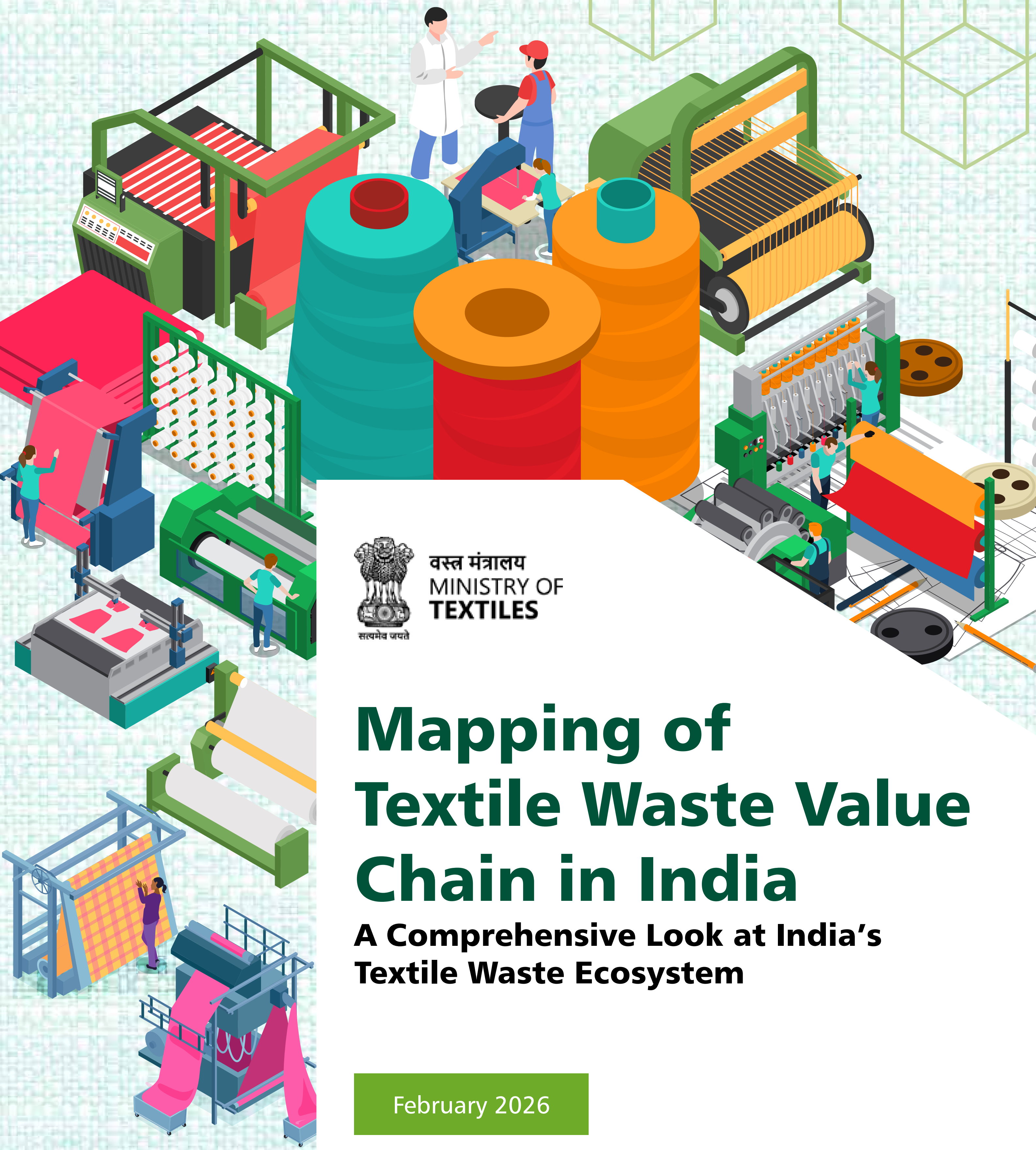


वस्त्र मंत्रालय
MINISTRY OF
TEXTILES

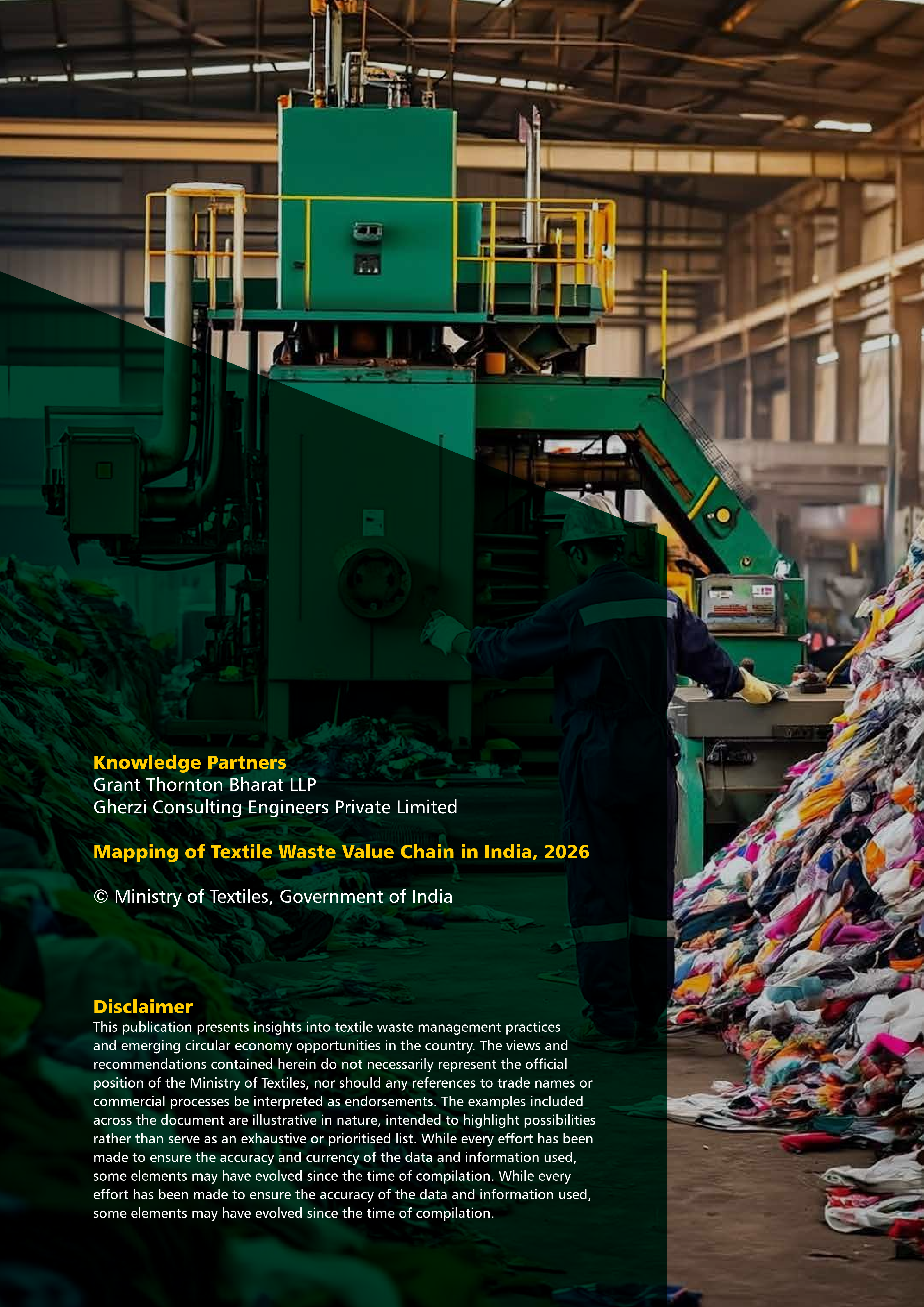
# Mapping of Textile Waste Value Chain in India

## A Comprehensive Look at India's Textile Waste Ecosystem

February 2026

Ministry of Textiles, Government of India
Udyog Bhawan, New Delhi

www.texmin.nic.in



**Knowledge Partners**
Grant Thornton Bharat LLP
Gherzi Consulting Engineers Private Limited

**Mapping of Textile Waste Value Chain in India, 2026**



## Disclaimer

This publication presents insights into textile waste management practices and emerging circular economy opportunities in the country. The views and recommendations contained herein do not necessarily represent the official position of the Ministry of Textiles, nor should any references to trade names or commercial processes be interpreted as endorsements. The examples included across the document are illustrative in nature, intended to highlight possibilities rather than serve as an exhaustive or prioritised list. While every effort has been made to ensure the accuracy and currency of the data and information used, some elements may have evolved since the time of compilation. While every effort has been made to ensure the accuracy of the data and information used, some elements may have evolved since the time of compilation.

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TEXTILES

सत्यमेव जयते

# Mapping of Textile Waste Value Chain in India

## A Comprehensive Look at India's Textile Waste Ecosystem

सत्यमेव जयते

**गिरिराज सिंह**

भारत सरकार में
केंद्रीय वस्त्र मंत्री

## संदेश

भारतीय सभ्यता की यात्रा में वस्त्र हमेशा एक विशिष्ट स्थान रखता है। वे शिल्पकारिता, हमारी प्रतिभा और सीमित संसाधनों से उत्कृष्ठ सृजनशीलता के संबंध में हमारी क्षमता की कहानी बताते हैं। अभी भी, यह क्षेत्र हमारी अर्थव्यवस्था के सबसे मजबूत क्षेत्रों में से एक बना हुआ है, जो कि लाखों परिवारों को सहायता प्रदान करता है, आंचलिक विकास को बढ़ाता है और विनिर्माण तथा व्यापार में एक विश्वसनीय वैश्विक भागीदार के रूप में भारत की स्थिति को मजबूत करता है।

जैसे-जैसे दुनिया उत्पादन के अधिक टिकाऊ और जिम्मेदार स्वरूप की ओर बढ़ रही है, भारत के पास नेतृत्व करने का दायित्व और अवसर दोनों है। वस्त्र अवशिष्ट अभी भी मुख्य चुनौती है। हम उपयोग की जाने वाली सामग्रियों का प्रबंधन कैसे करते हैं, और उसका पुनः उपयोग करते हैं, यह न केवल हमारे पर्यावरणीय भविष्य को संवारेगा अपितु आने वाले वर्षों में हमारी औद्योगिक प्रतिस्पर्धात्मकता भी तय करेगा। यदि हमें भविष्य के लिए तैयार वस्त्र पारिस्थितिकी तंत्र का निर्माण करना है तो स्पष्टता, उद्देश्य और नवाचार के साथ इस चुनौती का समाधान करना आवश्यक है।

इस रिपोर्ट को विशेष रूप से महत्वपूर्ण बनाने वाली ऐसी क्षमता है, जो अक्सर भौगोलिक क्षेत्रों, आपूर्ति श्रृंखलाओं और संस्थागत जिम्मेदारियों में समेकित है। वस्त्र अपशिष्ट कैसे उत्पन्न होता है, जहां-जहां से यह उत्पन्न होता है और इसमें से कितना एकत्रित किया जाता है, इसका अध्ययन अधिक सूचित और रणनीतिक कार्रवाई के लिए आधार तैयार करता है। यह ज्ञान महत्वपूर्ण होगा क्योंकि हम रिकवरी सिस्टम को मजबूत करते हैं, नई प्रौद्योगिकियों को सक्षम करते हैं, और परिसंचरण के लिए मार्ग बनाते हैं जो भारत की व्यापकता और विविधता के अनुकूल हो।

हमारे देश की एक लंबी परंपरा रही है कि हम संसाधनों का महत्व समझते हैं तथा जो कुछ हमारे पास है उसको भी प्रयोग के योग्य बनाते हैं जिससे संसाधनों का मूल्यांकन करने, जो हमारे पास है उसकी मरम्मत करने और सामग्रियों के जीवन का विस्तार होता है। जैसे-जैसे हम अपनी वस्त्र क्षमताओं का आधुनिकीकरण और विस्तार करेंगे, ये मूल्य हमारी प्रगति के केंद्र में रहने चाहिए। एक स्वच्छ, अधिक कुशल और अधिक गोलाकार मूल्य श्रृंखला न केवल एक पर्यावरणीय आकांक्षा है, अपितु यह एक आर्थिक अनिवार्यता भी है।

मैं इस अध्ययन में किए गए सहयोगात्मक प्रयास को स्वीकार करता हूं और इसमें शामिल सभी भागीदारों की प्रतिबद्धता की सराहना करता हूं। यहां प्रस्तुत अंतर्दृष्टि वस्त्र क्षेत्र के निर्माण के हमारे साझा राष्ट्रीय लक्ष्य में सार्थक योगदान देगी जो वैश्विक रूप से प्रतिस्पर्धी, पर्यावरणीय रूप से जिम्मेदार और भारत की स्थायी शक्तियों का प्रतिबिंबित करती है।

**(गिरिराज सिंह)**

सत्यमेव जयते

## Message

**Giriraj Singh**

Minister of Textiles
Government of India

Textiles have always held a special place in India's civilisational journey. They tell the story of our craftsmanship, our ingenuity, and our ability to create value from limited resources. Even today, the sector remains one of the strongest anchors of our economy, supporting millions of families, driving growth across regions, and reinforcing India's standing as a trusted global partner in manufacturing and trade.

As the world moves toward more sustainable and responsible forms of production, India has both an obligation and an opportunity to lead. The challenge of textile waste is central to this moment. How we manage the materials we use, and reuse, will shape not only our environmental footprint but also our industrial competitiveness in the years ahead. Addressing this challenge with clarity, purpose, and innovation is essential if we are to build a future-ready textile ecosystem.

What makes this report particularly significant is its ability to bring focus to an issue that is often dispersed across geographies, supply chains, and institutional responsibilities. By offering a clearer understanding of how textile waste is generated, where it travels, and how much of it is recovered, the study lays the groundwork for more informed and strategic action. This knowledge will be important as we strengthen recovery systems, enable new technologies, and create pathways for circularity that are suited to India's scale and diversity.

Our country has a long tradition of valuing resources, repairing what we own, and extending the life of materials. As we modernise and expand our textile capacities, these values must remain at the heart of our progress. A cleaner, more efficient, and more circular value chain is not only an environmental aspiration, it is an economic imperative.

I acknowledge the collaborative effort that has gone into this study and appreciate the commitment of all partners involved. The insights presented here will contribute meaningfully to our shared national goal of building a textile sector that is globally competitive, environmentally responsible, and reflective of India's enduring strengths.

(Giriraj Singh)

सत्यमेव जयते

## Message

**Pabitra Margherita**

Minister of State for
External Affairs and
Textiles
Government of India

India's textile sector is entering a period of important transformation. While our heritage of skill and craftsmanship remains a source of national pride we must also equip the industry to respond to new expectations of sustainability and responsible growth. How we handle textile waste will play a significant role in shaping this future, particularly as production expands and consumption patterns evolve across the country.

What stands out in this study is its close attention to the realities on the ground. By drawing on the experiences of recyclers, workers, manufacturers and local collection networks, it offers a clearer understanding of how materials move through the system. These insights are essential for developing approaches that are fair, practical and inclusive, especially for the small and medium enterprises and informal actors who support much of our textile economy.

The report points to meaningful opportunities. Strengthening recovery systems in clusters, encouraging modern recycling technologies and improving connections across the value chain can support new livelihoods, reduce environmental pressures and enhance India's position in global markets. As we work towards these goals, it is important that our solutions reflect the needs of our people and the diversity of our industrial landscape.

I appreciate the collaborative effort behind this study. It will provide valuable guidance as we continue to shape a textile ecosystem that honors India's traditions and prepares our industry and workforce for the future.

(Pabitra Margherita)

## Message

**Neelam Shami Rao, IAS**
Secretary
Government of India

As the Ministry of Textiles strengthens its focus on circularity, resource efficiency, and sustainability, one challenge consistently stands out: the need for reliable, granular data to understand how textile waste is generated, handled, and recovered across the country. This study addresses that need with clarity and rigour, and thus it is an important step in building the evidence base required for informed decision-making.

Particularly, valuable is the way the report brings structure to a system that is often fragmented and poorly documented. By mapping waste streams, tracing processing pathways, and identifying gaps that limit material recovery, it provides insights that will directly guide our efforts, whether in developing traceability frameworks, improving data architecture, or evaluating extended producer responsibility models tailored to India's textile landscape.

At a time when global sustainability expectations are evolving rapidly, this analysis gives us the confidence to shape India's response based on evidence rather than assumption. It will serve not only as a reference for policymaking within the Ministry but also as a useful foundation for engagement with other Ministries, State Governments, and industry stakeholders.

I appreciate the thoughtful work that has gone into this study. It will play a meaningful role in helping refine our strategic priorities and in advancing India's transition toward a more responsible, resilient, and globally competitive textile sector.

(Neelam Shami Rao)

## Message

**Rohit Kansal**
Additional Secretary
Government of India

India's relationship with textiles is woven as much into our cultural memory as into our economic foundations. For thousands of years, Indian households and artisans have practiced what the world now celebrates as circularity, often quietly, intuitively, and with deep respect for material value. Whether through rafugari, godhadi, chindhi durries, or the countless everyday acts of reuse and repair, our society has long embraced a way of living where nothing is wasted and everything can find renewed purpose.

It is this civilisational ethos that gives India a unique starting point as we confront today's environmental and industrial challenges. This study anchors contemporary debates in our long history of resource stewardship while offering a clear-eyed view of the realities of the modern textile economy.

One of the most compelling aspects of this work is its commitment to data. For a sector as diverse and geographically dispersed as textiles, information has been a persistent gap. By highlighting the varying degrees of industrial linkage, the role of informal actors, and the differences in recovery and utilisation patterns, the report brings much-needed clarity to where interventions must be prioritised. Equally important is the study's documentation of the distinct dynamics of pre-consumer and post-consumer waste. These insights help identify the points at which better collection, improved sorting, and targeted technological investments can deliver transformative impact.

Taken together, the findings presented herewith can guide policymaking, infrastructure planning, and industry action. They highlight India's journey toward circularity has ancient beginnings, and how its next phase will require purposeful collaboration, strong data systems, and sustained institutional commitment.

I commend all contributors for their work. This report will, I am confident, serve as a valuable resource in guiding India's transition toward a textile ecosystem that is both globally competitive and firmly aligned with our enduring values of responsibility, ingenuity, and care.

(Rohit Kansal)

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# Executive Summary

## Executive Summary

India's textile sector stands at a pivotal juncture. As one of the world's most dynamic fibre-to-fashion industries, it plays a vital role in driving economic growth and supporting millions of livelihoods. **The projected market value of the textile recycling sector in India is expected to reach $3.5 billion by 2030, driven by the rising demand for sustainable fashion solutions. The rapid expansion of the textile recycling market highlights potential to generate approximately 1 lakh new green jobs in India in next 5 years.** Yet, alongside these strengths, the sector faces mounting challenges around resource use, waste generation, and environmental sustainability. **This report provides a comprehensive overview of the textile waste ecosystem, mapping pre- and post-consumer value chains, evaluating technologies and business models that can drive circularity, and benchmarking global policy frameworks.** By bringing together data-driven insights and stakeholder perspectives, it offers a roadmap to position India as a global hub for sustainable and circular textiles, balancing industrial competitiveness with environmental responsibility.

Estimation of textile waste generation in India was done using a mixed-method approach combining quantitative sampling, stakeholder consultations, and waste flow analysis to estimate textile waste across pre- and post-consumer value chains in India. For pre-consumer waste, a stratified sampling of textile units was complemented by interviews and focus group discussions with key actors including collectors, recyclers, upcyclers, and technology providers. For post-consumer waste, 23 geographically diverse cities were selected from a pool of 68, with 92 interviews conducted across municipal bodies, informal networks, and commercial establishments. All findings were triangulated with secondary data and validated through sensitivity analysis in consultation with the Ministry of Textiles, ensuring credible national level estimates.

India's textile industry stands at an inflection point. While we are a global leader in fiber-to-fashion production, we also generate over 7,073 kilotons per annum of textile waste annually. This reveals that waste is not just an environmental liability, it is an economic opportunity. The transition to a circular textile economy is no longer optional, it represents a prerequisite for maintaining export competitiveness, meeting global buyer expectations, and fulfilling our sustainability commitments.

With textile waste generation of 7,073 KTPA comprising 58% post-consumer and 42% pre-consumer streams, the circular economy opportunity spans multiple dimensions. Pre-consumer waste demonstrates exceptional recovery rates with 97% recycled through upcycling (58%) and downcycling (39%), while post-consumer waste faces infrastructure and policy gaps despite strong community-driven recovery networks.

Building on these findings, it is important to note that the Indian textile industry itself is already taking meaningful steps towards textile-to-textile recycling. Leading manufacturers such as Vardhman, Arvind, Shahi Exports, and Usha Yarns have integrated circularity into their operations through advanced recycling facilities, sustainable sourcing practices, and closed-loop manufacturing systems. These initiatives are reducing dependence on virgin fibers, conserving water and energy, and aligning India's production base with global sustainability benchmarks. The Life Cycle Assessments conducted as part of this study further validate the benefits of these interventions, demonstrating measurable reductions in greenhouse gas emissions across cotton, viscose, and polyester garments. While cotton recycling shows modest reductions of around 3 percent, viscose and polyester demonstrate far greater climate gains at 38 percent and 22 percent respectively. Although some recycling processes involve marginally higher energy use, the overall environmental benefits significantly outweigh the trade-offs, establishing textile-to-textile recycling as a cornerstone of India's transition towards a circular economy.

**As part of this study, technological pathways available for valorizing textile waste were also examined. Four primary recycling approaches - mechanical, thermo-mechanical, chemical, and thermo-chemical, were studied.** Mechanical recycling, while commercially mature and cost-effective, is constrained by fiber quality degradation, whereas thermo-mechanical processes enable better retention for synthetics but require highly pure feedstock. Chemical recycling offers the greatest potential for achieving true textile-to-textile circularity, delivering near virgin quality fibers and handling blended inputs, though it remains capital and energy intensive at pilot stages. Thermo-chemical recycling, on the other hand, is versatile and capable of processing contaminated or mixed waste into syngas for industrial applications, but it is not yet adapted for closed-loop textile use. A comparative assessment was conducted that showed that **no single technology is sufficient on its own, underscoring the need for a hybrid ecosystem where mechanical recycling provides scale, chemical recycling drives quality and circularity, and thermo-chemical recycling addresses complex waste streams.**

**Five practical and scalable circular business models that can drive systemic change in the sector were assessed under this study**

**01 Circular Supply Chains**
Replacing virgin inputs with renewable and recycled resources

**02 Recovery & Recycling**
Take-back systems, sorting, and material recovery

**03 Product Life Extension**
Repair, refurbishment, and remanufacturing to maximise product use

**04 Sharing Platforms**
Rental, resale, and swap systems that keep garments in circulation

**05 Product-as-a-Service**
Leasing and subscription models where ownership remains with the provider

**Collectively, these models suggest that India's transition will require a blended strategy: scale up mechanically driven recovery for volume, pilot and commercialise chemical/advanced recovery for quality, invest in repair/ resale infrastructure to extend use, and enable digital platforms and PaaS pilots to mainstream access-over-ownership approaches.**

Extending the analysis beyond technologies and business models, a comparative policy assessment to benchmark global readiness for textile circularity was also done as part of this study . Using a six-pillar framework (i.e. targeting, coordination, transparency, implementation, commitment, and engagement). The evaluation covered leading policies across Europe, North America, and Asia. The findings reveal a highly uneven policy landscape: while the Netherlands' Extended Producer Responsibility Decree and Japan's Circular Economy Vision demonstrate relative maturity through embedded reforms and digital integration, most frameworks, including the EU's Sustainable Textiles Strategy and France's AGEC Law, remain at starter or sub-mature stages due to gaps in enforcement and financing. Emerging markets such as Vietnam are establishing national roadmaps, but require significant capacity building, while China and U.S. state-level acts still operate in fragmented, early forms. **No country has yet achieved a fully mature, holistic regime, but the convergence of best practices especially around EPR mandates, eco-design, transparency measures, and financial support provides valuable lessons.**

For India, the implications are clear: **building a strong and adaptive policy ecosystem will require coordinated cross-sector engagement, robust monitoring, and alignment with international benchmarks to enable the scaling of textile circularity at pace and scale.**

The path forward lies in aligning with global circularity standards, **building recycling capacity at scale, and positioning India not just as a low-cost textile producer but as a global hub for sustainable and circular textiles.** To unlock this opportunity, India must integrate technology, formalize its vast informal sector, and design a policy ecosystem that balances innovation with inclusivity.

## Key Insights that emerged from the study:

**India generates 7,073 kTPA of textile waste annually. Of this, more than 70% is systematically recovered and routed to recycling, downcycling, or upcycling streams, demonstrating on-going progress on sectoral circularity and resource efficiency.** Waste mapping assessment reveals total textile waste comprises 42% pre-consumer and 58% post-consumer streams.

**The spinning industry has established the benchmark for closed-loop operations in textiles, with nearly 100% of spinning waste being re-integrated in situ to produce new fibers.** Soft waste generated during the spinning process is immediately reused within the same process without requiring separate collection and processing. The spinning sector's success stems from homogeneous waste streams, proximity of generation to processing facilities, and established quality standards for recycled inputs.

**The garmenting stage (Tier-1 manufacturers) presents the most significant opportunity to curb pre-consumer waste generation, currently estimated at 1,850 kTPA**. This represents 70.75% of all pre-consumer textile waste, comprising cotton (524 kTPA), polyester (321 kTPA), viscose (49 kTPA), and blended materials (~760 kTPA).

**Panipat is emerging as India's textile waste processing hub amid recycling bottlenecks.** Most textile cluster lack on-site waste processing infrastructure. Instead, these clusters collect and transport pre-consumer waste to centralized hub in Panipat. Given the inherently local nature of waste, cluster level recycling facilities should be deployed to process at source and accelerate circularity.

**Over half of India's post-consumer textile waste is currently recovered and diverted from landfills, with the informal sector playing the most critical role in the value chain.** India's post-consumer textile waste sector sustains approximately 4-4.5 million livelihoods, predominantly women from marginalized communities. Despite challenges in recognition and working conditions, these informal networks achieve 55% waste recovery rates.

**Recycling is a critical business imperative and must be enabled through policy instruments.** Mechanical recycling is the most established textile recycling method, with mature applications across a wide range of fiber types. Chemical recycling, although still in demonstration phases, is gaining traction due to its scalable ability to break down fibers at the molecular level. Effective policy frameworks must support and accelerate the deployment of both technologies to realize closed-loop circular models.

We believe circular solutions exist, the challenge lies in achieving scale, speed, and synergy across the value chain. **The transition to circular textiles represents not merely an environmental imperative but an industrial transformation that will determine India's competitive position in the global textile market for decades to come.**

# Chapter 1

# Overview of Existing Systems for Textile Waste Management in India

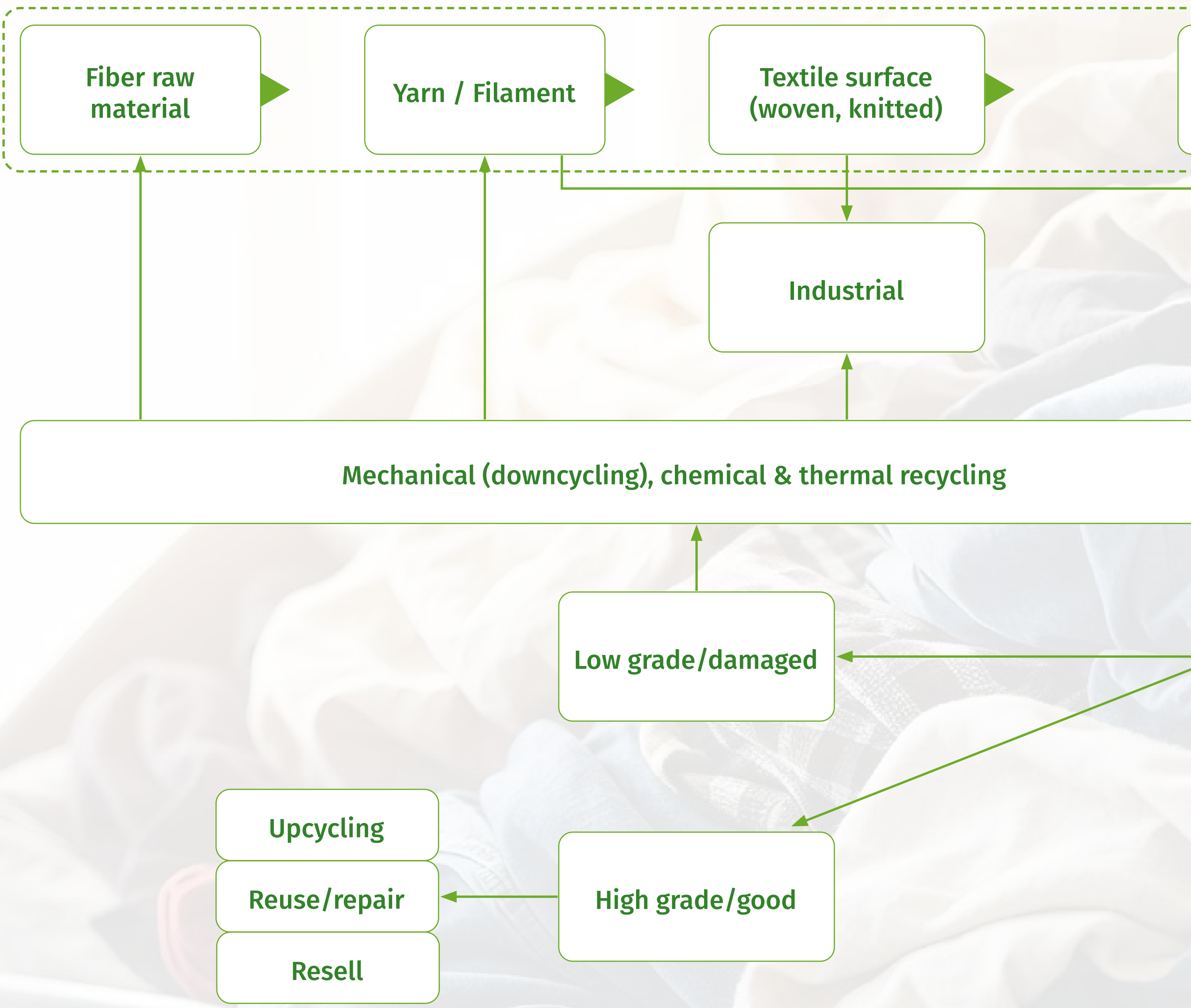
## Chapter 1 - Overview of Existing Systems for Textile Waste Management in India

Textile waste is generated throughout the production-to-consumption cycle, encompassing discarded materials and used garments. It is broadly categorized into pre-consumer waste from manufacturing processes and post-consumer waste arising after products reach and are used by consumers.

# Pre-Consumer Textile Waste

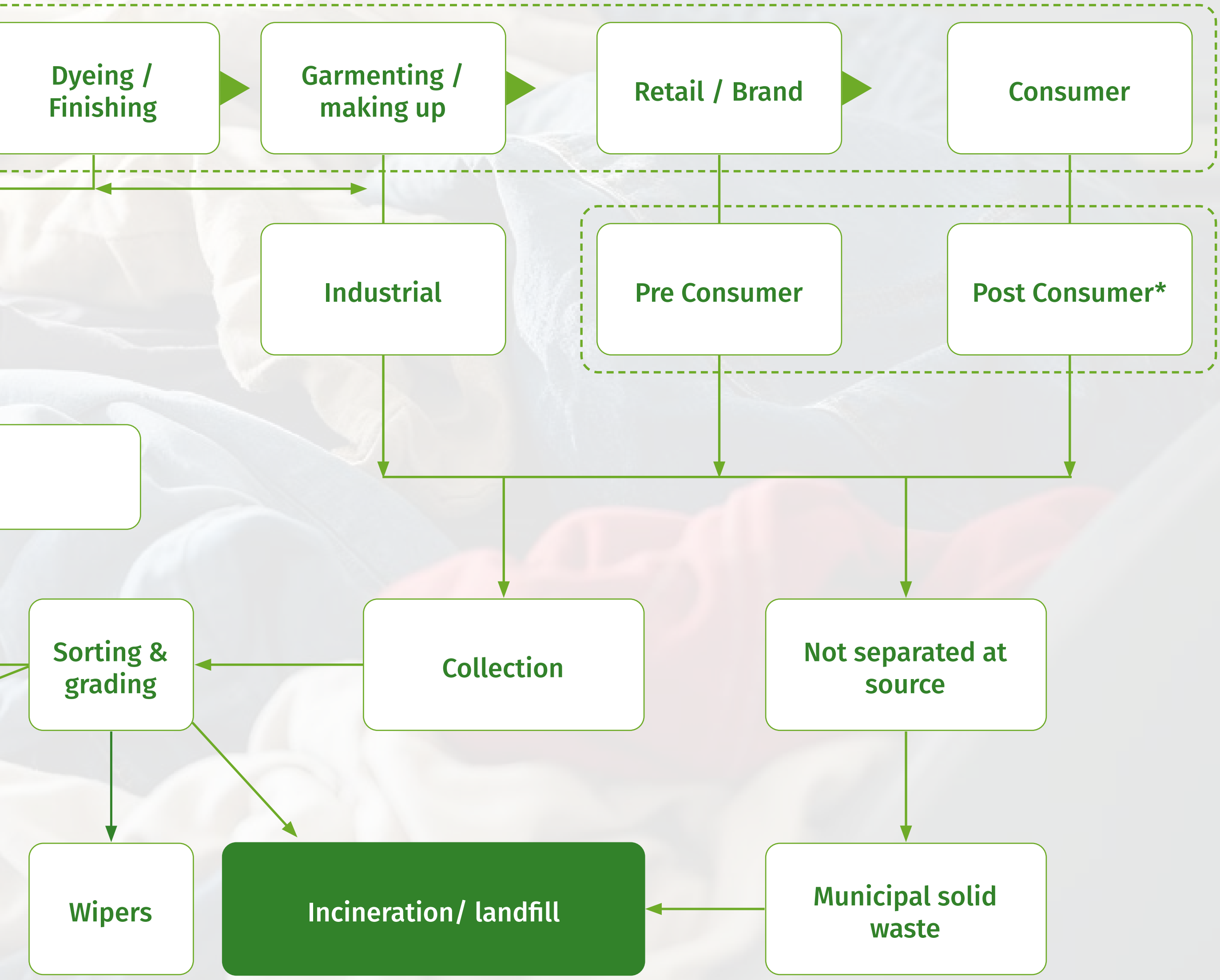
Pre-Consumer Textile Waste produced during the manufacturing process, and before the finished article reaches the consumer. This includes waste produced during the combing, blowing, and carding processes, waste produced during spinning, yarn waste, draw frame waste, sliver waste, scrap waste or cutting waste, and packaging and trimmings[4].

**Figure 1 Stream-wise Distribution of Textile Waste in India**




4. Textiles Committee, Government of India (2022) Circularity in the Indian Textile & Apparel Industry. Available at: https://www.textilescommittee.nic.in/sites/default/files/publications/CSPFTS_compressed_0.pdf

Waste produced during the combing, blowing, and carding processes, waste produced during spinning, yarn waste, draw frame waste, sliver waste, scrap waste or cutting waste.

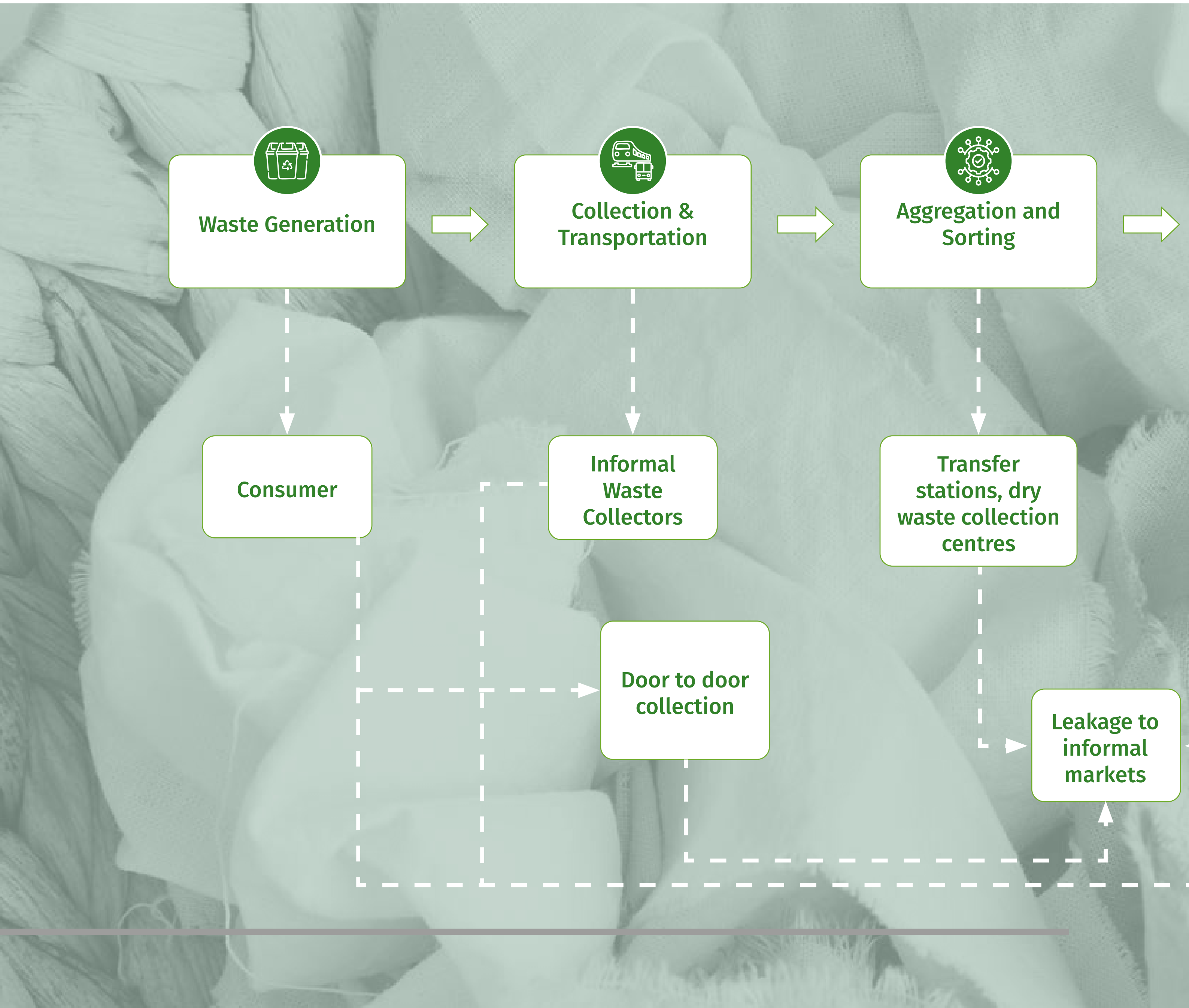


# Post-Consumer Textile Waste

Post-consumer textile waste primarily consists of discarded garments and household textiles after end use. It forms the largest portion of textile waste in India. Collection systems for this waste are typically managed by local bodies through door-to-door collection, often supplemented by informal networks, such as the Waghri Community[5] who play a significant role in aggregation, reuse, and resale.

Despite these efforts, most post-consumer waste either gets reused in low-value applications, downcycled, incinerated, or landfilled. Its recovery

**Figure 2 Snapshot of Textile Waste Value Chain in India, with Focus on Post-consumer**



is often economically unviable due to challenges in segregation, contamination, and lack of traceability. Nonetheless, addressing post-consumer textile waste is essential, as it offers significant potential to divert vast volumes of textile material away from landfills.

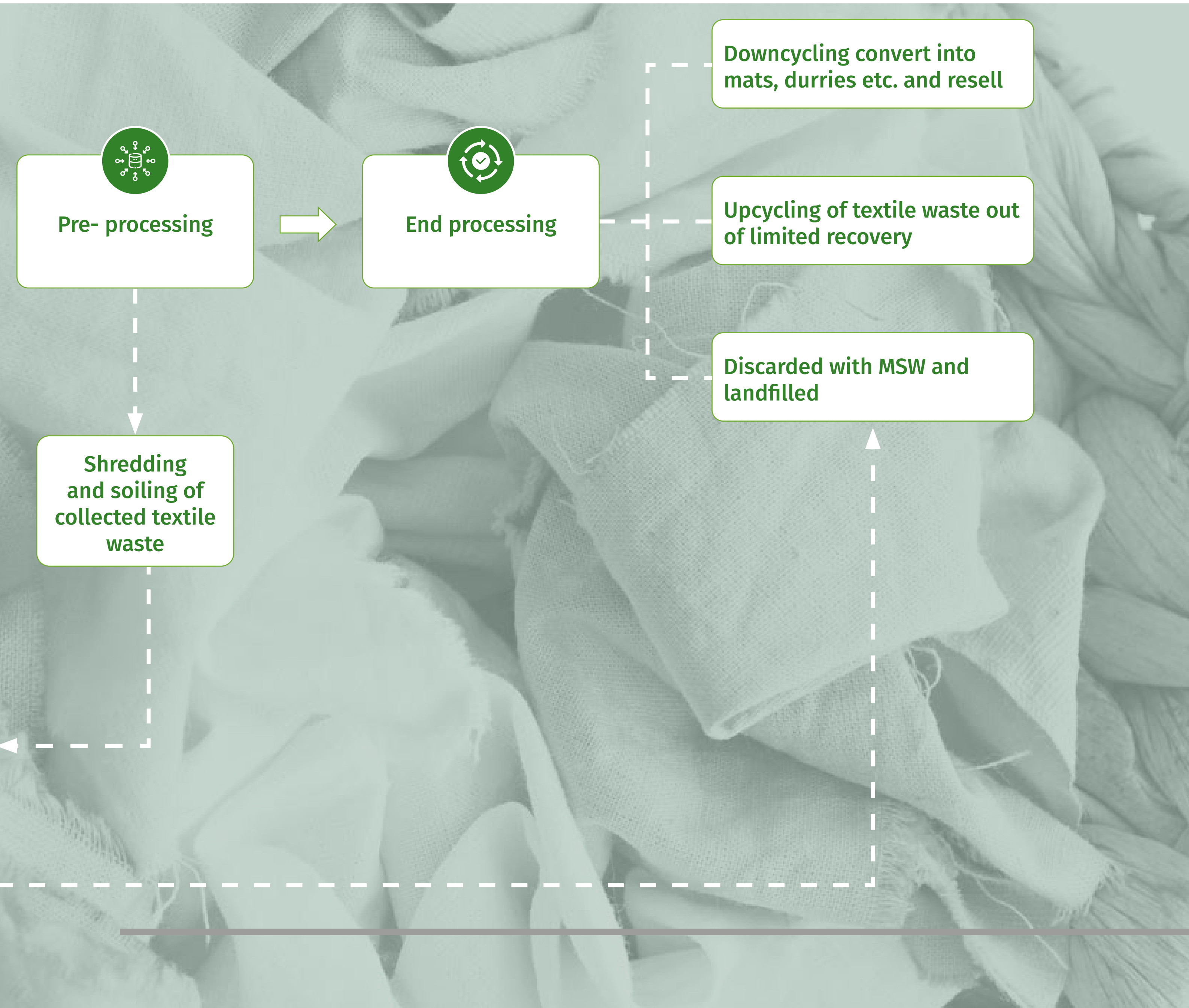
Currently, the value chain for post-consumer textile waste follows a predominantly linear trajectory, from generation to collection, aggregation, and final disposal without adequate loops for recycling or reuse.

## Imports

A relatively smaller portion of textile waste (approx. 600 kilotons annually[6]) is imported into India. This includes second-hand clothing and mutilated rags, primarily sent for recycling and reprocessing[7].

**Given the scale and impact of this sector, there was a critical need to undertake a detailed study on textile waste value chain mapping in India. As this would help in identifying gaps, quantifying waste flows, assessing recovery potential, and informing targeted interventions for enabling a circular textile economy.**

For details, please refer section 14.1



# Economic Significance and the Imperative for Circular Transition

The textile industry in India, often described as the "spinning wheel" of the nation's industrial and economic growth, stands as a testament to the country's rich cultural heritage and entrepreneurial spirit. Historically, the country's textile traditions have contributed significantly to India's global trade, making it a prominent player in the international textile market. The Indian textile industry is the second largest vertically integrated in the world after China. The industry was worth US 157 billion in 2021-22 contributing ~ 2% of the country's GDP, 7% of industry output in value terms and 10% of country's merchandise exports (MOSPI, DGCIS). India's textile and apparel exports have increased from $35.1 billion to $42.9 billion from 2019 to 2022, contributing significantly to nation's total export earnings, comprising about 10% of the total merchandise exports and representing about 5% share of the world market[1].

However, this rapid growth comes with environmental consequences. Textile waste amounts to staggering 7,073 tonnes (with ~5 % MOE) per annum. The textile industry's current reliance on linear value chains, where textiles flow from production to consumption and then end up in landfills or are incinerated, results in releasing harmful emissions into the ecosystem. Shifting towards a circular textile economy offers India a vital opportunity to mitigate these impacts while unlocking economic, social, and environmental gains[2].

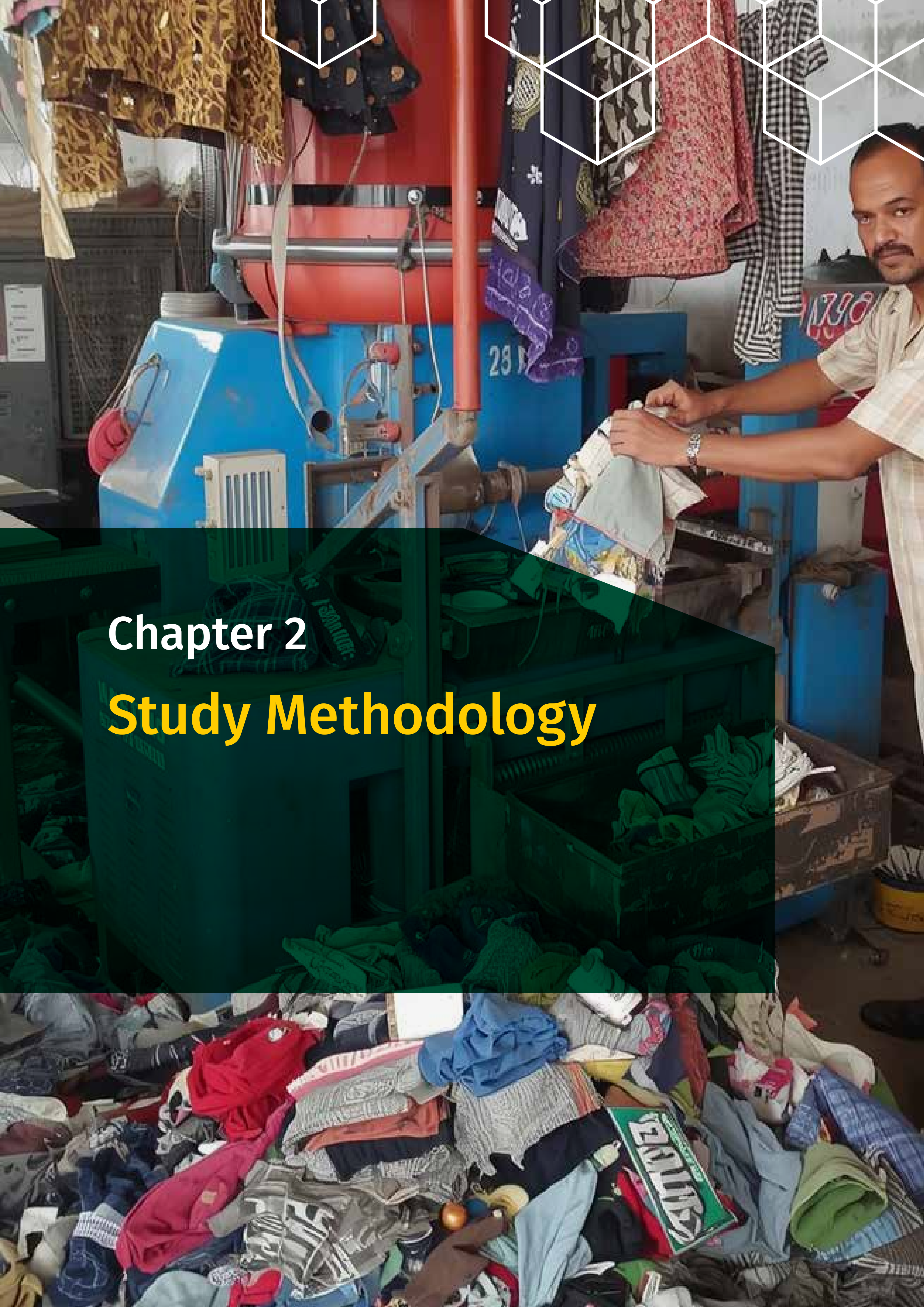
India's textile industry manifests in diverse forms, encompassing the large mill sector and a vast decentralised sector comprising a vast network of Micro, Small and Medium Enterprises (MSME). Textile production has a complex value chain, consisting of both natural and synthetic materials which go through several stages of processing and manufacturing before the end-product, its use, reuse, and final disposal[3]. These include composite textile mills, spinning mills, power looms, knitting and hosiery units, independent textile processors and garment manufacturing units. The industry is highly fragmented and spread over several industrial clusters which have evolved across the length and breadth of the country. With rising incomes, fast fashion trends, and increasing consumption, the volume of textile waste generated has grown substantially. The sector currently operates largely within a linear value chain model, where waste generated at various stages is inadequately recovered while mostly ends up in landfills or is incinerated.

**The projected market value of the textile recycling sector in India is expected to reach $3.5 billion by 2030, driven by the rising demand for sustainable fashion solutions. The rapid expansion of the textile recycling market highlights potential to generate approximately 1 lakh new green jobs in India in next 5 years[1]. Across the textile recycling value chain, jobs will span – waste collection, aggregation/trading, manual/semi-automated sorting, pre-processing (cutting/shredding/baling), recycling operations (technicians/operators), allied utilities, lab/EHS, reverse-logistics coordination, traceability/quality-assurance etc., to streamline feedstock and offtake.**

1. Making India a Zero Waste Fashion Country, Report by Department of Textiles, Government of Maharashtra, https://cdnbbsr.s3waas.gov.in
2. Fashion for Good (2022) Wealth in Waste: India's Potential to Bring Textile Waste Back into the Supply Chain. Available at: https://www.fashionforgood.com/report/wealth-in-waste/
3. Ministry of Textiles, Government of India (2023) Annual Report 2022-23. Available at: https://texmin.nic.in/sites/default/files/English%20Final%20MOT%20Annual%20Report%202022-23%20%28English%29_0.pdf

# Chapter 2

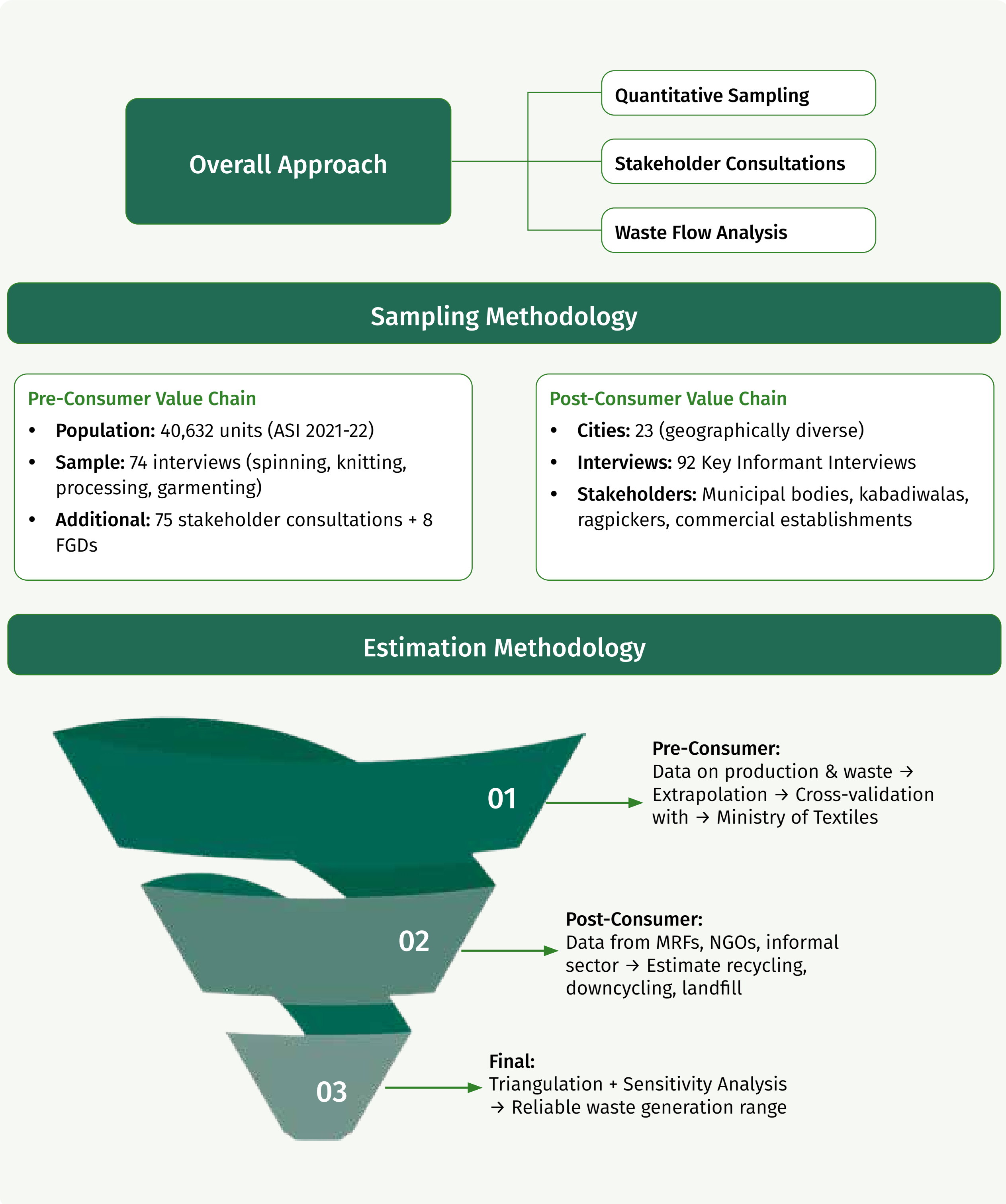
# Study Methodology



# Chapter 2 - Study Methodology

This study employed a mixed-method approach combining quantitative sampling, stakeholder consultations, and waste flow analysis to estimate textile waste generation across pre and post-consumer value chains in India.

Figure 3 Methodology Adopted



# 2.1 Sampling Methodology

### Pre-consumer value chain

The sampling was based on a stratified scientific approach, aligned with a 99% confidence interval and a 3% margin of error. Using the Annual Survey of Industries (ASI) 2021–22 data provided by the Ministry of Textiles, the total population of textile manufacturing units (40,632) was considered. A sample size of 74 interviews was distributed proportionally across key segments, including spinning, knitting, processing, and garmenting units.

To validate quantitative findings and capture qualitative insights, additional consultations were conducted with 75 stakeholders and 8 Focus Group Discussions across key enabler groups, such as Waste Collectors/Traders Organisation, Recyclers, Upcyclers, Waste import and sorting organization, and technology providers.

### Post-consumer value chain

The study focused on 23 cities selected from a pool of 68 million-plus and capital cities, ensuring geographic diversity across north, south, east, west, and central India. Four interviews were conducted per city, covering municipal bodies, informal stakeholders (e.g., kabadiwalas, ragpickers), and commercial establishments. A total of 92 Key Informant Interviews were conducted across the post-consumer value chain.

# 2.2 Estimation Methodology

### Pre-consumer waste

Primary data was collected on production volumes and waste generation rates through segment-specific questionnaires. This data was extrapolated to estimate industry-wide waste volumes. The study also mapped adoption of manufacturing technologies and assessed processing capacities to understand downstream waste flows. Estimates were cross validated using secondary literature and consultations with the Ministry of Textiles. Sensitivity analyses were conducted to define realistic waste generation ranges.

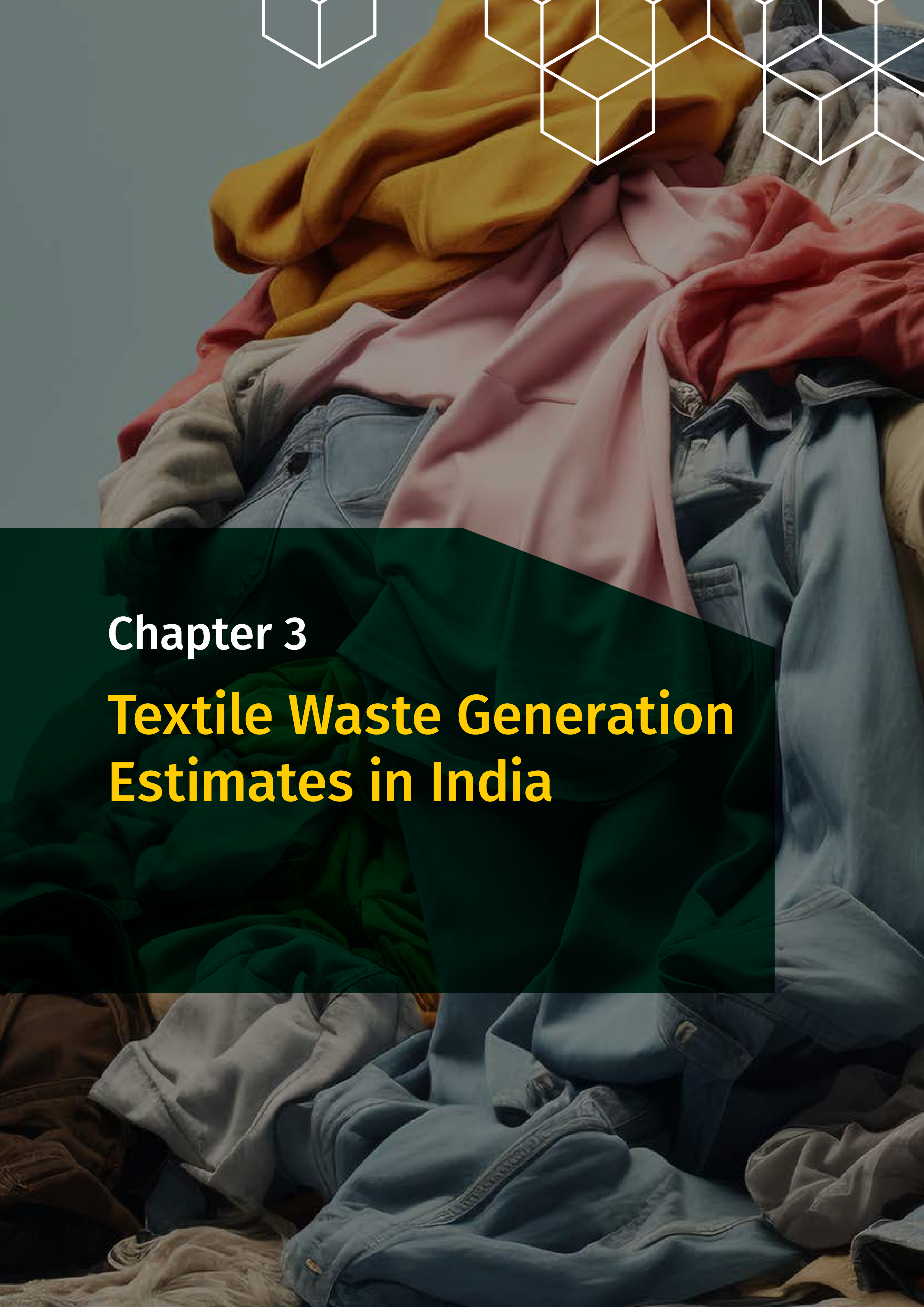
### Post-consumer waste

Data was gathered from Material Recovery Facilities, municipal records, NGOs, informal sector actors, and second-hand textile markets. This included information on collection, sorting, reuse, downcycling, and final disposal. Volumes of textile waste entering recycling streams, downcycled into products like RDF or industrial rags, and ultimately landfilled or incinerated were estimated.

# 2.3 Final Estimation

All data points were triangulated with secondary sources to validate findings. Final waste generation and disposal estimates were derived through extrapolation, incorporating variations through sensitivity analysis in consultation with Ministry of Textile to present a reliable range of textile waste quantity for both pre- and post-consumer segments.

For details, please refer section TBC.



# Chapter 3

# Textile Waste Generation Estimates in India

## Chapter 3 - Textile Waste Generation Estimates in India

Based on the primary research and estimation methodology described earlier, the total textile waste generated in India is estimated to be 7,073 KTPA (with ~5 % MOE). This comprises approximately:

**Pre-consumer waste: 2,973 KTPA**

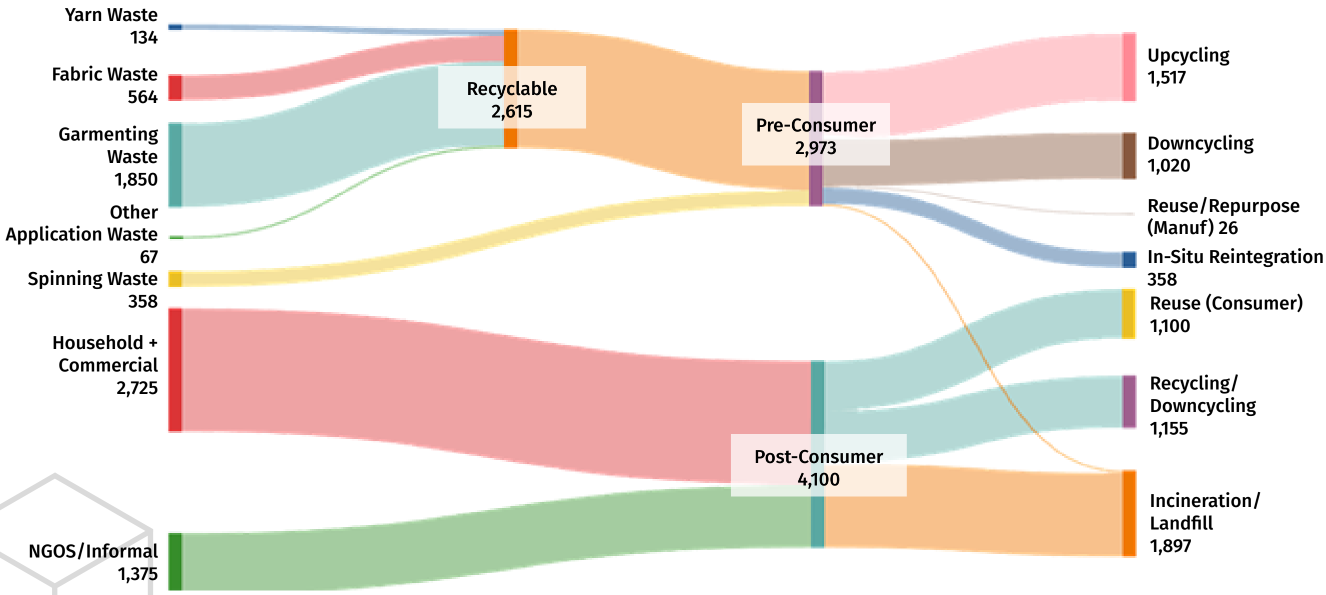
**Post-consumer waste: 4,100 KTPA**

The study conducted an end-to-end analysis of pre-consumer textile waste generated across various segments, ranging from yarn production, fabric processing, garment manufacturing, to other industrial textile applications. These estimations were based on field surveys, industry data, and extrapolated production-to-waste ratios.

Post-consumer textile waste primarily originates from household discards, which are either collected by urban local bodies or flow through informal channels, including donations and hand-me-downs. In many cases, NGOs such as Goonj have created community-driven textile redistribution models where used textiles serve as incentives or rewards for local work[8].

Imported textile waste, estimated at 600 KTPA, consists of second-hand clothing and mutilated rags, largely traced through harmonised system codes. This stream is more formalized and flows primarily into the recycling and sorting ecosystem.

### Figure 4 Stream-wise Distribution of Textile Waste in India




8. Goonj Foundation (2024) Annual Report. Available at: https://goonj.org/

Following the estimation of textile waste generation, the processing pathways of each waste stream (i.e. pre-consumer and post-consumer) were assessed. The analysis revealed distinct trends in how waste is handled, reused, recycled, or discarded across the two segments.

**Pre-consumer textile waste** tends to have a relatively higher processing rate. A significant portion is reused within manufacturing operations as raw material or is recycled and downcycled to create new products, such as industrial rags, insulation materials, or stuffing. Only a small fraction of this waste is rendered non-usable and consequently disposed of via landfilling or incineration.

**Post-consumer textile waste,** by contrast, faces major challenges in collection and processing. A considerable portion is handled through informal networks, including community-based organisations, NGOs (i.e. Goonj) and waste management enterprises (i.e. Green Worms, Saahas Zero Waste, Hasiru Dala, ReCircle, etc.) where reuse/ recycling/ upcycling are driven by collective efforts, primarily involving women. However, due to limited formal recovery systems and significant leakages in the value chain, a large share of post-consumer textile waste ends up in landfills or is incinerated.

For details, please refer section 14.3

# Chapter 4

# Pre-consumer Textile Waste

Chapter 4 - Pre-consumer Textile Waste

# 4.1 Constitution

Pre-consumer textile waste refers to materials discarded during various stages of textile production, before reaching the end consumer. This includes fabric trimmings, yarn ends, defective garments, and unsold inventory often composed of high-quality virgin fibers[9]. These materials, if properly collected and processed, can be recycled and reintroduced into the production cycle, supporting a circular textile economy and reducing dependence on virgin inputs.

For example, in the production of a cotton t-shirt, pre-consumer waste can arise at multiple points yarn and fabric scraps from spinning, weaving, or knitting; cutting waste during garment stitching; and unused finished products returned to manufacturers. These discards may be untreated or chemically processed, depending on their production stage.

It is important to distinguish pre-consumer waste from ‘soft waste’. **Soft waste refers to material generated during spinning process (approx. 358 KTPA) that is immediately reused within the same process. In contrast, pre-consumer waste requires separate collection and processing for reuse or recycling**[10].

# 4.2 Estimation

The approach adopted for mapping and estimating pre-consumer textile waste focused on calculating the quantum of waste generated across different segments of textile manufacturing. Waste estimates were derived as a proportion of total production output at each stage and for each fiber type. As previously mentioned, the total estimated pre-consumer textile waste in India stands at **2,615 KTPA (excluding spinning waste), accounting for approximately 36% of the country’s total textile waste**.

The estimated flow of waste across the value chain shows that of the 2,615 KTPA generated:

- **2,537 KTPA (~97%) is recycled, including 1,517 KTPA through upcycling and 1,020 KTPA through downcycling.**
- **26 KTPA (~1%) is reused.**
- **52 KTPA (~2%) is disposed of via landfilling or incineration.**

9. Textiles Committee, Government of India (2022) Circularity in the Indian Textile & Apparel Industry. Available at: https://www.textilescommittee.nic.in/sites/default/files/publications/CSPFTS_compressed_0.pdf
10. Textile Sphere (2019) Waste Management in Spinning. Available at: https://www.textilesphere.com/2019/09/waste-management-in-spinning.html

The detailed flow and segment-wise estimates are presented in the summary below.

**Figure 5 Fiber and Process-wise Quantification of Pre-consumer Waste in India**

| Total Raw Fiber Production and Waste Generation (including net imports) | | Waste Generated at Each Successive Stage of Value Chain (in KT) | | | |
|---|---|---|---|---|---|
| Type | Total Raw Fiber + Filament Production (incl Net Import) | Spinning Waste (raw fiber input) | Yarn Waste | Fabric Production Waste | Garmenting Waste |
| Cotton | 5,050 | 284.1 | 43.1 | 164.5 | 524 |
| Polyester | 3,551 | 22.3 | 39.6 | 98.3 | 320.6 |
| Viscose | 909 | 12.1 | 2.3 | 15 | 49.1 |
| Acrylic | 74 | 2.2 | 1.2 | 2.8 | 9.3 |
| Wool | 110 | 2.1 | 0.5 | 2.2 | 7.5 |
| Silk | 39 | 0.3 | 0.5 | 1.6 | 5.2 |
| Jute | 1,314 | 30.7 | 11.1 | 51.8 | 175.1 |
| All Others | 1923 | 4.2 | 35.7* | 227.8* | 759.2* |
| Total Fibre + Filament Production Annually (KT) | 12970 | ~358 | ~134 | ~564 | ~1,850 |

Variation of +-3% linked to lower and upper limit respectively

Total in-situ waste

*Blended fiber waste

# 4.3 Key Trends and Observations from Field

### i. Limited On-site Sorting and Processing

Stakeholder interactions and field visits revealed that formal textile clusters across India carry out minimal on-site sorting, segregation, or recycling. Most pre-consumer textile waste is transported to Panipat for downstream processing.

In clusters like Vapi, Silvassa, and Daman, **aggregators collect waste and sell it to larger players who route it to Panipat**

In Mumbai, basic material-wise sorting occurs locally (e.g., in Sion), but **waste is eventually directed to Panipat and parts of Uttar Pradesh**

In Saharanpur, where garmenting dominates, **waste is largely unsorted mixed clips that are sent directly to Panipat**

Given Panipat's pivotal role in the textile ecosystem, a summary of the observations from Panipat is outlined below:

**Case Study: Panipat Cluster**

Panipat cluster **produces approximately 5400-7200 TPD of mink blankets.** The predominant activities undertaken in the cluster are **waste recycling, processing, and knitting**. Since most clusters do not process and recycle their textile waste on-site, a large amount of waste is diverted to the Panipat cluster. Therefore, **around 3500-5250 TPD waste is brought into Panipat cluster.**

**Many manufacturers sell mixed-format waste, hindering textile-to-textile (T2T) recycling.** Survey observations reveal that local manufacturers perform waste collection, sorting, and storage, but sell waste mixed, limiting T2T recycling. Significant potential exists for improving in-house waste sorting. Polyester yarn and fabric waste are shredded to create recycled yarn, used for felt production and polyester popcorns, yet **T2T recycling for polyester remains underutilized despite available technologies.**

### ii. Linkages Between Formal and Informal Markets

The coexistence of formal and informal markets in the textile industry reveals a complex dynamic. Informal market stakeholders are highly prevalent, while formal waste handlers have a fragmented presence. This leads to limited adherence to waste purchasing contracts, even for large manufacturers. The concentration of power among a few formal buyers reduces suppliers' bargaining power and limits selling prices, increasing supply chain vulnerabilities. Despite these challenges, formal markets benefit from superior sourcing, transportation, and storage infrastructure. Unlike the variable waste collection in many clusters, Surat stands out with its efficient daily collection system.

Summary of the observations from the Surat cluster is outlined below:

**Case Study: Surat Cluster**

Surat's textile cluster is a **hub for spinning, weaving, processing, finishing, fabric manufacturing, and technical textiles. Generating approximately 762 TPD of textile waste, predominantly polyester (90%), the cluster consumes 4,666 TPD of polyester for weaving.** Despite daily waste collection by manufacturers, selling frequency varies with market trends, which can vary from every few days to once in 6 months.

The cluster **features downcyclers producing ropes from yarn waste, and low-quality yarn and 'chindi waste' used for baby clothes or filling in pillows and mattresses.** Larger export-focused companies integrate sustainable practices, such as renewable energy and **certifications like OEKO TEX and GRS.** The cluster has a **mix of formal and informal structures,** with **dyeing companies employing mostly contractual workers** and export-heavy companies maintaining formal operations.

**Case Study: Katran Market**

Katran Market in Mongolpuri, Delhi, is a prime example where informal handlers sort cutting waste by colour and sell over 10 TPD to formal clusters in Panipat for recycling. The roadside waste handlers buy raw cutting waste from trucks sent by companies in Noida, Gurugram, Manesar, Jaipur, and Delhi, particularly cutting waste, sort and segregate the waste based on colour, and sell them in Panipat.

Cutting waste is segregated into colour and fabric wise before being sent to Panipat for further processing

### iii. Garmenting as the Largest Waste Contributor

Garmenting emerged as the largest contributor to pre-consumer textile waste, accounting for approximately 1,850 KTPA (~15% of total textile waste).

Cotton
**(524 KTPA)**

Polyester
**(321 KTPA)**

Viscose
**(49 KTPA)**

Acrylic
**(9 KTPA)**

Wool
**(7.5 KTPA)**

Silk
**(5 KTPA)**

Others/blended
**(736 KTPA)**

Prominent garmenting waste clusters include Mumbai, Ludhiana, and Saharanpur. A brief case study from Ludhiana is presented below.

**Case Study: Ludhiana Cluster**

Ludhiana cluster has 12,000 knitting machines and produces **3,600 tons of knitted fabric daily.** Of this, **1,550 tons are consumed for garmenting within Punjab,** while **2,050 tons are sent outside,** mainly to Delhi NCR. **The garmenting process generates 10-20% clip waste.**

Waste handling in the cluster involves **immediate transfer of 6-8 ton lots,** with **handlers engaged on 6-month contracts.** Polyester waste is used for filling or mixed with low-quality yarn for **Open End processing. Most materials are recycled and sent to Panipat and Uttar Pradesh for further processing into low-grade yarn,** filling, handcrafts, and fleece blankets, as limited processing is done within the cluster itself.

### iv. Limited Policy Landscape

The textile waste management sector faces significant challenges due to the limited policy landscape governing its operations. Despite growing global awareness of sustainability and the circular economy, few regulations exist to guide the textile industry toward effective waste management. This lack of regulatory framework hampers efforts to promote recycling and sustainable practices within the industry. One of the most notable gaps in policy is **the absence of a HSN code for recycled yarn.** Without an HSN code, recycled yarn lacks formal recognition in trade, **making it difficult for manufacturers to claim benefits or incentives for using such materials.** This not only discourages the adoption of recycled inputs but also undermines efforts to build a circular economy in the textile sector. In contrast, the EU mandates that by 2025, at least 60% of garments must contain recycled content, thereby incentivizing sustainable practices.

This regulatory gap in India is further worsened by a global textile market downturn marked by declining production, unsold inventories, and reduced demand from export markets such as the EU and USA.

**v. Women's Role in Informal Waste Value Chains**

Women play a vital role in the informal pre-consumer waste economy. In markets like Katran, women are actively engaged in sorting and segregating waste by colour and fabric type. This not only creates livelihood opportunities but also highlights the need for better recognition and working conditions.

**vi. Market Development for Recycled Products**

Current regulations for import-based recycling require re-export of 50% of the imported value. However, a significant portion leaks into the domestic market[11]. Roughly INR 62 crore worth of imported waste from 2,000 monthly containers is diverted locally. This unaccounted inflow sustains the Panipat recycling hub but complicates policy enforcement. Furthermore, the absence of an HSN code for upcycled products limits opportunities for market development, exports, and formal sector incentives.

# 4.4 Stakeholders

The value chain for pre-consumer textile waste is primarily unorganised and informal, characterised by a network of brokers, agents, and middlemen who facilitate the flow of information between suppliers and demand entities. Despite its informal nature, this stream is decentralized, and stakeholders within the value chain are vigilant in preventing leakages to ensure optimal utilisation of waste from manufacturers, either within or external to the textile industry, to maximise returns.

**Textile Manufacturers & Exporters** (Spinning mills, weaving units, knitting units, garmenting factories, home textile manufacturers): These units generate most of the pre-consumer textile waste through fabric cutting, stitching, and production rejects, often selling it to local scrap dealers or disposing of it with mixed waste.

**Fabric & Yarn Processing Units** (Dyeing, printing, finishing units): Processing facilities create waste such as fabric rejects, defective rolls, and offcuts during dyeing, printing, and finishing, with disposal sometimes done without segregation.

**Waste Collectors & Aggregators** (Scrap dealers, bulk buyers from factories, intermediary traders): These actors purchase pre-consumer waste from factories, sort it (mainly manually), and resell it to recyclers or small scale reusers.

11. GIZ (2023) Building an Inclusive and Circular Textile Waste Value Chain in India. Available at: https://www.giz.de/en/downloads/giz2023-en-factsheet-building-an-inclusive-and-circular-textile-waste-value-chain-in-india.pdf

# 4.5 Key Geographies/ Clusters Studied

The primary geographical clusters for pre-consumer textile waste management in India are centred around major recycling hubs, each serving as a significant contributor to the nation's textile waste ecosystem. In our study, **visits and interviews were conducted to collect data from 14 clusters cross the country.** Each cluster is involved in certain segments of textile value chain and generates textile waste.

**Some clusters such as Panipat are efficient in recycling** and collect textile waste from other clusters as well. While others such as **Surat have an efficient waste collection system** as opposed to other clusters where collection system is unorganized. The clusters studied as part of this study with their pre-dominant activities involved in the pre-consume textile value chain are listed below:

**01 Kanpur**
Knitting and Cut, Make, and Trim (CMT).

**02 Saharanpur**
Garmenting

**03 Mumbai**
Weaving, Fabric Processing and Garmenting with major focus on Garmenting.

**04 Ludhiana**
Spinning, Knitting, Processing, and Garmenting.

**05 Bengaluru**
Apparel Making / CMT and some amount of technical textile manufacturing.

**06 Ichalkaranji**
Weaving majorly, some level of spinning and processing.

**07 Bhilwara**
Weaving majorly, followed by spinning and processing.

**08 Ahmedabad**
CMT / Apparel making (with respect to polyester consumption).

**09 Surat**
All processes involving polyester - spinning, weaving, processing, finishing, fabric manufacturing and technical textiles.

**10 Vapi**
Silvassa and Daman

**11 Panipat**
Waste recycling, processing, knitting.

# Chapter 5

# Post Consumer Textile Waste

Chapter 5 - Post Consumer Textile Waste

# 5.1 Constitution

Post-consumer textile waste constitutes the largest share of total textile waste and is managed predominantly through informal channels such as hand-me-downs, donations, or sale at low prices in second-hand markets. This category includes textiles discarded by households, commercial establishments, industries, and institutions once they can no longer be used for their original purpose.

The waste stream typically consists of used clothing, bedding, towels, and other household textiles that have been washed and worn multiple times[12]. The condition of these items can range from slightly used to heavily worn. Importantly, a considerable portion of post-consumer waste has not reached its true end-of-life and can be diverted from disposal through reuse or donation programs, giving the products a second life with new users.

However, items that are heavily soiled, damaged, or excessively worn are generally unsuitable for recycling and are directed towards landfills or incineration.

# 5.2 Estimation

The study adopted a structured approach to map and estimate post-consumer textile waste generation, assessing the quantum of waste flowing through both formal and informal channels. Site visits were conducted to MRFs part of the formal collection network, to assess quantities collected directly from households, retailers, boutiques, and NGOs. In parallel, post-consumer markets for used clothing were engaged with to capture data on collection, trade, and processing within the informal sector.

Based on this assessment, the total estimated post-consumer textile waste in India is 4,100 KTPA, accounting for approximately 58% of the country's total textile waste generation[13].

12. Textiles Committee, Government of India (2022) Circularity in the Indian Textile & Apparel Industry. Available at: https://www.textilescommittee.nic.in/sites/default/files/publications/CSPFTS_compressed_0.pdf
13. Fashion for Good (2022) Wealth in Waste: India's Potential to Bring Textile Waste Back into the Supply Chain. Available at: https://www.fashionforgood.com/report/wealth-in-waste/

# 5.3 Key Trends and Observations from Field

- **Limited source segregation:** The study team observed that there is limited segregation of textile waste at source, before going into formal channels such as Material Recovery Facilities. This leads to mixed waste streams, hindering efficient sorting and processing.

- **Direct Market Linkages:** Existing market for reusable textiles lacks solutions for heavily damaged/soiled items, while advanced sorting technologies are underutilised. Investment in innovative technologies for efficient sorting and development of processing methods for lower quality textiles can maximise resource recovery.

- **Limited Technological adoption:** There is limited adoption of advanced sorting technologies by waste handlers, which hinders efficient waste processing and potential for material recovery. We realise that financial support through PPP model can encourage waste handlers to adopt innovative sorting technologies for better textile waste utilisation.

- **Informal value chain:** The study team observed that most of the post-consumer textile waste goes though 'hand-me-downs' by consumers to organisations like NGOs and further to communities. This increases the life cycle of the textile products. However, because of the informal nature of the value chain, most of the post-consumer waste is unaccounted and not quantified. The study team conducted a visit to Goonj, an NGO working in collection, processing, and distribution of post-consumer textile waste, which includes a large portion of textile waste.

- **Efficient Use of Post-Industrial Waste:** There is a focus on using post-industrial waste more efficiently to ensure the correct quantity of waste reaches the right locations. This involves municipal corporations addressing capacity training issues and activating the value chain properly to prevent good waste from being downcycled instead of being recycled.

- **Active role of communities in waste collection:** The communities like Waghri community, play an important role in post-consumer waste collection. A high percentage of the waste is collected through the informal channels through hand-downs and contributions, which extend the lifespan of the products by 1-2 years. Local communities facilitate this through collection of used apparels either through collection drives or door to door collection. This can be better understood through the case study of the model adopted by the Waghri community.

- **Focus on Activation of Value Chains:** The challenges associated with waste either not reaching appropriate recycling channels or being downcycled underscore the need to activate and optimize textile value chains. Achieving this requires coordinated efforts among stakeholders to enable a more efficient and traceable flow of recyclable materials across the industry.

**Case study: Goonj**

Goonj collects and repurposes post-consumer textile waste for rural development. This case study outlines their process from collection and sorting to distribution through various impactful initiatives.

## Collection and Sorting Process

Goonj collects textile waste through organized drives, individual contributions, and temporary collection spaces. Contributions vary in quality based on donors' socio-economic status. After collection, textiles are sorted into three categories: usable clothes, slightly damaged items for repair, and completely damaged items for upcycling by "Green by Goonj." Additionally, clothes are sorted by size to meet the needs of different recipients.

## Distribution Channels and Key Initiatives

**Cloth Kits for Work (CFW):** Goonj incentivises community development by offering kit bags in exchange for labor on infrastructure projects. These kits include clothes, quilts, and woolen items, fostering sustainable development and community empowerment.

**Urban Surplus to Rural Schools:** School kits made from upcycled waste include utilities, toys, stationery, and seating items, enhancing educational resources and fostering parental involvement.

**Sanitary Pads and Hygiene Kits (Not Just a Piece of Cloth Initiative):** This initiative repurposes cloth into reusable sanitary pads and underwear, accompanied by educational materials. It aims to break the stigma around menstruation and improve hygiene in remote areas.

**Case Study: Waghri Community at Raghubir Nagar Market, Delhi**

The **Waghri community,** also referred to as Deviputras or Waghris, plays an essential role in managing post-consumer waste. **'Ghoda Mandi' at the Raghubir Nagar market in Delhi** was visited. The community's primary operation involves collecting used clothing from d**oor-to-door from Delhi, Noida, Gurugram, and other nearby daily in exchange of utensils.** They sort these textiles at their homes, separating wearable items for personal use and preparing the rest for sale at local markets early in the morning. This system not only diverts substantial amounts of post-consumer textile waste from landfills but also provides low-cost clothing options to economically disadvantaged populations.

However, the Waghris face significant operational challenges in their efforts. For over 30 years, they have been active at markets like the Raghubir Nagar market in Delhi where they typically sell the clothes along with **approximately 2000-3000 other sellers in the Mandi.** They sell the products at meagre rates with **pants and t-shirts ranging from Rs. 30-50 and banarasi saris being the most expensive ranging from Rs. 200-400 only.** Limited income and minimal recognition of their contributions to waste management exacerbate these difficulties.

# 5.4 Stakeholders

***NGOs***

*Collect* | *Sort* | *Distribute* | *Recycle*

NGOs and charitable organisations **organise community collection drives to collect wearable clothing from households.** They sort the clothes and distribute wearable ones to those in need, while products or disposing of them in landfills. recycling unwearable ones into other

***Informal Collectors***

*Barter* | *Resell* | *Reuse*

Informal waste collectors barter old clothes for utensils or money from households and sell them to aggregators or local second-hand clothing markets. They segregate, wash, and iron clothes, selling wearable ones based on quality, while using non-wearable ones in non-textile industries.

***Municipal Collectors***

*Segregate* | *Landfill/Incinerate*

Municipal waste collectors collect textile waste from household waste bins. They segregate the waste at designated centers and sell recyclable textiles to ragpickers, while non-recyclable materials are sent to landfills or incinerated for energy recovery.

***Manufacturers***

*Take-back programs* | *Recycled materials*

Textile manufacturers and brands play a significant role in managing post-consumer textile waste through take-back programs, product redesign for recyclability, and the use of recycled materials in their products.

***Recycling Units***

*Mechanical recycling* | *New yarns*

Formal recycling units specialise in the mechanical recycling of textile waste. They use advanced technology to sort and process textile waste into new yarns, fabrics, and products, contributing to a more sustainable textile industry.

***Research***

*Innovation* | *Sustainable practices*

Academic and research institutions contribute to the development of innovative recycling technologies and sustainable practices in the textile industry through research and collaboration with industry stakeholders.

***Waste Management***

*Collection* | *Processing* | *Reuse*

Waste management companies are involved in the collection, transportation, and processing of textile waste, ensuring that it is properly managed and recycled.

# 5.5 Key Geographies/Clusters Studied

Considering the source of post-consumer textile waste in India cannot be limited to geographical locations considering the nature of waste. In order to reasonably estimate the quantum of generation of the post-consumer textile waste, **the study team conducted key informant interviews with various stakeholders** across multiple cities. The team conducted visits to and collected data from **12 Municipal Corporations across 6 states**, which are:

The study team also conducted interviews of individual consumers from across **20 cities from 8 states** to understand the consumption and disposal patters and map the value chain of the textiles waste post their End of Life. The team also conducted interviews of **waste handlers from Kandla and Vapi, Silvassa & Daman, technical textiles from 7 cities and experts from Ichalkaranji and Panipat.**

01 Mohali

02 Chandigarh

03 Mumbai

04 Turbhe-Navi Mumbai

05 Panvel-Navi Mumbai

06 Bengaluru

07 Kanpur

08 Unnao

09 Saharanpur

10 Chennai

11 Coimbatore

12 Tambaram

## Chapter 6

# Key Industry Initiatives for Textile-to-textile Recycling

# Chapter 6 - Key Industry Initiatives for Textile-to-textile Recycling

The Indian textile industry is undergoing a significant transformation, driven by the urgent need to reduce environmental impact, conserve resources, and promote a circular economy. Leading manufacturers are adopting innovative practices ranging from advanced recycling technologies and sustainable material sourcing to closed-loop manufacturing systems to minimise waste and extend the lifecycle of materials. These initiatives not only reduce dependency on virgin resources but also align with global Sustainable Development Goals, ensuring long-term resilience and competitiveness. The following case studies showcase four industry players - Vardhman Textiles Limited (Vardhaman Group), Arvind Limited, Shahi Exports Pvt. Ltd. (Shahi Exports), and Usha Yarns Limited (Usha Yarns) - that have embedded circularity in their operations.

## Vardhman Group

Vardhman Group is one of India's leading textile manufacturers, producing yarn, fabric, acrylic fiber, and sewing threads. Headquartered in Ludhiana, Punjab, the company operates across multiple states and serves domestic and international markets. Guided by strong sustainability commitments, Vardhman aims to achieve **Zero Waste to Landfill by 2025**[14].

| Category | Details |
|---|---|
| **Company Overview** | **Leading textile manufacturer in India; HQ in Ludhiana, Punjab** |
| **Key Facts** | • Recycling facility since Dec 2021<br>• 6,600 MT rPET/year<br>• 520 MT recycled cotton/year<br>• >60,000 MT BCI cotton sourced annually<br>• Member of global sustainability platforms |
| **Circularity Interventions** | • **Modern Recycling Facility:** Processes spinning hard waste, fabric clips (54.3% utilization)<br>• **Material Recycling:** Recycled polyester, cotton, filament integration<br>• **Sustainable Sourcing:** BCI cotton, no formaldehyde, global sustainable cotton<br>• **Plastic Waste Recycling:** 1,290 MT recycled in FY23; 70% plastic waste recycled; HDPE packaging<br>• **Collaborations:** Re:Source (post-consumer recycling), Lenzing Refibra |
| **Impact** | • Reduced virgin fiber use<br>• Improved waste diversion<br>• Lowered chemical usage<br>• Steady recycled material adoption |
| **SDG Alignment** | • **SDG 6:** Effluent treatment since 1995<br>• **SDG 9:** Recycling infrastructure innovation<br>• **SDG 12:** Advanced fiber recycling<br>• **SDG 17:** Global partnerships |

14. Vardhman Textiles Limited (2024) ESG Databook. Available at: https://www.vardhman.com/Document/ESG/ESG%20Databook.pdf; Vardhman Group (2025) Sustainability Overview. Available at: https://www.vardhman.com/Sustainability/Overview

## Arvind Limited

Arvind Limited, headquartered in Ahmedabad, Gujarat, is India's largest denim producer and a key player in cotton shirting, knits, and other fabrics.

The company is globally recognised for embedding sustainability into its textile manufacturing[15].

| Category | Details |
|---|---|
| **Company Overview** | **India's largest denim producer; HQ in Ahmedabad, Gujarat** |
| **Key Facts** | • 16.2 MW rooftop solar plant<br>• 61% sustainable cotton (2022–23)<br>• Pioneer in post-consumer textile recycling |
| **Circularity Interventions** | • **PurFi Partnership:** Converts waste to high-quality fibers (96% less water, 90% less energy)<br>• **Re-Weave & Renew:** Denim waste recycling; 25% virgin cotton reduction<br>• **PET Initiative:** 10+ million bottles recycled/year; goal: 100% recycled polyester by 2025<br>• **Renaissance Initiative:** Closed-loop denim manufacturing<br>• **BCI Cotton Expansion:** From 14,750 acres (2014–15) to 112,756 acres (2018–19) |
| **Impact** | • 14,026 MT $CO_2$ emissions avoided<br>• Reduced polyester dependence<br>• 44.84% freshwater use reduction<br>• Significant renewable energy generation |
| **SDG Alignment** | • **SDG 7:** Renewable energy<br>• **SDG 8 & 9:** Sustainable industrial growth<br>• **SDG 6:** Water conservation<br>• **SDG 11:** Sustainable cities via waste management |

15. Arvind Limited and PurFi Global (2022) Partner to Combat Massive Textile Waste Problem in a Giant Leap in Textile Circularity. Available at: https://www.businesswire.com/news/home/20221120005083/en/Arvind-Limited-and-PurFi-Global-Partner-to-Combat-Massive-Textile-Waste-Problem-in-a-Giant-Leap-in-Textile-Circularity

## Shahi Exports

Shahi Exports, India's largest garment exporter, operates a vertically integrated supply chain from spinning to garmenting. The company has built a reputation for innovation, sustainability, and strong industry collaborations[16].

| Category | Details |
|---|---|
| **Company Overview** | **India's largest garment exporter; vertically integrated supply chain** |
| **Key Facts** | • 3,000+ MT fabric scrap recycled/year<br>• Goal: 30% virgin material reduction by 2025<br>• Member of Ellen MacArthur CE100 Network |
| **Circularity Interventions** | • **Fabric Waste Reduction:** Precision cutting, digital sampling, yarn recycling<br>• **Collaborations:** Birla Cellulose, Usha Yarns (viscose & recycled cotton)<br>• **RE:TURN Project:** 500 MT textile waste diverted/year<br>• **Innovative Materials:** "Altag" from agricultural residues (AltMat)<br>• **Plastic Reduction:** 11.5 MT reduction in plastic consumption annually |
| **Impact** | • 30% water savings in dyeing/finishing<br>• Coal eliminated from garment factories<br>• Post-consumer garment reuse |
| **SDG Alignment** | • **SDG 6:** Water conservation<br>• **SDG 11:** Waste management<br>• **SDG 13:** Climate action<br>• **SDG 17:** Collaborative innovation |

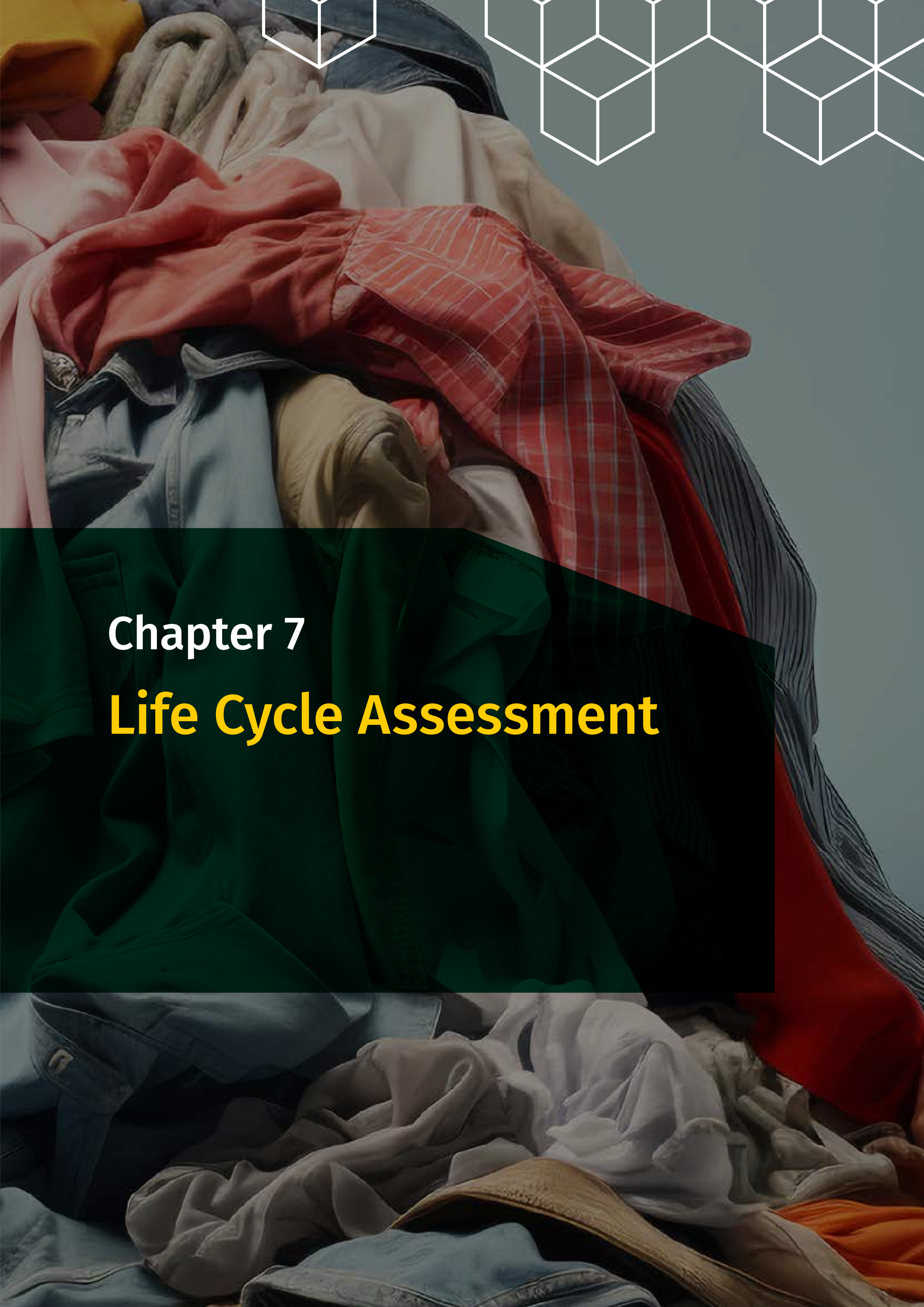
16 Shahi Exports Pvt. Ltd. (2024) Sustainability Report FY 2023-24. Available at: https://www.shahi.co.in/wp-content/uploads/2024/12/Shahi-Exports-Sustainability-Report-FY-2023-24.pdf; Shahi Exports (2025) Sustainability. Available at: https://www.shahi.co.in/sustainability/

## Usha Yarns

Founded in 1995, Usha Yarns Limited is a leading Indian recycler of textile waste into high-quality yarns. Based in Ludhiana, the company supplies sustainable yarns to major global brands[17].

| Category | Details |
|---|---|
| **Company Overview** | **Textile waste recycler; HQ in Ludhiana; founded in 1995** |
| **Key Facts** | • 12,000 MT recycling capacity (target: 24,000 MT by 2026)<br>• Clients: Adidas, Nike, Puma<br>• 95%+ waste recycled/reused |
| **Circularity Interventions** | • **Waste Recycling:** Pre/post-consumer waste, PET to yarn<br>• **Resource-Efficient Production:** 40% less water, 25% more energy-efficient, 90% low-impact chemicals<br>• **Waste Management:** Segregation of hazardous, non-hazardous, e-waste<br>• **Certifications:** GRS certified, Higg MSI for LCA<br>• **Zero Discharge & Energy Recovery:** Zero wastewater by 2025; waste-to-energy projects |
| **Impact** | • 35% lower carbon emissions vs virgin yarn<br>• >12,000 MT textile waste diverted/year<br>• Reduced water, chemical, fossil fuel use across the supply chain |
| **SDG Alignment** | • **SDG 12:** Responsible production<br>• **SDG 6:** Water conservation<br>• **SDG 13:** Lower GHG emissions |

17. Usha Yarns (2024) Sustainability in Textile. Available at: https://ushayarns.in/sustainability-in-textile-usha-yarn/; Usha Yarns (2025) The Future of Recycled Textiles: Shaping Sustainable Fashion with Usha Yarns. Available at: https://ushayarns.com/the-future-of-recycled-textiles-shaping-sustainable-fashion-with-usha-yarns/



# Chapter 7

# Life Cycle Assessment

## Chapter 7 - Life Cycle Assessment

Life Cycle Assessments (LCA) conducted as part of this study clearly demonstrate substantial opportunities for reducing carbon emissions by re-integrating recycled textiles into the manufacturing supply chain. This approach can significantly lower the environmental footprint of textile production.

The study was conducted using a mix of primary (process related data) and secondary (for fibre production and recycling data) data sources

For detailed methodology, please refer section 14.4

# 7.1 LCA for Cotton T-Shirts

LCA focused on quantifying the environmental impacts associated with the production of cotton t-shirts, comparing a garment made entirely from virgin cotton to one composed of a blend of 25% recycled cotton and 75% virgin cotton. The analysis is especially concerned with the climate impact in terms of power usage and carbon dioxide equivalents ($CO_2$ eq).

**Table 1 LCA 100% Virgin Cotton T-Shirt**

**Process A - 100% Virgin Cotton T-Shirt**

| Parameters | UOM | Farming | R Fiber | Spinning | Knitting | Processing | Garmenting | Total |
|---|---|---|---|---|---|---|---|---|
| Percentage | % | 100% | 0% | | | | | |
| Power | (kWh/T-Shirt) | | | 0.652 | 0.153 | 2.738 | 0.255 | 3.798 |
| $CO_2$ eq | gms | 0.311 | | 0.370 | 0.080 | 1.550 | 0.140 | 2.451 |

**Table 2 LCA 25% Recycled +75 % Virgin Cotton T-Shirt**

**Process B - 25% Recycled Cotton + 75% Virgin Cotton T-Shirt**

| Parameters | UOM | Farming | R Fiber | Spinning | Knitting | Processing | Garmenting | Total |
|---|---|---|---|---|---|---|---|---|
| Percentage | % | 75% | 25% | | | | | |
| Power | (kWh/T-Shirt) | | 0.091 | 0.675 | 0.153 | 2.740 | 0.255 | 3.914 |
| $CO_2$ eq | gms | 0.233 | 0.015 | 0.372 | 0.080 | 1.550 | 0.140 | 2.390 |

### Comparative Analysis and Conclusions

LCA revealed that using 25% recycled cotton reduces the total energy requirement and $CO_2$ emissions associated with manufacturing a t-shirt. The total power reduction was marginal, but the decrease in $CO_2$ eq was notably impactful, demonstrating a 3% reduction in climate impact. This illustrated the benefits of integrating recycled materials into production processes, not only for energy conservation but also for significant reductions in greenhouse gas emissions.

This data supports the textile industry's move towards more sustainable practices by quantifying the environmental benefits of recycling cotton, thus encouraging stakeholders to adopt recycling strategies to minimise climate impact.

# 7.2 LCA for Viscose T-Shirts

LCA focused on the environmental impacts associated with the production of viscose t-shirts, comparing garments made from 100% virgin viscose derived from wood pulp to those produced from 100% recycled viscose[18] . The analysis particularly evaluated the climate impact in terms of power usage and $CO_2$ equivalents, highlighting the potential reductions achieved by utilising recycled materials.

**Table 3 LCA 100% Virgin Viscose T-Shirt**

**Process A — 100% Virgin Viscose T-Shirt**

| Parameters | UOM | Wood pulp | R Fiber | DWP | Spinning | Knitting | Processing | Garmenting | Total |
|---|---|---|---|---|---|---|---|---|---|
| Percentage | % | 100% | 0% | | | | | | |
| Power | (kWh/T-Shirt) | | | 0.188 | 0.478 | 0.126 | 2.028 | 0.206 | 3.026 |
| $CO_2$ eq | gms | 0.780 | | 0.110 | 0.340 | 0.080 | 1.390 | 0.130 | 2.830 |

**Table 4 100% Recycled Viscose T-shirt**

**Process B — 100% Recycled Viscose T-Shirt**

| Parameters | UOM | Wood pulp | R Fiber | DWP | Spinning | Knitting | Processing | Garmenting | Total |
|---|---|---|---|---|---|---|---|---|---|
| Percentage | % | 0% | 100% | | | | | | |
| Power | (kWh/T-Shirt) | | 0.239 | 0.188 | 0.478 | 0.126 | 2.028 | 0.206 | 3.265 |
| $CO_2$ eq | gms | | -0.300 | 0.110 | 0.340 | 0.080 | 1.390 | 0.130 | 1.750 |

18. Shen, L. and Patel, M.K. (2010) Life cycle assessment of man-made cellulose fibres. Department of Science, Technology and Society (STS), University Utrecht.

### Comparative Analysis and Conclusions

LCA revealed a significant reduction in climate impact when using recycled viscose as compared to virgin viscose. Specifically, the total $CO_2$ eq emissions are reduced by 38%, illustrating a substantial decrease in the environmental burden. This reduction is attributed mainly to the avoidance of initial wood pulp production and the efficient use of recycled materials, which conserves resources and reduces waste.

This analysis underscores the environmental benefits of recycling viscose, demonstrating how substantial energy and emissions savings can be achieved. It supports the adoption of recycled materials in textile production as a viable strategy for reducing the industry's overall environmental impact, promoting more sustainable practices within the sector.

# 7.3 LCA for Polyester T-Shirts

LCA focused on the environmental impacts associated with producing polyester t-shirts, specifically comparing the use of 100% virgin polyester to 100% recycled polyester (RPET). The focus is on quantifying the climate impact in terms of power usage and carbon dioxide equivalents ($CO_2$ eq), highlighting the benefits of utilizing recycled polyester.

**Table 5 LCA 100% Virgin Polyester T-Shirt**

**Process A — 100% Virgin Polyester T-Shirt**

| Parameters | UOM | Virgin Polyester | Recycled Polyester | Spinning | Knitting | Processing | Garmenting | Total |
|---|---|---|---|---|---|---|---|---|
| Percentage | % | 100% | 0% | | | | | |
| Power | (kWh/T-Shirt) | | | 0.326 | 0.109 | 1.781 | 0.179 | 2.395 |
| $CO_2$ eq | gms | 0.530 | | 0.180 | 0.060 | 1.000 | 0.100 | 1.870 |

**Table 6 LCA 100% Recycled Polyester (RPET)**

**Process B — 100% Recycled Polyester (RPET) T-Shirt**

| Parameters | UOM | Virgin Polyester | Recycled Polyester | Spinning | Knitting | Processing | Garmenting | Total |
|---|---|---|---|---|---|---|---|---|
| Percentage | % | 0% | 100% | | | | | |
| Power | (kWh/T-Shirt) | | | 0.326 | 0.109 | 1.781 | 0.179 | 2.395 |
| $CO_2$ eq | gms | | 0.120 | 0.180 | 0.060 | 1.000 | 0.100 | 1.460 |

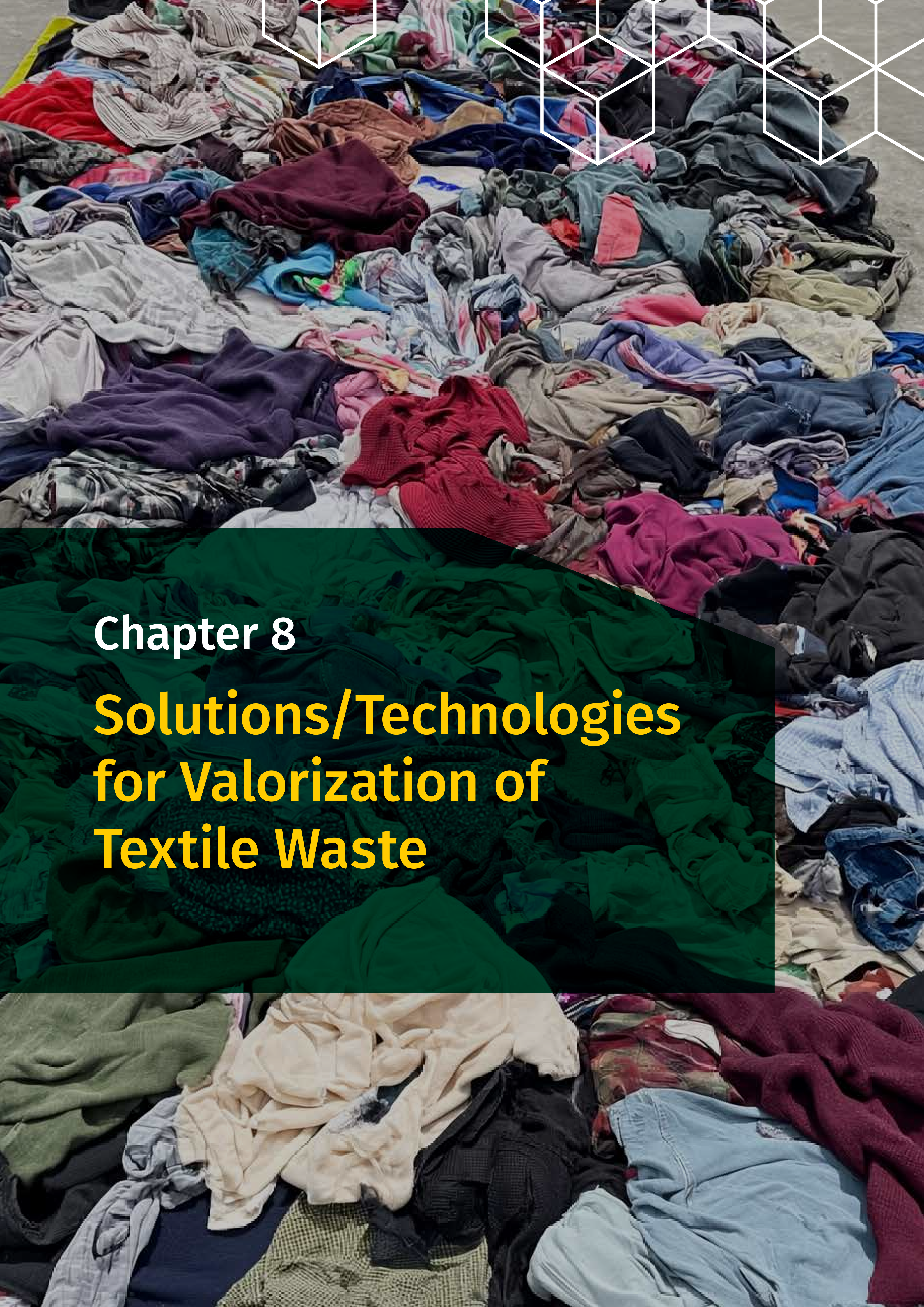
## Comparative Analysis and Conclusions

The aim of LCA study was to understand the impact of three different textile fibers compared to their recycled fibers on the environment. The various environmental impact factors – climate change, Eutrophication, Ozone depletion, Water use, Land use, Acidification, toxicity, smog creation etc., wherever applicable. The impact of fibre production or cultivation and recycling on climate has been studied in detail. However, the impact of process is limited to CO2 eq emissions, as recycling was the main aim of the study. Since the study was limited to cradle to gate, hence postproduction use, and Transport and Distribution have not been considered in the LCA assessment.

LCA showed that using 100% recycled polyester leads to a significant reduction in $CO_2$ emissions by 22% per t-shirt compared to those made from 100% virgin polyester. This reduction underscores the effectiveness of recycling polyester in terms of lowering the carbon footprint associated with the production of polyester garments. Power consumption remained the same in both processes, suggesting that the energy required for processing recycled polyester is comparable to that for virgin polyester. This indicates that the energy efficiency of using recycled polyester is equivalent to that of using new materials. Substantial decrease in $CO_2$ eq for the recycled polyester option highlights the environmental benefits of diverting used polyester from waste streams and reprocessing it into new garments. This reduction mainly stems from avoiding the initial production phase of polyester, which typically involves significant emissions from the extraction and processing of petroleum-based raw materials.

This analysis provides robust evidence supporting the shift towards using recycled polyester in textile production to achieve substantial environmental benefits, particularly in reducing greenhouse gas emissions. It advocates for increased recycling initiatives within the industry, promoting sustainability and resource efficiency.

**The LCA results clearly show that integrating recycled fibers into garment production reduces greenhouse gas emissions across all three textile types, with the magnitude of benefit varying by material.** While cotton shows modest gains (~3% $CO_2$ reduction), viscose and polyester demonstrate substantial reductions (~38% and ~22%, respectively), primarily by avoiding resource-intensive virgin material production stages. However, we note a trade-off i.e. slightly higher energy usage in recycling, up to 8% more in some cases. Energy consumption differences are minor, indicating that recycling does not introduce significant additional processing energy demands. **Overall, the analysis validates recycling as an effective climate mitigation strategy in the textile sector, with the greatest impact achieved when recycled content fully replaces virgin inputs, but technological innovation is needed to make recycling more energy efficient.**



# Chapter 8

# Solutions/Technologies for Valorization of Textile Waste

# Chapter 8 - Solutions/Technologies for Valorization of Textile Waste

The textile industry is increasingly turning to advanced recycling technologies to address environmental challenges and enhance sustainability. These technologies - **Mechanical, Thermo-Mechanical, Chemical,** and **Thermo-Chemical Recycling,** each offer unique benefits for transforming textile waste into usable resources[19]. Mechanical recycling is cost-effective but limited by fiber quality degradation, while thermo-mechanical recycling allows for better fiber integration with some energy cost. Chemical recycling, though more costly, breaks down fibers to their monomers for high-quality fiber reproduction, and thermo-chemical recycling transforms waste into synthetic gas for broad industrial use. **These 4 overarching recycling technologies includes an array of sub-technologies and can recycle different fiber types.**

## Table 7 Overview of Recycling Technologies

| Technologies | Mechanical | | Thermo-mechanical | | Chemical | | Thermo-chemical |
|---|---|---|---|---|---|---|---|
| | Open loop | Close loop | Open loop | Close loop | Pulping | Solvent | |
| Description | Use physical forces (cutting, opening, garneting,) | | Combine physical forces and heat to melt thermoplastic textiles and recover the polymers | | Use sulphate, sulphite and sulphur-free to produce cellulosic pulp | Use solvent-based dissolution and filtration to extract polymers | Use partial oxidation reaction of polymers to produce syngas |
| Cotton | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| MMCF | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| Poly-cotton | ✓ | ✓ | | | | ✓ | ✓ |
| PES | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| PA | ✓ | ✓ | | | | | ✓ |
| Acrylic | ✓ | ✓ | | | | | ✓ |
| Wool & blends | ✓ | ✓ | | | | | ✓ |
| Aramid | ✓ | ✓ | | | | | ✓ |
| Other blends | ✓ | ✓ | | | | | ✓ |

✓ Mature & commercialized ✓ Demonstration stage ✓ Needs further development for the treatment of textile waste

# 8.1 Details of Recycling Technologies

Table 8 Textile Recycling Pathways

| Category | Mechanical Recycling | Thermo-Mechanical Recycling |
|---|---|---|
| **Principle** | Physical processing of textile waste to recover fibers without altering chemical composition. "What goes in, comes out." | Uses heat and pressure to melt synthetic fibers (e.g., polyester, polyamide) for polymer recovery and re-extrusion. |
| **Applicable Fibers** | All fiber types (cotton, polyester, blends, etc.) | Synthetic fibers only (polyester, polyamide). Not applicable to cotton/MMCF. |
| **Key Applications** | • Open-loop: cleaning rags, padding, shoddy fibers.<br>• Closed-loop: recycled yarns/textiles.<br>• Innovations: blending with virgin fibers; "soft" recycling reducing fiber loss. | • PET to yarn/textile reprocessing.<br>• Insulation and functional nonwovens. |
| **Advantages** | • Cost-effective, simple.<br>• Versatile across fibers.<br>• Commercially mature with strong Indian base. | • Lower energy use vs chemical.<br>• Less quality loss than mechanical.<br>• Proven in PET recycling. |
| **Challenges** | • Fiber shortening (30–40%).<br>• Limited performance for high-blend fabrics.<br>• Market acceptance issues. | • Needs >99% pure feedstock.<br>• Contamination & elastane difficult.<br>• Limited textile feedstock availability. |
| **Current Penetration in India** | • High: shredding, baling, blending, open-end spinning.<br>• Growing: hydroentangling, nonwovens, separation tech. | • High: PET recycling lines.<br>• Growing: insulation, functional nonwovens. |
| **Leading Providers** | Laroche (France), Balkan Textile (Turkey), Dell'Orco & Villani (Italy), Perfect Equipment (India). | Starlinger (Austria), Tecnofer (Italy), Toyobo (Japan), Yongxing (China), Zhejiang Boretech (China). |
| **Future Needs (by 2030)** | • Manage high-blend fabrics better.<br>• Market acceptance for products with ~65% recycled content purity. | • Melt filtration for blended/contaminated inputs.<br>• Scale from PET to full textile recycling. |

| Chemical Recycling | Thermo-Chemical Recycling |
|---|---|
| Breaks down fibers into polymer or monomer components via chemical processes. | Gasification (partial oxidation) of fibers into syngas ($H_2$, CO, hydrocarbons), further processed into fuels/chemicals. |
| Both natural (cellulosic) & synthetic fibers; some blended fabrics. | All fiber types, including contaminated or mixed waste. |
| • Polymer-level: dissolving pulp (cotton/MMCF), solvent/polyester recycling.<br>• Monomer-level: methanolysis, glycolysis, hydrolysis, enzymatic recycling. | • Syngas conversion into methanol, ammonia, synthetic fuels, adhesives, construction materials. |
| • Near-virgin fiber quality.<br>• Handles blends/contamination.<br>• Enables true circularity. | • Processes all fibers (incl. contaminated/mixed).<br>• Produces high-value industrial outputs.<br>• Established in other waste streams. |
| • High energy demand.<br>• Mostly pilot stage for textiles.<br>• Capital-intensive scale-up. | • High energy consumption.<br>• Limited adaptation for textile feedstocks. |
| • Low: R&D & pilot projects.<br>• Examples: Worn Again, Renewcell, Infinited Fiber, Södra–Lenzing “Once More” process. | • Low: early-stage/pilot.<br>• Interest in polymer-to-syngas applications. |
| Infinited Fiber (Finland), Worn Again (UK), Cure (Netherlands), Teijin (USA), Aquafil (Italy). | Kinetics Technology (Italy), Sundrop Fuels (USA), Suncoal (Germany), Xylowatt (Belgium). |
| • Tolerate up to 10% elastane blends.<br>• Lower energy costs.<br>• Commercial-scale plants in India. | • Major energy efficiency gains.<br>• Textile-specific system design.<br>• Integrate renewables to cut emissions. |

# 8.2 Comparative Assessment of Textile Recycling Technologies

**Table 9 Comparative Assessment of Textile Recycling Technologies**

| Parameter | Mechanical | Thermo-Mechanical |
|---|---|---|
| Energy Use | Good | Medium |
| Water Use | Good | Medium |
| Chemicals Use | Good | Medium |
| Process Cost | Good | Medium |
| Quality of Material | Poor | Medium |
| Impurity Handling | Poor | Poor |
| Adoption Stage | **Commercial & Mature** | **Limited/Niche** |

The comparative analysis reveals that no single recycling technology provides a perfect balance across sustainability, scalability, and quality:

- **Mechanical recycling:** Most mature, resource-efficient, and cost-effective, but limited by quality loss and inability to handle impurities at scale.
- **Thermo-mechanical recycling:** Offers better quality retention for synthetics yet restricted by purity requirements and modest adoption in textiles.
- **Chemical recycling:** Holds the greatest promise for true circularity due to virgin-quality outputs and impurity tolerance, though it is currently energy- and cost-intensive and at pilot/ demonstration stages.
- **Thermo-chemical recycling:** Provides feedstock versatility and multiple industrial applications

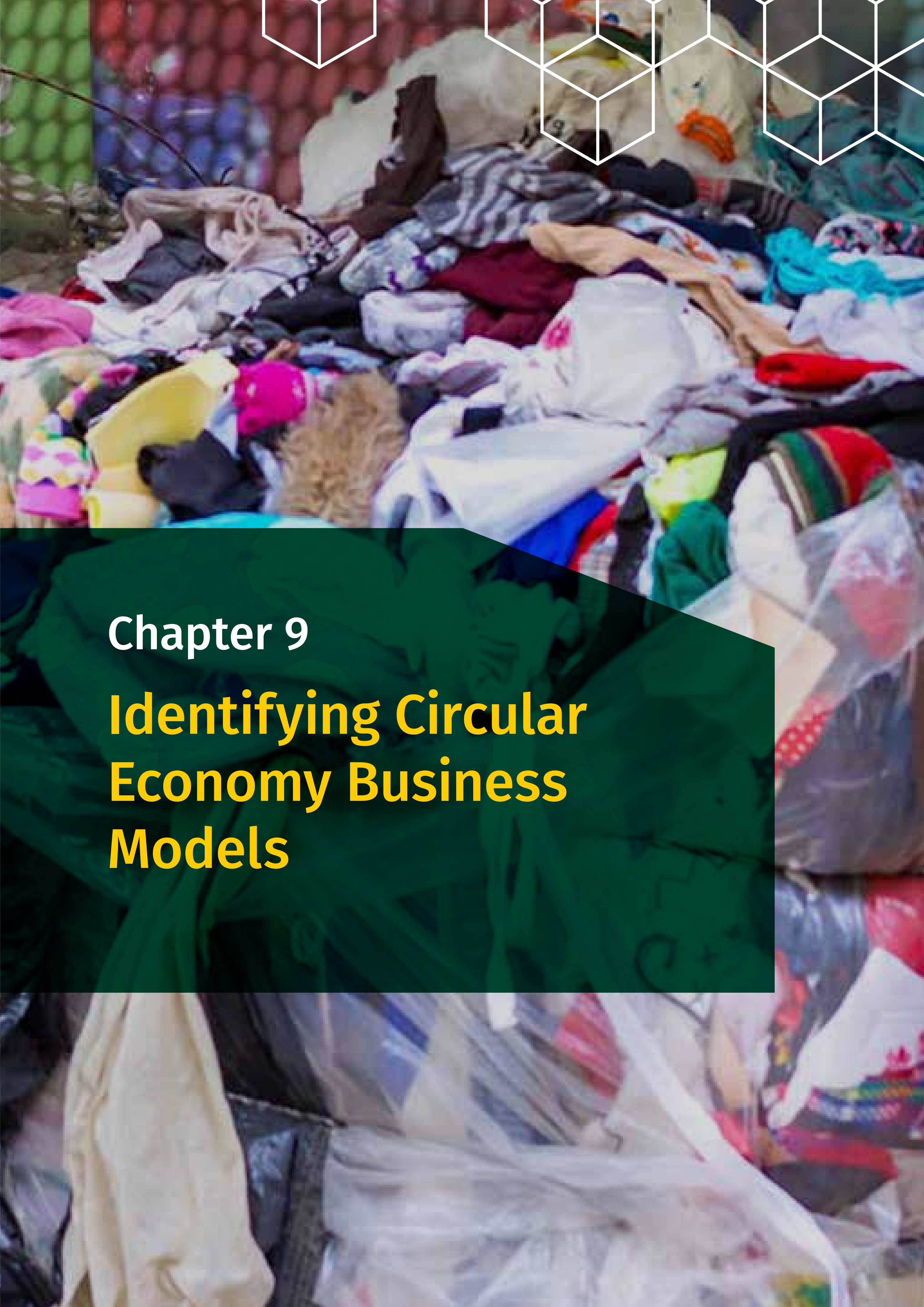
| Chemical (Polymer) | Chemical (Monomer) | Thermo-Chemical |
|---|---|---|
| Medium | Poor | Needs significant improvement |
| Poor | Poor | Good |
| Medium | Poor | Good |
| Medium | Poor | Medium |
| Medium | Good | Good |
| Medium | Good | Good |
| **Pilot/Demo** | **Pilot/Demo** | **Very Early/Conceptual** |

but faces energy efficiency challenges and lacks closed-loop potential for textiles.

**Overall, mechanical recycling remains the backbone of textile recycling today, while chemical recycling, particularly monomer-level processes represent the most viable future pathway toward circular textile systems.** Thermo-mechanical and thermo-chemical recycling will likely play complementary roles in addressing specific feedstock types and industrial applications.

By 2030, a **hybrid recycling ecosystem,** leveraging mechanical recycling for scale, chemical recycling for quality and circularity, and thermo-chemical recycling for complex and contaminated waste will be essential for India and globally to transition toward sustainable textile waste management.

For details, please refer section 14.5



# Chapter 9

# Identifying Circular Economy Business Models

# Chapter 9 - Identifying Circular Economy Business Models

The transition to a **circular economy in the textile sector requires practical, scalable solutions** that address environmental, social, and economic challenges while reducing dependency on finite resources. Unlike the traditional linear "take–make–waste" model, **circular business models are designed to keep materials in use for as long as possible,** extract maximum value from them, and recover and regenerate products at the end of their service life.

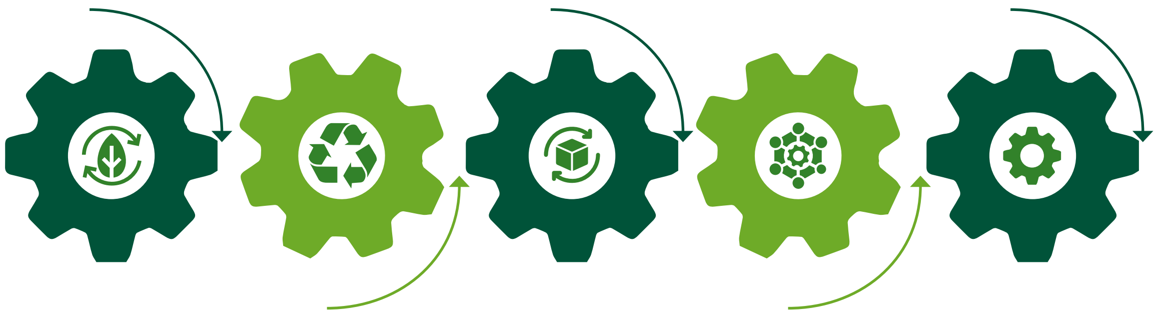
This section identifies **five key circular economy business models** that have proven effective across global and Indian textile value chains:

### Figure 6 Circular Economy Business Models

**Circular Supply Chain Model**
Integrates renewable, recycled, or biodegradable materials into production, keeping resources in continuous circulation.

**Product Life-Extension Model**
Extends the lifespan of garments through repair, refurbishment, remanufacturing, and resale.

**Product as a Service (PaaS) Model**
Shifts ownership from the consumer to the provider, with textiles offered as a subscription or rental service.



**Recovery & Recycling Model**
Reclaims fibres and materials from post-consumer textiles and production waste for reuse in new products.

**Sharing Platform Model**
Enables renting, swapping, or reselling underutilised clothing and textiles, maximising asset use.

Each model is explained through:

- **A concise overview of its principles and relevance to the textile sector.**
- **Key principles that define its approach.**
- **Challenges and considerations for implementation and scaling.**
- **Curated case studies, presented in a standardised table format for easy comparison, highlighting global and Indian examples, their innovations, impact, and replicability potential in India.**

## Case studies assessed

### Table 10 Circular Model Case Studies

| Case Study | Business Model | Country/Region | Core Focus |
|---|---|---|---|
| Bamboo as a Sustainable Raw Material | Circular Supply Chain | Global | Renewable bamboo fibers as an alternative to cotton. |
| Geetanjali Woolens | Circular Supply Chain | India / Africa | Closed-loop upcycling of post-consumer textiles. |
| Football Clubs & Fashion Brands | Circular Supply Chain | Europe | Jerseys and accessories made from recycled plastics. |
| SOEX I:CO | Recovery & Recycling | Germany | Retail take-back with automated sorting and chemical recycling. |
| Reverse Resources | Recovery & Recycling | Global Platform | Digital marketplace for textile waste. |
| Mended | Product Life-Extension | Netherlands | Garment repair network via digital platform. |
| Patagonia | Product Life-Extension | USA | Resale and repair ecosystem. |
| Eslando | Sharing Platform | England | Digital Product Passports linking brands and recyclers. |
| Trove – Recommerce OS | Product as a Service | USA | Brand-operated resale via recommerce system. |

| Key Impact | Ideas for Replication in India |
|---|---|
| Reduced water/pesticide use; renewable input. | High – needs certification, tech investment, awareness. |
| Lower emissions; social upliftment. | Already operational – can scale with better sorting and OEM ties. |
| Waste diversion; job creation. | Moderate – needs biotech partnerships and pilots. |
| Large-scale diversion of plastic; mainstreaming circular materials. | Partner with Indian sports leagues; collaborate with luxury and fast-fashion brands. |
| Waste reduction; social benefit. | High – leverage retail & NGO networks. |
| Landfill diversion; industrial recycling. | High – adapt sorting methods and retail integration. |
| Landfill diversion; community engagement. | Already operational – can expand nationwide. |
| Transparent waste traceability. | Deploy in Tirupur/Surat textile clusters; integrate with EPR systems; link with government waste tracking initiatives |
| Waste reduction; water savings. | Moderate – adapt tech to Indian blends. |
| Extended garment life; artisan income. | High – integrate with retailers and training programs. |
| Waste reduction; transparency. | High – needs recycling hubs and awareness campaigns. |
| 100,000+ garments repaired; 935 tonnes plastic waste prevented; 98% of product line uses recycled materials | Build repair hubs and resale platforms. |
| Landfill diversion; behaviour change. | High – retail chains as collection hubs. |
| Higher recycling; transparency. | Moderate – pilot with Indian brands. |
| Increased reuse; brand monetisation. | High – integrate with social commerce. |
| Landfill diversion; resale growth. | High – adapt to e-commerce and local refurbishment hubs. |

# 9.1 Circular Business Models - Overview

### 9.1.1 Circular supply chain model

The **Circular Supply Chain Model redefines the traditional textile production system** by replacing the linear “take–make–dispose” approach with a regenerative, closed-loop cycle. In this model, **textile waste is not treated as an endpoint but as a valuable resource that is recovered, processed, and reintroduced into the production cycle.** This transition reduces dependence on virgin resources, enhances supply chain resilience, and mitigates the environmental and economic risks associated with raw material extraction.

The model **integrates renewable, recyclable, and biodegradable materials into continuous production cycles.** By designing products for durability, repairability, and recyclability from the outset, it ensures that material value is preserved for as long as possible. **Circular supply chains also enable manufacturers to gain greater control** over material flows, improving predictability, lowering costs, and reducing waste leakage into landfills.

For the textile sector, the **approach addresses rising raw material costs, resource depletion risks, and growing consumer demand for sustainable products.** It aligns with “cradle-to-cradle” design principles, eliminating waste by treating end-of-life materials as inputs for new production. Technologies such as textile-to-textile recycling, mechanical and chemical fiber recovery, and sustainable blending (e.g., recycled with virgin fibers) are central to making this model viable at scale.

**Key Principles**

**Resource Substitution**
Replace scarce or non-recyclable inputs with renewable, recycled, or biodegradable materials.

**Value Preservation**
Maintain the physical and functional properties of materials through high-quality recovery processes.

**Closed-Loop Control**
Track and manage textile products across their lifecycle to minimise waste generation and environmental harm.

**Challenges & Considerations**

**Market Demand**
Premium pricing for circular products may limit mass adoption without strong consumer awareness and incentives.

**Material Availability**
Requires consistent supply of high-quality, affordable recycled inputs, supported by strong collection and processing infrastructure.

**Technological Gaps**
Scaling advanced textile recycling methods remains costly and complex, requiring continued R&D investment.

## Case Studies – Circular Supply Chain Model

### Table 11 Case Studies Circular Supply Chain Model

| Case Study | Country/ Region | Overview | Key Interventions / Innovations | Impact (Social / Environmental / Economic) | Challenges | Ideas for Replication in India |
|---|---|---|---|---|---|---|
| **Bamboo as a Sustainable Raw Material[20]** | Global | Bamboo is a renewable, fast-growing fiber crop requiring minimal pesticides and water, offering an eco-friendly alternative to cotton. | Mechanical fiber extraction; closed-loop chemical recovery; blending bamboo with cotton to reduce virgin input. | Reduced water and pesticide use; renewable material supply; longer garment lifespan. | No clear sustainability standards; higher cost of mechanical processing; need for chemical waste recovery systems. | Establish certification and standards; invest in processing technology; run consumer awareness campaigns. |
| **Geetanjali Woolens[21]** | India / Africa | GRS-certified closed-loop system upcycling post-consumer textiles into new fibers and yarns, reducing virgin cotton demand. | Fiber reclamation from old garments; blending recycled and virgin cotton; dye-free processes; rural women employment. | Lower carbon emissions; reduced water and energy use; social empowerment. | Complex sorting processes; low consumer awareness; difficulty scaling without advanced tech. | Already operational scaling needs improved sorting infrastructure, awareness campaigns, and OEM partnerships. |
| **Carbios[22]** | France | Uses enzymatic recycling to break down PET and textiles into reusable monomers. | Heat-resistant enzyme development; industrial PET depolymerization; partnerships with biotech labs. | Diverts plastic/textile waste; reduces carbon footprint; creates local jobs. | Scaling enzymatic processes; industry adoption; regulatory compliance. | Partner with local biotech labs; align with waste policy incentives; pilot in PET-heavy textile clusters. |
| **Football Clubs & Fashion Brands[23]** | Europe | Jerseys made from recycled plastics; tote bags and luxury goods from 100% recycled inputs. | Advanced plastic-to-fiber processing; Gucci's "Equilibrium" platform integrating circularity in luxury fashion. | Large-scale diversion of plastic from landfill; normalisation of circular materials in mainstream and luxury markets. | Maintaining quality for elite performance textiles; high costs of certified recycled inputs. | Adopt for sports leagues and apparel brands; collaborate with luxury/ fast-fashion labels to create India-specific circular collections. |

20. Ellen MacArthur Foundation. (2017). A New Textiles Economy: Redesigning Fashion's Future. Retrieved from https://ellenmacarthurfoundation.org/a-new-textiles-economy
21. Geetanjali Woolens Pvt Ltd (2019) In the Pursuit of Sustenance for Sustainability. In: Green Behavior and Corporate Social Responsibility in Asia. Emerald Insight. Available at: https://www.emerald.com/insight/content/doi/10.1108/978-1-78756-683-520191005/full/html
22. Carbios (2025) Enzymatic Recycling Technology. Available at: https://www.carbios.com/en/enzymatic-recycling/
23. Ellen MacArthur Foundation. (2017). A New Textiles Economy: Redesigning Fashion's Future. Retrieved from https://ellenmacarthurfoundation.org/a-new-textiles-economy

### 9.1.2 Recovery & recycling model

The **Recovery & Recycling Model** transforms the way textiles are handled at the end of their lifecycle by reclaiming valuable materials from both post-consumer products and production process waste. Instead of sending these materials to landfill or incineration, **they are recovered, processed, and reintroduced into the value chain,** either as raw materials for new textiles or as inputs for alternative applications.

This model operates on two interconnected strategies:

1. **End-of-Life Product Recovery –** Reclaiming fibers, fabrics, and components from used garments and home textiles through take-back systems, donation programs, and sorting facilities.
2. **Production Waste Recovery –** Capturing and reusing manufacturing by-products (e.g., cutting scraps, off-spec fabric) within the same production cycle or diverting them to other industries.

For the textile sector, **this model directly reduces landfill waste, decreases virgin material demand, and supports compliance with Extended Producer Responsibility (EPR) regulations.** Successful implementation requires strong collection infrastructure, advanced sorting and recycling technology, and consumer engagement to return used products.

**Key Principles**

**Resource Focus**
Maximise recovery of embedded materials and energy from both post-consumer and production-stage waste.

**Born-Circular Design**
Design products for easy disassembly, enabling high-value material recovery.

**Incentivised Returns**
Use deposits, contracts, or product-as-a-service models to encourage consumers to return used items.

**Quality Preservation**
Maintain material quality to allow recycling into high-value applications, not just downcycling.

**Challenges & Considerations**

**Infrastructure Needs**
Premium pricing for circular products may limit mass adoption without strong consumer awareness and incentives.

**Consumer Participation**
Requires consistent supply of high-quality, affordable recycled inputs, supported by strong collection and processing infrastructure.

**Technological Advancements**
Scaling advanced textile recycling methods remains costly and complex, requiring continued R&D investment.

## Case Studies – Recovery & Recycling Model

### Table 12 Case Studies Recovery and Recycling Model

| Case Study | Country/ Region | Overview | Key Interventions / Innovations | Impact (Social / Environmental / Economic) | Challenges | Ideas for Replication in India |
|---|---|---|---|---|---|---|
| **Puket – "Meias do Bem"[24]** | Brazil | Collects old/damaged cotton socks from any brand, turning them into blankets for vulnerable communities. | In-store take-back points; sorting and washing; fiber shredding; compression into blanket material; distribution with new socks. | Reduced textile waste; community welfare through blanket distribution. | Logistics across large geography; maintaining hygiene and quality control; scaling without losing effectiveness. | Retail networks for collection; collaborate with NGOs for distribution; address logistics through regional hubs. |
| **SOEX I:CO[25]** | Germany | In-store clothing take-back system linked to automated sorting and chemical recycling via the EU-funded RESYNTEX project. | Retail-based collection bins; fully automated material sorting; chemical treatment to convert old textiles into secondary raw materials. | Diverts textiles from landfill; enables industrial-scale chemical recycling; supports circular economy goals. | Complexity of sorting mixed fibers; low consumer awareness; need to stay ahead of tech evolution. | Integrate into major retail chains; blend manual and automated sorting; promote awareness to encourage returns. |
| **Greenworms[26]** | India | Collects post-consumer textile waste from households, segregates, and channels it into reuse, upcycling, or recycling streams. | Community collection drives; fiber-based sorting (single/mixed/colour); swap programs; repair and redesign; partnerships with recyclers. | Diverts waste from landfill; supports community engagement; promotes local reuse and recycling. | Segregation accuracy; limited consumer awareness; logistics of collection and hub operations. | Expand community-driven collection; partner with recyclers; invest in segregation technology; |
| **Reverse Resources[27]** | Global Platform | Digital marketplace for textile waste connecting brands, manufacturers, and recyclers. | Tracks >1,000 tonnes of post-industrial waste monthly; 138 manufacturers and recyclers onboarded; 11 major fashion brands integrated. | Transparent waste traceability; scaled waste diversion; fosters brand–recycler partnerships. | Standardising waste classification; scaling digital adoption across fragmented supply chains. | Deploy platform in textile clusters (Tirupur, Surat); integrate with EPR compliance and government waste tracking systems. |

24. Ellen MacArthur Foundation. (2017). A New Textiles Economy: Redesigning Fashion's Future. Retrieved from https://ellenmacarthurfoundation.org/a-new-textiles-economy
25. SOEX (2025) Textile Recycling Solutions. Available at: https://www.soex.de/en/services/recycling/
26. Greenworms. (2024). Greenworms Waste Management Solutions. Retrieved from https://greenworms.org/
27. Reverse Resources (2025) About Reverse Resources. Available at: https://reverseresources.net/about/

### 9.1.3 Product life-extension model

The **Product Life-Extension Model** challenges the “take–make–waste” culture by keeping products in use for as long as possible through repair, refurbishment, remanufacturing, and repurposing. Instead of discarding items due to damage, changing fashion trends, or perceived obsolescence, this model focuses on recapturing value from existing products.

In the textile sector, this means **extending garment lifespans through design choices that prioritise durability and repairability,** as well as establishing service models that make repairs and upgrades accessible to consumers. It also encompasses remanufacturing, breaking down products into components that can be rebuilt into as-good-as-new items.

For businesses, the **model opens new revenue streams through repair services, second-life sales, and brand loyalty.** For the environment, it reduces demand for virgin materials, decreases waste generation, and lowers the carbon footprint of production.

**Key Principles**

**Durability by Design**
Create garments that last longer, using higher quality materials and reinforced construction.

**Repair and Upgrade Services**
Offer accessible, affordable repair and alteration options to extend product lifespan.

**Reuse and Remanufacturing**
Recover components or materials from returned garments for refurbishment or reconstruction.

**Consumer Engagement**
Shift customer perception from disposable fashion to value retention in clothing.

**Challenges & Considerations**

**Consumer Mindset**
Overcoming the habit of discarding rather than repairing.

**Service Infrastructure**
Building skilled repair networks and logistical systems for garment handling.

**Standards & Quality**
Maintaining consistent quality in refurbished or remanufactured goods.

## Case Studies – Product Life-Extension Model

### Table 13 Case Studies Product Life- Extension Model

| Case Study | Country/ Region | Overview | Key Interventions / Innovations | Impact (Social / Environmental / Economic) | Challenges | Ideas for Replication in India |
|---|---|---|---|---|---|---|
| **Hybridworks**[28] | USA | Recovers 100% cotton from blended fabrics and breaks down polyester into reusable components, reducing landfill waste. | Fiber separation technology; polyester depolymerisation; fully automated processes; water-efficient systems. | Reduces textile waste; saves up to 24x water vs. conventional processes; lowers virgin material use. | Need for ongoing R&D; market adoption challenges; scaling without efficiency loss. | Adapt tech for Indian fiber blends; partner with local mills; run awareness campaigns with brands. |
| **Mended**[29] | Netherlands | Connects consumers, brands, and local craftspeople to repair garments and comply with EPR requirements. | Digital platform for repair requests; craftsman matching algorithm; brand partnerships; nominal consumer fees. | Extends garment life; supports local artisans; reduces textile waste. | Building skilled craftsman network; consumer preference for new over repaired; brand onboarding. | Train tailors via NGOs; integrate with fashion retailers; promote repair culture via influencers. |
| **Silfir**[30] | Germany | Produces durable, repairable garments with end-to-end care services and full recycling at end-of-life. | Circular design for recyclability; QR code traceability; reusable packaging; wood-fiber antibacterial fabrics; 24-month service guarantee. | Reduces waste and resource use; promotes transparency; lowers washing frequency. | Scaling take-back and recycling; logistics for nationwide collection; integrating into fragmented supply chains. | Collaborate with Indian manufacturers; set up local recycling hubs; run consumer education campaigns. |
| **Patagonia**[31] | USA | Comprehensive resale and repair system; partnership with Infinna Fiber for recycled fiber integration. | Online resale platform; fishing-net recycling; fiber-to-fiber circular inputs. | 100,000+ garments repaired; 935 tonnes of plastic waste avoided; 98% of product line uses recycled materials. | Scaling resale operations globally; ensuring product durability and repair accessibility. | Leverage e-commerce resale, build repair hubs, and pilot fishing-net recycling along coastal regions. |

28. Hybridworks (2025) Truly Circular Textile Solutions. Available at: https://www.hybridworkstextile.com/
29. Mended. (2024). Mended: Garment Repair Platform. Retrieved from https://mended.com/
30. Silfir. (2024). Silfir: Circular Design and Traceability. Retrieved from https://silfir.com/
31. Patagonia (2024) Worn Wear Program. Available at: https://wornwear.patagonia.com/

### 9.1.4 Sharing platform model

The **Sharing Platform Model** maximises the utilisation of existing textile assets by enabling people and businesses to rent, share, swap, or resell underutilised garments and fabrics. By shifting focus from ownership to access, it reduces demand for new production, extends product lifecycles, and opens new income opportunities for owners of idle clothing or textile goods.

**Digital platforms are central to this model, connecting asset owners with potential users through online marketplaces or peer-to-peer networks.** Sharing models may operate as **co-ownership** (shared purchase and usage) or co-access (temporary use without ownership). Both approaches increase asset turnover, reduce waste, and encourage more responsible consumption patterns.

For the textile industry, **this model supports circularity by keeping products in circulation longer,** delaying disposal, and reducing the need for virgin resource extraction. It can be applied to consumer fashion, corporate uniforms, workwear, or specialised textiles such as event decor.

#### Key Principles

**Resource Efficiency**
Reduce environmental impact by maximising use of existing products.

**Economic Opportunity**
Generate revenue for owners and provide affordable access for users.

**Digital Enablement**
Use online platforms to manage listings, transactions, and quality control.

**Collaborative Consumption**
Promote a cultural shift from individual ownership to shared access.

#### Challenges & Considerations

**Trust & Quality**
Require robust user verification, garment inspection, and hygiene protocols.

**Logistics & Infrastructure**
Need efficient cleaning, storage, and delivery systems.

**Consumer Mindset**
Overcoming hesitancy towards shared clothing due to hygiene or style preferences.

## Case Studies – Sharing Platform Model

### Table 14 Case Studies Sharing Platform Model

| Case Study | Country/ Region | Overview | Key Interventions / Innovations | Impact (Social / Environmental / Economic) | Challenges | Ideas for Replication in India |
|---|---|---|---|---|---|---|
| **Redress – Takeback Programme**[32] | Hong Kong | Collects clothing from any brand via retail store drop boxes for reuse, resale, upcycling, or recycling. | In-store collection points; sorting by condition; upcycling or downcycling; resale of reusable garments. | Diverts textile waste from landfill; increases lifespan of garments; shifts consumer behaviour towards circular fashion. | Changing consumer mindset; large-scale logistics; maintaining quality standards. | Use retail chains as collection hubs; partner with upcyclers/ recyclers; run campaigns to normalise second-hand fashion. |
| **Eslando**[33] | England | Connects brands with textile recyclers through Digital Product Passports (DPPs) that track a product's lifecycle. | DPP technology; transparency in material origin, manufacturing, and recycling pathways; brand–recycler partnerships. | Increases recycling rates; promotes transparency; empowers consumers with sustainability data. | Low consumer awareness of DPPs; need brand adoption; scaling tech integration. | Collaborate with Indian brands; pilot DPPs in EPR compliance programs; run digital awareness drives. |
| **Nold**[34] | England | Commission-free resale platform where users list items via simple product scan, bridging resale and first-sale markets. | Product database integration; revenue-sharing or fixed-fee models for brands; peer-to-peer marketplace. | Expands access to affordable clothing; increases reusability; enables brands to monetise resale. | User adoption; convincing brands to participate; tech functionality. | Onboard Indian fashion brands; integrate with social commerce; incentivise first-time users through discounts. |

32. Redress. (2024). Redress Takeback Programme. Retrieved from https://www.redress.com.hk/
33. Eslando (2025) Marketplace for Recyclable Textiles. Available at: https://www.eslando.com/
34. Nold. (2024). Nold: Pre-loved Fashion Marketplace. Retrieved from https://nold.com/

### 9.1.5 Product as a service (PAAS) model

The **Product as a Service Model** shifts textiles from a traditional sales model to a service-based approach, where the manufacturer or provider retains ownership, and the customer pays for access or usage over a set period. Products are leased, rented, or subscribed to, rather than purchased outright.

**This model incentivises durability, repairability, and high-quality materials, as the provider benefits from extending product life and reducing replacement costs.** By controlling the end-of-life stage, providers can recover materials for reuse or recycling, ensuring that garments are responsibly processed and kept within the value chain.

In the textile sector, **PaaS can apply to high-value or high-turnover categories such as corporate uniforms, outdoor gear, baby clothing, or special-occasion wear.** It aligns business profitability with circular economy goals by prioritising long-term product performance over short-term sales volume.

## Case Studies – Product as a Service Model

Table 15 Case Studies Product as a Service Model

| Case Study | Country/ Region | Overview | Key Interventions / Innovations | Impact (Social / Environmental / Economic) | Challenges | Ideas for Replication in India |
|---|---|---|---|---|---|---|
| **Trove – Recommerce Operating System**[35] | USA | Partners with apparel brands to take back, evaluate, and resell pre-owned products via brand-operated platforms. | Product vetting and pricing; resale platform integration; logistics for collection and redistribution; data analytics. | Diverts garments from landfill; increases resale market share; strengthens brand–consumer relationships. | Integrating with existing brand operations; ensuring consistent product quality; scaling logistics. | Partner with Indian brands for resale programs; adapt platform to local e-commerce ecosystems; develop regional refurbishment hubs. |

35. Trove. (2024). Trove: Recommerce Operating System. Retrieved from https://trove.com/

## Key Principles

**Long Term Value**
Design products for longevity, with materials that withstand repeated use and care.

**Access Over Ownership**
Customers pay for product functionality without bearing the cost or responsibility of ownership.

**Continuous Engagement**
Maintain customer relationships through service, maintenance, and upgrades.

**Responsible End-of-Life**
Provider manages product return, refurbishment, or recycling to keep materials in circulation.

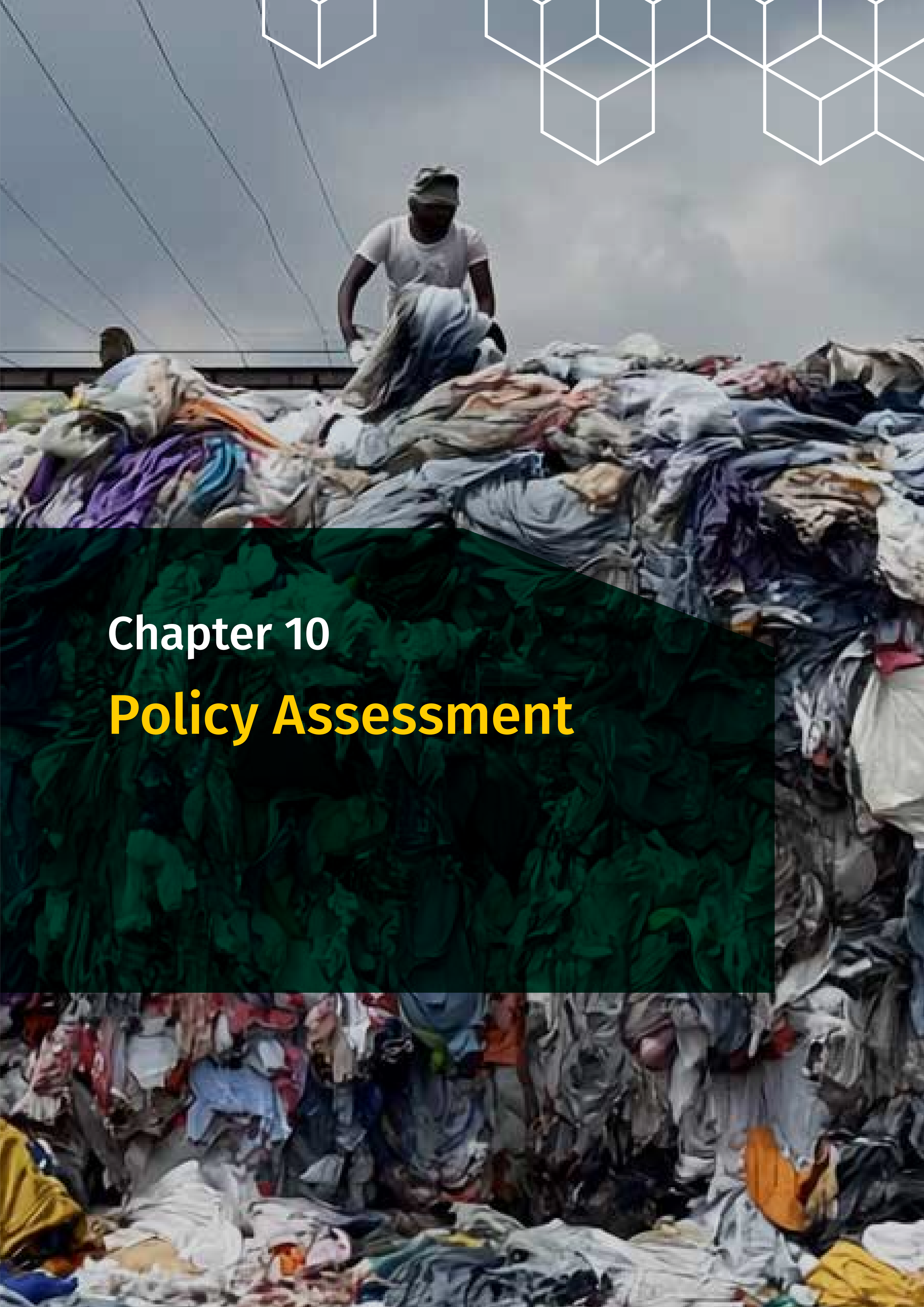
## Challenges & Considerations

**Mindset Shift**
Require robust user verification, garment inspection, and hygiene protocols.

**Trust & Transparency**
Need efficient cleaning, storage, and delivery systems.

**Logistics**
Require robust user verification, garment inspection, and hygiene protocols.

**Regulatory Alignment**
Adapting contracts and consumer laws to support leasing and subscription models.



# Chapter 10
# Policy Assessment

## Chapter 10 - Policy Assessment

To systematically evaluate the readiness and effectiveness of policies supporting textile circularity, the study developed a comprehensive Policy Assessment Framework. The framework aims to map the existing policy ecosystem and assess the extent to which policies engage with critical stakeholders such as manufacturers, retailers, recyclers, technology providers, consumers, and government agencies.

It is structured around a 6-Pillar Policy Assessment Framework - Targeting, Coordination, Transparency, Implementation, Commitment, and Engagement, designed to capture both the strengths and shortcomings of current policies. By applying defined scoring levels (0–4) and assigning policy grades (Starter, Sub-Mature, Mature), the framework enables a structured evaluation of global policy gaps, identifies challenges in achieving textile circularity, and highlights opportunities for policy enhancement to align with market needs and sustainability goals.

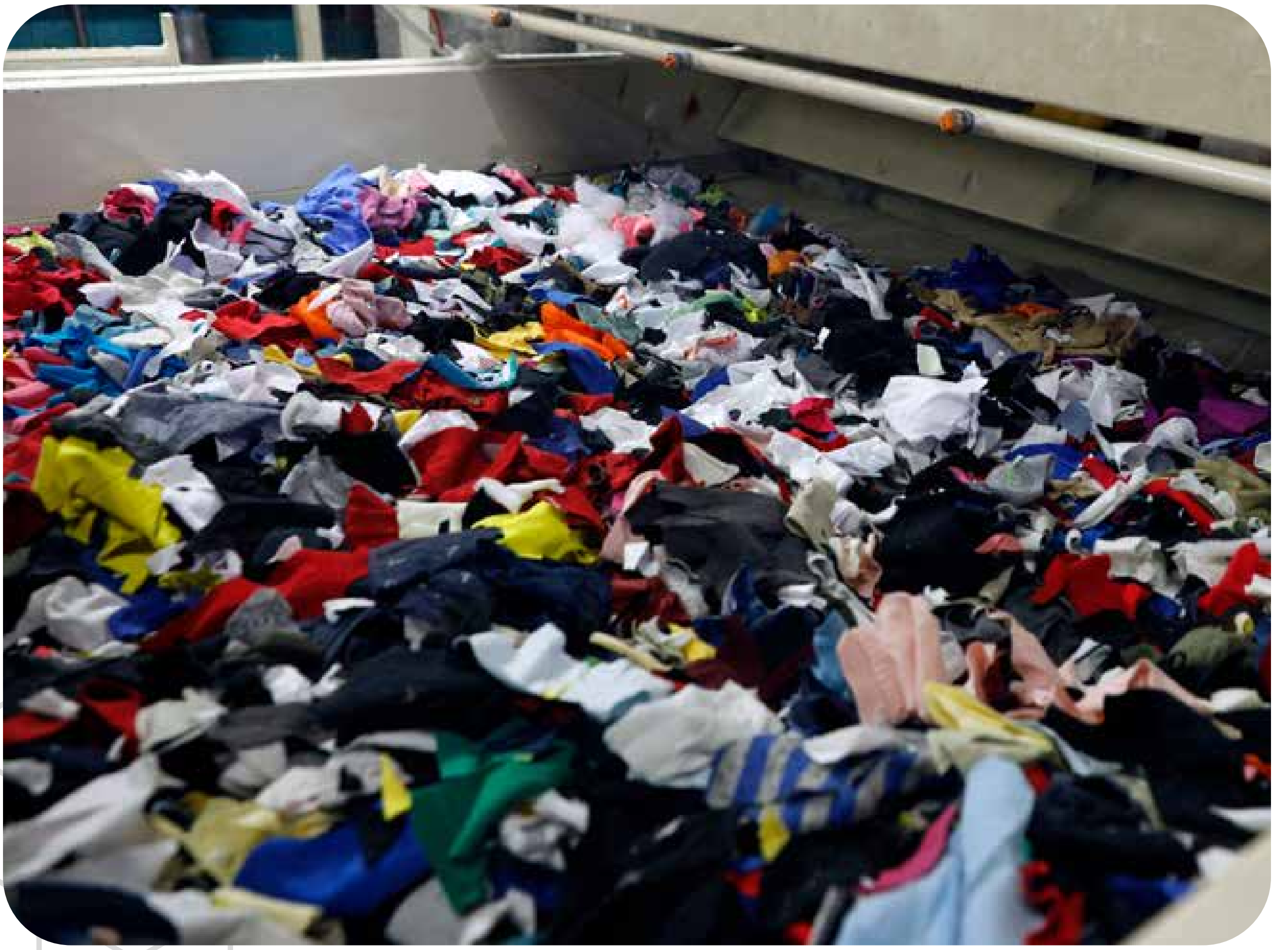


**Figure 7 6 - Pillar Policy Assessment Framework - Targeting, Coordination, Transparency, Implementation, Commitment, and Engagement**

### Policy Assessment Pillars

**Targeting**
Careful matching of objectives of the policy and overall focus areas - matching market needs

**Coordination:**
Coordination with existing policies and markets to leverage effectiveness

**Transparency**
Dissemination of detailed substance and operating mechanism of a policy to ecosystem stakeholders

**Engagement:**
Stakeholder engagement mechanism to understand need of market participants

**Commitment:**
Commitment levels of policy, consistent with the need of the market - in terms of duration, scale and enforcement

**Implementation:**
Translating goals and objectives of policy into action, including defined institutional structure

### Scoring Levels

Level 0 → Level-1 (Developing) → Level-2 (Functioning) → Level-3 (Engaged) → Level - 4 (Embedded)

### Policy Grading Mechanism

| *Policy Grade* | *Description* | *Score Category* |
|---|---|---|
| Starter | Policies with focus on ecosystem enablement capacity building, awareness etc. | 0-2 |
| Sub-Mature | Policies for strengthening demand and supply side mechanisms for textile circularity | 2-3 |
| Mature | Focus on dedicated policy and strategy for circular textiles, along with active incentive mechanisms | 3-4 |

The global textile and apparel sector is undergoing a paradigm shift as governments increasingly recognise the urgent need to transition from a linear “take–make–waste” model to a circular economy framework. Policies introduced across geographies ranging from supply creation initiatives in Japan[36] and China[37], to Extended Producer Responsibility mandates in the Netherlands[38], California[39], and France[40], to Demand-side measures in the European Union and New York[41] - reflect diverse approaches to addressing textile waste, resource efficiency, and sustainable consumption. While these frameworks vary in scope, ambition, and maturity, they collectively demonstrate a growing international consensus on the need for systemic reform.

This comparative assessment benchmarks eight leading policies, spanning Europe, North America, and Asia across six key pillars: Targeting, Coordination, Transparency, Engagement, Commitment, and Implementation. The exercise highlights not only the array of global efforts but also the emerging best practices that can inform future interventions.

36. Japan Ministry of Economy, Trade, and Industry. (2020). Circular Economy Vision 2020. Tokyo: Government of Japan
37. China National Development and Reform Commission. (2022). Implementation Opinions on Accelerating the Development of Circular Economy in the Textile Waste Recycling Sector. Beijing
38. Government of the Netherlands. (2023). EPR for Textiles Decree. The Hague: Ministry of Infrastructure and Water Management.
39. California State Legislature. (2023). Responsible Textile Recovery Act. Sacramento: State of California.
40. France Ministry for Ecological Transition and Territorial Cohesion. (2022). Anti-Waste for a Circular Economy (AGEC LAW). Paris: Government of France.
41. New York State Legislature. (2022). Fashion Sustainability and Social Accountability Act. Albany: State of New York.

**Table 16 Policy Assessment Summary**

| # | Name of Policy | Domains of Policy Assessment: Targeting | Coordination | Transparency |
|---|---|---|---|---|
| 1 | **EU Strategy for Sustainable and Circular Textiles - European Union** | 4 – Embedded | 2 – Functioning | 2 – Functioning |
| | **Policy Focus:** Establishes a vision for a circular textile economy by promoting eco-design, introducing extended producer responsibility, tackling microplastics, preventing destruction of unsold textiles, and empowering consumers with transparency tools such as Digital Product Passports. Aims to create systemic change across the entire textile value chain. | | | |
| 2. | **Ecodesign for Sustainable Products Regulation – European Union** | 3 – Engaged | 3 – Engaged | 2 – Functioning |
| | **Policy Focus:** Strengthening supply creation by mandating durability, repairability, recyclability, recycled content, and transparency through Digital Product Passports. The regulation expands sustainability requirements beyond energy efficiency to all product groups, aligning with the EU Green Deal and Circular Economy Action Plan | | | |
| 3. | **EPR for Textiles Decree - Netherlands** | 4 – Embedded | 4 – Embedded | 3 – Engaged |
| | **Policy Focus:** Legally mandates producers and importers of clothing and household textiles to finance, organize, and report on textile waste collection, reuse, and recycling. Aims to shift financial burden from taxpayers to producers, set ambitious quantitative targets (50% reuse/recycling by 2025, 75% by 2030), and drive fiber-to-fiber recycling as part of the Dutch circular textiles agenda. | | | |
| 4. | **Fashion Sustainability and Social Accountability Act - New York, USA** | 1 – Developing | 2 – Functioning | 2 – Functioning |
| | **Policy Focus:** Requires large fashion retailers/brands (>\$100M revenue) to disclose environmental and social impacts, adopt responsible sourcing, ensure fair wages, and improve transparency across global supply chains. Aims to direct capital and consumer choice toward sustainable and ethical brands, by mandating reporting and due diligence on environmental footprint and labour practices. | | | |
| 5. | **Implementation Opinions on Accelerating the Development of Circular Economy in the Textile Waste Recycling Sector - China** | 2 – Functioning | 1 – Developing | 2 – Functioning |
| | **Policy Focus:** Strengthening circular economy in textiles through increased resource utilization, waste reduction, producer–consumer responsibility systems, pilot projects, and integration of recycled materials (especially PET-based fibers) into mainstream use. Seeks to align circular economy with national green development goals while balancing feasibility, safety, and economic rationality. | | | |

| Engagement | Commitment | Implementation | Composite Policy Score | Policy Grade |
|---|---|---|---|---|
| 2 – Functioning | 1 – Developing | 1 – Developing | 2 | Starter |
| 2 – Functioning | 1 – Developing | * 1 – Developing | 2 | Starter |
| 3 – Engaged | 1 – Developing | 3 – Engaged | 3 | Mature |
| 1 – Developing | 2 – Functioning | 1 – Developing | 1.5 | Starter |
| 1 – Developing | 1 – Developing | 1 – Developing | 1.3 | Starter |

**Table 16 Policy Assessment Summary *(continue)***

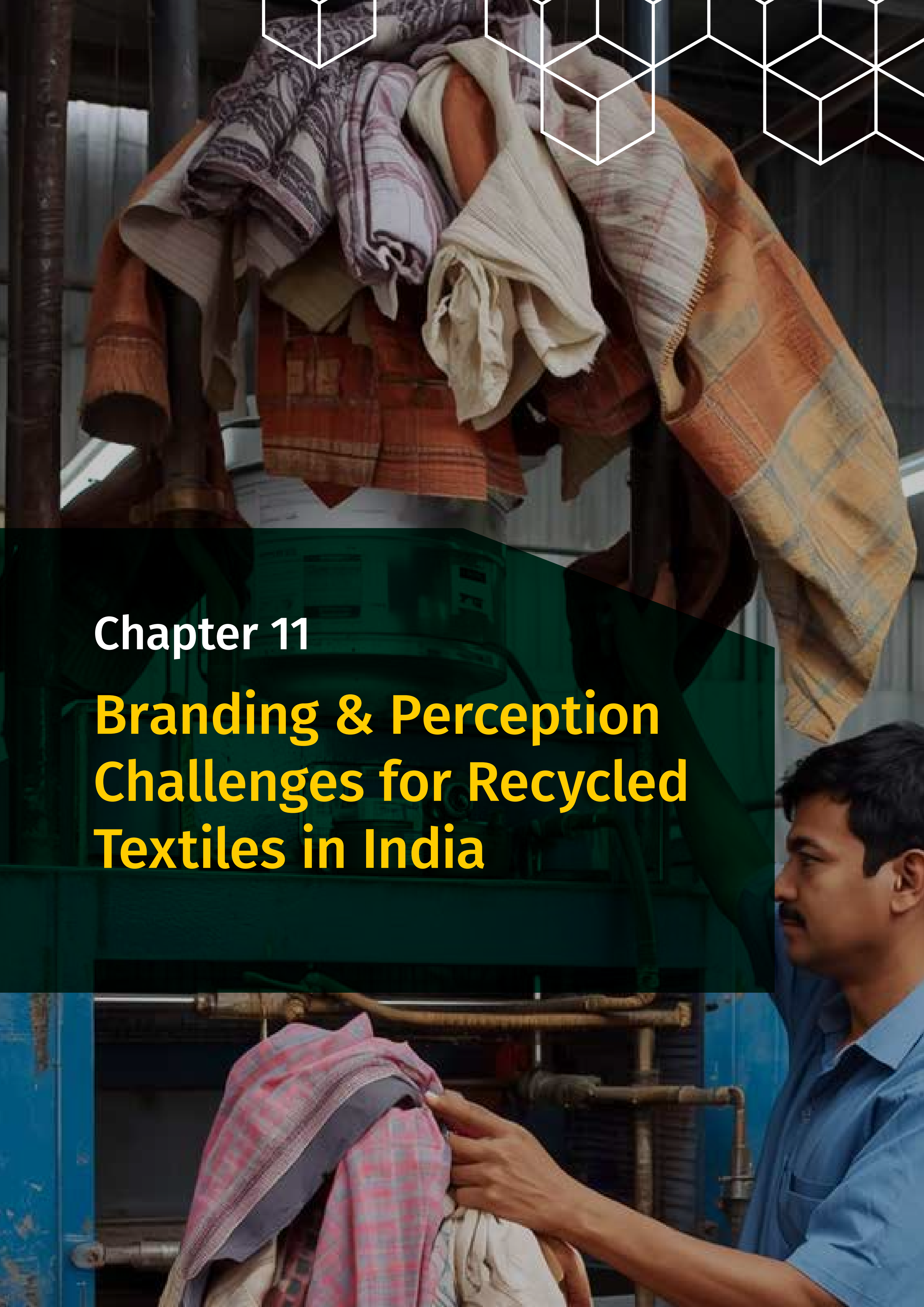
| # | Name of Policy | Targeting | Coordination | Transparency |
|---|---|---|---|---|
| | | Domains of Policy Assessment | | |
| 6. | **Responsible Textile Recovery Act - California, USA** | 2 – Functioning | 2 – Functioning | 2 – Functioning |
| | **Policy Focus:** Establishes Extended Producer Responsibility for textiles, shifting costs from taxpayers to producers, mandating stewardship programs, and targeting 60% landfill diversion by 2030 through improved collection, recycling, and infrastructure. | | | |
| 7. | **Anti-Waste for a Circular Economy - France** | 1 – Developing | 2 – Functioning | 3 – Engaged |
| | **Policy Focus:** Demand generation through transparency, eco-design incentives, bans on destruction of unsold products, and funding support for reuse/repair. | | | |
| 8. | **National Circular Economy Roadmap - Vietnam** | 3 – Engaged | 2 – Functioning | 2 – Functioning |
| | **Policy Focus:** Promoting resource efficiency and circularity (closing loops, eco-design, recycling, innovation) | | | |
| 9. | **Circular Economy Vision 2020 - Japan** | 2 – Functioning | 4 – Embedded | 2 – Functioning |
| | **Policy Focus:** Supply creation through recycling, innovation, and digital integration | | | |

| Engagement | Commitment | Implementation | Composite Policy Score | Policy Grade |
|---|---|---|---|---|
| 1 – Developing | 3 – Engaged | 1 – Developing | 1.8 | Starter |
| 3 – Functioning | 3 – Engaged | 2 – Functioning | 2.3 | Sub-Mature |
| 2 – Functioning | 2 – Functioning | 2 – Functioning | 2.2 | Sub-Mature |
| 2 – Functioning | 3 – Engaged | 2 – Functioning | 2.5 | Sub-Mature |

The comparative analysis reveals that while Policy innovation is accelerating, the global landscape of textile circularity policies remains uneven. **Netherlands - EPR Decree and Japan's - Circular Economy Vision demonstrate stronger maturity by embedding industry-wide reforms and integrating digital technologies.** The EU's Strategy for Sustainable and Circular Textiles and France's AGEC Law reflect a balance of demand-side and producer-focused levers but require more robust implementation frameworks. Emerging economies such as Vietnam are laying important foundations with national circular economy roadmaps, though capacity building remains critical. In contrast, China's Implementation Opinions and the U.S. state-level acts (New York Fashion Act and California Textile Recovery Act) remain in nascent or sub-mature stages, reflecting fragmented or experimental approaches.

Overall, the assessment underscores that no single country has yet achieved a fully mature and holistic textile circularity regime. To accelerate progress, policymakers should prioritize cross-sectoral coordination, robust monitoring frameworks, stronger public engagement, and long-term financial commitments. International convergence around best practices, coupled with local adaptation, will be key in scaling textile circularity in India.

For details, please refer section 14.6



Chapter 11

# Branding & Perception Challenges for Recycled Textiles in India

## Chapter 11 - Branding & Perception Challenges for Recycled Textiles in India

Recycled textiles in India face a unique set of challenges that extend beyond technology and supply chain. While the technical feasibility of recycling fabrics has progressed, societal perceptions remain a significant barrier to mainstream adoption. Many consumers still associate recycled textiles with compromised quality, limited aesthetics, and higher costs. Overcoming these perceptions requires a targeted strategy that integrates quality assurance, transparent communication, consumer engagement, and value demonstration.

### Key Challenges

Figure 8 Key Challenges associated with Branding & Perception Strategies for Recycled Textiles in India

#### Prevalent Social Perceptions

Long-held biases around recycled fabrics, such as assumptions of poor hygiene, reduced comfort, or outdated designs undermine consumer confidence. Without direct exposure to high-quality recycled products, these perceptions persist.

#### Quality & Durability Concerns

Consumers often believe recycled fabrics cannot match virgin materials in longevity, texture, and performance. This perception is reinforced by inconsistent product quality in the market.

#### Lack of Transparency

Limited visibility into sourcing, processing, and ethical manufacturing practices erodes trust. Consumers rarely have access to information about where recycled materials come from or how they are transformed into garments.

#### Limited Consumer Engagement

Traditional marketing methods do not adequately convey the value proposition of recycled textiles. Without interactive experiences, consumers remain passive observers rather than informed participants.

#### Price Point Barriers

Higher production costs driven by small-scale recycling operations, specialized processing, and innovative materials can make recycled textiles more expensive than conventional options, deterring price-sensitive buyers.

# 11.1 Interventions Required

**Figure 9 Definitive Interventions for Branding & Perception Strategies for Recycled Textiles in India**

### 01 Quality Assurance through Design Partnerships

- Collaborate with established designers and skilled artisans to integrate recycled materials into high-fashion and everyday wear collections.
- Highlight versatility by showcasing recycled textiles across diverse styles from couture to streetwear through capsule collections and curated retail displays.
- Implement rigorous quality checks and durability testing to reinforce consumer confidence.

### 02 Sustainable Packaging as Brand Identity

- Integrate eco-friendly packaging into the overall brand narrative, ensuring that the unboxing experience reflects the sustainability ethos.
- Clearly label packaging as recyclable, compostable, or reusable, reinforcing the commitment to responsible consumption.

### 03 Addressing the Price Point Paradox

- Communicate openly about cost structure highlighting the value of ethical sourcing, fair wages, and environmental benefits.
- Develop tiered product lines that offer both premium and more affordable recycled options, widening accessibility.
- Explore scale-up partnerships with large retailers to reduce per-unit costs and reach broader markets.

### 04 Transparency & Storytelling

- Adopt supply chain tracking systems that allow consumers to see a product's journey from material sourcing to final production.
- Use QR codes on labels linked to interactive online content featuring process videos, artisan profiles, and sustainability metrics.
- Humanize the brand through storytelling that features both the environmental impact avoided (e.g., water saved, waste diverted) and the people behind the products.

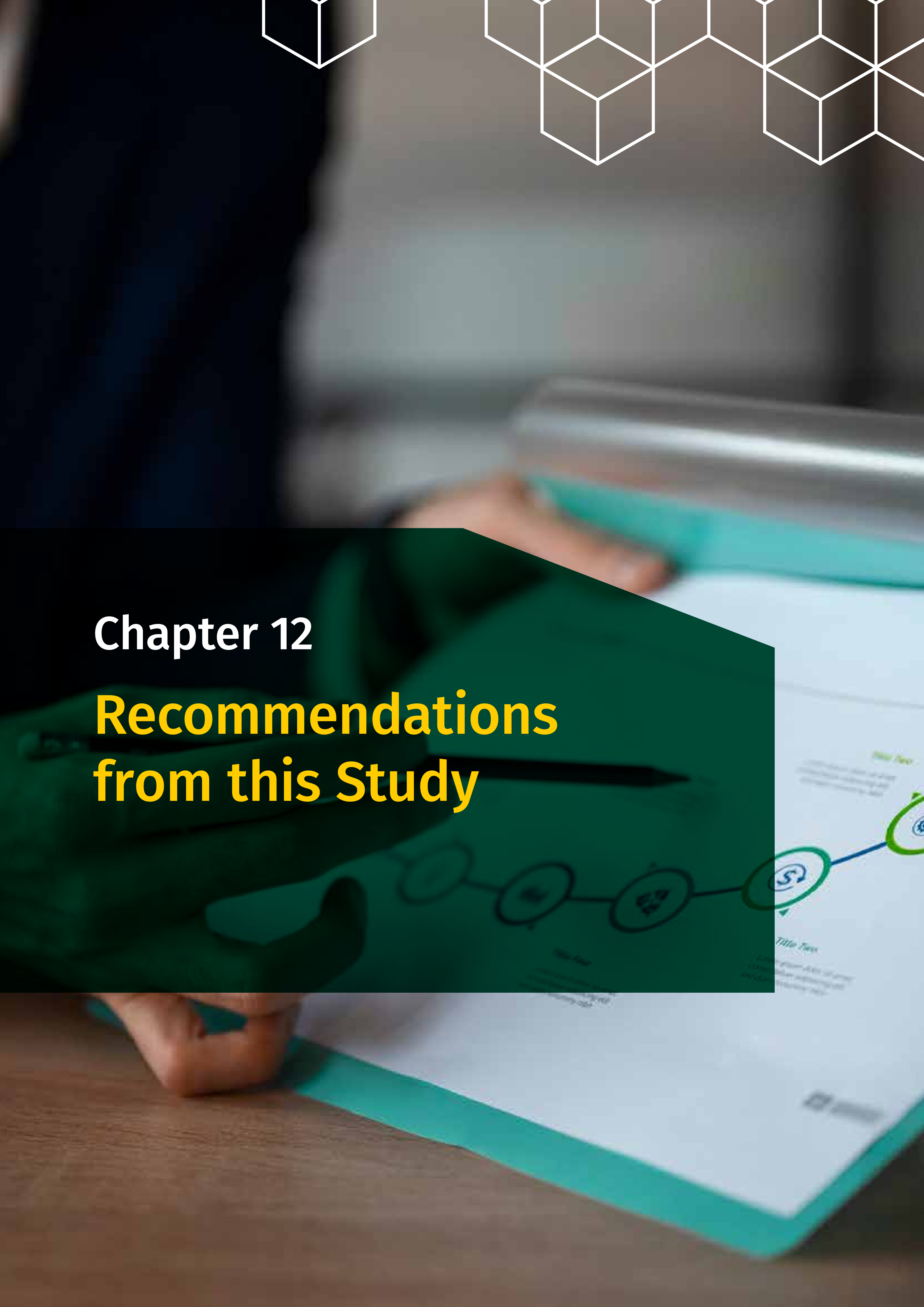
### 05 Consumer Engagement Beyond Marketing

- Host workshops, live demonstrations, and upcycling events to give consumers hands-on exposure to recycled textiles.
- Partner with influencers, stylists, and sustainability advocates to normalize recycled fabrics in aspirational settings.
- Encourage user-generated content through campaigns where customers share their own styling of recycled pieces.

## Intended Outcomes

An effective branding and perception strategy should achieve:

- **Increased Consumer Trust –** through visible quality, transparent processes, and credible certifications such as the Global Recycled Standard (GRS).
- **Mainstream Acceptance –** positioning recycled textiles not as an alternative but as an equal or superior choice to virgin fabrics.
- **Market Differentiation –** enabling brands to stand out in a competitive fashion sector through a clear sustainability narrative.
- **Sustainable Growth –** driven by higher repeat purchases, expanded product lines, and positive word-of-mouth advocacy.



# Chapter 12

# Recommendations from this Study

## Chapter 12 - Recommendations from this Study

This report presents a comprehensive set of recommendations aimed at strengthening India's transition toward a circular textile economy. The recommendations have been developed through a combination of policy analysis, stakeholder consultations, and market insights, and are designed to guide both government and industry stakeholders in creating an enabling ecosystem for textile recycling and reuse. These recommendations have been presented below across - i) Textile recycling technologies and ii) Policy interventions.

Together, these recommendations provide an all-inclusive blueprint for accelerating India's journey toward circular textiles, balancing technological advancement, regulatory support, financial mechanisms, and market awareness.

# 12.1 Scaling Textile Recycling Technologies

The textile industry is at a critical juncture where recycling technologies must move from fragmented pilots to large-scale, integrated solutions. Each recycling pathway (i.e. mechanical, thermo-mechanical, chemical, and thermo-chemical) offers distinct advantages and challenges in terms of scalability, cost, material quality, and environmental performance. A structured roadmap that sequences short-term technology upgrades, medium-term pilot and demonstration plants, and long-term commercialization is essential to accelerate adoption. Below roadmap provides a time-bound framework for scaling these technologies, supported by enabling policies, investments, and market development, thereby laying the foundation for a circular and sustainable textile economy.

### Table 17 Roadmap for Scaling Textile Recycling Technologies

| Technology | Short-term (2–3 years) | Medium-term (3–5 years) | Long-term (5–10 years) |
|---|---|---|---|
| Mechanical Recycling | • Upgrade existing shredding, tearing, and fiber processing equipment for higher efficiency and quality.<br>• Establish cluster hubs/ recycling centers for efficient collection, sorting, and pre-processing.<br>• Introduce QC measures and skill development for workers in sorting & fiber handling.<br>• Leverage government schemes (e.g., PM-MITRA) to set up pilot recycling hubs. | • Expand facility capacity and logistics to handle higher waste volumes.<br>• Deploy advanced automated sorting systems (AI, optical sorting).<br>• Strengthen partnerships with manufacturers and brands for offtake of recycled fibers.<br>• Integrate recycling with regional textile hubs. | • Large-scale integrated mechanical recycling plants linked with manufacturing clusters.<br>• Standardized recycled fiber quality certifications.<br>• High consumer adoption driven by fashion brands committing to recycled content.<br>• Closed-loop "textile-to-textile" systems mainstreamed. |
| Thermo-Mechanical Recycling | • Conduct R&D to improve process parameters (esp. for polyesters & nylons).<br>• Pilot trials on mixed waste streams to validate feasibility.<br>• Build raw material supply chains for consistent feedstock. | • Scale pilot plants into semi-commercial facilities.<br>• Develop regional hubs with specialized thermo-mechanical equipment.<br>• Collaborate with academia & industry to optimize fiber properties. | • Commercial-scale thermo-mechanical recycling plants. - Integration into mainstream fiber manufacturing.<br>• Certification & branding of thermo-mechanically recycled fibers.<br>• Strong market acceptance for blended recycled fibers. |
| Chemical Recycling | • Intensive R&D on depolymerization techniques for cotton, polyester, and blends.<br>• Lab-scale validation of cost-effective catalysts, solvents, and reaction pathways.<br>• Public-private R&D consortia formed. | • Install pilot/demo-scale plants to validate scalability & economics.<br>• Secure feedstock supply via tie-ups with brands & waste collectors.<br>• Attract early-stage investors for technology deployment.<br>• Frame enabling policies for chemical recycling. | • Commercial-scale plants integrated with textile clusters.<br>• Production of monomers/ polymers at scale, replacing virgin inputs.<br>• Policy mandates & incentives for recycled material adoption.<br>• Global partnerships for export of recycled feedstock. |
| Thermo-Chemical Recycling | • Establish incubators/ research hubs focused on pyrolysis, gasification, and hybrid thermo-chemical processes.<br>• Conduct proof-of-concept studies with mixed and contaminated waste.<br>• Develop small pilot units for validation. | • Scale promising technologies into semi-commercial demonstration facilities.<br>• Secure regulatory approvals & safety standards.<br>• Build partnerships with chemical/fuel industries for offtake. | • Large-scale thermo-chemical plants producing fuels, chemicals, or feedstock.<br>• Integration with circular economy industrial parks.<br>• Investment flows from global green funds and climate finance.<br>• High-value applications for outputs (e.g., specialty chemicals, sustainable fuels). |

# 12.2 Policy Interventions

The transition to a circular textile economy in India requires a coordinated blend of policy direction, market activation, and implementation. Textile waste, both pre-consumer and post-consumer presents not only an environmental challenge but also an untapped economic opportunity in fiber recovery, product innovation, and job creation. However, without a clear strategic framework, enabling mechanisms, and a time-bound roadmap, isolated interventions risk fragmentation and limited impact.

These recommendations are structured into three interconnected pillars:

1. **Strategic Policy Framework for Circular Textiles in India –** establishes the overarching regulatory, institutional, and governance architecture to drive systemic change. It defines the vision, sets measurable national targets, and embeds circularity principles into textile production, trade, and waste management policies.

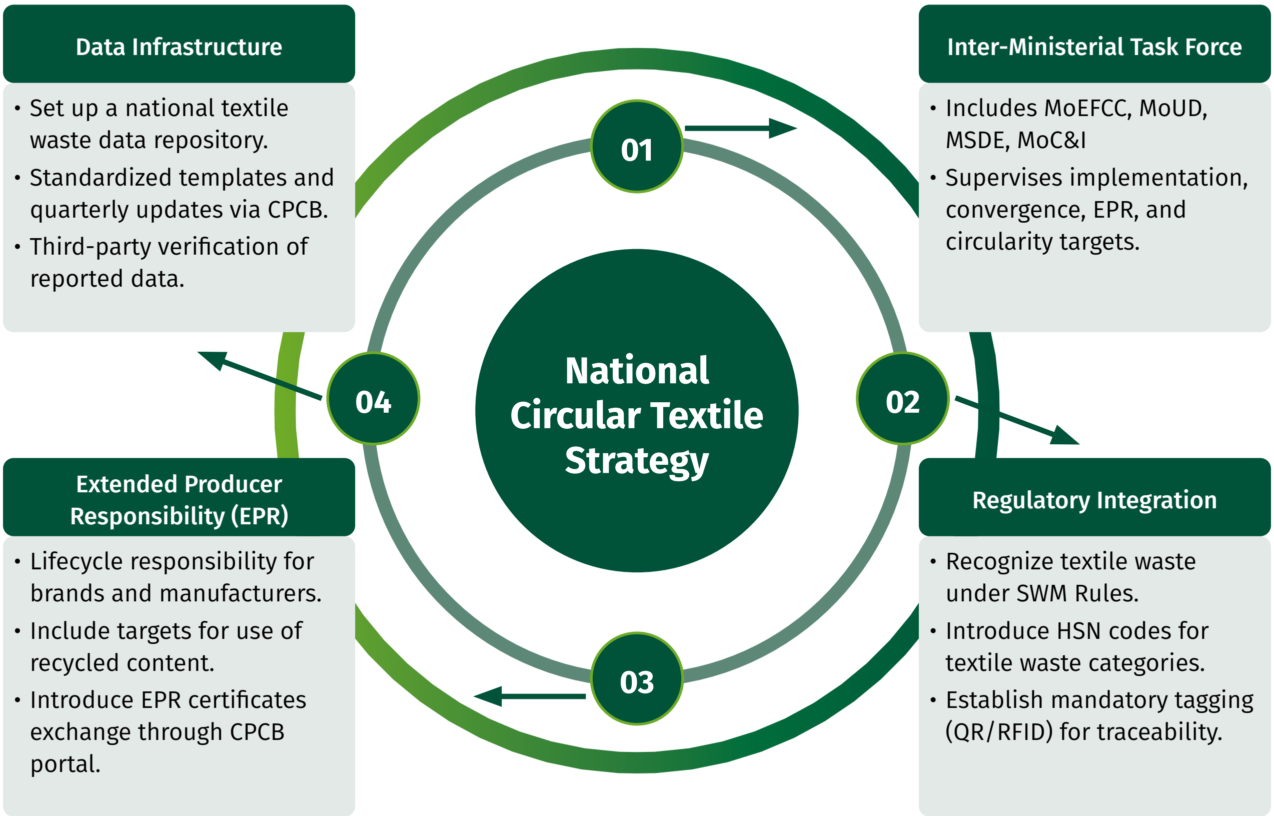
2. **Enablers for Market Activation, Awareness & Financing –** outlines the practical mechanisms to stimulate demand, mobilise capital, and build capacity across the value chain. It focuses on strengthening supply–demand linkages, incentivising innovation, and creating an informed ecosystem that supports sustainable consumption and production.

3. **Phase-Wise Roadmap –** sets out a sequenced action plan to transition from foundational pilots to nationwide adoption. It prioritises interventions by impact and feasibility, ensuring momentum in the short term while laying the groundwork for long-term systemic transformation.

Together, these three pillars provide a **cohesive blueprint to unlock the economic, environmental, and social potential of circular textiles in India.** They identify the policy levers to align national priorities, the market and financing enablers to accelerate adoption, and the phased actions to ensure a smooth and scalable transition. The recommendations are designed to guide both immediate interventions and long-term strategy, offering government, industry, and civil society a shared path to reduce waste, recover value, and position India as a global leader in sustainable textile production and consumption.

### 12.2.1 Strategic Policy Framework for Circular Textiles in India

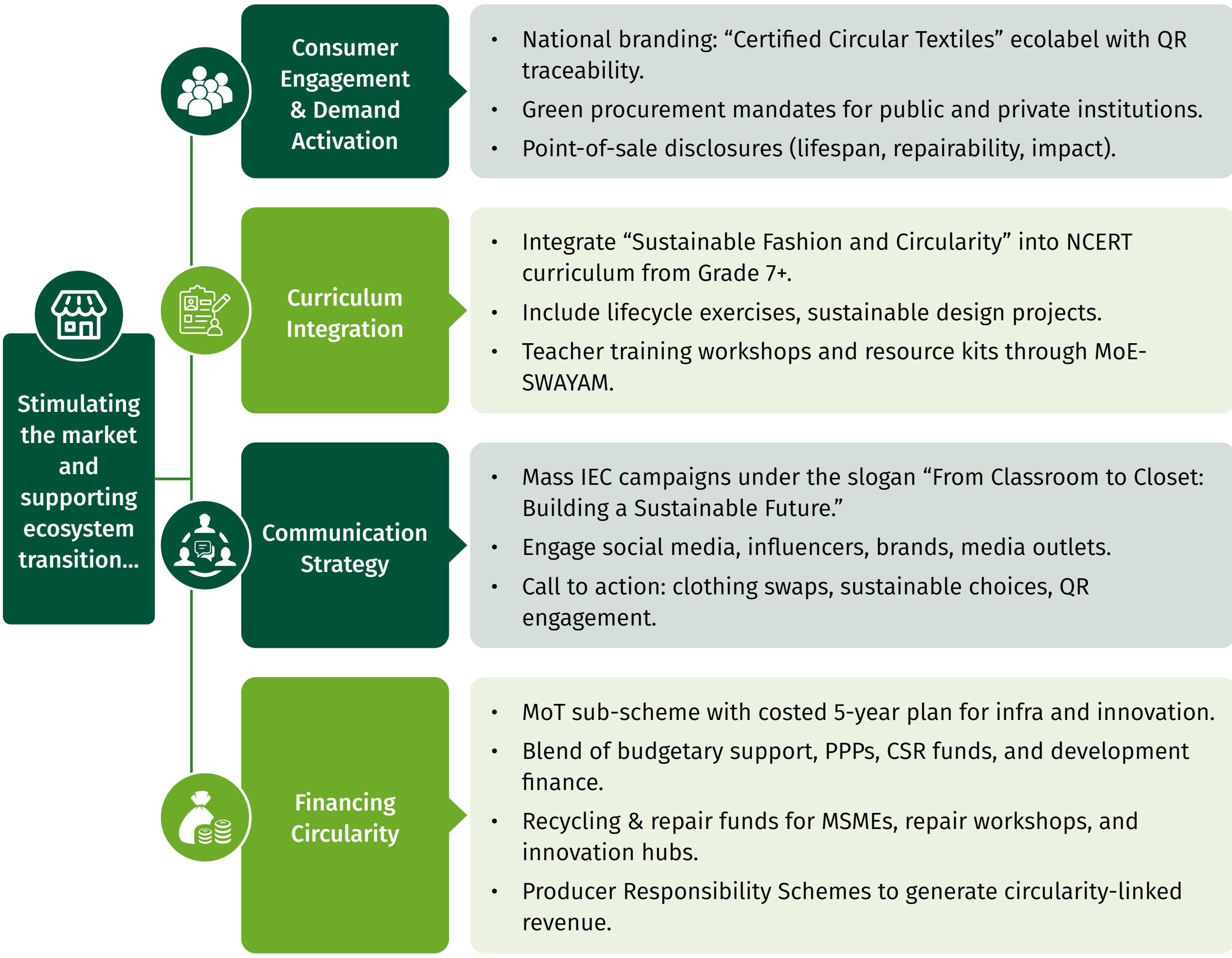
Figure 10 Strategic Policy Framework for Circular Textiles in India




The strategic policy framework serves as the **institutional backbone** for a national shift towards circularity in textiles. It focuses on creating governance, data, and regulatory systems that make downstream market activation and financing both measurable and enforceable.

### 12.2.2 Enablers for Market Activation, Awareness & Financing

**Figure 11 Strategic Policy Framework for Circular Economy Textiles in India**




This pillar translates the policy framework into **practical mechanisms that drive uptake** by industry, investors, and consumers. It focuses on reducing perceived risks, building trust, and ensuring that both the supply and demand sides of the circular textile economy are primed for participation.

## Key enablers include

**Consumer Awareness Campaigns –** National-level outreach to highlight the environmental and quality benefits of recycled textiles, targeting both urban consumers and export buyers.

**Market Linkages –** Create digital marketplaces and matchmaking platforms connecting waste generators, recyclers, and manufacturers.

**Access to Capital –** Offer concessional financing and blended finance options to MSMEs adopting recycling technologies or redesigning products for recyclability.

**Skill Development –** Integrate circular textile modules into existing skilling programmes (e.g., Samarth) and partner with design institutes to train on recyclable product design.

**Public Procurement Mandates –** Require a minimum percentage of recycled textiles in government tenders to stimulate demand at scale.

By combining **capital mobilisation, demand creation, and workforce readiness,** this set of enablers ensures that policy is not just **announced**, but **activated** in the market, with measurable uptake across the value chain.

### 12.2.3 Phase-wise Roadmap

The roadmap provides a **sequenced approach** to implementing circular textile policies, ensuring that foundational systems are in place before scaling market interventions. It balances **quick wins** with **long-term structural reforms,** reducing risk of policy fatigue and ensuring industry readiness.

**Table 18 Policy Recommendations Phase-Wise Roadmap**

| Focus Area | Short-Term (0–2 Years) | Medium-Term (2–5 Years) | Long-Term (5+ Years) |
|---|---|---|---|
| **Regulatory & Governance** | • **Recognize textile waste** under SWM Rules<br>• Introduce **HSN codes**<br>• Set up Inter-Ministerial Task Force **(IMTF-CT)**<br>• **Mandate tagging** (QR/RFID) at source | • **Implement national EPR framework** with traceability and reporting<br>• **Enforce recycled content targets** | • Institutionalize circular textile regulations<br>• **Align India's circularity policy** with global best practices |
| **Infrastructure & Technology** | • **Pilot textile recycling clusters** in hubs like Panipat, Tiruppur with TRF, MRF, repair units<br>• Encourage local semi-automated sorting models | • **Expand TRF network** across states<br>• **Promote digital product** passports<br>• Support upcycling & downcycling infra | • **Establish export-grade facilities for recycled yarn**<br>• **Decarbonize production** using renewable energy integration |
| **Data & Monitoring** | • **Launch pilot data systems** in key clusters<br>• **Standardize data** reporting formats<br>• Initiate national repository setup | • **Operationalize CPCB-managed data platform** with dashboard<br>• **Third-party data audits** and compliance checks | • **Institutionalize benchmarking** vs global KPIs<br>• **Use M&E insights** for adaptive policy refinement |
| **Market Activation & Demand** | • **National IEC campaign** on circular textiles<br>• **Introduce Certified Circular Textiles label**<br>• Point-of-sale QR info | • **Mandate green procurement** across public/private sector<br>• **Partner with industry** for demand-generation efforts | • **Make circular textiles a market norm** through branding, certification and verified supply chains |

**Table 18 Policy Recommendations Phase-Wise Roadmap *(continued)***

| Focus Area | Short-Term (0–2 Years) | Medium-Term (2–5 Years) | Long-Term (5+ Years) |
|---|---|---|---|
| **Education & Capacity Building** | • **Launch school-based circularity** module (NCERT – Grade 7+)<br>• **Begin teacher training**<br>• **Train informal workers** in sorting and recycling | • **Integrate circularity** into textile/fashion curricula at NIFTs, design schools<br>• **Host workshops** with EU, Japan | • **Institutionalize skill development** for circular design and production across academia and industry |
| **Financing & Incentives** | • **Set up sub-scheme** under MoT<br>• **Provide seed grants** and infra subsidies<br>• **Initiate repair & reuse fund** | • **Implement PRS/EPR-linked** financing<br>• **Promote blended finance models** for infra/R&D<br>• Fund public-private pilots | • **Establish large-scale innovation fund**<br>• **Mobilize donor/ development finance** for scaling national circularity |
| **Stakeholder Convergence** | • Map existing programs (SBM, PM Mitra, Skill India)<br>• Launch Circularity Portal for knowledge sharing | • **Set up formal multi-stakeholder platform** under ESG Task Force<br>• **Enable convergence** across ministries | • **Institutionalize cross-sector convergence platform** for long-term sustainability coordination |

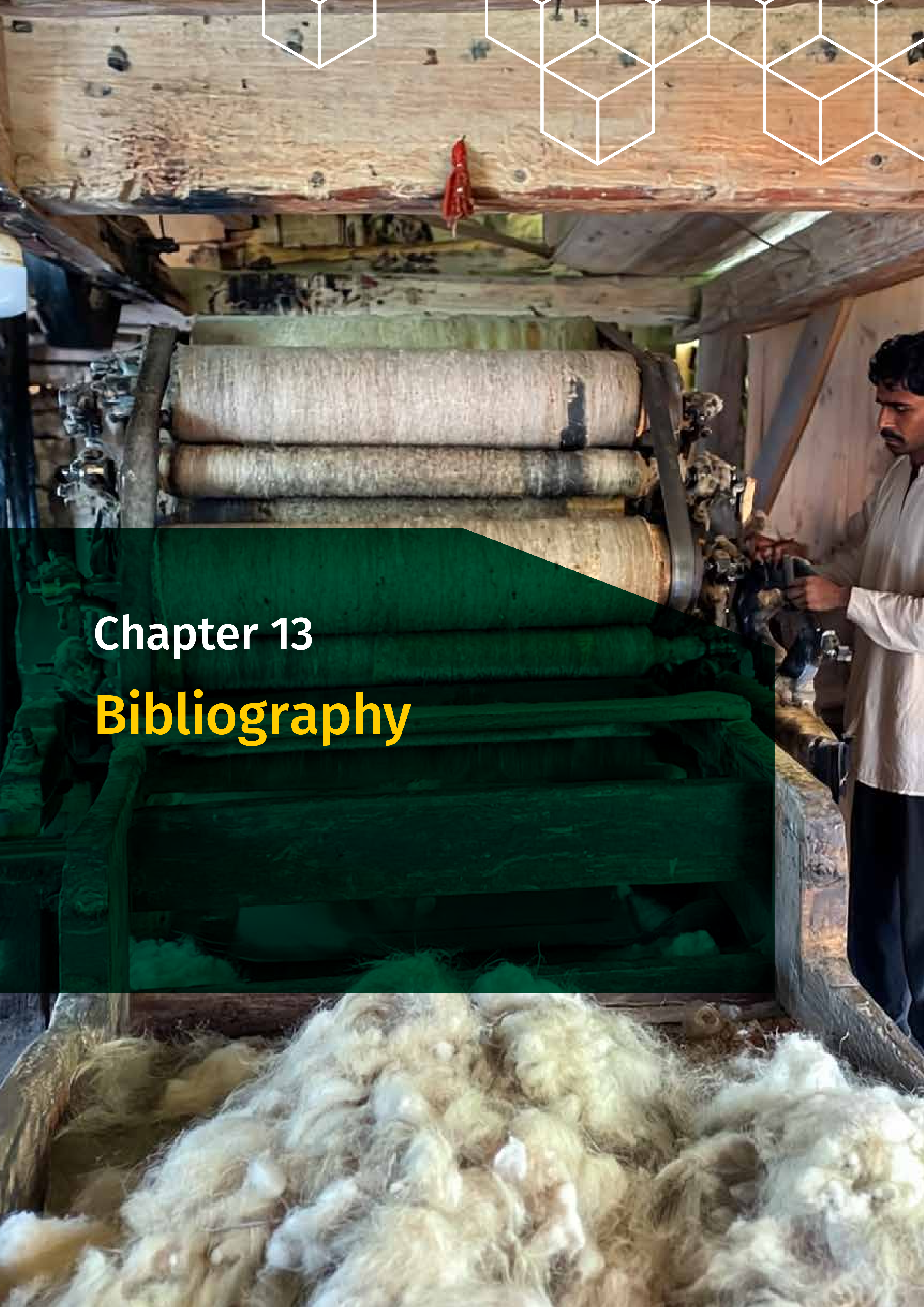
India's textile industry is entering a decisive phase in its development. Long recognised as a global leader in fibre-to-fashion production, the sector now faces the twin challenge and opportunity of managing the vast volumes of textile waste it generates. This study has highlighted that waste should not be regarded solely as an environmental burden but as a valuable economic resource that, if managed effectively, can underpin a transition towards circularity, strengthen competitiveness, and enhance sustainability outcomes.

The analysis presented in this report demonstrates that while pre-consumer waste in India already shows high recovery rates, post-consumer waste continues to lag due to gaps in infrastructure, policy, and market systems. At the same time, encouraging examples from industry leaders confirm that circular solutions are both feasible and impactful. Life Cycle Assessments further reinforce that recycling offers measurable climate gains, particularly for viscose and polyester, underscoring the critical role of scaling textile-to-textile recycling.

The recommendations from this study set out a comprehensive blueprint for advancing India's circular textile economy. On the technology front, a hybrid recycling ecosystem that combines mechanical recycling for scale, chemical recycling for quality and circularity, and thermo-chemical processes for complex waste will be necessary to address the diversity of textile waste streams. Policy interventions, structured around a three-pillar framework of regulatory integration, market activation, and phased implementation, will be vital in providing the governance, incentives, and monitoring systems required to unlock systemic change. Equally important will be efforts to strengthen branding and consumer awareness so that recycled textiles are positioned not as inferior alternatives, but as high-value, sustainable products aligned with global expectations.

The way forward requires aligning India's textile industry with international circularity standards while tailoring solutions to its unique industrial structure and socio-economic context. Building recycling capacity at scale, formalising the role of the informal sector, and fostering innovation through public and private collaboration will be essential.

Ultimately, **the transition to circular textiles in India is not simply an environmental imperative but a strategic industrial transformation.** It represents an opportunity to create new jobs, strengthen global trade competitiveness, and ensure that growth in the sector is both inclusive and sustainable. As the recommendations set out in this report are pursued in coordination, India will position itself not just as a leading textile producer but as a global hub for sustainable and circular textiles in the decades to come.



# Chapter 13
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## Chapter 13 - Bibliography


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# Chapter 14

# Annexure

## Chapter 14 - Annexure

# 14.1 Quantification of Net Imported Textile Waste

| HS Code of Product[42] | HS Product Description | Export Qty (KT) | Import Qty (KT) | Net impact (KT) |
|---|---|---|---|---|
| 5003 | Silk waste (including Cocoons unsuitable for reeling, yarn waste and garneted stock) | 2.190 | 0.032 | -2.158 |
| 5103 | Waste of wool or of fine or coarse animal hair, including yarn waste but excluding garneted stock) | 1.392 | 0.038 | -1.354 |
| 5202 | Cotton waste (including yarn waste and garneted stock) | 45.591 | 58.641 | 13.050 |
| 530130 | Flax, tow and waste, including yarn waste and garneted stock | 0.803 | 0.081 | -0.722 |
| 530290 | Hemp (cannabis sativa L), processed (other than retted) (but not spun), true hemp tow and waste (including yarn waste and garneted stock) | 0.008 | 0.097 | 0.089 |
| 530390 | Jute and other textile bast fibres processed but not spun, tow and waste of these fibres, including yarn waste and garneted stock (excluding flax, hemp (cannabis sativa L), and ramie) | 0.071 | 1.942 | 1.871 |
| 5505 | Waste (including noils, yarn waste and garneted stock), of man-made fibres. | 4.211 | 14.750 | 10.539 |
| 6310 | Rags, used or new scrap twine, cordage, rope and cables and worn-out articles of twine, cordage, rope or cables, of textile materials. | 27.372 | 589.847 | 562.475 |
| 6309 | Textiles, worn clothing and other worn articles. | 71.782 | 186.543 | 114.761 |
| Total Net Imported Waste (in KT) | | | | 698.551 |
| **Non usable waste @14% (Used in other purpose, not recycled)** | | | | **14.0%** |
| **Net Imported waste available** | | | | **601** |

42. UN Comtrade Database. Retrieved from https://comtradeplus.un.org/

# 14.2 Detailed - Sampling Methodology

### Table 19 Number of Interviews of Stakeholders Interviewed Under Pre-consumer Waste Value Chain

**Number of interviews of stakeholder groups interviewed under pre-consumer waste value chain**

| Segment | Sample Size |
|---|---|
| Waste Collectors/Traders Organization | 2 FGDs + 15 KIIs |
| Upcycler Units | 2 FGDs + 15 KIIs |
| Recycler Unit | 2 FGDs + 15 KIIs |
| Waste import and sorting organization | 2 FGDs + 15 KIIs |
| Organizations providing technology solutions for textile waste valorization | 2 FGDs + 15 KIIs |
| Total | **8 FGDs + 75 KIIs** |

## Post-consumer value chain

The study focused on million plus population cities and capital cities i.e., 68 cities in the country, exclusively due to presence of mature waste management systems and significant quantum of textile waste generation in these cities.

To ensure uniform representation of the cities in the sample visits conducted, minimum one-third of these 68 cities i.e., 23 cities were visited.

Implementing a geographic stratification approach for selecting cities for study visit ensured that our sample accurately reflects the diversity of post-consumer textile waste management practices across India. 23 cities were further distributed based on the geographic stratification to cover the north, south, east, and west regions of India. The number of cities covered in each region, has been highlighted in the table given below:

## Regions covered for KIIs under post-consumer waste value chain

### Table 20 Regions Covered for KII under Post-consumer Waste Value Chain

| Region | Proportion of million plus and capital cities in region | Number of cities to covered in each Region |
|---|---|---|
| North | ~29% | 7 |
| South | ~13% | 3 |
| East | ~22% | 3 |
| West | ~29% | 7 |
| Central | ~7% | 2 |
| Total | | **23** |

## Segment-wise stakeholders interviewed under post-consumer waste value chain

### Table 21 Segment-wise Stakeholders Interviewed Under Post-consumer Waste Value Chain

| Stakeholder Group | Minimum of interviews conducted per city | Minimum number of interviews conducted |
|---|---|---|
| Formal Channels, covering municipal corporations, solid waste management operators at pre-processing and processing sites, NGOs etc. | 1 | 23 |
| Informal Channels, covering kabadiwalas, ragpickers and informal textile waste processing clusters | 2 | 46 |
| Commercial Establishments, including individual retailers, retailers and brands | 1 | 23 |
| Total | | **92** |

# 14.3 Detailed – Textile Waste Estimation Methodology

To estimate the textile waste generation, processing, and disposal numbers across each segment of the pre-consumer and post-consumer textile waste value chain, a systematic approach was taken, utilising extrapolation from sample waste generation figures gathered during the survey. The study conducted **primary research for both the pre-consumer and post-consumer textile value chains, focusing on the waste generated at each stage.** This involved field visits to various textile stakeholders, where data was collected through a combination of questionnaire surveys and interviews to obtain comprehensive and detailed information. The waste generation estimates were derived from the primary research and were validated against existing studies through secondary research. The key steps undertaken to conduct the primary research are follows:

## 14.3.1 Pre-consumer waste

**Step 1: Determining Quantum of Production and Waste Generation Rates**

**Data collection for quantifying textile waste value chain:** During the survey, data on total quantum of production for each segment within the textile industry and the quantum of textile waste generation was collected. Separate questionnaires were developed for interviewing stakeholders in pre- and post-consumer textile value chain to collect quantitative data on textile waste generation, management practices, and challenges. The questionnaires are attached later.

The data was collected through interviews done with stakeholders from the respective segment identified above from pre-consumer textile waste value chain.

**Waste Generation Rate:** For each textile industry segment, the study identified and estimated the average percentage of waste generated relative to the total consumption during textile production process. This involved analyzing the waste generation as a percentage of total production and this data will be collected during the primary survey.

**Step 2: Analysis of Primary Data Collected and Extrapolation**

**Average Waste Generation for each segment:** Average waste generation within the sample for each segment was calculated, considering the specified range of waste generation figures obtained.

**Total Capacity Estimation:** The average waste generation rates from the sample data was used to extrapolate the total waste generation for the entire industry segment. This involved scaling up the sample averages to the total known or estimated capacities of the respective segment.

**Step 3: Integration of Textile Processing and Manufacturing Technology Adoption Rates**

**Technology Mapping:** A mix of primary and secondary data was utilized to map the proportion of prevalence of textile manufacturing technologies within each industry segment.

**Secondary Data Triangulation:** The primary data collected was corroborated with secondary sources to understand and validated the waste generation rates of different technologies for textile processing and manufacturing.

**Step 4: Pre-Consumer Waste Processing and Disposal Estimation**

**Processing Capacity Identification:** For each segment, the capacity of existing waste processing and disposal facilities was assessed, including recycling operations.

**Waste Flow Calculation:** The flow of waste was calculated through the various processing and disposal pathways, based on the waste generation estimates (linked to waste generation rates, identified capacities of waste management facilities.

**Step 5: Validation and Sensitivity Analysis**

**Data Validation:** The extrapolated waste generation and processing numbers were cross-validated with existing reports to ensure consistency and reliability. Consultations were conducted with Ministry of Textiles to ascertain the accuracy and reliability of the estimations.

**Draw out final range of estimations:** Performed sensitivity analyses to understand how variations in key assumptions (e.g., waste generation rates, technology adoption levels for textile manufacturing) could impact the overall waste estimation. Adjusted the model as necessary to reflect a realistic range of outcomes.

### 14.3.2 Post-consumer waste

**Step 1: Data Collection on Waste Generation and Disposal Patterns**

During visits to these MRFs, the study collected data on the quantities of textile waste processed, utilising records and reports maintained by the operators managing the facilities. These records included detailed logs of waste received, categorized by type (including textiles) and source (both household and commercial). Data was gathered on:

**Volume of Textile Waste:** Quantifying the total volume of textile waste received by each MRF within a specified timeframe, on a daily, monthly, and annual basis to understand time-based trends as well.

**Source Breakdown:** Differentiating between waste received from household sources and that originating from commercial establishments, to assess the relative contributions to the post-consumer textile waste stream.

**Sorting Efficiency Estimation:** The study estimated the efficiency of sorting processes and the fraction of textiles that are routed to various end-of-life pathways in waste management facilities in respective cities (both formal and informal channels).

**Step 2: Understanding Collection Trends to cross-validate quantitative data collected.**

**Collection Data Analysis:** Select NGOs and other agencies involved in formal collection mechanisms as well as informal market stakeholders such as kabadiwalas, ragpickers engaged in collection of post-consumer textile waste from source.

The flow of textile waste collected through community programs, donation bins, and urban take-back mechanisms was analysed to estimate the share of post-consumer textiles directed toward recycling, downcycling, or disposal.

**Step 3: Estimation of Textile Reuse and Recycling**

**Second-hand market analysis:** The volume and frequency of transactions in second-hand clothing markets were studied to estimate the scale of textile reuse prevalent in post-consumer value chain. For this purpose, interviews were conducted with individual retailers, retail chains and markets selling second-hand clothing.

**Assessment of recycling capacities:** The intake of textile waste as a proportion of total solid waste in solid waste processing facilities (recycling plants, Waste 2 Energy facilities etc.) was assessed to determine the volume of post-consumer textile waste being processed at unit level, including the proportion that undergoes downcycling and gets converted into Refuse Derived Fuel (RDF) in Waste2Energy facilities. For this purpose, waste processing facilities managed by respective municipal corporations or agencies contracted by municipal corporations for managing solid waste in the city.

**Step 4: Understanding recycling (including downcycling) and waste disposal practices**

**Identifying flow of downcycling:** Common downcycling pathways for textiles, such as conversion into industrial rags, stuffing material, or insulation, and estimate the percentage of post-consumer waste directed to each pathway were identified.

**Quantification of post-consumer textile waste disposal:** Based on total flow estimations, the volume of textile waste that is neither recycled nor downcycled but rather discarded in landfills or incinerated was calculated. This was estimated, based on the quantum of waste flow data obtained from the respective waste management facilities.

Finalising the waste flow numbers for both pre-consumer and post-consumer textile waste value chain.

**The key activities that were undertaken at the final stage of analysis of the study are as follows:**

**Data Validation:** The extrapolated waste generation and processing numbers were cross-validated with existing reports to ensure consistency and reliability. Consultations were done with Ministry of Textiles to ascertain the accuracy and reliability of the estimations.

**Draw out final range of estimations:** Perform sensitivity analyses was conducted to understand how variations in key assumptions would impact the overall waste estimation. Accordingly, model was adjusted as necessary to reflect a realistic range of outcomes.

### 14.3.3 Segment and process wise quantification of textile waste in India

**Table 22 Segment and Process Wise Quantification of Textile Waste in India**

| | Waste Value Chain | Percentages (Wherever Applicable) | Quantum (in KTPA) |
|---|---|---|---|
| **Pre-Consumer value chain** | | | |
| **1** | **Total Waste generation** | | **2,973** |
| **1.1** | Yarn waste | 5.12% | 134 |
| **1.2** Fabric Production Waste | | 21.56% | 564 |
| **1.3** | Garmenting Waste | 70.7% | 1,850 |
| **1.4** | Other Application Waste | 2.5% | 67 |
| **1.5** | Recyclable Waste | | 2,615 |
| | Spinning Waste (in-situ waste re-integrated into production supply chain) | | 358 |
| **2** | **Waste Processing and Disposal** | | |
| **2.1** | Upcycling | 58% | 1,517 |
| **2.2** | Down cycling | 39% | 1,020 |
| **2.3** | Reuse/Repurpose | 1% | 26 |
| **2.4** | Incineration & landfilled | 2% | 52 |
| **Post-consumer value chain** | | | |
| **1** | **Total waste generation** | | **4,100** |
| **1.1** | Household level collection done by ULB’s | 66% | 2,725 |
| **1.2** | NGO’s or informal collectors | 34% | 1,375 |
| **2** | **Waste processing and disposal** | | |
| **2.1** | Reuse, Recycling (including downcycling) | 55% | 2,255 |
| **2.2** | Incineration and Landfilling | 45% | 1,845 |

# 14.4 Life Cycle Assessment - Detailed Methodology

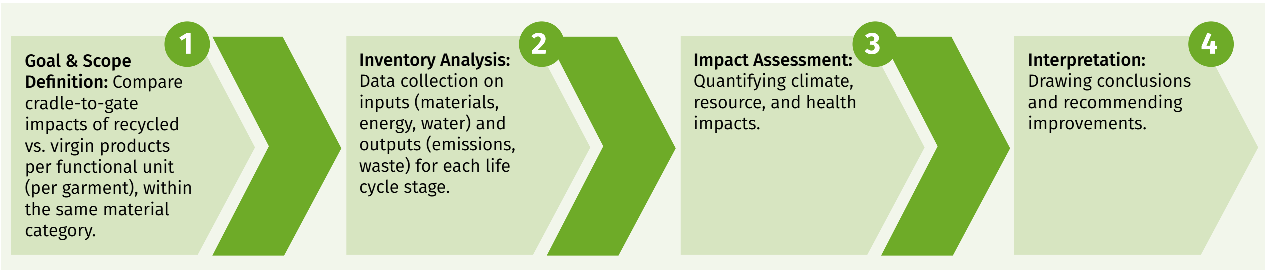
This study assessed the environmental benefits of recycling textile waste specifically cotton, viscose, and polyester compared to producing them from virgin materials. It focused on **post-consumer and post-industrial textile waste** that would otherwise be landfilled or incinerated, and examines its diversion into **mechanical, chemical, or thermo-mechanical recycling** processes. The **objective** was to quantify environmental savings, particularly reductions in carbon emissions, resource use, and pollution, and to support a shift toward recycled fiber sourcing in the textile industry.

**Two main research questions guided the assessment:**

How do environmental impacts of recycled textiles compare to those from virgin materials?

Is the benefit significant enough to warrant industry-wide change?

The LCA followed **ISO 14040/14044 standards** and included four phases:




Products and processes that were assessed:


The **functional unit** is one garment, with comparisons only within the same category. The scope is **cradle-to-gate**, covering processes from raw material collection to garment manufacturing, excluding use and disposal.

**Breakdown System Boundaries -** Parts of a product's life cycle that were included in the analysis.

The assessment started at the point where textile waste is collected or where raw materials are extracted and concluded at the gate of the facility where the final product is manufactured. This boundary choice focused on the production and pre-use phases of the product lifecycle, allowing for a detailed analysis of the impacts associated with material sourcing, manufacturing processes, and intermediate treatments.

**System Boundaries for LCA: Cradle-to-Gate**

**Virgin Material Pathways**

- Virgin Cotton (Case A):
  Cultivation → Harvesting → Initial processing
- **Virgin Viscose (Case B):**
  Forestry → Chemical processing → Fiber production
- **Virgin Polyester (Case C):**
  Petroleum extraction → Refinement → Fiber production

**Recycled Material Pathways**

- **Starting Point:** Collection & sorting of textile waste
- **Cotton:** Mechanical recycling (physical breakdown into fibers)
- **Viscose:** Chemical recycling (dissolving cellulose → regenerate fiber)
- **Polyester:** Thermo-mechanical recycling (heat + mechanical processes)

**Key assumptions and limitations** - Certain limitations and key assumptions were necessary to streamline the analysis and focus on the most impactful environmental factors.

1. Environmental Impact of Spinning and Knitting: It was assumed that the environmental impact associated with the spinning and knitting processes is identical across all case studies, whether they involve virgin or recycled materials.
2. Exclusion of Infrastructure and Capital Goods: The LCA does not account for the environmental impacts of infrastructure and capital goods required for textile production. This included the construction and maintenance of factories and machinery.
3. Omission of Certain Environmental Impacts: Some environmental impacts, such as toxicity and broader ecological effects (e.g., biodiversity impacts due to land use changes), were not considered in this study.
4. Substitution Rate: A substitution rate of 1:1 was assumed for the purposes of comparison. This meant each garment made from recycled material is presumed to replace one equivalent garment made from virgin material directly.
5. Allocation of Environmental Impacts: Using the cut-off method, the environmental impacts from the initial production and use phases of the textile materials were not allocated to the recycled products.

# 14.5 Recycling Process - Current Penetration and Key Technology Providers

## 14.5.1 Mechanical recycling details

**Current Penetration in India**

Table 23 Recycling Process - Current Penetration and Key Technology Providers

| S. No. | Technological Solution | Description of Technology | Level of Penetration |
|---|---|---|---|
| 1 | Portfolio of separation technologies and services, products such as Decanter Centrifuges, Disc, drum and table filters, filter centrifuge and presses, extractors, thickeners | Mechanical conditioning process based on tearing, Chemical Recycling, Mechanical recycling for textile to textile | Growing Adoption |
| 2 | Cutting and tearing technology, TM method and the autoclave technology using prepregs were also utilized. | Aim of this project is to close the technological gap in between available waste materials on the market and their functional re-use. | Low Adoption |
| 3 | Hydroentangling Machines | Involves using high-pressure water jets to mechanically entangle fibers and create a non-woven fabric. This is particularly useful for recycling cotton and other natural fibers. | Medium - Growing interest in nonwovens |
| 4 | Needle Punching | Involves punching barbed needles through layers of fibers to interlock them and create a fabric. Commonly used in recycling carpet and other non-apparel textiles. | High - Established technology |
| 5 | Shredding | Transforming post-consumer textile waste into shredded fibers used to manufacture recycled polyester yarns. | High - Most established recycling method |
| 6 | Baling | compress sorted textiles into compact bales for easier storage, transportation, and subsequent processing in their recycling facilities | High - Essential for collection & transportation |
| 7 | Fiber Blending | Blending various fibers like cotton, polyester, viscose, and polypropylene for nonwoven applications | High - Established practice |
| 8 | Hooked take first-hand the amount of fabric waste from European fashion textile factories produced and give them a new life. The idea was simple: take these surplus materials and put them into crafty use. | Tackling the waste of the fashion industry by using it for new yarns | Emerging |
| 9 | Fully integrated 360º vertical production process, pre-consumer, post-consumer and post-industrial waste shredding service | Develop high quality recycled yarns from pre-consumer textile waste | Medium |
| 10 | Open-End Spinning | Used in textile recycling to produce yarn from recycled fibers | High (Established technology) |
| 11 | Blended Yarn Spinning | Combining recycled fibers with virgin fibers to create yarns with specific properties, expanding product offerings. | High (Established technology) |
| 12 | Spun Yarn Production | Utilize spun yarns to create fabrics | High (Established technology) |

**Key Technology Providers**

Table 24 Key Technology Providers

| S.No. | Company Name | Process | Location |
|---|---|---|---|
| 1 | Laroche Sa | Soft waste and cleaning lines. | France |
| 2 | Balkan Textile | Soft / hard waste lines. | Turkey |
| 3 | Dell'Orco & Villani | Soft / hard waste & PCTW. | Italy |
| 4 | Margasa | Soft / hard waste and cleaning line. | Spain |
| 5 | HSN Machinery | Soft / hard waste and cleaning line. | China |
| 6 | Perfect Equipment | Soft / hard waste lines. | India |
| 7 | Harmony Enterprises | Recycling baller/ compactor. | USA |
| 8 | Ebisu Siryo Co. | Non-woven recycling. | Japan |
| 9 | Masias Maquinaria | Foam / Textile waste shredding. | Spain |
| 10 | Pierret Industries | Hard waste cutting line. | Belgium |

## 14.5.2 Thermo-mechanical recycling details

## Current Penetration in India

Table 25 Current Thermo-Mechanical Recycling penetration in India

| S.No. | Technological Solution | Description of Technology | Level of Penetration |
|---|---|---|---|
| 1 | Thermo-Mechanical Recycling | It melts the fibers using heat and pressure, allowing for further processing into new materials. | High - Most established recycling method |
| 2 | Creation of heat and acoustic insulation, as well as shredded textiles from recycled textile material. | Secondary processing of textile waste shredded textiles for insulation, 20-years of know-how experience of SK-TEX s.r.o. company. | Growing |

## Key Technology Providers

Table 26 Thermo-Mechanical Key Technology Providers

| S.No. | Company Name | Process | Location |
|---|---|---|---|
| 1 | Starlinger | PET, PA, PP etc. recycling lines. | Austria |
| 2 | Tecnofer Ecoimpianti | PET & other plastic recycling line. | Italy |
| 3 | Toyobo Technology | Films and Functional Material. | Japan |
| 4 | Yongxing Machinery | PET and PP recycling line. | China |
| 5 | Zhejiang Boretech | PET recycling line. | China |

### 14.5.3 Chemical recycling details

**Table 27 Chemical Recycling penetration in India**

**Current Penetration in India**

| S.No. | Technological Solution | Description of Technology | Level of Penetration |
|---|---|---|---|
| 1 | Key separation technology, Worn Again Technology. | Transform current textile recycling systems with scalable chemical technologies. | Low Adoption |
| 2 | Circulose pulp, which is then dried and shipped to customers in square blocks. These producers make regenerated cellulose fibers, which are then made into viscose and lyocell for the production of new textiles. | Converts high cellulose textiles into a slurry to produce CIRCULOSE®, a branded 'dissolving pulp' packaged into bales | Low Adoption |
| 3 | Technology based on the 'Green Chemistry Principles, recovers cellulose from cotton and transforms polyester into its basic building blocks. Both products can then be processed into new, high-quality textile fibers. | Upcycling chemical technology | Low Adoption |
| 4 | Technology to develop the unique 'Once More' process. Plant with capabilities to process 50,000 tons of colored blended post-consumer textile waste, producing 63,000 tons of pulp with 50% recycled content. | Joint project by Södra and Lenzing aiming to demonstrate an innovative industrial-scale system for chemical recycling of textile waste. | Low Adoption |
| 5 | Break the cellulose down at the molecular level, activate it with urea and dissolve it to create a liquid cellulose. technology uses responsible, ZDHC and MRSL compliant chemical The liquid cellulose is wet spun into new fiber filament and cut to staple length, washed and dried. | Technology turns textile waste that would otherwise be landfilled or burned into something truly valuable: Infinna™, a premium-quality, circular textile fiber that reduces the world's reliance on virgin raw materials. | Low Adoption |
| 6 | Collection of clothing containing fabrics such as polyester, cotton, viscose, and elastane, removes the components that can't be recycled and then uses chemicals to break the material down. | Recycling old textiles to make fashionable sunglasses. | Low Adoption |
| 7 | Patented biotech process that uses oxidation and fermentation to transform any kind of textile waste into three products: sanitized textile pulp from synthetic fibers and nanocellulose and bioethanol from natural fibers. | Smart Textile Waste Upcycling Micro factories' enable local and low-cost upcycling of large volumes of low-value textile waste into high value raw materials using a patented technology. | Low Adoption |
| 8 | Online DNA sequencing, engineered microorganism, biological process to dye textiles, which eliminates the use of harsh chemicals and reduces environmental impact. | Colorifix is developing a revolutionary dyeing process to help the textile industry dramatically reduce its environmental impact. | Emerging |
| 9 | Chemical Fiber Processing | Utilize chemicals to break down textile waste into monomers or precursors for producing new fibers or polymers. | Moderate (Depends on specific process & application) |
| 10 | Chemical Recycling | Involve chemical treatments to break down textile fibers on a molecular level and recreate new materials (virgin-quality polyester, cellulose, PET polymers, etc.). This essentially converts textile waste into new raw materials. | Emerging/ Growing (Significant research & development ongoing). |

## Key Technology Providers[43 44 45]

### Table 28 Chemical Recycling Key Technology Providers

| S.No. | Company Name | Process | Location |
|---|---|---|---|
| 1 | Infinited Fiber | Collection & sorting<br>Disintegration<br>Fiber separation<br>Carbamation<br>Dissolving and wet spinning. | Finland |
| 2 | Worn again | Collection & sorting<br>Pre-processing<br>Pre-treatment<br>Dissolving (cellulose pulp/pet resin)<br>Spinning into fiber | U.K. |
| 3 | Cure | Polyester waste<br>Discovering solution<br>Piot plant<br>Finding partner | Netherlands |
| 4 | Teijin | Collection & sorting<br>Crushing<br>Chemical decomposing<br>Polymerizing<br>Spinning | U.S.A. |
| 5 | Evrnu | Regenerative Cellulosic<br>Cellulosic solvent systems<br>Regenerative Polyester<br>Recoverable Stretch<br>Bio Engineered Fibers | U.S.A. |
| 6 | Aquafil | Manufacturer of closed loop PA 6 fibers and polymers, PA 6.6 and Dryarn microfibers. | Italy |

43. Fashion for Good. (2022). Wealth in Waste: India's Potential to Bring Textile Waste Back into the Supply Chain. Amsterdam: Fashion for Good
44. Textile Exchange. (2023). Textile Exchange Standards. Retrieved from https://textileexchange.org/
45. GIZ. (2021). Textile Waste Management in India: A Roadmap. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

### 14.5.4 Thermo-chemical recycling

### Current Penetration in India

**Table 29 Thermo-Chemical Recycling Current Penetration in India**

| S.No. | Technological Solution | Description of Technology | Level of Penetration |
|---|---|---|---|
| 1 | Thermal management systems Renycle® | Low environmental impact and high-performance engineering polymers that use mainly selected and traceable raw materials based on post- industrial and post-consumer PA 6 and PA 6.6. | Growing adoption |
| 2 | Thermo-Chemical Recycling. | Converting textiles waste into Syn gas. | Low - Emerging technology. |

### Key Technology Providers

**Table 30 Thermo-Chemical Recycling Key Technology Providers**

| S.No. | Company Name | Process | Location |
|---|---|---|---|
| 1 | Kinetics Technology | Technology development & research | Italy |
| 2 | Sundrop fuels | Sundrop Fuels is biorefinery in Louisiana, produce more than 225 million gallons (more than 675 kt) of 87-octane bio gasoline | U.S.A. |
| 3 | Suncoal | Suncoal's CarboREN technology enabling the conversion of biomass to bio coal which can be utilized in energy application. | Germany |
| 4 | Xylowatt | Xylowatt developed the NOTAR® reactor, an innovative and patented technology that produces a clean tar free syngas from natural and recycled biomass gasification, Syngas. | Belgium |

# 14.6 Policy Assessment - Detailed Analysis

## 14.6.1 Circular economy action plan – European Union

### Table 31 Policy Assessment EU Strategy for Sustainable and Circular Textiles

| Region/Country | European Union |
|---|---|
| Name of the Policy | EU Strategy for Sustainable and Circular Textiles[46] |
| Type of Policy | ESG Policy |
| Role of Policy | Supply Creation |
| Issuer Agency | European Union |
| Status of implementation | Adopted in 2022 |
| Brief of Policy | **Background:**<br>To establish a coherent framework and a vision for a circular textile system in the EU.<br>**Objective:**<br>• To promote eco-design for durable, repairable, and recyclable textiles.<br>• To improve waste management through extended producer responsibility.<br>• To prevent destruction of unused apparel<br>• To tackle micro plastics pollution<br>• To empower consumers through 'Digital Product Passports' and transparency<br>• To introduce Extended Producer Responsibility for circular design |
| **Detailed Assessment** | |
| Targeting | **Level: 4 – Embedded**<br>👍 Targets diverse stakeholders across the value chain.<br>👍 Promotes eco-design principles for durable, reparable, and recyclable textiles.<br>👍 Addresses specific needs of each group, such as encouraging eco-design through financial incentives for manufacturers and promoting responsible consumption through awareness campaigns.<br>👎 Lacks focus on specific non-textile materials within the industry. |
| Coordination | **Level: 2 – Functioning**<br>👍 Sets up a framework for collaboration between the EU Commission, member states, and stakeholders, including foreign suppliers.<br>👍 Demonstrates a proactive approach for coordinating efforts at the EU level and ensuring alignment with national and regional policies. |
| Transparency | **Level: 2 – Functioning**<br>👍 Provides clear estimates of the post-consumer textile waste for implementing the plan's measures to enhance its credibility.<br>👍 Establishes clear, quantifiable indicators and a transparent monitoring framework would allow for regular assessment of progress, identify potential challenges, and ensure accountability.<br>👍 Introduces safeguards for consumers through 'EU Ecolabel' especially against recycled plastics |

46. European Commission. (2022). EU Strategy for Sustainable and Circular Textiles. Brussels: European Commission

| Region/Country | European Union |
|---|---|
| Engagement | **Level: 2 – Functioning**<br>Demonstrates efforts to engage with stakeholders through consultations, workshops, and public consultations.<br>Encourages the active involvement of businesses, industry associations, environmental organizations, and other relevant actors in shaping circular economy policies.<br>Proactively taking a holistic view by incorporating the entire waste value chain from collection to reuse and recycling |
| Commitment | **Level: 1 – Developing**<br>Identifies specific funding sources, outlining budget allocations for different measures, and clarifying responsible entities would demonstrate a firm commitment to implementation.<br>Provides targeted support to stakeholders, particularly SMEs and local authorities, would equip them to effectively implement the plan's measures. |
| Implementation | **Level: 1 – Developing**<br>Defines clear indicators, data collection methods, and reporting mechanisms to track progress towards goals and identify areas for improvement.<br>Lays out action points and timelines for implementation.<br>Details on monitoring and evaluation methods for measuring progress and impact are limited. |

## 14.6.2 Ecodesign for sustainable products regulation - European Union

### Table 32 Policy Assessment Ecodesign for Sustainable Products Regulation

| Region/Country | European Union |
|---|---|
| Name of the Policy | Ecodesign for Sustainable Products Regulation (ESPR)[47] |
| Type of Policy | Environmental Regulation |
| Role of Policy | Supply Creation |
| Issuer Agency | European Commission |
| Status of implementation | Entering into force on July 1, 2024 |
| Brief of Policy | **Background:** The regulation aimed at transforming the EU's production and consumption patterns towards greater sustainability. It expands the scope of ecodesign requirements beyond energy efficiency to encompass broader environmental impacts, resource use, and circularity. This includes mandates for durability, repairability, recyclability, recycled content, and restricted hazardous substances.<br>**Objective:**<br>To increase the number of circular products placed on the EU market.<br>To reduce the environmental footprint of products throughout their lifecycles.<br>To foster innovation and competitiveness in the sustainable product sector.<br>To improve product durability, repairability, and recyclability. |
| **Detailed Assessment** | |
| Targeting | **Level: 3 – Engaged**<br>Applies to all product groups placed on the EU market, with phased implementation allowing for adaption.<br>Recognizes the role of information asymmetry in consumer decision-making, requiring product-level disclosure.<br>Initial focus on specific product groups like electronics and textiles might delay comprehensive coverage of other sectors. |

47. European Commission. (2023). Ecodesign for Sustainable Products Regulation (ESPR). Brussels: European Commission

| Region/Country | European Union |
|---|---|
| Coordination | **Level: 3 –Engaged**<br>• Aligns with the broader EU Circular Economy Action Plan and Green Deal objectives.<br>• Promotes collaboration among member states, stakeholders, and experts in developing ecodesign requirements.<br>• Leverages existing data frameworks and regulations to reduce administrative burden. |
| Transparency | **Level: 2 – Functioning**<br>• Provides clear cost estimates for implementing the plan's measures to enhance its credibility.<br>• Introduces Digital Product Passport or DPP containing information on circularity and other environmental aspects.<br>• Establishes clear, quantifiable indicators and a transparent monitoring framework would allow for regular assessment of progress, identify potential challenges, and ensure accountability. |
| Engagement | **Level: 2 – Functioning**<br>• Transparency encourages consumer engagement and informed purchasing choices based on environmental factors.<br>• Data availability enables future advocacy and campaigns by NGOs and environmental groups.<br>• Potential for industry-led initiatives and collaborations to accelerate and improve implementation.<br>• Limited consumer education and awareness campaigns could hinder the effectiveness of information disclosure in empowering consumers. |
| Commitment | **Level: 1 – Developing**<br>• Long-term vision embedded within the broader Circular Economy Action Plan and Green Deal.<br>• Gradual implementation with phased product groups allows for adaptation and improvement based on data and feedback.<br>• Dependence on administrative fines for enforcement might not be sufficient to ensure long-term adherence and continuous improvement |
| Implementation | **Level: 1 – Developing**<br>• Clear timelines and defined phases for implementing ecodesign requirements for different product groups.<br>• Monitoring and evaluation mechanisms in place to track progress and identify areas for improvement.<br>• Potential for delays in developing and implementing detailed ecodesign requirements for specific product groups. |

### 14.6.3 EPR for textiles decree - Netherlands

**Table 33 Policy Assessment - EPR for Textiles Decree - Netherlands**

| Region/Country | Netherlands |
|---|---|
| Name of the Policy | EPR for textiles decree[48] |
| Type of Policy | Environmental Regulation |
| Role of Policy | Supply Creation |
| Issuer Agency | Ministry of Infrastructure and Water Management, Government of The Netherlands |
| Status of implementation | Entered into force on July 1, 2023 |

48. Government of the Netherlands. (2023). EPR for Textiles Decree. The Hague: Ministry of Infrastructure and Water Management

| Region/Country | Netherlands |
|---|---|
| Brief of Policy | **Background:**<br>Considering the significant volume of textile waste generated in The Netherlands (305 Kilotons in 2018), this decree places responsibility for recycling and preparing textile products for re-use on producers of clothing and household textiles in the Netherlands. Producers are also mandated to establish and fund a suitable collection system for textile waste. The decree sets quantitative targets for recycling and preparing for re-use, aligning with circular textile program objectives. Targets include preparation of 50% of textile products for re-use or recycling by 2025, with specific targets for fiber-to-fiber recycling and increasing the targets to 75% by 2030.<br>**Objective:**<br>• To increase the percentage of reused and recycled textiles by 2025 (50%) and 2030 (75%), with specific targets for fiber-to-fiber recycling and domestic reuse.<br>• To ensure re-use, recycling, less wastage, and less pollution by promoting better collection, recycling and re-use via measures which are less binding, like the granting of subsidies or the conclusion of voluntary agreements.<br>• To shift the financial burden of textile waste management from taxpayers to producers, incentivizing circular design and waste reduction. |
| **Detailed Assessment** | |
| Targeting | **Level: 4 – Embedded**<br>• Decree focuses exclusively on textile waste streams and circularity approaches.<br>• Targets all producers and importers of clothing and household textiles placed on the Dutch market, regardless of size or product category.<br>• Sets ambitious recycling and reuse targets (50% by 2025, 75% by 2030), with specific goals for fiber-to-fiber recycling and domestic reuse.<br>• Recognizes the potential for both domestic and international reuse and recycling markets.<br>• Initial focus on larger producers through EPR Textile Foundation might overlook challenges and needs of smaller companies. |
| Coordination | **Level: 4 – Embedded**<br>• The implementing framework provides for coordination between the Ministry of Infrastructure and Water Management and Human Environment and Transport Inspectorate (ILT) which has been delegated the responsibility of implementation of the Decree.<br>• Employs an industry-funded EPR Textile Foundation called Stitching UPV Textile for collective implementation and cost-sharing.<br>• Monitoring and enforcement measures underscore the commitment to ensuring compliance.<br>• Also, limited involvement of external stakeholders (consumers, NGOs, government) beyond producers and collectors could reduce the breadth of coordination. |
| Transparency | **Level: 3 – Engaged**<br>• Producers are obliged to report annually on the quantity of textile products placed on the market, promoting transparency.<br>• Targets align with those announced in the Progress Report of the Policy Programme for Circular Textile, providing clarity on policy objectives.<br>• Verification and validation procedures for producer data and greenwashing prevention measures are not yet fully defined.<br>• However, no specific mechanisms for grievance redressal<br>• Further, the benefits and risks of promoting circularity in textile waste including mechanisms for grievance redressals could be clearly explained. |

| Region/Country | Netherlands |
|---|---|
| Engagement | **Level: 3 – Engaged**<br>• Encourages collective compliance through PROs, fostering industry-wide engagement.<br>• The creation of Stitching UPV Textile for joint implementation reflects collaboration and stakeholder involvement.<br>• Limited consumer awareness and education campaigns could hinder the effectiveness of transparency measures in empowering informed action.<br>• Also, the policy could enhance engagement by providing more explicit examples and lessons learned from stakeholder engagement in similar contexts. |
| Commitment | **Level: 1 – Developing**<br>• Producers are individually responsible for the implementation of extended producer responsibility (EPR) for textiles, indicating a high level of commitment.<br>• Sets ambitious recycling and reuse targets, showcasing a commitment to circular economy principles.<br>• Sets annual reporting and monitoring & evaluation mechanism to ensure long term and periodic commitment.<br>• The mechanism for allocation of resources for the implementation could be clearly laid down. |
| Implementation | **Level:3 – Engaged**<br>• The policy outlines specific targets for 2025 and 2030, demonstrating a clear direction for implementation.<br>• Establishes the UPV Textile foundation for collective fulfilment of obligations.<br>• Monitoring and enforcement mechanisms are in place, indicating a proactive approach to policy implementation.<br>• Since the decree is in initial stages of implementation, the effectiveness of results is yet to be validated. |

### 14.6.4 Fashion sustainability and social accountability act - New York, USA

**Table 34 Policy Assessment Fashion Sustainability and Social Accountability Act - New York, USA**

| Region/Country | New York, USA |
|---|---|
| Name of the Policy | Fashion Sustainability and Social Accountability Act (New York Fashion Act)[49] |
| Type of Policy | Environmental and Human Rights Regulation |
| Role of Policy | Directing Capital |
| Issuer Agency | City of New York |
| Status of implementation | Adopted in 2022 (Timing of implementation unknown) |
| Brief of Policy | **Background:**<br>The Fashion Sustainability and Social Accountability Act focuses on enhancing the environmental and social sustainability practices within the operational framework of major clothing retailers and brands in New York City. It aims to improve the environmental and social sustainability practices of large clothing retailers and brands operating in New York City. The act focuses on transparency, supply chain traceability, and responsible sourcing.<br>**Objective:**<br>• To require brands to disclose information about their environmental and social impacts throughout their supply chain.<br>• To encourage responsible sourcing practices, including fair labour standards and sustainable materials use.<br>• To minimize the environmental footprint of brands' operations and product lifecycles.<br>• To ensure fair wages and working conditions for workers in the garment industry. |

49. New York State Legislature. (2022). Fashion Sustainability and Social Accountability Act. Albany: State of New York

| Region/Country | New York, USA |
|---|---|
| **Detailed Assessment** | |
| Targeting | **Level: 1 – Developing**<br>• Focuses on large retailers and brands (revenue exceeding $ 100 mn), which have significant influence on the fashion industry and supply chain.<br>• Addresses both environmental and social sustainability issues, encompassing a broader scope than solely energy efficiency.<br>• Excludes sale of apparel. |
| Coordination | **Level: 2 – Functioning**<br>• Promotes transparency and self-reporting, potentially encouraging companies to take proactive steps towards sustainability.<br>• Outlines a comprehensive due diligence process for fashion sellers, aligning with international standards.<br>• Encourages collaboration with impacted stakeholders and rights holders, enhancing coordination in remediation efforts.<br>• Limited coordination with national and international sustainability initiatives could lead to inconsistencies and missed opportunities for collaboration. |
| Transparency | **Level: 2 – Functioning**<br>• Requires public disclosure of sustainability performance data, empowering consumers and stakeholders with information.<br>• Mandates reporting on supply chain due diligence efforts, potentially increasing visibility into ethical sourcing practices.<br>• Lack of clear guidelines on data standardization and verification procedures could lead to inconsistencies and confusion. |
| Engagement | **Level: 1– Developing**<br>• Public disclosure can encourage dialogue and collaboration among stakeholders, including consumers, NGOs, and industry players.<br>• Transparency measures can empower consumers to make informed purchasing decisions based on sustainability criteria.<br>• Lack of formal mechanisms for stakeholder involvement in policy development and monitoring could limit public participation. |
| Commitment | **Level: 2 – Functioning**<br>• Sets ambitious long-term goals for reducing environmental and social impacts within the fashion industry.<br>• Phased implementation allows for adaptation and adjustments based on initial experience and feedback.<br>• Dependence on voluntary compliance and self-reporting raises concerns about long-term commitment and continuous improvement. |
| Implementation | **Level: 1 – Developing**<br>• The bill was introduced to the NY State Legislature in 2022 and revised in 2023; It needs to pass both the NY State Assembly and the Senate before it can become law.<br>• Clear timeline and milestones for implementation outlined in the legislation.<br>• Established reporting and data collection mechanisms in place.<br>• Detailed regulations and operational guidelines for supply chain due diligence and reporting requirements still under development. |

### 14.6.5 Implementation opinions on accelerating the development of circular economy in the textile waste recycling sector - China

**Table 35 Policy Assessment - Implementation Opinions on Accelerating the Development of Circular Economy in the Textile Waste Recycling Sector - China**

| Region/Country | China |
|---|---|
| Name of the Policy | Implementation Opinions on Accelerating the Development of Circular Economy in the Textile Waste Recycling Sector[50] |
| Type of Policy | Environmental and Economic Regulation |
| Role of Policy | Increase resource utilization and recycling rate |
| Issuer Agency | National Development and Reform Commission (NDRC) |
| Status of implementation | Effective since September 2022 |
| Brief of Policy | **Background:**<br>The regulation emphasizes resource utilization, environmental protection, and sustainable development. It defines circular economy activities and sets guidelines for planning, implementation, and participation by the government, market, enterprises, and the public. It prioritizes feasibility, economic reasonability, and resource conservation in promoting circular economy, stressing safety in waste recycling and resource recovery.<br>**Objective:**<br>• To reduce of resource consumption and waste generation.<br>• To promote recycling and resource recovery across different sectors.<br>• To establish responsibility systems for producers and consumers.<br>• To increase the overall resource utilization rate in China to a certain level by a specific deadline. |
| **Detailed Assessment** | |
| Targeting | **Level: 2 – Functioning**<br>👍 Targets various sectors, including manufacturing, construction, textiles, agriculture, and consumer goods.<br>👍 Differentiated requirements and responsibilities for different stakeholders, such as producers, consumers, and waste management companies.<br>👍 Focuses on key materials with high environmental impact and resource potential.<br>👎 Exemptions for certain sectors or activities might limit the law's reach. |
| Coordination | **Level: 1 – Developing**<br>👍 Establishes a multi-level governance framework with roles for national, provincial, and local governments.<br>👍 Encourages utilization of textiles made from recycled materials in public procurement programmes (military and police uniforms, school uniforms)<br>👎 Over-reliant on use of chemical fibers (especially recycled PET) |
| Transparency | **Level: 2 – Functioning**<br>👍 Sets tangible targets and timelines for ramping up circularity.<br>👍 Promotes key technological breakthroughs and industrial development in the high-value utilization of waste textiles.<br>👍 Promotes access to information for consumers and stakeholders through online platforms.<br>👎 Accessibility of environmental information could be improved for non-technical audiences. |

50. China National Development and Reform Commission. (2022). Implementation Opinions on Accelerating the Development of Circular Economy in the Textile Waste Recycling Sector. Beijing

| Region/Country | China |
|---|---|
| Engagement | **Level: 1 – Developing**<br>👍 Establishes a goal-responsibility system for circular economy promotion, engaging local governments in planning and execution.<br>👍 Advocates for sound management systems in enterprises and public institutions to reduce resource consumption and enhance recycling.<br>👎 Promotes citizen engagement through fostering a sense of resource conservation and responsible consumption.<br>👎 Future potential can only be unlocked with chemical recycling technologies |
| Commitment | **Level: 1 – Developing**<br>👍 Establishes financial mechanisms, such as green funds and subsidies, to support circular economy initiatives.<br>👍 Long-term vision embedded within broader ecological civilization and green development goals.<br>👎 Requires local governments to adopt a goal-responsibility system but lacks details on accountability measures. |
| Implementation | **Level: 1 – Developing**<br>👍 Pilot projects and demonstration zones are being established to test and refine circular economy approaches.<br>👍 Initiatives captured in the 10 Year Textile Industry Plan<br>👎 Encourages the establishment of an industrial waste information exchange system but lacks clear guidelines on implementation. |

### 14.6.6 Responsible textile recovery act - california, USA

**Table 36 Policy Assessment Responsible Textile Recovery Act – California, USA**

| Region/Country | California, USA |
|---|---|
| Name of the Policy | Responsible Textile Recovery Act[51] |
| Type of Policy | Environmental Regulation |
| Role of Policy | Waste Diversion |
| Issuer Agency | California Department of Resources Recycling and Recovery |
| Status of implementation | Adopted in September 2023; full program launch expected in 2025 |
| Brief of Policy | **Background:**<br>The Act mandates producers of clothing and textiles to establish and fund stewardship programs for the collection and recycling of post-consumer textiles in California. This aims to divert textiles from landfills and promote a circular economy model for the industry. The Act recognizes of Extended Producer Responsibility (EPR) as a potential solution for incentivizing circularity in various product categories.<br>**Objective:**<br>• Increase the diversion rate of discarded textiles from landfills to at least 60% by 2030.<br>• Encourage development of efficient and comprehensive collection and recycling infrastructure for textiles.<br>• Shift the financial burden of managing textile waste from taxpayers to producers, incentivizing waste reduction and sustainable practices. |

51. California State Legislature. (2023). Responsible Textile Recovery Act. Sacramento: State of California

| Region/Country | California, USA |
|---|---|
| **Detailed Assessment** | |
| Targeting | **Level: 2 – Functioning**<br>• Targets all producers of clothing and textiles sold in California, regardless of size or brand.<br>• Broad definition of "covered products" encompasses apparel, textiles, and footwear.<br>• Potential administrative burden for smaller producers, particularly during program development and initial phases. |
| Coordination | **Level: 2 – Functioning**<br>• Establishes stewardship programs through producers or stewardship organizations, promoting collaborative efforts.<br>• Provides for potential collaboration among producers, recyclers, and CalRecycle through stewardship organizations.<br>• Potential overlap and duplicity with existing or future federal EPR regulations could create confusion and inconsistencies. |
| Transparency | **Level: 2 – Functioning**<br>• Requires program operators to submit detailed stewardship plans and annual reports to CalRecycle, ensuring public access to key information.<br>• Mandates CalRecycle to maintain a public list of compliant producers and program performance data.<br>• Promotes transparency in program funding and expenditure through dedicated accounts.<br>• Restrictions on public access to certain confidential business information might hamper full transparency and public scrutiny |
| Engagement | **Level: 1 – Developing**<br>• Imposes responsibility on producers, fostering direct engagement in waste management.<br>• Encourages innovation and collaboration in developing better textile sorting, recycling, and reuse technologies.<br>• Consumer engagement through awareness campaigns and information availability on collection locations. |
| Commitment | **Level: 3 – Engaged**<br>• Sets regulatory mechanisms for periodic review and adjustment, showcasing commitment to effectiveness.<br>• Phased implementation allows for initial program development and adjustments before full launch, promoting adaptability.<br>• Dependence on administrative fines and enforcement mechanisms might not be sufficient to ensure long-term commitment and continuous improvement. |
| Implementation | **Level: 1 – Developing**<br>• CalRecycle actively engaged in stakeholder consultations and development of program regulations.<br>• Clear timeline for program development and implementation, with key milestones outlined.<br>• Establishes a dedicated fund for financial support, enhancing implementation capability.<br>• Lack of detailed regulations and operational guidelines for collection systems, sorting, and recycling processes. |

## 14.6.7 Anti-waste for a circular economy – france

### Table 37 Policy Assessment Anti-Waste for a Circular Economy - France

| Region/Country | France |
|---|---|
| Name of the Policy | Anti-Waste for a Circular Economy (AGEC LAW)[52] |
| Type of Policy | Environmental Regulation |
| Role of Policy | Demand Generation |
| Issuer Agency | Ministry for Ecological Transition and Territorial Cohesion of France |
| Status of implementation | Adopted in April 2022, gradual implementation from January 1st, 2023 |
| Brief of Policy | **Background:**<br>The law is a French transposition of the European objectives outlined in the Circular Economy Package of 2018 and further enhanced in 2019. It aligns with the European Commission's Action Plan. It addresses a wide range of environmental challenges, emphasizing the reduction of single-use plastic, fostering transparency in product information, and promoting circular practices across various sectors. It introduces disclosure requirements related to recycled material content, recyclability, harmful substances, microplastics, and traceability.<br>**Objective:**<br>• To gradually eliminate of single-use plastic, with a complete ban by 2040.<br>• To prohibit the destruction of unsold non-food products, promoting their use through donation to associations by creating funds for reuse with over €50 million each year.<br>• To extend the responsibility of manufacturers in waste management by creating new channels and transforming the 'polluter pays' principle. |
| **Detailed Assessment** | |
| Targeting | **Level: 1 – Developing**<br>• Targets a wide range of environmental issues, including single-use plastic, endocrine disruptors, and planned obsolescence.<br>• Focuses on informing consumers about product qualities and environmental impacts.<br>• Addresses different actors across the value chain, from manufacturers and importers to consumers and local authorities.<br>• Incentives were introduced in 2023 for consumers to claim €10-25 for repairing their clothes to extend useful life. An independent initiative being mooted calls for imposition of a €5 per garment tax on ultra-fast fashion brands. |
| Coordination | **Level: 2 – Functioning**<br>• Establishes commitment to extended producer responsibility (EPR) by making producers and importers individually responsible for compliance.<br>• Introduces industry-funded mechanisms for collective implementation, promoting cost-sharing and collaboration.<br>• Further strengthening coordination through dedicated working groups or platforms could enhance communication and address potential conflicts. |
| Transparency | **Level: 3 – Engaged**<br>• Mandates manufacturers to disclose information on product composition, repairability, and environmental impact.<br>• Promotes Open data access for various information, including spare parts availability and waste management data.<br>• Targets align with Circular Textile Progress Report, providing clarity on policy objectives.<br>• Verification procedures for producer data and greenwashing prevention measures are not yet fully defined. |

52. France Ministry for Ecological Transition and Territorial Cohesion. (2022). Anti-Waste for a Circular Economy (AGEC LAW). Paris: Government of France

| Region/Country | France |
|---|---|
| Engagement | **Level: 3 – Functioning**<br>Encourages collective compliance through Producer Responsibility Organizations (PROs), fostering industry-wide engagement.<br>Provides financial support to encourage participation from civil society organizations and small businesses.<br>Limited consumer education and awareness campaigns could hinder the effectiveness of information disclosure in empowering consumers. |
| Commitment | **Level: 3 – Engaged**<br>Sets ambitious targets for waste reduction, recycling, and eco-design, particularly focusing on single-use plastics.<br>Establishes dedicated funds and investments are allocated to prioritized areas.<br>Long-term commitment can be strengthened by establishing a clear roadmap with measurable milestones and regular progress evaluations. |
| Implementation | **Level: 2– Functioning**<br>Defines clear implementation mechanisms and timelines for various measures.<br>Establishes monitoring and evaluation frameworks to track progress, identify challenges and identify areas for improvement.<br>Strengthening enforcement mechanisms and capacity building for relevant actors will be crucial for effective implementation. |

## 14.6.8 National circular economy roadmap – Vietnam

### Table 38 Policy Assessment National Circular Economy Roadmap - Vietnam

| Region/Country | Vietnam |
|---|---|
| Name of the Policy | National Circular Economy Roadmap (2021-2030)[53] |
| Type of Policy | ESG Policy |
| Role of Policy | Promote resource efficiency |
| Issuer Agency | Ministry of Industry and Trade of the Socialist Republic of Vietnam |
| Status of implementation | Adopted in 2021, under development |
| Brief of Policy | **Background:**<br>Aims to transform Vietnam's economy from linear to circular through promoting resource efficiency, closing material loops, and fostering innovation. It recognizes the environmental and economic benefits of a circular economy and identifies key priorities for action across various sectors.<br>**Objective:**<br>• To increase recycling rates for key materials like plastics, metals, and textiles.<br>• To develop and implement innovative technologies for resource recovery and reuse.<br>• Promote eco-design principles in product development and manufacturing. |
| **Detailed Assessment** | |
| Targeting | **Level: 3 – Engaged**<br>Targets diverse stakeholders across the value chain, including manufacturers, recyclers, consumers, and public authorities.<br>Focuses on priority sectors like manufacturing, agriculture, and tourism, recognizing their specific resource use patterns.<br>Considers regional variations and aims to adapt circular economy approaches for different contexts. |
| Coordination | **Level: 2 – Functioning**<br>Establishes a framework for collaboration between relevant ministries, local governments, and industry stakeholders, aligning with other national strategies for coherence.<br>Cross-ministerial collaboration and alignment ensures holistic implementation.<br>Integration with existing national plans fosters synergy and resource optimization.<br>Potential bureaucratic hurdles could hinder timely and efficient action. |

53. Vietnam Ministry of Industry and Trade. (2021). National Circular Economy Roadmap (2021–2030). Hanoi: Government of Vietnam

| Region/Country | Vietnam |
|---|---|
| Transparency | **Level: 2 – Functioning**<br>👍 Sets clear goals and indicators for progress tracking and requires companies to report on resource use and waste generation for data-driven decision-making.<br>👍 Corporate reporting on resource use promotes accountability and transparency.<br>👎 Information accessibility and understanding for non-specialists (e.g., consumers) need improvement. |
| Engagement | **Level: 2 – Functioning**<br>👍 Conducts stakeholder consultations and workshops for policy development and supports industry-led initiatives and collaborations with NGOs for promoting circular economy practices.<br>👍 Mechanisms for public participation and feedback during implementation could be strengthened. |
| Commitment | **Level: 2 – Functioning**<br>👍 Diverse funding sources diversify and sustain implementation efforts.<br>👍 Allocated budgets for key areas address crucial infrastructure and innovation needs.<br>👎 Lacks detail on long-term financial commitment and resource allocation beyond 2030. |
| Implementation | **Level: 2 - Functioning**<br>👍 Defined action points and timelines ensure focused and timely implementation.<br>👍 Monitoring and evaluation mechanisms allow for course correction and adaptation.<br>👎 Requires robust capacity building initiatives and technical support for stakeholders to effectively implement the NCER. |

## 14.6.9 Circular economy vision 2020 - Japan

### Table 39 Policy Assessment Circular Economy Vision 2020 - Japan

| Region/Country | Japan |
|---|---|
| Name of the Policy | Circular Economy Vision 2020[54] |
| Type of Policy | Environmental Regulation |
| Role of Policy | Supply Creation |
| Issuer Agency | Ministry of Economy, Trade, and Industry |
| Status of implementation | Entered into force on May 2020 |
| Brief of Policy | **Background:**<br>The policy highlights the significant issue of textile waste, with 73% of discarded clothes globally being burned or landfilled. It emphasizes the need for the textile and apparel industry in Japan to transition towards more sustainable business models. This includes adopting mass-customization, leveraging e-commerce, and encouraging the use of sharing models to enhance the industry's value through digital technology. The policy also stresses the importance of advancing textile recycling efforts, such as recycling textiles from PET wastes and developing mono-material textiles that are easier to recycle.<br>**Objective:**<br>• To boost enterprise disclosure of circular activities and develop systems for evaluating their contributions to circularity.<br>• To increase ESG investments by promoting circular economy activities and establishing guidance for investor-enterprise communication.<br>• To establish markets where circular products are fairly priced and valued, addressing consumer willingness to pay |

54. Japan Ministry of Economy, Trade, and Industry. (2020). Circular Economy Vision 2020. Tokyo: Government of Japan

| Region/Country | Japan |
|---|---|
| **Detailed Assessment** | |
| Targeting | **Level: 2 – Functioning**<br>👍 Recognizes the global challenge of textile waste with 73% of discarded clothes being burned or landfilled.<br>👍 Encourages the textile industry to shift towards circular business models, responding to consumer demand for sustainable products.<br>👍 Emphasizes the promotion of textile recycling, including the use of PET wastes for new textiles and the development of recyclable mono-material textiles.<br>👎 Further emphasis could be laid on textile waste value chain. |
| Coordination | **Level: 4 – Embedded**<br>👍 Advocates for the integration of digital technology in enhancing industry circularity, such as through e-commerce and sharing models.<br>👍 Suggests industry-wide modifications but lacks explicit details on cross-sector or policy coordination mechanisms.<br>👍 Highlights existing company-led initiatives for product collection and recycling yet does not clearly define coordination with broader environmental policies. |
| Transparency | **Level: 2 – Functioning**<br>👍 Clearly outlines objectives for improving circularity in the textile sector, providing transparency on policy goals.<br>👍 Details efforts in textile recycling and the need for technological advancements, though specifics on monitoring mechanisms are not provided.<br>👎 Discusses challenges in textile waste management and potential solutions, offering some level of transparency. |
| Engagement | **Level: 2 - Functioning**<br>👍 Indicates the need for the textile industry to adapt to sustainable practices, implying stakeholder involvement.<br>👍 Acknowledges the role of consumer demand in driving industry changes towards circularity.<br>👎 Focuses primarily on industry and consumer roles, with less emphasis on broader stakeholder engagement such as government or NGOs. |
| Commitment | **Level: 3- Engaged**<br>👍 Demonstrates a commitment to integrating circular economy principles within the textile sector.<br>👍 Encourages the adoption of innovative technologies and business models to facilitate textile recycling.<br>👍 Indicates government support for the transition towards sustainable textile practices, showing a commitment to long-term industry changes. |
| Implementation | **Level: 2– Functioning**<br>👍 Mentions the implementation of recycling initiatives, such as creating textiles from PET wastes, indicating actionable steps.<br>👍 Suggests the use of digital technologies to improve the circularity of textiles, providing a pathway for implementation.<br>👎 Acknowledges the need for further development in recycling technologies and materials, highlighting ongoing implementation efforts and challenges |

## 14.7 Standard and Certification Evaluation

International directives and standards advocating for efficient resource use and the management of restricted chemical substances are integral to promoting safe and sustainable textile production. They emphasise resource efficiency and circularity through standards like ISO 14001, while safeguarding human and environmental health through restrictions on harmful chemicals in production. These guidelines emphasise practices like reuse, recycling, and recoverability, contributing to environmentally responsible manufacturing. Tailored environmental regulations for textile industries of all sizes are essential for minimizing the use of harmful substances, ensuring human and environmental health. Removing such substances from the production cycle enhances safety during various stages, and these regulations facilitate risk identification and the exploration of substitutes for hazardous chemicals. Moreover, these standards mandate the provision of fabric use and care information to consumers through product labels, enhancing awareness and responsible consumption. Some relevant international standards and certifications are:

International validation and certification options for recycling processes and products were evaluated. Basis study, suitable standards and certifications shall be recommended to MoT that align with India's objectives and ensure credibility in the global market. Some globally recognised voluntary standards that were studied have been provided below:

1. **Global Organic Textile Standards (GOTS)**[55]: GOTS certification is a universally accepted comprehensive textile standard to assure the organic status of textile raw materials from its production till it reaches the users. The advantages of this certification are manifold for the consumers such as tracking of sowing, bio-composting, harvesting details, eco-friendly manufacturing, as well as eco-labelling.
2. **Publicly Available Specification (PAS) 2050**[56]: PAS 2050 in collaboration with BSI devised methods to identify and quantify life cycle greenhouse gas (GHG) emissions during product manufacturing, transportation, storage, use, recycling, and disposal. The aim of PAS 2050 is to create awareness and enable corrective measures accordingly for reduction in GHG emissions.
3. **Indian Standard for Organic Textiles (ISOT)**: India is the largest producer of organic cotton, a desirable fiber which is in high demand in European countries and USA. Textile products made with 95% certified organic fiber (natural and devoid of GMO) and rest 5% with man-made cellulosic fibers and post-consumer recycled textiles, are labelled as organic textile material.
4. **Organic Crop Improvement Association (OCIA)**: It is one of the first organic certification system mandated in 1985. It is a non-profit organization to certify organic cotton and other fiber yielding crop. India and Bangladesh are major cotton and jute producer. The certification and technical assistance provided by OCIA help farmers in cotton and jute export to US and Canada.
5. **Sustainable Resolution (Su. Re)**[57] **in India**: Su. Re project is an ambitious initiative launched by Textile minister, Govt. of India, to save the planet. It is the first time that clothing manufacturing association of India (CMAI) with 16 signatories having combined industry value of 30,000 crore rupees, pledged to use sustainable raw materials, and processes for their apparel brands. Project Su. Re aims to develop complete sustainable sourcing and a sustainable chain by the year 2025.
6. **Global Recycled Standard (GRS)**[58]**:** The Global Recycled Standard (GRS) is a comprehensive certification that ensures the traceability and integrity of recycled materials used in products. Recognized globally, GRS sets stringent criteria for the entire supply chain, addressing the collection, processing, and manufacturing stages. It verifies recycled content percentages and encourages sustainable practices, promoting transparency and accountability in the textile industry.
7. **Recycled Claim Standard (RCS):** The Recycled Claim Standard (RCS) is a certification focused on verifying the recycled content in products. It provides a transparent approach to trace the journey of recycled materials through the supply chain. RCS ensures that companies accurately claim the recycled content in their textiles, fostering consumer confidence and supporting environmentally conscious practices in the textile and apparel sectors.
8. **OEKO-TEX Standard 100**[59]**:** The OEKO-TEX Standard 100 is a globally recognized certification ensuring that textile products are free from harmful substances. It sets limits on the use of certain chemicals in textile manufacturing, addressing potential health risks. This standard encompasses rigorous testing and certification processes, promoting consumer safety and environmental stewardship in the textile industry.

55. Global Organic Textile Standard (GOTS). (2023). Global Organic Textile Standard Version 7.0. Retrieved from https://global-standard.org/
56. PAS 2050. (2011). Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. British Standards Institution
57. Su.Re. (2019). Sustainable Resolution (Su.Re) Project. Clothing Manufacturers Association of India (CMAI). Retrieved from https://cmai.in/sure-project/
58. Global Recycled Standard (GRS). (2023). Global Recycled Standard. Textile Exchange. Retrieved from https://textileexchange.org/
59. OEKO-TEX®. (2023). OEKO-TEX® Standard 100. Retrieved from https://www.oeko-tex.com/

9. **EU Ecolabel:** The EU Ecolabel is a prestigious certification awarded to products and services that meet high environmental standards set by the European Union. Applied to textiles, this label signifies that the product has undergone stringent assessments throughout its life cycle, considering factors such as resource use, energy efficiency, and environmental impact. The EU Ecolabel encourages sustainable practices and empowers consumers to make environmentally conscious choices when selecting textile products.

A list of eco-labels and standards relevant for the study is given below:

### Table 40 List of Eco Labels and Standards

| # | Eco-label | Category | Company/Country |
|---|---|---|---|
| 1 | MADE IN GREEN | All forms of textiles- raw materials, semi-finished, and end products | OEKO-TEX, Germany |
| 2 | DETOX TO ZERO | Wastewater, sludge treatment and chemical management system in textile industry | OEKO-TEX, Germany |
| 3 | Leather standards | Leather garment and accessories production | OEKO-TEX (Germany) |
| 4 | Blue angel | Textiles and apparels | Umweltbudesamt (Germany, father of eco labels 1978) |
| 5 | Miljoval | Criteria for eco-friendly processing, laundry reagents and energy use | Good environmental choice (Sweden) |
| 6 | Coop Naturaline | Entire textile chain including pure organic cultivation and pollution tests | Eco-label from Switzerland |
| 7 | Eco | Eco-textiles, footwear and leather | Migros for health, environment and trade fair (Switzerland) |
| 8 | NF Environment | Textile & apparels | French standardization organization (1991) |
| 9 | Organic | Textiles containing 95% certified organic fiber | ISOT, India |
| 10 | Made with organic fiber | Textiles containing 70 to 94% organic fiber | ISOT, India |
| 11 | Otto versand | Clothing, home furnishing | Germany |
| 12 | Hessnatur | GOTS and Fair-Wear Foundation certified garments | Hess Natur |
| 13 | Green Cotton | Organic cotton production | Denmark |
| 14 | EKO-Seal | Textiles from inorganic fibers, undergarments, diapers, furnishing fabrics | Holland |
| 15 | Eco Mark | Fabric, reusable diapers, towels, bed linen, bags, | Korea |
| 16 | Green Mark | Unbleached fabric, reusable diapers, shopping bags | Taiwan |

| # | Eco-label | Category | Company/Country |
|---|---|---|---|
| 17 | Environmental choice | Organic cotton products | Canada |
| 18 | Environmental labelling | Silk products | China |
| 19 | Eco-label | Garments and furnishing for domestic use | European countries EU-label |
| 20 | Nordic environmental labelling (Milijomarkt) | Organic and man-made textiles | Scandinavian countries Nordic Eco-label |
| 21 | Body wholesome textiles | Textile and its effect on human skin | Denkendorf |
| 22 | Sticheting Milieukeur | Textiles for apparels | Netherlands |
| 23 | Trees | Textiles and apparels | Austria |
| 24 | Eco-mark | Natural and man-made textiles | India |
| 25 | Eco-mark | Fresh and used Textiles, nappy from used textiles, furnishing fabrics, PET clothing, Unbleached fabrics, bags | Japan |
| 26 | 1000 | Eco management | Germany |
| 37 | Soil association organic standard | Organic textiles | UK |

# Chapter 15

# Abbreviations

## Chapter 15 - Abbreviations

| Acronym/Abbreviation | Full Form / Context |
|---|---|
| AGEC/ AGEC LAW | Anti-Waste for a Circular Economy Law (France) |
| Aramid | Aromatic Polyamide – High-performance synthetic fiber |
| ASI | Annual Survey of Industries |
| BCI | Better Cotton Initiative |
| BIS | Bureau of Indian Standards |
| BSI | British Standards Institution |
| CE100 | Ellen MacArthur Circular Economy 100 Network |
| CEAP | Circular Economy Action Plan (EU) |
| CFW | Cloth Kits for Work (Goonj initiative) |
| CIRCULOSE® | Branded dissolving pulp (Renewcell) |
| CMAI | Clothing Manufacturers Association of India |
| CMT | Cut Make and Trim |
| $CO_2$ eq | Carbon Dioxide Equivalent |
| CPCB | Central Pollution Control Board |
| DGCIS | Directorate General of Commercial Intelligence and Statistics |
| DPP | Digital Product Passport |
| DWP | Dissolving Wood Pulp |
| ECA | Environmental Compliance Audit (context: standards) |
| EEDEN | Upcycling chemical technology provider |
| EKO-Seal | Eco-label for textiles (Holland) |
| EPR | Extended Producer Responsibility |
| ESG | Environmental, Social, and Governance |
| EU Ecolabel | European Union Ecolabel |
| FGD | Focus Group Discussion |
| GMO | Genetically Modified Organism |
| GOTS | Global Organic Textile Standard |
| GRS | Global Recycled Standard |
| HDPE | High-density Polyethylene |
| HS | Harmonized System |
| HSN | Harmonized System of Nomenclature |

| Acronym/Abbreviation | Full Form / Context |
|---|---|
| IIT | Indian Institute of Technology |
| IMTF-CT | Inter Ministerial Task Force on Circular Textiles |
| Infinna™ | Brand name for circular textile fiber (Infinited Fiber) |
| ISO | International Organization for Standardization |
| ISOT | Indian Standard for Organic Textiles |
| KII | Key Informant Interview |
| KTPA | Kilotons Per Annum |
| kWh | Kilowatt Hour |
| LCA | Life cycle assessment |
| LMC | Lucknow Municipal Corporation |
| MMCF | Manmade Cellulosic Fibers |
| MoC&I | Ministry of Commerce and Industry |
| MoEFCC | Ministry of Environment, Forest and Climate Change |
| MoE-SWAYAM | Ministry of Education (SWAYAM platform) |
| MoHUA | Ministry of Housing and Urban Affairs |
| MoSPI | Ministry of Statistics and Programme Implementation |
| MoT | Ministry of Textiles |
| MRF | Material Recovery Facility |
| MRSL | Manufacturing Restricted Substances List |
| MSDE | Ministry of Skill Development and Entrepreneurship |
| MSME/ MSMEs | Micro, Small and Medium Enterprises |
| MSW | Municipal Solid Waste |
| MW | Megawatt |
| NIST | National Institute of Standards and Technology (USA) |
| NJPC | Not Just a Piece of Cloth (Goonj initiative) |
| Nucycl® | Brand name for recycled fiber (Evrnu) |
| OCIA | Organic Crop Improvement Association |
| OCS | Organic Content Standard |
| OEKO-TEX | International certification for textiles free from harmful substances |
| OEM | Original Equipment Manufacturer |
| PA | Polyamide – Commonly known as Nylon; lightweight, elastic, durable |
| PA 6 / PA 6.6 | Polyamide 6 / Polyamide 6.6 |

| Acronym/Abbreviation | Full Form / Context |
|---|---|
| **PaaS** | Product as a Service |
| **PAS** | Publicly Available Specification (PAS 2050) |
| **PAS 2050** | Publicly Available Specification 2050 (GHG emissions) |
| **PES** | Polyester – Synthetic Fiber made from petroleum; strong, wrinkle-resistant |
| **PET** | Polyethylene Terephthalate |
| **PLA** | Polylactic Acid (bioplastic, context: recycling) |
| **PM-MITRA** | Pradhan Mantri Mega Integrated Textile Region and Apparel |
| **PP** | Polypropylene |
| **PRS** | Plastic Responsibility System |
| **PSF** | Polyester Staple Fiber |
| **PTFE** | Polytetrafluoroethylene (context: technical textiles) |
| **QR/RFID** | Quick Response / Radio Frequency Identification |
| **R&D** | Research and Development |
| **RCS** | Recycled Claim Standard |
| **RDF** | Refuse Derived Fuel |
| **RFP** | Request for Proposal |
| **RMG** | Ready Made Garment |
| **RPET** | Recycled Polyethylene Terephthalate |
| **SBM** | Swachh Bharat Mission |
| **S-TUFS** | Scheme for Technology Upgradation Fund for Recycling Industry |
| **Su.Re** | Sustainable Resolution (India) |
| **SWM Rules** | Solid Waste Management Rules |
| **T2T** | Textile-to-Textile (recycling) |
| **TPD** | Tonnes per Day |
| **TRF** | Textile Recycling Facility |
| **TUFS** | Technology Upgradation Fund Scheme |
| **ULB** | Urban Local Bodies |
| **UPV Textile** | EPR Textile Foundation (Netherlands) |
| **ZDHC** | Zero Discharge of Hazardous Chemicals |
| **ZLD** | Zero Liquid Discharge |

# List of Tables

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**Mapping of Textile Waste Value Chain in India, 2026**