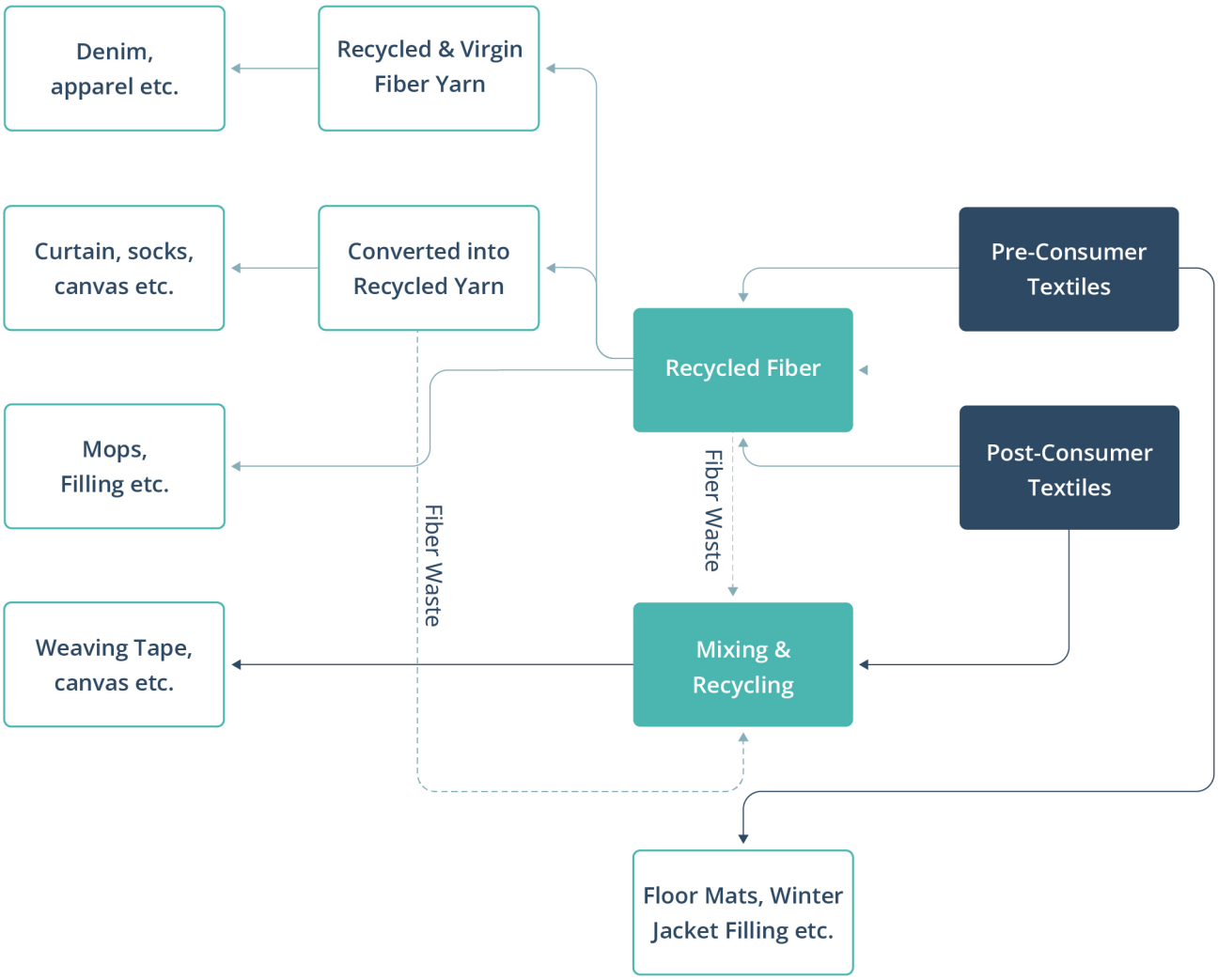
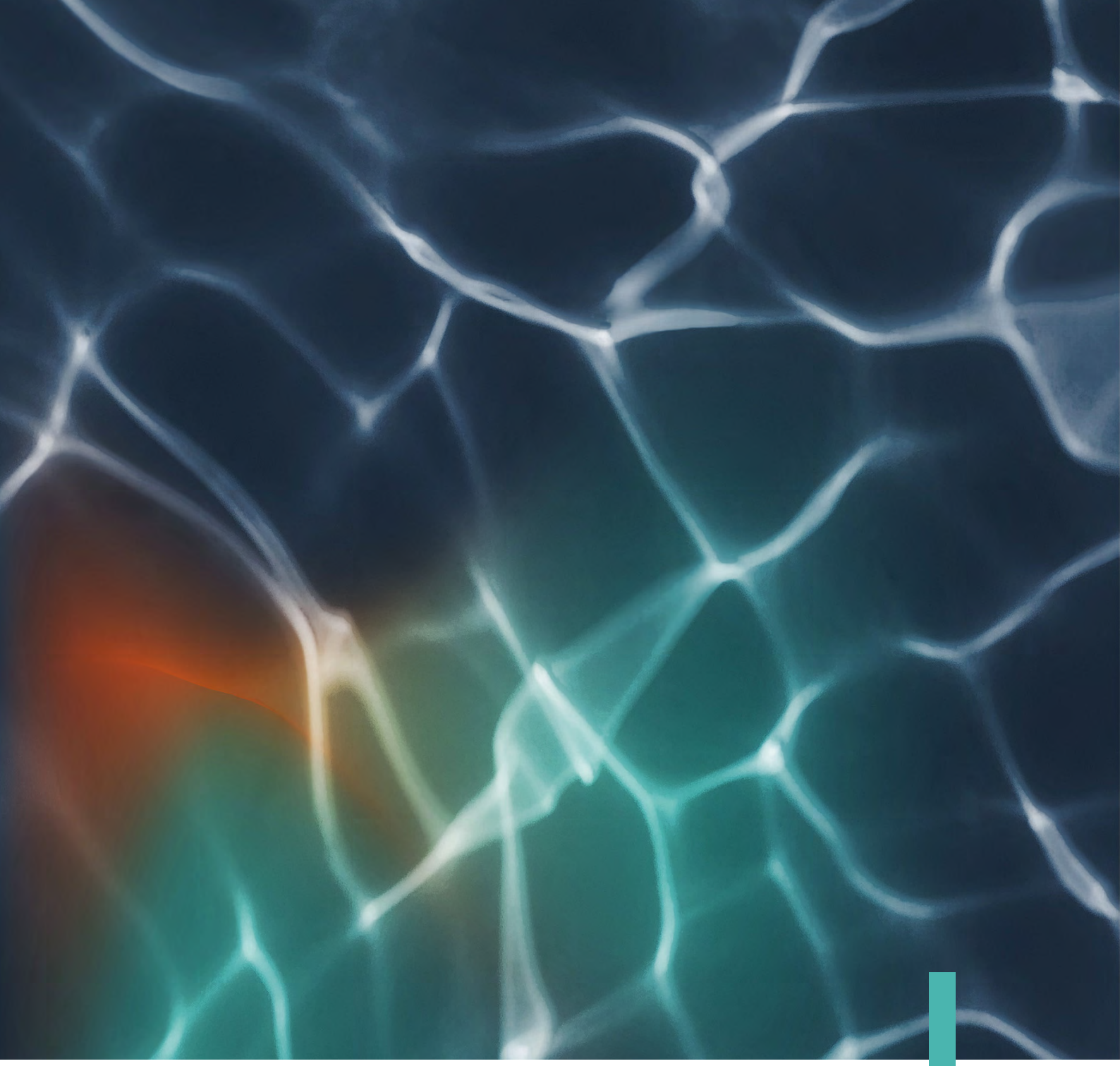


Figure 11. Valorization of textile waste and ecosystem in Pakistan

Uses Cases Of Textile Waste

	Reuse	Recycle	Downcycle
Pre-Consumer Textile Waste	**Overproduction** ▪ ~45 Ktons of apparel are overproduced annually. ▪ Sold at lower prices to wholesalers, resellers or directly to consumers. **Bigger Cut Panels** ▪ Produced due to excessive or inaccurate fabric cutting ▪ Used in kind's wear, patchwork, or small accessory items on a very small scale, often by cottage industries.	**Spinning Waste** ▪ Used in mechanical recycling for blending with virgin fibers. It is also mixed during recycling to achieve higher fiber lengths ▪ Applications include denim, apparel, knitwear, and home textiles. **Garment and Mill Waste** ▪ Recycled fibers are mixed with virgin fibers to maintain strength and quality.	**Dead Stock** ▪ Pre-consumer dead stock is used in the production of low quality products such as cleaning wipes, insulation material, and stuffing for furniture. **Low-Quality Fibers** ▪ Repurposed for industrial applications, including automotive padding or mattress stuffing. **Rags** ▪ A total of 66 Ktons of mutilated rags, valued at $50 million, were exported to various countries. The United States was the largest importer, receiving 28 Ktons worth $28 million.
Local Post-Consumer Textile Waste	**Donations** ▪ Clothes donated to charities (e.g., Akhuwat Foundation). ▪ Direct donation by households. **Resale in Second-Hand Clothing Market** ▪ Collected door-to-door by street vendors in exchange for items or money. ▪ Sold in second-hand markets after sorting, repairing, cleaning and pressing.	**Limited Recycling** ▪ Collected clothing is shredded and recycled into fibers for industrial products, such as stuffing or soundproofing materials. ▪ Limited scale of fiber-to-fiber recycling due to lack of feedstock.	**Low Quality Material** ▪ Used for cleaning rugs, wiping cloths, and other low value industrial products. ▪ Repurposed for making carpets, mats, or insulation material.
Imported Textile Waste	**Resale in Second-Hand Clothing Market** ▪ Imported clothes are sorted, graded, repaired, and sold in second-hand markets across Pakistan. **Export to Other Countries** ▪ Around 30 to 35% of imported clothes are re-exported to African countries such as Kenya, Mozambique, and Tanzania.	**Limited Recycling** ▪ Lower-grade imported materials are sometimes shredded or recycling into industrial fibers. ▪ Constraints exist due to the mixed composition of imported textiles. Recycling is primarily done for denim, 100% cotton, and wool.	**Low Quality Material** ▪ Used for low-value applications, such as cleaning materials, padding, or insulation.

Figure 12. Use cases of textile waste in Pakistan



5 Challenges, Opportunities and Strategic Actions

5.1 Challenges

Despite Pakistan's prominence in South Asia as a hub for textile recycling—with nearly 450 units engaging in mechanical recycling, processing a substantial share of both pre-consumer and post-consumer waste—the industry still faces notable challenges. While these hurdles do not negate Pakistan's significant recycling capacity, addressing them could enhance efficiency, environmental stewardship, and overall sustainability in the textile sector.

General Challenges

- **Recycling complexity**

  In Pakistan, the majority of waste is recycled through mechanical recycling. However, this method is best suited for mono materials and poses significant challenges when dealing with blended materials. This process often produces fibers of lower quality and shorter lengths, limiting their reuse to low-grade products. Meanwhile, advanced technologies like chemical recycling, which could enhance efficiency and output quality, are not in use.

Manufacturer-Related Challenges

- **Lack of Textile Waste Management**

  Textile manufacturers produce large amounts of waste but typically are not involved in its direct management or recycling. Instead of actively handling or recycling their own waste, many simply sell or hand it off to waste handlers or recycling companies without considering the environmental benefits. Nonetheless, textile manufacturers could significantly influence sustainability by collaborating more closely with these waste-management partners, incorporating recycled materials back into their production processes, and making deliberate efforts to reduce their environmental impact. By doing so, they would help create a more eco-friendly and sustainable textile industry.

- **Lack of Proper Waste Segregation**

  In Pakistan, the lack of proper waste segregation at the factories has resulted in inconsistencies and a lack of transparency in waste flow. Manufacturers often sell mixed waste through a cost-bidding process without prior sorting, relying on waste handlers and sorters to segregate the materials. This creates significant challenges for sorters, who struggle to accurately separate the waste by fabric type or color. Even during the recycling process, additional labor is often required to manage the mixed waste effectively. However, spinning waste is treated differently. It is collected and stored separately during manufacturing.

- **Contamination**

Manufacturing waste, particularly pre-consumer waste, is often contaminated with materials such as metals, oil stains, wrappers, trims, mixed fabric, and paper. Dust from improper cleaning also contributes to this contamination, and the occasional disposal of waste in bins leads to additional contamination. As a result, this makes the sorting process more difficult and significantly hinders the ability to recycle or repurpose textile waste effectively.

- **Compliance & due diligence regulation:**

  Adhering to standardized waste management practices remains a major challenge for manufacturers in Pakistan. Regulations such as the HIGG FEM (Higg Facility Environmental Module) waste module require factories to verify and document that they sell waste only to certified and responsible waste handlers, ensuring proper waste disposal within the supply chain. Similarly, Extended Producer Responsibility (EPR) policies, increasingly adopted in various countries, particularly in the EU, hold manufacturers accountable for the entire lifecycle of their products, including end-of-life waste management. Under EPR, producers must ensure their waste is collected and recycled by certified and responsible waste handlers. However, weak enforcement and poor practices in Pakistan make it hard for manufacturers to follow international waste management rules.

Waste Handlers-Related Challenges

Waste handlers have been invisible actors within the textile and apparel supply chains, and this dynamic will change when recycling rates increase. The management of textile waste in Pakistan, although crucial, is facing the following challenges.

- **Inefficient Waste Collection System**

  An established system for collecting textile waste exists in Pakistan, but it operates informally with limited tracking of incoming and outgoing waste. The lack of proper oversight leads to inefficiencies and waste leakage at various stages. While the system functions, the absence of formal infrastructure and monitoring hinders its effectiveness.

- **Identification by touch and by burn**

  The identification of textile waste in Pakistan is primarily done through manual methods, such as touch or burning techniques, to distinguish between cotton and blended materials. These methods are prone to handling errors and inefficiencies, as they rely heavily on subjective judgment. Proper identification is a critical step in the recycling process, as it ensures materials are sorted by type, composition, and quality. Without accurate identification, recycling becomes less effective, leading to poor-quality recycled products and increased waste. This issue is particularly prevalent in the informal sector, where reliance on unskilled labor further exacerbates inefficiencies.

- **Decolorization or Bleaching**

In Pakistan, de-colorization or bleaching is more commonly practiced due to the high demand for bleached fibers. This process enables recyclers to blend treated fibers with virgin cotton and integrate spinning and mill waste into various compositions. However, it is not a standard process, so many waste handlers in other countries do not use this method. Additionally, the chemicals used in bleaching are harmful to the environment and can damage the fibers, making them less durable. To reduce this harm, it is important to find more eco-friendly methods for removing color, adopt chemical management guidelines, and treat and recycle wastewater.

- **Social issues**

  In Pakistan, sorting of textile waste is mostly done by women, who are often paid lower wages than their male counterparts. This underpaid labor contributes to inequality and exploitation in the industry. Additionally, there is a large disparity in pay and benefits among workers, which varies widely from factory to factory. Workers associated with certain factories for the long term often receive additional support, such as assistance with family functions (e.g., weddings) or during illnesses, but this support is inconsistent and largely depends on the factory's policies. However, the lack of proper training and safety measures for workers involved in manual sorting and processing exposes them to hazardous working conditions. This is further exacerbated by improper handling of chemicals during processes like bleaching, which poses serious health risks.

- **Fragmented and Informal Textile Waste Value Chain**

  The supply chain is highly unorganized for all waste streams, leading to leakages of waste in the system. It is largely managed by the informal sector, which lacks standardized procedures and proper oversight, resulting in challenges with traceability and efficiency. The presence of numerous middlemen in the value chain adds to the cost at every step, ultimately making the sourcing of desired feedstock very expensive. This lack of regulation leads to challenges in tracking the origin and processing of waste, which in turn affects the overall efficiency and accountability of the recycling system.

Recyclers-Related Challenges

The textile recycling sector in Pakistan faces the following key challenges that hinder its growth and efficiency.

- **High energy costs**

  Pakistan faces the highest energy tariffs in the region, increasing production costs and reducing profitability for recyclers. These high costs make it difficult for businesses to invest in modern equipment and advanced recycling technologies, limiting overall

efficiency and product quality. As a result, the sector's profit margins are shrinking, hindering its growth and competitiveness.

- **Limited infrastructure and facilities**

  Many recycling units in Pakistan rely on outdated technology, which limits their ability to process waste efficiently. Additionally, the increasing complexity of textile materials—such as blended fabrics and synthetic fibers—makes recycling more challenging. Without proper infrastructure and modern equipment, a large portion of textile waste remains underutilized/downcycled, leading to economic losses.

- **Mechanical Recycling Limitations**

  Mechanical recycling in Pakistan primarily depends on processing high-percentage cotton waste/mono material. However, textiles made from blends of cotton and synthetic fibers—such as polyester-cotton or elastane blends—have low-value use cases because they cannot be efficiently recycled. Instead.

- **Quality Issues in Recycled yarn**

  In Pakistan, most recycling units struggle to produce high-quality recycled yarn due to technological limitations, leading to lower prices for their products. These low-quality yarns are often used to make coarser yarn count. Major causes of the low-quality yarn are old machinery, and poor segregation of waste. When waste is not properly sorted and becomes contaminated, it results in lower-quality feedstock for mechanical recycling, further reducing the quality of the recycled yarn. Globally, advanced mechanical and chemical recycling technologies can significantly improve yarn quality, but these require substantial investment. Due to uncertain financial returns and the absence of proven business models for chemical recycling in Pakistan, most recyclers are reluctant to invest in these technologies.

- **Regulatory and policy gaps**

  The regulatory framework for textile recycling in Pakistan is currently inadequate to support a thriving recycling industry. The Pakistan Textile and Apparel Policy 2020–25 includes some provisions for recycling, but they fall short of addressing the industry's needs comprehensively. For example, there are no mandatory recycling targets, and the existing regulations lack enforcement mechanisms to ensure compliance. To support recycling initiatives and improve traceability, enhanced legislation is required

  At the same time, global regulations on textile recycling are becoming stricker, especially in the EU, which enforces laws like EPR, and the Digital Product Passport. Other key markets, including the US, Canada, India and China, have also introduced policies to ensure responsible recycling and clear labeling. To maintain and grow its exports,

Pakistan must strengthen its policies, enhance recycling practices, and keep pace with these evolving global standards.

Addressing these challenges will enhance sustainability, improve economic viability, and strengthen Pakistan's position in the global recycled textile market.

5.2. Opportunities

To overcome the above discussed challenges, the stakeholders can target several opportunities available for improvement.

- **Pakistan as a circular sourcing hub**

Pakistan has the potential to establish itself as a key circular sourcing hub in the global market, particularly amid evolving international trade dynamics. With a well-developed recycling sector and a skilled workforce, the country could be able to attract global brands seeking sustainable and eco-friendly materials. To avail this opportunity and strengthen its competitive edge, Pakistan must enhance recycling methods, invest in advanced technologies beyond mechanical recycling, and drive innovation in circular economy practices. By doing so, the country can expand its market share, solidify its leadership in sustainable sourcing, and ensure long-term growth in the global recycling industry.

- **Capitalizing on Existing Import-Export Dynamics**

Pakistan is already a major importer of second-hand clothing and re-exports part of it. There is potential to process imported materials further, converting them into higher-value recycled products. This will further establish the position of Pakistan as a country that can handle the textile waste effectively, adhering to international requirements. Increase the economic return on imported textiles and reduce waste sent to landfills or low-grade uses.

- **Regional Leadership in Sustainable Textiles**

Few regional competitors currently specialize in advanced textile recycling. By upgrading technology and creating supportive policies, Pakistan can stand out as a leader in South Asia. Attract business from neighboring countries as well as across the globe who are looking for sustainable textile processing and reinforce Pakistan's role as a pivotal recycling destination.

5.3. Call for Actions

To improve Pakistan's textile recycling ecosystem and align it with global standards, the following strategic initiatives are recommended:

i. Improving Transparency and Accessibility of Textile Waste

- ☐ Manufacturers should be encouraged to integrate circular design principles into their products, treating waste as a resource to promote internal innovation and reduce waste.
- ☐ Initiate post-consumer waste collection programs such as household and retail collection initiatives to reduce landfill contributions.
- ☐ Develop a real-time mapping system to track the generation and flow of textile waste. It is essential in promoting efficient recycling opportunities and ensuring better waste management practices.

ii. Establishing a Waste Collection and Material Sorting System

- ☐ Set up organized waste collection systems for factories, retailers, and consumers to ensure a steady supply of recyclable materials. Place bins at the end of each cutting table for immediate disposal of off-cuts.
- ☐ Develop uniform rules for categorizing waste (e.g., cotton, blends, synthetics) across the industry.
- ☐ Provide training sessions or reference materials to factory staff and waste handlers, ensuring consistent application of these guidelines.
- ☐ Invest in new technology, like material scanners and automated sorting systems, to enhance the accuracy and efficiency of waste segregation.
- ☐ Strengthen existing recycling hubs in key cities like Karachi, Faisalabad, and Lahore, and establish new ones near textile manufacturing areas to reduce logistics costs.
- ☐ Offer tax breaks and subsidies to support the development of recycling infrastructure and the adoption of advanced recycling technologies, such as chemical and hybrid recycling methods.
- ☐ The government can support these efforts by offering tax breaks and subsidies for building recycling infrastructure. Additionally, investing in new recycling methods, like chemical and hybrid technologies, can help process synthetic fibers and blended materials.

iii. Promoting Collaboration Between Stakeholders

- ☐ Establish collaborations between the government, private sector, and NGOs to fund and expand recycling projects.
- ☐ Develop programs where manufacturers and retailers take responsibility for collecting and recycling textile waste, ensuring a closed-loop system.
- ☐ Pursue global partnerships that align local recycling efforts with international sustainability requirements, opening up new markets for recycled materials.

iv. Strengthening Legislation for Recycling and Circular Economy

- ☐ Introduce mandatory waste segregation laws for industries, requiring them to separate waste at the source and offering tax benefits for compliance.
- ☐ Developing national standards that align with global norms, such as the Global Recycled Standard (GRS) and Eco-design for Sustainable Products Regulation (ESPR), will ensure consistency and sustainability.

- ☐ Implement EPR policies to hold manufacturers accountable for managing their product life-cycle, including the collection and recycling of their products.

v. Public Awareness Campaigns on Textile Recycling

- ☐ Launch campaigns to inform stakeholders about the environmental and economic benefits of modern recycling practices.
- ☐ Partner with universities and research institutions to create training programs focused on advanced recycling techniques and sustainability.
- ☐ Engage NGOs in awareness programs targeting both the formal and informal sectors to improve overall recycling practices and foster greater participation

vi. Investing in Advanced Recycling Technologies

- ☐ Invest in chemical recycling infrastructure to process blended fabrics and synthetic fibers, enabling the production of high-quality recycled materials.
- ☐ Promote T2T recycling by adopting automated sorting and chemical recycling technologies to transform post-consumer textiles into high-value raw materials.
- ☐ Explore and adopt advanced sorting technologies, such as Near-Infrared Spectroscopy (NIR), Hyperspectral Imaging (HSI), and Artificial Intelligence (AI)-based sorting systems, to improve the efficiency and accuracy of textile waste sorting.

vii. Supporting Small-Scale Designers and Sustainable Fashion

- ☐ Encourage small-scale designers to use remanufactured or repurposed fabrics to create unique, eco-friendly collections, fostering a culture of upcycled fashion in Pakistan.
- ☐ Provide platforms and incentives for designers to showcase and sell sustainable fashion products, both locally and internationally.

Figure 13. Strategic recommendations for enhancing textile recycling ecosystem in Pakistan

By implementing these strategies, Pakistan can build a robust, future-oriented textile recycling industry that will not only meet domestic needs but also compete effectively on the global stage. These initiatives will ensure the industry's long-term sustainability, drive economic growth, and reduce the environmental impact of textile waste.

Conclusion

Pakistan's textile recycling industry, though one of the oldest and largest in the region, faces significant challenges that hinder its full potential. The sector is dominated by mechanical recycling, which is effective for homogeneous materials like cotton but struggles with blended fabrics, leading to downcycling and lower-quality products. The informal nature of the industry, coupled with inefficient waste collection, contamination, and lack of traceability, further complicates recycling efforts. High energy costs and outdated technology also limit the production of high-quality recycled materials, reducing profitability and competitiveness.

Despite these challenges, Pakistan has a strong foundation to build upon. The country's long history of textile recycling, coupled with its strategic position as a major importer and re-exporter of second-hand clothing, provides a unique opportunity to establish itself as a circular sourcing hub. Investments in advanced recycling technologies, such as chemical recycling, and improvements in waste segregation and traceability can significantly enhance the quality and value of recycled materials.

Public-private partnerships and international collaborations can drive innovation, policy reforms, and capacity building, fostering a more sustainable and competitive industry. Strengthening legislation, such as implementing Extended Producer Responsibility (EPR) and aligning with global standards, will ensure compliance and promote circularity. Public awareness campaigns and education programs can further support these efforts, encouraging stakeholders to adopt sustainable practices.

By addressing these challenges and leveraging opportunities, Pakistan can transform its textile recycling industry, reducing environmental impact, enhancing economic growth, and positioning itself as a leader in sustainable textile production. This will not only benefit the domestic economy but also align Pakistan with global sustainability trends, ensuring long-term competitiveness in the international market.

Glossary of Terms

1. **Bleaching**: A chemical process used to remove color from textile fibers, making them suitable for blending with virgin materials and improving their quality for recycling.
2. **Blended Fabrics**: Textiles made from a combination of different fibers, such as cotton-polyester blends, which are challenging to recycle due to their mixed composition.
3. **Chemical Recycling**: A process that breaks down textiles into their raw molecular components, enabling the production of high-quality recycled fibers, especially useful for blended fabrics.
4. **Circular Economy**: An economic system aimed at minimizing waste and making the most of resources by reusing, recycling, and repurposing materials in a closed-loop system.
5. **Contamination**: The presence of foreign materials (e.g., metals, oil stains, wrappers) in textile waste, which complicates the recycling process and reduces the quality of recycled materials.
6. **Decolorization**: The process of removing color from textile fibers, often through bleaching, to prepare them for recycling.
7. **Downcycling**: The process of recycling materials into products of lower quality or functionality compared to the original material.
8. **Extended Producer Responsibility (EPR)**: A policy approach where manufacturers are held accountable for the entire lifecycle of their products, including end-of-life waste management.
9. **Fast Fashion:** A business model that produces cheap, trendy clothing quickly to meet consumer demand, often leading to increased textile waste.
10. **Global Recycled Standard (GRS)**: An international certification that ensures the credibility and transparency of recycled materials in the supply chain.
11. **Mechanical Recycling**: A recycling method that involves physically breaking down textiles into fibers, which are then respun into new yarns or fabrics. It is most effective for homogeneous materials like cotton.
12. **Post-Consumer Waste**: Textile waste generated after consumers have used and discarded products, such as worn-out garments, bed linen, and towels.
13. P**ost-Industrial Waste (PIW)**: Waste generated during the manufacturing process, such as fabric ends, unsold garments, and by-products of spinning, weaving, and garment production.
14. **Pre-Consumer Waste**: Waste generated before a product reaches the consumer, including post-industrial waste and unsold materials.

15. **Recycling Infrastructure**: The physical facilities and systems used to collect, sort, process, and recycle textile waste.
16. **Textile-to-Textile (T2T) Recycling**: The process of recycling used textiles into new textile products, maintaining the material's original properties and functionality.
17. **Traceability**: The ability to track and document the flow of textile waste through the supply chain, ensuring transparency and compliance with sustainability standards.
18. **Valorization**: The process of converting waste materials into higher-value products through reuse, recycling, and repurposing.
19. **Virgin Materials**: New, unused raw materials that have not been previously processed or recycled.
20. **Waste Segregation**: The process of separating different types of waste (e.g., cotton, polyester, blends) to improve recycling efficiency and reduce contamination.
21. **Wet Processing**: A series of chemical treatments applied to raw fabrics to transform them into finished products, such as dyeing, printing, and finishing.
22. **Yarn Waste**: Waste generated during the yarn production process, including blow room waste, carding waste, and pneumafil waste.
23. **Open-End Spinning**: A spinning technology used to make yarn.
24. **Near-Infrared Spectroscopy (NIR)**: A technology used for sorting textile waste by analyzing the material's composition based on its interaction with near-infrared light.
25. **Hyperspectral Imaging (HSI)**: An advanced sorting technology that uses a wide range of the electromagnetic spectrum to identify and categorize textile waste.
26. **RFID (Radio-Frequency Identification)**: A tracking technology that uses electromagnetic fields to automatically identify and track tags attached to textile waste.
27. **Digital Watermarks**: Embedded codes or patterns in textiles that can be scanned to provide information about the material's origin, composition, and recycling history.
28. **Artificial Intelligence (AI)-Based Sorting**: The use of AI algorithms to automate the sorting of textile waste, improving accuracy and efficiency.
29. **Augmented Reality (AR) for Manual Sorting**: A technology that enhances manual sorting processes by providing real-time visual guidance to workers.
30. **Closed-Loop System**: A recycling system where materials are continuously reused, recycled, and repurposed without being discarded as waste.
31. **Flea Markets**: Informal markets where second-hand goods, including textiles, are sold.
32. **Patchwork**: A textile art form where pieces of fabric are sewn together to create decorative items, such as quilts.
33. **Rilli**: A traditional Pakistani quilt made by stitching together old clothes into colorful patterns.
34. **Akhuwat Foundation**: A charitable organization in Pakistan that distributes clothing to those in need.