FASHION FOR GOOD
SORTING FOR CIRCULARITY: INDIA
POST-CONSUMER PILOT REPORT

UNLOCKING INDIA'S WASTE OPPORTUNITY:

CAPITALISING ON THE UNTAPPED POTENTIAL OF POST-CONSUMER WASTE

December 2023

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DISCLAIMER

This report has been commenced by Fashion for Good with support from Circle Economy. The authors take full responsibility for the contents and conclusions. The participation of the industry experts and affiliates who were consulted and acknowledged here, does not necessarily imply endorsement of the report's contents or conclusions. To quote this report, please use the following reference: Fashion for Good and Circle Economy, Unlocking India's Waste Opportunity: Capitalising on the Untapped Potential of Post-Consumer Waste, December 2023. Use of the report's figures, tables or diagrams, must fully credit the respective copyright owner where indicated. Reproduction must be in original form with no adaptions or derivatives. For use of any images in the report please contact the respective copyright holders directly for permission. The images used in this report belong to the authors, with the consent of the individuals photographed.

ABOUT STUDY PARTNERS

FASHION FOR GOOD is the global platform for innovation. Fashion for Good unites the entire fashion ecosystem, from brands, manufacturers and suppliers, to consumers, to collaborate and drive the change towards a circular industry. At the core of Fashion for Good is its Global and Asia Innovation Programme. The Innovation Programme supports disruptive innovators on their journey to scale, providing hands-on project management, access to funding and a robust ecosystem of mentors and experts. Fashion for Good also initiates Foundational Projects, consortium projects that bring innovators, brands, manufacturers and funders together to validate technologies and processes, to accelerate supply chain implementation. The Good Fashion Fund catalyses access to finance for manufacturers in India, Bangladesh and Vietnam to shift at scale to more sustainable production processes. To activate individuals and industry alike, Fashion for Good houses the world's first interactive museum dedicated to sustainable fashion and innovation to inform and empower people from across the world, a Circular Apparel Community co-working space, and creates open-source resources and reports to action change.

Fashion for Good's programmes are supported by founding partner Laudes Foundation, co-founder William McDonough and corporate partners adidas, BESTSELLER, Burberry, C&A, CHANEL, Inditex, Kering, Levi Strauss & Co., Otto Group, Patagonia, PVH Corp., Reformation, Target and Zalando, and affiliate and regional partners Arvind Limited, Birla Cellulose, Norrøna, Pangaia, Paradise Textiles, Shahi Exports, Teijin Frontier, Vivobarefoot, Welspun and W. L. Gore & Associates. **To learn more about Fashion for Good, visit fashionforgood.com**

CIRCLE ECONOMY is a global impact organisation with an international team of passionate experts based in Amsterdam, empowering businesses, cities and nations with practical and scalable solutions to put the circular economy into action across the globe. Circle Economy was a partner of Fashion for Good for the 'Sorting for Circularity Europe' project last year. With their expertise not only on-field, but also with the project and technology used, Circle Economy has been a crucial knowledge partner for the project, providing best practices based on learnings from the previous pilots. **To learn more about Circle Economy, visit circle-economy.com**

Executive Summary

Every year in India, 3,944 ktonnes of post-consumer domestic waste is collected. Approximately 48%, or 1893 ktonnes, of Post-Consumer Domestic Waste (PCD), has the potential to be used as feedstock for the recycling industry. Unfortunately, due to the lack of proper collection and sorting systems in India, this waste remains unutilised leaving the potential of post-consumer waste untapped in India.

Through the Sorting for Circularity India's pre-consumer pilot and Wealth in Waste study, it can be ascertained that the valorisation of textile waste is crucial for achieving circularity in the Indian textile industry. While pre-consumer waste is already being utilised in textile-to-textile recycling, the potential of post-consumer domestic textile waste remains untapped. India is at a crucial juncture in time, with the unique potential to become a leader in textile recycling and promote circularity in the textile industry. Not only are there huge quantities of waste generated in the country, but the recycling infrastructure is currently operating sub-optimally, utilising only imported post-consumer waste. Additionally, with governments around the world under pressure to assess the impacts of the fashion and textile industry, along with an upcoming surge in more stringent legislation as it pertains to textile waste, the value of post-consumer waste is expected to rise. Consequently, it is expected as the legislation develops the post-consumer export rate from certain countries will go down.

Given this scenario, the Sorting for Circularity India project expanded its focus to include post-consumer textile waste, in addition to pre-consumer waste, in order to comprehensively address and analyse the textile waste landscape. This assessment of post-consumer textile waste was materialised by conducting an evaluation of the market, the existing technological innovations and their commercial viability. In order to fully harness the recycling potential in India, the need to develop systems and infrastructure for collection, sorting, and preprocessing was identified. Technological interventions in colour and composition sorting through the adoption of semi-automated and fully-automated approaches were undertaken, and an optimised valorisation of post-consumer waste was encouraged within the existing ecosystem.

Of the two pilots conducted in the post-consumer pilot program, the pilot with Matoha (for semi-automated sorting) was carried out in southern India, with a total of 35,493 kgs of post-consumer textile waste collected and sorted from the cities of Bangalore, Chennai, and Calicut. The pilot with PICVISA (for fully-automated sorting) was executed at its test centre in Spain, with 1,228 kgs of post-consumer textile waste collected and sorted from the European region.

While it was clear that technological intervention can help the sorting infrastructure scale rapidly, this report provides a detailed understanding of how technologies such as Matoha's FabriTell and PICVISA's ECOSORT can be integrated into the current landscape of sorting and recycling.

Through the pilots, the nuances of post-consumer waste in India were better understood and analysed in regard to composition, colour, and complexity. The data highlights the potential of recycling in India and how various stakeholders can play a hand in valorising post-consumer waste. A key observation from the pilots was that 100% cotton waste held the largest share in the waste mix, followed by polyester-rich material.

One of the pilots concluded with the use of the Reverse Resources platform to ensure traceability and enable matchmaking between sorters and recyclers. The materials were transferred to various recyclers and downcyclers for a range of products based on the material composition.

Under the Matoha Pilot, 88% of the total quantities were found to be non-rewearable and only 10% as rewearable. Within the Picvisa pilot, the total quantities were considered non-rewearable.

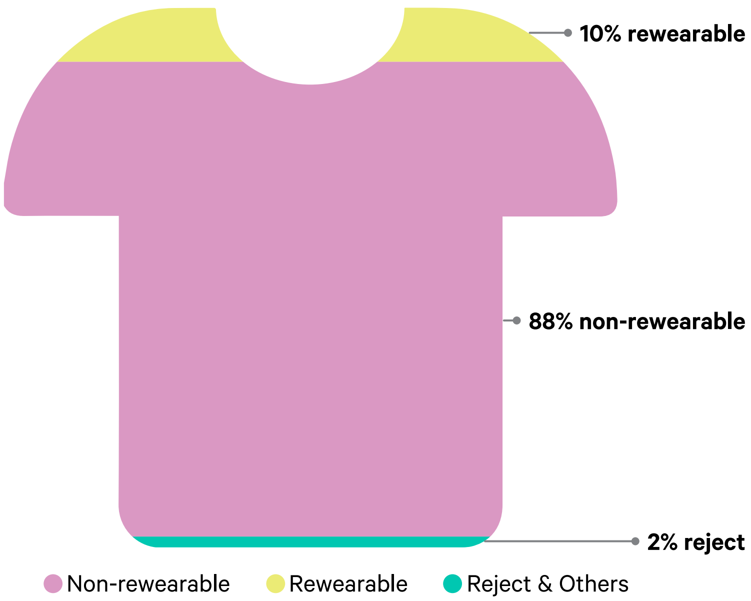


Illustration 1: Breakdown of the total quantities collected for Matoha Pilot, as per their usage

In the case of rewearable materials, collection methods and geographical location played an integral role. While one facility found 27.5% of rewearables in their material mix, another found absolutely no rewearables. Rewearables were further sorted into Grade 1 and Grade 2 based on their markets. Additionally, rewearability was also biased and subjective as per the sorter at each facility.

In terms of composition, both pilots showed consistent results for 100% Cotton and Cotton Rich materials. The Matoha Pilot identified 43.4% and the PICVISA Pilot found 33% of materials as 100% Cotton in composition. In both pilots, the cotton rich materials were 7.5% and 8% in Matoha and PICVISA pilots respectively.

The preferred feedstock for recycling in the Indian landscape is currently 100% White Cotton. **In the case of colour segregation, data from both pilots proved that post-consumer domestic textile waste has a high potential for valorisation.** Data from both pilots reflected that white held a large percentage of the material mix.

On the other hand, Multicolour (in the case of Matoha Pilot) and Others (in the case of PICVISA Pilot) held a large share of the material mix, which is a category that is not currently considered as feedstock for recycling in India.

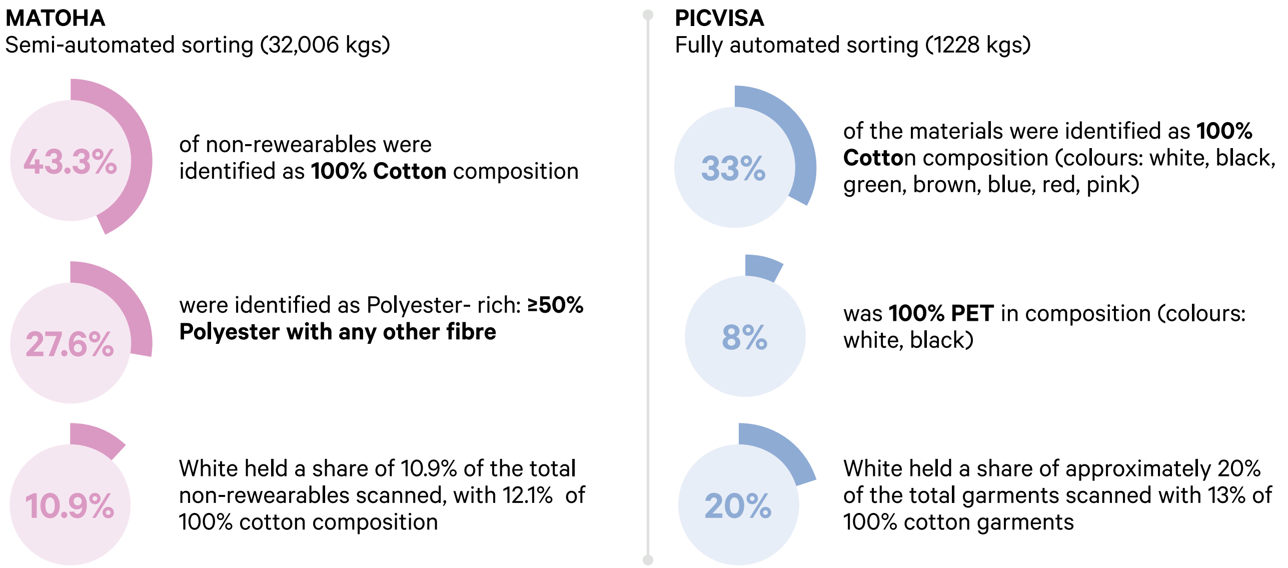
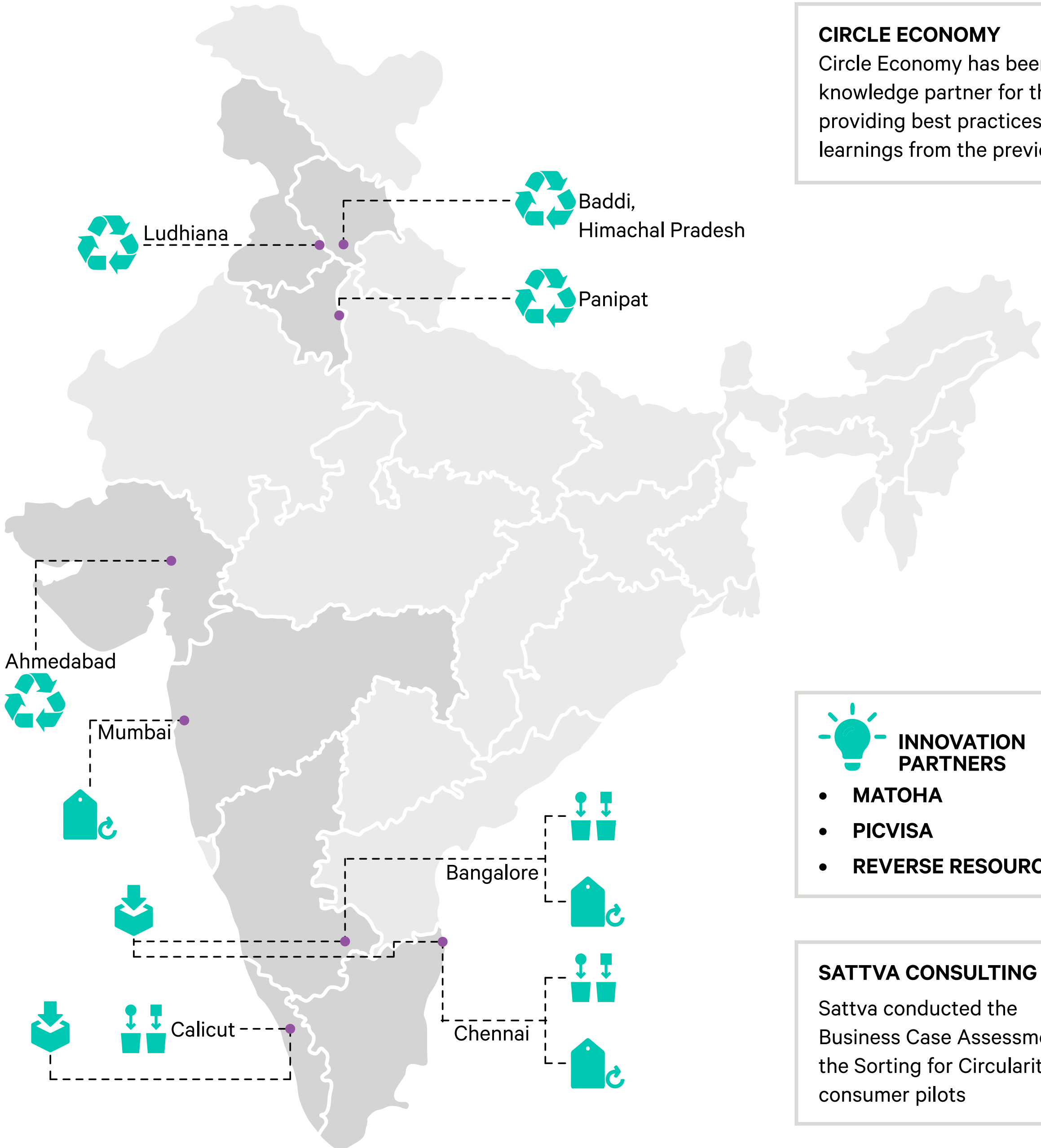


Illustration 2: Composition and Colours Learnings from both pilots

This report covers both pilots and their methodology and activities. The sections include:

1. **STAKEHOLDER PROFILES:** This section covers the various stakeholders in the project and their roles in the project.
2. **CURRENT LANDSCAPE OF POST-CONSUMER WASTESTREAM IN INDIA:** This section maps the current situation of post-consumer waste in India and leads into how previous learnings helped develop the aim and objectives of the project.
3. **OVERVIEW OF THE METHODOLOGY:** This section defines the methodologies of both the technological interventions in the post-consumer pilots and the steps undertaken.
4. **REWEARABLE SECTION:** This section covers the current markets and existing players in the resale industry. It also includes the analysis of rewearable textiles from one of the pilots.
5. **NON-WEARABLES ANALYSIS:** This section focuses on the non-rewearable category of the pilots with both semi-automated and fully-automated technologies from Matoha and PICVISA respectively. The section defines the methodology of the pilots and how technological intervention plays a role in the current sorting infrastructures.
6. **MATERIAL TRANSFER TO RECYCLERS:** This section traces the waste for one of the pilots and highlights the role of Reverse Resources in the waste landscape.
7. **PILOT LEARNINGS:** This section dives deeper into the stakeholders who were a part of the pilot and what learnings came from the project. The section also highlights the results of testing the material and the accuracy of the technologies.

Stakeholder Profiles



CIRCLE ECONOMY
Circle Economy has been a crucial knowledge partner for the project, providing best practices based on learnings from the previous pilots.

INNOVATION PARTNERS

- **MATOHA**
- **PICVISA**
- **REVERSE RESOURCES**

SATTVA CONSULTING
Sattva conducted the Business Case Assessment for the Sorting for Circularity post-consumer pilots

Collection:
- Residential collection (Bangalore)
- Commercial collection (Bangalore)
- Household collection (Calicut)
- H&M garment collection programme (Chennai and Bangalore)

Sorters
- Saahas zero waste - Bangalore
- Greenworms- Calicut
- Uptex- Chennai
- Hasirudala Innovations- Bangalore

Resale
- Kiabza- Mumbai
- Relove- Mumbai
- Local resale market- Bangalore
- India Wasted 360- Bangalore and Chennai

Recyclers
- Arvind- Ahmedabad
- Vardhaman textiles- Baddi, Himachal Pradesh
- Usha Yarns- Ludhiana
- Kakkar Spinning Mills- Panipat
- Kaygee enterprises- Panipat

Illustration 3: Current landscape of post-consumer textile waste in Panipat and the various end products they end up in

KNOWLEDGE PARTNER

CIRCLE ECONOMY is a global impact organisation with an international team of passionate experts based in Amsterdam, empowering businesses, cities and nations with practical and scalable solutions to put the circular economy into action. Circle Economy was a partner of Fashion for Good for the 'Sorting for Circularity Europe' project last year. With their expertise not only on-field, but also with the project and technology used, Circle Economy has been a crucial knowledge partner for the project, providing best practices based on learnings from the previous pilots.

INNOVATION PARTNERS

Founded in 2018 in the UK, **MATOHA** specialises in automated sorting solutions through near-infrared (NIR) spectroscopy. Their technology enables the accurate identification and sorting of materials, contributing to better diversion of textile waste feedstock to the recycling industry. As a Fashion for Good innovator from 2023, we used the Matoha FabriTell desktop scanners to test and understand how their technology could serve as an intervention in the existing sorting infrastructure in India.

PICVISA, based in Spain, is an innovative technology-based company that designs, develops and produces optical sorting equipment for the classification of materials, and recovery and valorisation of waste. The optical sorting is based on machine vision and artificial intelligence. As a Fashion for Good Innovator of 2022, a post-consumer pilot was carried out at their test centre in Spain.

Founded in 2014 in Estonia, **REVERSE RESOURCES** was a Fashion for Good innovator in 2018 and is a Software-as-a-Service (SaaS) platform that digitises, connects and scales global textile-to-textile recycling. RR digitises data on textile waste flows which enables the entire supply chain to track, trace and valorise textile waste. We connect fashion brands, manufacturers, waste handlers and recyclers building the infrastructure to scale circular supply chains, which enables the effective management of textile waste flows.

SORTER PROFILES

In preparation for the pilot, a comprehensive assessment of waste management organisations was conducted, resulting in the selection of four facilities as sorters. These organisations had prior experience handling various waste streams and were currently either in the process of establishing textile waste as a separate stream in their operations or expressed a strong interest in setting up a textile recovery facility. The chosen sorters were specifically selected for their pioneering approach to waste management and their existing capabilities in handling textile waste, which we recognised as crucial assets for the successful implementation of this pilot.

GREENWORMS is a waste management company located in the southern state of Kerala, with a goal to spread awareness and culture of sustainable development and create synergy between the private and public sectors and civil society. Greenworms participated in both Matoha and Picvisa pilots.

SAAHAS ZERO WASTE (SZW) is an end-to-end waste management company that offers its services in the management of a variety of waste. SZW participated in both the Matoha as well as the Picvisa pilot, and were also an integral part of our pre-consumer study. They conducted their own collection (residential and commercial) and also received material from H&M's Garment collection programme under the Matoha pilot. Within the pilot, they sorted a total of 17.7 tonnes of PCD, and set up their pre-processing capabilities under the pilot.

ENVIU is an international organisation which focuses on using impact-driven entrepreneurship to build companies that address social and environmental issues and drive failing markets towards a new normal. With this mission in mind, they set up Uptex in Chennai, a textile waste management company. Uptex participated in both Matoha and Picvisa pilots.

HASIRU DALA aims to support waste workers and improve the livelihood and quality of life of waste pickers by providing total waste management services through them to bulk generators of waste. They participated only in our Matoha pilot, and collected and sorted a total of 2.4 tonnes of material, collected by residential collection across Bangalore.

RECYCLER PROFILES

In preparation for the pilot, an assessment of feedstock requirements as well as an understanding of recycling potential was conducted for a better understanding of the waste landscape. We identified a range of recyclers who supported both pilots in their own capacities, and provided us integral insights from their perspective. Each recycler was chosen for their expertise and understanding of the industry, which we believe was an asset for our pilot.

Arvind
FASHIONING POSSIBILITIES

Founded in 1933, in Ahmedabad, **ARVIND** Ltd prides itself on being one of the largest integrated textile and branded apparel players in India. Arvind owns 22 global patents for environmental solutions, and is the largest fire protection fabric producer in the country. Arvind participated in the Picvisa pilot to assess the feasibility of Picvisa's technology from a recycler's perspective.

Founded in 1996, Usha Yarns, located in Chandigarh, has been working with post-industrial and post-consumer waste. As pioneers in high-grade, mechanical recycling, **USHA YARNS** provides a diverse range of recycled products in hundreds of solid and melange shades. Usha Yarns played the role of a recycler in both Matoha and Picvisa pilots.

Vardhmān

Founded in 1965, in Ludhiana. Punjab, **VARDHMAN** Textile Ltd. is India's largest vertically integrated textile manufacturer with multiple production facilities across the subcontinent. Due to the complete in-house control over each stage of production, it offers its clients high-grade mechanical recycling capabilities with unmatched agility, flexibility, and traceability. Their products include recycled cotton yarn, recycled polyester cotton yarns and speciality blended yarns. Vardhman played the role of a recycler in our Matoha pilot.

HSN MACHINERY

Established in 1990 in the major recycling hub of Panipat, **KAKKAR SPINNING MILLS** is globally renowned for its technological focus on Machinery and components for Fibre & Yarn processing. They produce materials such as cotton yarn, viscose yarn, and polyester yarn for the home and textile industry. Kakkar Spinning Mills played the role of a recycler in our Matoha pilot.

Established in 2016, **KAY GEE ENTERPRISES** holds an expertise in mechanical recycling in India. Located in Panipat, they are one of the leading suppliers and traders of poly-cotton yarn, recycled cotton yarn, recycled cotton fibre etc. They have been working with imported post-consumer waste and their products are focused on low-grade recycling of a large variety of compositions into products such as high and low-grade felt and yarns for the home industry. Kaygee participated as a recycler in our Matoha pilot.

CONSULTANT FOR BUSINESS CASE ASSESSMENT STUDY

SATTVA CONSULTING is a leading consulting firm in the social impact sector and works with corporate CSR, foundations, multilaterals, non-profits, and social enterprises on scalable and sustainable solutions for social impact. Sattva conducted the Business Case Assessment for the Sorting for Circularity post-consumer pilots.

Introduction

With a surge in recycling commitments and legislation in recent years, it is integral for strategic key players to accelerate and scale up to prepare and support the transition towards a more circular fashion industry. With the introduction of vital and strapping legislation such as the Extended Producer Responsibility (EPR)[1] by the European Commission, which will be implemented over a course of time in the European Union. Legislations like these will not only help implement and support the collection, sorting, re-use, and recycling capacities of these countries, it will pose an indirect effect predominantly in the provision and volumes of imported post-consumer feedstock to countries such as India. As reported in our Wealth in Waste report launched last year, imported textile waste holds a market share of 7% of the total textile waste[2]. Of this, second-hand post-consumer material accounts for 32% of the total imported material from developed countries such as the USA, Japan, Canada, and the EU.

India is at a crucial juncture in time, with a unique potential to become a leader in the circular textile ecosystem. Not only are there huge quantities of waste generated in the country, but the recycling infrastructure is currently operating suboptimally, utilising only imported post-consumer waste. Additionally, as mentioned above, with governments around the world under pressure, along with the implementation of more stringent legislation, the value of post-consumer waste will shoot up. Apart from them, the industry is under pressure due to regulatory shocks and lots of new legislation targeting the textiles industry. With that, it may be expected that the post-consumer export rate from certain countries will go down. With this in mind, it is important for the industry to start focusing and finding opportunities in domestic post-consumer waste and find ways that can ensure that this waste can be used as feedstock within our current recycling and reuse infrastructure. The Sorting for Circularity India post-consumer pilot was conducted with the dual objective of piloting technologies for sorting and traceability, and assessing the quality and viability of recycled fibre, in order to demonstrate the possibility of a closed-loop system for post-consumer waste.

> **“As the global fashion industry embraces circularity, India has the potential to play a leading role in this transition. Public polices play a key role in catalyzing and accelerating development of a circular textile and apparel industry. Through a comprehensive set of policy measures including strengthening textile waste management infrastructure, promoting public-private partnerships, formalizing workforce, investing in R&D, leveraging digitalization, reframing textile schemes and encouraging circular apparel exports, both centre and state governments can provide a fillip to a sustainable and a more resource efficient textile industry.”**
>
> Sundar Senthilnathan, Head of Public Affairs, H&M Group

In turn, these developments across the world are expected to drive an increased demand for not just post-consumer textiles, but also an opportunity to capitalise on the available domestic post-consumer material. While there has been a surge in innovation in recycling technologies, particularly those that can deal with a variety of different textile materials and operate fibre-to-fibre recycling at scale. To complement this technology, there is also a need to formalise and develop the collection and sorting infrastructure in India.

The Indian apparel market is projected to experience an annual growth rate of 3.34%[3] While the average volume of apparel per person in the European market amounts to 41.5 pieces in 2023, the Indian apparel market amounts to 23.8 pieces in 2023, and will continue to see volume growth by 3.8% each year[4]. This means that by 2027, volumes close to 38.9 billion pieces will be placed across the apparel market in India. It is reported in our Wealth in Waste Report[5] that approximately 7,793 ktonnes or 8.5% of global textile waste, is accumulated in India every year. 59% of this waste finds its way back into the textile industry through reuse and recycling but only a fraction of this makes it back into the high-end global supply chains due to quality and visibility challenges. The remaining 41% is downcycled (19%), incinerated (5%) or ends up in a landfill (17%). Out of total waste circulation, 51% comes from domestic post-consumer collection, 42% from pre-consumer sources, and only 7% is imported post-consumer waste.

While India has robust recycling hubs that have been operating for decades, it lacks a robust textile collection system, which hinders the flow of domestic feedstock to localised recycling. The varied cultural characteristics also play a role in the waste flows and feedstock quality. Factors such as frequent-washing, utilising products until visible signs of wear and tear, and the importance of tailor-made garments, contribute to the diversity of the quality in the collected garments. In the course of the project, it was found that collection methods and the areas covered play an integral role in the collection of rewearable garments, which means a significant share of garments are diverted to recycling and downcycling. With this in mind, the Sorting for Circularity methodology was developed, in order to divert materials for a variety of applications, ensuring optimised environmental and economical results for all the stakeholders involved.

> **“By turning its wealth of textile waste into resources for its textile production industry, India is putting circularity into action and showcasing what a circular textiles value chain could look like at scale. An efficient sorting ecosystem supported by innovative technologies is fundamental to safeguard the availability of the consistent feedstock closed-loop recycling requires.”**
>
> Hilde van Duijn, Head of Global Value Chains, Circle Economy

Current Landscape of Post-Consumer Domestic (PCD) Waste in India

Post-consumer textile waste can be defined as materials that have been discarded after it has been used by a consumer and could be in the form of a full item or even a part of it[6]. While it may or may not be functional when it is disposed of, in this age of the booming recycling technologies, it is integral to understand the potential of this waste to ensure its valorisation back into not only the textile industry but corresponding ones. While pre-consumer waste already plays an integral part of the current recycling landscape in India, particularly in the recycling hubs of Panipat and Tirrupur[7], post-consumer waste currently holds a much smaller recycling market share when compared to pre-consumer (or post-industrial). Currently, the majority of post-consumer waste used in the recycling industry has been collected and imported into India. Obtaining high-quality domestic post-consumer waste is challenging due to the lack of proper collection and sorting infrastructures in India, making it complex to access the quality feedstock of post-consumer waste in India.

Predominantly, in recycling hubs, post-consumer waste is purchased from traders and local sellers for recycling. Within the Indian landscape of textile waste, Panipat and Kandla are hubs for post-consumer textile waste (PCD) and Tirrupur in the South of India, which deals with pre-consumer waste predominantly. After the material arrives at recycling facilities, it undergoes a sorting process to identify and remove soilage and stains, while simultaneously manually segregating it by colour.

When it comes to high-grade recycling, composition sorting is an integral step for recyclers. In addition to this, colour segregation is also integral for particular recyclers to ensure consistency in the colour of the recycled products. Furthermore, for textile-to-textile recycling, sorting and segregation need not be as detailed. In most cases, material that does not get directed to fibre-to-fibre recycling ends up in other textile-to-textile recycling avenues like the wiper industry, felting, and paper/cardboard production. The final destination for residual waste from the recycling industries often ends up being disposed of through methods of incineration in cement kilns.

In order to harness the recycling potential of India, collection and sorting systems and infrastructure for post-consumer waste need to be set up. By enabling technological intervention in the infrastructure, we can encourage the optimised valorisation of post-consumer waste in India.

With the intention to understand the recyclability of post-consumer domestic waste, it is integral to delve deeper into understanding the nuances of PCD waste. This includes the understanding of composition, colour and rewearability, which can all be good indicators for the future of the recycling industry. From our observations and learnings, it was important to also understand how technology and innovation can help us reach the goals for recycling, and help transition and establish infrastructure around collection, sorting and preprocessing, to support the recycling industry.

With the need to fully harness the recycling potential in India, and develop systems and infrastructure, an assessment of semi-automated and fully-automated sorting innovations was integral to evaluate the valorisation of post-consumer textile waste in India.

Sorting for Circularity India Post-Consumer Pilot with Automated Sorting Technologies and Digital Traceability

The Sorting for Circularity India Project aims to establish coherence in the post-consumer textile waste landscape. From sorting to recycling infrastructures the project aims to ensure how low-value textiles can be optimised after they are disposed of from less circular destinations to better, more sustainable solutions like recycling. Under the post-consumer waste stream, we tested two different innovations and developed pilots accordingly; one of the pilots aimed to test semi-automated innovation using MATOHA's FabriTell desktop scanners (referred to as FabriTell), while the second pilot tested out fully automated innovation using PICVISA's ECOSORT TEXTIL (referred to as ECOSORT). In addition to these two partners, Reverse Resources provided their platform to digitally trace the waste which was sorted (from the sorter to the recyclers/downcyclers) and their expertise to allocate the waste to the best available use case.

- The pilot with Matoha was conducted to analyse the PCD textile waste stream and test the feasibility of FabriTell scanners from three different south Indian cities (Bengaluru, Calicut and Chennai). The pilot was conducted for a 6 month duration with ~33 tonnes of waste across four facilities.
- The pilot with Picvisa was conducted to extend the learnings of the first pilot to assess the feasibility of fully automated sorting technology in India. Since bringing in the technology to the probable user for assessment was not a suitable option considering the high costs associated with the technology and its transport, a reverse approach was adopted here to evaluate the technology.

After conducting the pilots, it is evident that post-consumer textile waste offers a significant opportunity to drive the circular economy forward in India. This report delves into post-consumer pilot initiatives with a focus on technologies such as Matoha and Picvisa that can harness the potential of automated sorting technologies to revolutionise textile-to-textile recycling and help evaluate a business case for sorters, aiming to devise and integrate sorting systems into their existing operations within India.

Methodology For Sorting Hubs

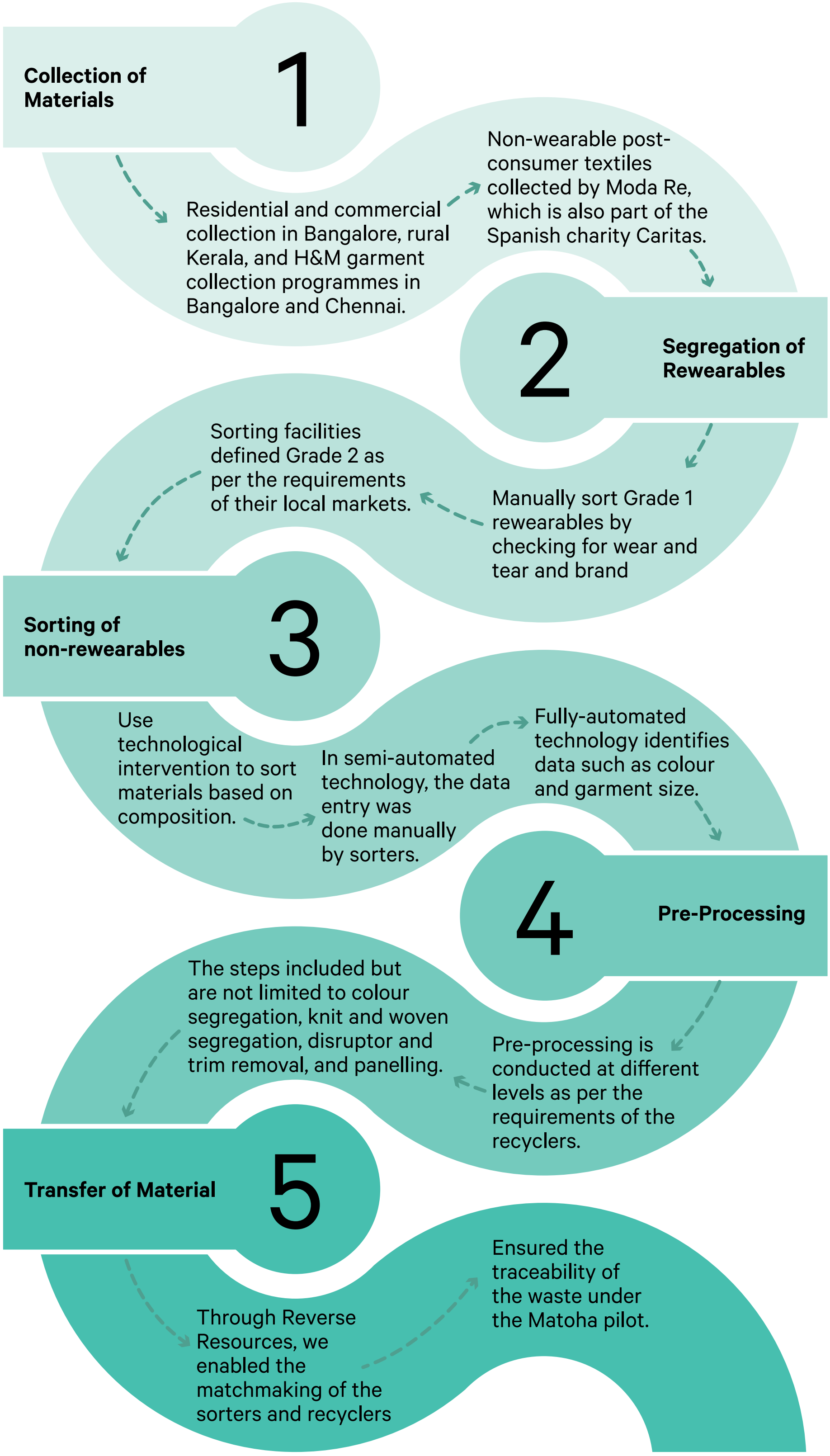


Illustration 4: The pilot methodology for the entire post-consumer pilot

1. **Collection** of Post-Consumer Waste: For the purpose of the pilot, the post-consumer materials were collected from different sources
    - Collection of Post-Consumer Domestic textile waste or PCD was through residential collection in Bangalore, Household collection in rural Kerala, and through H&M garment collection programmes in Bangalore and Chennai.
    - Non-wearable post-consumer textiles collected by Moda Re, which is also part of the Spanish charity Caritas.
2. **Segregation of Rewearables:** As per the requirements of resale markets in India, sorters were trained to manually identify Grade 1 rewearable garments by checking for wear and tear and by brand. Grade 2 rewearables are identified and classified by the sorting facilities as per the requirements of their specific local markets.
3. **Sorting of non-rewearables using technological intervention** to sort materials based on composition. In addition to composition, the fully-automated technology identifies data such as colour and garment size. Furthermore, under the semi-automated Matoha pilot, the data entry was done manually by sorters. To understand the methodology please refer to Annex 2.1 for the Matoha pilot methodology and Annex 2.6 for the Picvisa methodology.
4. **Pre-processing** of the materials: Pre-processing steps are done manually regardless of technology intervention. Under the Matoha pilot we conducted pre-processing at different levels as per the requirements of the recyclers. Pre-processing steps include but are not limited to colour segregation, knit and woven segregation, disruptor and trim removal, and panelling.
5. **Transfer of material** to recyclers: Using the Reverse Resources platform, we enabled the matchmaking of the sorters and recyclers and ensured the traceability of the waste under the Matoha pilot.

Analysis of Rewearable Garments

According to research by the Ellen MacArthur Foundation, clothing reuse is one of the most direct levers that can be used to reduce waste and pollution in the fashion and clothing industry[8]. The rewearable market in India currently is one that is predominantly within the informal economy[9]. Within India, the prevailing practices include wearing garments until their full utility followed by donation or handing them down to younger family members or domestic help within households, or repurposing them for household use. While there is a lack of reliable global data on the detailed quantities that follow each flow, the report highlights the current system of the life cycle, which illustrates that the Global South 'reuses and remakes' on average three times before it goes into reuse and is only disposed to local downcycling and recycling industries[10].

The combination of high utility rate and the lack of collection methods in India, restricted the use and presence of formalised second-hand stores in the country. However, due to increasing interest in sustainable living among the younger generations, there is a noticeable surge in both online and offline second-hand marketplaces. India has a large informal second-hand clothing market that operates on buying used clothing and selling it within India. When it comes to the relevance of the informal sales of second-hand clothes in India, with time there has been the development of other avenues of buying and selling. The closest link between the formal and informal second-hand players would be online/ social media stores. These stores are run predominantly by the younger generation, who procure their stock from local markets in their cities. The next avenue for second-hand sales are through local resale markets in the metropolitan cities. Major cities like Delhi, Bangalore and Mumbai have local markets where garments are sold along with surplus. According to the primary research conducted during our Wealth in Waste report, the final stakeholders in the value chain for resale of domestic second-hand clothing are the retailers that sell the second-hand clothing in flea markets in India. On the other hand, 32% of imported waste is accounted for by second-hand clothing. Additionally, according to the import policies of India, the used clothing category is a restricted trade in India and its import is only allowed in the Kandla Special Economic Zone (KASEZ)[11].

This gave rise to an opportunity within our pilot and helped us define how sorting processes and the growth of the second-hand market in India today can be integrated into our sorting methodology. Based on our pilot findings and the material scanning, we observed that the rewearables comprised only 10% of the total 33,178.85 kgs of materials collected.

> **"I am confident that the market for second hand will continue to grow in India, and believe that the issue in the success of second hand platforms can be indebted to the fact that India is a manufacturing country and there is ample availability of cheaper new alternatives instead of buying new."**
>
> Kirti Poonia, Founder, ReLove

Relove

Pan India
Pan India

Through the partner brand website

Through the partner brand website

Relove has mastered brand value and customer loyalty, and their data shows that brands have achieved a 22x return[12]

Mumbai

Resale through partner brand website

Pan India

2021

Peer to Peer

Kiabza – Fashionably smart

Consumers in Tier 1 cities
Consumers in Tier 2 and 3 cities

Manual quality check and entry into algorithm to validate brand

Through the Kiabza e-commerce website

Through the Kiabza e-commerce website

Mumbai

Recommerce

Pan India

2019

C2B2C

Wasted – infinite possibilities

Karnataka, Tamil Nadu and Telangana
Pan India

Manual

Online through the rebirth collective, offline from their brick-and-mortar store

Resale spaces like theirs, find a lack of sorting knowledge and recycling infrastructure, which prevents them from sending material that can go into recycling.

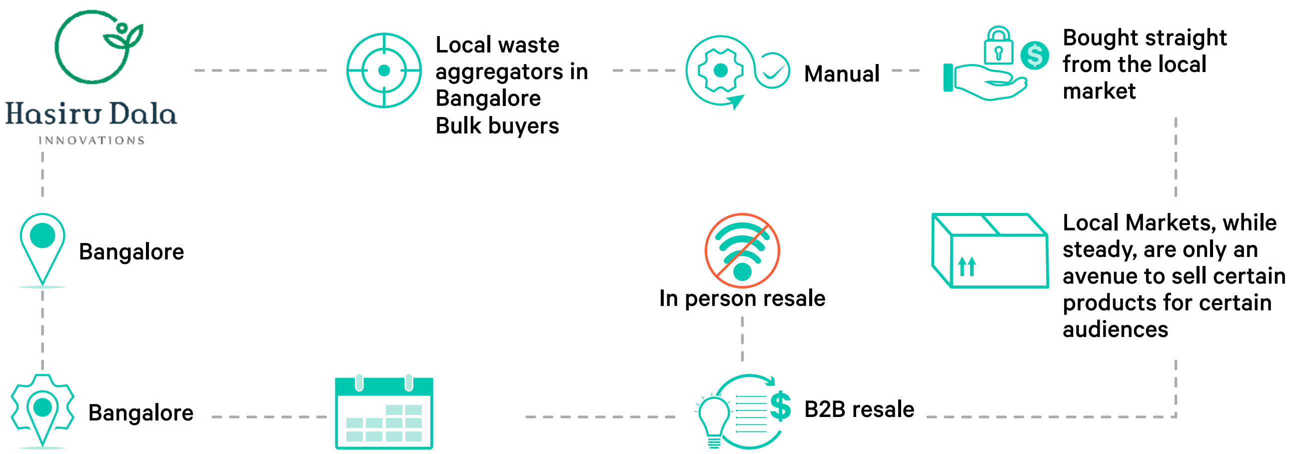
Chennai, Bangalore

& Retail

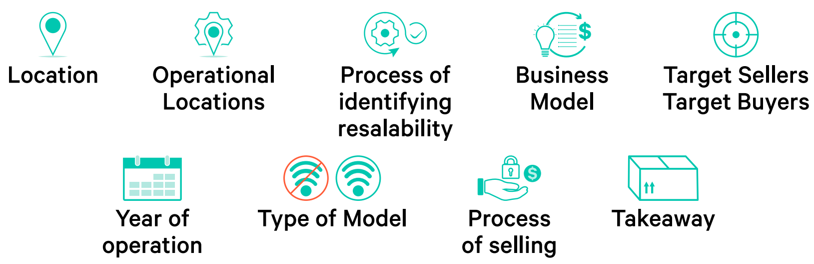
Chennai, Bangalore and Hyderabad

Founded 2019 and launched in 2018

Donation Model



COMMON LEGEND (For Page 23 and 24)



METHODOLOGY TO IDENTIFY REWEARABLES

For the pilot's success, it was important to train the sorters to differentiate between re-wearable and non-rewearables garments. The following instructions were followed in the process of identifying rewearables:

1. The first step involved examining garments for wear and tear, which varied on the garment type. For example, tops were checked for wear and tear in specific areas like armpits, the behind/under the collar and the back. Whereas when it came to bottoms, the front rise/back rise or the bottom hem of the garment for fraying or wear and tear. However, it is important to note that although the sorters were trained for this process, their subjectivity remained in their assessment.
2. Sorters were provided with a list of brand logos based on the requirements of online second-hand platforms. The first step was to check each garment for a garment tag or main label. If the garment did not contain a tag, it was considered non-rewearable in most cases. Some of the facilities involved in second-hand markets incorporated their own methodologies for identifying rewearables.

LEARNINGS FROM REWEARABLES

The low percentage of rewearables can also be a consequence of the cultural habits of consumption in India. Due to the lack of standardised apparel sizes, many people, particularly in rural India, prefers to buy ready-to-stitch fabric and customise it to their size and preferences, rather than opting for ready-to-wear options[13]. This, along with the aforementioned requirements of a few second-hand platforms in India, influenced the quantity of rewearables found in different facilities.

Interestingly, this played a role in the results at the Greenworms facility in Kerala, where out of 12,000 kgs sorted, no garments met the specifications of rewearables as defined in the pilot. Meanwhile, SZW collected a total of 4590 kgs of rewearables, accounting for 27.48% of their total material, while Uptex collected 75 kgs of rewearables, representing a mere 1.24% of their material.

Sorting Facility	Rewearables		Total Quantities collected	Share of Rewearables
	GRADE 1 Sold on Resale platforms and marketplaces	GRADE 2 Sold in Local resale markets		
Greenworms	0 kgs		12,707 kgs	0%
Saahas Zero Waste	2984 kgs	1607 kgs	15,902 kgs	27.5%
Uptex	75 kgs		6,079 kgs	1.2%
Hasirudala		30 kg	2,471 kgs	1.2%

Illustration 5: Overview of share of Rewearables at the various facilities

CASE STUDY OF SAAHAS ZERO WASTE

Out of a sample size of 52,302 garments from the total quantities collected at the facility, it was found to contain a mix of Grade 1 and Grade 2 Rewearables. Grade 1 garments are characterised by high quality and higher value that could be re-sold through second-hand platforms both online and offline. Grade 2 garments are lower grade material sold in local second-hand markets and are selected subjectively, based on the local market that SZW works with. From the total 4,591 kgs of rewearables found at their facility, 2,984 kgs were found to be Grade 1 and 1607 kgs was Grade 2.

Grade 1:
We analysed the Grade 1 materials to understand the type of resellable materials collected during the course of the pilot at the SZW facility. Of a sample size of 1,428 garments, we found that 77% of rewearables in the Grade 1 category were Women's clothes and 15% to be Men's. Baby clothes had the smallest share when it came to rewearables. In terms of garment type, the category of tops, which includes blouses, held a share of 39.9% of the total. Finally, in terms of material composition, the data that was captured manually by entering values from the garment tags, we observed that 35% of garments had a 100% cotton composition.

Analysis of Non-Rewearable Garments

Post-consumer textile waste is a heterogeneous mixture of garment types, colours and compositions with trims and accessories (or disruptors). Such garments are composed of fibres like cotton, polyester, wool, acrylic, viscose, etc. These fibres are either the sole component or are mixed with other fibres to create a blend. The management of post-consumer textiles is a complex process that demands an efficient system of collection, sorting, and recycling.

The primary challenges faced by any post-consumer textile waste recycler are:

- Unsorted post-consumer textile waste feedstock with varying colours and compositions
- Lack of systematic and efficient access to such feedstock
- Poor traceability of the feedstock

The first step towards achieving higher valorisation of waste is to create efficient processes for sorting based on colour and composition.

With this in mind, the Sorting for Circularity India project conducted a pilot for post-consumer waste collected and sorted domestically using Matoha FabriTell Scanners, and based on its learning, carried out a second pilot to asses the technological feasibility of the fully-automated PICVISA ECOSORT.

Matoha FabriTell rapidly identifies natural, man-made, and blended fibres of all textures and colours with a textile identifier that requires little to no technical expertise to operate. The FabriTell devices can instantly identify textile items, enabling their rapid and accurate sorting. The device is highly portable and can be powered by an optional built-in battery. NIR analysis is very quick and typically no sample preparation is needed. However, the accuracy of this technique is lower than a full laboratory analysis of the sample. The desktop version is an all-round device for a range of use cases. It's portable, can be powered by an optional built-in battery, and can accurately identify a wide range of fabrics and blends. The device allows to save up to three layers per garment and has the potential to provide data while the sorting process is taking place. The device takes less than 1 second to identify the composition and, throughout our pilot, sorters had an average scanning speed of 20 seconds per scan (per layer). The tasks carried out within the 20 seconds included picking up the garment, placement on the scanner, inputting colour and category data, and putting away the garment in the respective bucket.

PICVISA's robotic sorting system for textiles combines an optical sorter and a lateral air-blowing system. The optical sorter identifies and separates textiles based on composition of natural, man-made, and blended fibre, colour and/or shape based on a combination of Near-Infrared (NIR), Red-Green-Blue (RGB) camera technology and artificial intelligence (AI) algorithms. As soon as an item is scanned by the optical sorter and the category is determined, the piece is moved to the evacuation belt where the garment is moved to the respective category basket by air blowers. The scanning speed is one second per garment, and the conveyor belt moves at a speed of 1 metres per second.

The non-rewearable categories are the focal point of the composition analysis.

INTRODUCTION TO THE SORTING TECHNOLOGIES

	Manual Sorting	Semi-Automated Sorting using Matoha FabriTell	Fully-Automated Sorting using Picvisa's ECOSORT
Description	Sorting involves assessing the composition by hand-feel or reading of composition tags and identifying the colour visually. The material is manually moved.	Sorting involves assessing the composition by NIR scanning and identifying the colour manually. The material is moved manually.	Sorting involves computer vision for assessing the composition by NIR and AI and identifying the colour through a VIS camera. The material is moved mechanically.
Material Library	Not applicable	Pure fabric: 9 Two-component blended fabric: 17[14]	Pure fabric: 10 Two-component blended fabric: 5 [15]
Colour Library	Manually identified	Manually identified Colour options input: 14	Computer vision identified Colour options input: 14 (hues can be selected for each colour)[15]
Productivity	80 kg per day, per sorter	100 kg per day, per sorter	7,000 kg per day, per machine
Accuracy	Low (subject to manual bias/ error)	High (~95%)	High (~95%)
Additional Infrastructure Requirements	None	No additional space. Can be easily integrated into the manual sorting infrastructure.	May or may not require additional space. Industrial set-up required due to higher energy consumption.
Cost per machine	Not applicable	INR 2,60,000 GBP 2500 Price of one machine	INR 4,48,70,000 EUR 500,000 Price of turnkey solution[16]

Illustration 6: Overview of Sorting Infrastructure

UNPACKING THE NON-REWEARABLES UNDER THE MATOHA PILOT

The segregation of the non-rewearables under the pilot was for the purpose of recyclability, and to ensure the redirection of materials to the right destinations. Textiles were segregated based on the following characteristics: 1) the composition of the material, 2) the colour of the garment, 3) the presence of disruptors, and 4) the type of garment. The data was captured through the Matoha FabriTell device, Matoha application and observed using on-ground- monitoring and daily surveillance. This section goes into detail about the potential feedstock found during our analysis.

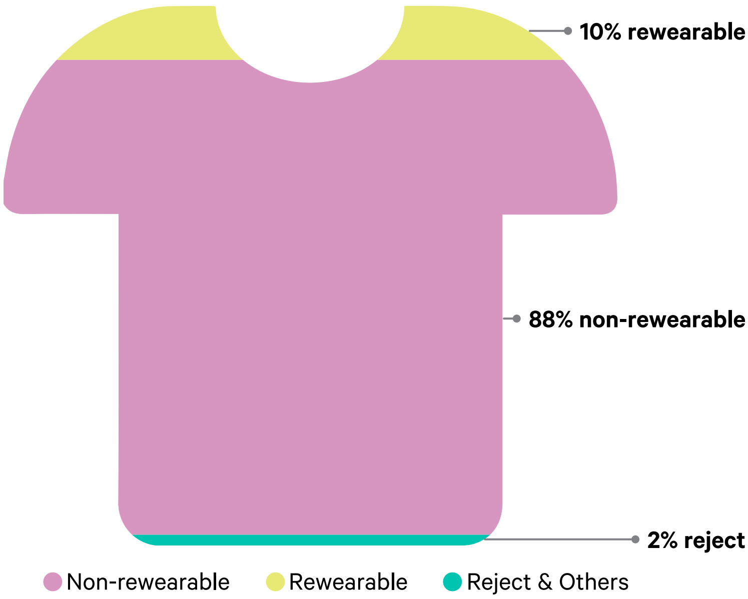


Illustration 7: Breakdown of the total quantities collected, as per their usage

The Matoha pilot was designed to sort non-rewearable material into 7 categories based on composition. These categories were defined using the input of recyclers in India, and were based on their feedstock requirements.The seven categories defined for the pilot were:

1. 100% Cotton
2. Cotton Rich: ≥95% Cotton with Elastane
3. Cotton Rich: ≥70% Cotton with Polyester (no elastane)
4. Cotton Rich: ≥50% Cotton with any other fibre
5. Polyester-Rich: ≥50% Polyester with any other fibre
6. Any wool/Acrylic blend
7. Others and Unknown

METHODOLOGY OF MATOHA PILOT

1. **Collection of post-onsumer waste:** For the purpose of the pilot, the post-consumer materials were collected from different sources
    - Collection of PCD was through residential collection in Bangalore, Household collection in rural Kerala, residential collection through Dry Waste Collection Centers (DWCCs) in Bangalore and through H&M garment collection programme in Bangalore and Chennai
2. **Segregation of rewearables:** As per the requirements of resale markets in India, sorters were trained to manually identify Grade 1 rewearable garments by checking for wear and tear and by brand. Grade 2 rewearables are identified and classified by the sorting facilities as per the requirements of their specific local markets.
3. **Non-rewearables are put through sorting using Matoha devices,** and the following steps were taken (see Annex 2.4 for a more detailed description)
    - Items are picked up individually and placed on the device - the device displays the composition on the devices' screen, and the LED on the device lights up as per the category its composition falls under
    - The sorters manually entered details such as colour, disruptor and garment type, for the purpose of data collection. In the case of multi-layered garments, the second layer (at most two layers were scanned) was then scanned and saved to the previous sample
    - If the result of the scan was "unknown", the sorter manually entered the composition if a label was found
    - The sample was placed in the bucket with the corresponding colour from the LED light on the Matoha device
4. **Pre-processing of the materials:** Pre-processing steps are done manually regardless of technology intervention. Under the Matoha pilot we conducted pre-processing at different levels as per the requirements of the recyclers. Pre-processing steps include but are not limited to colour segregation, knit and woven segregation, disruptor and trim removal, and panelling.
5. **Transfer of material to recyclers:** Using the Reverse Resources platform, we enabled the matchmaking of sorters to recyclers and ensured the traceability of the waste under the Matoha pilot.

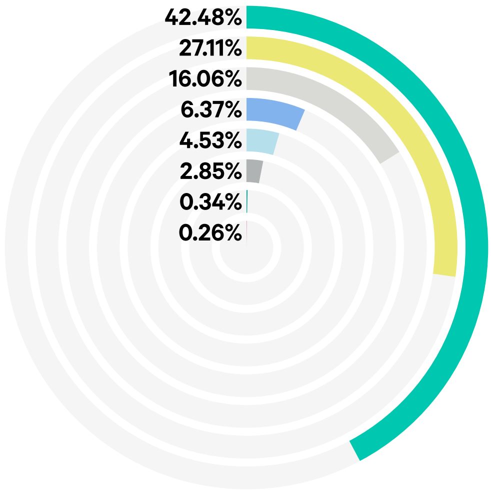
Once the material was scanned using the Matoha device, the materials were pre-processed to different levels at different facilities based on the needs of particular recyclers interested in the feedstock.

To ensure data analysis accuracy and address concerns regarding data consistency, we have decided not to include the data collected from HDI/HD in the results. Nevertheless, it's essential to acknowledge that HDI/HD remains a significant organization involved in collecting and processing textile waste in India.

COMPOSITION ANALYSIS

The two most prevalent fibre composition categories in the non-rewearables category were 100% Cotton, holding a share of 43.3% and Polyester-Rich (more than 50% polyester + any other fibre) holding a share of 27.6% At two out of three facilities, SZW and Uptex, the predominant category was 100% cotton, and at the third facility (Greenworms), polyester-rich slightly surpassed 100% cotton category. Understandably, categories like wool and acrylic blends were not found in abundance due to geographical location. Cotton rich: 95% cotton with elastane was also less than 1% of the material since the technology finds it difficult to identify elastane.

With semi-automated sorting of polyester-rich materials, the polyester waste stream could increase the recycling value by 1098 Kilo MT per year.



Composition Analysis- Total quantity from all three facilities

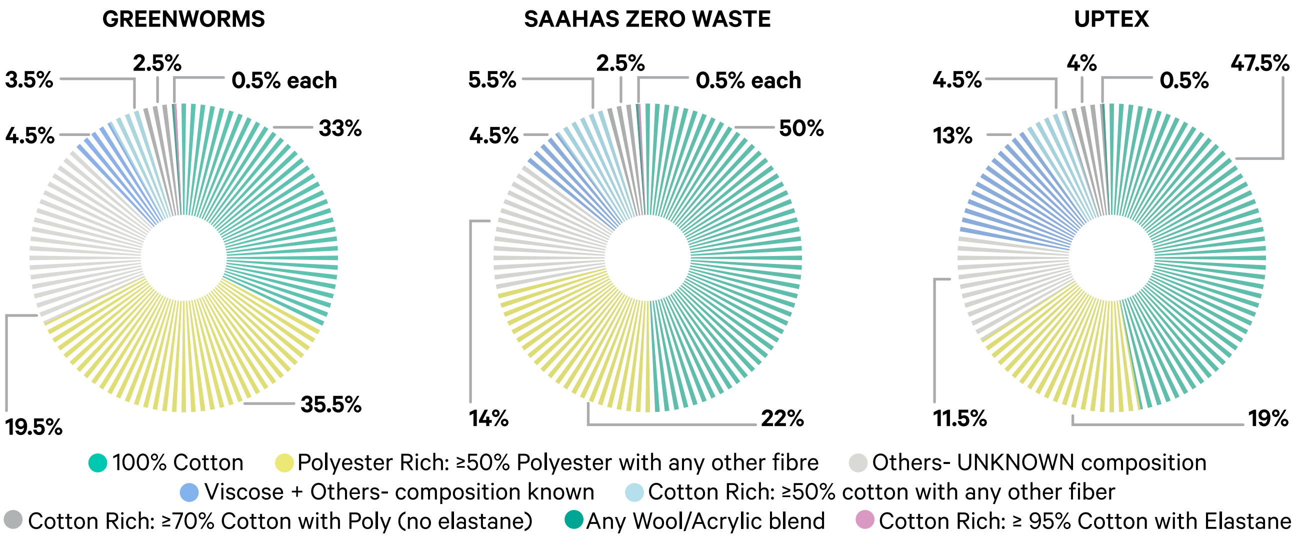


Illustration 8: Composition Analysis

The samples were further tested for accuracy by NimkarTek Technical Services Pvt. Ltd and the findings are given below (detailed test results in Annex 2.9):

Detected composition from FABRITELL	Verification from Fibre Composition Analysis at Lab	Reasoning for Discrepancy
100% Cotton	● ● ● ● ⊗ up to 3% elastane detected	Identification of elastane through NIR is an issue, the reason for this is that elastane is typically incorporated into the core of yarns, which NIR fails to scan since it only looks at the yarn's surface.
≥ 70% Cotton with Polyester	● ● ● ● ● +/- 8% range	Matoha claims to identify composition with an accuracy of ±10%
≥ 50% Cotton with any other fibre	● ● ● ● ● +/- 2% range	Matoha claims to identify composition with an accuracy of ±10%
≥ 50% Polyester with any other fibre	● ⊗ ⊗ ⊗ cotton identified as viscose	Unclear
	⊗ up to 2% elastane detected	Identification of elastane through NIR is an issue
100% Polyester	● ● ● ● ⊗ Acrylic detected in stripes of the fabric	Matoha claims to identify composition with an accuracy of ±10%
		When scanned using Matoha, the layer is scanned and can miss out elements like small fabric patches or stripes
Wool/Acrylic Blends	● ● ● ● ●	None

Key: ● Sample **passed** testing
⊗ Sample **failed** testing

Illustration 9 : An overview of the Lab Test results of samples (see Annex 2.9 for detailed report)

COLOUR ANALYSIS

Within the Matoha pilot, a total of 12 colours were being recorded in the manually added data for each garment. A total of 44.6% of materials were scanned as multi-coloured, 9.2% was scanned as Black, 10.3% as White and 10.3% as Blue. Brown, Green, Pink and Grey were between 5,6%- 3.7% and the lowest quantities of Purple, Yellow, Orange and Red that ranged between 1.2%-2.7%.

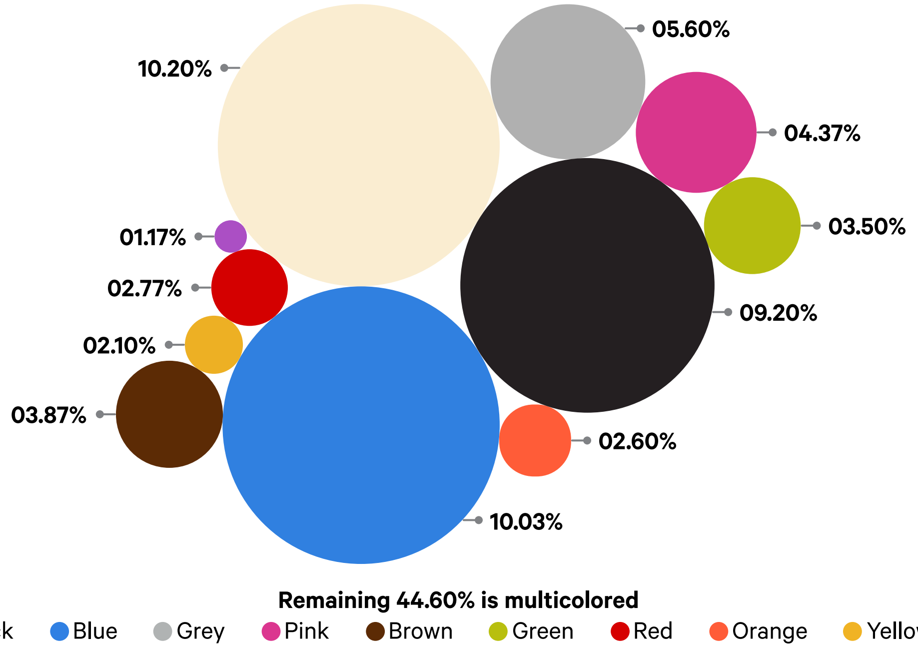


Illustration 10: Breakup of colours of non-rewearables as per Matoha Data

GARMENT TYPE ANALYSIS

As per the illustration 11, during the course of the pilot, the garment category of tops which include t-shirts, jackets, hoodies and sweaters, blouses, polo shirts as well as Indian tops like kurtas and sari blouses were found to be most common. Followed by bottoms, including jeans, pants, shorts, and skirts. Followed by the third category i.e. overalls including dresses, jumpsuits and nightwear. The accessories include medium and small accessories such as gloves, socks and scarves. All innerwear is included in the underwear category. Lastly, and of the smallest quantity, are baby clothes, which include Indian wear. In Annex 2.3, you can find the garments categories in more detail.

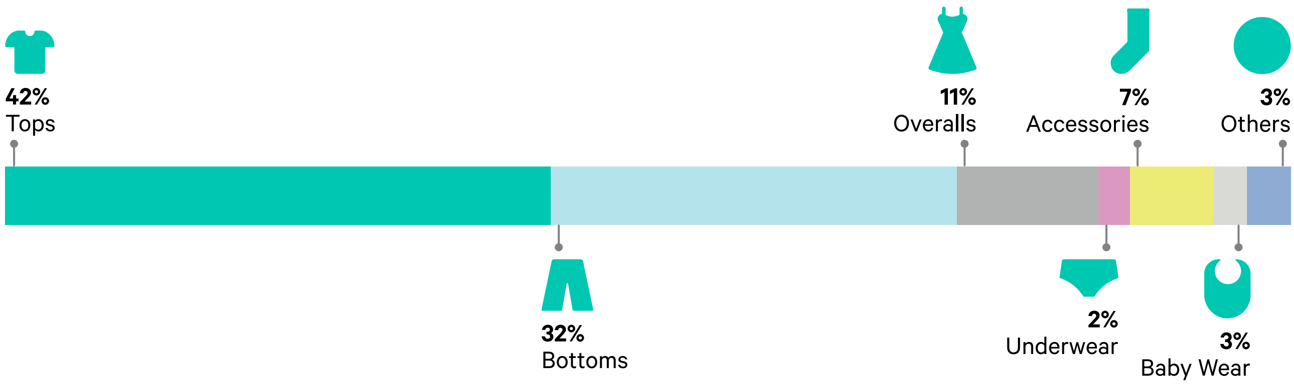


Illustration 11: Garment type breakup of the total non rewearable quantities

DISRUPTOR ANALYSIS

Out of these 6 disruptor materials, the largest portion was found to be Fabric Disruptors, which accounted for 36.06% of the total disruptors.

We also observed that the geographical location and the collection methods played a role in the multitude of different kinds of materials, and the number of disruptors and multi-layer materials. In terms of garments that were mono-layer, we observed that Greenworms had the highest volume of multi-layered garments, accounting for 8.11% of their material. Both Uptex and SZW had volumes of less than 1% that accounted for multi-layered garments.

The activities under the Matoha pilot from four individual sorters are given below.

Greenworms

Under the pilot, Greenworms collected 12,707 kgs of non-rewearables from rural household collections. They scanned all material using the Matoha devices using the methodology defined, and had an average of 23 seconds per scan (per layer) for the duration of the pilot. After sorting, they went on to pre-processing of their Polyester-rich and 100% Cotton material. The polyester-rich material was further segregated into 100% Polyester and cotton-polyester blends with ≥30% cotton present. The 100% Cotton was colour segregated into three top colours- Black, Blue and White. Their material was sent to 2 recyclers at the end of the pilot. Out of their total quantities, the polyester-rich category slightly surpassed the 100% cotton category when it came to largest volumes. Greenworms was also found to have the highest share of multi-layered materials, accounting for 8.11% of their total quantity.

“This FFG pilot project has helped us to understand the post-consumer textile waste value chain in much deeper way, the possibility of various technology integration was very insightful, based on this learning, we own an exclusive Textile Recovery Facility with 30 tonnes per month capacity now.”

Jabir Karat, Co-Founder of Green Worms

Saahas Zero Waste (SZW)

Under the pilot, SZW collected a total of 15,902 kgs of PCD, of which 10,067 kgs were found to be non-rewearable from urban residential and commercial collection and H&M garment collecting programme. They scanned all material using the Matoha devices after the segregation of rewearables, and had an average of 20 seconds per scan. After sorting, they went on to pre-processing all the 100% Cotton into approximately 15 colours. The white 100% cotton then went into knit and woven segregation as per the request of the recycler. The knit 100% white cotton, was then pre-processed for trip and disruptor removal, followed by panelling. The total materials were sent to 4 recyclers at the end of the pilot. When it comes to composition, 100% cotton held a share of almost 50% of the total non-rewearables. Polyester-rich followed in quantities with a share of 22% of the total volumes.

"Matoha has proven to be a game-changer, offering precise readings and enhancing operational efficiency for domestic post-consumer textile waste. It can pave the way for a budget-friendly sorting solutions at a small scale , creating a diverse supply of high-quality feedstock for recyclers. It's output is very dependable and we hope that this can be integrated into the sorting businesses that currently exist in India."

Shobha Raghavan, Chief Operating Officer, Saahas Zero Waste

Uptex (Enviu)

Under the pilot, Enviu collected a total of 6,079 kgs, of which 6,004 kgs of non-rewearables from H&M's garment collection programme across Chennai. They scanned all material using the Matoha devices after the segregation of rewearables, and had an average of 20 seconds per scan. After sorting, they went on to pre-processing of all the 100% Cotton, Cotton rich (50% with any other fibre), Polyester-rich (50% polyester with any other fibre) and the unknown/others category. 100% cotton was colour sorted into white and other colours, and the white category was then sorted for knit and woven. The knit 100% white cotton, was then pre-processed for trip and disruptor removal, followed by panelling. Cotton rich (50% cotton with any other fibre) was colour segregated to solid colours and multicoloured. The rest of the categories (unknown/others and polyester-rich) were segregated into 5 colours- black, dark grey, dark blue, light blue and light grey. This colour segregated material was used under The Good Felt Project as feedstock and the rest of the materials were sent to 3 recyclers. The project has been launched in collaboration with Ikea Foundation and the felt is being created at Kaygee Enterprises, one of the recycling partners in the pilot. The Good Felt project received their first corporate order from GIZ, for laptop sleeves, and is currently in production.

Hasirudala Innovations (HDI)

Under the pilot, HDI collected 2,471 kgs of PCD from urban residential and collection. Of this volume, 2,471 kgs were identified as non-rewearable. The materials were scanned using the Matoha devices after the segregation of rewearables. After sorting, they went on to pre-processing all the 100% Cotton into 3 top colours- black,white and green. The 100% cotton that was colour segregated (black, white and green), went through the pre-processing step of trim/disruptor removal. The total materials was sent to 1 recycler at the end of the pilot[17].

AN OVERVIEW OF THE MATOHA PILOT ACTIVITIES

Sorting Facility	Infrastructure	Collection			Sorting	Pre-processing	
		Collection Method	Quantity (in KGs)	Non rewearable quantity (in kg)		Composition category	Steps
Green-worms	New textile recovery facility Location: Thama-rassery, Kerala Area: 3000 sq m2	Already existing collection system Household collection, occasionally with dry waste collection, from rural Kerala specifically Calicut and Kasaragod districts	12,707	12,707	All materials were scanned using the Matoha Devices with three main actions: 1. Sorting the rewearables and non wearables	100% Polyester	1. Using the Matoha scanners into three categories-100% polyester, Polyester-Cotton blends with a composition of more than 30% cotton and 50% polyester with any other fibre.
						100% Cotton	1. 3 top colours-black, blue, white and the rest was considered as multicolour
Saahas Zero Waste	New textile recovery facility Location: Bangalore Area: 4000 sq m2	Already existing collection system Collection drives from residential apartments and clients	10,067	12,114	2. Scanning the garments using Matoha and adding garment details on the Matoha application	100% Cotton	1. Colour segregation into 15 colours 2. Knit and woven segregation 3. Disruptor and trim removal
		Garment collection from 5 H&M stores in Bangalore	6,638				

<table>
<tr><th>Sorting Facility</th><th>Infrastruc-ture</th><th colspan="3">Collection</th><th>Sorting</th><th colspan="2">Pre-processing</th></tr>
<tr><th colspan="2"></th><th>Collection Method</th><th>Quantity (in KGs)</th><th>Non rewearable quantity (in kg)</th><th></th><th>Composition category</th><th>Steps</th></tr>
<tr><td rowspan="5">Uptex</td><td rowspan="5">Already existing textile recovery facility
Location: Chennai
Area: 15000 sq m2</td><td rowspan="5">Garment collection from 3 H&M stores in Chennai</td><td rowspan="5">6,079</td><td rowspan="5">6,004</td><td rowspan="6">3. Placing the garments into their bucket as per LED light on Matoha</td><td>100% Cotton</td><td>1. Colour segregation into white and other colours
2. Knit and woven segregation
3. Disruptor and trim removal</td></tr>
<tr><td>50% Cotton with any other fibre</td><td>1. Solid colour and multicolour segregation</td></tr>
<tr><td>Others</td><td rowspan="3">1. Colour segregated to 5 colours- black, dark grey, dark blue, light blue and light grey
2. Inspected for discolouration</td></tr>
<tr><td>Unknown</td></tr>
<tr><td>50% Polyester with any other fibre</td></tr>
<tr><td>Hasiru-dala</td><td>New textile recovery facility
Location: Bangalore
Area: 300 sq m2</td><td>Already existing collection system Residential collection from Bangalore through dry waste collection centres</td><td>2,471</td><td>2,441</td><td>100% cotton</td><td>1. Colour segregation to top 3 colours- Black, white and green
2. Disruptor removal for the three colours segregated</td></tr>
</table>

Illustration 12: An Overview of Matoha pilot activities

UNPACKING THE NON-REWEARABLES THROUGH THE PICVISA PILOT

From the above section, we understand that an improvement over manual sorting is semi-automated sorting, which involves the use of desktop or hand-held scanners to first detect the composition. The colour is then manually identified and used for sorting taking into account the detected composition. While this approach is more efficient and can accurately assess composition, it may lack sufficient throughput at larger volumes.

Large volumes and high-value recycling demand a much more effective and efficient technology capable of dealing with the complexity of post-consumer garments. Automated sorting makes it possible to handle such large volumes while simultaneously producing high-quality feedstock for recyclers. Automated sorting can pave the way for valorising textile waste, transforming it into a resource that can boost textile circular business models.

PICVISA's portfolio consists of two products for textile waste sorting - ECOCLIP for sorting post-industrial clippings, and ECOSORT for sorting post-consumer textile waste. ECOSORT was tested in Fashion for Good's "Post-consumer India Pilot". It was developed in the year 2021 and enables the recycling industry to identify and separate textiles based on composition, colour, and/or shape.

The categories of fabrics that ECOSORT can recognise and separate can be customised according to the customer's needs. Specifically, the percentage composition that the machine should identify can be set (within a specified % range). The customer can further define the shades that they would like to categorise under each colour. This enables them to pick their own configurations in terms of composition, and colour from their requirements of textile feedstocks needed for their end-products. The capability of sorting is achieved with an AI algorithm that is trained on an extensive material library. The material library consists of a variety of colour shades and 15 categories of fibre compositions, comprising both pure and blended fibres. This library is continually updated based on customer needs and is also made available to the customer.

We used a feedstock of post-consumer non-rewearable garments collected from the European market for this analysis. The material tests carried out involved the most prevalent compositions and colours based on the initial results of the Matoha pilot and feedback from the pilot participants.

The categories defined for the pilot were:

1. 100% Cotton
2. Cotton Rich: ≥70% Cotton
3. Cotton Rich: ≥70% Cotton with Polyester
4. 100% Polyester
5. Polyester-Rich: ≥70% Polyester with Cotton
6. 100% Viscose
7. 100% Nylon
8. 100% Wool
9. Cotton/ Acrylic Blends
10. Cotton/ Viscose Blends

We performed the following analysis onsite:

a. Material analysis: composition and colour,
b. Garment size analysis and
c. Efficiency analysis.

Each of these are discussed in the table below

METHODOLOGY OF PICVISA PILOT

1. **Collection** of post-consumer waste: Non-wearable post-consumer textiles were collected by Moda Re, which is also part of the Spanish charity Caritas. The weight of the entire feedstock was 1228 kgs (or 1.3 tonnes).
2. **Sorting the non-rewearables** with the PICVISA ECOSORT, consisting the following steps (see Annex 2.6 for a detailed description):
    - Setting the sorting categories on the dashboard.
    - Picking up items individually and feeding to the conveyor.
    - Automated sorting by the machine.
    - toring the sorted material.
3. No pre-processing steps or transfer of materials to the recyclers were done under the Picvisa pilot.

COMPOSITION ANALYSIS

The combined composition and colour ECOSORT sorting results are given below.

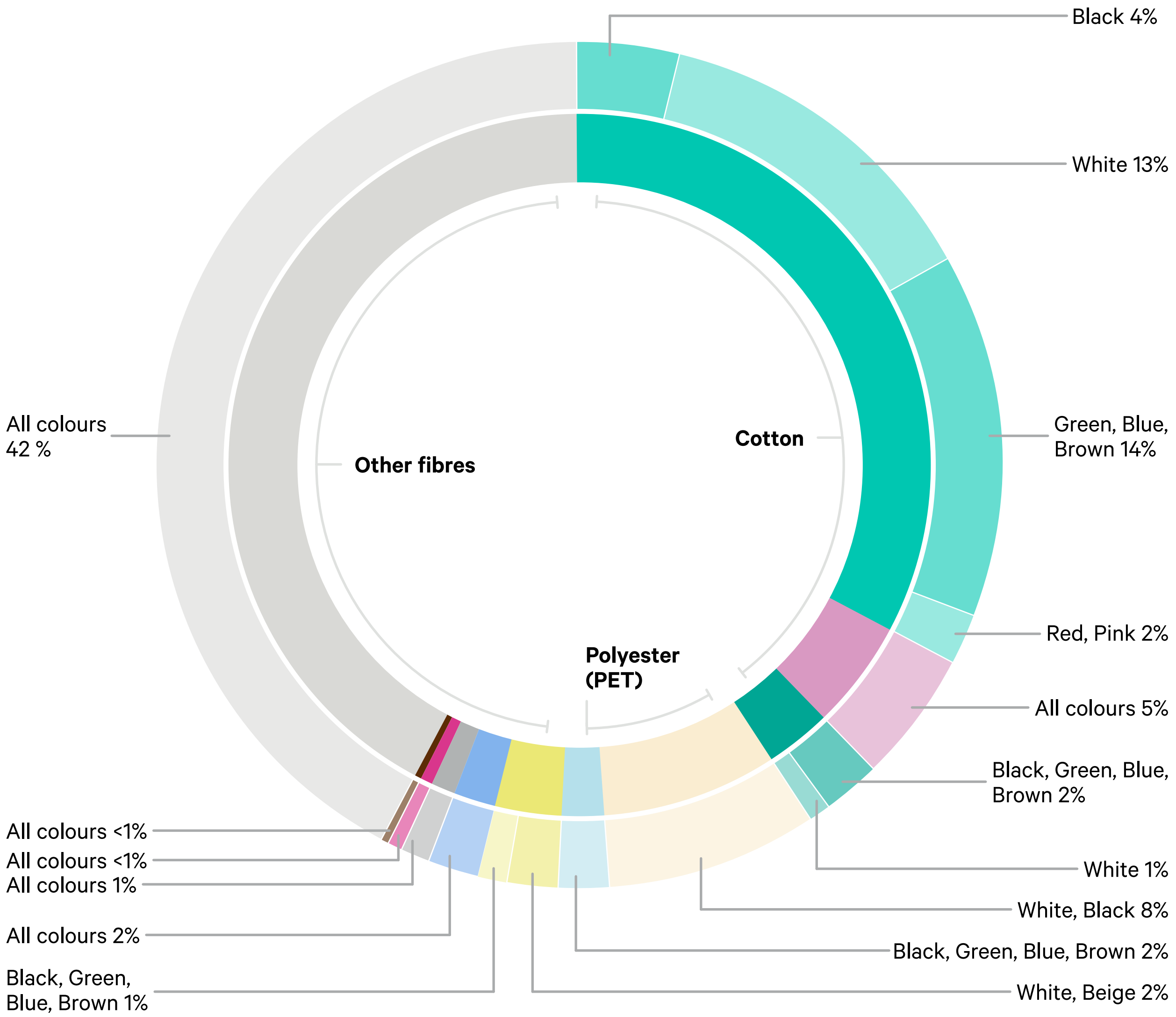


Illustration 13: Composition Analysis

A quick initial verification was performed by visual and hand-feel tests. This verification was done by experienced stakeholders present onsite during the trial, and the results were found to be promising. Two concrete types of verification tests were performed on these samples.The first verification was with Matoha's desktop scanner. Although this scanner also uses NIR for the detection of the composition, testing against it enabled us to assess the relative speed of ECOSORT's detection. It also enabled verification of sorting against a third-party solution. The second verification was done with chemical testing, for which we used five random samples from the five most preferred categories by recyclers, viz.: (a) 100% Cotton, (b) 100% Polyester (PET), (c) 100% Wool, (d) 70% Cotton, 30% PET and (e) 30% Cotton, 70% PET. The testing was conducted by NimkarTek Technical Services Pvt. Ltd. The fibre content of the samples was determined using ISO 1833-1:2020 and ISO 1833-11:2017 test methods.

The findings are given below:

Detected composition from ECOSORT	Verification from Matoha	Verification from Fibre Composition Analysis at Lab	Reasoning for Discrepancy	Inference / Rectification
100% cotton	●●●●●	●●●● ⊗ 48% flax (linen) detected	Flax being a cellulosic fibre like cotton, the spectral responses are very similar. Note that the ECOSORT material library has separate entries for hemp and cotton.	The erroneous sorting of flax may not be a major issue, since it can potentially be recycled with cotton, either mechanically or chemically.
100% Polyester (PET)	●●●● ⊗ unable to detect lace fabric	One of the five samples contained 9% elastane.	●●● 9% elastane detected ⊗⊗ 58% nylon detected	PICVISA is currently testing out sensors for elastane detection that work with different wavelengths. However, the current barrier to implementation is the cost of such sensors.
	Unable to detect lace/ net fabric accurately	One of the five samples contained 58% nylon.	●●● 9% elastane detected ⊗⊗ 58% nylon detected	These samples were intentionally chosen to be black, and it highlights an important limitation.

100% Wool	●●●●●	●●● ⊗⊗ up to 10% nylon detected	Even though both nylon and wool are polyamides with a similar spectral response, difference between nylon and wool is feasible with the ECOSORT. However, there is a possibility of error when the content of nylon is low in the garment.	The presence of nylon in small quantities is not a challenge for mechanical recycling of wool. Nylon is commonly blended with wool yarns to (a) Reduce cost, (b) Improve moisture-wicking properties compatible with wool, and (c) Improve flexibility, durability and dimensional stability.
70% Cotton, 30% PET	●●●●● +/- 7% range	● +/- 10% range ⊗⊗ less than 60% cotton. ⊗ viscose detected ⊗ 100% cotton	The model is reinforced for polyester-cotton mixture as that is a more common blend. While viscose can be distinguished from cotton in pure fabrics, the model can be also trained for blends.	Viscose being a cellulosic fibre, it can be chemically recycled (by pulp formation) with cotton.
70% PET, 30% Cotton		●●● ⊗⊗ less than 60% polyester	The sorting takes into account a margin of +/- 10% for blends.	

Illustration 14: An overview of the Lab Test results of samples (see the detailed test results in Annex 2.10)

A final observation was that the accuracy of the system depends on the information on fibre compositions that have been stored in the data library. A mature and well-trained system can achieve an accuracy as high as 95%. We can thus infer that a large and diverse material dataset is critical to ensure accurate sorting.

COLOUR ANALYSIS

A post-consumer waste recycler for high-value products usually requires specific and accurate colour sorting of the feedstock. We thus chose colour combinations to sort based on the most prominent colours from the Matoha pilot and conversations with recycling stakeholders. The sorted garments were manually inspected for colour accuracy. We found that the accuracy of colour sorting of ECOSORT is good and ticks off most of the requirements of a recycler. ECOSORT could easily identify a large variety of colours: from dark to light all the way to pastels. ECOSORT allows the selection of hues and shades of colours from a long list. For example, a user can define green as hues and shades of dark green, olive green, parrot green or blue-green, but another user may define the same green as just dark green.

Thus, an added advantage of ECOSORT is that colour sorting is done exactly according to colour values, and not via manual visual inspection which can induce the bias from the manual sorter.

Colour	Capability to distinct	Limitation
Black		• Carbon black coloured garments can cause challenges for NIR scanning.
White		• Observed a few white base (white more than 90%) fabric with coloured print. • Observed striped fabric with major white stripes and very fine other coloured yarn.
Red		• Observed purple coloured fabric • Contained majority of embellished fabric
Pink		
Green, Blue, Brown		• Observed grey coloured fabric, maroon coloured fabric • Contained majority of printed fabric
Key: Represents the capability on a scale of five		

Illustration 15: Limitations in colour distinction by VIS Camera

On first look, these may seem to be limitations of ECOSORT. However, since it's possible to tune colour sorting settings and choose exact colour values, it's possible to handle these cases as well. The customer/user thus needs to carefully tune the settings to achieve high sorting accuracy as per their requirements. Similarly, for striped, chequered, and printed garments, the colour-sorting AI algorithm can be trained to detect such patterns and reject those garments.

GARMENT ANALYSIS (SIZE-WISE SEGREGATION)

Some customers may also find the need to sort different garments of the same composition, for example, a 100% cotton shirt should be separated from 100% cotton socks. A good method to achieve such sorting is to sort by garment size. As mentioned above, ECOSORT also identifies the garment size to determine the amount of air to be blown for physical sorting. The already available size data can then also be used to define a suitable sorting constraint in ECOSORT for storing according to size.

We also tested this capability to sort a mix of socks, masks, handkerchiefs, undergarments etc. and found reasonably good results.

EFFICIENCY ANALYSIS - THROUGHPUT

In the previous subsections, we determined that composition & colour sorting are fairly accurate. We now turn our attention to the evaluation of the throughput of sorting with ECOSORT.

ECOSORT claims a throughput of approximately 900 to 1000 kgs per hour. The throughput is related to the average weight of garments processed. ECOSORT can process one garment per second on each conveyor, and the average weight of each garment is considered 300 grams. Based on this, PICVISA recommends that for a sorting capacity of 10,000 tonnes per annum, ECOSORT's optimal configuration is with 12 hoppers and a single conveyor.

In our tests, we observed a throughput of around 400-500 kgs per hour, for a four-hopper configuration of ECOSORT. Note that this highly depends on the speed of feeding garments into the machine - the number observed during the trials was with a moderately experienced workforce. With a more experienced workforce, the number may be much higher, or much lower with a less experienced workforce. Additionally, during the testing, there was a significant presence of small garments like socks and underwear, which brings down the throughput but generally the post-consumer waste garments have a bigger size.

PICVISA recommends that for a sorting capacity of 10,000 tonnes per annum, ECOSORT's optimal configuration is with 12 hoppers and a single conveyor. Note that this number is considering a sorting rate of one garment per second and an average garment weight of 0.3 kg.

AN OVERVIEW OF THE PICVISA PILOT ACTIVITIES

Sorting Facility	Infra-structure	Collection		Sorting	Pre-processing	
		Collection Method	Quantity (in KGs)		Composition category	Steps
PICVISA Test Centre	Industrial Scale testing facility. Number of sorting outputs: Four Location: Calaf, Spain Area: 800 m^2	Non-wearable post-consumer textiles collected by Moda Re, which is also part of the Spanish charity Caritas.	1,228	The sorting process was carried out using PICVISA's ECOSORT and involved four main actions: 1. Setting the sorting categories 2. Feeding the material to the sorter 3. Automated sorting on ECOSORT, and 4. Storing the sorted material. Each step involved data collection.	- 100% cotton - 70% cotton / 30% PET - >70% cotton - 100% PET - 70% PET / 30% cotton - 100% viscose - 100% nylon - 100% wool - Cotton/ acrylic blends - Cotton/ viscose blends	Due to a low quantity of the sorted material, it was not transported to recyclers and hence did not involve any pre-processing steps. However, the accuracy of the compositions were tested via a fibre composition analysis at a verified testing lab.

Illustration 16: Overview of the PICVISA pilot activities

COMPARATIVE ASSESSMENT OF BOTH PILOT OBSERVATIONS

FABRIC COMPOSITION

MATOHA
Semi-automated sorting (32,006 kgs)

43.3% of non-rewearables were identified as **100% Cotton** composition

27.6% were identified as Polyester- rich: **≥50% Polyester with any other fibre**

7.5% held the share for **cotton rich** compositions. This includes both ≥70% cotton with polyester (no elastane) and ≥50% cotton with any other fibre

21% was scanned under the **UNKNOWN** category

PICVISA
Fully automated sorting (1228 kgs)

33% of the materials were identified as **100% Cotton** composition (colours: white, black, green, brown, blue, red, pink)

8% was **100% PET** in composition (colours: white, black)

8% held the share for **cotton rich** compositions. This includes both ≥70% cotton with polyester and ≥70% cotton with any other fibre

42% of material went into the **OTHERS** category

Consolidated insights from both the pilots:

- **100% Cotton:** Considering the volumes of post-consumer waste collected in India, recyclers can expect 1720.83 ktonnes of 100% Cotton for recyclability from domestic waste every year.
- **Polyester-rich:** polyester-rich quantities observed in both pilots showed a great opportunity for chemical recycling in India
- **Elastane** proved to be a limitation in general when it comes to NIR technology. Within the pilot, Elastane was being identified as 'Contamination'

Illustration 17: Comparative assessment of composition for both pilots

COLOUR SEGREGATION

MATOHA
Semi-automated sorting (32,006 kgs)

10.9%

White held a share of 10.9% of the total non-rewearables scanned, with 12.1% of 100% cotton composition

10.8%

Blue was found to hold 10.8% of the total garments scanned

9.4%

Black held a share of 9.4% in the total material mix

PICVISA
Fully automated sorting (1228 kgs)

20%

White held a share of approximately 20% of the total garments scanned with 13% of 100% cotton garments

14%

Dark Colours- Green, Blue and Brown held a share of 14% in the 100% cotton category

Black and other dark colours (Green, Brown, Blue) were also abundantly found in the total material mix.

Consolidated insights from both the pilots:

- **White, 100% Cotton:** From both pilots, we observed that this colour under the cotton coategories are the most sought after feedstock. Through both pilots, white held the largest share of the material mix
- Multicolour and others also held a large share of the quanities under the pilots, which are a category that can currently not be considered for feedstock for recycling in India

Illustration 18: Comparative assessment of colour for both pilots

BENEFITS AND LIMITATIONS

MATOHA	PICVISA
Benefits - Real-time data collection - Addresses illiteracy issues by guiding sorters to place garments in the correct coloured buckets without the need to read compositions	**Benefits** - Customisable sorting outputs - High throughput - Complete surface scanning - Real-time data collection - Modular set-up
Limitations - While it allows multi-layer scanning, it is difficult to identify which bucket it needs to be placed in	**Limitations** - Not suitable for multi-layered garments - High energy consumption

Illustration 19: Comparison of the benefits & limitations of both pilots

Material Transfer From Sorters to Recyclers

With the success of the platform in our pre-consumer pilot, Reverse Resources began to build the post-consumer offering on their platform, and supported the post-consumer pilot to ensure traceability and link the right sorters to the recyclers.

Once sorting was completed, materials were required to reach their respective recyclers, and with this in mind, Reverse Resources expanded their platform and onboarded the sorters. Their platform conducted in detail the transfer of material under one of the pilots (Matoha) and ensured traceability of the sorted material. The purpose of the creation of the sorter profiles was not only for the smooth transfer of materials, but also to make the process of matchmaking between sorters and recyclers smoother. The detailed breakup of all the materials logged on to the platform can be found below in Illustration 20.

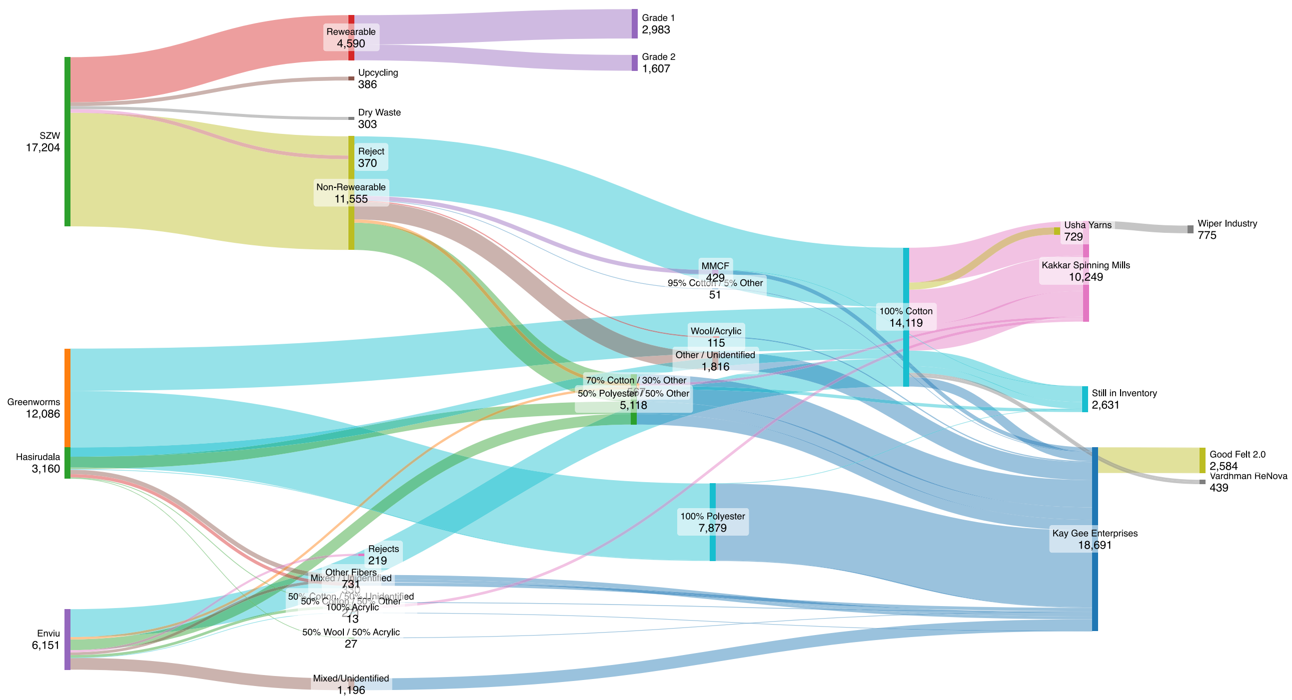


Illustration 20: The total quantities, compositions and final destinations, as per the Reverse Resources platform data

It was clear that 100% cotton and cotton blends were the most popular feedstock that almost every high-grade recycler had a requirement for. Additionally, they all also wanted only solid, light colours which further reduced the quantity of ‘ideal’ feedstock for mechanical recycling.

To top that, the lack of chemical recycling infrastructure in India left a large gap for requirement of polyester and blend feedstock, resulting in the feedstock ending up in the downcycling industry instead of high-grade chemical recycling.

> **“Matoha is a breakthrough technology for post industrial and post-consumer material, and can ensure faster and easier textile waste sorting is practically made accessible to lay a foundation for composition based textile waste recycling.”**
>
> Harshit Kakkar , Head of marketing and P.R., Kakkar Spinning Mills

Pilot Learning

LEARNINGS FROM THE RESALE INDUSTRY

While the lack of resale platform can be attributed to several factors, there were a range of areas that were found to be of concern across the industry in the region. The first is the need for a cultural shift. While consumers who sell their products to second hand platforms are plenty, the consumers are still not comfortable purchasing second hand due to its low quality and plenty of cheaper options available in the market. A cultural shift is required for second hand products, which can ensure a flow in inventory. Additionally, when it comes to second-hand clothing in India, the masses largely depend on donation, giving it to younger siblings or domestic help and reusing the materials within the household as mops or wipers. Lastly, a lack of legislation and investment in India has set the second-hand space back, and the scaling of online second-hand platforms is not possible without the support of these external stakeholders.

With regards to the pilot, the lack of second-hand marketplaces resulted in potentially rewearable material being considered non-rewearable and ending up in recycling rather than reuse.

> **“Resale of Clothing is at a very nascent stage in India and needs a massive push from all stakeholders viz the Brands, the Government and the Consumer. It has the potential to be game changer in years to come if all stakeholders work together with conviction.”**
>
> Nohar Nath, Founder and CEO, Kiabza and Kishko Group

LEARNINGS FROM SORTERS

The pilot allowed sorters to understand their potential of post-consumer waste and the value of technological intervention within the existing infrastructure. The learnings from their feedback have been highlighted below:

- **Collection of material** within the pilot, resulted in awareness drives when it came to residential and commercial collection. This allowed sorters to gain more exposure and allow them to set up long term partnerships for collection. Garment collecting programmes such as H&M’s programme can ensure a continuous supply of materials in the long run. In the long run, the municipalities need to focus on setting-up regional or community level collection infrastructure.
- **Technological intervention** such as Matoha or Picvisa can help fasten the sorting process and increase productivity.
- **New revenue streams** can be introduced for sorters though the sorting process. Sorters also recognised a higher value of rewearable garments and through pre-processing of non-rewearables.

- **Improving the skills** of sorters through the implementation of technology solutions like FabriTell or ECOSORT.. Although technology adoption was initially unfamiliar to the sorters, by the conclusion of the pilot program, they had gained confidence in the process and recognised the benefits of the technology.
- **Commercial feasibility** is still a concern for sorters considering the distance between sorting facilities and recycling hubs. Additionally, concerns were also raised about the commercial viability of the technology to be integrated into the current infrastructure especially with regards to pricing and maintenance.
- **The lack of second-hand marketplaces for Grade 1 garments**, has pushed sorters to set up their own second-hand markets and swaps.
- **Reverse Resources** has helped sorters connect with recyclers and understand their requirements and expectations of post-consumer waste in the long run.
- **Support is required** for sorters to integrate technology into the current sorting infrastructure. Support can be in the form of financing and legislation.

LEARNINGS FROM THE MATOHA PILOT

The Matoha devices allowed the pilot to experiment with technological intervention in the existing sorting ecosystem and helped us understand the feasibility of the devices in India.

Advantages of the technology:

- Speed of scanning is 20 seconds per scan, relatively faster than manual sorting (this includes the manual entry of data). The identification speed of the scanners is < 1 second, and data collection was only being done for the purpose of analysis.
- Able to provide real time data about garment type, colour, number of disruptors, etc, which allows data monitoring. The customisable features of Matoha allowed the scanning to be according to the asks of recyclers
- LED lights on devices resolved illiteracy issues by guiding sorters to place garments in the correct coloured buckets without needing to read compositions
- Accuracy of ± 10% for composition identification

Current limitations of the technology:

- Presence of elastane is difficult to identify, and is commonly identified as ‘contamination’
- The device finds it difficult to distinguish between fibres that are similar in nature eg. cotton and linen
- In the Indian context, machines operated at high temperatures, with uncertain impacts on readings
- While Matoha allows for scanning of several layers of a single garment, it is difficult for sorters to identify which bucket it needs to be placed in

LEARNINGS FROM THE PICVISA PILOT

PICVISA offers a complete solution of ECOSORT which includes the following:

- A sorting line for post-consumer textiles
- Colour/Composition/Shape Identification technology
- Textile spectrum library (or material library)
- An analysing tool for the data collected during sorting.

> **"PICVISA's advanced sorting capabilities align perfectly with the needs of sorters in India, where the volumes, complex garment materials and feedstock quality can be challenging. This technology has the potential to transform our sorting operations, but it requires a robust infrastructure with local technical support systems and substantial investment. It's time for brands, businesses and governments to commit to making sustainable textile waste management a reality through suitable funds and EPR mechanisms. While capital investments and running costs are challenges, a well-crafted business plan and support from stakeholders can bridge the gap from pilot to scale."**
>
> Shobha Raghavan, Chief Operations Officer, Saahas Zero Waste

Advantages of the technology:

ECOSORT is advantageous in terms of its customisability, modularity, throughput, complete surface scanning and real-time data collection.

- Customisability : This applies to many facets of ECOSORT:
    - The number of categories/hoppers can be variable (6 - 24) in a single conveyor. The number of categories can be up to 48 by adding a second conveyor.
    - The conveyors can be doubled, resulting in doubling the throughput and sorting categories.
    - The AI sorting algorithm is flexible and can be trained to accommodate better and different kinds of sorting. For example, sorting knitted and woven garments since deep learning can identify features like knitted structures if the knitting is significantly prominent.
- Modularity: A customer can choose to avail of either the entire system or just sections of it from PICVISA.
    - The system accommodates other automatic feeding systems like a bale breaker that moves material up the conveyor.
    - The system can also be easily extended to add a loop conveyor belt to recirculate garments that did not get classified and sorted the first time.
    - It is possible to add an automatic bunker and press or even dust collectors at the end.

- Throughput: The high speed of scanning and efficient sorting system is a big advantage of ECOSORT.
    - The throughput is much better than manual or semi-automatic sorting systems that necessarily require manual efforts.
    - The high throughput is an enabler for sorting high volumes that are typical of the Indian market.
- Complete surface scanning: Different to Matoha's scanner, ECOSORT scans the whole garment together.
    - Due to this, practically, the composition detection results were found to be consistent across different scans of the same garment, which is not necessarily true with Matoha's scanner.
    - A second advantage of whole garment scanning is that the user can define a majority composition detection configuration - in this, a garment with a main fabric and a secondary fabric can be defined to be sorted to the main fabric. For example, a garment with the main fabric as 100% cotton (majority) and a fabric disruptor of 100% PET (minor) can be defined to be sorted under 100% cotton.
- Data collection: Another benefit of ECOSORT's dashboard is the capability of real-time data collection.
    - This facilitates the integration with Software-as-a-Service (SaaS) platforms that help in the matchmaking of sorted textile waste with the recyclers.
    - Such software also helps with ease of selling the sorted garments, and may also help bring in new buyers with very specific requirements. An example of such a SaaS platform is Reverse Resources, who was also a part of the sorting trial of this pilot.

Current limitations of the technology:

- ECOSORT is not suitable for multi-layered garments, since it scans only the top layer. Such garments are frequently found in the Indian market.
- Based on our tests, the machine needs to have greater composition detection accuracy and be robust to outliers
- ECOSORT consumes a high amount of energy; 75 KW for a 24-hopper configuration (including optical sorter, conveyor belts and air compressor). This requires an industrial infrastructure.
- The capital incurred by ECOSORT is about 10 times more than that for Matoha, which is detailed in the Business Case section.
- ECOSORT customers should optimise for minimal idle time for the technology to be feasible. This implies a consistent flow of feedstock, which may be difficult to achieve perpetually.

Correlating the Advantages and Limitations for Post-consumer Domestic garment types

Post-consumer domestic garments from the Indian region predominantly include Kurtas, Sarees, Blouses, and Indian Pyjamas. To reiterate for context here, the characteristics of some of these garments differ from Western garments - longer lengths (especially for sarees and kurtas), embellishments and multiple layers. Thus, ECOSORT needs to have the capability to handle garments having such varied properties. We tested a small representative sample set of Indian garments onsite with ECOSORT and found the results to be quite promising. We also found that the blower used for physical sorting was capable of handling long-length garments without any additional tuning. This is owing to the technology's capability to scan the entire garment enabling size estimation. However, as highlighted in the limitations section, ECOSORT is not suitable for multi-layered garments.

The pilot thus shows that the ECOSORT technology of PICVISA is suitable for Indian post-consumer textile waste, but not immediately. A few technical challenges as described above need to be solved, and the cost needs to be reduced which is achievable as the technology matures by economies of scale or even by local manufacturing. PICVISA offers second-hand equipment from time to time along with renting and leasing services. These are currently offered in Europe and help with the high initial investment required. PICVISA also connects potential customers to banks to avail of these services.

In the current state, ECOSORT is a strong candidate to be used in the Indian post-consumer textile market, from a purely technical standpoint. Our pilot also highlighted the need for cross stakeholder collaborations which will drive early and cost effective adoption of PICVISA's technology.

LEARNINGS FROM THE RECYCLERS

- The distance between the recycling hubs and the sorting hubs is currently quite substantial for the efficient processing of textile waste in India. To ensure the economic viability of sending these materials for recycling, it is imperative to reduce this gap significantly.
- The quality of domestic feedstock is not as high as that of imported waste due to the different and multiple usage patterns in the region. Therefore, domestic post-consumer waste will need to be mixed with imported post-consumer waste for the purpose of recycling.
- Additional steps might need to be integrated into the current sorting process, from the feedback collected from recyclers at the end of the pilot. Current concerns over the quality of the feedstock can help us understand what steps can help reduce the steps needed on the recycler's end.
- Concerns over the quantity of tailor made garments or locally made garments in the collected quantities, as they may not meet compliance requirements for recycling or to be reused again.
- The purity of material is important for high-grade recyclers. This is true for both Matoha and Picvisa technologies. Under the pilots, SFC India conducted laboratory tests to check the composition which proved to be helpful to recyclers.
- Once testing was conducted, we discovered that while Matoha is more accurate, the problem of 100% accuracy remains. Once we received feedback from the high grade recyclers, we understood that they are still concerned about this, and think the current accuracy will cause disruption and quality challenges in the recycled material. As per the in house testing done by one of the recyclers, they found contamination of 11% in their 100% cotton feedstock.

LEARNINGS FROM THE REVERSE RESOURCES

- The PCW supply chains are already geographically segmented in India which make logistics tricky in some cases and would suggest a business case for developing regional hubs to optimise processes and delivery costs. At this stage however it appears that only few players are working in this direction and could be the trendsetters in the next few years.
- The PCW feedstock from India is different than that of Europe, which is where a lot of the solutions and technologies for PCW recycling are being developed. The optimisation of collection, sorting, matchmaking and recycling of the waste needs to be conducted at a regional level based on the solutions and learnings from Europe.
- There is little experience in the quality of locally sourced PCW in India, which strongly impacts the overall matchmaking (who is capable of recycling what). There is a need for more education with both

sorters and recyclers to understand what the quality of the PCW is and how it affects the quality/applications of the recycled material.
- There is a clear gap between the cost of the technologies for sorting and scanning and the current budget Indian sorters can expend on those technologies. Having a more practical approach with the scale-up of more affordable solutions like handheld scanners would allow for faster adoption of those technologies.

“Automated textile sorting technology will help recycling companies to meet quality & sustainability standards and will increase the competitiveness of their products in the market. Manual sorting is a tedious and laborious task that requires a lot of time and resources, making it impractical for textile recycling companies. At the same time, there is a shortage of specialised sorters. The lack of specialised sorters limits the recycling capacity of textiles, as it makes the sorting process less efficient, more expensive and with a greater margin of error.
PICVISA fits in for checking the quality of incoming raw material. With this pilot study, we could see and convince ourselves that automating the sorting of textile waste enables accurate and fast sorting of different types of textiles by composition, colour or size. It also increases the quality and value of recycled materials and improves the efficiency of the overall recycling process.”

Harvinder Rathee, Chief Operating Officer, Arvind

This report focused and analysed the pilot activities and learnings, the aim of the report is to understand the landscape of post-consumer waste and how it can be valorised to ensure its best use case. In order to understand the commercial viability of the technologies and their interventions in the current scenario, we brought in Sattva Consulting and Circle Economy to conduct a Business Case Assessment. The next section of this toolkit focuses on this and can be found here.