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MINISTRY OF
TEXTILES



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Comprehensive Assessment and Circular Economy Business Models for Panipat Textile Recycling Cluster



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भारत सरकार
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Ministry of Textiles

FOREWORD

The textile and apparel sector has always been closely intertwined with India's identity and development. From handlooms and traditional crafts to advanced manufacturing, it reflects an enduring spirit of craftsmanship and innovation while supporting millions of livelihoods. As we progress towards the vision of Viksit Bharat, the sector will continue to play a pivotal role in driving sustainable, globally competitive and inclusive economic growth. Building on long-standing traditions of reuse and resource stewardship, vibrant textile clusters, a dynamic MSME ecosystem, women-led enterprises and growing digital capabilities, the country is well positioned to emerge as a global leader in circular and sustainable textiles.

Among these clusters, Panipat occupies a distinctive place. Over several decades, it has developed a robust recycling ecosystem, transforming domestic and imported pre- and post-consumer textile waste into value-added products such as recycled yarn, blankets, durries and home furnishings, while supporting livelihoods, entrepreneurship and exports. As global markets increasingly embrace sustainability, traceability and circular production, the cluster demonstrates how innovation, resource efficiency and manufacturing excellence can strengthen India's position as a global leader in circular textiles and sustainable industrial development.

It is in this context that the report, 'Comprehensive Assessment and Circular Economy Business Models for the Panipat Textile Recycling Cluster', assumes particular significance. Going beyond a diagnostic assessment, the report maps the cluster's recycling ecosystem, analyses material flows and value chains, and identifies practical interventions to strengthen its long-term competitiveness. It highlights the cluster's established strengths, including colour-to-colour recycling and innovative waste-to-yarn and waste-to-product models, while presenting five circular business opportunities and a structured roadmap to support the cluster's continued evolution. By combining technical analysis with actionable recommendations on resource efficiency, traceability, quality enhancement and institutional collaboration, the report provides a practical framework for strengthening Panipat's position as a globally competitive hub for circular textiles.

I commend all the partner organisations whose contributions have made this publication possible. By bringing together rigorous analysis, practical recommendations and a clear implementation pathway, this report will serve as a valuable reference for policymakers, industry, financial institutions and development partners, supporting informed decision-making and collaborative action across the textile value chain. The Ministry of Textiles remains committed to fostering innovation, sustainability and competitiveness, and the insights presented in this report will contribute meaningfully to the continued advancement of India's circular textile ecosystem.


(Arti Kanwar)



EUROPEAN UNION

DELEGATION TO INDIA AND BHUTAN

Foreword

EU Delegation

Globally, the textile and apparel sector stands at a defining moment. It remains one of the world's most employment-intensive and trade-linked industries, while also carrying a significant responsibility to reduce resource use, waste, carbon emissions, and environmental impacts across value chains. As one of the world's leading textile producers and exporters, India has both the scale and capability to shape the future of circular textiles. The sector contributes over 12% of India's exports and provides livelihoods to around 45 million people, making its sustainable transformation critical not only for climate and environmental outcomes, but also for inclusive economic growth, enterprise resilience, and employment.

The European Union (EU) and India share a strong and growing partnership focused on joint prosperity but also with a strong focus on sustainability, particularly on advancing resource efficiency, circular economy, and sustainable industrial development. The EU remains one of the world's largest markets for textiles and apparel, with total global imports valued at USD 263.5 billion in 2024 and the recently agreed Free Trade Agreement (FTA) with India will offer further market opportunities in the EU for Indian products. This work on circularity highlights the scale and long-term potential of the EU market for Indian textile exporters. For India, therefore, the transition to circularity is not only an environmental necessity; it is also a strategic opportunity to access diverse and high-value markets, strengthen Micro, Small and Medium Enterprise (MSME) competitiveness, and build future-ready industrial clusters.

Panipat exemplifies how industrial clusters can achieve circularity at scale through sustained enterprise, innovation, and adaptation. This report **“Comprehensive Assessment and Circular Economy Business models for Panipat Textile Recycling Cluster”** positions Panipat not merely as a recycling hub, but as a potential model for inclusive, compliance-ready, and globally competitive circular textile production. Realising this potential requires coordinated investments and partnerships across material efficiency, worker welfare, social entrepreneurship and ensuring traceability and responsible production. This work aligns closely with the EU's commitment to circular textiles. I would like to congratulate the EU–India Resource Efficiency and Circular Economy Initiative (EU-I RECEI) funded by the European Union and the German Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN), implemented by GIZ India in close cooperation with the Ministry of Environment, Forest and Climate Change (MoEFCC), and the Ministry of Textiles, Government of India for preparing this report.

The Delegation of the European Union to India would like to thank the Ministry of Textiles, for its continued collaboration and reaffirms its commitment to support India's sustainable textile transition and strengthening the EU-India partnership in this key economic sector.

I hope this report serves as a practical foundation for dialogue, investment, and action. It is an invitation to reimagine Panipat Cluster's role in a rapidly changing global textile economy and to demonstrate how circularity can support enterprise growth, environmental responsibility, and inclusive development at scale.



Franck Viault
Minister Counsellor
Head of Cooperation



Embassy
of the Federal Republic of Germany
New Delhi

FOREWORD

German Embassy

India and Germany have a long-standing partnership in sustainable development, climate action and environmental cooperation. Through the Indo-German Green and Sustainable Development Partnership (GSDP), India and Germany are aligning the cooperation towards the achievement of our shared global climate and sustainability goals. The transition towards a circular economy is central to this cooperation, and the textile sector - given its scale, resource intensity and global trade footprint - is a key focus for joint action.

The National Circular Economy Strategy (NKWS) of Germany gives specific attention to clothing and textiles, advancing circular economy practices for responsible production and consumption. A draft action programme for the implementation of NKWS was adopted by the German Federal Cabinet in June 2026 and identifies twelve priority measures to be advanced by the end of 2027, with a focus on accelerating implementation, supporting innovation, strengthening industry engagement and promoting practical circular economy solutions.

India has long stood at the forefront of global excellence in the textile sector, which is renowned for its rich heritage, vibrant clusters, skilled workforce and global market presence. Panipat is one of the key clusters in India known for its recycling economy and has for decades given new life to textile waste from across the world, demonstrating that circularity can emerge from necessity as much as from policy design. It is in this context that the report "**Comprehensive Assessment and Circular Economy Business models for Panipat Textile Recycling Cluster**" assumes profound significance. The report presents an evidence-based assessment and presents clear opportunities to enhance domestic waste integration, streamline environmental compliance, modernise manual processing and achieve global competitiveness. I congratulate Circular Economy Solutions Preventing Marine Litter in Ecosystems and EU-India Resource Efficiency and Circular Economy Initiative (funded by the German Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN) and co-funded by the European Union implemented jointly with Ministry of Environment, Forest & Climate Change, Government of India) for preparing this assessment report and business models.

The German Embassy and BMUKN would like to take this opportunity to thank the Ministry of Textiles, Government of India for its continued support for the cooperation without which this work would not have been possible. Germany remains committed to supporting India's textile industry in building resource-efficient, socially inclusive, and competitive circular systems.

I congratulate the partners involved in developing this report. I hope it will serve as a practical foundation for the policy dialogue, investment, and institutional collaboration needed to help Panipat realise its full potential as a circularity hub.

Taina Gellhoff

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List of Abbreviations

CE	Circular Economy
CETP	Common Effluent Treatment Plant
CPCB	Central Pollution Control Board
CSR	Corporate Social Responsibility
CSRD	Corporate Sustainability Reporting Directive
CSDDD	Corporate Sustainability Due Diligence Directive
DPP	Digital Product Passport
EPFO	Employees' Provident Fund Organisation
EPR	Extended Producer Responsibility
ESIC	Employees' State Insurance Corporation
ETP	Effluent Treatment Plant
EU	European Union
EU –I RECEI	EU – India Resource Efficiency and Circular Economy Initiative
FICCI	Federation of Indian Chambers of Commerce & Industry
FMC	Foundation for MSME Clusters
GATS	Global Alliance for Textile Sustainability
GST	Goods and Services Tax
HSDM	Haryana Skill Development Mission
HSPCB	Haryana State Pollution Control Board
MFA	Material Flow Analysis
MLD	Million Litres per Day
MSE	Micro and Small Enterprises
MSME	Micro, Small and Medium Enterprises
NE	Number English (yarn count system)
NIC	National Industrial Classification
NIR	Near-Infrared
NRLM	National Rural Livelihoods Mission
OE	Open-End (yarn mills)
PADMA	Programme to Accelerate Development for MSME Advancement
PAT	Perform, Achieve and Trade (energy efficiency scheme under BEE)
PPE	Personal Protective Equipment
SBM-T	Swachh Bharat Mission (Textile-related initiatives)
SBTi	Science Based Targets initiative
SHG	Self-Help Group
SIDBI	Small Industries Development Bank of India
UNEP	United Nations Environment Programme
ZED	Zero Effect, Zero Defect

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Executive Summary

Panipat, often called the “Textile Recycling Capital of India,” is among the world’s largest hubs for recycled yarn, with over 26,000 MSMEs producing nearly 75% of India’s shoddy yarn output. The cluster’s industrial base runs almost entirely on textile waste as an input (woollen rags, textile waste, and post-consumer garments) which are shredded and spun into low-cost yarn feeding a vast ecosystem of blankets, durries, and rugs for the railway, defence, and low-value export markets.

Panipat’s recycling-led growth reflects a cluster in transition, balancing two complementary strengths. On one hand, it embodies what many describe as circularity born of necessity, where waste materials are given a second life through deeply embedded industrial practices. On the other hand, it is currently anchored in downcycling, a necessary stage for circular transition, producing textiles such as shoddy yarn or filler materials, with clear potential to progress toward the higher margins associated with apparel-grade fibres or textiles.

Panipat cluster demonstrates strong potential to emerge as a circular textile hub by converting textile waste into recycled yarns, home textiles, garments, blankets, and specialised products. Its established regional waste collection and sorting networks can be formalised to strengthen domestic textile waste supply chains in addition to imported waste. Panipat’s strong recycling capabilities offer a solid foundation for circular transition, with clear opportunities to enhance domestic waste integration, streamline environmental compliance, modernize manual processing, and move up the value chain beyond downcycling. Residues such as short fibres, sludge, and mixed waste represent an untapped resource stream. Better utilisation of these could help the cluster shift from high-volume, low-value production toward more diversified, higher-value pathways.

The Panipat cluster also presents best case examples like colour-to-colour recycling that offers a high-impact best practice by avoiding dyeing, thereby reducing water use, chemical load, energy demand, emissions, and production costs. The cluster’s recent evolution from waste-to-yarn to waste-to-product models shows potential for higher-value circular products, including hybrid recycled yarns and institutional-use recycled textiles. Emerging technical textile recycling, including high-performance and institutional waste streams, can help position the cluster as both a bulk recycling centre and a specialised innovation hub.

Meanwhile, global buyers increasingly require verified recycled content, digital traceability, and compliance with frameworks such as the EU Textile Strategy and Digital Product Passport. Most MSMEs are in need of adequate finance, technology upgradation, and institutional support to meet these requirements, as immediate concerns such as energy costs, certification expenses, and tariff uncertainty also dominate business priorities.

Panipat has pathways to modernise sorting and recovery, upgrade dyeing processes, integrate informal workers into the formal value chain, and develop higher-value products from waste. With coordinated support from government, financial institutions, international and domestic brands, industry associations, and businesses, the cluster can evolve from a survival-driven recycling base into a compliant, innovative, and globally competitive circular textile hub. The below image maps out the opportunities that exists across the cluster.

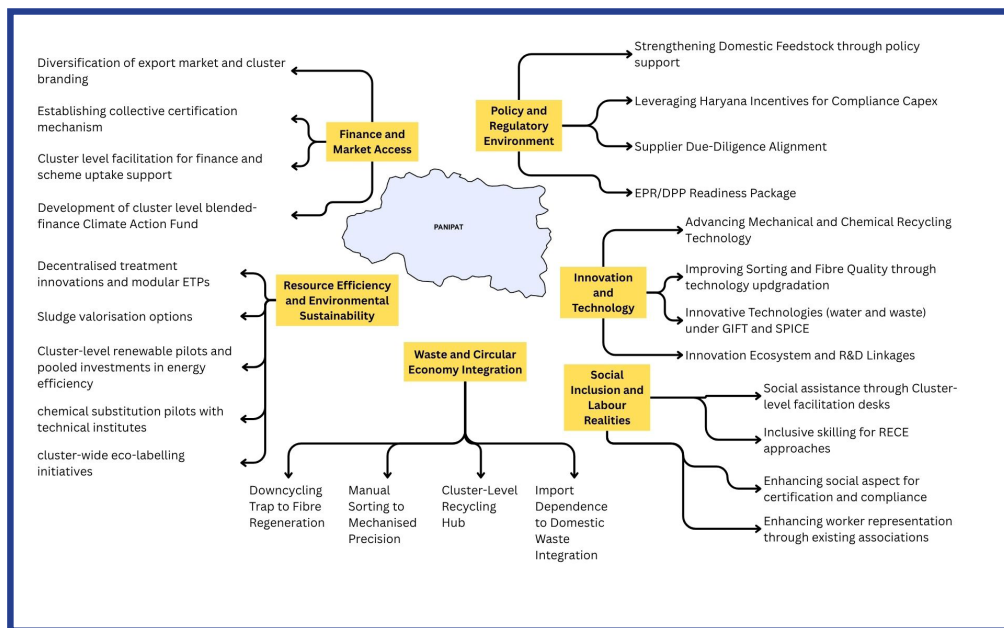


Figure 1: Opportunity Mapping of Key Thematic Areas at Cluster Level

Five Business Case Studies for Textile Circularity

The business case studies demonstrate how circularity can be translated into practical and investible models within textile clusters. These case studies move beyond general recommendations and show specific pathways through which cluster level institutions can reduce waste, improve material efficiency, create value from textile residues, and strengthen market readiness.

The five business case studies cover the following circularity pathways:

Business Opportunity 1- Material-Efficient Technology and Software

This model addresses avoidable fabric losses in Panipat's ready-made garment and home-textile MSMEs by combining in-unit CAD/marker software with a shared digital cutting facility equipped with auto-spreading, CNC high-ply cutting, plotting, digitising and barcode/Rfid systems. The opportunity is significant because fabric represents more than 40% of product cost, while manual marker planning and cutting can cause 1–3% avoidable material loss, re-cuts and inconsistent quality.

The proposed 20-MSME pilot assumes each unit processes 1,500 kg/day over 300 days. A conservative two-percentage-point improvement in cutting yield would save about 9,000 kg of fabric per MSME annually, equivalent to ₹12.6 lakh in raw-material savings. Across 20 units, quantified annual benefits are estimated at ₹2.23 crore, after accounting for the loss of scrap-sale income. Total initial investment is about ₹3.74 crore, or ₹18.7 lakh per MSME, including software, workstations, traceability tools, training and member contribution to the shared facility. Indicative payback is under three years.

The model also creates 25–30 skilled jobs, trains more than 50 workers, improves quality consistency and generates traceable, cleaner off-cuts for recyclers and upcyclers. Successful implementation depends on accurate baseline audits, strong SPV governance, reliable facility scheduling, operator capability and sustained use of digital production data. The business case offers a practical, relatively low-risk route to reduce waste at source while improving competitiveness and buyer readiness.

Business Opportunity 2-Common Facility for Sorting Waste and Felting for End-of-Life Waste

This case proposes a shared facility, owned by an SPV of 10 MSMEs and operated professionally under a performance-based service agreement, to sort mixed textile waste to buyer specifications and convert

non-spinnable fractions into needle-punched felt. It replaces fragmented, trader-led handling with a dual-path model: spinnable material is quality-graded and sold to open-end yarn manufacturers, while end-of-life and non-spinnable material is processed into padding, acoustic and packaging felts.

The facility is designed for approximately 1,800 tonnes of input per year. Half the feedstock is handled through a sorting and QA service-fee model, while the balance is purchased or aggregated for resale. The model projects annual gross benefits of about ₹4.44 crore: ₹27 lakh from service fees, ₹63 lakh from margins on sorted spinnable waste, ₹3.44 crore from approximately 459 tonnes of felt, and ₹10 lakh from by-products or reject streams.

Estimated capital expenditure is ₹6.19 crore, equal to roughly ₹61.9 lakh per participating MSME. The main equipment package includes sorting lines, a shredder/opener, needle-punch felting line, bale press, material-handling equipment, dust collection, utilities, QA systems and digital traceability. Key benefits include higher waste realisation, lower handling and logistics costs, fewer buyer rejections, stable cash flow and improved compliance and worker safety.

Critical risks are feedstock variability, felt-price volatility, power intensity, product-quality consistency, working-capital pressure and governance disputes. Buyer commitments, clear specifications, disciplined QA and professional operations are essential to viability.

Business Opportunity 3-In-House Mechanical Recycling for Fibre-to-Fibre Yarn Production

This model enables an individual MSME to convert segregated cotton cuttings and hosiery waste into recycled open-end yarn instead of selling mixed scrap to informal traders. The process integrates source segregation, sorting, opening and cleaning, carding and drawing, open-end spinning, winding, quality control and batch-level traceability. It is well aligned with Panipat's existing open-end spinning ecosystem and growing buyer demand for certified recycled content.

The base case assumes 4 tonnes of pre-sorted textile waste/ day, one eight-hour shift and 300 operating days annually. At an estimated 75–76% yield, the facility would produce approximately 9.12 lakh kg of recycled yarn/year, mainly in the Ne 12–20 range. At an assumed selling price of ₹125/kg, annual yarn revenue is estimated at ₹11.40 crore, with a further ₹15 lakh from by-product resale, bringing total direct benefits to about ₹11.55 crore/ year.

The model reduces dependence on external fibre, captures value currently lost through scrap sales and supports GRS/Transaction Certificate-ready documentation and future Digital Product Passport requirements. It can also reduce downstream dyeing through shade-wise segregation and create formal jobs in sorting, QA, operations and maintenance.

Commercial success depends on strict control of fibre composition, colour and elastane contamination, reliable feedstock supply, stable yarn quality, buyer qualification and disciplined maintenance. Major risks include yield slippage, price competition from virgin fibre, downtime, working-capital needs and operator capability. Pilot trials and firm offtake commitments should precede full-scale investment.

Business Opportunity 4-Shared Facility for Chemical Recycling

This case proposes a 10-MSME SPV to establish a shared hydrothermal recycling facility for polycotton waste. The process separates blended textiles into two saleable fibre-to-fibre outputs: cellulosic pulp sheets for viscose or lyocell production and fibre-grade recycled PET chips or flakes for polyester processors. The model addresses a waste stream that is currently downcycled, traded at low value or landfilled because conventional mechanical recycling cannot efficiently separate blended fibres.

The proposed plant has a nameplate capacity of 2 tonnes per day and would handle about 700 tonnes of inbound waste annually. After approximately 5% sorting rejects, net process feed is estimated at 665 tonnes. Expected output is around 296 tonnes each of pulp and recycled PET, with roughly 73 tonnes of residues routed to authorised co-processing. Annual cash benefits are estimated at ₹4.78 crore, comprising about ₹2.37 crore from pulp sales, ₹2.13 crore from recycled PET sales and ₹28 lakh in avoided disposal costs. The project also estimates approximately 3,448 tonnes of CO₂-equivalent emissions avoided per year.

Estimated capital expenditure is ₹25.65 crore, or ₹2.565 crore per MSME on an equal-equity basis. The investment includes sorting, hydrothermal processing, product finishing, utilities, ETP/ZLD, laboratory, safety and civil infrastructure.

This is the most capital- and technology-intensive case. Viability depends on vendor validation, consistent feed composition, firm offtake contracts, high plant uptime, effective ETP/ZLD operation, certification and strong SPV governance. Technology ramp-up, market pricing and compliance are the principal risks.

Business Opportunity 5-Upcycling with Social Entrepreneurs and Self-Help Groups

This inclusive circular-economy model links Panipat MSMEs with social enterprises and self-help groups to transform segregated cutting waste and rejected fabrics into design-led apparel, accessories, home décor and lifestyle products. MSMEs provide clean, segregated feedstock and, where possible, workspace; community enterprises manage product design, sorting, stitching, finishing and sales. Cluster associations, livelihood missions and design institutions support training, incubation and market access.

The illustrative model creates 10 enterprises, each using about 20 tonnes of textile waste annually. Together, they divert 200 tonnes per year and generate estimated annual benefits of ₹3.18 crore. This includes ₹8 lakh in avoided disposal costs, ₹40 lakh from waste sales, ₹2.25 crore in income for 150 enterprise workers and ₹45 lakh for 30 additional workers in packaging, logistics and distribution. The model also estimates approximately 1,038 tonnes of CO₂-equivalent emissions avoided annually, although this impact is not monetised. Direct financial benefit to participating MSMEs is about ₹48 lakh per year.

Initial capital requirement is approximately ₹25 lakh per enterprise, or ₹2.5 crore for 10 units, covering workspace setup, sewing and cutting equipment, design and branding, training and working capital. The approach can formalise women's employment, improve safety and social protection, diversify Panipat's product base and strengthen ESG credentials.

Key challenges are product-market fit, design quality, consistent feedstock, enterprise management, branding, e-commerce access and working capital. Long-term success requires anchor buyers, sustained design mentorship, quality standards and a cluster-level facilitation mechanism rather than one-time training alone.

Potential Institutional Use Cases

The assessment report and the five circular business case studies can support institutional adoption of resource efficiency and circular economy approaches across textile MSMEs, clusters, associations, technical institutions, and government-supported programmes.

- **Cluster-Level Circularity Planning:** The resources can help clusters identify shared challenges and plan collective solutions such as sorting, recycling, traceability, and common infrastructure.
- **Support for Recycling Hub Development:** The business case studies can inform practical models for recycling hubs, covering waste prevention, sorting, felting, mechanical recycling, chemical recycling, and upcycling.
- **Demonstration of Practical Circular Economy Pathways:** The five business cases can serve as illustrative models showing how circularity can be implemented through different routes based on MSME and cluster readiness.
- **Replication Across Textile Clusters:** The business cases can be adapted across textile clusters based on local production systems, waste streams, market orientation, and institutional capacity.



Overview

The assessment of Panipat is situated within broader discussions on the circular economy, particularly in the context of textile production and recycling. Academic literature highlights that while circular economy is often promoted as a future-oriented strategy led by design and technological innovation, in practice, many economies of the Global South already operate circular systems rooted in necessity rather than policy¹. Panipat exemplifies this. For decades, its enterprises have recycled imported and domestic textile waste, demonstrating resource efficiency and waste upgrading long before circular economy frameworks became global policy priorities. As a nodal point in transnational circuits of waste upcycling, it stands in need of further integration with global compliance regimes.

1.1 Research Methodology

The study adopted a dual-layered methodology designed to balance breadth with depth. On one hand, it adopts a structured lens for evaluating the systemic health of industrial clusters. On the other, it integrated a sector-specific deep dive into textile waste flows, recognising that Panipat's competitive identity is inseparable from its role as a recycling hub. By combining a generalised framework with sectoral specificity, the methodology ensured both comparability with other clusters and sensitivity to the unique contours of Panipat's recycling economy.

Analytical Framework and Thematic Pillars

The inquiry was structured around six thematic pillars that emerged from a synthesis of international best practices and contextual realities:

1. Resource Efficiency and Sustainability– physical assets such as sorting yards, transport networks, power supply, machineries etc.
2. Waste and Circular Economy Integration: Energy and water use, and waste treatment facilities.
3. Social Inclusion, Skilling and Labour Realities – labour composition, skill availability, training gaps, and mechanisms for workforce upgrading.
4. Policy and Regulatory Environment – policy frameworks, enforcement mechanisms, and institutional governance at local, state, and national levels.
5. Finance and Markets – credit access, financial instruments, export opportunities, market diversification, and price competitiveness.
6. Innovation and Technology – mechanisation, digitalisation, process upgrading, and the adoption of circular solutions.

¹Iacovidou, E., Hahladakis, J. N., & Purnell, P. A Systems Thinking Approach to Understanding the Challenges of Achieving the Circular Economy. *Environmental Science and Pollution Research*, <https://link.springer.com/article/10.1007/s11356-020-11725-9>

These pillars provided the backbone for both data collection and analysis, ensuring that technical, economic, social, and policy dimensions were captured holistically.

Stakeholder Consultations

Stakeholder engagement served as the entry point and validation loop for the study. The consultation process unfolded in multiple stages:

Institutional Mapping: Initial scoping was done through online and in-person interactions with industry associations such as the Global Alliance for Textile Sustainability Council (GATS), and the Foundation for MSME Clusters (FMC). These bodies provided both sectoral insights and access to enterprises.

Administrative Interfaces: Meetings with district-level authorities helped situate the study within Panipat's governance ecosystem, aligning it with ongoing policy interventions.

Field Engagement in Panipat: In-person consultations were conducted with a spectrum of actors, MSMEs, informal recycling units, waste traders, and exporters. These served dual purposes: (a) knowledge dissemination, especially on circular economy trends and compliance trajectories, and (b) data gathering, particularly around waste handling practices, cost structures, and operational challenges.

The diversity of stakeholders ensured that perspectives from both formal and informal economies were included.

Data Collection

A mixed-methods strategy was adopted to capture both quantitative indicators and qualitative insights.

A. Secondary Research:

Literature Review: Academic papers, trade studies, and previous cluster-level reports were reviewed.

Policy Mapping: Relevant national and state-level schemes (e.g., SBM-T, EPR frameworks) were examined to contextualise regulatory pressures. Apart from that international policies and compliances were studied thoroughly to understand the standing of Panipat in the global market.

Industry Reports: Market trend analyses and benchmarking studies were used to triangulate primary findings.

B. Primary Data:

Online Survey² : Disseminated through associations to MSMEs, self-help groups (SHGs), and informal units. Surveys were sent to ~320 MSMEs. Through responses, the report captured baseline information on production volumes, workforce profiles, sourcing practices, and compliance challenges.

Key Informant Interviews: 11 targeted interviews were held with recyclers, traders, regulators, association, and equipment suppliers to supplement survey responses and clarify ambiguities.

C. Material Flow Analysis (MFA):

Conducted for imported rags, domestic pre-consumer waste, post-consumer waste, and recycling residues.

² Panipat Cluster Assessment Survey

Traceability mapping sought to capture the movement of fibres from import or collection to processing and re-entry into domestic or export markets.

Analysis and Validation

The analysis proceeded with the following approach:

Quantitative Assessment:

- Metrics such as recycling efficiency, infrastructure adequacy, workforce composition, and compliance levels were applied.
- Comparative indicators were used to highlight performance gaps.

Qualitative Assessment: Explored dimensions such as operational bottlenecks (e.g., access to finance, traceability barriers), innovation readiness, and social realities of the workforce (informality, wage volatility, gendered vulnerabilities).

Comparative Benchmarking: Panipat's profile was benchmarked against peer clusters such as Tirupur (export-oriented apparel). This exercise provided a relative understanding of Panipat's strengths and deficits in recycling efficiency, compliance, and market orientation.

Validation: Draft findings were shared back with stakeholders in Panipat through structured workshops and consultations. Feedback from industry representatives, regulators, and local actors was integrated into the final analysis to ensure contextual accuracy and stakeholder ownership.

Cross-Sectional Analysis: The report applies a cross-sectional analytical framework that deliberately examines overlaps and interactions across the six pillars rather than treating them in isolation. This methodology recognises that Panipat's challenges—whether in resource inefficiency, labour precarity, or compliance deficits—are mutually reinforcing. By tracing how financial constraints shape technological adoption, how labour conditions mediate environmental outcomes, and how regulatory gaps distort market incentives, the analysis identifies systemic interdependencies and highlights that integrated interventions can deliver much better benefits.

Final Outputs

The methodology is intended to produce the following outputs:

- MSME Mapping: Identification of enterprises across the recycling, dyeing, weaving, and export segments.
- Fabric-Type Breakdowns: Disaggregation of recycling flows by input type (e.g., woollens, cotton blends, synthetics).
- Skills Gap Analysis: Assessment of current workforce skills versus emerging needs for compliance, mechanisation, and circular economy adaptation.
- Best Practices Identification: Documentation of innovative practices within the cluster and in comparable geographies.
- Inter-Cluster Knowledge Exchange: Positioning Panipat within broader national and global dialogues on textile circularity.

1.2. Panipat Cluster Overview and Historical Evolution

Panipat's identity as a textile hub is historically embedded in both craft traditions and industrial restructuring. The cluster was known in Mughal and colonial times for its handloom weaving and durrie production, and the city's textile base was transformed after 1947, when refugee weavers resettled in the area, bringing with them skills and networks that revitalised Panipat's loom industry³. Over the following decades, Panipat became synonymous with woollen blankets, supplying bulk orders to Indian Railways, the military, and global markets.

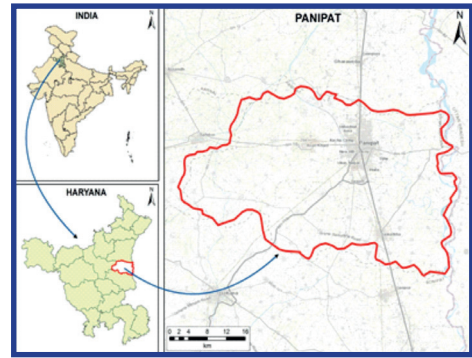


Figure 2: Spatial Mapping of Panipat District

By the 1980s and 1990s, Panipat had begun to pivot more strongly toward recycling, importing vast quantities of woollen rags and post-consumer textiles. The availability of low-cost raw material, coupled with the city's dense network of small-scale shredding and spinning units, positioned Panipat as the nucleus of India's recycled yarn industry, anchoring thousands of weavings and dyeing units that convert reclaimed fibres into low-cost home textiles. According to the FICCI (2023) Panipat's textile cluster report, the combined export from all the units of the cluster is estimated at Rs. 11,700 crores.

This historical trajectory situated Panipat within what is described in circular economy literature as the *"global economy of waste value."* This framework challenges conventional understandings of waste as the "end of life" of a commodity, instead recognising that discarded materials often circulate through global markets, re-entering production systems as valuable resources. Waste, therefore, is not a fixed category but a variable one, shifting between waste and value depending on its context, classification, and processing.

Panipat demonstrates how waste becomes the foundation of an entire industrial ecosystem. Woollen rags, discarded clothing, and mixed textile wastes from around the world are exported to India under tariff codes such as HS 6309 ("worn clothing") and 6310 ("other rags and scraps"). In the countries of origin, these materials are designated as waste, often subject to landfill diversion targets or second-hand export restrictions. Yet upon arrival in Panipat, they are transformed into economic resources. Sorting units, often staffed by women workers, classify the rags according to fibre composition and colour; shredding and spinning units convert them into recycled fibres and yarn; and weaving units produce guddas, blankets, mats, and rugs. These products are then sold all over domestic and global markets.

Currently, under the GATS association, recycling is the core activity, collectively undertaken by 350+ member recyclers. The association as of now process 3,000+ tons/day, making the association's current capacity to recycle 10.95+ lakhs of textile waste annually, unprecedented in any other textile cluster across India⁴.

³Federation of Indian Chambers of Commerce and Industry (FICCI). Panipat Textile Cluster Profile Report. https://seet.ficci.in/pdf/Report_PanipatTextileCluster-Profile.pdf

⁴Information from CITI's Panipat Cluster Connect (Aug 2025) where GATS presented Panipat as a case study on 'India's Circular Powerhouse. The World's Circular Future'



Figure 3: Facts regarding Panipat by GATS (Source: www.gats.org.in)

This circular flow illustrates how Panipat sustains its industrial base not on virgin resources but on globally traded discards. What is considered waste in one geography becomes value in another, producing livelihoods and export earnings. As Lepawsky (2018)⁵ argues, such flows demonstrate that waste is not marginal to the global economy but integral to it, underpinning entire clusters of industrial activity. Panipat, therefore, is not simply a local recycling hub but a nodal point in transnational circuits of waste upcycling.

Panipat is different from most textile clusters in India that are powered by cotton and yarn, as it is powered by waste. The cluster imports woollen rags and post-consumer textiles from across the world, sorts and shreds them, and spins them into recycled or “shoddy” yarn. This yarn feeds a thriving ecosystem of weaving units producing blankets, durries, rugs, and mats, with Indian Railways, the army, and low-cost export markets as the primary buyers.

In this way, Panipat’s entire value chain is built around giving waste a second life many of these applications remain low-value and downcycled presenting an opportunity for further value-enhancement. The image below explains the value chain that dictates the flow of textiles and textile waste in the cluster Home furnishing factories’ rejects, and surplus yarn are channelled through layers of sorting, mending, redyeing, and recycling into new products (yarn, rugs, blankets, guddas). The system ensures almost nothing is wasted though much of it is low-value recycling, with significant dependence on informal labour.

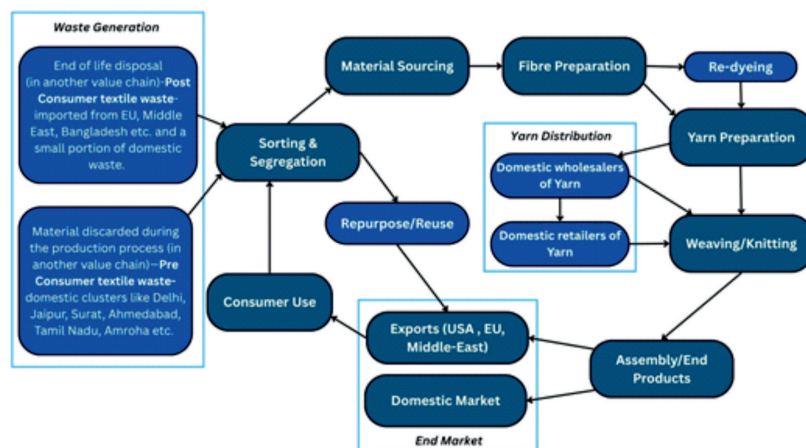


Figure 4: Textile Recycling Value Chain of Panipat, Note: The value chain was developed through field interactions

⁵Lepawsky, J. *Reassembling Rubbish: Worlding Electronic Waste*. Cambridge, MA: MIT Press; 2018. https://www.researchgate.net/publication/337947663_Reassembling_Rubbish_Worlding_Electronic_Waste_by_Josh_Lepawsky_The_MIT_Press_Cambridge_MA_2018_240_pp_paper_4200-ISBN-978-0262535335

Waste Generation: The textile recycling process in India begins with the generation of waste, which arises from two major sources. The first is post-consumer textile waste, which includes discarded garments and household textiles that have reached the end of their lifecycle. A significant share of this waste is imported from regions such as the EU, Middle East, and Bangladesh, where faster consumption cycles lead to higher rates of discards, while only a smaller portion originates from Indian households due to the country's traditional culture of prolonged use, repair, and reuse⁶. The second stream is pre-consumer textile waste, which is generated during the production process in domestic textile hubs. This waste is comprised of offcuts, rejected fabrics, defective dye lots, and unsold inventory, and is more concentrated in major clusters such as Delhi, Jaipur, Surat, Ahmedabad, Tamil Nadu, and Amroha. Unlike post-consumer waste, pre-consumer waste tends to be cleaner and more uniform, making it more suitable for direct recycling.

Collection and Sorting: Both waste streams enter the system through collection and sorting, a pivotal stage that determines the efficiency and value of the recycling chain. Waste is gathered by a network of informal workers, aggregators, and traders who ensure a steady supply of raw materials for recycling. At this stage, textiles are sorted by fibre type, colour, and quality. This classification decides whether the waste will be directed toward recycling, reused in alternative forms, or discarded. Sorting today is largely manual and labour-intensive, and this is precisely where the greatest opportunity for improvement lies. As one of the most critical steps in establishing the foundation for material recovery, even modest gains in consistency here could meaningfully strengthen output quality across the value chain.

Material Sourcing: From the sorting centres, suitable textile waste is directed towards material sourcing units, which act as intermediaries between collectors and industrial recyclers. These units consolidate supply, ensuring that recyclers receive waste in the volumes required for processing. At this stage, the fragmented inputs from various locations are pooled together, strengthening the supply chain and allowing for large-scale recycling operations to function efficiently.

Repurposing and Reuse: Textiles that cannot be recycled into yarn are repurposed and reused in secondary applications. They are transformed into cleaning cloths, mats, mattress fillings, insulation material, or innovative upcycled products in fashion and home décor. This stage helps extend the life of textile materials and reduces the burden on landfills, ensuring that value is extracted even from the lowest-quality waste streams.

Fibre Preparation: The recycling journey continues with fibre preparation, where waste textiles are shredded back into fibres. This step helps transform discarded cloth into a raw material that can be reintroduced into the production cycle. Fibres are cleaned and sometimes blended to create a uniform base for spinning. However, one of the major challenges in this stage is the shortening of fibre length during shredding, which reduces the strength of the yarn produced. Cotton waste is usually converted into shoddy yarn, while synthetic waste is melted and extruded into new filaments.

⁶European Environment Agency. (2023). *EU exports of used textiles in Europe's circular economy*. <https://www.eea.europa.eu/en/analysis/publications/eu-exports-of-used-textiles>

Re-dyeing: In certain cases, the recovered fibres undergo re-dyeing to achieve consistency in colour and improve usability. This step is particularly important when fibres are to be used for higher-value applications. However, re-dyeing is resource-intensive, consuming large amounts of water, which raises sustainability concerns of standardisation of colour palette for recycling process compatibility and low water dyeing technologies.

Yarn Preparation: The processed fibres are then spun into yarns through the yarn preparation stage. These yarns are generally coarser in quality, with counts ranging from NE 10 to NE 20, which makes them suitable for lower-end products. However, in clusters such as Panipat, there is a gradual transition towards finer yarns, going up to NE 40, which indicates the potential for higher-value recycling. The quality of yarn at this stage is heavily influenced by the precision of sorting and the blending process during fibre preparation.

Distribution of Yarn: Once spun, the yarn enters the market directly through domestic wholesalers and retailers, who distribute it to manufacturers across clusters. This stage ensures the movement of recycled yarns into the production ecosystem, linking recyclers with both small-scale weaving and knitting units as well as larger organized factories. Wholesalers and retailers thus play a crucial role in bridging the gap between raw material producers and the broader textile industry.

Weaving and Knitting: In the other cycle, after preparation of yarn, it is then fed into weaving and knitting operations, where it is transformed into fabrics. These fabrics cater to multiple segments, including low-cost products such as blankets, upholstery, and carpets, etc. In more advanced recycling ecosystems, the yarn is also used to create garments and fashion textiles. However, the lower tensile strength of recycled yarns continues to restrict their use in premium-quality fabrics, limiting the scope of application.

Assembly and End Products: The fabrics produced are sent for assembly into finished products, where they are cut, stitched, or otherwise processed into garments, home textiles, and industrial applications. This stage reconnects the recycling value chain with the broader textile market, ensuring that recycled materials are integrated into mainstream consumption.

Market: The end products, made from recycled yarns and fabrics, reach the market, where they are sold both domestically and internationally. India plays a unique role in exporting recycled textile products to USA, EU and other low- and middle-income countries in middle east, which have a strong demand for affordable goods. At the same time, a growing domestic movement for sustainable fashion is opening new opportunities for higher value recycled and upcycled products within India itself.

Consumer Use: Consumers purchase and use the recycled products, completing the traditional product lifecycle. However, unlike linear systems, in India's recycling-driven economy, these products often re-enter the cycle after their use phase. They may become post-consumer waste once again or be diverted into the reuse pathway.

Overall, the textile recycling chain is not a linear sequence but a circular system where waste re-enters at multiple points. By integrating both imported post-consumer waste and domestic pre-consumer waste, India has become a global hub for recycling and reprocessing textiles. Addressing existing

opportunities in sorting efficiency, fibre quality retention, environmentally responsible dyeing and processing could significantly strengthen India's position in the global circular textile economy.

1.3. Enterprise Mapping for RE-CE Interventions

The NIC-based mapping of MSMEs in Panipat provides a granular picture of how enterprises are distributed across the textile value chain and where RECE interventions could have the greatest impact. An NIC-code-based analysis of 26,647 Udyam-registered enterprises across Panipat under relevant textile and recycling NIC codes highlights its unique identity as a recycling-led cluster. This same data also points to clear structural opportunities within the cluster that could accelerate its transition toward upcycling.

Enterprise Density Across the Value Chain

The mapping highlights a strong concentration of activity in textile and garment production with 15,477 MSMEs, and in distribution with 7,223 MSMEs. Yarn and fabric production, dominated by open-end spinning and weaving, accounts for 3,233 enterprises, while fibre production remains marginal with only 537 enterprises. End-of-life and resource recovery activities are represented by just a handful of enterprises, underscoring Panipat's condition despite being globally recognised as a recycling hub, formal recovery enterprises remain extremely limited.

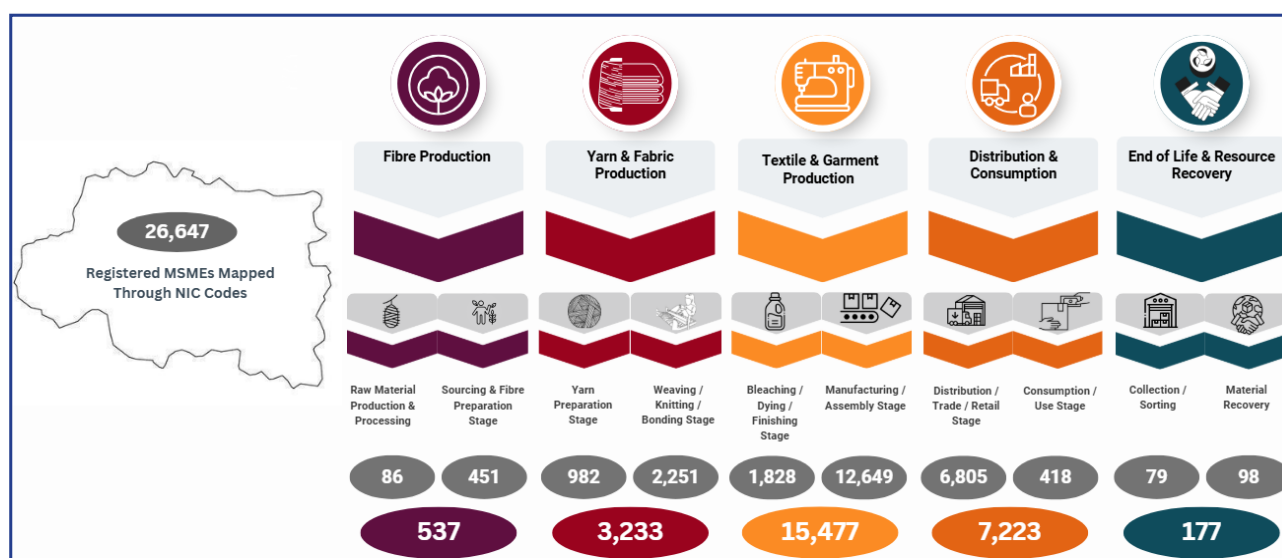


Figure 5: Number of Registered NIC Codes of MSMEs across the textile value chain in Panipat, Haryana

The NIC mapping reinforces Panipat's dual identity: a cluster dense in production with significant opportunity to build strong formal recovery infrastructure. While enterprises are highly concentrated in recycling-driven spinning, weaving, and product manufacturing, critical enablers such as mechanised sorting, sludge valorisation, and digital traceability represent clear areas for development. This creates a compelling opportunity: with targeted interventions, Panipat could be repositioned as a circularity pioneer, scaling beyond blankets and durries into certified, higher-value recycled textiles.



OPULLO

Regular Elastic waist

48

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Panipat's recycling economy sits at the crossroads of opportunity and vulnerability. Field evidence and secondary literature show that its strengths lie in large-scale waste valorisation, survival-driven ingenuity, and export linkages. The report maps Panipat's waste value chain across six interconnected themes: (i) Resource Efficiency and Environmental Sustainability, (ii) Waste and Circular Economy Integration, (iii) Social Inclusion and Labour Realities, (iv) Policy and Regulatory Environment, (v) Finance and Market Access, and (vi) Innovation and Technology.

The six thematic areas explored in this report are deeply interconnected levers that will further the sustainability journey of Panipat for its transition into a world-class compliance-ready recycling hub in the global circular economy. A few cross-cutting patterns emerge.

- First, informality is present across every theme including labour relations, finance, waste handling, and compliance reporting alike. This structural informality keeps costs low in the short term, but formalising these areas represents a significant opportunity to unlock finance, technology, and premium buyers.
- Second, buyer-driven compliance expectations around labour rights, carbon reporting, traceability, and certifications, cut across all themes, yet costs are borne almost entirely by MSMEs. There is a need for balanced cost-sharing arrangements between buyers and MSMEs.
- Third, stronger institutional coordination could unlock significant potential synergies: policies, finance, and technologies already exist, and with the right facilitation mechanisms, these can be made far more accessible to enterprises across the cluster.

At the same time, systemic opportunities cut across themes. Cluster-level facilitation hubs can simultaneously address finance, certification, and policy navigation. Blended finance can unlock both environmental technologies and labour inclusion. SHG- or cooperative-led worker models can solve both gender equity and traceability credibility. Domestic feedstock integration reduces waste vulnerabilities while aligning with EPR mandates. These connecting threads illustrate that Panipat's transition depends less on isolated fixes and more on orchestrating convergence across the five themes.

The next sections unpack these dynamics in detail. Each theme reveals how Panipat's recycling ecosystem actually operates on the ground. Together, these deep dives move beyond policy intent and illustrate how Panipat's realities both connect to and diverge from global frameworks. By tracing these linkages theme by theme, the report highlights where Panipat is already demonstrating recycling ingenuity and where structural shifts are required.

2.1. Resource Efficiency & Environmental Sustainability

Resource efficiency and environmental sustainability are foundational to the textile sector's circular transition. Efficient use of water, energy, and chemicals not only reduces ecological harm but also determines long-term competitiveness. For MSMEs, aligning production systems with sustainability frameworks is no longer discretionary but central to securing compliance, financing, and market access.

Panipat, as a recycling hub, has significant opportunity to strengthen its environmental performance. Dyeing and finishing operations are water and chemical-intensive, CETPs face capacity pressures, sludge disposal practices vary, and renewable energy adoption remains an untapped area. This dynamic, a cluster globally celebrated for recycling yet with room to strengthen its environmental credentials, highlights significant untapped opportunity for Panipat to lead as a model of credible, compliant circularity.

2.1.1 Cluster Resources and Environmental Footprint: Opportunities within Systemic Gaps

Panipat's recycling-based production is dominated by dyeing, spinning, and weaving, each of which imposes heavy demands on water, chemicals, and energy. Secondary data (FICCI, 2023; Haryana State Pollution Control Board reports) combined with MSME interviews highlight the following critical stress points:

I. Water and Effluent Management

- Panipat's industrial ecosystem generates an estimated 98.87 MLD of wastewater, of which ~73.93 MLD (75%) is treated through two 21-MLD CETPs and individual treatment plants (Haryana State Pollution Control Board, 2023)⁷. There are approximately 88 discharge points⁸ along the Yamuna River where partially treated or untreated effluents are released (Fair Planet, 2024).
- There is need for structured sludge management along with monitoring through data collection on the total sludge generated and treated. The existing incentives for CETP and sludge treatment remain underutilised as it is perceived in not adding further buyer advantage.

Strengthening effluent treatment infrastructure represents a significant opportunity to protect local water resources and reinforce Panipat's credibility in global markets increasingly sensitive to environmental compliance. Research also points to this pattern across Indian clusters, where CETP performance can be enhanced through improved utilisation and stronger accountability mechanisms (TERI 2024)⁹.

Environmental performance in Panipat can be strengthened by addressing three key focus areas:

- (i) Expanding and upgrading infrastructure such as CETPs,
- (ii) Reinforcing enforcement to drive more consistent compliance, and
- (iii) Reframing compliance costs as a competitiveness investment for recycled products.

Making these focus areas explicit is critical for prioritising interventions and clarifying decision-making pathways. These same areas also highlight significant untapped potential: (i) decentralised treatment innovations, (ii) modular ETPs, and (iii) sludge valorisation options such as co-processing in cement kilns or bio-brick production could transform waste into revenue-generating resources. If linked to buyer certifications or market incentives, CETP participation and responsible effluent management could evolve from being perceived as a compliance cost into a strategic advantage in export markets.

⁷ Haryana State Pollution Control Board. (n.d.). Panipat. https://hspcb.org.in/uploads/pages/panipat_689be14e7fbc3.pdf

⁸ Fairplanet. (n.d.). Voices from Panipat condemn clothes recyclers for polluting air and water <https://www.fairplanet.org/story/voices-from-panipat-condemn-clothes-recyclers-for-polluting-air-and-water/>

⁹ TERI (2024): Integration of Tadox® Technology to Achieve Net Zero in Textile Wastewater Treatment: Policy Recommendations Based on Pilot Study in a CETP.

https://teriin.org/sites/default/files/files/Policy_Brief_on_Net_Zero_in_Textile_Wastewater_Treatment.pdf

II. Energy and Carbon Intensity

- The cluster consumes an estimated 3,96,288 tonne of oil equivalent (toe) annually, translating into 12.82 lakh tonnes of CO₂ emissions (FICCI, 2023)¹⁰. Thermal energy accounts for 90–95% of total demand, used in dyeing, drying, and aging. Electricity, both grid supply and backup, constitutes less than 5–10% of overall energy consumption. Renewable energy adoption is also slowly scaling up and can be further strengthened.
- Field-level interactions revealed MSMEs currently perceive energy costs as ‘inevitable overheads,’ pointing to a clear opportunity to reframe this as an area of strategic investment. Literature also suggests that MSMEs in India can strengthen energy efficiency uptake through greater awareness of payback periods and access to concessional finance (CEEW, 2018). Additionally, developing cluster-level carbon accounting and green financing mechanisms could help position Panipat favourably on future buyer sourcing maps shaped by carbon footprint reporting.

This underlines opportunities for cluster-level renewable pilots and pooled investments in energy efficiency, supported by SIDBI’s green finance lines or international climate funds. If co-designed with buyers who increasingly demand carbon reporting, such initiatives could reposition Panipat as a frontrunner in adaptive, low-carbon manufacturing.

III. Chemicals and Processing

- Dyeing processes in Panipat currently rely on low-cost synthetic dyes, including azo dyes that face restrictions in global markets, presenting a clear opportunity for cleaner alternatives. Sludge generated from dyeing offers significant potential for structured management solutions to prevent secondary air and soil pollution.
- MSME interviews point to opportunities for greater awareness-building around non-toxic alternatives and access to efficient dyeing technologies through existing schemes. Additionally, aligning ESG-linked buyer requirements more closely with MSME capacities could help close compliance gaps. Secondary reports note that small enterprises can benefit from targeted support for chemical substitution, addressing cost, technical know-how, and supply chain fragmentation (ZDHC, 2024)¹¹.

This opens up strong potential for collaborative upgrading: i) chemical substitution pilots with technical institutes – dyers during interviews and on-ground interactions expressed genuine interest in opening cluster-level R&D departments, especially for dyeing units, to minimise waste and pollution, and to co-create actionable solutions rooted in local realities; ii) shared chemical management hubs that lower per-unit costs; and iii) cluster-wide eco-labelling initiatives to reduce compliance barriers while enhancing global credibility.

Secondary evidence from peer clusters demonstrates that transformation is achievable when compliance pressures are reframed as opportunities for market access and upgrading. With these practices embedded, Panipat is well-positioned to evolve from a recycling hub into a genuinely credible model of sustainable circularity, strengthening both its ecological standing and its competitiveness in increasingly compliance-driven global markets.

¹⁰Southeast European Textile Cluster. (n.d.). Panipat textile cluster profile report https://seet.ficci.in/pdf/Report_PanipatTextileCluster-Profile.pdf

¹¹ZDHC Foundation. Impact Report 2024: <https://www.roadmaptozero.com/impact-report-2024?>

2.2 Waste & Circular Economy Integration

Waste management lies at the heart of RECE. For textiles, the ability to reduce, recover, and regenerate fibres determines how effectively recycling systems can move toward higher-value circular loops. Clusters that can align waste streams with modern compliance, technology, and social safeguards are better positioned to move from volume-based recycling to value-based circularity.

In India, textile waste management is still dominated by the informal sector. Over 70% of post-consumer textile waste generated are collected and processed by rag-pickers, small traders, and unregistered enterprises (IDR 2025)¹². While frameworks like Swachh Bharat Mission 2.0 signal ambition, domestic post-consumer waste remains poorly segregated and disconnected from formal recovery systems. There are steps towards greater integration of domestic textile waste into formal circular economy pathways.

2.2.1 Textile Waste Sources

Panipat's recycling economy operates at the intersection of three distinct waste sources: imported waste (pre and post), domestic post-consumer waste, and internal process waste.

I. Imported Pre- and Post-Consumer Rags

Historically, Panipat's recycling strength has come from importing woollen rags and discarded garments from the EU, US, and Middle East.

These inputs are sorted manually, often by women workers, into reusable textiles and input material for recycled fibres, on-field interactions indicated towards 70–80% of imported rags being recoverable; the rest become residues dumped, burned, or incinerated.

Global trade policies—tightened waste import restrictions in the EU and China, also leads to supply risks for Panipat's long-term feedstock resilience.

II. Domestic Post-Consumer Waste

There is generation of significant volume of textile waste domestically, and there is a need to develop strategies and pathways for channelising textile waste from cities and villages to recycling hubs like Panipat. Primary surveys with MSMEs reveal that entrepreneurs view domestic sourcing as fragmented, unreliable, and costly due to lack of pre-processing hubs and organised collection.

III. Secondary Process Waste (Internal Waste Flows)

Waste generated within the cluster itself is equally significant.

Recovered fibres are shredded and spun into coarse yarn (NE 2–20)¹³, which is recycled into blankets and mats. This process creates short-fibre residues and dust, that is recycled into

¹²India Development Review (IDR). *Building Circularity in Post-Consumer Textile Waste Management*. <https://idronline.org/article/ecosystem-development/building-circularity-in-post-consumer-textile-waste-management/>

¹³"NE" (Number English) denotes the cotton yarn count system, where lower numbers indicate coarser (thicker) yarn and higher numbers indicate finer yarn. Counts in the range of NE 2–20 are considered coarse, typically used in low-value products such as blankets and rugs, unlike finer counts (NE 40 and above) which are associated with high-value fabrics.

insulation, embroidery paddings (compressed or wax based) or filling material in and around Panipat. On ground discussions and observations that some of the units in the cluster are moving towards NE 40 yarn.

Dyeing and finishing add another waste stream: synthetic dye sludge. Field interviews with dyeing units confirmed that sludge treatment is minimal, with many operators relying on outsourcing it to companies for safe disposal or sometimes low-cost disposal, creating secondary pollution.

2.2.2 Opportunities

The ecosystem of Panipat presents several areas ready for advancement across technological, environmental, social, and institutional dimensions, and upon mapping, each of these represents a corresponding opportunity for transformation:

I. Fibre Regeneration

The recycling process remains significantly focused on recycling measures where fibres are shredded into coarse yarn (NE 2–20) and channelled into low-margin products such as blankets, carpet backings, and durries, and very limited higher-value realisation like apparels. Some units are beginning to produce finer counts such as NE 40 yarn, demonstrating the technical feasibility of moving up the value chain. Scaling such practices through fibre-to-fibre recycling pilots can regenerate longer and stronger fibres needed for finer yarn counts, opening pathways to high-value applications (like shirting, finer knits, or higher-end home textiles) while reducing waste leakages.

II. Manual Sorting to Mechanised Precision

Sorting continues to rely on manual, women-led rag segregation that struggles to manage increasingly complex blends. The result is mixed, low-grade fibre unsuitable for apparel-grade recycling. By adopting mechanised sorting and fibre grading technologies, including Near-Infrared (NIR)¹⁴ blend detection, recyclers can ensure consistency, improve material recovery, and produce certified recycled yarns for global markets.

III. Cluster-Level Recycling Hub

A cluster-level Recycling Hub in Panipat can act as a shared facility for MSMEs, integrating mechanised sorting, sludge valorisation, and decentralised wastewater treatment. By pooling infrastructure and finance, the hub would reduce input heterogeneity, improve fibre quality, lower compliance costs, and enable adoption of advanced recycling and traceability systems. Positioned as a common facility centre (CFC), it can become a circularity accelerator, repositioning Panipat as India's first compliance-ready Textile Recycling Park.

IV. Import Dependence to Domestic Waste Integration

Panipat remains highly dependent on imported rags, leaving recyclers vulnerable to sudden trade disruptions. Establishing structured reverse logistics for domestic post-consumer textiles via municipal partnerships, housing society linkages, and CSR-backed collection pilots can provide stable and higher quality feedstock, improve traceability, and strengthen domestic textile circularity.

¹⁴European Parliament. *Parliament Adopts New EU Rules to Reduce Textile and Food Waste*. <https://www.europarl.europa.eu/news/en/press-room/20250905IPR30172/parliament-adopts-new-eu-rules-to-reduce-textile-and-food-waste>

2.3. Social Inclusion and Labour Realities in Panipat

Labour is a core asset underpinning Panipat's recycling economy, and strengthening social inclusion and worker welfare is central to both cluster resilience and global competitiveness. Aligning with global frameworks such as the ILO's Decent Work Agenda and the EU's CSDDD and CSRD presents an opportunity to embed stronger protections, fair wages, and decent work standards into the cluster's growth trajectory.

2.3.1 Cluster-Level Labour Realities in Panipat

An estimated 20,000–70,000 workers are employed across recycling, spinning, dyeing, and weaving, the majority of them migrants. Wage structures currently show gender disparity where women, largely engaged in sorting, earn approximately ₹300–400/day, while men in technical and higher-skilled roles earn ₹600–700/day. These present a clear opportunity for wage parity and skill-based mobility pathways.

- Consultations with cluster stakeholders point to an opportunity to strengthen the formal integration of this workforce. Supporting the workers who sustain Panipat's recycling economy through improved access to registration, safety systems, and career progression pathways.
- Recent trade shifts (with industry estimates suggesting up to 25% of jobs¹⁵ in the home textile sector affected by order slowdowns) underscore the value of diversified trade portfolios and reinforce the case for building more resilient, adaptable employment structures (Fibre2Fashion, 2025).
- Informal & contractual labour dominate Panipat's recycling value chain, which is built almost entirely on informal and contractor-mediated employment. Migrant male workers from Bihar, Jharkhand, and Uttar Pradesh dominate heavy tasks in sorting, spinning, dyeing, and weaving, while both local and migrant female workers are concentrated in sorting and finishing. Field interviews highlighted that ~60% of the labourers working in Panipat are migrant population. Moreover, thin profit margins push MSMEs to externalise social costs. Employment contracts are typically oral or brokered through contractors, leaving workers invisible in formal databases and enterprises unaccountable for social protection. Lots of units highlighted that workers are hired through private contractors, so shortages are faced during festivals or sudden departures. At times, whole lines are left idle for days. This system creates instability for MSMEs (production stoppages, attrition) while locking workers into low-wage, unprotected labour.
- Skilling remains apprenticeship-driven and craft-based, particularly in dyeing, where practitioners emphasise the specialised expertise required. Structured, cluster-level training modules represent a significant opportunity to build on this existing craft knowledge, ease machinery-cost concerns, and support productivity and fibre-quality gains.
- Gendered division of labour is deeply entrenched. Women are confined to sorting, warp preparation, and light manual work, while men dominate spinning, weaving, logistics, and higher-value buyer-facing roles. Employers often describe sorting as "female work" and during on-ground interactions,

¹⁵Fibre2Fashion. US' 50% Tariff on India Threatens Panipat's Textile Jobs & Exports. <https://www.fibre2fashion.com/news/textiles-import-export-news/us-50-tariff-on-india-threatens-panipat-s-textile-jobs-exports-304849-newsdetails.htm>

it was realised that women's participation in higher-value roles has not been systematically incentivised, while men are usually given the high paying roles. Expanding structured pathways for women into higher-value roles, consistent with India's G20 commitments on gender equality in labour markets, represents a meaningful opportunity to close the wage gap and strengthen income outcomes.

- Occupational health and safety systems, including PPE use and ESIC/PF enrolment, have room for expansion across the cluster, particularly for cash-paid migrant labour.¹⁶

2.3.2 Opportunities within Systemic Gaps

Panipat's labour-intensive recycling economy has strong potential to build more robust social foundations. Strengthening informality safeguards, expanding social protection access, and addressing gendered labour dynamics would both improve worker welfare and support exporter readiness under emerging global due-diligence regimes.

I. Social assistance through Cluster-level facilitation desks

ESIC and EPFO access remains limited among MSMEs. Cluster-level facilitation desks, supported by district labour departments, can help contractual and informal workers register under ESIC/EPFO/ Shram Yogi Scheme, an opportunity that, if linked to buyer recognition, turns social protection into a compliance advantage.

II. Inclusive skilling for RECE approaches

Co-developing structured recycling curricula with NITRA, HSDM, and MSME-DI would professionalise Panipat's largely informal skill-transfer model, strengthening fibre quality and workforce readiness for mechanisation.

III. Enhancing social aspect for certification and compliance

Scaling women-led SHGs for pre-processing and mechanised sorting, and linking them to certification pathways, offers a strong route to both inclusion and compliance credibility.

IV. Enhancing worker representation through existing associations

Formalising worker cooperatives or SHG federations, linked with associations like GATS and exporter groups, would strengthen advocacy and support proactive alignment with buyer expectations on grievance redressal.

Together, these four areas offer a practical pathway to build Panipat's labour economy into a compliance-ready, socially inclusive hub while supporting global buyer requirements and strengthening long-term workforce stability.

2.4 Policy and Regulatory Environment

Policy and regulation underpin MSMEs' transition to RECE, shaping access to finance, technology, and global value chains. The EU Green Deal (through ESPR, DPPs, and EPR), alongside CSRD and CSDDD, is

¹⁶Arisa & Sympany. *Textile Recycling Unravelled: Exploring Post- and Pre-Consumer Textile Recycling Value Chains in Panipat, India*. <https://arisa.nl/wp-content/uploads/TextileRecyclingUnravelled.pdf>

elevating traceability and social compliance as market-access priorities. Nationally, CGTMSE, CLCSS, ZED, SPICE, GIFT, and NAPCC reflect strong policy intent for sustainable industrialisation, with continued opportunity to strengthen uptake among MSEs through streamlined collateral, documentation, and digital-access pathways.

2.4.1 Policy interacting at Cluster-Level

Policy frameworks in Panipat present both immediate opportunities and areas for stronger translation into practice. Haryana's AatmaNirbhar Textile Policy (2022–26) offers subsidies for CETPs, ZLD adoption, and cleaner technologies; addressing upfront capital thresholds would broaden accessibility for smaller dyers and recyclers. Streamlining GST structures would similarly support formalisation. Robust global, national, and state-level frameworks exist – the opportunity now lies in strengthening the pathways that help MSMEs translate these into practical, on-the-ground benefits

Currently, the cluster interacts with policy domain through the following:

- Global Alliance for Textile Sustainability Council (GATS) as an association advocating for India-specific circularity metrics; facilitates dialogue on textile waste reuse/recycling; promotes peer learning; supports traceability and carbon footprint quantification; amplifies recycler voices in EPR, compliance, and circular business models. It is recognised as a key intermediary bridging micro-enterprises and policy forums; partners with Green Story, H&M Foundation, etc.
- Local industry associations attempt to facilitate shared infrastructure and promote voluntary certifications like ISO 14001; supported by Ministry of MSME, GOI, reimbursements for certification costs (FICCI, 2023), with limited uptake. These associations represent MSMEs in policy dialogues in a limited capacity but can play a coordinating role for cluster-level needs.
- Government Institutions (DMC, MSME-Development Institute, HSIIDC) offer scheme access, cluster-level industrial infrastructure, and development support, with an opportunity to deepen circularity specific focus, providing facilitation at state/district levels; act as enablers for industrial development
- Greater uptake of central schemes as MSME-focused instruments such as TUFS, CLCSS, CGTMSE, SPICE, and GIFT offer strong potential for technology adoption and cleaner production. However, Panipat's MSME segment show limited access due to collateral requirements, complex paperwork, and low digital capacity.
- GST regime harmonisation with the needs represents an opportunity to encourage more units into the formal system, expanding access to policy benefits.
- Presence of Haryana Textile Policy 2019 that aimed at R&D, innovation, and sustainability-driven entrepreneurship as strategic priorities. Further, it also introduced incentives for skill training, design centres, and cleaner technologies, aiming to create an ecosystem where clusters like Panipat could modernise processes. Additionally, AatmaNirbhar Textile Policy (2022–2026) extended targeted support for MSMEs by providing capital investment subsidy ¹⁷, interest subsidy scheme ¹⁸, SGST Reimbursement ¹⁹, and sustainable production incentives like support for CETPs, ZLD adoption, water-efficient dyeing. Currently, due to high upfront land and machinery costs, these

¹⁷20–25% on eligible machinery costs

¹⁸reimbursement of up to 6% for working capital/term loans

¹⁹refund of state tax portion to reduce operating costs

remain viable options for larger firms. Interactions revealed that in the dying subsector even if four to five units were to share the cost of a ZLD/CETP, at least 2,000 sq ft of land and appropriate machinery would still be required which are investments that could be managed by larger firms, for smaller units the process was described as challenging and risky, without generating proportionate profits.

- PADMA Scheme 2023 has been launched with an intention to strengthen India's textile value chains with targeted product-level support, especially technical textiles, power loom products, organic throw blankets, and curtains. Broadening the scope of scheme to better reflect Panipat's recycling-led product mix would increase its relevance to the cluster.
- CETP capacity at Sector 29 and consistent compliance represent priority areas for continued investment, building on MSMEs' existing engagement with CPCB norms
- Global regulation outpaces local readiness as EU ESPR, DPP, and EPR demand traceability and recycled-content verification. Strengthening – sourcing transparency around rag imports would help Panipat's MSMEs stay ahead of these requirements.
- Existing practices like informal labour and lack of protective measures further expose vulnerabilities under regulatory policies like CSRD and CSDDD that demand that brands scrutinise supplier-level risks on emissions, effluents, and labour conditions ^{20 21}.
- Institutional leadership is strengthening like GATS and OE Yarn spinning mills are piloting DPPs, carbon foot printing, and certifications, while SIDBI's new Panipat branch could anchor finance for compliance. Expanding the network of MSMEs through a unified platform would further the collective action and enable scale-up.
- Continued external policy engagement would help Panipat build on its recycling scale and strengthen its standing with global buyers.

Institutions such as GATS and other industry associations are already playing an active role in shaping the regulatory environment, and there is strong potential to extend their reach to a broader base of MSMEs.

2.4.2 Opportunities to bridge Policy-to-Practice

Cluster stakeholders describe a clear opportunity to close the gap between global compliance shifts and the practical capacity to act on them. Panipat's recyclers are strategically positioned to serve global sustainability agendas as one of the world's largest textile recycling hubs; building the operational mechanisms to translate global, national, and state-level frameworks into daily practice. A policy-to-practice bridge and will strengthen Panipat's continued integration into global value chains.

The following four operational areas are critical to reposition Panipat from a policy-receiving cluster to a compliance-ready partner:

²⁰Pansera, M., Barca, S., Martinez Alvarez, B., Leonardi, E., D'Alisa, G., Meira, T., & Guillibert, P. *Toward a Just Circular Economy: Conceptualizing Environmental, Labor and Gender Justice in Circularity Studies. Sustainability: Science, Practice and Policy* <https://www.tandfonline.com/doi/full/10.1080/15487733.2024.2338592#abstract>

²¹CPCB guidance/SOPs explicitly classify textile ETP secondary sludge as hazardous (Schedule-1 Category 35.3) and prescribe TSDF (Treatment/Storage/Disposal Facility)/co-processing routes – meaning most sludge is supposed to be handled as hazardous and sent to authorised facilities.

I. Strengthening Domestic Feedstock through Policy Support

Reducing reliance on imported rags through structured national and state policy that recognises textile waste as a resource, mandates ULB waste management under Swachh Bharat Mission 2.0, and links AatmaNirbhar subsidies to verifiable domestic sourcing would build consistent, traceable feedstock pathways.

II. Leveraging Haryana Incentives for Compliance Capex

Haryana's AatmaNirbhar Textile Policy already includes subsidies for the industry. Mapping subsidy disbursement to compliance KPIs such as verified sludge disposal compliance, reduced effluent load from dyeing units, adoption of mechanised fibre-sorting equipment, and certification uptake (GRS, GOTS, etc), would help translate existing incentives into measurable global competitiveness gains.

III. Supplier Due-Diligence Alignment

Global buyer expectations under the EU's CSDDD and CSRD²² are shifting compliance from environmental metrics alone to encompass labour standards, grievance redressal, and gender inclusion. For Panipat, preparing cluster-level documentation frameworks that cover worker remediation mechanisms, gender inclusion strategies (particularly for women sorters), and integration of informal labour into social protection, can pre-empt buyer questionnaires and reduce transaction risks. These processes can be supported by India's four Labour Codes (on wages, safety, social security, and industrial relations) and social protection schemes like ESIC, EPFO, and NAMASTE (if expanded to textile waste workers). By embedding these existing legal and welfare frameworks into cluster-level compliance systems, Panipat can present verifiable, buyer-ready due diligence that transforms labour inclusion from an informal necessity into a compliance advantage.

IV. EPR/DPP Readiness Package

With global demand for verifiable recycled content and traceability down to fibre blends, there is need to develop cluster-level data systems to enable exports²³. The mechanisms are intended to ensure transparency, regulatory compliance, and buyer confidence in sustainability claims. This digital backbone is needed to be created as a cluster level ecosystem that will allow compliance with EU eco-modulated fees under EPR and seamlessly integrate into DPP reporting systems. A cluster-level facilitation hub could reduce costs by providing shared digital infrastructure rather than leaving individual MSMEs to adopt expensive tools independently, reducing the cost of certification and traceability for each product line (SKU costing²⁴) by creating a shared material

²²European Commission. Corporate Sustainability Due Diligence. https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en

²³Requirements of traceability and verification protocols such as batch-level identification numbers (to track inputs across the supply chain), Near-Infrared (NIR) spectroscopy for fiber-blend detection, recycled-content declarations (to disclose and certify the proportion of recycled materials used), and auditable process logs (to maintain verifiable records of sourcing and production).

²⁴"SKU costing" means the cost calculated per Stock Keeping Unit (SKU). An SKU is a unique identifier for each distinct product a company sells, for example, a blue wool blanket, size 60x90 cm would be one SKU, while a red cotton rug, size 40x60 cm would be another. When compliance, certification, or traceability is required, each SKU often has to be

passport at the association level. This passport would cover common materials such as verified sorted textile waste, recyclable fluff, recycled OE yarns, and circular fabrics, making compliance more affordable and accessible for MSMEs. There is a need for localisation of these frameworks through facilitation hubs, pooled compliance systems, and KPI-linked subsidies.

2.5. Financial and Market Access

Finance and market access are core enablers of MSME transition to RECE, shaping their ability to invest in cleaner technologies, achieve compliance, and access higher-value trade. For Panipat, this means aligning with EU frameworks like ESPR, DPP, CSRD, CSDDD, CBAM, which now tie finance and market entry to traceability and sustainability, while overdependence on a few countries exposes the cluster to shocks like tariff hikes²⁵. Nationally, schemes exist to de-risk green investments, and certifications can unlock premium buyers, but thin margins, reliance on informal credit, and prohibitive certification costs create a two-tier system where larger exporters secure opportunities while smaller recyclers remain stuck in low-value markets.

2.5.1 Cluster-Level Finance and Market Landscape

Panipat's finance and market systems reflect the duality of impressive scale with resilience and structural fragility. The cluster supplies to many brands and market players but most MSMEs remain excluded from affordable formal finance needed to drive sustainability market. Rising compliance costs, limited financial avenues for improvements, and overdependence on the United States for exports leave enterprises trapped in a survival cycle, where day-to-day operations are sustained, and transformation into globally competitive, compliant, and higher-value markets remains constrained. Field visits and interactions reveal a diverse set of perspectives for financial and market related drivers.

- Many MSMEs currently rely on trader credit or informal borrowing. Thus, there is an opportunity for expanding access to formal finance instruments (SPICE, GIFT, CGTMSE) including through improved bookkeeping support and digital integration. These would help lower capital costs and free up resources for technology upgrades and certification.
- SIDBI's new local branch is a strong step toward improving MSME access to financial knowledge and procedures, and associations like GATS are actively working with the state textile department to expand uptake of Haryana's AatmaNirbhar Textile Policy support.
- Environmental compliance costs (ETP operation, sludge disposal, certified inputs) represent an area where collective solutions, like shared CETPs/CFCs, could improve cost efficiency, alongside expanded technology coverage under GIFT and SPICE.
- Rising compliance pressures as buyers demand certifications like GOTS, GRS, RCS, SEDEX, and OEKO-TEX, along with digital traceability aligned with EU's DPP. The cost of certification (₹5–10 lakh per unit) are a barrier for micro-enterprises with turnovers of barely ₹2–5 crore. Many units reported spending ₹4–5 lakh on certification without securing a single order, treating compliance

documented or certified separately. This makes the cost per SKU (per product variant) quite high for MSMEs in clusters like Panipat, because they sell large numbers of low-value, varied products (many different colours, sizes, blends).

²⁵Polyestertime. Recycled Plastics – Chemical Recycling and Advanced Polymers. Recycled Plastics – Chemical Recycling and Advanced Polymers Chemical recycling is an emerging technology where plastics are depolymerized into monomers, which can then be repolymerized into virgin-quality plastics 26-08-2025 • Polyestertime

as a sunk cost rather than a market opportunity. Thus, forward linkages for uptake are needed to enable market access that the certifications provide.

- Expanding awareness of certification processes and building trust in certifying agencies would help more MSMEs confidently pursue market-access certifications. Encouragingly, major brands including H&M, IKEA, and Inditex are already collaborating with the cluster on circular transition initiatives aligned with EU supply chain compliance²⁶²⁷.
- Export markets are currently concentrated in the US. Increased diversification would help build resilience against trade policy shifts of the kind recently experienced.

2.5.2 Opportunities within existing Systemic Gaps

Panipat's finance and market access landscape presents clear opportunities for systemic upgrading across international, national, and local levels:

- I. Diversification of export markets and cluster branding: – Expanding into the Middle East, Africa, Japan, Korea, and Latin America (building on platforms like IHTS), paired with a “sustainable recycled textiles” cluster brand, would strengthen Panipat's position in global value chains and support co-financing of compliance costs with buyers.
- II. Establishing collective certification mechanisms: – Pooled certification managed through cluster associations would reduce per-unit costs and build trust, with strong potential to position Panipat as India's first DPP-ready recycling hub (Switch Asia EU, 2024)²⁸.
- III. Cluster-level facilitation for finance and scheme uptake: – A dedicated facilitation desk to aggregate applications for SPICE, GIFT, and CGTMSE, alongside SIDBI's new branch as a knowledge hub, would expand access to concessional and green finance.
- IV. Development of a cluster-level blended-finance Climate Action Fund: – De-risking MSME investment through blended finance would unlock capital for mechanised sorting, certification, and cleaner production, with repayments channelled through cluster associations.

Diversification, collective mechanisms, and green finance pooling together offer a strong pathway for Panipat's continued transformation.

2.6. Innovation and Technology

Technology and innovation are the backbone of RECE in textiles, driving circularity through mechanised sorting, fibre-to-fibre recycling, low-impact dyeing, and digital traceability that reduce waste and emissions while opening higher-value markets. For clusters like Panipat, technology is now essential for compliance under EU frameworks (ESPR, DPP, EPR) and to remain globally competitive. India's policies like Start-up Mission, Waste to Wealth, SBM-Textiles, SPICE, GIFT, and ZED aims to support cleaner technologies and formalise MSME recycling hubs, though uptake remains limited.

²⁶Textile Exchange. *Materials Circularity Index (MCI) Insights 2022*. https://textileexchange.org/app/uploads/2024/01/Textile-Exchange_MCI-Insights_2022.pdf

²⁷ESG News. *Zara, H&M, IKEA and Primark to Launch Textile Waste Pilot Ahead of EU Regulations*. <https://esgnews.com/zara-hm-ikea-and-primark-to-launch-textile-waste-pilot-ahead-of-eu-regulations>

²⁸SWITCH-Asia. *Green Threads: Positioning India's Recycling Clusters as Leaders in Circular Fashion* <https://switch-asia.eu/news/green-threads-positioning-indias-recycling-clusters-as-leaders-in-circular-fashion/>

2.6.1 Cluster-Level Technology and Innovation Landscape

The current technological base in Panipat remains rooted in manual sorting, shredding, and open-end spinning-processes first set up decades ago. While this system has kept millions of tonnes of textiles out of landfills, it locks the cluster into a low-value recycling pathway through producing coarse, low-value yarns for bulk orders while carrying a heavy environmental footprint. Innovation in Panipat is incremental and primarily focused on production efficiency rather than systemic transformation. Field insights underscore the dual reality of Panipat's innovation ecosystem.

- Manual sorting practices reflect deep craft expertise (visual fibre and shade classification), complemented by early trials of technologies like Matoha FabriTell²⁹ scanners for blend-based sorting for fibre and increasing efficiency of the workforce.
- Sorters highlight that shade judgement currently requires human expertise, an insight that can help shape technology adoption that complements, rather than replaces, this skill.
- A number of spinning mills have already introduced mechanised shredders and open-end spinning with traceability modules, pointing to a clear pathway for broader adoption across the cluster.
- Dyeing units are increasingly adopting certified dyes. However, expanding access to water-efficient, context-specific technologies under existing MSME schemes would accelerate this shift further and address the tech adoption vacuum in the dyeing subsector.
- Panipat shows sparks of innovation with MSMEs testing blended recycled yarns, felting for insulation from denim waste, upcycled products by design-led firms, CSO supported textile waste supply chain strengthening, and start-up supported pilots in traceability hinting at the potential for digital solutions. Integration of these technologies may be furthered through greater awareness, developing business case for innovations, finance for modernising technologies, and institutional support.
- Digital traceability platforms, including blockchain-based fibre passports, are gaining traction internationally, yet remain absent in Panipat. Efforts like the Green Threads programme³⁰ (FMC, Switch-Asia) have introduced exporters to EU traceability tools such as Reverse Resources and DPP pilots.

While the enabling environment is strong (growing recognition of Panipat by brands, policymakers, researchers, and foundations, which generates insights and attention as a recycling hub), actual uptake is slow due to finance, collateral, and administrative hurdles. This technological lag reinforces Panipat's structural vulnerability- creating a downcycling trap. This creates a paradox: technology is available and incentivised, but institutional mechanisms for collective applications or facilitation at the cluster level remain weak. Innovation pathways need to be reframed from efficiency-driven to transformation-driven, integrating mechanised sorting, advanced recycling, and digital compliance infrastructure.

2.6.2 Opportunities within existing systemic gaps

At the cluster level, the following systemic gaps and corresponding opportunities emerge:

I. Advancing Mechanical and Chemical Recycling Technology

Heavy reliance on shoddy yarn production currently limits value capture at scale. Disseminating knowledge on technologies for RECE, piloting modern mechanical , chemical, and large-scale

²⁹Matoha Instrumentation Ltd. FabriTell Desktop – Textile Material Identification Device
FabriTell (desktop) | Matoha

³⁰SWITCH-Asia. Green Threads: Positioning India's Recycling Clusters as Leaders in Circular Fashion. <https://switch-asia.eu/news/green-threads-positioning-indias-recycling-clusters-as-leaders-in-circular-fashion/>

recycling technologies that are validated in partnership with associations like GATS and financial institutions to assist Panipat move towards higher-value markets is needed.

II. Improving Sorting and Fibre Quality through technology upgradation

Manual, labour-intensive sorting results in inconsistent fibre quality, and consistency across blends, limiting potential for apparel-grade recycling that the cluster needs. Deployment of mechanised sorting and blend identification technologies like NIR scanners and Matoha FabriTel can improve precision, consistency, and reduce supply chain leakages and inconsistencies.

III. Innovative Technologies (water and waste) under GIFT and SPICE

Innovative technologies exist for RECE in textile production and textile waste management processes, however limited uptake due to lack of incentive. Promoting and incentivising technologies like low water dyeing, critical recycling technologies, sorting and segregation innovations, sludge valorisation, innovative co-production (insulation, construction) under SPICE and GIFT schemes becomes important to introduce at cluster level.

IV. Innovation Ecosystem and R&D Linkages

Panipat's innovation landscape reflects strong survival-tested practices with clear runway for continued technological advancement. Building on isolated pilots to drive systemic adoption, through localised R&D institutes, scheme alignment, and shared digital infrastructure represents the clear path forward.

2.7. Best Practices and Emerging Examples from Panipat

Panipat cluster is one key cluster that has demonstrated that waste becomes raw materials at scale. With circularity and DPP requirements coming in EU, Panipat MSMEs can become leaders in circular exports if they modernise and have access to better finance and schemes. Panipat's strength lies in the fact that recycling is already embedded in everyday production.

2.7.1 Regional Textile Waste Linkages and Informal Sorting Networks

Globally, textile circularity depends not only on recycling technology, but also on collection, sorting, aggregation, and pre-processing systems. UNEP's textile circularity roadmap³¹ and the EU Strategy for Sustainable and Circular Textiles³² also highlight the increasing importance to sorting systems, reuse channels, recycled fibres, and extended producer responsibility.

In India, this is especially relevant because textile waste still moves through highly decentralised networks, many of them informal. Panipat reflects this reality very clearly. Its recycling strength is not built only inside factories and mills, but also through a wider network of sorters, aggregators, traders, and transporters spread across India. This also creates an important opportunity: Panipat can reduce its dependence on imported materials by strengthening organised domestic textile waste supply chains from urban production and consumption centres.

³¹<https://www.unep.org/resources/publication/sustainability-and-circularity-textile-value-chain-global-roadmap>

³²https://environment.ec.europa.eu/strategy/textiles-strategy_en

Katran Market–Panipat informal sorting and supply linkage³³

A strong example of Panipat's ecosystem is its linkage with informal textile waste markets such as Katran Market in Mongolpuri, Delhi. The Katran Market sorts cutting waste by colour and sells over 10 tonnes per day to formal clusters in Panipat. The waste comes from Noida, Gurugram, Manesar, Jaipur, and Delhi. This demonstrates that Panipat cluster operates with a good network of waste collectors and suppliers with urban spaces in Northern India. It depends on a wider regional waste supply chain involving garment factories, informal handlers, traders, transporters, sorters, and recyclers. This demonstrates the potential of the domestic market, and it connects to Panipat cluster for recycling of pre and post-consumer waste.

2.7.2 Colour-to-Colour Recycling and Avoided Impact of Wet Processing

Textile dyeing and finishing are among the most resource-intensive stages of the textile value chain. For recycling clusters, this makes avoided dyeing an important sustainability opportunity. Instead of recycling waste and then dyeing the yarn again, colour-based recycling allows already-coloured waste to be converted into yarn of the same or similar shade. This approach can reduce water use, chemical load, energy demand, effluent generation, and production costs. It also aligns with global buyer expectations around lower-impact materials, safer chemicals, and credible recycled-content claims.

Colour-to-colour, no-dye recycled yarn model³⁴

A very strong circularity case for Panipat is colour-to-colour recycling. Instead of dyeing recycled yarn again, waste is sorted by colour and converted into yarn of the same or similar colour. This saves water, chemicals, energy, and dyeing cost. Recycled yarn with avoided dyeing impact is a good showcase from Panipat. For export buyers, this can be linked to lower water use, lower chemical load, lower emissions, and traceable recycled content. One notable example is Kakkar's spinning mill where yarns are pre-dyed through the recycling process, with no additional colours or chemicals required, and it offers multiple colour options. KS Spinning and Kakkar use colour-to-colour approaches, avoiding dyeing, bleaching, and additional chemical processing in some recycled yarn lines.

If colour-sorted inputs, avoided dyeing, batch-level material flows, and buyer specifications are recorded properly, Panipat's colour-to-colour yarn can become a recognised low-impact product category rather than remaining an under-documented cluster practice.

2.7.3 From Waste-to-Yarn to Waste-to-Product Circularity

Globally, circular textiles are moving beyond basic recycling towards higher-value loops. The focus is shifting from simply diverting textile waste away from landfill to retaining greater material and economic value within the supply chain. The Ministry of Textiles' value-chain study also notes that India's textile recycling sector could reach a market value of around USD 3.5 billion by 2030 and generate green jobs across collection, aggregation, sorting, pre-processing, recycling, quality assurance, and traceability functions.

Panipat's circular economy does not stop at "waste-to-yarn" and it has demonstrated that it can move into "waste-to-product" models where recycled inputs are converted into denim, knitwear, home textiles, branded garments, and circular collections. This creates higher value than selling recycled fibre or low-count yarn alone.

³³<https://www.texmin.gov.in/static/uploads/2026/03/407c2f186a2044a4497c9c9803d16a2c.pdf>

³⁴<https://apparelresources.com/business-news/sustainability/textile-waste-panipat-answer/>

Case: Recycled denim and higher-value garment loops³⁵

Aadi Sustainability is a useful example of moving from low-value recycling to higher-value products. Industry reporting says Aadi Sustainability handles around 15,000 tonnes of material per month and converts recycled inputs into denim garments, producing 6–7 lakh denim pieces per year, with buyers including Reliance, Ed-a-Mamma, Monte Carlo, Madame, WROGN, and Landmark Group.

This type of model is important as it demonstrates that Panipat can move beyond “waste-to-yarn” and enter “waste-to-product” loops. Recycled denim, recycled knitwear, home textiles, and branded circular collections create higher value than selling recycled fibre or low-count yarn alone.

Case: Hybrid recycled yarn for higher-strength products

Panipat is evolving and positioning as a key hub for the development of hybrid recycled yarns, where recycled cotton, wool, acrylic or polyester fibres are blended with stronger fibres to meet buyer requirements. This is key as mechanically recycled fibres are often shorter and weaker than virgin fibres. By blending recycled fibres with polyester, rPET or virgin fibre, Panipat units can produce yarns that meet higher strength, durability and export specifications.

KS Spinning has been reported to blend recycled cotton with polyester for added strength and to produce recycled yarns for buyers across more than 29 countries. Kay Gee Enterprises recycles post-consumer textile waste into fibres and spins yarn counts ranging from NE 2s to 20s, including raw white and coloured yarns using open-end spinning technology³⁶. Technology providers are also helping improve recycled-yarn quality. Trützschler’s TRUECYCLED solution³⁷ is deployed in Panipat and in other regions of India for cutting, tearing, carding and drawing of secondary fibres, with installations designed to produce better-quality yarn from pre-consumer and post-consumer textile waste.

Case: Shoddy wool-to-institutional blanket model³⁸

A strong circularity case from Panipat is its long-established shoddy wool and recycled blanket ecosystem. Instead of treating old woollen garments, acrylic rags and discarded winter clothing as waste, Panipat’s recyclers tear them back into fibre, re-spin them into shoddy yarn, and convert them into blankets, rugs and durries. This is one of the clearest examples of industrial-scale textile recycling in India.

Recycled fibre-based blankets from Panipat serve government procurement channels such as disaster relief, defence and railways, as well as international humanitarian agencies such as the Red Cross and UNHCR. The model shows how a low-value waste stream can be converted into a functional, durable and high-volume product.

For Panipat, such models can help diversify the cluster beyond bulk products like blankets, mats, and low-margin yarns. They also create stronger buyer-facing stories around recycled content, product traceability, and circular design. The best practice potential lies in building more partnerships between recyclers, spinners, fabric mills, garment manufacturers, and brands so that recycled material remains within higher-value supply chains. Instead of only selling low-count recycled yarn, the cluster is advancing towards buyer-specific yarn recipes, finer counts, hybrid blends, quality testing and product development partnerships.

³⁵<https://recyclr.org/>

³⁶<https://apparelresources.com/business-news/sustainability/textile-waste-panipat-answer/>

³⁷<https://blog.truetzschler.com/2025/09/04/from-waste-to-value-state-of-the-art-truecycled-installations-in-india/>

³⁸https://fmc.org.in/wp-content/uploads/2026/02/Panipat-Textile-Recycling-DSR-Final_Draft-12-02-2026.pdf

2.7.4 Technical Textile Recycling and Specialised High-Value Waste Streams

Technical textile recycling is evolving as an important but complex area of circularity. Technical textiles are designed for performance rather than appearance and are used in sectors such as defence, aerospace, safety, healthcare, automobiles, construction, and infrastructure. Because these materials are often engineered for strength, durability, chemical resistance, flame resistance, or protective performance, they are difficult to recycle through conventional textile recycling systems.³⁹ In India, technical this has direct national relevance because technical textiles are a strategic growth area. The National Technical Textiles Mission was launched in 2020 to boost the sector, with a focus on research, market development, exports, education, training, and skill development.

Case: ACTRS Panipat – technical textile and aramid fibre recycling⁴⁰

A high-value example from Panipat is the Advanced Centre for Textile Recycling and Sustainability (ACTRS) supported under the National Technical Textiles Mission and linked with IIT Delhi. The centre has worked on recycling of national flags and aramid fibre waste from bulletproof vests, helmets, protective gear, and defence/aerospace applications.

This demonstrates that Panipat can move beyond conventional shoddy recycling into technical textile recycling, including high-performance fibres. ACTRS at Panipat has delivered pioneering solutions in aramid fibre recycling. Panipat can thus develop specialised recycling lines for technical textiles, uniforms, institutional textiles, defence textiles, and high-strength fibres. This would diversify the cluster beyond blankets and low-count yarn.

Technical textile recycling opens a pathway into specialised waste streams such as uniforms, institutional textiles, defence textiles, protective gear, aramid fibres, and other high-strength materials. This can help diversify the Panipat cluster's identity from a bulk recycling hub to a specialised textile recovery and innovation centre.

³⁹https://www.switch-asia.eu/site/assets/files/3603/circular_economy_technical_textiles.pdf

⁴⁰<https://www.pib.gov.in/PressReleasePage.aspx?PRID=2194792®=48&lang=2>



CHAPTER 3

RECOMMENDATIONS FOR A ROADMAP FOR TRANSITIONING TO A CIRCULAR ECONOMY HUB

India's textile sector has historically been anchored in decentralised clusters, each with its own specialisation. It has been openly stated by the senior officials from the Ministry of Textiles that every district in India is working on textiles in some form or another, making textiles a pan Indian heritage.

Among these, Panipat stands apart as the country's largest recycling hub, sustaining nearly a million livelihoods across formal and informal segments. Its historical trajectory: from a woollen blanket town to the shoddy capital and now the "Recycling Capital of India" demonstrates how local enterprise, migrant labour, and global demand dynamics have shaped its recycling ecosystem. Panipat's current position highlights the resilience and potential of recycling economies for textiles in India.

By learning from its 60+ years of evolution, successes in waste valorisation, and recognising its persistent efforts to move towards circularity allows designing pathways that enable other textile clusters in India to embed recycling and circularity at scale. Panipat is an ideal case for a transitioning to a global circular economy hub, where lessons on waste as a resource, recycling entrepreneurship, supportive associations, social inclusion, and technology can be operationalised into a replicable model for building a sustainable textile future across India's diverse clusters.

3.1 Framework Overview: Phases of Transition to a Recycling-Driven Cluster

To achieve a circular, recycling-driven model, textile clusters may progress through a series of phases, from initial preparedness to full-scale transformation. Each phase emphasizes institutional readiness, stakeholder engagement, and systemic transformation:

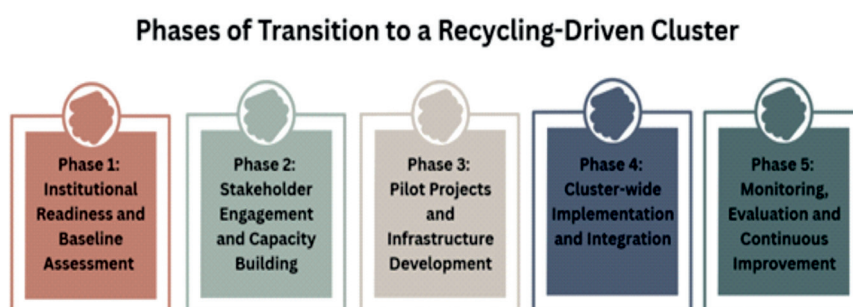


Figure 6: Phases of Transition

Phase 1: Institutional Readiness and Baseline Assessment

Cluster Task Force: Form a multi-stakeholder cluster task force comprising textile committee, industry association leaders, local government, MSME representatives, informal sector representatives, and experts.

Baseline Mapping: Conduct a comprehensive assessment of the cluster's current state of resource use (water, energy, materials), waste generation, recycling activities, workforce profile (including informal workers), and environmental performance including areas for significant improvement.

Vision & Target setting: Using baseline data, set a vision and quantifiable targets ensuring alignment with national missions (e.g. goals under SBM Urban 2.0) and international trends (e.g. EU's requirements for durable textile made of recycled fibres).

Institutional Capacity Building: Initiate training for the local institutions on circular economy concepts, business models, and relevant regulations. Leverage tools like the Textiles Circularity Toolkit for best practices. Build partnerships with local technical institutes (e.g. SASMIRA, NIFT, SITRA), expert organisations and bilateral/multilateral projects for ongoing advisory support.

Phase 2: Stakeholder Engagement and Capacity Building

Awareness and Dialogue: Conduct workshops, meetings, and focus groups with all stakeholders (MSME owners, workers' unions, informal waste collectors, local officials, global buyers/brands, and community members) to share the vision and address concerns.

Training & Skill Development: Launch capacity-building programs on two fronts:

- Technical training for MSMEs and workers on new recycling technologies, efficient processes, and quality management.
- Business training on circular business models, compliance, and knowledge on how to utilise schemes like SAMARTH and partner with ongoing initiatives.

Inclusion of Informal Sector: Actively involve informal recyclers, waste pickers, and artisans in training and decision-making. Encourage inclusion of cooperatives or SHGs for waste collectors to address the social inclusion imperative, creating formal supply chains with training and better livelihoods

Stakeholder Pledges: Have cluster enterprises and buyers sign on to a "Cluster Circularity Pledge", a voluntary commitment to pursue resource efficiency and fair labour practices. This can be facilitated by industry associations and tied to recognition (awards, publicity) for early adopters, setting a normative push for others.

Phase 3: Pilot Projects and Infrastructure Development

Pilot Projects: Identify quick-win projects (Shoddy Yarn, Recycled OE Yarn mills) and implement them at pilot scale. Use these pilots to demonstrate viability and refine approaches before scaling. Notably, Panipat's recycling units already showcase the practice of circularity by converting textile waste into shoddy yarn and blankets from discarded garments.

Common Infrastructure: Plan and initiate development of shared facilities that may be unaffordable for individual MSMEs. High-impact infrastructure includes renewable energy, CETP, Collection & Sorting Centres for textile waste, Recycling Parks or smaller estate (like SIDCO estate in Coimbatore) focusing on recycling aspects and providing relevant support for MSMEs for easy adoption.

Technology Trials: Introduction of modern technologies by piloting it in a few units with subsidy support can showcase its benefits and become case study for adoption. During this phase, there is also a need to ensure viability gap funding through grants or soft loans for pilots. Tap into MSE-SPICE funds for circular projects and MSE-GIFT for clean technology upgrades. Also, knowledge exchange with national and global best practices and experiences will also enable continual process of improvement.

Monitoring & Learning: Establish a monitoring system to track pilot outcomes (resource savings, cost implications, social impact) and a feedback loop for stakeholders to learn from these demonstrations. Use results to inform broader rollout in the next phase.

Phase 4: Cluster-wide Implementation and Integration

Policy Enforcement & Incentives: Work with local authorities and regulators to strengthen enforcement of environmental and labour regulations, paired with incentives for compliance. Simultaneously, offer incentives like rebates on water/energy tariffs for units meeting recycling targets, fast-track ZED certification subsidies for compliant MSMEs, or recognition in cluster rankings.

Value Chain Integration: Embed circular practices across each stage of the textile value chain in the cluster. Promote use of recycled fibres by cluster spinning/weaving units; link them with suppliers of such fibres or set cluster targets for recycled content in products. Encourage manufacturers to adopt these as raw material inputs. Encourage segregation and channelisation of scraps from different factory units to the cluster's sorting/recycling system. Work with brands and municipalities to channel used clothing into the cluster's recycling network and partner with second-hand markets. This closes the loop, making the cluster a hub not only for production but also for end-of-life processing.

Market Linkages for Recycled Products: Strengthen connections to markets for the outputs of recycled processes. Develop branding for cluster-made recycled products emphasising their sustainability. Industry associations can facilitate buyer-seller meets focused on sustainable textiles, inviting global buyers who have commitments to recycled content. Leverage schemes like GeM (Government e-Marketplace) and public procurement to prefer recycled textiles (e.g. blankets for government relief programs made from Panipat's shoddy yarn).

Financial and Business Model Integration: By now, permanent financial solutions should be in place. This includes revolving funds or credit lines for MSMEs to continually upgrade technology (with banks/SIDBI perhaps offering green finance at lower interest, aligned with GIFT scheme goals), and business models that make recycling profitable.

Phase 5: Monitoring, Evaluation and Continuous Improvement

Cluster Sustainability Dashboard: Develop a public dashboard or annual report for the cluster, reporting key metrics. This transparency builds accountability

Milestone Reviews: Set specific milestones (1-year, 3-year, 5-year) during the roadmap and formally review progress at each. Celebrate successes and identify laggards, bottlenecks and adjust strategies or seek external expertise to course correct.

Continuous Stakeholder Engagement: Keep the multi-stakeholder dialogue alive through periodic forums where entrepreneurs, workers, managers, officials, and buyers convene to discuss ongoing issues to enable just transition.

Institutionalize R&D and Innovation: Establish ties with research institutes for R&D on circular textiles including new recycling methods for polyester blends and natural dye alternatives, etc. Possibly create a Cluster Innovation Centre or partner with a Centre of Excellence to pilot advance next stage cutting-edge solutions. Encourage MSMEs to pursue certifications and standards (such as Global Recycled

Standard, fair trade labels) to continuously improve credibility and quality. The continual information on guidelines and regular support will enable cluster to proactively adapt and modernise to become global circular hub.

3.2 Conclusion

The Panipat textile cluster stands at a pivotal juncture. Evidence from the field demonstrates that circularity is an everyday practice: MSMEs recycle waste, re-dye rejects, reuse water, and depend on labour-intensive recovery of fibres. This embedded circularity represents a significant, underrecognized asset with strong potential to be elevated as global buyer demand and financing mechanisms mature. Panipat's MSMEs are already acting as sustainability pioneers, with a clear runway to strengthen environmental performance and market resilience further. It inhabits a dual reality where MSMEs are simultaneously sustainability actors and survival-driven enterprises with a strong need for improved environmental performances and managing the global market volatility.

The central insight is that Panipat's transition toward a resilient circular hub can be achieved through enabling compliance, technological advancements with financial support and a reconfiguration of distribution of risks and rewards across the value chain. Costs of certification and traceability may be shared, governments may provide predictable subsidies, infrastructure, and policy clarity; and MSMEs must be supported to upgrade skills, technology, and social inclusion models. Without these enablers, sustainability will remain aspirational rather than actionable.

A way forward vision for the cluster builds on the adaptive practices already in motion:

1. Shared Infrastructure and Finance

- Establish cluster-level CETPs, ZLD parks, and renewable energy systems to distribute costs equitably.
- Expand concessional credit and targeted subsidies (ETPs, certification, renewable energy) to ease financial bottlenecks.

2. Recognition and Value Capture

- Build branding and certification mechanisms that formally recognise Panipat's long-standing recycling practices.
- Develop pooled or cluster-level certification models to reduce costs and strengthen collective bargaining with buyers.

3. Skills and R&D for Circular Transitions

- Set up a dyeing skills academy and cluster-level R&D hub to professionalise tacit skills, improve process safety, and foster grassroots innovations.
- Support SHG and women-led upcycling models with design, market linkages, and institutional partnerships.

4. Policy Alignment and Risk-Sharing

- Streamline GST and create targeted schemes that lower the cost of compliance.
- Build policy mechanisms that build resilience in face of global shocks (tariffs, trade disruptions) by offering relief measures and stabilisation funds.

5. Narrative Shift: From Survival to Sustainability-as-Opportunity

- Reframing sustainability as a business case linked to competitiveness, cost reduction, and market access is needed.

In conclusion, Panipat MSMEs are adaptive survivors, innovating within constraints. Their practices already embody many principles of circular economy, and with systemic recognition and support. A collective transition strategy rooted in shared infrastructure, fair cost distribution, inclusive skills, and policy coherence, can unlock Panipat's potential as a globally visible hub of socially inclusive circularity.

WASTE
WASTE

THIS GARMENT IS MADE WITH 100% RECYCLED MATERIAL.
IT CONTAINS FIBERS SOURCED FROM WASTE IN CLOTHING PRODUCTION,
HELPING TO MINIMIZE THE ENVIRONMENTAL IMPACT
OF THE MATERIALS USED.



The preceding sections of this report provided a comprehensive assessment of Panipat's textile recycling ecosystem by examining the cluster's value chain, enterprise landscape, and six thematic pillars comprising resource efficiency and environmental sustainability, waste and circular economy integration, social inclusion and labour realities, policy and regulatory environment, finance and market access, and innovation and technology. The assessment highlighted key structural bottlenecks that constrain the cluster's transition towards higher-value circularity, including inefficient material utilisation, fragmented waste management systems, limited technology adoption, weak traceability and compliance mechanisms, constrained access to finance, and the absence of shared infrastructure for advanced recycling and value addition.

Building on these findings, this section translates the identified challenges and opportunities into practical, investment-oriented business opportunity cases. Each case follows a structured framework that begins with an assessment of the current business landscape, outlining prevailing practices, operational limitations, and associated costs. It then identifies a specific business opportunity arising from these gaps and develops it into a commercially viable circular business model. The proposed cases present the intervention, implementation approach, indicative investment requirements, expected benefits, and anticipated economic, environmental, and social impacts.

Collectively, these business opportunity cases provide actionable pathways for industry, policymakers, financial institutions, and development partners to strengthen Panipat's circular textile ecosystem, enhance industrial competitiveness, improve resource productivity, and accelerate the cluster's transition towards higher-value, technology-enabled, and globally competitive textile recycling. The five cases presented in this section focus on

- 1. Material-Efficient Technologies for Resource Optimisation**
- 2. Common Facility for Textile Waste Sorting and Felting**
- 3. Mechanical Fibre-to-Fibre Recycling**
- 4. Shared Chemical Recycling for Mixed Textile Waste**
- 5. Upcycling through Social Entrepreneurs and Self-Help Groups (SHGs).**

Together, these interventions address opportunities across the textile value chain by promoting technology adoption, shared infrastructure, advanced recycling, and inclusive circular business models that can be scaled within Panipat and replicated across other textile clusters in India.



CUTTING
WASTE

4.1 Business Opportunity Case 1: Investing in Material-Efficient Technology & Software

4.1.1 Introduction and Context

Panipat is a dense textile hub where hundreds of MSMEs convert recycled yarns and low-cost fabrics into ready-made garments (RMG), blankets, durries and other home-textiles. While this ecosystem already embodies “circularity” through large-scale recycling of textile waste, the conversion stage (spreading, marking, cutting, bundling) remains largely manual. As a result, fabric – typically the largest cost component – suffers avoidable losses from sub-optimal marker planning, inconsistent lay quality, and re-cuts. Off-cuts are sold at low scrap value, offering minor recovery relative to the raw-material loss.

Business Case 1 targets this bottleneck by introducing material-efficient technology at two levels: (i) in-unit CAD/marker software to raise cutting yield and digitise planning; and (ii) a shared digital cutting facility (auto-spreader + CNC high-ply cutter, plotter, digitiser) operated by a cluster special-purpose vehicle (SPV) to pool high-capex equipment. This approach reduces raw-material consumption at source, improves product consistency, and enables digital traceability, key to meeting emerging buyer and policy requirements.

4.1.2 Rationale

Panipat’s RMG and home-textile MSMEs face high fabric costs and inefficient material use due to manual cutting and marker planning. Fabric makes up over 40% of product cost, yet most units still rely on non-digital methods, leading to 1–3% avoidable losses and inconsistent quality of cut parts and resulting finished goods (such as size/fit deviations, grainline/notch errors, panel mismatches, shade mixing). This drives re-cuts and repairs (extra fabric and labour required) and generates larger off-cuts and scrap, which are sold at low value, together eroding margins and adding to the environmental load.

Introducing CAD-based marker optimisation and a shared digital cutting facility (auto-spreader + CNC cutter) offers a direct route to higher yield and lower waste. Even a 2-percentage point gain in material efficiency can save about 9 tonnes of fabric per MSME annually, translating to ₹12–13 lakh in savings each year with a payback under 3 years.

The timing is right: rising raw-material costs, digital traceability requirements from buyers, and enabling government schemes such as MSE-CDP, GIFT, and SPICE create both financial and policy momentum. This intervention would modernise Panipat’s circular textile ecosystem – reducing waste at source, digitising production, and preparing MSMEs for next-generation compliance and competitiveness.

4.1.3 Business as Usual Case

Current Production and Waste Handling Practice

In Panipat’s RMG and home-textile cluster, most MSMEs still follow manual cutting and marker planning practices. Fabric is spread and marked on paper patterns or by chalk on lay tables, cut with straight knives, and bundled by hand. There is limited digital control over pattern layout or fabric consumption.

The off-cuts and trimmings generated from these manual operations are collected loosely and sold to local scrap dealers at ₹15–25 per kg or informally diverted to nearby recycling units. No system exists for differentiating reusable remnants from unusable waste, leading to mixing and value loss.

For many small units, waste is viewed as a by-product, not a production inefficiency. Most cutting rooms lack yield tracking or marker efficiency data, and fabric reconciliation is done manually, often with 3–5% discrepancy between purchase and production records. The absence of digital traceability also makes it difficult to meet brand-level waste documentation or due-diligence norms.

Costs Implications of the Current Model

Manual planning and cutting not only create visible waste but also hide embedded financial losses in raw material, labour time, and rework. Fabric constitutes the largest input cost (~40% of total product cost). Even a 2% inefficiency in production translates to roughly ₹12–13 lakh per MSME per year, a recurring, invisible loss.

Additional costs arise from:

Re-cuts and rejections due to quality control caused by inconsistent pattern placement and size errors (estimated 6–8% of lots).

Manual layout time (30–40 minutes per marker vs. 5–10 minutes digitally).

Untracked scrap transport and handling (₹3–5/kg), adding 1–2% to total operational cost.

While waste sales bring minor recovery (~₹20/kg), this offsets less than 10% of the material value lost. The current model therefore locks MSMEs in a cycle of low yield, high effort, and low value recovery.

Systemic Risks and Limitations

Continuing with the current approach exposes both economic and regulatory risks for the cluster:

- **Profit erosion:** Even with high use of secondary/recycled materials, Panipat's units remain exposed to input price and quality volatility; heavy grams per square meter (GSM) products keep fabric as the dominant cost, and yield losses or re-cuts magnify the impact of recycled market swings.
- **Competitiveness gap:** International buyers increasingly prefer suppliers with digital planning, traceable waste flows, and resource-efficiency credentials.
- **Social and operational risks:** Manual cutting rooms are labour-intensive and often manned by informal workers, leading to ergonomic strain and injury risk, inconsistent quality, and avoidable accidents from outdated tools and practices.
- **Lock-in effect:** Without digital transition, Panipat's MSMEs risk being confined to low-value markets and unable to access green-finance incentives.

4.1.4 Description: Business Opportunity Case 1

New Production and Waste Handling Practice

The proposed business case introduces CAD-based marker optimisation and a shared digital cutting facility as a step-change in how Panipat's MSMEs handle material efficiency and pre-consumer waste.

Under this system, each participating MSME uses CAD software for pattern making, grading, and auto-nesting to generate high-efficiency marker layouts. These digital markers are transferred to a shared cutting room, equipped with an auto-fabric spreader and CNC high-ply cutter, ensuring precision and consistency.

The new system digitises the entire fabric-cutting value chain:

- **Digital pattern and marker creation:** Every design, size set, and lay plan is computer-generated for maximum yield.
- **Automatic spreading and cutting:** The shared facility executes markers with repeatable accuracy and minimal re-cuts.
- **Digital traceability:** Barcode/RFID tags attached at bundle level enable tracking of production and residual waste.
- **Waste segregation:** Remnants are pre-sorted (reusable vs. scrap) at the facility, reducing contamination and easing recycling.
- **Data integration:** Each MSME receives monthly yield, off-cut, and productivity reports, creating a measurable baseline for circularity.

This model transforms waste from an unmonitored loss into a measured performance indicator, while pooling capital-intensive machinery under a cooperative framework.

Practice Example

Hisar Textile & Allied CFC Pvt Ltd, Haryana⁴¹

Located in the Textile & Allied Products Cluster, Hisar (Haryana, India), a micro & small textile cluster engaged in auto-accessories and allied fabrics. The cluster faced high material wastage (~20–30%) in cutting and designing, low automation and limited access to high-precision cutting/design facilities. 12–15 units formed a SPV to set up a Common Facility Centre (CFC) with shared cutting/design infrastructure. The CFC included computerised fabric cutting and design studio/ lamination capability enabling job-work of members and non-members. The project cost was estimated at ₹ 2.09 crore; financed as members' equity and state grant under the "Mini Cluster Scheme" of Haryana. The facility aims to reduce fabric wastage, improve quality and enable units to access larger buyers.

This nearby cluster example shows how a shared facility model works in practice: SPV + CFC structure + state grant support. It demonstrates that cutting/design facility can be pooled across units and reduce wastage significantly. While the technology details differ (Panipat home-textile vs. Hisar auto-accessories), the model is transferable: shared CAD/design + shared cutting machines.

Benefits and Social Impact Linkages

Beyond the direct productivity gains, the intervention contributes to the cluster's broader social and circular transition:

Benefit Area	Description	Illustrative Impact
Resource efficiency	CAD-enabled marker optimisation lifts fabric yield by ~2 percentage points.	~9 t fabric saved per MSME/year; cumulative ~180 t for 20-unit pilot.
Waste minimisation	Segregated off-cuts enable cleaner feedstock for Panipat's recycling ecosystem.	Better input quality for mechanical recyclers; reduced landfill volume.

⁴¹Diagnostic Study Report of Textile and Allied Products Cluster, Hisar - https://cdnbbsr.s3waas.gov.in/s3f48c04ffab49ff0e5d1176244fdb65c/uploads/2021/05/2021052638-1.pdf?utm_source=chatgpt.com

Economic value creation	Shared facility lowers individual capex burden and stabilises production costs.	Average ₹12–13 lakh saving per MSME/year; payback < 3 years.
Digital capability building	MSMEs acquire digital design, data tracking, and marker planning skills.	50+ workers trained; improved readiness for EPR and traceability.
Social inclusion & upskilling	Skilled operator, planner, and technician jobs created at the shared facility.	25–30 decent-work opportunities; potential for women and youth inclusion.
Circular supply-chain integration	Cleaner remnants and traceability support local upcyclers and waste-based enterprises.	Strengthens linkages with SHGs and social entrepreneurs in textile recycling.

Total Benefits

Assumptions taken for creating impact across 20 MSMEs at unit level and a shared facility as a subscription and pay-per-use model

Assumption	Working Value	Notes
Daily throughput per unit (baseline)	1,500 kg/day ⁴²	Typical small/medium Panipat cutting–stitching unit (2–3 tables)
Reference operating range (daily throughput)	Micro: 600–900 kg/day Small: 1,100–1,600 kg/day Medium: 1,800–2,500 kg/day	To localise per unit before modelling
Operating days/year	300	One shift; downtime embedded
Benchmark yield gain from CAD/marker	2 percentage points	Conservative cluster starter. Ranges from 1–3% (Pamuk and Yildiz 2016) ⁴³
Yield gain – sensitivity	1 / 2 / 3 percentage points	For scenario analysis ⁴⁴
Raw material (fabric/yarn) cost	₹140/kg	Working placeholder for Panipat mix ⁴⁵
Waste handling/haulage rate	₹4/kg	Transport/ULB/trader charge (if applicable)

⁴²Daily throughput per unit (1,500 kg/day) & reference operating range (micro/small/medium).

Practitioner baseline from cluster interviews and cutting-room capacity sanity checks (tables × lay length × shifts). To be field-validated in the Y1 audit.

⁴³ A Study about parameters affecting the marker plan efficiency – https://www.researchgate.net/publication/317774362_A_Study_about_parameters_affecting_the_marker_plan_efficiency

⁴⁴ Scenario band aligned to literature-reported ranges for marker efficiency improvements; final values to be replaced with pilot measurements.

⁴⁵ Working placeholder to be replaced with Panipat-specific BoQ/vendor quotes (recycled yarn/fabric mix, GSM band). Use this only for modelling; update with live procurement data during Y1 baseline. (Exploration of prices at India Mart as cluster pricing varies week-to-week.)

Scrap resale value	₹20/kg	Net waste benefit = (avoided handling/tipping) – (foregone scrap resale)
AMC / support for CAD	15% of licence cost/year (range 12–20%)	Many vendors now bundle support & upgrades via annual subscriptions ⁴⁶
Planner/operator (incremental)	₹30,000/month	Range ₹25–35k/month; using ₹30k
Cohort size for calculations	20 units	Multiply per-unit figures
Baseline annual input per unit	4,50,000 kg/year	1,500 kg/day × 300 days
Baseline → RM saved per unit	9,000 kg/year	4,50,000 × 2%
RM saving per unit	₹12,60,000/year	9,000 × ₹140
Waste-handling saving per unit (gross)	₹36,000/year	9,000 × ₹4; adjust to net using scrap resale (₹20/kg)
Rejection / QA re-cut rate (baseline)	7% of lots (working)	Typical non-optimised apparel factories report ~6–8% defect/rework; we set 7% until audit. (Startup Financial Projection) ⁴⁷
GST treatment (output)	Garments ≤ ₹2,500: 5% Garments > ₹2,500: 12% Most fabrics: 5%	Reflect recent GST revisions
Audit-verified daily throughput	1,500 kg/day (pre-audit value)	Replace with audit figure when available

Benefit calculator for 20 MSMEs

Particular	Value per Unit	No of Units	Total Benefit
Cost savings on waste disposal for MSMEs (net of scrap resale @ ₹20/kg)	₹-1,44,000/year	20	₹-28,80,000
Cost savings on raw material textile (+2 pp yield gain)	₹12,60,000/year	20	₹2,52,00,000
Total Annual Benefits (quantified lines)	₹11,16,000/year	20	₹2,23,20,000

⁴⁶ ~15% of licence (12–20% range) OR included in subscription.

Major vendors increasingly bundle support & upgrades in annual subscriptions (i.e., no separate AMC); legacy perpetual models commonly used 12–20% AMC.

⁴⁷ Apparel IE literature documents persistent sewing/cutting defects and rework; exact % varies by style and controls. Use 6–8% band until audit, then replace with measured FPY/RTY

International Journal of Research in Industrial Engineering - https://www.riejournal.com/article_193831_b2ac1bdcadb99d5e2802f28ff01cd40a.pdf

Cost

Particular	Cost / unit	No of Units	Total cost	Remarks
Capital Expenditure (CAPEX)				
CAD/Marker software licence	₹4,50,000	20	₹90,00,000	Core digital tool for marker optimisation; ex-GST cost.
Workstation (for CAD)	₹1,00,000	20	₹20,00,000	i7/Ryzen7, 32 GB RAM, 1 TB NVMe spec; ensures stable CAD operation.
Barcode/RFID (set-up)	₹60,000	20	₹12,00,000	Enables traceability, reduces mis-bundles/re-cuts.
Installation & initial training	₹50,000	20	₹10,00,000	Vendor onboarding & staff training; critical for yield realisation.
Member CAPEX contribution to shared facility (one-time)	₹11,25,000	20	₹2,25,00,000	Share of cluster cutting room (CNC cutter, spreader, plotter, digitizer, infra)
CAPEX contingency (5%)	₹85,000	20	₹17,00,000	5% buffer for exchange rate, cabling, and spec adjustments.
Per-unit CAPEX subtotal	₹18,70,000	20	₹3,74,00,000	Total per-unit CAPEX including contingency.
Operating Expenditure (OPEX – Year-1)				
AMC / software support (annual)	₹67,500	20	₹13,50,000	15% of licence; includes updates/support.
Planner/Operator (incremental, annual)	₹3,96,000	20	₹79,20,000	Buffered @₹33k/month reflecting Panipat labour norms.
Shared facility subscription (annual)	₹12,00,000	20	₹2,40,00,000	Provides access to CNC/spreader with defined hours and Service Level Agreement (SLA).
Shared facility OPEX allocation (annual)	₹1,54,000	20	₹30,80,000	Covers AMC/spares/power/consumables for shared infra.
Local logistics to shared room (annual)	₹1,50,000	20	₹30,00,000	Transport for fabric/panel movement; assumes batching/milk-runs.
OPEX contingency (5%)	₹95,000	20	₹19,00,000	5% on OPEX lines to offset fuel/tariff fluctuation.
Per-unit OPEX subtotal (Year-1)	₹20,62,500	20	₹4,12,50,000	OPEX including contingencies.
Total costs for first year (CAPEX + OPEX + Subscription)	₹39,32,500	20	₹7,86,50,000	Conservative Year-1 total; excludes taxes/rent/interest.

Return on Investment

Metric / Parameter	Value (₹)	Basis / Remarks
Total CAPEX (outlay)	₹ 18,70,000	CAD + workstation + RFID + training + shared-facility share + 5 % contingency
Total OPEX (annual)	₹ 20,62,500	Planner + AMC + shared OPEX + logistics + 5 % contingency
Total Year-1 Cost (CAPEX + OPEX)	₹ 39,32,500	Conservative first-year cost; ex-GST
Annual Material Savings (+2 pp yield)	₹ 12,60,000	9,000 kg × ₹ 140 / kg
Net Waste Disposal Impact (after scrap)	₹ -1,44,000	Net negative if scrap resale @ ₹ 20/kg
Potential QA / Time / Energy Savings	₹ 1,00,000 (est.)	Conservative placeholder; to be validated post-audit
Total Quantified Annual Benefits	₹ 12,16,000	Sum = (₹12.6 L – 1.44 L + 1.0 L)
Net Annual Cash Flow (before financing)	₹ -8,46,500	Annual benefit ₹ 12.16 L – OPEX ₹ 20.62 L
Payback Period (on CAPEX only)	≈ 1.5 years (if OPEX seen as recurring expense)	₹18.7 L / ₹12.6 L ≈ 1.5 yrs; if OPEX separately budgeted
Effective Payback (all-in)	≈ 3.2 years (est.)	₹39.3 L / ₹12.16 L ≈ 3.2 yrs
Internal Rate of Return (IRR 5-yr horizon)	~ 22 – 24 %	Based on 5-year life, constant benefit, flat OPEX; conservative
Breakeven Year (on cash basis)	Year 3 to 4	Positive cumulative net after Year 3
Residual value of CAPEX (Year 5)	₹ 6–7 L (~35 %)	Usable resale value of CAD/workstation assets

Viewed as a pricing decision, breakeven needs only a modest premium of ~₹2–3/kg (≈ 60–90 paise/mtr at 200 gram per square meter (GSM)), or ~₹9/kg if covering all Year-1 costs purely via price. For 300 GSM, this increases to 9135 paise/mtr. Breakeven requires only a small premium per kg/meter, becoming lower after the Credit Linked Capital Subsidy Scheme CLCSS) subsidy (approx. 15%) is netted off the capital cost.

Interpretation/Notes

- Payback: ≈ 3 years when considering full cash outflow; improves to ~1.5 yrs if OPEX treated as recurring program expense.
- IRR: Moderate 22–24 % on conservative inputs; will improve once QA/time/energy savings (+ additional 1–1.5 L/yr) are validated.
- Upside sensitivity: Each +0.5 pp yield gain adds ≈ ₹ 3 L benefit per year → IRR can exceed 30 %.
- Downside buffer: Even with +1 pp yield gain and same OPEX, IRR stays ~12–14 %, still viable.
- Exclusions: GST, rent, financing cost; returns will modestly adjust if those are added.

Enabling Factors

Panipat's transition to material-efficient production is supported by strong policy, financial, and ecosystem enablers.

- **Policy Support** → Schemes such as MSE-CDP (up to 70–80% grant for Common Facility Centres) and Haryana’s Mini Cluster Scheme (state co-funding up to 90%) make the shared cutting and CAD facility fully eligible for grant support. New initiatives like SPICE and GIFT under the Ministry of Textiles further promote investments in circular and resource-efficient technologies, while EU–India RECEI can provide technical co-financing.
- **Financial Levers** → The shared-facility SPV structure drastically reduces MSME-level investment—bringing individual outlay to ~₹11–12 lakh versus ₹40–50 lakh if purchased individually. Access to SIDBI’s low-interest loans and MSME subsidies like CLCSS and taking up voluntary certifications like ZED can further cut costs like with a capital subsidy applied (CLCSS), the price-only breakeven premium falls by ~10–15%, making the upgrade viable even with minor price adjustments., while CSR and blended-finance partners can support pilot set-up and training.
- **Technical and Ecosystem Readiness** → Panipat’s dense cluster of 350+ MSMEs, existing recycler ecosystem, and vendor availability for CAD, auto-spreader, and CNC systems make the transition technically feasible. The shared centre can also serve as a digital skilling and incubation hub, training local planners, operators, and youth.
- **Governance and Sustainability** → A formal SPV-based governance model under the cluster association ensures transparent booking, cost recovery, and maintenance. Digital dashboards and standard SLAs will track yield, uptime, and cluster-wide impact.

Implementation Plan

Short-term (Year 1)			
Activity	KPI	Timeline	Cost Incurred
Formation of Cluster SPV and submission of CFC proposal under MSE-CDP / State Mini Cluster Scheme	SPV registered; DPR approved by MSME Dept	Q1–Q2 (Year 1)	Yes
Procurement and installation of CAD software licences and workstations across 20 MSMEs	20 CAD workstations functional	Q2 (Year 1)	Yes
Site readiness, procurement, and installation of auto-spreader, CNC cutter, plotter, digitiser	Shared facility operational	Q2–Q3 (Year 1)	Yes
Capacity building for planners, operators, QA staff on digital marker creation and nesting	50+ personnel trained	Q3 (Year 1)	Yes
Pilot production run across 10–20 MSMEs to validate yield and productivity	2 pp average yield gain; 6 % waste reduction	Q4 (Year 1)	Yes
Establish baseline monitoring system for fabric yield, off-cut waste, and uptime	Digital data dashboards active	Q4 (Year 1)	No (OPEX covered under subscription)

Mid-term (Year 2-3)			
Activity	KPI	Timeline	Cost Incurred
Year 2: Stabilise at 20 MSMEs (no expansion)	≥90% uptime; ≥80% booking fulfilment	Q1-Q4 (Y2)	No (operational)
Integrate digital dashboards cluster-wide; fine-tune SLAs	12 monthly performance reports	Q1-Q4 (Y2)	No
Implement milk-run logistics for fabric/cut-panel movement	<48h standard turnaround	Q2-Q4 (Y2)	Yes (minor OPEX)
Link recyclers/SHGs for clean remnant utilisation	≥60% off-cuts segregated & diverted	Q3-Q4 (Y2)	No
Year 3: Add 10 MSMEs (onboarding & training)	Membership = 30 active MSMEs	Q1-Q2 (Y3)	Yes
Capacity optimisation (shift extension/scheduling)	≤10% queue delay at peak	Q2-Q3 (Y3)	No
Independent operational audit (yield, QA, energy)	Verified +2 pp yield cluster avg.	Q4 (Y3)	Yes (audit cost)
Long-term (Year 4-5)			
Activity	KPI	Timeline	Cost Incurred
Year 4: Increase membership to 40 MSMEs	Membership = 40 active MSMEs	Q1-Q2 (Y4)	Yes
Institutionalise as Centre of Excellence (CoE) for digital production	CoE notified/recognized	Q2-Q3 (Y4)	No (SPV revenues/TA)
Buyer co-branding & traceability pilots	≥2 brand MoUs; 1 pilot live	Q3-Q4 (Y4)	No
Year 5: Plan a 2nd shared facility (feasibility, DPR, land/space)	DPR approved; funding tied up	Q1-Q3 (Y5)	Yes
Finance & procurement strategy for Facility-2 (MSE-CDP + soft loans)	Sanction letters in place	Q2-Q4 (Y5)	No (facilitation)
Cluster impact study & replication roadmap	Final report published	Q3-Q4 (Y5)	Yes (research budget)

4.1.5 Conclusion

Business Case 1 offers a high-certainty, first-move pathway for Panipat's MSMEs to cut material loss and strengthen competitiveness. By deploying CAD/marker optimisation inside each unit and consolidating high-capex cutting assets in a shared facility, the cluster can convert small percentage gains in yield into large absolute savings (₹12-13 lakh per MSME per year at a 2-pp gain), while standardising quality and enabling data-driven operations.

The model is financially and institutionally viable: individual outlays are capped through the SPV/CFC structure; payback periods are reasonable under conservative assumptions; and policy instruments can lower effective costs further. Operationally, the shared facility is managed through subscriptions/SLAs and supported by logistics “milk runs,” ensuring equitable access without bottlenecks. Digitised bundle tracking and monthly dashboards create the evidence base buyers and regulators increasingly expect.

Key implementation risks, under-utilisation, scheduling delays, and skills gaps, are mitigated through (i) cohort-based onboarding and guaranteed usage quotas, (ii) transparent booking and uptime KPIs, and (iii) structured training and vendor AMC. With these guardrails, Business Case 1 does more than trim waste: it institutionalises digital productivity, strengthens circular linkages with recyclers and upcyclers, and positions Panipat as a model, traceable, low-waste textile cluster ready for the next phase of growth and compliance.



4.2 Business Opportunity Case 2: Common Facility for Sorting Waste and Felting for End-of-Life Waste

4.2.1 Introduction and Context

Panipat's textile MSMEs generate mixed pre- and post-production waste (cotton, blends, selvedge, hard waste) that is presently sold in mixed bales to traders with limited quality assurance (QA), traceability, or end-use optimisation. Non-spinnable residues often end up in low-value uses or disposal, while spinnable fractions face frequent rejections due to inconsistent specifications (colour, composition, moisture, contamination). The absence of a shared, spec-driven hub keeps costs high, realisation low, and compliance/documentation weak.

4.2.2 Rationale

A common facility, co-owned by MSMEs, standardises the entire loop (intake → sorting to yarn-maker specs → felting of end-of-life fractions → traceable dispatch). This dual-path model (spinnable to open-ended (OE) yarn; non-spinnable to needle-punched felts) converts what is now a cost centre into a value stream, stabilises cashflows through a mix of service fees and product sales, and creates reliable quality for buyers. Shared Capex and pooled volumes reduce unit costs, while basic digital traceability, Standard-operating-Procedures (SOPs), and compliant infrastructure make the cluster buyer-ready and future-proof.

Ownership will sit with a Special Purpose Vehicle (SPV) formed by the participating MSMEs (or the local Association), while day-to-day operations are leased to a professional operator under a clear Service Level Agreement. (SLA). The SLA will define KPIs for uptime, yield, QA compliance (spec adherence, rejection rates), and Operational Health and Safety (OHS), with a fixed management fee plus a performance-linked incentive to align interests.

4.2.3 Business as Usual Case

Current Waste Circularity Practice

- Each MSME handles waste separately; mixed textile waste is loosely sorted and sold as "as-is" bales.
- Spinnable fractions leak to traders without QA specs; non-spinnable waste goes to low-value uses like stuffing/filling (mattresses, pillows, quilts/rajai, soft toys, pet beds), wipers/rags (shop cloths, mops), ropes/twines from "chindi" for charpai/cot, RDF/co-processing to cement kilns; or landfill/dumping for highly contaminated mixes..
- Minimal traceability; no common standards for colour, composition, moisture, or contamination.

Costs Implications of the Current Model

- Higher handling cost per unit due to re-handling, low bale density, and fragmented logistics.
- Lower realisation (₹/kg) because of mixed grades and inconsistent quality.
- Hidden costs: space blockage, dust/housekeeping, ad-hoc labour, and occasional penalties for improper storage/transport.

Systemic Risks and Limitations

- Demand risk: yarn makers and buyers reject lots due to contamination or unclear specs.
- Compliance risk: weak documentation for State Pollution Control Board (SPCB)/fire/OHS; poor dust control.

- Market risk: dependence on a few traders; volatile prices with no service-fee buffer.
- Social risk: informal labour, limited personal protective equipment (PPE)/benefits, and no structured skilling—leading to high errors and turnover.
- Scalability limit: no shared facility → cannot aggregate volumes, standardise QA, or develop higher-value products (e.g., felts).

4.2.4 Description: Business Opportunity Case 2

New Waste Circularity Practice

- MSMEs co-own a common sorting and felting facility.
- Mixed wastes are pre-sorted to yarn-maker specs; only non-spinnable residues go to a needle-punch felting line (padding/acoustic/packaging grades).
- Operations run with standard bale/roll IDs, QA, and digital dispatch logs so buyers get consistent quality and traceability.

Proposed Value Chain

Shift from trader-led, mixed bales to a spec-driven hub that aggregates feedstock, applies QA, and converts rejects into saleable felts.

Key steps

- Collection & Intake: Partner + external MSME wastes pooled; gate checks for moisture/metal/colour.
- Primary Sorting: Fibre/composition/colour segregation; contaminants removed.
- Path A – Spinnable: Bale to OE yarn makers against agreed specs (composition, colour, moisture).
- Path B – Non-spinnable: Shred/open → needle-punch felting → cut/pack to gram per square meter (GSM)/size.
- QA & Traceability: Inline GSM/thickness checks; bale/roll IDs; digital logs.
- Sales & Logistics: Contracted offtake to yarn makers and furniture/mattress/packaging buyers; co-processing for true rejects.

Prerequisites

- SPV/Co-op & MoUs (partners + external suppliers).
- Spec sheet (bale/roll, contamination limits, moisture %) and buyer LOIs.
- SPCB/fire compliances, 12–15k sq ft site, reliable power.
- Core team (ops, QA, logistics) and basic Management Information System (MIS) for weigh scales/IDs.
- Working capital line for sales lots.

Benefits

- ✓ Higher realisation: spec bales fetch better ₹/kg; felts monetise residues.
- ✓ Lower unit cost: shared labour/power/logistics; better bale density and routing.
- ✓ Reduced rejection & disposal through QA and dual-path processing.

- ✓ Stable cashflows: mix of service fees + product sales.
- ✓ Compliance & buyer readiness: documentation, traceability, increased OHS.
- ✓ Social impact: formal jobs, scope for SHG-led pre-sorting.
- ✓ Environmental gains: landfill diversion, lower dust/leaks, circular use within the cluster.

Total Benefits

Note: For the following calculations it is assumed that the SPV will be created by 10 MSMEs. A 10-member SPV is small enough for decisions and big enough for lender comfort and working capital lines.

Category	Value per unit (₹)	Quantity / Units	Total annual benefit (₹ lakh)	Remarks / basis
Service fee (sorting/QA for partner lots)	3 / kg	900,000 kg (900 t)	27	50% of feedstock billed as service to 10 MSMEs ⁴⁸
Margin on sale of sorted spinnable waste	7 / kg (net margin)	900,000 kg (900 t)	63	External/partner mix sold to OE yarn makers ⁴⁹
Sale of felt sheets (from EoL fraction)	75 / kg	459,000 kg (≈459 t)	344	30% EoL of total 1,800 t → 540 t input; 85% yield → 459 t felt ⁵⁰
By-products / rejects (co-processing/odd lots)	—	—	10	Conservative estimate from occasional lots
Total Annual Benefits (Gross Revenue)	444	Sum of above		

Notes

- Throughput assumed at ~1,800 t/year input; split: 50% fee model, 50% sale model.
- Felt realisation @ ₹75/kg is a blended average for padding/acoustic/packaging grades.
- Quantities and rates align with earlier Capex/Opex assumptions; tweak rates/throughput to reflect vendor quotes or buyer LOIs.

Cost

Costs aspects

- Capex footprint, machinery lot, shared: Single “machinery package” (sorting + shredder/opener + needle-punched felting + bale press + MHE) keeps integration costs low; 10-way equity split brings the per-MSME ticket down to manageable levels while retaining industrial throughput.

⁴⁸Falls within India sorting/handling cost bands reported by IDH's cost analysis of textile waste systems (₹6–90/kg across all steps; fee-for-sorting typically low single-digits for simple grade separation), so ₹2–₹4/kg is a conservative cluster benchmark.

⁴⁹Supported by market spreads between graded cutting waste (white: ₹50–60/kg; mixed: ₹6–35/kg) and downstream OE yarn prices (₹120–220/kg depending on count/quality); a ₹7/kg net margin after procurement/handling is a prudent assumption.

⁵⁰Needle-punched/acoustic/packaging felts in India list between ₹150–₹290/kg (retail/quoted), so ₹65–₹90/kg ex-factory blended for bulk B2B is conservative

- Lean layout & utilities: 12–15k sq ft with clear dirty/clean zones minimises re-handling; central dust filtration avoids multiple small units; common low tension (LT) panel and shared Diesel Generator (DG) cut electrical duplication.
- Service-fee + product-sale model: Blending partner service fees (predictable cash) with felt/spinnable sales (higher margin) stabilises monthly cashflows and lowers break-even revenue.
- Working-capital lightness: For partner lots, fee-for-service reduces inventory carry; sales lots need modest working capital—secured via buyer letters of Intent and a small Cash Credit (CC)/Overdraft OD line tied to dispatch cycles.
- Path to lower unit cost: Throughput ramp (6→7–8 TPD), product mix upgrades (calendaring/acoustic), and rooftop solar/ power purchase agreement (PPA) reduce ₹/kg production cost over Years 2–4.

Challenges

- Feedstock variability: Mixed fibre, colour, and contamination can depress yields.
- Price volatility for felts/sorted waste: Downturns in furniture/mattress or yarn demand can squeeze margins.
- Power cost & downtime: Needle-punch and opening are power intensive; outages raise rework and labour idle time.
- Quality assurance at scale: Consistent GSM, thickness, and bonding in felts; contamination limits for yarn-maker lots.
- Compliance & OHS: SPCB consents, fire/NBC, and dust exposure norms can slow operations if not maintained.
- Logistics leakages: First-mile collection and city-radius dispatch can inflate ₹/ton.
- Governance among 10 partners: Disputes on slots, pricing, and profit shares risk delays.
- Skilling & turnover: Sorting accuracy and machine operation need trained hands; churn increases rework.
- Technology fit & upgrades: Wrong felting spec or under-sized opener limits product mix.
- Working-capital pinch in ramp-up: Sales lots require cash before collections stabilise.

Head	Qty/Spec	Cost (₹lakh)	Remarks
Capital Expenditure (CAPEX)			
Machinery package (combined)	1 lot	435	Sorting lines (2), heavy-duty shredder + opener/fluffer (1 set), needle-punch felting line 2.2–2.5 m (1 line), bale press 50–70T (1), forklift & material-handling (1 + ancillaries)
Dust collection & filtration	Baghouse + ducts	20	Central dust system with cyclones, filters, silencers
Electricals & power backup	LT panel, cabling, DG	38	LT panel, MCCs, cable trays, earthing, DG (as needed)
Civil works & utilities	12–15k sq ft	60	Flooring, racking, partitions, ventilation, drains

Safety & compliance	OHS/Fire	7	Fire detection/suppression, hydrants, PPE, signage
QA/Lab setup	Basic textile QA	5	Moisture meter, GSM cutter, balance, sample press
IT & traceability	Barcode/RFID + MIS	8	Weighbridge/floor scales integration, dispatch logs
Contingency @ ~8%	On above heads	46	Price movement, installation sundries
Total CAPEX	619		
Per-MSME share (10 partners)	-₹61.9 lakh	Equal equity split	
Operating Expenditure (OPEX)			
Workforce	-33-36 blended @ -₹25-27k cost to company (CTC)/month incl. Provident fund (PF)/ Employees' State Insurance (ESI)	102	Sorters (~22), operators (6), QA (2), admin (2), supervisors (3); staggered shifts to cover receiving + production
Electricity	-600,000 kWh/year @₹10/kWh	60	Shredder/opener, needle-punch line, conveyors; average connected load ~250 kW, 8 h/day, 300 days
Maintenance & consumables	-5-6% of mech capex (excl. needles)	24	Lubes, blades, bearings, belts, minor spares; preventive maintenance
Needles & felting wear	Needle boards & wear parts	6	Periodic replacement of needle boards and felting cloths
Rent/lease & housekeeping	Industrial shed + services	30	12-15k sq ft; cleaning supplies, janitorial, security
Insurance, permits & compliance	Cluster norms	8	Property & liability insurance, SPCB consent renewal, audits, fire/OHS compliance
Logistics (inbound & outbound)	-₹2,000/ton blended for 1,800 t/ year	36	First-mile collection + local dispatch to buyers
IT/MIS & accounting	Software + CA/ professional fees	6	Traceability system, scale integration, bookkeeping
Water, compressed air & utilities	Fixed + variable	4	Process cooling/housekeeping water, compressor power, minor utilities
Misc. & contingency	Unplanned small expenses	4	Tools, PPE top-ups beyond capex kit, training refreshers
Total OPEX / year	280		
Per-MSME share (10 partners)	-₹28 lakh/year	If costs are pooled and split equally	

Machinery package (combined) – 1 lot (₹435 lakh)

- Sorting lines (2 lines): Modular tables, conveyors, magnetic traps, pick-bins, QC belt, bale strapping interface; designed throughput ~4–5 t/shift across 2 lines with ergonomic pick stations.
- Heavy-duty shredder + opener/fluffer (1 set): Twin-shaft or single-shaft shredder (≥ 30 –45 kW) with changeable blades; opener/fluffer with beater/lickerin for fibre opening to ≤ 40 –60 mm; integrated metal detection and safety interlocks.
- Needle-punch felting line (2.2–2.5 m working width, 300–500 kg/h): Pre-card/opener feed, cross-lapper, needle loom (2–3 boards) with variable frequency drives, drafting and wind-up; product GSM 500–1,500 for padding/acoustic/packaging grades; provision for calendar/edge-trim recirculation.
- Bale press (50–70 ton): Double-ram hydraulic press, automatic tying, 80–120 kg bales; bale ID printing for traceability.
- Forklift & material-handling: 2.5–3.0T forklift (electric or diesel), hand pallets, floor scales (2 number.), racking and bins; turning radius compatible with aisle layout.

Return on Investment

	Initial investment cost (₹)	Annual operational costs (₹/year)	Annual benefits (₹/year)	Simple payback period
Total investment (facility)	6,19,00,000	2,80,00,000	4,44,00,000	~3.8 years
Per MSME investment (1/10 share)	61,90,000	28,00,000	44,40,000	~3.8 years

Per-kg view perspective for MSMEs – At ~1,800 t/year, break-even revenue is ~₹15.6/kg (Opex ÷ throughput), while the base-case realisation is ~₹24.7/kg, leaving ~₹9.1/kg to service capex and margin. Targeting a ~4-year payback on the ₹619 lakh capex, the implied capex recovery is ~₹8.6/kg, which is already covered within the current ₹/kg headroom.

Enabling Factors

- ✓ SPV/Co-op with clear bylaws and transparent management information system (MIS) for 10 partners.
- ✓ Supply MoUs + bale/spec sheets (colour, composition, moisture, contamination).
- ✓ Buyer LOIs/rate bands with OE yarn makers and mattress/furniture/packaging buyers.
- ✓ 12–15k sq ft compliant site with reliable 3-phase power, ventilation, and central dust collection.
- ✓ Integrated machinery package commissioned (sorting, shredder/opener, needle-punch felting, bale press).
- ✓ SOPs + core team (intake, sorting, QA, EHS, traceability with bale/roll IDs).
- ✓ Working-capital line + AMC/spares to smooth cashflow and maintenance.
- ✓ Logistics contracts & route clustering for predictable ₹/ton.

Implementation Plan

Short-term (Year 1)			
Activity	KPI	Timeline	Cost Incurred
Form SPV/Co-op; partner MoUs (10 MSMEs + 5 external suppliers)	SPV registered; 15 MoUs	Q1	Yes
Secure site, utilities & permits (SPCB Consent to Establish, fire/ NOC)	12–15k sq ft ready; CTE received	Q1–Q2	Yes
Vendor RFQs→order “Machinery package”; hire core team	PO released; 8 key hires onboard	Q2	Yes
Install & commission sorting, shredder/opener, felting, bale press	SAT signed; trial run completed	Q3	Yes
SOPs for QA, EHS, traceability; buyer LOIs for felt & yarn-makers	6 SOPs approved; 4 LOIs signed	Q3	Yes
Pilot operations & ramp to 60–70% capacity; first 100 t felt dispatched	100 t felt sold; ≥95% on-time dispatch	Q4	Yes

Mid-term (Year 2–3)			
Activity	KPI	Timeline	Cost Incurred
Expand feedstock network; route optimisation	+20 supplier MoUs; logistics cost/ton ↓10%	Y2 H1–H2	Yes
Throughput ramp & second shift (as needed)	Avg 6–7 TPD; uptime ≥85%	Y2 H2–Y3 H1	Yes
Product development: acoustic/ packaging grades; basic calendar add-on	3 Stock Keeping Units (SKUs) launched; price realisation +₹5–₹8/kg	Y2 H2	Yes
Certifications & systems (ISO 9001, basic OHS/SA compliance)	ISO 9001; OHS checklist ≥90%	Y3 H1–H2	Yes
Working-capital line & digital MIS (weighbridge link, batch IDs)	WC facility in place; 100% digital dispatch logs	Y2 H1–Y3 H1	No (minor)

Long-term (Year 4–5)			
Activity	KPI	Timeline	Cost Incurred
Debottlenecking & yield improvement (dust recovery, edge-trim recirc)	Yield +2–3%; waste to co-proc <5%	Y4	Yes
Market diversification (mattress/ furniture, 2 new cities)	6 anchor buyers; <30% revenue from single buyer	Y4–Y5	No
Rooftop solar/green power; energy KPI	Grid kWh/ton ↓12–15%	Y4	Yes

Social inclusion & formalisation (SHG pre-sorting; benefits coverage)	100% workers on PF/ESI; 50% women in sorting	Y4–Y5	Yes
Optional capacity add (needle board/loom upgrade) based on demand	+20–25% felt output; payback ≤3 yrs on add-on	Y5	Yes

4.2.5 Conclusion

By moving from fragmented, trader-led small quantity waste handling to a shared, spec-driven specialised sorting and felting hub, the MSMEs in Panipat can unlock better quality, predictable offtake, and stronger compliance, while turning residual waste into marketable products and formal jobs. This is a practical, scalable pathway to circularity that fits the cluster's strengths and market linkages.



4.3 Business Opportunity Case 3: In-House Mechanical Recycling for Fibre-to-Fibre Yarn Production

4.3.1 Introduction and Context

Panipat's knit/recycling ecosystem generates steady volumes of cotton cuttings and hosiery scrap, most of which is currently moved through informal buyers with minimal colour/fibre segregation, weak traceability, and low recovery value. At the same time, downstream buyers are increasing demand for certified recycled content and Digital Product Passport (DPP)/traceability-ready inputs. The cluster already has Open-ended (OE)-spinning know-how (Ne 10–16), maintenance vendors, and an available workforce making it a practical setting to convert factory waste into saleable yarn. Business Case 3 proposes an MSME-scale, in-house mechanical route: source-segregation→opening/cleaning → card/draw → OE spinning to produce 100% recycled yarn (with optional low-% blends where required). This shifts value from scrap sales to yarn revenue, reduces external raw-material dependence, and creates a credible compliance trail (Global Recycled Standard (GRS)/Transaction Certificate (TC)-ready, DPP fields) while embedding Operational Health & Safety (OHS), dust control and fire safety.

4.3.2 Rationale

Mechanical recycling for fibre-to-fibre yarn in Panipat hinges on disciplined source segregation (colour/fibre wise, elastane control), followed by opening/cleaning to remove trash and metal, and carding/drawing to produce OE-ready sliver. This sliver is spun on OE rotors (Ne 10–16) to make 100% recycled yarn for knit and weaving applications; optional low-% blending with virgin can be used for higher counts or specific strength targets. By converting factory cuttings into saleable yarn in-house, units replace low-value scrap sales with direct yarn revenue, reduce external raw-material dependence, and avoid tipping/transport on waste. The model fits Panipat's existing OE ecosystem, scaling it up and enabling traceable recycled content (GRS/TC-ready), supporting EU-aligned circularity while lowering material costs, diverting waste from landfill, and improving resource efficiency.

4.3.3 Business as Usual Case

Current Waste Circularity Practice

- Mixed cutting/hosiery waste stored in open bags/containers with minimal colour/fibre segregation; elastane/polypropylene (PP) contamination common.
- Periodic sale to informal aggregators/kabaddi networks at low, volatile prices; occasional disposal with general solid waste.
- Little traceability (no lot IDs/Certificates of Analyses (CoAs)); paperwork limited to gate passes and sale bills.
- Downcycling dominant (wipers/filler/shoddy mix) rather than fibre-to-fibre recovery; value locked in waste leaves the unit.
- Ad hoc housekeeping: dust/lint accumulation, limited Relative Humidity (RH) control, basic personal protective equipment (PPE); fire and operational health and safety (OHS) risks unmanaged.

Costs Implications of the Current Model

- Direct handling costs: internal labour time, bagging, space use, housekeeping, and frequent short-haul transport.
- Low realisation: mixed/contaminated waste fetches discounted rates, especially with elastane/colour mix; frequent buyer deductions.

- Hidden losses: yield loss and rework from contamination back-flowing into production; pilferage/shrinkage of bags.
- Compliance overheads: periodic audit observations (housekeeping, OHS, waste records) trigger corrective costs without creating value.
- Opportunity cost: forgoing in-house raw-material creation and the margin on recycled yarn, leaving money on the table.

Systemic Risks and Limitations

- Regulatory tightening: rising expectations on segregation, safe storage, and lawful disposal; potential penalties or stoppages.
- Market access risk: export buyers moving to recycled-content, DPP/traceability requirements; current practices lack credible data trails.
- Price & buyer dependence: scrap price volatility and reliance on a few traders; weak bargaining power.
- Reputation & ESG: visible waste mismanagement (lint, fires, contractor dumping) undermines brand/customer confidence.
- Lock-in to low value: current practices entrench downcycling and prevent transition to fibre-to-fibre models with better unit economics.
- Supply risk: when external scrap markets tighten, units face input cost spikes without the hedge of in-house recycling.

4.3.4 Description: Business Opportunity Case 3

New Waste Circularity Practice

- Source-segregated feedstock: Colour- and fibre-wise segregation at the cutting floor; elastane/PP flagged and isolated; sealed, barcoded bags with GRN + lot ID.
- Women-led sorting cell: Final QA sorting to spec (shade bins, elastane $\leq 5\%$); bale/box press for clean logistics; dust capture along with PPE and other safety gears in place.
- Opening & cleaning line: Bale opener $\rightarrow$ mixer $\rightarrow$ fine opener with metal/trash removal; spark detection and fire-safe ducting; cleaned fibre issued against lot IDs.
- Card/Drawing $\rightarrow$ OE spinning: Sliver produced under RH control; OE rotors (Ne 10–16) convert cleaned fibre to 100% recycled yarn; cone winding and pack.
- Traceability & CoA: Single lot lineage from Goods Receipt Note (GRN) $\rightarrow$ sliver CoA $\rightarrow$ yarn CoA; digital pack list and buyer documentation (GRS/TC-ready, DPP fields captured).
- Closed-loop option: Where feasible, yarn routed to in-house/partner knitting to create fabric/garments; new post-consumer/production waste re-enters the loop.
- By-product valorisation: Card/rotor waste segregated and sold as a separate line item to maximise recovery value; zero-landfill policy for textile fractions.
- Compliance & OHS embedded: Fire hydrants/sprinklers, dust filtration, PPE and quarterly drills; statutory records and audit trails maintained.
- Commercial discipline: MoUs for steady feedstock, multi-buyer channels (B2B + marketplaces), Days Sales Outstanding (DSO) ≤ 45 days; working capital (WC) line against receivables.
- Inclusion & skills: Formal contracts, fair wages, and continuous upskilling for sorting/QA operators, with a target share of women in these roles.

Proposed Value Chain

The new system introduces a MSME-level mechanical recycling line integrating semi-automated sorting, fluffing, blending, and spinning to produce high-grade recycled yarn.

Key steps

- Collection & Sorting – Manual and near-infrared (NIR)-assisted segregation by composition and colour; exclude waste with > 5 % elastane.
- Fluffing / Opening – Multi-roller opening line with dust-control, yielding longer, cleaner recycled fibre.
- Blending – Controlled mixing of recycled and virgin fibres (typically 50 / 50 or 70 / 30 ratio).
- Carding & Drawing – Carding sliver to align fibres; drawing for evenness.
- Spinning – Open-end or friction spinning for yarn counts 15–20 Ne; optional ring or air-jet for finer counts.
- Winding & Steaming – Finishing and quality inspection.
- Traceability & Certification – Batch-wise QR tagging; RCS/GRS certification for recycled content; integration into DPP platforms

Prerequisites

- Composition-based sorting and colour grading.
- Waste feedstock with < 5 % elastane.
- R&D support for optimum blend ratio.
- Capacity building for MSMEs on machine operation, QA, and documentation.

Benefits

- ✓ Additional revenue stream from recycled yarn sales (base: ~9.12 lakh kg/year at ₹125/kg).
- ✓ Raw-material savings via closed loop when using in-house cuttings—less external cotton purchase, lower tipping/transport.
- ✓ Stable, shade-sorted feedstock → lower dye load for downstream users; consistency improves repeat orders.
- ✓ EU-readiness: aligns with incoming DPP/EPR expectations and buyer due-diligence on recycled content (GRS/ TC traceability).
- ✓ Brand and marketplace access through verified recycled yarn stock keeping unit (SKUs); supports brand circularity targets (fibre-to-fibre).
- ✓ Cost resilience: partial hedge against virgin price swings; controllable input through own waste processing.
- ✓ Reputation & ESG signalling: visible climate/resource benefits; supports cluster leadership positioning for Panipat.
- ✓ Local jobs & skills: operator, QA, and maintenance roles; scope for women-led sorting and QC cells.
- ✓ Scalable platform: same line can add counts/blends or feed a second OE line once demand is locked.

Total Benefits

Benefit head	₹ crore/yr	Basis / calc notes
Yarn sales (primary)	11.40	9.12 lakh kg/year × ₹125/kg
By-product / soft waste resale	0.15	Conservative resale from hard/soft waste streams
Total Direct Benefits	11.55	

Assumptions taken for creation of an inhouse fibre to fibre recycling facility for an MSME for a revenue generating business model

Parameter	Value	Remarks
Cluster & model	Panipat – Mechanical fibre-to-fibre	In-house sorting → opening/cleaning → card/draw → OE yarn
Operating schedule	1 shift/day (8 hrs), 300 days/year	Conservative MSME schedule
Input feedstock	4.0 t/day pre-sorted textile waste	Cotton hosiery clips/cuttings; >5% elastane lots excluded ⁵¹
Yield (input → saleable yarn)	~75%	Covers hard waste, lint, QA rejects + ~3% collection/segregation loss ⁵²
Yarn output (steady state)	~3,040 kg/day (≈ 9.12 lakh kg/year)	4,000 kg/day × 0.76 × 300 days
Product	100% recycled OE yarn	Shade-sorted lots to reduce downstream dye load ⁵³
Typical yarn count band	Ne 12–20 (OE)	Matches OE rotor spec and waste fibre length profile
Selling price (ex-GST)	₹125/kg	Conservative, Panipat market-aligned
By-product resale	₹0.15 crore/year	Hard/soft waste resale (conservative)
Raw material cost	₹30/kg (on input mass)	Purchase + local logistics
Power & utilities	₹15/kg (on yarn)	Composite across opener, card/draw, OE, HVAC
Packaging & dispatch	₹4/kg (on yarn)	Cones, bags, local freight
Labour strength	~35 persons	Supervisors, operators, QA/QC, store, admin ⁵⁴

⁵¹Volume is a project assumption sized to Panipat availability; need for pre-sorting and elastane control is consistent with mechanical-recycling quality constraints.

⁵²Yield sensitivity is well-documented: mechanical opening/tearing can degrade fibres; disciplined sorting/QA improves recoverability. Use ~70–80% as conservative band; 75% is your base.

⁵³OE (rotor) route is standard for recycled cotton yarns; The shade sorting aims to reduce downstream dyeing which is common practice in Panipat.

⁵⁴Project assumption for 1-shift pilot scale; It needs to be refined with actual line-balancing and SOPs.

Parameter	Value	Remarks
QA/Certification	₹15 lakh/year	GRS/TC audits, lab upkeep, testing consumables ⁵⁵
Prices shown	Ex-GST	Taxes, finance costs, depreciation excluded
Facility model	Leased shell	Civil/EHS upgrades included in CAPEX; no land cost
Ramp-up	Assumed achieved	Tables reflect steady-state year volumes & costs

Cost

Costs aspects

- Setting up recycling infrastructure (sorting line, opener/cleaners, card/draw, OE rotors, HVAC/dust, QA lab, EHS/civil, installation & training).
- Process development/R&D (pilot trials for yield, shade segregation, count range Ne 10–16; sampling for buyers).
- Certification & compliance (GRS/TC audits, lab testing, documentation, periodic renewals; OHS/fire & dust-control upkeep).
- Working capital (inventory of waste/work-in-progress (WIP)/yarn, receivables; interest/charges).
- Operating inputs (power & utilities, maintenance/spares, labour, packaging/dispatch, admin).

Challenges

- High-quality separation procedures (colour/fibre mix, elastane/PP contamination) required to hold yield and strength.
- Customer development (qualifying yarn buyers, meeting spec on evenness/Count Strength Product (CSP)/count and shade consistency).
- Blend/quality optimisation (deciding count range and fibre mix that balances quality, cost, and throughput).
- Market & policy headwinds (price volatility vs. virgin; limited explicit incentives for textile-to-textile recycling; finance frictions).
- Capability gaps (operator skills, preventive maintenance discipline, digital traceability/DPP readiness).
- Feasibility Challenge – Feedstock variability & contamination (elastane, shade mix), Yield slippage (rework), unplanned downtime, waste acquisition quality claims, shade specification (overload, demand of 1 shade), continuity of orders, cost volatility of domestic waste, and regulatory drift.

Asset/Package	Amount (in ₹crores)	Remark
Capital Expenditure (CAPEX)		
Colour-wise sorting & cutting line	0.6	Manual sorting line for ~15–20 t/day input; 12–16 sorting tables; 1 belt conveyor (12–18 m) with 5–7 colour/quality bins; inline magnetic separator; 2 hydraulic bale/box presses (15–20 t); dust extraction 15,000–20,000 m³/h with bag filters.

⁵⁵GRS/TC requires certified chain-of-custody and per-shipment TCs—budget a modest, recurring QA/compliance cost.

Asset/Package	Amount (in ₹crores)	Remark
Waste opener + cleaners (with metal/trash removal)	1.2	Bale opener + multi-mixer + fine opener; throughput 500–700 kg/hr on cotton waste; metal detector, trash extraction 3–5%; auto-feeder to cards; integrated spark detection & fire suppression on ducts.
Carding sets + draw frames (2 lines)	2.5	2–3 chute-fed cards (combined 180–220 kg/hr sliver); 2 autoleveller draw frames; 1,000 mm cans; sliver count 0.12–0.20 ktex suited for OE; online waste suction and flat-strip handling.
OE spinning line (1 line, ~3 t/day)	4.5	~320–360 rotors (54–65 mm); auto-piecing/doffing; electronic clearer; yarn count range Ne 6–20 (target Ne 10–16); delivery 2.5–3.0 t/day; cone winders (24–36 spindles) to 1–2 kg cones; basic UMC integration.
Humidification, HVAC, air handling & ducting	1	Central plant ~200–250 Tonnes of Refrigeration (TR); Relative Humidity (RH) control 55–60% @ 28–30 °C in carding/Open-End (OE); waste suction 30,000–40,000 m³/h; variable-speed fans; Hi Efficiency Particulate Air (HEPA) Filters/F9 final filters for fibre dust.
Electricals, PCC/MCC, cabling, compressors	0.7	1.6–1.8 MVA transformer; Power Control Centre (PCC)/Motor Control Centre (MCC) with Viable Frequency Drives (VFDs); power factor correction; DG interface; compressed air 2×75 kW screw compressors + dryers; ring main bus; earthing & lightning protection.
QA lab (Uster-lite setup), cones & handling	0.3	Evenness tester (Uster Test (UT)-class), Count Strength Product (CSP)/strength tester, twist/cone density, count balance, moisture meter; shade box; basic colour fastness kits; cone loading trolleys & pallets.
Civil modification & EHS (OHS, fire, dust)	1	Anti-static floors; dust-tight partitions; fire hydrant & sprinklers (NBC compliant), detectors/alarms; emergency lighting; marked egress; bag-filter house; noise abatement; safety signage & PPE stations.
Installation, commissioning & training	0.3	Original Equipment Manufacturer (OEM) installation, test runs, Site Acceptance Test (SAT); spare kit (year-1); SoPs; 3–4 weeks operator/supervisor training (sorting, QA, maintenance, OHS).

Asset/Package	Amount (in ₹crores)	Remark
Total CAPEX	11.1	₹11.10 crore
Operating Expenditure (OPEX)		
Raw material procurement (waste)	3.60	4,000 kg/day input × ₹30/kg × 300 days
Power & utilities	1.368	₹15/kg × 912,000 kg yarn/year
Labour (≈35 staff)	0.690	Avg. ₹20k/month incl. statutory; annualised
Maintenance & spares	0.730	≈₹8/kg × yarn output
Rent/lease & admin	0.296	~₹3.0 lakh/month equivalent
QA/Certifications/Lab	0.123	GRS/TC audits, testing consumables
Packaging & dispatch	0.365	₹4/kg × yarn output
Misc./contingency	0.600	Provision for incidentals
Total Operating Cost OPEX)	7.772	₹7.772 crore

Notes

- Reference volumes: Yarn output ≈ 3,040 kg/day → 912,000 kg/year.
- Throughput & yield: 4.0 t/day input; ~76% yield to yarn (covers hard waste + ~3% collection/segregation losses).
- Operating schedule: 1 shift/day (10 hours), 300 days/year.
- Exclusions: Financing costs, depreciation, one-time start-up losses, and taxes are not included here.

Return on Investment

	Initial investment cost (₹)	Annual operational costs ₹/year)	Annual benefits (₹/ year)	Simple payback period
Scenario 1 – Full setup (Textile waste processing + OE yarn making)	11.1	7.772	11.55	~2.94 years
Scenario 2 – Expansion of an existing OE yarn maker (add waste processing for in-house raw material)	4.5	7.9	11.55	~1.19 years

Enabling Factors

- Stable feedstock streams: Cluster density in Panipat enables colour-sorted cotton waste MoUs at required 4–5 t/day volumes.
- Proven OE route: Existing OE-spinning ecosystem (Ne 10–16 band) fits recycled fibre length/quality.
- Buyer pull for recycled yarn: Brands/processors seeking recycled content (GRS/TC) and shade-sorted lots.
- Workforce availability: Skilled operators/fitters available locally; quick ramp with targeted SOPs.
- Local services & vendors: Cards/rotors service, bale presses, bag filters, electricals available within the region.
- Finance linkages: WC lines against receivables and vendor credit; capex supported by phased installation.

Implementation Plan

Short-term (Year 1)			
Activity	KPI	Timeline	Cost Incurred
Secure feedstock MoUs (pre-sorted cotton waste)	≥3 MoUs covering ≥4 t/day	Q1–Q2	Yes
Install sorting + opener line; basic HVAC & dust extraction	Line commissioned; safety sign-off	Q2	Yes
Hire & train crew (sorting, OE ops, QA/OHS); SOPs	30–35 staff trained; SOPs issued	Q2–Q3	Yes
QA lab setup; baseline trials	Evenness/CSP baseline; CoA template	Q2–Q3	Yes
Pilot production & QC (shade lots Ne 10–16)	≥100 t pilot; yield ≥72%	Q3–Q4	Yes
Buyer onboarding (2 B2B), GRS pre-audit	2 Letter of Intent (LOIs)/ Purchase Order (POs); pre-audit passed	Q4	Yes

Mid-term (Year 2–3)			
Activity	KPI	Timeline	Cost Incurred
Throughput ramp-up & yield optimisation	4.5–5.0 t/day input; yield 76–78%	Y2 H1–H2	Yes
Channel diversification (domestic + 2 marketplaces)	4 active buyers; 2 SKUs online	Y2 H2–Y3 H1	No
Energy & maintenance programme	kWh/kg ↓ 8–10%; ≤2% unplanned downtime	Y2 H2–Y3 H2	Yes
Traceability/DPP-ready lot tracking	100% lots traceable; digital CoA	Y3 H1	Yes
Working capital & receivables discipline	DSO ≤45 days; WC line secured	Y2 H1–Y3 H1	No

Long-term (Year 4–5)			
Activity	KPI	Timeline	Cost Incurred
Capacity debottleneck/second OE line (if demand holds)	+25–50% yarn output	Y4 H1–H2	Yes
Product upgrades (higher count, blend variants)	Launch 2 new counts / blends	Y4 H2–Y5 H1	Yes
Export readiness (buyer audits/compliances)	2 export buyers onboarded	Y4–Y5	Yes
Social inclusion & OHS excellence	100% safety equipments; zero lost-time incidents; ≥30% women workforce	Y4–Y5	No/Yes*
Long-term supply locking	5-year feedstock contracts for ≥60% volume	Y5	No

4.3.5 Conclusion

Mechanical fibre-to-fibre recycling in Panipat is practical, cluster-ready, and market-aligned. By turning segregated factory cuttings into traceable recycled yarn, units replace low-value scrap sales with a reliable product line, strengthen compliance and buyer confidence, and reduce dependence on external raw material. The approach builds on the cluster's existing OE-spinning know-how, improves housekeeping and safety, creates better jobs, especially in sorting and QA, and provides a scalable platform for higher counts, blends, and future export readiness. In short: it converts a waste problem into a resilient, brand-ready opportunity.



4.4 Business Opportunity Case 4: Shared Facility for Chemical Recycling

4.4.1 Introduction and Context

The Panipat textile cluster generates substantial volumes of polycotton waste from cutting, processing, and post-consumer flows that are currently downcycled or disposed of with limited sorting and traceability. Under Business Case 4, a shared, centrally operated hub is proposed that introduces chemical fibre-to-fibre recycling, specifically hydrothermal separation, to convert this mixed waste into cellulosic pulp sheets and recycled PET(rPET) feedstock for use in mainstream fibre production. The approach builds on existing collection practices but adds mechanised sorting, quality control, compliant wastewater treatment, and certification so that recycled outputs meet buyer specifications and brand due-diligence requirements. The model is organised through a special purpose vehicle (SPV) of participating MSMEs to pool feedstock, capital, and risk, and to channel benefits back into the cluster through transparent surplus sharing and local spinner adoption.

4.4.2 Rationale

India's waste stream has large volumes of polycotton waste is currently downcycled or landfilled, forfeiting value. A shared hydrothermal recycling hub converts this mixed stream into two standard, market-ready products, cellulosic pulp sheets for viscose/lyocell makers and fibre-grade rPET for polyester processors, creating dual revenue legs while meeting brand and regulatory expectations for certified, traceable recycled content. A Special Purpose Vehicle (SPV) model secures feedstock, pools capital and risk, and enables transparent surplus sharing; mechanised sorting and an in-house lab stabilise quality, unlock offtake letter of intent (LOIs), and support Recycled Claims Standard (RCS)/Global Recycling Standard (GRS). Toll-regeneration of pulp to staple fibre brings immediate adoption by Panipat spinners, anchoring local demand without adding spinning capex. Net effect: higher realisation from the same waste, improved compliance and cluster reputation, and a scalable pathway to circular, textile-to-textile production.

4.4.3 Business as Usual Case

Current Waste Circularity Practice

- MSMEs and traders generate mixed textile waste (cuttings, rejects, post-consumer bales); materials are not consistently sorted by fibre mix or colour, and bale specs are rarely declared.
- Waste is stored in open areas or bins and moved by local contractors; most flows go to downcycling (shoddy/open-end) or low-value trading; contaminated lots are discarded or landfilled.
- There is no cluster-level chemical recycling, no common mechanised sorting, and limited traceability (no bale-to-lot genealogy or Certificates of Analysis (COAs)).

Costs Implications of the Current Model

- Pick-up/landfilling cost: about ₹4/kg for waste that cannot be sold or reused.
- Handling & space costs: on-site storage, double handling, and shrinkage losses.
- Lost value: high-quality polycotton/cotton-rich fractions forego fibre-to-fibre value and are downcycled or dumped.

Systemic Risks and Limitations

- Regulatory exposure: penalties for non-compliant disposal and Effluent Treatment Plant (ETP) lapses; tightening rules under State Pollution Control Boards (SPCBs).
- Cost escalation: rising transport/landfill fees and volatility in rag/downcycling prices.
- Market access & compliance: weak traceability conflicts with RCS/GRS and EU due-diligence/Extended Producer Responsibility (EPR) expectations; missed opportunities for certified recycled content.
- Operational disruption: fire/housekeeping risks from unsorted storage; variability in waste quality undermines any future offtake contracts.
- Opportunity loss: the cluster forfeits higher realisation from pulp board and rPET streams that could feed local spinning and brand supply chains.

4.4.4 Description: Business Case 4

New Waste Circularity Practice

This business case proposes a shared recycling hub for the Panipat cluster to implement chemical fibre-to-fibre recycling of polycotton waste. As with mechanical routes, the process begins with collection, pre-sorting by colour and fibre mix, removal of non-textile parts, opening, fluffing and carding. After the fabric is opened to fibre level, chemical steps are applied to separate materials and convert them into new fibre feedstocks rather than sending it to the landfill or downcycling.

Types of chemical recycling to distinguish:

- Depolymerisation processes break polymers down to monomers/intermediates that can be repolymerised (e.g., PET → monomers → PET resin).
- Thermo-mechanical processes melt and re-granulate polymers for new fibres or films (commonly used for single-polymer streams).
- Thermo-chemical processes reduce materials to lower-molecular building blocks (e.g., syngas, oils) used as chemical industry feedstocks.

Chosen practice for Panipat: Hydrothermal separation of polycotton blends (Depolymerisation process).

- Uses water, heat and a mild catalyst to selectively dissolve the cellulosic portion and liberate polyester from blends.
- Outputs two saleable, textile-to-textile streams: cellulosic pulp sheets ("pulp board") for viscose/lyocell producers, and fibre-grade RPET chips/flakes for polyester fibre/filament makers.

Shared facility workflow

- SPV with transparent surplus sharing; offtake LOIs in place prior to commissioning; option to toll-regenerate pulp into staple fibre for immediate spinner adoption in Panipat.
- Cluster collection → mechanised sorting (colour, fibre %, elastane check, removal of disruptors) → hydrothermal separation → pulp finishing (sheeting/drying/baling) → PET washing/drying/granulating → QA/QC → dispatch to off takers or toll-conversion.

Practice Example

Circ

Circ's chemical-recycling model takes polycotton textiles and, through a hydrothermal separation, cleanly splits them into two high-value streams: a cellulosic fraction that can be finished as dissolving-grade pulp for viscose/lyocell production, and a polyester fraction that can be sold as rPET feedstock or upgraded further. The model depends on reliable sorting to control blend ratios and elastane, standard compliance via Effluent Treatment Plant (ETP)/Zero Liquid Discharge (ZLD), and robust QA/traceability (COAs plus RCS/GRS). Commercially it runs on pre-agreed offtakes—pulp to fibre makers (with the option to toll-regenerate into staple for spinners) and rPET to polyester processors—allowing a shared facility or SPV to monetise both output legs while serving brand demand for certified, textile-to-textile content.

Benefits of chemical recycling

- ✓ Lower waste-handling costs for MSMEs through cluster collection and mechanised sorting (disruptors removed once, not at each unit).
- ✓ New revenue streams from selling pulp board and rPET chips/flakes instead of paying to dispose of mixed waste.
- ✓ Direct spinner adoption path via toll-regenerated staple fibre from pulp, accelerating local yarn business in Panipat.
- ✓ Operational efficiency gains for manufacturers using recycled inputs (stable specs, certified lots, reliable COAs).
- ✓ Customer/brand compliance uplift with RCS/GRS scope and traceable bale-to-lot data.
- ✓ Stronger cluster collaboration through a shared SPV with transparent surplus-sharing rules.
- ✓ Reduced virgin material demand by substituting it with recycled cellulosic/polyester content in yarns and fabrics.
- ✓ Lowered amount of residues sent to landfill as textile waste is converted to products and residues are routed to authorised co-processing.
- ✓ Local job creation in sorting, plant operations, QA/QC, logistics, and ETP/ZLD management.
- ✓ Risk and capital sharing across the cluster, lowering the burden on any single MSME.
- ✓ Environmental benefits: avoided ~3,448 tCO₂e/year (at 665 t/yr net feed) and reduced water/soil pollution through closed-loop treatment.

Total Benefits

The total benefits were calculated for a SPV with 10 MSMEs and no gate fee.

Line item	Value per unit (₹)	Units / Volume	Total benefit (₹/yr)	Remarks
Cellulosic product, baled pulp sheets ("pulp board")	80,000 / t	≈ 295.9 t/yr (44.5% of 665 t)	23,672,000	Standard form for viscose/lyocell mills; price to be indexed in LOIs.

PET product – rPET chips/flakes (fibre-grade)	72,000 / t	≈ 295.9 t/yr (44.5% of 665 t)	21,304,800	Fibre-grade IV band; option to toll-spin a tranche into staple/filament.
Tipping/landfill cost avoided (conservative)	4 / kg	700,000 kg/yr (gross inbound handled)	2,800,000	Counted on gross inbound bales; excludes rejects monetisation.
CO ₂ emissions avoided (impact metric)	5.19 kg CO ₂ / kg feed	665 t/yr → ~3,448 tCO ₂ e/yr	–	Impact KPI only; not monetised.
Total cash benefits			47,776,800 (≈ ₹4.778 Cr)	

Assumptions taken for creation of a shared facility by 10 MSMEs for a revenue generating business model.

Parameter	Value	Remarks
Facility model	Shared SPV of 10 MSMEs	Revenues from sale of pulp & rPET; surplus shared pro-rata (by tonnage × quality score).
Nameplate capacity	2.0 tonnes/day	Manufacturer-rated (“badge”) daily capacity of the hydrothermal line.
Operational availability	~92% of the year (~336 days)	Allows for maintenance, holidays, minor stoppages.
Inbound feed (Textile waste)	700 t/year	Cluster-sourced polycotton waste purchased at market rates + suitable in-house textile waste
Sorting rejects (“disruptors”)	~5% of inbound	Buttons/zips, high-elastane, heavy contamination removed at mechanised sorting.
Net feed to process	~665 t/year	700 t gross – 5% rejects → fits 2.0 t/day at ~92% availability.
Core process	Hydrothermal separation (polycotton)	Organic-acid catalysis at moderate T/P; produces a cellulosic stream and a polyester stream.
Cellulosic product form (yield)	Baled pulp sheets (“pulp board”) ~44.5% → ~296 t/year	Standard tradable form for viscose/lyocell mills; enables toll-regenerated staple for spinners.
PET product form (yield)	rPET chips/flakes (fibre-grade) ~44.5% → ~296 t/year	Tradable to polyester fibre/filament makers; toll-spinning option for cluster trials.
Residues & fines	~11% → ~73 t/year	Routed to authorised co-processing/handling.
Realisation (ex-works)	Pulp ₹80,000/t; rPET ₹72,000/t	Conservative mid-band pricing; to be indexed in offtake MOUs.

Parameter	Value	Remarks
Tipping/landfill avoided	₹4/kg (on inbound handled)	Conservative cluster benchmark; counted as a benefit.
Power usage & tariff	~640 kWh/t; ₹7.0/kWh	Planning value; refine with vendor performance test.
Water make-up	~2.6 m³/t net (≈ 1,729 m³/yr)	Closed-loop design targets ≥80–90% reuse.
Chemicals & consumables	~₹13,000/t net feed	Catalyst, neutralisers, filter aids/AC; to be vendor-validated.
Certifications	RCS/GRS in scope; TCs per lot	Annual audits budgeted; supports claims/traceability.
Compliance	ETP/ZLD with authorised disposal	Designed for colour/COD; sludge/AC to authorised handlers.
CO ₂ impact metric	~3,448 tCO ₂ e/year avoided	5.19 kg CO ₂ /kg × 665,000 kg; shown as impact (not monetised).

Cost

Costs aspects

- Textile waste sorting & pre-processing: mechanised sorting/NIR, bale opening, re-baling, QC.
- Establishing the shared facility: hydrothermal line, pulp & rPET finishing, utilities, ETP/ZLD, lab, safety systems (CAPEX ~₹25.65 Cr).
- Operating & maintenance: power, water/ETP, chemicals, staff, repairs/spares, certifications, insurance/admin, OPEX contingency.
- Logistics (inbound/outbound): moving member MSME bales to hub and dispatching pulp board / rPET to buyers or tollers.
- Working capital: inventory and receivables for pulp/rPET lots (even with buyer-arranged transport).

Challenges

- Mobilising investment: closing equity from 10 MSMEs and securing debt/grants for the SPV.
- Cluster coordination: aligning members on feed specs, quality scoring, and surplus-sharing without gate fees.
- Technology ramp-up: building in-house skills to run hydrothermal operations, QA/QC, and ETP/ZLD to compliance from day one.
- Offtake certainty & pricing: converting LOIs to firm contracts; managing price/yield volatility for pulp board and rPET.
- Feedstock variability: maintaining steady cotton: poly ratios and elastane limits; enforcing rejects (~5%) without dispute.
- Traceability & certification: sustaining RCS/GRS audits and timely Transaction Certificates to meet brand requirements.

Items	Line item(s)	Cost (₹ Cr)	Remarks
Capital Expenditure (CAPEX)			
Sorting & Pre-processing	Bale opener; Belt conveyors; Manual sorting tables; Fibre identification; Metal detector; Elastane screening; Scales; Re-bale press	2	Stabilises feed; enables 5% disruptor removal & quality scoring.
Hydrothermal Separation – Core Process	Feed hopper & variable-speed screw; Pressurised reactor; Heat-exchanger; Primary solid-liquid separation; Neutralisation & counter-wash; Polishing filters; Pulp dewatering press; PET fraction washer	9	2.0 t/day textile feed; availability target $\geq 92\%$.
Cellulosic Product Finishing	Pulp refiner/disperser; Sheet former; Wet press; Air/cylinder dryer; Sheet cutter & stacker; Bale press & wrapper	0.9	Delivers standard pulp board (baled sheets) for viscose/lyocell offtake.
PET Product Finishing	Granulator/flaker; Hot-air dryer; Bagging station	0.75	Fibre-grade rPET chips/flakes; optional toll-spin to staple/filament.
Utilities & Material Handling	Steam boiler; Air compressor; Cooling tower/chiller; Make-up water treatment; Chemical dosing skids w/ double containment; Forklifts/pallet jacks; Storage racks	1.3	Sized to hit ≤ 700 kWh/t and ≤ 3 m ³ /t make-up targets.
ETP / ZLD	Equalisation; dissolved air flotation DAF (if required); membrane bioreactor (MBR)/reverse osmosis (RO); Evaporator/Agitated thin film dryer (ATFD) (ZLD case); Sludge filter press; Carbon/IX columns	4	Designed for colour/COD; reuse $\geq 80-90\%$; brand-grade compliance.
QA/QC Laboratory	Blend identification (NIR)/Chemical fingerprinting (FTIR); Pulp viscosity/DP and brightness meter; Ash furnace; PET IV tester; Moisture analysers; pH/ORP/cond.; Sample prep; Barcode/ERP for lot genealogy	0.75	Enables COAs & claims (RCS/GRS); supports offtake specs.
Safety & Compliance	Fire hydrant & extinguishers; eye-wash & safety showers; spill kits & bunding; gas/temperature alarms; electrical earthing & interlocks	0.5	OHS + audit readiness; aligns with SPCB & buyer audits.
Building & Civil	~1,200 m ² process hall + sorting bay + utility trenches	2.3	If in-kind lease is granted, move to OPEX (₹0 lease line retained).

Items	Line item(s)	Cost (₹ Cr)	Remarks
Electrical & Integration	HT/LT panels, cabling, MCC/PLC networking, fire & safety integration	0.8	Includes install/commissioning.
Licences, Commissioning & Training	Consents; vendor/EPC commissioning; SOPs; operator training	0.6	
Contingency (~12%)		2.75	FX, freight, minor scope changes.
Grand Total CAPEX		₹25.65 Cr	Per-MSME (10 members): ₹2.565 Cr (all-equity view).
Operating Expenditure (OPEX)			
Power	-640 kWh/t × 665 t = 4,25,600 kWh @ ₹7.0/kWh	29,79,200	Keep headroom for tariff hikes; scope for rooftop/3rd-party PPA later.
Water (make-up)	-2.6 m³/t × 665 t = 1,729 m³ @ ₹40/m³	69160	Closed-loop; targets ≥80–90% reuse.
ETP/ZLD O&M	Power, chemicals/membranes, sludge & AC handling	16,15,000	Designed for colour/COD; brand-grade compliance.
Chemicals & consumables	₹13,000/t × 665 t	86,45,000	Catalyst, neutralisers, filter aids; vendor to validate post-performance test.
Operators & staff	15 staff @ ₹18,000/month	32,40,000	3-shift lean crew incl. QC & maintenance.
Repairs & spares	≈ 2% of machinery value	25,00,000	Bearings, seals, filters, instrumentation, minor overhauls.
Certifications (RCS/GRS + audits/TCs)	Annual scope, surveillance audits & TCs	7,50,000	Keeps supply chain claim-ready.
Insurance & statutory	Plant + liability	6,00,000	—
Admin / IT / ERP / security	Fixed overheads	8,00,000	ERP supports lot genealogy & TCs.
Lease (space)	₹0	0	In-kind/cluster support; shown explicitly.
Misc. / contingency (OPEX)	10% of subtotal above	21,19,836	Buffer for Foreign exchange, consumables, small works, freight variance.
Total OPEX (annual)		2,33,18,196 (≈ ₹2.3318 Cr)	

Capex List

Sorting & Pre-processing (front end)

- Bale opener (1–2 Tonnes Per Hour): feeds evenly; adjustable spike lattice.
- Conveyors (belt + slider beds): infeed, QC lanes, rejects line; 500–1,000 mm width.
- NIR fibre identifier (inline or bench): cotton/poly %, elastane flag; $\geq 1,000$ scans/min (inline) or handheld guns for spot checks.
- Elastane screening station (quick lab): solvent/burn tests; elastane % estimate.
- Metal detector / over-band magnet: pulls zips, staples, hooks.
- Manual sorting tables with lighting & suction.
- Bale press (down-stroke, 30–50 ton): re-baling sorted lots with barcode tags.
- Weighbridge / floor scales: inbound/outbound mass balance.

Hydrothermal Separation Line (core process)

- Feed hopper & screw feeder: 0.5–1.0 m³; variable speed.
- Pressurised hydrothermal reactor: 2–3 m³, 100–130 °C, 2–4 bar; SS316L lining; steam-jacket or electric/oil heating; agitation ≥ 20 –30 rpm; safety interlocks (pressure release valve (PRV), burst disk).
- Heat-exchanger (plate/shell-tube): energy recovery from hot effluent.
- Solid-liquid primary separator: decanter centrifuge (10–25 kN) or pressure filter.
- Neutralisation & wash tanks: 2–3 stages; pH control; SS316L; 5–10 m³ each.
- Polishing filtration: bag/cartridge filters (5–25 μ m).
- Pulp dewatering press: twin-roll or screw press; 25–35% solids cake.
- Polyester fraction washer: counter-current wash + friction washer; 1–2 TPH textile equivalent.
- Hot-air dryer (PET) (if producing dry chips/flakes): 120–160 °C, residence 2–4 h; IV preservation.

Cellulosic Product Finishing (pulp sheets)

- Pulp refiner / disperser (optional): homogenise fibre slurry.
- Sheet former (continuous or batch): 1–1.5 m web; 200–400 kg/h dry basis.
- Wet press (nip pressure 2–4 bar).
- Through-air / cylinder dryer: to 6–10% moisture; 80–110 °C.
- Sheet cutter & stacker: 50–80 cm $\times$ 70–100 cm sheets; counting & stacking.
- Bale press / strapper: 200–250 kg bales; moisture sensor inline.
- Wrapping station: PE wrap or kraft with label/QR.

PET Product Finishing

- Flaker / granulator (if needed): 200–500 kg/h.
- Thermal crystalliser (optional): for stable IV prior to sale.
- Bagging station: Flexible Intermediate Bulk Container (FIBCs)/25 kg; inline metal detector.

Utilities & Material Handling

- Steam boiler (oil/gas/electric): 600–1,000 kg/h @ 8–10 bar (size to duty).
- Compressed air: 7–8 bar, 2–5 m³/min; dryer + receiver.
- Cooling tower / chiller loop: 30–60 TR (depends on heat recovery).

- Water treatment (make-up): softener/RO as needed.
- Chemical dosing skids: acid/base, antiscalant, oxidants; double containment.
- Forklifts / pallet jacks; racks for bale storage.

ETP / ZLD (compliance)

- Equalisation tank (15–25 m³), pH correction, coagulation–flocculation, DAF (if fats/oils), MBR/RO (2-stage), evaporator / ATFD (if ZLD), sludge press.
- Carbon/ion-exchange columns (if brightness/metals limits apply).
- Stack & vents with appropriate scrubbers (if required).

QA/QC Lab (claims + offtake specs)

- NIR/FTIR (fibre ID); viscometer / Pulp, brightness meter, ash furnace, or outsource metals, PET IV tester, moisture analysers, pH/ORP/cond. Meters.
- Sample prep: cutters, mills, sieves; refrigerated storage for retains.
- Barcode/ERP: lot genealogy from bale → outputs; label printer & scanners.

Safety & Compliance

- PPE & IH: eyewash, showers, spill kits; LEL detectors (if solvents later); bunds for chemical tanks.
- Fire & electrical: hydrants, extinguishers, earthing, VFD panels with interlocks.

Return on Investment

	Initial investment cost (₹)	Annual operational costs (₹/year)	Annual benefits (₹/year)	Simple payback period
End product of the new value chain: Pulp board (cellulosic) + rPET chips/flakes	25,65,00,000	2,33,18,196	4,77,76,800	≈ 10.5 years

Enabling Factors

- ✓ The existing yarn & fabric ecosystem in India enables rapid adoption of toll-regenerated staple fibre made from pulp and steady demand for rPET chips/filament.
- ✓ Cluster SPV of 10 MSMEs with mechanised sorting secures ~700 t/yr gross feed and delivers consistent, spec-stable bales for continuous operation.
- ✓ Offtake pathways already identified: pulp board to viscose/lyocell producers (with toll-conversion back to staple) and rPET chips/flakes to polyester fibre/filament makers.
- ✓ Regulatory and infra support feasible via state single-window clearances (CTE/CTO, Hazardous waste) and land/lease waivers; closed-loop ETP/ZLD design is standardisable.
- ✓ Finance options available: Small Industrial Development Bank of India (SIDBI) green credit lines, state industrial incentives, and impact investors; power costs can be lowered via rooftop/third-party solar Power Purchase Agreement (PPA).
- ✓ Brand/EPR pull for recycled content strengthens medium-term pricing and offtake visibility for both pulp board and rPET outputs.

Implementation Plan

Short-term (Year 1)			
Activity	KPI	Timeline	Cost Incurred
Form SPV (10 MSMEs), governance	SPV registered; profit-share policy approved	Y1-Q1	0.05
Pilot & offtake setup (50–100 tonnes pilot; LOIs/MOUs)	Yields validated; $\geq 70\%$ of capacity under LOIs (cellulosic + rPET)	Y1-Q1–Q2	0.45
Permits & financing (Consent to Establish (CTE)/Consent to Operate (CTO), EHS, loan/grant if any)	All consents in hand; financing docs signed	Y1-Q1–Q2	0.20
Procurement & site works	Major POs placed; civil/utilities ready	Y1-Q2–Q3	18.50
Installation, commissioning & training	14-day continuous run accepted; SOPs signed	Y1-Q3–Q4	6.45

Mid-term (Year 2–3)			
Activity	KPI	Timeline	Cost Incurred
Performance test & ramp-up	Uptime $\geq 85\%$; yields on-spec; throughput ≥ 600 – 650 t/yr net	Y2-H1	– (in OPEX)
RCS/GRS certification & surveillance	Scope issued; TCs per lot; audits passed	Y2-Q2 $\rightarrow$ Y3-H2	0.75/yr (included in OPEX)
Market adoption (spinner trials & repeat orders)	≥ 10 mills trialled; ≥ 5 repeat buyers	Y2-H1 $\rightarrow$ Y3-H1	0.10
ETP/ZLD & chemicals optimisation	Water reuse $\geq 90\%$; chem cost $\downarrow 5$ – 10%	Y2-H2 $\rightarrow$ Y3-H1	0.15
Energy cost action (optional solar PPA)	$\geq 15\%$ power via PPA; tariff $\leq ₹5.5$ /kWh	Y2-H2	0 (PPA)

Long-term (Year 4–5)			
Activity	KPI	Timeline	Cost Incurred
Capacity strategy decision (2nd shift / Line-2)	Gate approved if: offtake $\geq 70\%$, ETP $\geq 95\%$ months, Debt Service Coverage Ratio (DSCR) $\geq 1.3\times$	Y4-H1	0.05
Product value upgrade (optional PET crystalliser)	rPET IV stability $\uparrow$ realisation + ₹2–3k/t	Y4-H2	0.75–1.00
Digital Product Passport pilots (brands)	DPP live with ≥ 3 buyers	Y4-H2 $\rightarrow$ Y5-H1	0.10

4.4.5 Conclusion

Business Case 4 recommends establishing the shared hydrothermal hub as a practical pathway to circular, textile-to-textile flows in Panipat. The model can unlock dual revenues (pulp and rPET), reduce landfill dependence, and align the cluster with brand and regulatory expectations for certified recycled content, provided that feedstock MoUs, offtake commitments, and compliance systems are secured upfront. Key implementation risks relate to capital mobilisation, operational learning (sorting, QA/QC, ETP/ZLD), and managing utilities and chemicals responsibly; these are mitigated by phased commissioning, vendor performance tests, and disciplined governance of the SPV. With these enablers in place, the hub offers a replicable solution that upgrades current waste handling into a traceable, market-linked system and strengthens Panipat's competitiveness in a tightening sustainability landscape.



4.5 Business Opportunity Case 5: Upcycling with Social Entrepreneurs and Self-Help Groups (SHGs) in India

4.5.1 Introduction and Context

This business case is an effort to identify practical, inclusive models that reduce textile waste and create dignified livelihoods in India's MSME clusters. Focusing on Panipat, a large recycling hub where pre-consumer cutting waste and rejected fabrics are typically handled in linear, low-value ways, the case demonstrates how structured partnerships between MSMEs and 'upcycling social enterprises/SHGs' can convert waste into marketable, design-led products. By linking segregated feedstock from factories with community-based upcycling units, the model aims to cut disposal costs, formalise work, and retain more value locally while improving environmental outcomes.

4.5.2 Rationale

This business case demonstrates a win-win collaboration between textile MSMEs, waste aggregators, and local social entrepreneurs to transform textile waste into value-added upcycled products. The model integrates social inclusion with circularity by linking waste recovery, livelihood generation, and micro-enterprise creation within existing textile clusters.

Across India's textile hubs, large quantities of pre-consumer waste, such as fabric cuttings, rejected fabrics, and offcuts, are currently disposed of at a scrap cost to MSMEs. At the same time, thousands of informal workers and small women's collectives operate at the margins of these clusters, sorting, cleaning, and reusing this waste and discarded textiles with minimal market access or institutional support.

Social entrepreneurship presents a practical opportunity to connect these two disconnected ends of the value chain. By embedding small, community-driven upcycling social entrepreneurs/SHGs within or alongside MSME networks, waste can be transformed into higher-value products such as lifestyle accessories, apparel, and home décor. This approach not only reduces the environmental footprint of textile production but also creates dignified, local employment, particularly for women and youth.

The model builds on existing entrepreneurial and skilling ecosystems, leveraging design schools, cluster associations, and livelihood missions that can support enterprise incubation and product innovation. It thereby aligns circular business practices with inclusive growth, demonstrating how local MSMEs can evolve into socially responsible, resource-efficient enterprises while strengthening community resilience and market competitiveness.

4.5.3 Business as Usual Case

Current Waste Handling Practice

Panipat processes over 3,000 tonnes of textile waste per day across nearly 350 recycling MSMEs. However, despite this scale, waste handling remains largely linear and efficiency limited.

- **Mixed and unsorted waste:** Textile waste comprising cotton, polyester, wool blends, and synthetics is typically received in mixed, contaminated form from importers and domestic traders. Sorting is manual, inconsistent, and largely dependent on informal workers without mechanised infrastructure or fibre-recognition tools.

- **No systematic colour or fibre segregation:** MSMEs shred incoming waste directly, resulting in fibre breakage and quality loss. Most outputs are low-grade shoddy yarn used for blankets and durries, with limited diversification into higher-value products such as apparel yarns or circular fabric lines.
- **Informal disposal and leakages:** Residues such as mixed synthetics, trims, and non-recyclables are sold at marginal rates or discarded into open areas and drains, contributing to water and soil pollution.
- **Limited reuse or upcycling:** A handful of NGOs, micro-enterprises and local women-led stitching groups experiment with upcycled products, but remain disconnected from MSME supply chains due to lack of incubation, design mentorship, or market access.
- **Labour practices:** Sorting, tearing, and waste handling are undertaken by informal workers, often women migrants earning ₹4,500–₹6,000 per month, without formal contracts, adequate training, safety equipment, or social protection coverage.
- **Entrepreneurial ecosystem gaps:** Despite Panipat's dense industrial base, there are no dedicated innovation hubs or incubation centres focused on textile circularity. Start-ups and social entrepreneurs face multiple barriers, limited technical mentorship, absence of design-finance linkages, and minimal access to schemes for circular business models.
- **Lack of convergence:** Cluster associations such as GATS primarily represent recyclers, with minimal engagement in entrepreneurship promotion. The absence of a cluster-level facilitation mechanism limits the development of upcycling social entrepreneurs/SHGs that could valorise non-recyclable or low-value waste streams.

In essence, Panipat's system functions as a large-scale industrial recycling hub, but not yet as a circular entrepreneurship ecosystem. The emphasis remains on volume-based recycling rather than value creation, innovation, and inclusive participation, leaving significant opportunities untapped at the intersection of sustainability and livelihoods.

Costs of Current Waste Handling Model

- **Waste Collection and Disposal:** MSMEs pay private contractors to collect and dispose of unusable textile residues averaging around ₹3–₹5 per kg of waste or earning scrap value of about ₹20 /kg.
- **Storage and Space Costs:** Factories require large open areas to store mixed and rejected waste before disposal.
- **Transportation Costs:** Waste transport to dumping sites or contractors outside the cluster adds ₹400–₹600 per tonne in logistics costs.
- **Hidden Environmental and Social Costs:** Landfilling and open dumping generate pollution, odour, and health hazards for local communities.

Risks of Current Model

- Disposal and transport costs are increasing due to stricter local monitoring and reduced dumpsite/landfill capacity.
- Poor sorting, due to the lack of formal training among others, and fibre mixing lead to irreversible value loss of usable textile fibres across the value chain including post-consumer textile waste.
- Dependence on informal, low-paid workers without safety measures exposes the cluster to reputational and ethical risks under emerging ESG norms.

- Dumping and open burning of non-recyclable waste pollute soil and water and contribute to microfibre release into the Yamuna basin.
- Continued production of low-value shoddy yarn keeps the cluster trapped in a commodity cycle, vulnerable to global price fluctuations and shrinking margins.
- Global buyers increasingly demand traceable, socially compliant supply chains. Failure to adapt may exclude Panipat units from preferred supplier lists of major brands.

4.5.4 Description: Business Case 5

New Waste Handling Practice

To address current inefficiencies, textile MSMEs in Panipat can collaborate with local social enterprises, SHGs, and design-led start-ups to upcycle pre-consumer cutting waste and rejected fabrics into higher-value lifestyle, fashion, and home décor products. This approach links MSMEs generating waste with community-based enterprises skilled in stitching, embroidery, and product innovation. Under this model, MSMEs provide segregated textile waste and basic workspace, while social enterprises manage sorting, design, and fabrication. Cluster associations and livelihood missions can support training, market access, and incubation. The model converts waste into a local economic resource—reducing landfill burden, creating dignified employment, and strengthening MSME sustainability through social inclusion and brand value.

Practice Example

Iro Iro – Jaipur’s Upcycling Studio

Iro Iro is a design-driven social enterprise based in Jaipur that transforms textile waste into contemporary garments and home décor using traditional craft techniques. The enterprise collaborates with local weavers and tailors to collect surplus yarns, rejected yarns/fabrics, and cutting waste from textile units, which are then re-spun, rewoven, and reimaged into new fabrics and garments. Each product is created through a zero-waste design process, combining sustainability with craftsmanship. By integrating waste recovery with skill-based livelihoods, Iro Iro demonstrates how textile circularity can coexist with artisanal empowerment and modern design sensibilities. This model is portable to Panipat via MSME–SHG MoUs and cluster design support. Its model offers a blueprint for clusters like Panipat, where social enterprises/SHGs can collaborate with MSMEs to upcycle factory discards into value-added, marketable products for conscious consumers in India and abroad.

Value Chain

Waste Generation → Waste Sorting & Preparation → Product Design & Upcycling → Distribution → Retail

Benefits of Upcycling with Social Entrepreneurs

Once the upcycling social entrepreneurs/SHGs–MSME partnerships become operational, multiple economic, social, and environmental benefits will emerge for the cluster and surrounding communities.

Direct Benefits

- ✓ Partial resolution of the waste challenge depending on the scale of social enterprises.
- ✓ Reduction in waste-handling and disposal costs for MSMEs through direct material off-take.

- ✓ Creation of 15–20 new jobs per enterprise, mostly for women in sorting and stitching.
- ✓ Additional income opportunities along the value chain in packaging and distribution.
- ✓ Improved MSME–community relations through partnerships with local women’s groups.
- ✓ New product diversification in fashion, décor, and lifestyle segments.

Indirect Benefits

- ✓ Increased economic value retained within the cluster through local micro-enterprises.
- ✓ Reduced CO₂ emissions and local pollution from less dumping and burning.
- ✓ Formal inclusion and safer work conditions for informal waste workers.
- ✓ Enhanced visibility of Panipat as a socially responsible and circular textile hub.
- ✓ Improved ESG profile and buyer confidence for participating MSMEs.

Total Benefits

Assuming the creation of 10 enterprises (each enterprise utilises 20 tonnes of textile waste per year):

Particular	Value per Unit	Number of Units	Total Benefit
Cost savings on waste disposal for MSMEs	₹4 per kg	200 tonnes/year	₹8,00,000
Sale of textile waste to upcycling social enterprises/SHGs	₹20 per kg	200 tonnes/year	₹40,00,000
Job creation – upcycling social enterprises/SHGs	₹1.5 lakh annual income per worker	150 workers	
(15 workers/enterprise)	₹2,25,00,000		
Job creation – value chain	₹1.5 lakh annual income per worker	30 workers	
(3 workers/enterprise)	₹45,00,000		
CO ₂ emissions avoided	5.19 kg CO ₂ per kg textile waste	200 tonnes diverted	1,038,000 kg CO ₂ (≈ 1,038 t CO ₂)
Total Benefits	₹3,18,00,000 / Year		

MSME direct financials = ₹48,00,000/yr; remainder is local livelihood income; CO₂ not monetised

Cost and Challenges

Cost

Costs of waste collection and sorting:

- Leasing of workspace in/near the cluster – ₹2,40,000 per year per enterprise (≈600–800 sq ft, indicative local estate rates).
- Building basic shed / fit-outs – ₹1,500–₹2,000 per sq ft (one-time).
- Workforce costs (sorting & stitching) paid by enterprises – ₹1,50,000 per worker per year (≈15 workers per enterprise).

Costs for training local entrepreneurs

- Cost of training per enterprise focuses on skilling and capacity building – ₹1,50,000.

Investment costs (financing entrepreneurs)

- Average initial investment required – ₹25,00,000 per enterprise (workspace setup, machines & tools, branding kit, initial working capital).

Particular	Cost per unit	Cost/Enterprise	Total cost
Capital Expenditure (CAPEX)			
Workspace setup (shed, racking, lighting)	₹5,00,000 / setup	₹5,00,000	₹50,00,000
Machines & tools (sewing, overlock, cutting, press, QC)	₹12,00,000 / set	₹12,00,000	₹1,20,00,000
Design/branding starter kit	₹1,50,000 / kit	₹1,50,000	₹15,00,000
Training & incubation (entrepreneur + team)	₹1,50,000 / enterprise	₹1,50,000	₹15,00,000
Initial working capital (materials, packaging, freight float)	₹5,00,000 / enterprise	₹5,00,000	₹50,00,000
Total CAPEX	₹25,00,000	₹2,50,00,000	

Particular	Cost per unit	Cost/Enterprise	Total cost
Operational Expenditure (OPEX)			
Wages – production and value chain staff (12+3)	₹1,50,000 per worker-year	₹22,50,000	₹2,25,00,000
Wages – Group heads, key positions, and supervisor (3)	₹2,40,000 per worker-year	₹7,20,000	₹72,00,000
Utilities (power, water, internet)	₹2,00,000 per year	₹2,00,000	₹20,00,000
Space lease/maintenance	₹2,40,000 per year	₹2,40,000	₹24,00,000
Logistics & last-mile (waste pickup, deliveries)	₹3,00,000 per year	₹3,00,000	₹30,00,000
Packaging & consumables	₹2,50,000 per year	₹2,50,000	₹25,00,000
Machinery upkeep (spares, AMC)	5% of Machines & tools	₹60,000	₹6,00,000
Product design development	₹50,000 per year	₹50,000	₹5,00,000
Marketing/e-commerce fees & shoots	₹1,50,000 per year	₹1,50,000	₹15,00,000
Total OPEX (Annual)		₹42,20,000	₹4,22,00,000

	Cost per Enterprise	Total cost
Total costs for first year (CAPEX and OPEX)	₹67,20,000	₹6,72,00,000

Assumptions

- ❖ Scale & units → 10 enterprises; each processes 20 tonnes/year of textile waste → 200 tonnes/year total.
- ❖ Waste pricing → MSME sale price = → 20/kg (segregated waste to upcycling units); disposal saving = → 4/kg (landfill/transport avoided)

- ❖ Jobs → 15 workers/enterprise; 3 value-chain workers/enterprise (sorting/storage/packaging/retail)
- ❖ Wages → Production & value-chain workers → 1.5 lakh/worker/year; Admin/Supervision/QC ₹2.4 lakh/worker/year.
- ❖ Emissions → 5.19 kg CO₂ per kg mixed fabric diverted (used for CO₂-avoidance estimate).

Challenges

- Low scalability at early stage without strong brand/retail linkages.
- Space and sorting processes add costs for factories and require coordination.
- Competitiveness of upcycled products in design, quality, and pricing.
- Access to funding and working-capital lines for small enterprises.
- Logistics requirements for regular segregated waste pick-ups and deliveries.
- Pre-treatment and storage needs (cleaning, colour/fibre segregation, dry storage).

Enabling Factors

- Cluster association access: GATS, manufacturer clusters, and local trader networks can broker steady, segregated feedstock and basic workspace MoUs with MSMEs.
- Entrepreneur & SHG base: Existing women's groups, stitching units, and micro-entrepreneurs in/around Panipat can be quickly onboarded and trained.
- EU Supply Chain Compliance: Emerging brand due-diligence/traceability expectations (ESG) increase demand for documented waste recovery and inclusive work practices.
- Design & skills pipeline: NIFT/NID alumni, ITIs, Skill India curricula can support product design, prototyping, and line-balancing training.
- Market linkages: Buyer interest in ESG/circular sourcing (domestic brands, export home-textile buyers) plus online marketplaces for upcycled goods.
- Light-capex readiness: Upcycling lines need sewing, cutting, pressing—equipment widely available in Panipat with local servicing.
- Logistics footprint: Established waste aggregation and transport routes in the cluster enable regular, segregated off-take schedules.
- Finance avenues: CSR partnerships, cluster-level revolving working-capital pools, SIDBI/MSME credit lines, and vendor advances from buyers.
- Traceability tools: Simple waste transfer notes, batch IDs, and digital ledgers can evidence diversion and support emerging compliance asks.
- Municipal support: Urban Local Bodies (ULB) facilitation for sheds, storage permits, and streamlined registrations to reduce start-up friction.

Implementation Plan

Short-term (Year 1)			
Activity	KPI	Timeline	Cost Incurred
Partner mapping (MSMEs, traders, SHGs) & due diligence	Roster: ≥30 MSMEs, ≥15 SHGs	Q1	No
MoUs for segregated waste + basic workspace	10 signed MoUs	Q2–Q3	No

Training plan & curricula (operators, supervisors, entrepreneurs)	Curricula finalised; ToT completed	Q2	Yes (minor)
Skilling cohorts (operators & entrepreneurs)	≥150 workers + 10 entrepreneurs trained	Q2–Q4	Yes
Design bootcamps & line-balancing practice	20 SKUs prototyped; SOPs adopted	Q3–Q4	Yes
Enterprise setup (fit-out, machines, hiring)	10 units readiness completed	Q3	CAPEX
Baselines & dashboards (waste/jobs)	Logs active; monthly reporting	Q3–Q4	No
Pilot production & QA	10,000 units; defect rate <3%	Q4	Yes
Waste diversion run-rate	~100 tonnes waste (training period impact)	Q4	No

Mid-term (Year 2)			
Activity	KPI	Timeline	Cost Incurred
Strengthen segregation & supply cadence	≥90% colour/fibre-sorted feedstock	H1	Process
Throughput & efficiency	Output ≥60–65%; rework <4%	H1–H2	Yes
Channel onboarding (B2B + 2 marketplaces)	3–5 buyer trials live; 2 marketplaces active	H1–H2	Marketing
Working-capital pool	₹1.5–2.0 cr revolving facility operational	H1	Finance
Portfolio & markets	25–30 active SKUs; 6–8 steady B2B buyers	H1–H2	Marketing
Skills & wage ladder (refresh)	2 upskilling cycles; avg. wages +10–12%	H1–H2	Yes
Traceability & ESG	Quarterly dashboard; batch-level WTNs	Quarterly	No
Waste diversion target	200 tonnes / year	H2	No

Long-term (Years 3+)			
Activity	KPI	Timeline	Cost Incurred
Scale & replication	Scale up to 20 more enterprises (total 30)	Y3–Y4	Select CAPEX
Channel depth	12–15 B2B accounts; Repeat rate ≥70%	Y3–Y4	Yes
Margin uplift via design/yield	Gross margin +5–7 pts; Fabric yield +3–5%	Y3	Process
Inclusive governance	Cluster Circular Cell formalised; SOPs adopted	Y3	No
Impact at scale	≥ 540+ jobs; ≥400+ tonnes/year waste diversion; ~2,100 tCO ₂ e avoided	Y3–Y4	No
Investment readiness	Blended finance closed for next tranche	Y3+	Finance

4.5.5 Conclusion

Upcycling with social entrepreneurs offers Panipat a realistic pathway to move from volume-driven recycling to value-creating circularity. With modest capex, predictable opex, and clear roles—MSMEs supplying segregated feedstock and basic space; upcycling social entrepreneurs/SHGs delivering sorting, design, and fabrication—the cluster can unlock measurable gains: lower waste-handling costs, steady local income and jobs (especially for women), and verifiable diversion of textiles from landfill with associated CO₂ reductions. The Year-1 focus on skilling and quality, followed by Year-2 channel onboarding and Year-3 scale-up, provides a de-risked roadmap. Implemented with simple traceability, working-capital support, and facilitation by the cluster association and ULB, this model strengthens buyer confidence and ESG performance while building a resilient, inclusive circular ecosystem for Panipat.

Annexures

Annexure 1 – Primary Data Collection

Primary Research: Interactions on Field	
2 Industry Associations	3 Civil Society Organisation
MSMEs: • 1 Sorter: imported post---consumer textile waste, • 1 Shredder: textile waste shredding unit (waste to fluff) • 1 Recycled OE yarn spinner (fluff to yarn) • 2 Dyeing unit • 1 Weaving unit • 2 Exporters • 1 Home Furnishing Unit • 2 Post consumer Textile Waste Recycler • 1 Textile Machinery Manufacturer (focus on shredding machines)	
Policy Analysis	
A total of 15 policy documents were analysed, covering a spectrum of policies across international, national, and state levels. This multi-tiered review provided both breadth of perspective and depth of understanding on how global commitments intersect with national priorities and state-specific implementation.	

I. Questionnaires: Textile MSMEs

Panipat Textile Cluster Assessment: Textile MSMEs Questionnaires

Introduction & Consent

Panipat is not only a recycling hub but also an important textile manufacturing cluster, with around 3,000+ MSMEs producing home furnishings (e.g. carpets, durries, blankets) – about 75% of India's blankets are made here.

This survey is part of a cluster assessment, aiming to integrate circular economy practices into primary textile manufacturing. As a manufacturer in Panipat, your perspective on waste generation, recycled material use, skills, and infrastructure will help shape strategies for resource efficiency.

We appreciate your participation. Your information will be confidential and used to recommend improvements in policy, technology adoption, and market linkages for a sustainable textile value chain.

Participation is voluntary; please consent below to proceed.

Consent: I agree to participate in this survey.

☐ Yes ☐ No

Respondent Information (Required)

Name : _____

Organisation/Unit Name : _____

Role/Designation : _____

NIC Code : _____

Q1 → Business Profile:

(a): Main Product Type – What textiles/products do you manufacture?

- | | |
|--|--|
| ☐ Yarn/Spinning | ☐ Woven fabric (e.g. upholstery, denim) |
| ☐ Dying / Finishing | ☐ Garments/Apparel |
| ☐ Trader / Wholesaler | ☐ Other: _____ |

(b): Production Scale – Your approximate production capacity (or output) per month

- | | |
|---|--|
| ☐ Small (prototype/job work) | ☐ Medium (up to 50,000 units or equivalent) |
| ☐ Large (50,000–200,000 units) | ☐ Very large (> 200,000 units) |

(c): What fibres do you prominently work with?

- | | | | | |
|---------------------------------|-------------------------------|---|--|--|
| ☐ Cotton | ☐ Wool | ☐ Polyester/synthetics | ☐ Blends (poly-cotton etc.) | ☐ Others: _____ |
|---------------------------------|-------------------------------|---|--|--|

Q2 → Textile Waste Generation: Do you generate significant textile waste or scrap in production (e.g. fabric cuttings, leftover yarn, defect pieces)?

- | | |
|---|---|
| ☐ Yes, substantial waste (high wastage in processes) | ☐ Some waste (moderate, typical waste %) |
| ☐ Very minimal waste (high efficiency, low scrap) | ☐ Not sure |

If Yes: How much is generated per month _____

If yes: How do you primarily handle this production waste?

- | |
|---|
| ☐ Sell/Give to recyclers (formal or informal waste traders) |
| ☐ Reuse internally (e.g. reprocess in-house, down-cycle to other products) |
| ☐ Dispose as trash/landfill (no recycling) |
| ☐ Other: _____ |

Q3 → Use of Recycled Materials: Do you use any recycled or reclaimed materials in your manufacturing inputs? (e.g. recycled fiber, yarn, fabric)

- | |
|---|
| ☐ Yes, regularly – a significant portion of input is recycled (approximately ____% of input) |
| ☐ Occasionally – tried in limited products or pilot runs |
| ☐ No – only virgin materials used |
| ☐ Not applicable (e.g. you produce virgin yarn from raw fiber) |

If 'Yes': How much recycled material do you use per month: _____

If 'No': What are the reasons for not using recycled inputs? (Select all that apply)

- | |
|---|
| ☐ Quality concerns – recycled material doesn't meet required specs |
| ☐ Availability – not easily available or consistent supply |
| ☐ Cost – recycled is more expensive than virgin |

- ☐ Customer requirements – buyers demand 100% virgin content
- ☐ Unaware of options or technical know-how

Q4 → Interest in Circular Practices: How interested are you in adopting more circular practices (reducing textile waste, recycling waste, using recycled fibers, take-back programs) in your operations?

- ☐ Very interested – already implementing or actively planning
- ☐ Somewhat interested – open to ideas, but not started yet
- ☐ Neutral or unsure – need more information or incentives
- ☐ Not interested currently

Q5 → Buyer Demand for Sustainability: Are your customers/clients asking for sustainable or recycled content in your products?

- ☐ Yes, frequently – sustainability is a key requirement
- ☐ Occasionally – a few clients have shown interest
- ☐ Rarely/No – most clients do not specifically ask for it
- ☐ Not applicable (B2C brand without such feedback)

If applicable: Do you have any sustainability certifications (e.g. Organic, Fair Trade, Global Recycled Standard)?

- ☐ Yes (specify): _____
- ☐ No, none yet

Q6 → Technology & Efficiency:

(c): Would you consider adopting innovative recycling technology on-site if available (e.g. machine to recycle your own waste into fiber, pattern cutting waste reduction, waste shredding machines)?

- ☐ Yes, definitely interested
- ☐ Possibly, if proven and cost-effective
- ☐ Not interested/Not feasible for us

Q7 → Workforce & Skills:

(a): Do your supervisors and workers have the skills needed for new sustainable practices or technologies (e.g. operating new machines, handling recycled materials)?

- ☐ Yes, skill level is sufficient
- ☐ Somewhat – would benefit from additional training
- ☐ No – significant skill gaps exist

(b): Are there women or marginalized groups employed in production roles at your unit?

- ☐ Yes, significant inclusion (>50% of workforce)
- ☐ Moderate (25 - 50%)
- ☐ Some (a few in certain departments)
- ☐ None currently

Q8 → Collaboration in Cluster: Do you engage with Panipat's recycling units or traders (for example, selling them your scrap, or buying recycled yarn/fiber from them)?

- ☐ Yes, regularly (ongoing business relationships)
- ☐ Occasionally (as needs arise)
- ☐ No, little to no interaction

Q9 → Perceived Barriers: What are the main challenges for your company in becoming more circular or sustainable? (Select up to 3)

- ☐ Lack of viable recycled input materials (quality/availability)
- ☐ Additional cost and low margins for sustainable products
- ☐ No customer demand or willingness to pay for sustainable products
- ☐ Limited technical knowledge or support for circular processes
- ☐ Infrastructure issues (e.g. no nearby recycling facility or common treatment)
- ☐ Regulatory uncertainty or lack of incentives
- ☐ Other: _____

Q10 → Support Needed: Which support or incentives would encourage you to adopt circular economy practices? (Select top two)

- ☐ Financial incentives (grants, tax breaks for using recycled materials or waste reduction)
- ☐ Technical support (expert advice, R&D on recycling tech, testing labs)
- ☐ Better supply chain linkages (e.g. reliable sources of recycled fiber or buyers for recycled-content products)
- ☐ Training & capacity building for employees in new technologies
- ☐ Stronger regulations mandating recycling/recycled content (forcing industry-wide action)
- ☐ Consumer awareness campaigns (to create market demand for sustainable products)
- ☐ Other: _____

II. Questionnaires : Textile Waste Recycling MSMEs

Panipat Textile Cluster Assessment: Textile Recycling MSMEs Questionnaires

Introduction & Consent

Panipat is India's largest textile recycling hub, processing hundreds of tons of discarded textiles daily. This survey is part of a cluster assessment under the EU-India RECE project, aimed at strengthening circular economy practices in the textile sector.

As an owner/manager of a recycling MSME (handling post-consumer imports or pre-consumer factory waste), your insights are vital. We seek information on material sourcing, production processes, workforce, market, and technology.

Your responses will be confidential and used to identify needs and opportunities for improving infrastructure, skills, and policies supporting the cluster's growth. Participation is voluntary. By proceeding, you indicate your informed consent to participate.

Consent: I agree to participate in this survey.

☐ Yes ☐ No

Respondent Information (Required)

Name : _____

Organisation/Unit Name : _____

Role/Designation : _____

NIC Code : _____

Q1 → Business Profile:

(a): Workforce Size – Total number of employees (including informal workers)?

☐ 1 - 10 ☐ 11 - 50 ☐ 51 - 200 ☐ > 200

(b): Female Workers – Approximate percentage of your workforce that is women?

☐ 0 % ☐ Less than 25 % ☐ 25 - 50 % ☐ > 50 %

Q2 → Type of Textile Waste Processed: What are the primary sources of textile waste your unit recycles? (Select all that apply)

☐ Imported post-consumer garments ☐ Domestic post-consumer textiles
☐ Pre-consumer industrial waste ☐ Other: _____ (please specify)

Q3 → Monthly Textile Waste Procurement Volume (in Tonnes):

- Unsegregated Textile Waste per month (in tonnes)? _____
- Segregated Textile Waste per month (in tonnes)? _____
- Shredded Textile Waste per month (in tonnes)? _____
- Recyclable Fluff per month (in tonnes)? _____

Q4 → Monthly Textile Waste Processing Volume (in Tonnes):

Production of recycled end products per month (Mention units)? _____

Generation of textile waste generated per month (Mention units)? _____

Q5 → Raw Material Supply Reliability: Is the supply of raw textile waste for your unit adequate and reliable?

☐ Yes, always sufficient ☐ Usually, but occasionally face shortages
☐ No, supply is inconsistent or inadequate ☐ Not applicable (e.g. very small/on-demand sourcing)

If supply issues exist, is it a challenge due to? (Select if applicable)

☐ Limited domestic waste collection networks ☐ Import policy barriers or delays
☐ Low quality of available waste materials ☐ Other: _____

Q6 → Material Traceability: Do you track the flow of materials from input waste to output products (for example, through record-keeping or certification)?

☐ Yes, comprehensive tracking (Inventory records, 3rd-party traceability)
☐ Partial tracking (basic logs of inputs/outputs)
☐ No formal tracking of material flow currently
☐ Not sure / not applicable

Q7 → Recycling Technology & Machinery: What level of technology does your unit use in recycling operations?

- ☐ Basic/manual processes – predominantly manual sorting/cutting, older machines
- ☐ Intermediate mechanization – e.g. shredders, opening machines, semi-automated lines
- ☐ Advanced technology – modern high-speed machines, automated sorting, or chemical recycling
- ☐ Other: _____ (specify)

Q8 → Workforce Skills & Training:

(a): Do your workers (including machine operators) have formal training in recycling processes or machinery operation?

- ☐ Yes, most are formally trained/certified
- ☐ Some have received training, others learn on the job
- ☐ No formal training – mostly on-the-job learning

(b): Would you be interested in skill development programs for your workers (e.g. training in new techniques, safety, maintenance)?

- ☐ Yes, definitely
- ☐ Maybe, if conveniently provided
- ☐ Not a priority currently

Q9 → Worker Health & Safety:

(a): Do you provide protective gear to workers (gloves, masks, etc.) and safety measures in the unit?

- ☐ Yes, all necessary gears and safety protocols
- ☐ Some PPE provided, but not regularly used or enforced
- ☐ No, workers generally work without protective gear

(b): Are there any health checks or insurance/benefits provided for workers?

- ☐ Yes, regular health check-ups and/or insurance
- ☐ Only basic facilities (first-aid, check-ups)
- ☐ No health programs or benefits in place

Q10 → Market for Recycled Products: How would you describe the current demand for your recycled products?

- ☐ Very high demand – easily sell all output, market growing
- ☐ Moderate demand – steady buyers, but growth is limited
- ☐ Low demand – struggle to find buyers or get good prices
- ☐ Highly variable/uncertain – demand fluctuates greatly

Q11 → Primary Market Segments: Who are your main buyers or markets? (Select all that apply)

- ☐ Domestic traders/wholesalers (within Panipat or India)
- ☐ Export buyers (sell products to international markets)
- ☐ Direct to brands/manufacturers (supplying recycled fiber/yarn to textile companies)
- ☐ Local retail market (finished goods sold locally)
- ☐ Government or large contracts (Military blanket supply, GeM)
- ☐ Other: _____

Q12 → Competitive Advantage: Are your recycled products price-competitive compared to equivalent virgin products?

- ☐ Yes, our products are cheaper or similar in price to virgin alternatives
- ☐ Partially, we must offer slightly lower prices to compete
- ☐ No, recycled products are significantly more expensive to produce
- ☐ Not Sure

Q13 → Technology Adoption Plans: Are you planning to adopt any new recycling technologies in the next 1–2 years (e.g. automatic sorting, chemical recycling for fibers, etc.)?

- ☐ Yes, actively planning investment/upgrades
- ☐ Maybe, if financing or support is available
- ☐ No, not in the near future
- ☐ Not sure/need more information on new technologies

Q14 → Perceived Gaps & Needs: In your view, what are the biggest challenges for your recycling business? (Select up to 4 main issues)

- ☐ Market: Limited market or low prices for recycled products
- ☐ Raw Material: Inconsistent supply or quality of textile waste
- ☐ Technology: Outdated machinery, need better tech
- ☐ Finance: Difficulty in getting loans/investment for upgrades
- ☐ Regulations: Complex or costly compliance, policy barriers (e.g. import duty)
- ☐ Competition: Informal/unregulated competitors undercutting prices
- ☐ Infrastructure: Poor infrastructure (power, water treatment, waste disposal) in cluster
- ☐ Skilled Labor: Shortage of trained workers
- ☐ Other: _____

Q15 → Support & Future Plans: Which support measures would most help your unit's growth and circularity?
(Select up to 3)

- ☐ Infrastructure development – e.g. common effluent treatment, waste collection centers
- ☐ Financial incentives to subsidies/tax breaks for recycling units or equipment
- ☐ Technical assistance to access to new tech, R&D, pilot projects
- ☐ Training programs to upgrade worker skills and management capacity
- ☐ Stricter enforcement – ensure all players follow rules (to create level playing field)
- ☐ Market linkage – help connecting with buyers/brands interested in recycled products
- ☐ Policy reform – easier import of waste, export incentives, etc.
- ☐ Other: _____

Q16 → Additional Comments (Optional):

(Please provide any other insights or suggestions regarding textile recycling in Panipat.)

III. Questionnaire: Associations

Panipat Textile Cluster Assessment: Association Questionnaires

Introduction & Consent

The Panipat textile cluster relies on active industry associations and collectives to drive collaborative solutions. This survey is part of a cluster-wide assessment, this survey aims to gather the collective perspective on material flows, common infrastructure, skills, technology adoption, and policy needs.

As an industry association leader, you have a birds-eye view of the cluster's challenges and opportunities. Your responses will guide recommendations for cluster development (better waste management systems, modern technology, training, and policy advocacy).

All information will be kept confidential and used for research and planning purposes. Participation is voluntary; please indicate consent to proceed.

Consent: Our association agrees to participate

- ☐ Yes ☐ No

Respondent Information (Required)

Association/Organization Name : _____

Q1 → Membership Base: How many members (approximately) does your association represent?

- ☐ No of members: _____

Q2 → Circular Economy Awareness: How would you rate the overall awareness and engagement of your members with circular economy practices (recycling, waste reduction, sustainable methods)?

- ☐ High (5) – Many members actively pursuing sustainability
☐ 4 – Good awareness; some initiatives in place
☐ 3 – Moderate; topic is known but action is limited
☐ 2 – Low; only a few members engaged
☐ Very Low (1) – Most members are not aware or involved

Q3 → Common Cluster Issues: In your view, what are the top challenges facing the Panipat textile cluster that need collective action? (Select up to Four)

- ☐ Waste management & pollution (water/air pollution, waste disposal issues)
☐ Raw material supply of textile waste or recyclable fibers
☐ Energy costs & infrastructure related to textile waste supply chain and recycling
☐ Technological lag for recycling of waste
☐ Skilled labor shortage for textile waste processing
☐ Market access for sustainable products
☐ Finance & investment for green technologies upgrades
☐ Regulatory compliance
☐ Other: _____

Q4 → Technology Adoption: How prevalent is modern technology adoption among your members? (e.g. automated sorting, newer looms, recycling innovations)

- ☐ Many have upgraded to modern technologies ☐ Some early adopters, but majorly older methods
☐ Most still use basic or traditional technologies ☐ Not sure/varies widely

Q5 → Training & Skill Gaps: Does the cluster have sufficient workers' skilling initiatives for recycling waste?

- ☐ Yes – training programs are available and utilised ☐ Some – few programs exist but not widespread
☐ No – significant need for skilling ☐ Not sure

If "No" or "Some": What skill areas are most lacking?

- ☐ Processing skills (waste sorting, segregating, cleaning, handling)
☐ Technical skills (machine operation, maintenance)
☐ Safety and environmental management
☐ Quality control & contamination management
☐ Basic literacy/numeracy for work readiness
☐ Other: _____



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