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UNVEILING INDIA'S TEXTILE WASTE LANDSCAPE:

A COST ANALYSIS

2023

Credits

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About IDH and SATTVA

IDH operates globally in 12 different industry sectors, in over **40 countries, to deliver scalable, economically viable impact on the Sustainable Development Goals.** In the materials sector, IDH plays an important role in the adoption of better cotton, living wages, responsible sourcing, better working conditions, and structural safety. IDH continues to build on that strong foundation of sectoral expertise by convening partners, funding research, and working with brands to scale innovative closed loop solutions that address the growing textile and apparel waste concerns, both domestically and globally.

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आज़ादी का अमृत महोत्सव

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MESSAGE

The global fashion industry has witnessed a dramatic increase in production and consumption, leading to a surge in textile waste. As one of the largest textile manufacturing nations, India finds itself at the forefront of this challenge, generating 8.5 % of global textile waste each year. This poses immense environmental and social challenges that demand immediate attention. Addressing this issue is not only an ethical responsibility but also an opportunity to drive positive change and sustainable development.

In pursuit of understanding the strategic opportunities for interventions and investments in the textile waste value chain in India, IDH's Alternate Materials Accelerator Program (AMAP) commissioned a seminal research study titled "Unveiling India's Textile Waste Landscape: a cost analysis." This study is the first of its kind, providing crucial insights into the costs and business viability of key stakeholders across the textile waste value chain. The ultimate goal is to mainstream the textile waste chain in India and establish a closed loop textile industry.

This study serves as a valuable resource for policymakers, businesses, and individuals, empowering them to make informed decisions regarding textile and apparel waste management. By fostering collaboration, leveraging conducive policy environments, providing technological support, and promoting capacity building, we can effectively reduce the generation of textile and apparel waste while safeguarding our environment.

On behalf of the Ministry of Textiles, I express my appreciation to IDH for undertaking this seminal study, which comes at a timely juncture and holds immense value for all stakeholders in the textile value chain. I am confident that this study will prove invaluable to all stakeholders, paving the way for a more sustainable and resilient textile industry. Through concerted efforts, we can minimize environmental impacts, unlock new economic opportunities, and contribute to a healthier planet for generations to come.

(Prajakta L Verma)

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Acknowledgement

We would like to extend our deep regards to the stakeholders in the Indian textile waste ecosystem, consisting of manufacturers, recyclers, waste handlers, sorters and other industry stakeholders who shared their perspectives for this study. Their patient inputs allowed us to understand the costs at every level of the textile waste value chain in India along with detailed reasoning behind the same.

1. Executive Summary

India is one of the largest textile and apparel-sourcing regions in the world, with processing infrastructure and a skilled workforce for almost all activities ranging from spinning to apparel production, making it a key competitive sourcing destination for most global brands. Parallelly, India's domestic consumer market is also growing at a CAGR of 10%.[1] Both the production and consumption trends lead to a significant amount of textile waste generation. Despite the absence of advanced technologies[2], the Indian textile recycling ecosystem has established a stronghold in mechanical recycling and the usage of manual sorting methods. Currently, the textile waste being generated and handled in India can be classified across three waste streams: **pre-consumer, domestic post-consumer and imported waste.**

This study is an attempt towards identifying the potential opportunities for intervention and investment in textile waste management in India by understanding the current costs and business viability of the key stakeholders across the textile waste value chain. The study breaks down the Indian textile waste management value chain into three broad scenarios (as shown in the table below) of textile waste flows. A rapid dipstick of costs associated across the value chain has been done through ~20 stakeholder interviews.

RELEVANT STAKEHOLDERS	SCENARIO 1 (Waste generated by domestic manufacturers, but exported for recycling)	SCENARIO 2 (Waste generated by domestic manufacturers, and recycled domestically as well)	SCENARIO 3 (Waste imported from other countries, but recycled domestically)
Waste Generators	Manufacturers	Manufacturers	Not applicable (waste is generated by global consumers)
Waste Handlers	New-age pilots/ startups for pre-consumer waste	• Pre-consumer waste collectors • Pre-consumer waste aggregators	• Importers of post-consumer waste • Imported post-consumer waste aggregators
Waste Recyclers	New Age Patented Recycling Technologies	• Low-grade Mechanical Recycler • High-grade Mechanical Recycler • Downcycler	• Low Grade Mechanical Recycler • Downcycler
Type of waste	Pre-consumer cutting waste. Mostly cotton rich.	Pre-consumer cutting waste. Mostly cotton, polyester and some blended/mixed waste	Post-consumer waste imported from US, EU, UAE and East Asian countries. Consists of mostly cotton, acrylic and wool materials.*

Figure 1: Three scenarios of textile waste management analysed in the study

[1] Annual Report: India Textile & Apparel Industry 2021, Wazir Advisors and AEPC. Retrieved May 19, 2023 from https://aepcindia.com/system/files/Annual%20T%20and%20A%20Industry%20Report-2021.pdf

[2] The study refers to advanced technologies as those that can either take up materials beyond cotton and can produce recycled products close to the virgin-quality. These could be mechanical, chemical or mix of the two technologies.

* Mutilated rags and other fibre and yarn waste have not been covered in detail in this study

STAKEHOLDER DEEP-DIVE ACROSS ALL SCENARIOS: WASTE HANDLERS AND RECYCLERS

Five archetypes of waste handlers were analysed through the study: 1) Pre-consumer waste collectors; 2) Pre-consumer waste aggregators; 3) New-age pilots/ startups for pre-consumer waste; 4) Importers of post-consumer waste; and 5) Aggregators of imported post-consumer waste. **Further, four archetypes of recyclers** were analysed through the study: 1) High-grade mechanical recyclers; 2) Low-grade mechanical recyclers; 3) Downcyclers; and 4) New-age patented recycling technologies.

KEY FINDINGS	WASTE HANDLERS	WASTE RECYCLERS
Operating Costs	**The cost of procuring waste contributes >60% of the daily operating cost for all archetypes of waste handlers,** with new-age pilots/ startups for pre-consumer waste having the highest average per kg operating cost.	**The daily operating cost for the recyclers was found to range between INR 300K - 2500K ($3.6K - $30.25K) depending on the quality of waste and the level of sorting required.** High-grade mechanical recyclers had the highest average per kg operating cost.
Capital Expenses (Capex)	Capex **was not found to be very significant across the archetypes of handlers as the machinery cost was low.**	**The cost of machinery set-up was observed to be the biggest differentiator in capex requirement and was directly proportional to the quality of output.** New-age patented recycling technologies were found to have the highest capex.
Challenges	**The lack of formalisation of the sector as well as the absence of ecosystem recognition and lack of understanding of the trade, were found to be the core challenges faced by the waste handlers.**	It was observed that **all archetypes of recyclers face challenges in procuring waste of desired quality and producing the desirable quality of recycled output.**

Figure 2: Cost comparison between waste handlers & recyclers

OPPORTUNITIES IDENTIFIED:

By estimating the costs for each stakeholder archetype and the three scenarios, the study presents the following opportunities for key ecosystem stakeholders including brands, manufacturers, governments, investors and other key civil society actors:

1. The ecosystem has the opportunity to build consensus on waste value potential and responsibility sharing. This can help unlock the value potential of a significant quantity of textile waste.

2. Building transparency & traceability in the value chain can solve the waste feedstock (incoming waste for recycling purposes) challenges being faced by the industry.

3. The Indian textile waste value chain provides a significant opportunity for fostering innovation & technology, especially for waste recycling, that can lead to beneficial returns from all economic, social and environmental aspects.

4. Improving efficiencies of waste handlers through capacity building, technological interventions and other pathways can improve the effectiveness of the overall textile waste value chain in India.

5. Fostering an enabling environment through open knowledge sharing among stakeholders can pave the way for a more sustainable and efficient textile waste value chain.

Through the findings, this study aims to encourage multi-stakeholder participation and data-driven solutioning to mainstream the textile waste value chain in India and create a closed-loop textile industry.

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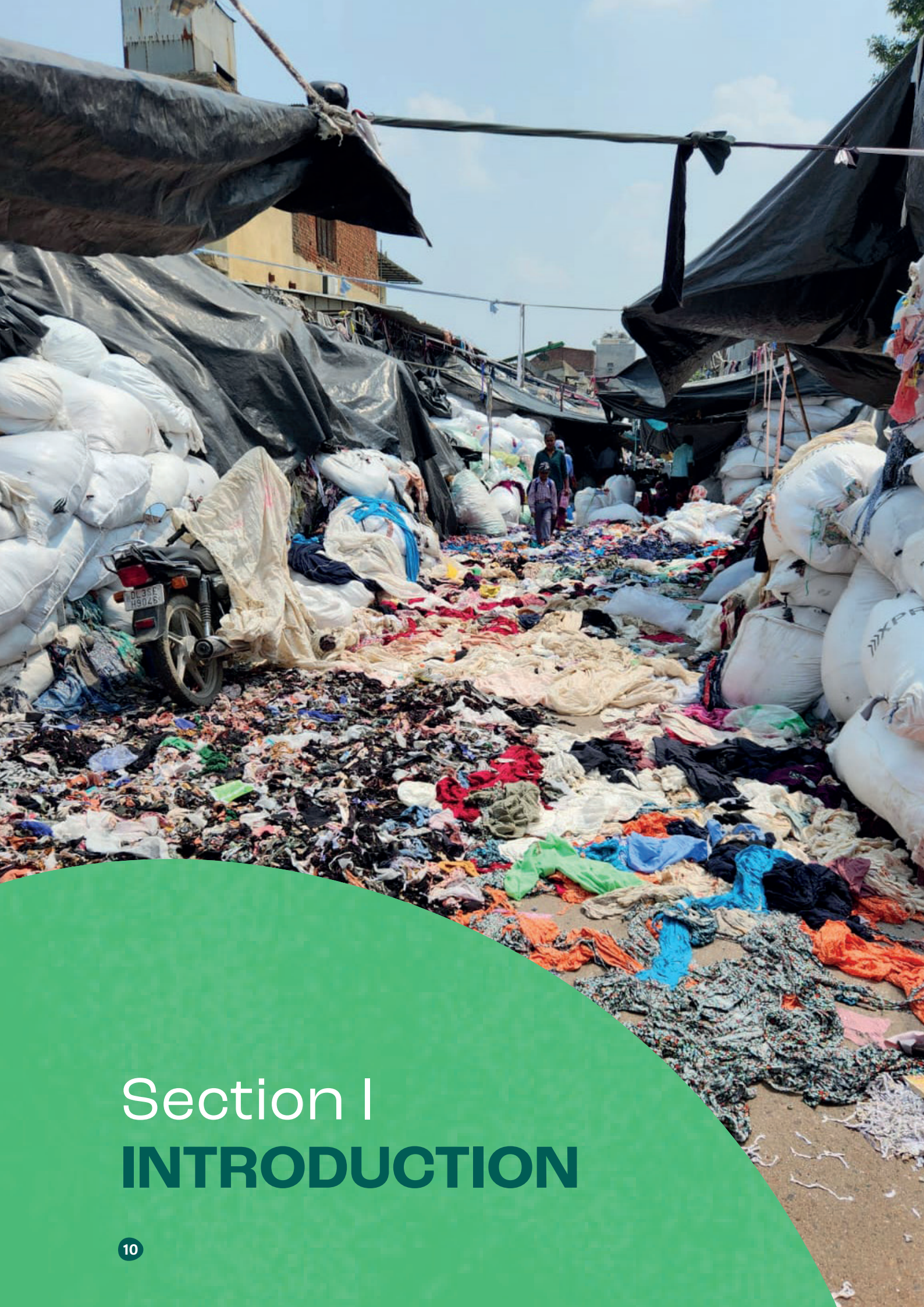


Section I
INTRODUCTION

3. About the Study

3.1. SIGNIFICANCE OF THE STUDY

India is one of the global leaders in textile and apparel manufacturing and also leads in the mechanical recycling of textile waste. The Textile and Apparel (T&A) industry is one of the largest contributors to India's economy constituting 2% of the country's GDP, 7% of industry output in value terms and 11.4% of the total exports[3]. Further, India is also an emerging consumer of textile and apparel products, with the domestic market growing at a CAGR of 10%[4]. Both the production and consumption patterns lead to a significant amount of waste generation. Estimates suggest that India manages ~7793 kilotons of textile waste annually from three sources- domestic manufacturers generating pre-consumer waste, domestic consumers generating post-consumer waste and imported waste coming from other countries. Despite the absence of extensive technologies, India established its recycling industry back in the 1990s[5] and today has a stronghold in mechanical recycling with a well-networked value chain (as depicted in Figure 3) for the management of textile waste. However, the industry is a mix of

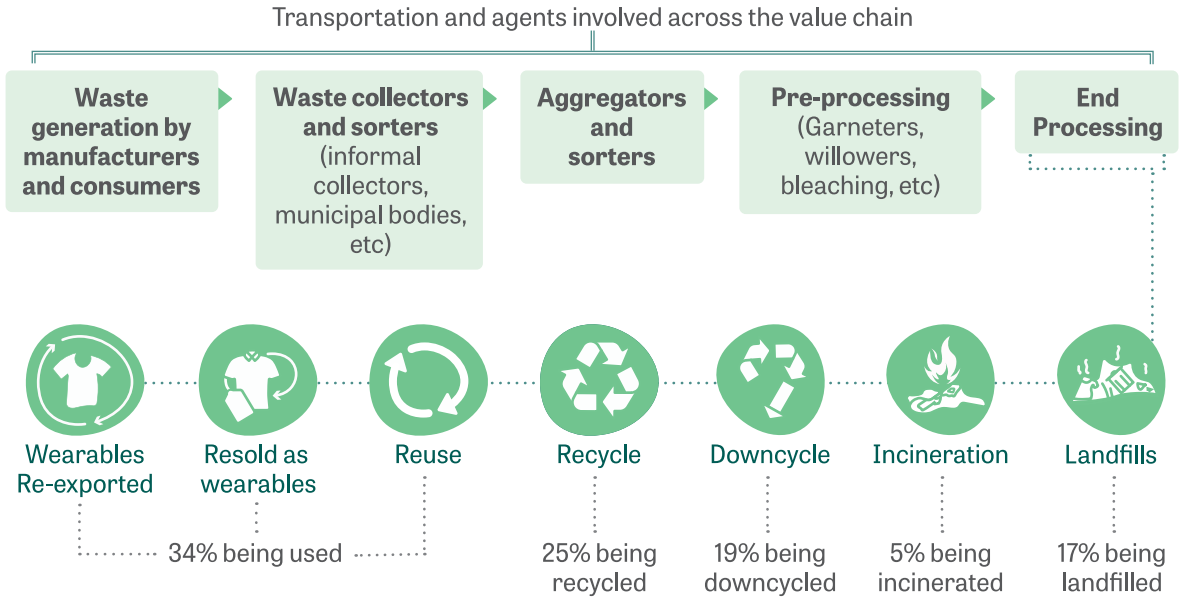


Figure 3: Value chain of textile waste in India[6]

[3] Textiles & Apparel: India- Knitting the Future. Retrieved May 18, 2023, from https://www.investindia.gov.in/sector/textiles-apparel

[4] Annual Report: India Textile & Apparel Industry 2021, Wazir Advisors and AEPC. Retrieved May 19, 2023 from https://aepcindia.com/system/files/Annual%20T%20and%20A%20Industry%20Report-2021.pdf

[5] Textile Recycling Unravelled, ARISA and Sympany. Retrieved May 19, 2023 from https://arisa.nl/wp-content/uploads/TextileRecyclingUnravelled.pdf

[6] Wealth in Waste (July, 2022). Fashion for Good and Sattva Consulting. Retrieved February 10, 2023, from https://reports.fashionforgood.com/wp-content/uploads/2022/07/Sorting-for-Circularity-Wealth-in-Waste.pdf

micro, small and large[7] stakeholders and approximately 41% of the waste is currently known to be moving out for usage in other allied industries[8]. Research indicates challenges around unorganised waste value chain and inefficient waste management as the major hindrance in realising the potential of the Indian textile waste management industry[9].

A common roadmap for all ecosystem stakeholders including brands, manufacturers, governments and investors is critical to drive the transition towards efficient utilisation of textile waste. The growing global focus on textile waste management and promoting closed-loop recycling provides India with a strong opportunity to present itself as a leader in the sector. Improved understanding of the operating structures and investment readiness of the Indian textile waste industry can act as an enabler for ecosystem stakeholders to invest in its growth. This study attempts to bring more visibility on the business aspects of the industry by unravelling the costs and efficiencies in the value chain so that ecosystem stakeholders can make informed decisions and enable the growth journey of the Indian textile waste management industry.

3.2 OBJECTIVES OF THE STUDY

This study aims to establish an understanding of the strategic opportunities for further interventions and investments in the textile waste value chain through a dipstick costing analysis.

The study provides insights on the following:

- Costs incurred by the various stakeholders in the textile waste value chain
- Challenges faced by the stakeholders in the textile waste value chain
- Variation in costs and challenges according to the three scenarios of textile waste flows
- Opportunities for ecosystem engagement and investments to drive systems change in the textile waste value chain

3.3 STUDY METHODOLOGY AND LIMITATION

Primary and secondary research was conducted across two months to understand the costs involved at each stage of the textile waste value chain. A total of 20 stakeholders across different stages of the value chain were interviewed to get varied perspectives and information on costs in the value chain. Six key areas of enquiry were studied through the primary interactions.

3.3.1 Study Sample & Focus Areas

Semi-structured interviews were conducted with each of the 20 stakeholders. Each of the interviews lasted for ~30 minutes and covered 15-20 questions around the six areas of enquiry highlighted in Figure 4.

Costs incurred and challenges faced in managing textile waste across the value chain were studied through six key areas of enquiry.

Figure 4: Areas of enquiry for the study

[7] Supra Note 5
[8] Supra Note 6
[9] Supra Note 6

The study respondents were selected based on their role in the value chain, the scenario of waste flow they belong to and their geographical location. The sampling, done through purposive sampling method, ensured the representation of at least 1-2 stakeholders from each part of the value chain. The breakup of the interviews is as follows[10]:

Scenario 1 (Textile waste is sourced in India and processed outside India): 3 stakeholders across manufacturers, waste aggregators and international recyclers

Scenario 2 (Textile waste is sourced and processed in India): 11 stakeholders across manufacturers, waste collectors, aggregators and domestic recyclers

Scenario 3 (Textile waste is sourced from outside India, might be processed in or outside India): 6 stakeholders across waste importers, aggregators and domestic recyclers

In terms of geographical representation, the study covered respondents from the following regions:

SELECTED GEOGRAPHIES	SIGNIFICANCE
Tiruppur, Tamil Nadu	Textile and apparel manufacturing and recycling hub
Chennai, Tamil Nadu	Textile and apparel manufacturing and waste collection hub
Bangalore, Karnataka	Textile and apparel manufacturing and waste collection hub
National Capital Territory of Delhi	Textile and apparel manufacturing and waste collection hub
Indore, Madhya Pradesh	Textile and apparel manufacturing and waste collection hub
Kandla, Kutch, Gujarat	Hub for importing post-consumer textile waste
Neemrana, Rath, Rajasthan	Textile waste recycling location
Amroha, Uttar Pradesh	Textile waste recycling and downcycling hub
Mohali, Punjab	Textile waste recycling location
Panipat, Haryana	Textile waste recycling and downcycling hub

Emerging recycling technologies from the Los Angeles, USA and Waregem, Belgium were also studied. A detailed breakdown of the geographical and stakeholder split is provided in Figure 5.

PRIMARY RESEARCH

2 Textile and apparel manufacturers (one with facilities in Delhi and Bangalore and one in Indore)	**2** New-age patented recycling technologies (1 in the US and 1 in Belgium)
2 Waste collectors (Both in Delhi)	**2** Importers of post-consumer waste (Both in Kandla)
5 Waste aggregators (2 in Bangalore, 1 in Panipat, 1 in Tiruppur and 1 in Chennai)	**7** Mechanical recyclers/ downcyclers (3 in Panipat, 1 in Neemrana, 1 in Mohali, 1 in Amroha, 1 in Tiruppur)

POLICY ANALYSIS

12 Regulations/policies / fiscal incentives by the Ministry of Textiles, Government of India, for the textile and apparel industry and other national waste management policies

Figure 5: Interviews and policy analysis conducted for the study

[10] The breakup double counts stakeholders that fall in more than one scenario. 20 unique stakeholders were interviewed for the study

3.3.2 Data Analysis

The study provides an in-depth analysis of two key stakeholders of the textile waste value chain - waste handlers and waste recyclers. Each stakeholder group is further broken down into smaller categories (referred to as 'archetypes' hereon), based on the type of waste they handle and their role in the value chain.

WASTE HANDLER
(intermediary between waste generator and recycler)

Five archetypes include:

- Pre-consumer waste collector
- Pre-consumer waste aggregator
- Importer of imported post-consumer waste
- Aggregator of imported post-consumer waste
- New-age pilots/startups for pre-consumer waste

WASTE RECYCLER
(process the waste to change its form)

Four archetypes include:

- High-grade mechanical recycler
- Low-grade mechanical recycler
- Downcycler
- New-age patented recycling technologies

Figure 6: Two key stakeholders analysed in the study

Cost analysis for each stakeholder has been divided into three broad categories and provides a floor and ceiling cost for each cost head, based on the information gathered through the interviews. [11] It is expected that the actual cost on a daily basis varies due to multiple factors and will fall somewhere within the given range of floor and ceiling costs. Further, certain informed assumptions have also been made in the costing analysis to ensure comparability and consistency in the data. [12] The three broad categories of cost include:

- **Capital Expenses (Capex):** This includes one-time investments made in the following:
  - » Land and factory set-up
  - » Machinery, including shredding machines, open-end spinning machines, waste handling machines, etc.
  - » Office set-up, including furniture, computers, etc.
- **Operating Expenses (Opex):** These include the daily/ monthly costs incurred by a stakeholder to run their operations. The following costs are covered under it:
  - » Cost of procuring waste
  - » Cost of labour and utilities involved in processing the waste
  - » Cost of transportation (to bring the waste into the facility)
  - » Salary costs of full-time employees
  - » Rental costs, if applicable
  - » Other miscellaneous costs pertaining to machine spare parts, food expenses, etc.
- **Inventory Cost:** This includes the cost of raw material and finished goods inventory maintained by the stakeholders.

The cost heads have been further analysed in the following ways:

- Average cost has been calculated from the given range of floor and ceiling costs to provide a simplified and comparable breakdown at places
- Payback period analysis has been done for the waste recycler archetypes to understand the investment opportunities in the same
- Cross-scenario comparisons have also been done using average costs

[11] Questionnaire for data collection has been added in Annexure III , attached in a separate technical appendix
[12] Detailed assumptions have been added in Annexure II , attached in a separate technical appendix

3.3.3 Study Limitations

This study was designed as a dipstick analysis with a limited scope and timeframe. Hence, the following limitations were faced that can be addressed in future:

- **Focus limited to import of second-hand clothing in India:** Import of mutilated rags, other yarn and fibre waste have not been studied in depth in this study due to a lack of stakeholder connections.
- **The current study takes a linear approach towards the waste going to recyclers:** However, there are multiple outlets of the waste to allied industries (automobile industry, paper & pulp industry, etc). This has not been accounted for and can be explored further in detail.
- **Perspectives of brands have not been studied:** Though an important stakeholder in the value chain, brands have a minimal role to play in the costing. Hence, their role has not been analysed in the current study.
- **Limited information on costs incurred by new-age patented recycling technologies:** Since these recyclers are mostly in pilot stages and also located outside the country, information on all cost heads was not available.
- **Information regarding the export value chain is limited:** This is largely because it is the most underdeveloped value chain in the Indian context, and includes very few stakeholders.
- **Domestic post-consumer waste has not been a core focus** and can be explored further. This was largely because the value chains for this waste type are largely informal and establishing stakeholder connections was difficult in the period of the study.

4. Understanding the three scenarios of textile waste management in India

Imported and domestic waste value chains are structured differently in India. While domestic waste aggregates and reaches recyclers, imported waste disaggregates as it moves through the value chain to reach the recyclers.

The study found that different value chains (scenarios) of textile waste management operate in India. The input and output of these scenarios vary, leading to differential costs as well. Though there is no clear demarcation possible amongst the stakeholders as they may be dealing with materials of both imported and domestic waste value chains, some amount of specialisation and scenario association was found to be consistent. Three such prominent value chains were examined in this study, while other variations are also known to exist. Figure 7 depicts these three value chains and Figure 8 details the characteristics of each of them.

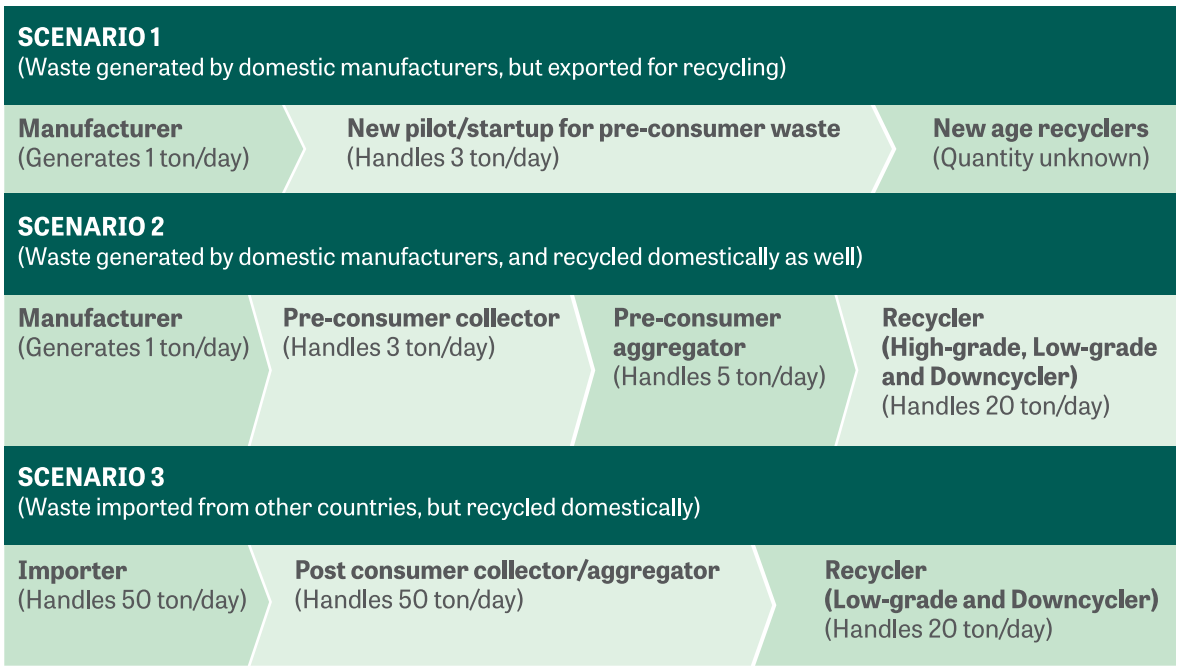
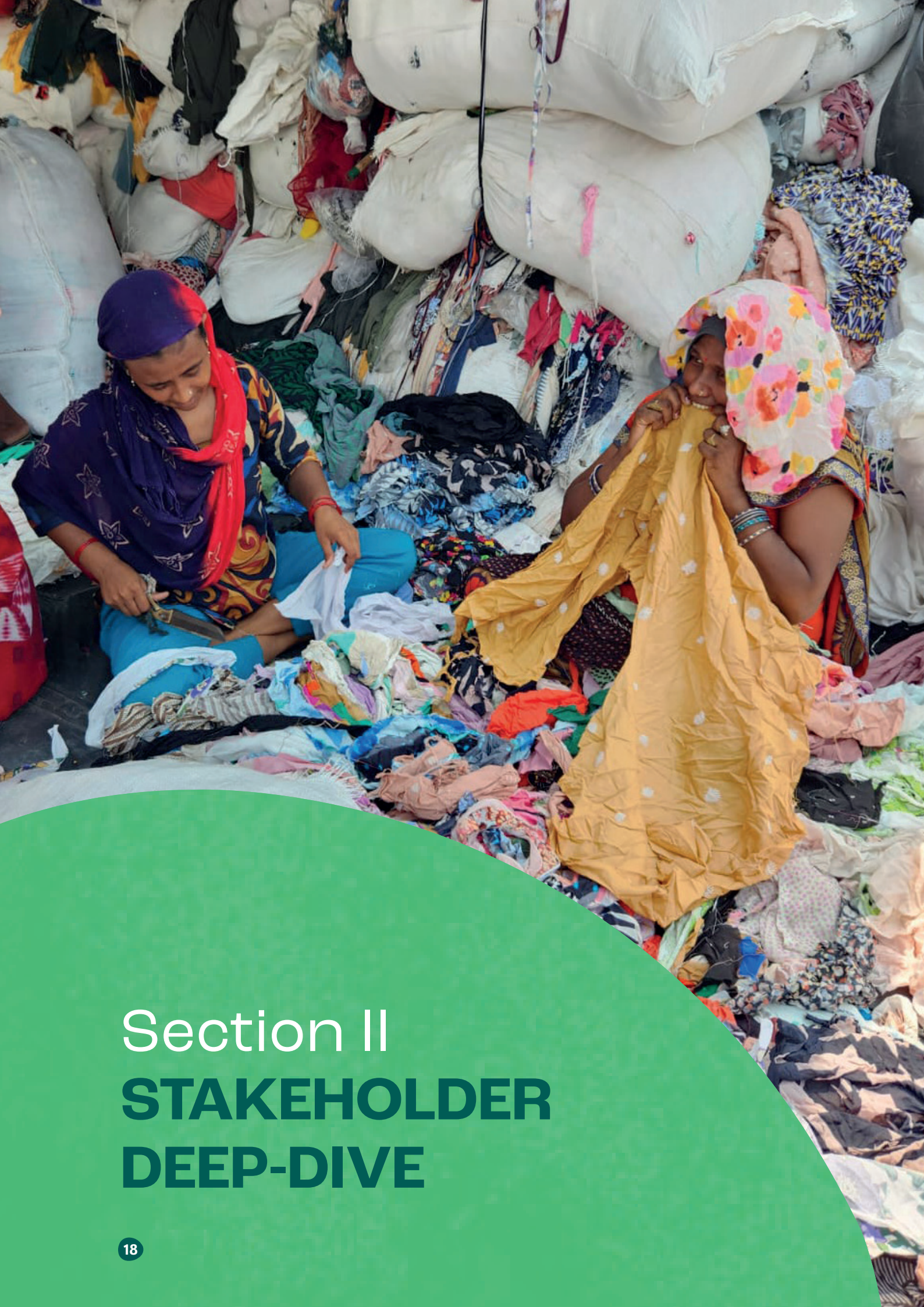


Figure 7: Illustrative scale of operations across the value chain of the three scenarios

COMPARISON PARAMETERS	SCENARIO 1 Textile waste is sourced in India and processed outside India.	SCENARIO 2 Textile waste is sourced and processed in India.	SCENARIO 3 Textile waste is sourced from outside India and processed in India.
Type of Waste	• Pre-consumer cutting waste. Mostly cotton-rich	• Pre-consumer cutting waste. Mostly cotton, polyester and blended/ mixed waste	• Post-consumer waste imported from US, EU, UAE and East Asian countries. Consists of mostly cotton, acrylic and wool materials
Source	• Pre-consumer textile waste from key manufacturing locations	• Pre-consumer textile waste from key manufacturing locations	• Second-hand clothing arrives at Kandla port from developed regions such as the USA, Canada, Japan, and EU • Mutilated rags imported from Korea, Vietnam and Bangladesh (not covered in depth)
Processing	• Textile waste is sent to chemical and advanced mechanical recycling technologies in the EU, US and other Western countries	• Most of the textile waste that is generated domestically converges at Panipat and Tiruppur. • Small-scale downcycling facilities are prominent in Amroha and parts of Rajasthan, Madhya Pradesh, Punjab and Gujarat	• Most of the textile waste that is imported converges at Panipat. Tiruppur receives some waste from Bangladesh and Vietnam. • Small-scale downcycling facilities are prominent in Amroha and parts of Punjab
End Use	• Processed waste is majorly sold as recycled products (could be yarn or in the form of fibre)	• Waste is either resold as wearables, recycled into yarns or downcycled, to be used by allied industries. • Recycled yarns are used in the home furnishing industry, domestically as well as exported to other countries	• Second-hand clothing is majorly re-exported to Africa and Southeast Asia. • The remaining waste is either recycled into yarns for the home furnishing industry or downcycled for allied industries
Stakeholders	• Waste collectors, aggregators, traders, exporters, recyclers and downcyclers	• Waste collectors, aggregators, traders, recyclers, resellers and downcyclers	• NGOs / Charities in other countries, exporters in other countries, importers, traders, recyclers, Indian re-exporters and downcyclers

Figure 8: Overview of the three scenarios



Section II
STAKEHOLDER DEEP-DIVE

5. Waste Handlers

Five prominent archetypes of waste handlers can be found in the Indian textile waste value chain, largely varying according to the type of waste handled. Due to the minimal machinery requirement, the capital requirement for starting a textile waste handling business is usually low but the operating costs can be high with the cost of procuring the waste itself forming the largest component.

5.1 WASTE HANDLER ARCHETYPES

Different types of waste are handled by different archetypes of waste handlers in India. While the imported post-consumer waste gets handled by importers and aggregators, the pre-consumer waste is collected by waste collectors, which is further accumulated by aggregators, who supply it to the recyclers. Apart from these traditional setups, there are new-age pilots and startups who engage with recyclers and are trying to build more structures and standards around the sorting process, and ensuring better working conditions for the workers.

TYPE OF WASTE HANDLED	PROCESSING DONE	OUTPUT/ PRODUCT	AVERAGE QUANTITY HANDLED*
PRE-CONSUMER WASTE- Collector			
Mixed and sorted cutting waste from manufacturers. Consist of all compositions	Sorting of waste	Waste sorted by colour or composition	**3 MT/ DAY**
PRE-CONSUMER WASTE- Aggregator			
Waste sorted by either colour or composition collected from collectors	Sorting, aggregation and storage of waste as per recycler needs	Waste sorted by recycler/upcycler needs	**5 MT/ DAY**
IMPORTED POST-CONSUMER WASTE *- Importer			
Consists of wearable and non-wearable clothing made of cotton, wool and acrylic. Imported from US, EU, UAE, Asian countries, etc.	Importing, sorting, re-exporting of second-hand clothing	Wearables re-exported to Africa and non-wearables sold in Indian recycling market	**50 MT/ DAY**
IMPORTED POST-CONSUMER WASTE *- Aggregator			
Non-wearable second hand clothing collected from importers. Made of cotton, wool and acrylic	Sorting of waste as per recycler specifications	Sorted waste for recycling, downcycling and upcycling use cases	**50 MT/ DAY**
New age pilots/ startups have also emerged in this space that ensure better working conditions (adequate space, well lit and ventilated working space, PPEs, etc) and wages for workers. In this research, we have studied one such startup dealing with pre-consumer cutting waste. Average quantity being handled is kept consistent with waste collectors at 3 MT/day. However, these startups directly engage with recyclers and hence are both collectors and aggregators. Similar pilots exist for domestic post-consumer waste as well.			

** Importers of pre-consumer waste/mutilated rags/fibre waste from Bangladesh and other countries have not been studied in detail in this study. Available cost data for these stakeholders have been duly mentioned in relevant places.*

Figure 9: Archetypes of waste handlers across value chains and scenarios

5.2 COSTS INCURRED BY VARIOUS ARCHETYPES OF WASTE HANDLERS

CAPITAL EXPENSES
(includes factory/ facility set-up cost, machinery cost, etc)

Pre-consumer waste collectors

INR **10K - 28K**
($121 - $339)

Pre-consumer waste aggregators

INR **100K - 130K**
($1.2K - $1.57K)

New Pilots/ Start-ups for pre-consumer waste

INR **400K - 500K**
($4.84K - $6.05K)

Importers of post-consumer waste

INR **500K - 2,200K**
($6.05K - $26.6K)

Aggregators of imported post-consumer waste

INR **200K - 700K**
($2.4K - $8.47K)

TOTAL INVENTORY COSTS AT ANY POINT OF TIME
(includes raw material and finished goods inventory)

Pre-consumer waste collectors

NOT AVAILABLE AS THEY PREFER ZERO INVENTORY

Pre-consumer waste aggregators

INR **30K - 1,500K**
($363 - $18.15K)

New Pilots/ Start-ups for pre-consumer waste

INR **65K - 900K**
($787 - $10.89K)

Importers of post-consumer waste

INR **9,000K - 103,250K**
($108.9K - $1249K)

Aggregators of imported post consumer waste

NOT AVAILABLE

5.2.1 Capital Expenses and Inventory Costs for Handlers

The preliminary dipstick study highlighted that the initial capital requirement for waste handlers can range between INR 10K and 2,200K ($121 and $26.6k), depending on multiple factors. This cost was found to be the highest for importers who deal with high quantities of imported post-consumer waste and have to install conveyor and baling machines. At the lowest end, were the pre-consumer waste collectors who were found to be working with small quantities of waste and did not have any machinery.

Pre-Consumer Waste Handlers:

The study suggested that the pre-consumer waste collectors on average deal with 3MT of waste per day. Pre-consumer aggregators, on the other hand, were found to have a bigger scale and dealt with roughly 5MT of waste per day. This change in the quantum of waste also translates into variation in the initial capital requirement.

> While the pre-consumer collectors were found to be spending between INR 10K - 28K ($121 - $339) on the initial setup, the capital requirement of pre-consumer aggregators went beyond INR 100K ($1.2K).

Our research estimates that this difference is mostly because many aggregators own vehicles for collecting the waste. Basic set-up including furniture (tables, chairs) and weighing machines remains common between both these archetypes of waste handlers.

> While the aggregators had a high inventory, collectors preferred to not hold any inventory.

The study found that the primary role of aggregators is to store waste and ensure that the right quantities are available for the right use case. Hence, they were found storing about 10MT of waste on any given day, whereas the pre-consumer collectors did not keep any inventory and preferred collecting the waste twice a week, spending the remaining time sorting and selling it.

Imported Post-Consumer Waste Handlers:

In contrast to pre-consumer waste handlers, imported post-consumer waste handlers (importers and aggregators) deal with 50MT of waste per day. The 16 authorised importers of this waste in Kandla Special Economic Zone were found to be importing about 100 to 250 containers every month, containing 15-20MT of waste each. Post-sorting, the non-wearable waste is transferred to the imported waste aggregators.

> The capital investment of importers ranged from INR 500K - 2,200K ($6.05K - 26.6K) while that of import aggregators was between INR 200K - 700K ($2.4K - $8.47K).

In terms of their setup, both importers and imported waste aggregators were found to be using baling machines. In addition, the importers were also found using conveyor belts and hence requiring a higher initial investment. The importers were also found to hold a higher inventory (as high as 1500 - 1750 MT in some cases).

New Pilots/ Start-ups for pre-consumer waste:

> The study suggested that the new-age pre-consumer waste handling pilots needed an initial capital of around INR 400K - 500K ($4.84K - $6.05K), which was significantly more than the traditional pre-consumer collectors and aggregators.

This was because of the costs involved with facility registration, vehicles, conveyor belts, baling machines, and other sorting consumables such as gloves, masks and PPEs to ensure better efficiencies and compliances. On average, these startups were found to be handling similar quantities to the pre-consumer waste collectors but some of these startups directly engaged with recyclers and therefore played the role of both collectors and aggregators.

5.2.2 Operating Costs for Handlers

The study found that the operating costs for handlers can range between INR 34K - 4,500K ($411 - $54.45K) per day depending on the quantum and quality of textile waste being handled. Further, we found that the cost of procuring waste contributed >60% of the daily operating cost for all archetypes of waste handlers and went up to 85% of the daily operating cost for certain archetypes.

Pre-Consumer Waste Handlers (including collectors and aggregators):

For the pre-consumer waste value chain, the sorting begins as the waste reaches pre-consumer collectors. While the collectors sort the waste by colour or composition, aggregators carry out detailed sorting to match recycler requirements.[13]

> The study observed a significant variation in the type of waste received by the collectors, leading to the cost varying anywhere between INR 12 - 119 per kg ($0.15 - $1.44) for waste collectors and INR 7 - 175 per kg ($0.08 - $2.11) for waste aggregators.

This variation indicates the practice of collecting both mixed and sorted waste at different prices and then sorting and cross-subsidising the cost of poor-quality material with the cost of the better quality waste. This explanation was also confirmed in the qualitative conversations with the stakeholders.

Other key cost components for the waste handlers included the following:

- The cost of sorting (manual labour) was found to be between INR 1 - 5 ($0.01 - $0.06) per kg across both stakeholders.

[13] Wealth in Waste (July, 2022). Fashion for Good and Sattva Consulting. Retrieved February 10, 2023, from https://reports.fashionforgood.com/wp-content/uploads/2022/07/Sorting-for-Circularity-Wealth-in-Waste.pdf

- The rental cost for the facility was found to range between INR 10K - 80K ($121 - $968) per month depending on the size and the location.
- Another small yet significant cost element was found to be the cost of transportation. It was found to be comparatively higher for aggregators as at times they might not only be collecting waste from within the city but also from neighbouring cities or states. Both stakeholders highlighted transportation costs to be an additional burden.

Imported Post-Consumer Waste Handlers:

> The study suggested that the importers of post-consumer waste had the highest floor cost of operations and the overall cost ranges between INR 1,200K - 4,200K ($14.52K - $50.82K) per day while the aggregators of imported post-consumer waste spent around INR 300K - 4,500K ($3.63K - $54.45K) daily on operations.

The highcost structure for both handlers can largely be attributed to their larger scale of operations. Though the freight costs for importing waste from countries such as the USA, EU, and UAE formed a significant share of the costs incurred by importers of post-consumer waste, the higher workforce requirement and formal structures of payment also added to the operating costs. However, the cost of waste itself did not have a wide range and was found to be slightly lower in this case (as against pre-consumer waste handlers).

Further for the aggregators of post-consumer waste, following observations were made:

- Aggregators of imported post-consumer waste procured diverse waste types including high-quality wool which comes at a higher cost.
- They also had large space requirements due to their high daily capacity. Even though the warehouse cost could be high in absolute terms, compared to other costs, it formed an insignificant portion of their total costs.

New Pilots/ Start-ups for pre-consumer waste:

> As per the study, new-age pilots of pre-consumer waste spent between INR 100K - 400K ($1.21K - $4.84K) daily on operations.

This included expenses on labour and utilities, transportation, procurement, rent, salaries and other miscellaneous costs. They were found to be incurring a greater labour cost due to limited scale and better provisions for workers such as adequate space for sorting the waste, well-lit and ventilated spaces, PPEs, modernised tools for operations, etc.

TOTAL OPERATIONS COST PER KG OF WASTE

(includes cost of waste, transportation, labour, utility, etc)

Pre-consumer waste collectors

INR **12 - 119 per kg**
($0.15 - $1.44 per kg)

Pre-consumer waste aggregators

INR **7 - 175 per kg**
($0.08 - $2.11 per kg)

New Pilots/ Start-ups for pre-consumer waste

INR **35 - 142 per kg**
($0.42 - $1.72 per kg)

Importers of post-consumer waste

INR **24 - 84 per kg**
($0.29 - $1.02 per kg)

Aggregators of imported post-consumer waste

INR **6 - 90 per kg**
($0.07 - $1.09 per kg)

TOTAL DAILY OPERATIONS COST OF WASTE HANDLING
(includes cost of waste, transportation, labour, utility, etc)

Pre-consumer waste collectors

INR **36K - 360K**
($436 - $4.36K)

Pre-consumer waste aggregators

INR **34K - 870K**
($411 - $10.52K)

New Pilots/ Start-ups for pre-consumer waste

INR **100K - 400K**
($1.21K - $4.84K)

Importers of post-consumer waste

INR **1,200K - 4,200K**
($14.52K - $50.82K)

Aggregators of imported post-consumer waste

INR **300K - 4,500K**
($3.63K - $54.45K)

5.3 CHALLENGES FACED BY THE WASTE HANDLERS

Even though all archetypes of handlers work to make the value chain efficient, the lack of formalisation of the sector, the absence of the ecosystem's recognition and lack of understanding of the trade are the core challenges faced by waste handlers.

- **Sourcing and Procurement challenges:** Stakeholders highlighted that the cost of waste is very dynamic as it depends on the cost of raw cotton and the availability of material. Hence, manufacturers find it hard to standardise their raw material procurement costs and it ultimately increases the cost of waste. Further, collectors and aggregators usually accept all types of waste to ensure the continuance of their business even though they might not receive adequate returns on the same.
- **Lack of established use-cases for handling the waste:** No set procedural standards or processes were found in the industry for handling and sorting waste. This is leading to two concerns in the industry. Firstly, the waste handlers are unable to maximise returns from all types of waste as they might not be aware of the use case for some of them. Due to this, they also end up storing the waste for a longer duration. Secondly, this could potentially be leading to increased efforts and costs for handlers to train their workers.

  The study found that the lack of established use-cases renders inconducive returns for the handlers and further hinders the formalisation of trade. Waste handlers are unable to ensure minimum wages, social security and safety measures for workers. All of these challenges were found to impact business feasibility for the handlers.
- **Challenges with transportation and storage of waste:** Though our analysis suggested that the storage of waste amounts to only 1-2% of the total operating cost, stakeholders highlighted that even this small share proves to be a significant hindrance to the viability of the business. Along with the high rent for storage facilities, handlers also have to bear the high transportation costs, which in turn was found to affect their profit margins.
- **Limitations of existing rules and policies:** The study highlighted that there is a lack of certifications, regulations and monitoring mechanisms for waste handlers. The absence of formal trade recognition, leading to the inability to access formal credit and other benefits was raised as a concern by multiple waste handlers. While government initiatives in this direction are shaping up, on-ground implementation along with clear accountability and responsibility of all the value chain stakeholders would be required to streamline the waste management practices. Best practices from the plastic and solid waste management systems in India[14,15] can be adapted to the context of textile waste management.

[14] Solid Waste Management Rules, 2016:https://cpcb.nic.in/uploads/MSW/SWM_2016.pdf
Municipal SWM Manual Part 1: https://cpheeo.gov.in/upload/uploadfiles/files/Part1(1).pdf
Municipal SWM Manual Part 2: https://mohua.gov.in/upload/uploadfiles/files/Part2.pdf

[15] Plastic Waste Management Rules: https://cpcb.nic.in/uploads/plasticwaste/2-amendment-pwmrules-2022.pdf
Guidelines on EPR for plastic packaging: https://cpcb.nic.in/uploads/plasticwaste/PWM-Amendment-Rules-2022.pdf

- **Constraints with scaling of operations:** Importers have reported a decline in the quality of imports from their global counterparts. Importers claimed that they are unable to sell 30% of their waste as it is not in good condition to be re-exported as re-wearables to Africa. While this is impacting the business feasibility and growth of the importers, it also provides an opportunity for the Indian recycling industry to access this waste.

HANDLERS OF DOMESTIC POST-CONSUMER WASTE:

Though domestic post-consumer waste was not a focus for this study, preliminary conversations with a leading waste aggregator highlighted similar challenges for this archetype as well. They suggested a total operating cost of INR 45 - 50 per kg ($0.54 - $0.61). This included sorting of waste and utilities. An additional expense was incurred in procuring the waste from across the city since that required a high transportation and purchase of vehicles. Post sorting, 30 to 40% of the waste was sold in the second-hand markets for ~INR 8 - 12 ($0.10 - $0.15) per kg. About 5-10% of the collected waste moved for upcycling use cases, 10% to thrift shops and 20-30% for recycling/ downcycling. Around 20% of the waste was found to be contaminated or soiled and was being sent for energy recovery to waste-to-energy plants as there are no processes and technology for recovering reject textile waste.

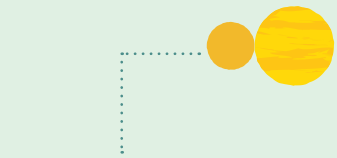
The aggregator highlighted that the biggest challenge for them was the cost of sorting facility and transportation involved in procuring the waste. Further, while this aggregator was ensuring worker well-being, they highlighted a need of government support for the upliftment of the workers , in terms of working conditions and capacity building, across the textile waste industry.

Waste Handlers

PRE-CONSUMER

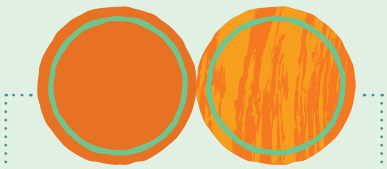
IMPORTED POST-CONSUMER

WASTE HANDLERS ARCHETYPES



Collector (Daily)
HANDLING **3 MT**

Aggregator (Daily)
HANDLING **5 MT**



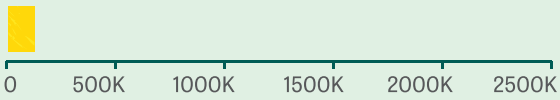
Importer (Daily)
HANDLING **50 MT**

Aggregator (Daily)
HANDLING **50 MT**

○ actual size to be 5 times the current size on the given scale as compared to pre-consumer

CAPITAL EXPENSES (Cost Breakdown)

INR 10K - 130K ($ 121 - $1.57K)



Factors affecting cost breakdown

- Trucks/ Transportation Vehicle
- Weighing machine
- Table, Chair, office furniture

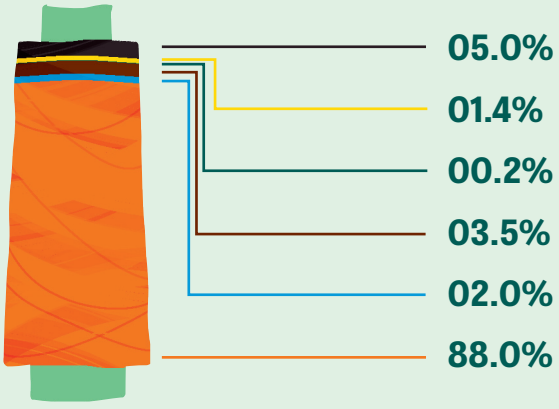
INR 200K - 2,200K ($2.42K - $26.62K)

Factors affecting cost breakdown

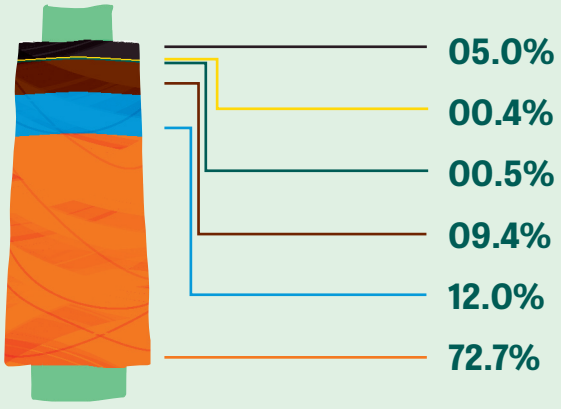
- Conveyor machine
- Weighing machine
- Table, Chair, office furniture
- Baling machine

OPERATING COST (Cost Breakdown)

INR 7 - 175 per kg ($0.08 - $2.11 per kg)



INR 6 - 90 per kg ($0.07 - $1 per kg)



● Cost of Waste ● Labour Cost ● Transportation ● Salary ● Rental ● Miscellaneous

For the sake of easy comparison, the average costs of the two types of pre-consumer waste handlers and imported post-consumer waste handlers have been taken into account.

CHALLENGES:

Sourcing & Procurement Challenges

"Cost of waste is very dynamic. It depends on the cost of raw cotton and the availability of material. I am forced to accept waste types that I don't need as I risk losing business if I decline to take a certain type of waste." - Waste handler in Tiruppur

Challenges with transportation & storage

"If I go for a proper facility, rental costs are too high for me and I have to pay them irrespective of waste availability. Transportation cost is also high because I have to source waste from multiple facilities." - Waste Handler in Delhi

Lack of established use-cases for handling waste

"There are no procedural standards on how I should manage my waste. We are just doing it as we understand it or how others around me are doing. If I want to improve these working conditions, I will have to bid a lower price for waste to manage costs. I won't get business in the bidding then."
- Waste Handler in Delhi

Constraints with Scaling of Operations

"As an importer, my imports have declined and I don't have a market for a portion of the waste I receive. I had to let go my workers to cut cost." - Waste Importer in Kandla

Limitations on Existing Rules & Policies

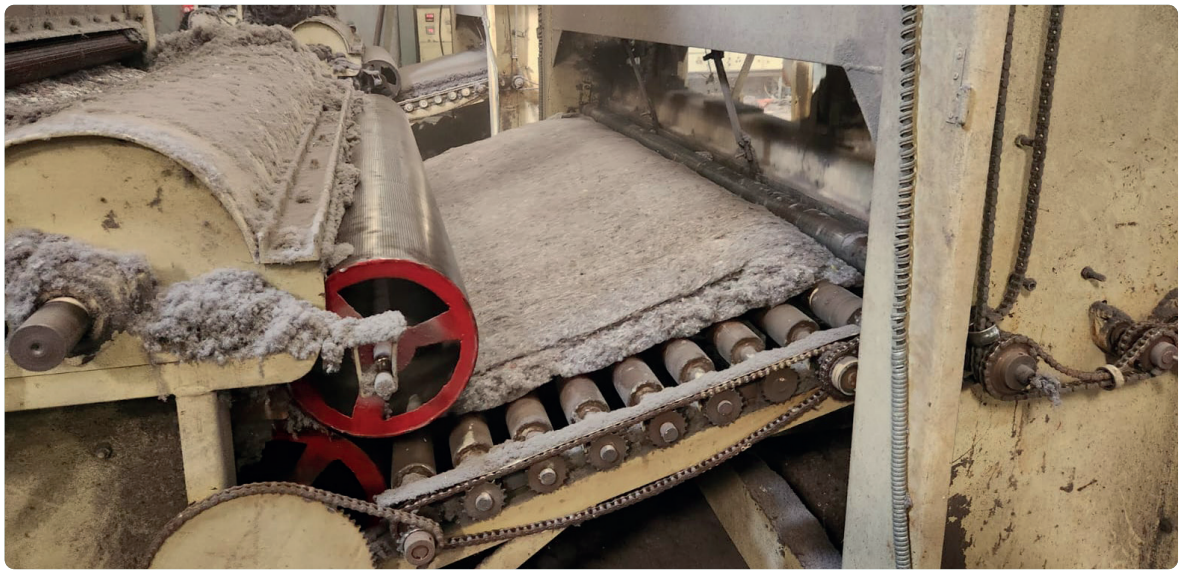
"No one recognises our trade. Plastic traders or e-waste traders are known and understood but we are not. We can't access formal credit also because of this."
- Waste Handler in Bengaluru

6. Waste Recyclers

Three prominent and one emerging archetype of waste recyclers can be found in the Indian textile waste value chain. All of them require a significant initial capital to set up their facilities. However, the concerns raised by them were more related to the supply of waste and the quality of their produce, which are directly impacting their business viability.

6.1. SPECIFICATIONS OF WASTE RECYCLERS

Low-grade mechanical recycling is the most matured and widely present archetype of recyclers in the country as they accept a wide range of waste. They can process knitted cotton waste, irrespective of colour and percentage of cotton (referred to as 'low-quality feedstock', hereon). High-grade mechanical recyclers, on the other hand, accept a niche quality of white/ pastel and knitted 100% cotton (referred to as 'high-quality feedstock', hereon), but their output is a finer yarn and goes for a good price in the international market. Downcyclers deal with materials that cannot be recycled back into yarn (also referred to as 'low-quality feedstock', hereon) and are also well-established in the country. Along with these archetypes, the new-age patented technology recyclers, who deploy chemical and mechanical processes for recycling textile waste see India as a potential destination for scaling up their operations in the near future.



TYPE OF WASTE HANDLED	PROCESSING DONE	OUTPUT/ PRODUCT	AVERAGE QUANTITY HANDLED*
HIGH-GRADE MECHANICAL RECYCLERS			
100% cotton, knitted, solid coloured waste	Sorting, shredding and open-end spinning of waste. Ring-spun process is also being piloted by a few	Cotton blend yarns of more than 20s Ne count	**10 - 30 MT/ DAY**
LOW-GRADE MECHANICAL RECYCLERS			
Knitted cotton and cotton rich waste (more than 50%) in solid colors	Sorting, shredding and open-end spinning of waste. Some recyclers just shred the waste and sell it to other open-end spinners	Cotton blend yarns of up to 20s Ne count	**2 - 20 MT/ DAY**
DOWNCYCLERS			
All kinds of coloured and printed waste, including cotton, polyester, blends, etc	Sorting and shredding of waste	Shredded fibres sold as fillers for beddings, paper and pulp industry, automobile industry, insulation, etc	**10 - 20 MT/ DAY**
NEW-AGE PATENTED TECHNOLOGIES			
Waste type depends on the technology. Can range from polyester rich to cotton rich	Entirely automated process and the material can be directly fed into the machine	Recycled fibre/ pellets for spinning	**Depends** on the setup. Currently in pilot stages only

* The study considers average daily quantity of 20 MT for each of the recycler archetypes for easier comparability.

Figure 12: Specifications of four types of textile waste recyclers[16]

[16] These parameters define an ideal organisation falling in these archetypes. However, practically there are no stringent boundaries between these archetypes and a single organisation could fall in different categories depending on the type of waste being dealt with or based on the buyer requirements.

6.2 COSTS INCURRED BY VARIOUS ARCHETYPES OF WASTE RECYCLERS

CAPITAL EXPENSES

(includes built factory cost. shredding, open-end spinning and other machinery costs)

High-grade mechanical Recyclers

INR **1,50,000K - 1,90,000K**

($1,815K - $2,299K)

Low-grade mechanical Recyclers

INR **52,600K - 80,000K**

($636K - $968K)

Downcyclers

INR **20,000K - 40,000K**

($242K - $484K)

New-age patented technologies

INR **4,380,000K - 5,840,000K ($53,001K - $70,668K) for 15,000 - 20,000 MT** CAPACITY PER YEAR

TOTAL INVENTORY COSTS AT ANY POINT OF TIME

(includes cost of raw material and finished goods inventory)

High-grade mechanical Recyclers

INR **1,20,000K - 2,00,000K**

($1,452K - $2,420K)

Low-grade mechanical Recyclers

INR **20,000K - 100,000K**

($242K - $1210K)

Downcyclers

INR **12,000K - 80,000K**

($145K - $968K)

New-age patented technologies

CANNOT BE ASCERTAINED FOR INDIA SINCE IT IS A PILOT OUTSIDE OF INDIA

6.2.1 Capital Expenses and Inventory Costs for Recyclers

The study found that the capital expenses required for recyclers are significantly higher than waste handlers. Further, high-grade mechanical recyclers require nearly three times more initial capital than a low-grade mechanical recycler and approximately six times more than that of a downcycler.

High-grade and low-grade mechanical recyclers:

> **Capital expenses on Machinery**
> High-grade mechanical recyclers usually deploy German or other European shredding and open-end spinning machines while low-grade mechanical recyclers utilise low-end or second-hand open-end spinning machines.

> **Inventory cost**
> The study found that both high-grade & low-grade recyclers maintained high levels of inventory of raw materials to ensure consistency in production leading to a high inventory cost.

Downcyclers:

> The study suggested that downcyclers had the least initial capital investment ranging between INR 20,000K - 40,000K ($242K - $484K)

This was because they only require a shredding machine and not the entire spinning set-up. In most cases, the downcycled material is used as fillers in the bedding, toy or automobile industry while some quantity of waste goes towards non-woven materials. It was also observed

that downcyclers store inventory for a lesser time when compared to high-grade & low-grade recyclers.

New-age patented recycling technologies:

> Preliminary conversations with a few new-age patented technologies recyclers suggested that the cost of setting up these units could potentially be as high as 25 times the cost of high-grade recyclers.

The annual capacity of these plants is expected to be double than that of a mechanical recycling plant[17] and the quality of output is also expected to be higher, however, the level of differentiation is not known yet. Since these technologies are in the pilot stage currently, set-up costs and inventory costs could not be standardised.

6.2.2 Operating Cost for Recyclers

The daily operating cost for the recyclers is expected to range between INR 300K - 2,500K ($3.63K - $30.25K) depending on the quality of waste and the level of sorting required.

High-grade and low-grade mechanical recyclers:

> The study suggested that high-grade recyclers incur the highest average daily operating costs which ranges from INR 1,200K - 2,100K ($14.52K - $25.41K) per day, while the operating costs for low-grade mechanical recyclers can range anywhere between INR 500K - 2,500K ($6K - $30.25K)[18].

The cost of waste procurement formed the highest share of operating costs for both of the mechanical recyclers. The high operating cost for high-grade recyclers can be attributed to the formal & large set-up of these units. Further, the higher range for low-grade mechanical recycling indicates a higher effort requirement for sorting as a wide variety and quality of waste is expected to be flowing to them.

Downcyclers:

> It was observed that downcyclers had a relatively lower operational cost ranging between INR 300K - 2,000K ($3.63K - $24.2K) per day.

The wide range of costs was found because of the variation in quality of textile waste received by the downcyclers. In certain cases, high-quality feedstock was also found moving to them, especially for further usage in the paper and pulp, and wipes industry. However, the overall lower operating costs exist since they usually have informal set-ups, do not have salaried employees and the owner themselves oversees the entire process, making the cost of salaries negligible. This, coupled with a reduction in the processes to be carried out for recycling brought down their operational cost.

New-age patented recycling technologies:

The operating costs for new-age patented technology recyclers could not be ascertained since they are currently in a pilot stage outside India. They deal with only specific waste types depending on the nature of their technology. This could range from polyester-rich to cotton-rich waste. The entire process is automated such that the material can be directly fed into the machine and the final product is achieved in the end.

TOTAL OPERATIONS COST PER KG OF WASTE

(includes cost of waste, transportation, labour and utilities)

High-grade mechanical Recyclers

INR **60 - 107 per kg**

($0.73 - $1.29 per kg)

Low-grade mechanical Recyclers

INR **26 - 125 per kg**

($0.31 - $1.51 per kg)

Downcyclers

INR **16 - 100 per kg**

($0.19 - $1.21 per kg)

New-age patented technologies

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[17] Mechanical recycling units (both high and low-grade) have been considered for an average capacity of 20 MT per day. For new-age patented technologies, the capacity is expected to be 40-50 MT per day.
[18] The ceiling cost is higher for low-grade mechanical recyclers since their labour cost in sorting of waste was found to be higher. Annexure II, attached in the technical appendix separately, provides further insights in the same.

TOTAL DAILY OPERATIONS COST OF WASTE RECYCLING

(includes cost of waste, transportation, labour and utilities)

High-grade mechanical Recyclers

INR **1,200K - 2,100K**
($14.52K - $25.41K)

Low-grade mechanical Recyclers

INR **500K - 2,500K**
($6.05K - $30.25K)

Downcyclers

INR **300K - 2,000K**
($3.6K - $24.2K)

New-age patented technologies

CANNOT BE ASCERTAINED FOR INDIA SINCE IT IS A PILOT OUTSIDE OF INDIA

6.3 CHALLENGES FACED BY WASTE RECYCLERS

All archetypes of recyclers face challenges in procuring waste of desired quality and quantity and producing the desirable quality of output.

- **Challenges with sourcing and procurement of waste:** Stakeholders highlighted that the desired volume and quality of waste was not available in the market, or in case it was available they did not have visibility on the same due to lack of transparency in the value chain. This was found to be especially true in the case of 100% cotton and cotton-rich material which has a high demand and lower supply. The concerns around procuring waste are expected to increase as the supply of imported pre-consumer waste from Bangladesh and Vietnam might decrease, owing to the growing recycling initiatives in these countries. It is hence becoming imperative for stakeholders to have greater visibility on the waste availability within India.
- **Challenges with waste-feedstock quality:** The study suggested that the concerns regarding the quality of waste included not only the unavailability of high-quality waste but also its impact on the operating cost of the recycler. Mixed quality and contaminated waste that reaches the recyclers requires additional efforts in sorting. This adds to the cost and makes it difficult to standardise operations. The challenge also indicates towards the lack of adequate capacity at the waste handlers' level.
- **Challenges with the processing of waste:** There have been limited investments in scaling high-end recycling techniques or new research to expand the value chain further. This is especially true for domestic post-consumer textile waste and low-quality feedstock which cannot be processed effectively using current technologies.
- **Output quality concerns:** Stakeholders suggested that recycled products are considered as cheaper alternatives rather than sustainable options as the high-quality waste is not available to all stakeholders and the low-quality feedstock yields a coarse yarn structure. Further, the low-quality recycled materials face high competition from products made from virgin materials (made from non-renewable sources) as they are available in finer quality at a cheaper cost. This leads to an overall lower acceptance of the existing quality of recycled yarns, especially low-grade recycled yarns and recycled non-wovens. This further impacts the livelihoods of the low-grade mechanical recyclers and downcyclers as they are unable to receive premium pricing for their products and do not have the means/ incentives to upgrade their processes. Innovative solutions are emerging but are limited to pilot stage and will require to scale up to create sustained impact.

CHALLENGES FACED BY TEXTILE AND APPAREL MANUFACTURERS:

Apart from waste handlers and recyclers, textile and apparel manufacturers are also an important part of the waste value chain as a significant amount of waste is generated at their end. They incur a cost of ~INR 4 ($0.05) per kg to handle and sort this waste and sell it further to pre-consumer waste collectors. Manufacturers have a small yet significant role in the value chain and the challenges faced by them validate the need for systemic interventions. Three major challenges were highlighted by the manufacturers:

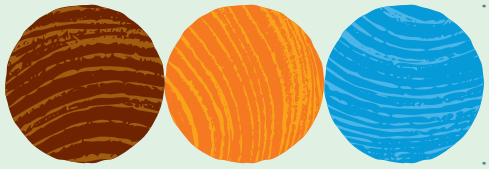
1. **There is a lack of recognition for waste trade in the ecosystem, which leaves manufacturers with no or few ways to identify credible collectors.** Without credibility certifications and transparency, manufacturers do not have any visibility on the practices being followed by the waste collectors. Further, unsafe or improper handling of waste can result in accumulation and contamination of this waste, resulting in adverse effects on the environment.

2. **Cost of sorting and storing is high and returns for manufacturers are not enough to scale the practice.** There is not enough space in the manufacturer's facility to sort and store the waste. Also, the cost of sorting is higher as compared to the returns received. Therefore, they are dependent on waste collectors and sell the waste to collectors in small batches.

3. **While a few manufacturers have also considered setting up their own recycling facilities, this has not been feasible as there is limited supply of waste and demand for recycled products and hence the economics of setting up a facility do not work in their favour.** They find it cheaper to procure recycled yarns from established vendors.

Waste Recyclers

WASTE RECYCLERS ARCHETYPES



HANDLING **20 MT** DAILY

- High-grade mechanical recycler
- Low-grade mechanical recycler
- Downcycler

CAPITAL EXPENSES (Cost Breakdown)

Cost breakdown of the Machinery Expenses

~INR 200K ($2.42K) **~INR 30,000K** ($ 363.02K) **~INR 80,000K** ($ 968.05K)

0 10000k 20000k 30000k 40000k 50000k 60000k 70000k 80000k

High-grade mechanical recycler · Low-grade mechanical recycler · Downcycler

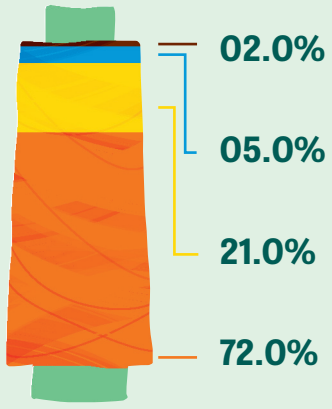
Other factors affecting cost breakdown

- Factory setup- land, building
- Table, Chair, office furniture
- Machine spare parts

OPERATING COST (Cost Breakdown)

High-grade mechanical recycler

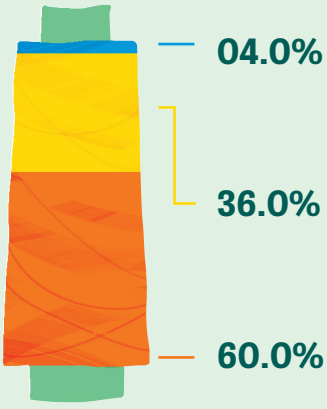
INR 60 - 107 per kg
$0.7 - $1.29 per kg



02.0%
05.0%
21.0%
72.0%

Low-grade mechanical recycler

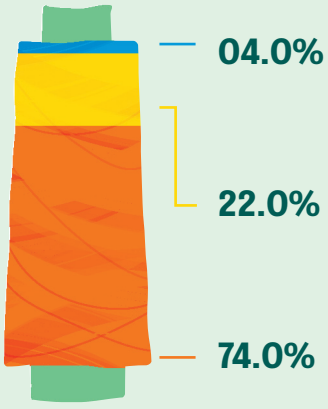
INR 26 - 125 per kg
$0.31 - $1.5 per kg



04.0%
36.0%
60.0%

Downcycler

INR 16 - 100 per kg
$0.2 - $1.2 per kg



04.0%
22.0%
74.0%

Cost of Procurement · Cost of Labour and Utility · Miscellaneous Expenses · Cost of Salaries

For the sake of easy comparison, the average costs of each of the archetypes have been considered.

CHALLENGES:

Challenges with the processing of waste

"The blended or printed waste we receive cannot be recycled into a good quality product using the current technologies. We don't want to invest in innovation as of now, our current capacity is not being utilised fully." - Waste recycler in Panipat

Output quality constraints

"Recycled products are looked at as cheaper alternatives and hence buyers prefer synthetic yarns. Innovative solutions might exist but we don't have access to them." - Waste recycler in Tiruppur

Challenges with waste feedstock quality

"High quality waste is expensive and hard to find. If I procure mixed quality waste, my cost to sort increases and it becomes hard to standardise quality." - Waste recycler in Neemrana

Challenges with sourcing & procurement

"The desired volume and quality of waste is not available in the market. We are not able to utilise our capacities completely. Imported waste might also stop coming in few years. We don't know what will happen." - Waste recycler in Tiruppur

Section III
SCENARIO-WISE FINDINGS

India's thriving textile industry indeed plays a significant role in servicing global brands, but it also generates a considerable amount of waste at both the pre-consumer and post-consumer levels. However, this waste management challenge presents an opportunity for transformation and innovation. By leveraging initiatives like the ***Alternate Materials Accelerator Program (AMAP)*** *of IDH and adopting responsible sourcing practices, the industry can unlock its full potential and make substantial progress in waste management.*

Collaborative efforts are key to addressing this issue effectively. By bringing together stakeholders from across the industry, including manufacturers, brands, waste management experts, and government bodies, we can develop holistic solutions that encompass the entire textile supply chain. Consensus-building and dialogue will be crucial in aligning the various perspectives and goals towards a common objective of sustainable waste management.

- JAGJEET SINGH KANDAL,
COUNTRY DIRECTOR - IDH INDIA HUB

7. Scenario-wise Findings

ANALYSIS PARAMETERS	STAKEHOLDERS ENGAGED	TYPE OF WASTE	WASTE HANDLERS Operating Cost Comparisons
SCENARIO 1 Collecting waste domestically but exporting it for recycling purposes:	Manufacturer > New age pilots/startups for pre-consumer waste > New age patented recycling technologies	Pre-consumer waste	**This scenario has the highest per kg operating cost at the handler's level.** This is largely because these handlers work with high-quality waste, are formal in nature and ensure worker well-being and development through more training and mechanised processes for sorting waste. Also, these are new-age startups and hence scale might not be optimised.
SCENARIO 2 Waste generated (by manufacturers) and recycled domestically	Manufacturer > Pre-consumer waste collector > Pre-consumer waste aggregator > High/ Low-grade mechanical recycler and downcycler	Pre-consumer waste	**Waste handlers in this scenario have the widest range of operating costs (INR 7 - 175 per kg, i.e., $0.8 - $2.1).** This is because, unlike other scenarios, a huge variety of pre-consumer waste comes to these handlers. This could include leftover fabric, bigger cut panels, and cutting waste of different material compositions.
SCENARIO 3 Waste is being imported and recycled domestically	Importer of post-consumer waste > Imported post-consumer waste aggregator > Low-grade mechanical recycler/ Downcycler	Imported post-consumer waste	**Importers of post-consumer waste have the highest daily operating costs but the average per kg operating costs were found to reduce as the waste moved to aggregators.** This is mostly because the high-quality imported waste is re-exported leaving a lower-quality of waste to enter India for recycling purposes.

Figure 15: Study Findings

WASTE HANDLERS Business Health	WASTE RECYCLERS Output Quality	WASTE RECYCLERS Business Health	KEY CHALLENGES
New-age pilots/ startups are working with mostly high-quality feedstock and are currently profitable. The scalability of these solutions needs to be explored.	Cannot be ascertained as most of these technologies are in pilot stages in other countries.	Cannot be ascertained as most of these technologies are inpilot stages in other countries.	• High costs associated with transportation of sorted waste as compared to the returns • Proof of concept for innovative recycling technologies in India is underway, but more concerted efforts are needed • Formalised waste collection start-ups have not been scaled and have not experimented enough in other scenarios to establish their proof of concept
Both pre-consumer waste collectors and aggregators were found to operate on minimal margins. They are able to cross-subsidise the cost of low-quality feedstock with that of high-quality feedstock, ensuring business viability.	Quality of output can vary from the >20s Ne count recycled yarn to low-quality shredded fibre suitable only for filling purposes.	The study found that high-grade mechanical recyclers receive premium value for their output, leading to a payback period of 1-2 years. For other archetypes, 5 years was found to be the average payback period.	• Lack of established use-cases and procedures for waste management are hindering the business feasibility of this scenario • Technology and innovation gaps exist for recycling low-quality waste feedstock • Connecting supply and demand of high-quality waste feedstock continues to be a bottleneck
Importers of post-consumer waste were found to have a stable business, owing to the re-exports of rewearables. Aggregators, on the other hand, were found to operate on lower margins.	The quality of recycled yarn is usually <20s Ne count and shredded fibre is also produced through downcycling processes.	The study found that the payback period for low-grade mechanical recyclers and downcyclers was 5 years on average, owing to the low-quality output.	• Technology and innovation gaps exist for recycling low-quality/ blended waste feedstock • Certain quantity of imported post-consumer waste has not been well utilised due to lack of visibility and standardised use case

Section IV

WAY FORWARD

8. Opportunities in the Textile Waste Ecosystem

The study presents five opportunities that require immediate ecosystem attention and can pave the way for greater returns.

Since the 1990s, India's textile waste management industry has sustained itself amidst all sorts of technological and economic changes. As the demand for sustainable alternatives continue to grow with support from global regulatory pressures, the demand for recycled textile products has begun to grow, providing this traditional industry with an opportunity to leverage its strengths and become a global leader. Ecosystem players including brands, manufacturers, governments, philanthropic institutions as well as private investors can play a significant role in supporting the industry through adequate investment, technological and knowledge support, enabling better process efficiencies and high-quality outputs. Efforts in this direction will not only help the textile industry to become more sustainable but would also contribute significantly to the economic sustenance and growth of the existing textile waste management industry in India.

The study presents the following five opportunities for the ecosystem to move in this direction:

1.

The ecosystem has the opportunity to build consensus on waste value potential (use-case) and responsibility sharing. This can further help to unlock the value potential of a significant quantity of textile waste.

The study highlights that one of the key challenges and areas of improvement for the sector is determining the best use case for different types of waste. All the interviewed stakeholders echoed this concern but the highest resonance was found among the waste handlers of pre-consumer waste (scenario 2), low-grade recyclers and downcyclers (also relevant to scenario 3), where the stakeholders were also found to be operating on low-profit margins or even losses in some cases.

By building a consensus on the waste value potential or creating common framework around the best use case for each type of waste, waste handlers will be able to avoid selling the waste at low prices or storing it for extended periods. This value potential or standards can be built using the economic and environmental returns of reusing, recycling or discarding the material. Coordinated efforts and equitable responsibility and accountability sharing can enable efficient management of low-value waste as well, without disproportionately impacting a few players. This might enable low-grade recyclers and downcyclers to recover their costs and sustain their operations.

The ecosystem has made significant strides in developing innovative solutions and technologies to develop a closed-loop textile waste management system, however, scaling up has been slow due to lack of coordination. Textile waste is not only a resource for the textile and apparel industry but is also utilised by other allied industries like the paper and pulp, automobile, toy industry, etc. Hence, this presents an opportunity for all relevant stakeholders of the textile waste and enables the ecosystem to come together in a pre-competitive space to build consensus and ensure better recovery of pre-consumer and post-consumer waste, reduce material value loss and the depletion of resources. The consensus-driven and collaborative approach will also create a standardised and profitable value chain, attracting increased investments and generating higher returns for all stakeholders.

2.

Building transparency & traceability in the value chain can solve the waste feedstock challenges being faced by the industry.

The study suggests that high-grade mechanical recyclers produce the highest value output and have the highest return on investment in the current Indian textile waste value chain. Despite the lucrative potential present in this archetype, waste supply challenges seem to be the bottleneck for these stakeholders. The stakeholders interviewed in the study suggested that they are unable to utilise their existing capacity due to challenges in sourcing the waste feedstock and hence, are not planning to expand in the near future.

Transparency and traceability solutions hold great potential to resolve this supply chain bottleneck. They can allow these recyclers to source waste more efficiently and reliably, ensuring a continuous supply of quality feedstock. Increased visibility on the availability of waste will help high-grade mechanical recyclers to attract more investments and scale up their operations. Further, low-grade recyclers might also be able to utilise this visibility and transition to high-grade operations, increasing their profit margins. Increasing traceability will also help the recyclers to meet brand standards on raw material traceability and as a result they will be able to unlock premium pricing.

These transparent and traceable systems are expected to be coherent with the emerging global regulations on the visibility of waste flows, minimising waste leakage and can also provide valuable insights into changes in global waste entering India and its potential implications for the Indian waste recycling industry.

3.

The Indian textile waste value chain provides a significant opportunity for fostering innovation & technology, especially for waste recycling, that can lead to beneficial returns on all economic, social and environmental fronts.

The study highlights a few clear technology gaps that call for the immediate attention of public, private and philanthropic investments. This is particularly pertinent to the low-quality waste feedstock that is currently being managed by low-grade mechanical recyclers and downcyclers. The study suggests that there exists a two-pronged concern with the current waste flow. Firstly, due to the coarse and low-quality output, the low-grade mechanical recyclers and downcyclers seem to have low returns from the output, leading to longer investment payback periods of 5 years on average. The suggested payback periods are significantly higher than that of high-grade recyclers. Secondly, the waste value realisation is not optimum in most cases. For example, polyester-rich materials are being converted into shredded fibres for filling purposes or non-woven applications, despite the high amount of resources (energy, fossil-fuel based derivatives, water, etc.) utilised in manufacturing them. The importance of

this opportunity is further supported by the findings of the Wealth in Waste (Fashion for Good and Sattva Consulting, 2022) report, which indicates that approximately 40% of waste currently lacks any recyclable value with existing technologies.[20]

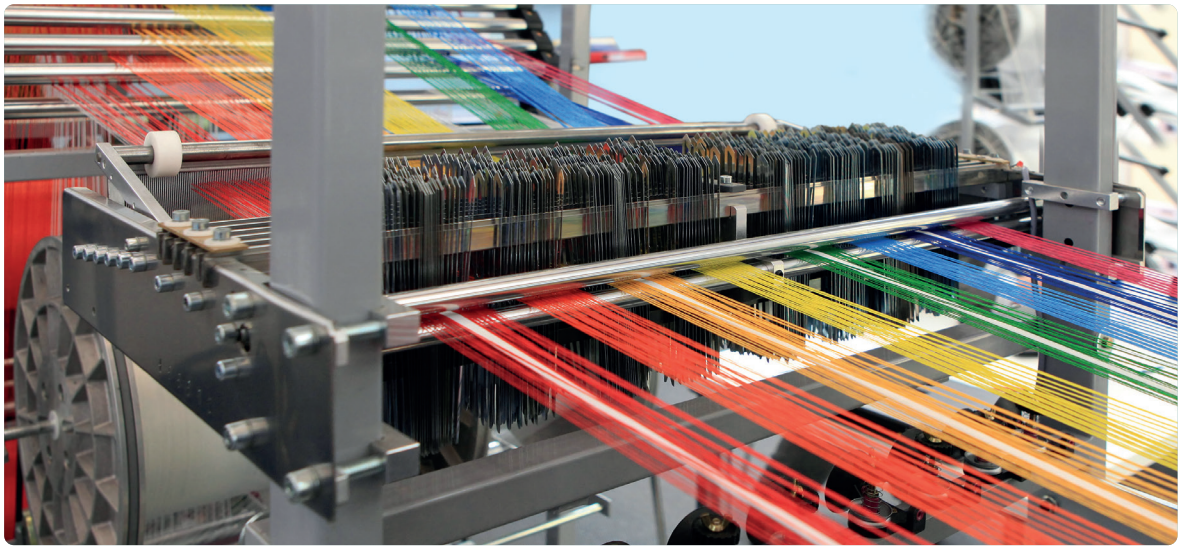
Hence, from both environmental and economic standpoints, technological innovations in this space become necessary. Though innovative solutions are emerging, they continue to remain at pilot stage and require scaling efforts. Seizing this opportunity has the potential to position India as a leader in high-quality recycling as it already has the required value chain and infrastructure for textile waste management.

4.

Improving efficiencies of waste handlers through capacity building, technological interventions and other pathways can improve the overall effectiveness of the textile waste value chain in India.

The cost analysis conducted in the study shows that waste handlers especially those involved in handling pre-consumer waste and aggregators of imported post-consumer waste are incurring higher costs compared to the returns they generate. This is influenced by various factors, including high rental and transportation costs, expensive waste procurement, redundant sorting efforts at different levels, and low demand for certain waste materials. On the other hand, concerns about contaminated waste were also highlighted by the recyclers. These concerns indicate an overall lack of operational efficiencies, which could potentially be a major factor behind the lack of adequate financial resources for these stakeholders. This further raises concerns about worker well-being as stakeholders have insufficient resources to address worker needs.

Private sector investments can help in building the efficiencies of waste handlers and their workers (sorters) through adequate training, infrastructure support, technology support, implementation of digital systems and practices, etc. This can lead to higher returns on the economic front by increasing worker productivity & the quality of output. On the social front, working conditions can be improved and social security provisions for the workers can be ensured using the increased returns. Further, by efficient sorting of waste, handlers can provide recyclers with a feedstock that is easier to process and has a higher value, streamlining the recycling process and reducing efforts required by recyclers.



[20] Wealth in Waste (July, 2022). Fashion for Good and Sattva Consulting. Retrieved May 17, 2023, from https://reports.fashionforgood.com/wp-content/uploads/2022/07/Sorting-for-Circularity-Wealth-in-Waste.pdf

5.

Fostering an enabling environment through open knowledge sharing among stakeholders can pave the way for a more sustainable and efficient textile waste value chain.

The presence of adequate knowledge contributes significantly to the development of any sector and the enabling environment around it. It ensures that all stakeholders holistically understand the sector without any blind spots and are aligned with its requirements. This becomes even more important for a niche sector like textile waste management, which even though has existed a long time but its complexities are understood by only a few. The study also found similar sentiments among the stakeholders interviewed, especially the waste handlers. In the interviews, the waste handlers highlighted that their trade does not seem to be recognised and understood by the ecosystem. Further, the stakeholders have been working with traditional practices with little or no infusion of new knowledge and practices around the trade. These concerns call for dedicated efforts and investments in creating open knowledge-sharing practices in the sector. Similar efforts from GIZ, UNEP and partnerships between UNDP and private companies have also been playing a significant role in shaping up India's progress on plastic waste management.[21, 22, 23]

By increasing awareness and creating an environment of knowledge sharing, the industry can collectively find innovative solutions and best practices to address the needs of the stakeholders. This knowledge exchange can lead to improved efficiencies, reduced costs, and enhanced operational conditions for waste handlers and recyclers. Moreover, it presents an opportunity to establish an enabling environment where support systems (investment, technology, know-how, etc) are readily available and stakeholders can learn from one another, share successful strategies, and improve current textile waste management practices.

[21] Rethinking Plastics: Circular Economy Solutions to Reduce Marine Litter. GIZ (n.d.). Retrieved June 14, 2023, from https://www.giz.de/en/worldwide/94003.html
[22] National Policy Workshop on Countermeasures for Riverine and Plastic Litter in India | United Nations in India. United Nations India (n.d.). Retrieved June 14, 2023, from https://india.un.org/en/163269-national-policy-workshop-countermeasures-riverine-and-plastic-litter-india.
[23] Plastic waste management. UNDP (n.d.). Retrieved June 14, 2023, from https://www.undp.org/india/projects/plastic-waste-management

9. Way Forward

This study observes that the textile waste value chain in India, although well-established, requires dedicated support to streamline the supply and demand while incentivising sustainable practices to bring the textile waste recycling industry into the mainstream textile sector.

This study aimed to identify the costs incurred and challenges faced in the textile waste value chain in India while elaborating on potential opportunities that can be taken up to uplift all stakeholders in the sector. Each stakeholder (manufacturer, importer, collector, aggregator, and recycler) has been individually reported on to illustrate the difference in processes across the value chain.

Across the different scenarios, the availability of desired quality and quantity of textile waste resonated as the most common challenge faced by stakeholders. Formalisation of the sector also emerged as a need of the hour for the sector as a whole. Based on responses received from actors within the industry, five opportunities have been identified which will enable textile waste businesses to grow sustainably through operational scaling, allowing them to operate on par with the global textile industry.

Post-consumer textile waste collected domestically, and pre-consumer textile waste imported from international markets have not been a core focus of this study. It remains to be seen and analysed how these two value chains can be incorporated into the mainstream textile sector, and how different external stakeholders can contribute towards the challenges faced by the players in these scenarios. The goal of this report is to initiate a conversation on the current state of textile recycling in the country and to motivate different external stakeholders such as consumers, brands, investors, and governments to participate in the formalisation and mainstreaming of the textile waste value chain in India to create a closed-loop textile industry.

Section V
ANNEXURE

Definitions and Abbreviations

TERM	DEFINITION
Waste Feedstock	The term has been used in the study to define the input waste material for any stakeholder, primarily waste recyclers. This incoming waste acts as an input to their recycling process.
Waste Generators	Waste generators is used in the study to refer to the stakeholders producing waste. This could be either the textile manufacturers across the value chain of textile product or consumer of textile products (both in India and globally).
Textile Manufacturers	Manufacturers of textiles generate textile waste during different manufacturing stages. This includes spinning waste, fabric trimmings/cuttings, fabric deadstock and unsold garment inventory. This study focuses primarily on fabric trimmings/ cuttings.
Waste Handlers	Waste handlers is the term used in the study to define intermediary stakeholders between the generator and recycler of waste. They do not change the form of the material but are involved in sorting, storing and making it ready for the use by recyclers. Waste Handlers consist of all types of waste collectors, aggregators and importers.
Waste Collectors	Collectors collect textile waste directly from manufacturers, factories or consumers (in the case of domestic post-consumer waste). The small and medium-sized collectors sort the waste according to one of the parameters: colour, size, material, etc, while the larger ones sort it based on all parameters depending on recycler needs. This activity could be facilitated by an aggregator in a few cases.
Waste Sorters	Waste sorters refers to all workers involved in sorting the waste. They could be working at either levels of a waste handler and recycler.
Waste Aggregators	Aggregators serve as a bridge between collectors and recyclers. They could be the same or different from agents, but their role is to ensure material aggregation and storage till the adequate demand for waste is found.

Waste Importers	Importers import second-hand clothing and mutilated rags from different countries. The importers working with second-hand clothing have a sorting facility to sort wearables and non-wearables. Other waste importers may not have an in-house sorting facility. The study focuses primarily on importers of second-hand clothing.
Waste Recyclers	The term is used in the study to address all categories of stakeholders that change the form of the material. They could be involved in shredding the textile material and/or making a recycled yarn from the same. They include high-grade mechanical, low-grade mechanical recyclers, downcyclers and new-age patented recycling technologies.
High-Grade Mechanical Recyclers	These recyclers sort, shred and spin textile waste, generally 100% or more than 90% cotton, knitted or solid coloured. They produce cotton blend yarns of more than 20s Ne Count (Ne Count define the thickness of a yarn).
Low-Grade Mechanical Recyclers	These recyclers sort, shred and spin waste, primarily knitted cotton and cotton waste (irrespective of the quantity). They produce cotton blend yarns of up to 20s Ne Count. Some low-grade mechanical recyclers just shred the waste and sell it to other open-end spinners for spinning.
Downcyclers	Downcyclers sort and shred all kinds of waste including cotton, polyester, blends, colours, and prints. They handle around 10-20 MT of waste per day to produce shredded fibres which are sold as fillers to the bedding industry, the paper pulp industry, the automobile industry, and other allied industries.
New age patented recycling technologies	New-age patented recycling technologies are those that are being introduced and piloted in other developed economies, wherein the entire recycling process is automated, leading to a higher quality of output. These could be chemical or a mix of chemical and mechanical recycling.
Conversion Rate	$1 = INR 82.64

For more details, refer to the technical appendix:

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