

Panipat Textile Recycling – Sustainability Readiness Report

Prepared by:
Foundation for MSME Clusters (FMC)
in partnership with
Reverse Resources and SUSTENT Consulting

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The report has also benefitted from learnings drawn from another ongoing project:

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This is the Final Draft for public circulation and inputs & comments are welcome for necessary incorporation at our end. The inputs may be provided to the Team Leader, Mr. Abhishek Naga, at abhishek@msmefoundation.org, with the subject line: **Panipat DSR Study – Comments & Inputs**.

The report is also available at: <https://fmc.org.in/publications/>

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Preface

The Foundation for MSME Clusters (FMC) presents this Diagnostic Study Report on Sustainability Readiness of the Panipat Textile Recycling Cluster as a comprehensive, research-based effort to deepen understanding of one of India's most significant industrial ecosystems. The report is the outcome of an intensive six-month engagement by a multidisciplinary team of six professionals, grounded mainly in primary research through direct interactions with more than 100 MSMEs across the cluster.

The information gathered through field engagement was systematically collated and analysed, and subsequently validated through Focus Group Discussions with MSMEs and stakeholders representing different segments of the value chain. The findings were further triangulated with secondary information from diverse sources, including data and insights from the Government of Haryana. This layered methodology ensures that the report reflects enterprise-level realities while capturing value-chain-wide perspectives. At the same time, the study is intended as a foundation for deeper inquiry across specific intervention areas and is not positioned as a static or exhaustive assessment.

Panipat is among the largest textile recycling clusters globally, with a gross annual turnover exceeding ₹1,30,000 crore (approximately €13 billion). With over 75 years of history, the cluster has evolved into a globally significant hub, currently contributing exports of around ₹30,000 crore (approximately €3 billion annually) and providing employment to more than 400,000 people, nearly a third of who are women.

This diagnostic study is path-breaking not only for guiding FMC's own interventions and those of its partners, but also for offering a replicable template for similar studies across textile and apparel clusters. With the Government of India, international agencies, and global buyers increasingly emphasising data-driven programme design and impact assessment, the report responds to a critical need for robust primary evidence.

FMC gratefully acknowledges the support and cooperation of MSMEs, industrial associations, business member organizations, workers, public institutions and all other stakeholders in Panipat. We also sincerely appreciate the financial and intellectual support of our donor partners, whose contributions have enabled the initiatives that this report seeks to inform. It is our hope that this

study serves as a valuable knowledge resource for advancing sustainable, inclusive, and competitive textile value chains in India.

The textile and apparel sector is undergoing a profound transformation as sustainability, circularity, and responsible production increasingly shape global trade and consumption patterns. In this context, this Diagnostic Study Report on Sustainability Readiness of the Panipat Textile Recycling Cluster represents a timely and valuable contribution to India's textile ecosystem.

Panipat occupies a unique position in the global textile recycling value chain. With a history spanning over a century, the cluster has evolved into one of the world's largest hubs for recycled textiles, supporting livelihoods for hundreds of thousands of workers while serving domestic and international markets. As regulatory frameworks—particularly in the European Union—redefine expectations around textile waste management, traceability, and recycled content, clusters such as Panipat will play a critical role in enabling a just and effective transition towards a circular economy.

This study stands out for the depth of its primary research and the robustness of its analytical approach. By engaging extensively with MSMEs across different segments of the value chain and validating findings through stakeholder consultations, the report establishes a credible baseline for informed decision-making. Such diagnostics are essential for designing targeted interventions, aligning public and private investments, and assessing the impact of sustainability initiatives over time.

The report also offers a replicable framework for other textile and apparel clusters in India and beyond. As governments, development agencies, and global brands increasingly collaborate through cluster-based approaches, evidence-led diagnostics such as this will be central to ensuring that sustainability transitions are inclusive, competitive, and resilient.

We trust that the insights presented in this report will support policy dialogue, programme design, and collaborative action among the actors at the cluster level, along with value chain, policy makers and other institutions towards strengthening sustainable textile value chains.

Mr. Mukesh Gulati

Executive Director

Foundation for MSME Clusters (FMC)

30th September 2025

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Abbreviation & Key Terms Glossary

Acronym	Full Form
AHP	Air Handling Plant
ATUFS	Amended Technology Upgradation Fund Scheme
BDSP	Business Development Service Provider
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BMO	Business Membership Organisation
BOCW	Building and Other Construction Workers Act
CBAM	Carbon Border Adjustment Mechanism
CETP	Common Effluent Treatment Plant
CFC	Common Facility Centre
CIPET	Central Institute of Petrochemicals Engineering and Technology
CLCSS	Credit Linked Capital Subsidy Scheme
CLCS-TUS	Credit Linked Capital Subsidy – Technology Upgradation Scheme
COD/BOD	Chemical Oxygen Demand / Biological Oxygen Demand
CRORE	10 Million
CSR	Corporate Social Responsibility
CPCB	Central Pollution Control Board
CSIR	Council of Scientific & Industrial Research
DANIDA	Danida is the term used for Denmark's development cooperation, which is an area of activity under the Ministry of Foreign Affairs of Denmark
DIC	District Industries Centre
DPP	Digital Product Passport
ESG	Environmental, Social, Governance
ESIC	Employee State Insurance Corporation
ETP	Effluent Treatment Plant
FGD	Focus Group Discussion
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GRS	Global Recycle Standard
GOTS	Global Organic Textile Standard
GST	Goods and Services Tax
HES	Haryana Environment Society
HEPC	Handloom Export Promotion Council
HKRNL	Haryana Kaushal Rozgar Nigam Limited
HSPCB	Haryana State Pollution Control Board
HSIIDC	Haryana State Industrial and Infrastructure Development Corporation
IEA	International Energy Agency
ILO	International Labour Organization
IMEX	Import-Export
ISO	International Organization for Standardization
Lakh	A hundred thousand or one tenth of a million
LCA	Life Cycle Assessment
MFI	Microfinance Institution
MLD	Million Litres per Day
MSE-CDP	Micro and Small Enterprises – Cluster Development Programme
MSME	Micro, Small, and Medium Enterprises

Acronym	Full Form
NABARD	National Bank for Agriculture and Rural Development
NCR	National Capital Region
NGO	Non-Governmental Organisation
NITRA	Northern India Textile Research Association
NRLM/NULM	National Rural/Livelihood Mission / National Urban Livelihoods Mission
OHS	Occupational Health and Safety
PET	Polyethylene Terephthalate
PF	Provident Fund
LPG	Liquefied Petroleum Gas
PMEGP	Prime Minister's Employment Generation Programme
PM-KUSUM	Solar scheme for rooftop/off-grid
PMKVY	Pradhan Mantri Kaushal Vikas Yojana
PPP	Public-Private Partnership
PPP Model	Purchasing Power Parity Model
R&D	Research and Development
RECP	Resource Efficient and Cleaner Production
SCB	Sustainable Cluster Branding
SDG	Sustainable Development Goals
SHG	Self-Help Group
SIDBI	Small Industries Development Bank of India
SPV	Special Purpose Vehicle
SSC	Sector Skill Council
STP/ZLD	Sewage Treatment Plant / Zero Liquid Discharge
Udyam	MSME Registration Portal
UNIDO	United Nations Industrial Development Organization
UNHCR	United Nations High Commissioner for Refugees
VFD	Variable Frequency Drive
ZED	Zero Defect Zero Effect

Glossary of Key Terms:

Term	Definition
Recycled Textiles	Textiles produced from post-consumer or post-industrial waste, processed through sorting, tearing, spinning, dyeing, and weaving.
Shoddy Yarn	Low-cost yarn made from mechanically shredded woollen or acrylic rags, widely produced in Panipat.
Open-End Spinning (OE)	A spinning technology used to convert recycled fibres into yarn; widely used in Panipat due to its efficiency in handling mixed fibres.
Sorting & Grading	Manual separation of used garments by fibre type, colour, texture and reuse potential; the first and most labour-intensive stage.
Tearing/Shredding	Mechanical opening of waste garments into fibres using Italian or Indian-made tearing machines.
Liquor Ratio	Ratio of water to fabric in dyeing; lower ratios indicate more efficient dyeing.
Biomass Briquettes	Agri-waste-based solid fuel used in boilers replacing coal in Panipat after NCR norms.
Value Chain Leakage	Loss of potential value due to inefficiencies, low prices, waste generation, or informal practices.

Term	Definition
Traceability	Ability to track textile material flow from waste import to final product, increasingly demanded by global buyers.
Digital Product Passport (DPP)	EU-mandated digital record containing environmental, material, and origin information for textile products.
Circular Economy	Production model focused on reducing waste and keeping materials in use as long as possible.
Cluster Development	Collective upgrading of MSMEs through shared infrastructure, governance, finance, and skills.
Effluent Load	Combined chemical concentration discharged from dyeing processes, measured via COD, BOD, TDS, etc.
Resource Efficiency	Efficient use of energy, water, materials, and chemicals to reduce waste and cost.
Scope 1/2/3 Emissions	Direct, indirect (electricity), and supply-chain emissions from cluster operations.
Heat Recovery	Capturing waste heat from boilers and dyeing machines for reuse, reducing fuel consumption.
Micro-Enterprise	Units with low investment levels (often INR less than 5 crore turnover), dominant in sorting and weaving.
Informal Workforce	Workers without contracts, social security, or stable wages, common in sorting and stitching but also prevalent in other operations.
Green Finance	Finance directed to low-carbon upgrades—efficient machinery, solar power, ETP improvements.
ESG Compliance	Buyer requirements on environment, labour rights, and governance performance.
Cluster Governance	Collective decision-making structure involving industry associations, government and institutions.
Low-Carbon Transition	Shift to cleaner energy, efficient technologies, and reduced emissions across units.
Blended Finance	Combining grants, concessional loans, and commercial finance to fund green upgrades.
Zero Liquid Discharge (ZLD)	System ensuring no wastewater leaves the unit; water is recycled internally.
Rotor Spinning	The technique used in open-end spinning that handles short recycled fibres efficiently.
Warp/Weft	Horizontal (weft) and vertical (warp) yarns in weaving; determines fabric quality and strength.
Process House	Dyeing/printing units that handle wet processing; the most resource-intensive stage.
Cluster Bedsread/Blanket Value Chain	The integrated flow from recycled fibres to finished blankets exported globally.

1. Executive Summary

1.1. Study Context and Rationale

The Panipat textile cluster, located in Haryana, stands at the heart of India's circular economy. Often called the "cast-off capital," it processes nearly 60% of India's recycled textile waste and contributes approximately INR 1,25,000 crore (Euro 12.5 billion¹) annually to the national textile economy, including exports of around INR 29,000 crore (Euro 2.9 billion). This vibrant hub produces recycled yarns, blankets, carpets, and home furnishings that reach both domestic and international markets, particularly Europe, America, Middle East, and Africa.

Despite its economic significance, the cluster faces mounting sustainability and competitiveness challenges. Outdated technologies, resource-intensive production, and high carbon emissions have created a risk of trade barriers, especially as global regulations such as the EU Green Deal, ESPR, and CBAM tighten environmental norms. Moreover, social vulnerabilities, especially the dependence on informal, low-wage, and gender-segregated labour, pose additional structural challenges.

Against this backdrop, the present diagnostic study was commissioned to assess the Panipat recycled textile cluster through an integrated lens of workforce skills, gender inclusion, and decarbonisation readiness. Key objectives of the study are -

1. Establish a baseline of energy use, emissions, and workforce skills;
2. Identify decarbonisation pathways aligned with India's Net Zero goals;
3. Map gendered labour patterns, skilling gaps, and inclusion barriers;
4. Recommend policy, financial, and institutional strategies for a low-carbon transition.

1.2. Cluster Profile and Economic Landscape

Panipat has evolved from a traditional handloom base into India's largest recycled textile ecosystem. The cluster encompasses around 6,400 micro, small, and medium enterprises engaged in sorting, spinning, weaving, dyeing, and finishing operations in addition to multiple allied service providers required by the cluster. Together, they process nearly 4,000 tonnes textile waste daily having major portion of imported textile waste- equivalent to around 14.50 lakh tonnes annually, sourced primarily from European, Asian and North American countries.

The sector directly and indirectly employs about 4.5 lakh workers, including 30–40% women. Most workers are migrants from Bihar, Uttar Pradesh, and West Bengal, and are employed in informal, unregistered setups. Women are concentrated in sorting, finishing, and stitching roles, activities that are highly labour-intensive yet low-paying and lacking social protections.

Panipat's recycled textile industrial footprint spans over 2,400 square kilometres, covering parts of Panipat, Karnal, and Sonapat. Specific industrial zones have developed functional specializations: Barsat and Noorwala for sorting, Faridpur and Kabri Road for spinning, and Sectors 25 and 29 for dyeing. Together, these nodes form a deeply interconnected network of circular textile production.

1.3. Environmental Footprint and Decarbonisation Baseline

Most of the dyeing units have transitioned from coal to biomass or LPG, overall energy efficiency levels vary across units, largely influenced by the age of installed boilers and variability in fuel quality, indicating opportunities for targeted technology upgrades and performance benchmarking. The observations

¹ One Euro equals INR 100 in mid-2025 when the study was conducted.

presented are based on sample-level diagnostics and stakeholder consultations and are intended to identify improvement opportunities rather than serve as compliance determinations for individual enterprises or regulatory authorities.

The cluster's dyeing units are said to consume nearly 50 million litres of water daily. The estimates however vary across different sources pointing to higher levels. The effluent treatment plants (ETPs) also exhibit varying levels of operational performance, with scope for improvement through enhanced operator training, process optimisation, and strengthened operations and maintenance practices. Digitalization and traceability are still at an early stage. Only export-oriented enterprises using certifications like GRS and GOTS have adopted partial tracking systems. Most MSMEs operate with paper-based or Excel-based records. There is growing awareness, however, that traceability will soon become a market prerequisite under EU circularity mandates, creating a strong case for a shared Digital Product Passport (DPP) system within the cluster.

1.4. Key Barriers to Decarbonisation

The study identifies four broad categories of challenges:

1. **Technological Barriers:** Predominance of obsolete machinery, low R&D engagement, and limited automation in sorting and finishing.
2. **Financial Constraints:** High upfront costs for energy-efficient or cleaner technologies, coupled with limited access to concessional green finance.
3. **Institutional Weaknesses:** Fragmented governance, weak coordination among industry bodies, and inadequate policy integration.
4. **Behavioural and Social Barriers:** Low awareness of environmental standards, gendered exclusion from skilling, and resistance to formalisation.

These issues collectively limit the cluster's ability to comply with emerging sustainability standards and compete globally in an increasingly low-carbon textile economy.

1.5. Workforce Skills, Gender Inclusion, and Social Dynamics

The study reveals a clear mismatch between the skills available and those required for a green, technology-driven textile ecosystem. Most workers acquire skills informally through on-the-job learning, with limited exposure to structured training in energy management, machine efficiency, wastewater treatment, or occupational safety.

Women form the backbone of Panipat's sorting and finishing operations but remain excluded from higher-skill, better-paying technical roles due to socio-cultural norms, lack of formal skilling avenues, and unsafe working environments. Wage disparity is widespread, and most women workers are paid on a piece-rate basis with no access to social security, healthcare, or savings mechanisms.

Recent interventions such as women-led stitching cooperatives, e-Shram registrations, and NGO-led training on occupational health, have shown promise but remain limited in reach. Building a gender-responsive skilling ecosystem and formalizing informal labour relationships will be crucial for achieving both social equity and industrial resilience.

1.6. Institutional and Financial Ecosystem

Panipat's industrial ecosystem is supported by around 30 industry associations/Business Member Organizations (BMOs), but only a few of them are active. These bodies facilitate policy dialogue, training, and infrastructure coordination but often lack dedicated focus on decarbonisation and gender inclusion.

Access to finance remains uneven. While larger enterprises can secure term loans for modernization, most MSMEs and informal units struggle to access formal credit due to low collateral and limited awareness of public schemes. Less than 15% of enterprises have accessed financial support under initiatives such as ZED, CLCS-TUS, or SIDBI's GIFT scheme for green financing. There is a pressing need to strengthen the capacity of bankers and financial intermediaries to assess green investments and link them to viable business returns.

On the technology front, progress has been incremental. Mechanized sorting, soft-flow dyeing, and high-speed looms have been introduced in a few advanced units, but large-scale modernization is hindered by cost and skill barriers. Engagement with R&D institutions like NITRA, IIT Delhi, and CIPET could bridge this gap by supporting process innovation and equipment design tailored to recycled materials.

1.7. Strategic Vision and Roadmap

The report envisions ***Panipat as India's first low-carbon, circular, and socially inclusive textile recycling cluster by 2035***. Achieving this vision requires an integrated roadmap with the following strategic priorities:

- ▶ **Energy and Process Decarbonisation:** Promote renewable energy, energy audits, boiler retrofits, and rooftop solarisation through blended finance.
- ▶ **Water and Chemical Management:** Scale ZLD systems, encourage low-liquor and dye-free technologies, and improve ETP performance through operator training.
- ▶ **Circular Value Chain Integration:** Establish automated sorting, fibre recovery hubs, and upcycling enterprises to minimize waste and increase material efficiency.
- ▶ **Workforce Development:** Set up a dedicated Green Skill and Inclusion Centre to train workers – especially women and youth – in sustainable production.
- ▶ **Digital and Traceability Systems:** Develop a cluster-wide traceability platform linked to DPP compliance and green branding.
- ▶ **Institutional Coordination and Finance:** Form a Decarbonisation and Resource Efficiency Cell (DREC) under a cluster SPV to drive public-private collaboration and mobilize green finance.

2. Introduction

2.1 Contextual Overview

The Panipat textile cluster, globally recognized for its recycled yarns and home furnishings, is a cornerstone of India's circular economy. Known as the "cast-off capital," Panipat processes nearly 60% of the country's recycled textile waste, reflecting its entrepreneurial strength and global relevance. The cluster contributes significantly to India's textile exports, with an annual turnover of approximately INR 1,25,000 crores, including nearly INR 29,000 crores from exports-half of which are destined for the European and American countries.

However, outdated technologies, resource-intensive processes, and high carbon emissions pose risks to the cluster's long-term competitiveness, particularly under emerging international trade regulations such as the EU Green Deal, ESPR, and CBAM. Against this backdrop, the study was undertaken to establish a comprehensive baseline of energy use, emissions, sustainability practices, and traceability mechanism. The objective of the study is to generate data required for testing the Reverse Resources and SUSTENT Consulting's models and to chart a structured decarbonisation pathway and traceability mechanism for the cluster.

2.2 Objectives and Scope

The study aims to undertake a comprehensive assessment of the Panipat textile recycling cluster, focusing on its environmental performance, sustainability challenges, establishing traceability and transition pathways toward a low-carbon, resource-efficient future.

- ▶ **Assess the carbon footprint** of the Panipat textile cluster across key production and processing stages.
- ▶ **Identify sustainability gaps** in critical operational areas including energy consumption, water use, material efficiency, chemical management, traceability of textile waste and social inclusion.
- ▶ **To assess current practices and develop** a clear roadmap for improving traceability.
- ▶ **Prioritise decarbonisation opportunities** aligned with India's climate commitments and emerging global trade and sustainability frameworks.
- ▶ **Develop a roadmap for a green transition** that safeguards and enhances the cluster's competitiveness in international markets.

The scope encompasses the entire recycled textile value chain-sorting, spinning, weaving, dyeing, finishing, and allied processes-with emphasis on energy efficiency, renewable energy adoption, traceability systems, and resource optimization.

2.3 Research Methodology

The study employed a **mixed-method approach** (Multiple data sources and analytical techniques) that combined quantitative and qualitative tools to ensure robust analysis. It included:

- ▶ Primary surveys and unit-level field assessments to capture ground level data on energy, water, chemical, material, traceability mechanism, use of digital platforms etc.
- ▶ Focus group discussions and stakeholder consultations with industry representatives, associations, technical experts, Business Development Service Providers (BDSPs), government stakeholders, policymakers etc.
- ▶ Carbon footprint assessment frameworks and benchmarking against global best practices to evaluate performance gaps.
- ▶ A targeted literature review of national and international decarbonisation pathways and emerging sustainability standards in the textile sector.

This multi-pronged & triangulation methodology enabled a comprehensive assessment of the cluster's sustainability performance and improvement opportunities.

2.4 Limitations of the Study

- ▶ The analysis is based on sample-level data collected from individual units, focus group discussions with BMOs and associations, as well as consultations with stakeholders including technical experts and BDSPs. As such, it may not fully capture variations across all cluster units.
- ▶ Reliable data on energy, water, chemicals, materials, and traceability were limited, affecting precision in carbon footprint calculations.
- ▶ The study reflects the current technological and operational landscape and does not account for future policy shifts, trade dynamics, or disruptive innovations.

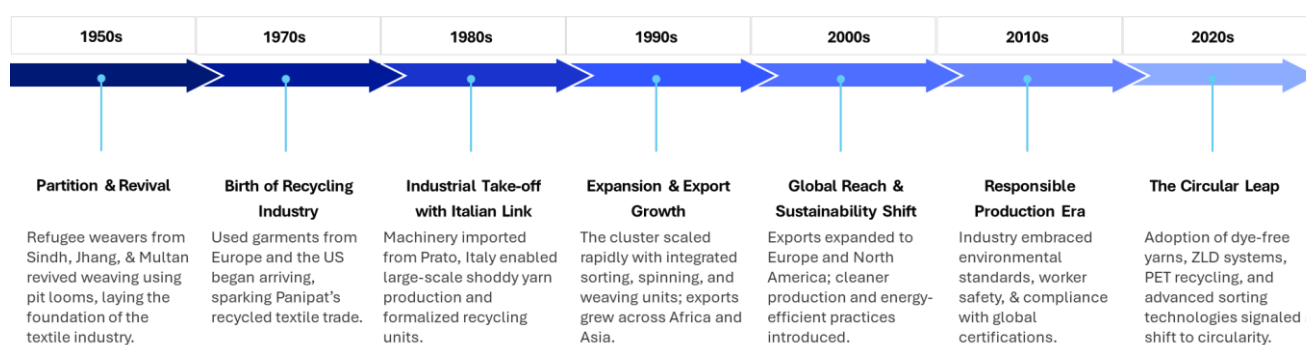
Despite these constraints, the findings provide a robust baseline for targeted decarbonisation strategies and a roadmap to strengthen the cluster's sustainable competitiveness. However, the turnover, employment and number of enterprises engaged is a function of performance of the cluster during any period.

3. Cluster Profile

3.1. Evolution of the Recycled Textile Industry in Panipat

Panipat, once known from the *Mahabharata* as Panduprastha and famed for its three historic battles (1526, 1556, and 1761), has transformed from a legendary battleground into the global hub of recycled textiles. This shift began after the Partition of 1947, when skilled weavers from regions like Sindh, Jhang, and Multan settled in Panipat. Bringing their traditional weaving expertise, they revived the craft on pit looms, laying the foundation for the city's modern textile industry and its rise as India's leader in textile recycling.

Figure 1: Historical Development of Panipat Recycled Textile Cluster



The Birth of a New Industry & Its Connect with Italy

In the 1970s, Panipat's textile sector underwent a transformation with the arrival of used clothing shipments from Europe and North America. Local entrepreneurs began sorting and repurposing these garments, establishing the foundation of India's largest textile recycling hub. Driven by the high cost and limited supply of virgin cotton, they turned to textiles waste as a cost-effective raw material.

The 1980s brought the first wave of industrial organization when several second-hand machines from Prato, Italy - a city known for textile recycling - were imported and installed in Panipat. Favourable trade policies, combined with public policy for MSME support, enabled Panipat's recycling industry to scale rapidly. With that, some of the informal sorting yards turned into structured processing units, and woollen rags were reborn as **shoddy yarn**.

The production of shoddy yarn was driven by economic efficiency. Using recycled fibres significantly reduced input costs compared to virgin cotton or wool, enabling the manufacture of affordable blankets, durries, and yarn for mass markets at home and abroad. The availability of low-cost second-hand machinery from Prato further allowed Panipat's entrepreneurs to expand production with minimal capital investment-turning shoddy yarn into both a cost-saving innovation and a scalable business model.

Industrial Take-off & Export Growth

By the 1990s, Panipat's recycling industry had gained strong momentum. Units multiplied, power looms operated around the clock, and skilled workers from neighbouring states strengthened its workforce. The city evolved into an integrated ecosystem of rag-sorting yards, spinning mills, dyeing units, and weaving workshops, earning it the title "**Shoddy Yarn Capital of India**". Its recycled products found export markets in Africa, the Middle East, and Latin America.

Through the 2000s, Panipat's recycled textiles reached further markets in Europe, and America. Export volumes rose steadily as buyers were drawn to the affordability and versatility of its products. However,

the following decade brought increasing scrutiny over pollution and labour conditions. In response, the cluster began adopting cleaner and more efficient production practices, supported by initiatives from the State Government, Small Industries Development Bank of India (SIDBI), and Bureau of Energy Efficiency (BEE) marking the beginning of its journey toward responsible and sustainable recycling.

The Circular Leap

By 2020, Panipat stood at crossroads-and chose transformation. Inspired by the global shift toward responsible circular economy and ESG compliance, industry leaders began adopting tangible and measurable interventions:

- ▶ **Dye-Free Yarn Production:** Several mills have started producing dye-free yarn directly from recycled textiles, using the inherent colours of waste fabrics. This approach eliminates the need for water-intensive, chemical-heavy dyeing, significantly reducing resource use and environmental impact.
- ▶ **Effluent Treatment & Water Management:** Several units have invested in Effluent Treatment Plant (ETPs) systems as well as in Common Effluent Treatment Plants (CETPs) to reduce wastewater, aligning with stricter environmental norms.
- ▶ **Certifications and Compliance:** Many enterprises have obtained globally recognized certifications such as Global Recycling Standards (GRS), Global Organic Textile Standard (GOTS), OEKO-TEX, and ISO 9000, validating recycled content, responsible sourcing, minimal chemical use, and alignment with global ESG standards.
- ▶ **Technology Upgradation:** Few MSMEs have introduced mechanical sorting technologies to improve accuracy and reduce manual errors.
- ▶ **Expanded Recycling Scope:** The cluster has diversified into PET bottle recycling, blending recycled polyester with textile fibres to expand its circular footprint beyond cotton, wool, and acrylic waste.

These actions collectively indicate a decisive shift from a cost-driven recycling model to a resource-efficient and compliance-oriented circular production system, positioning the cluster as a global example of circularity in the textile sector.

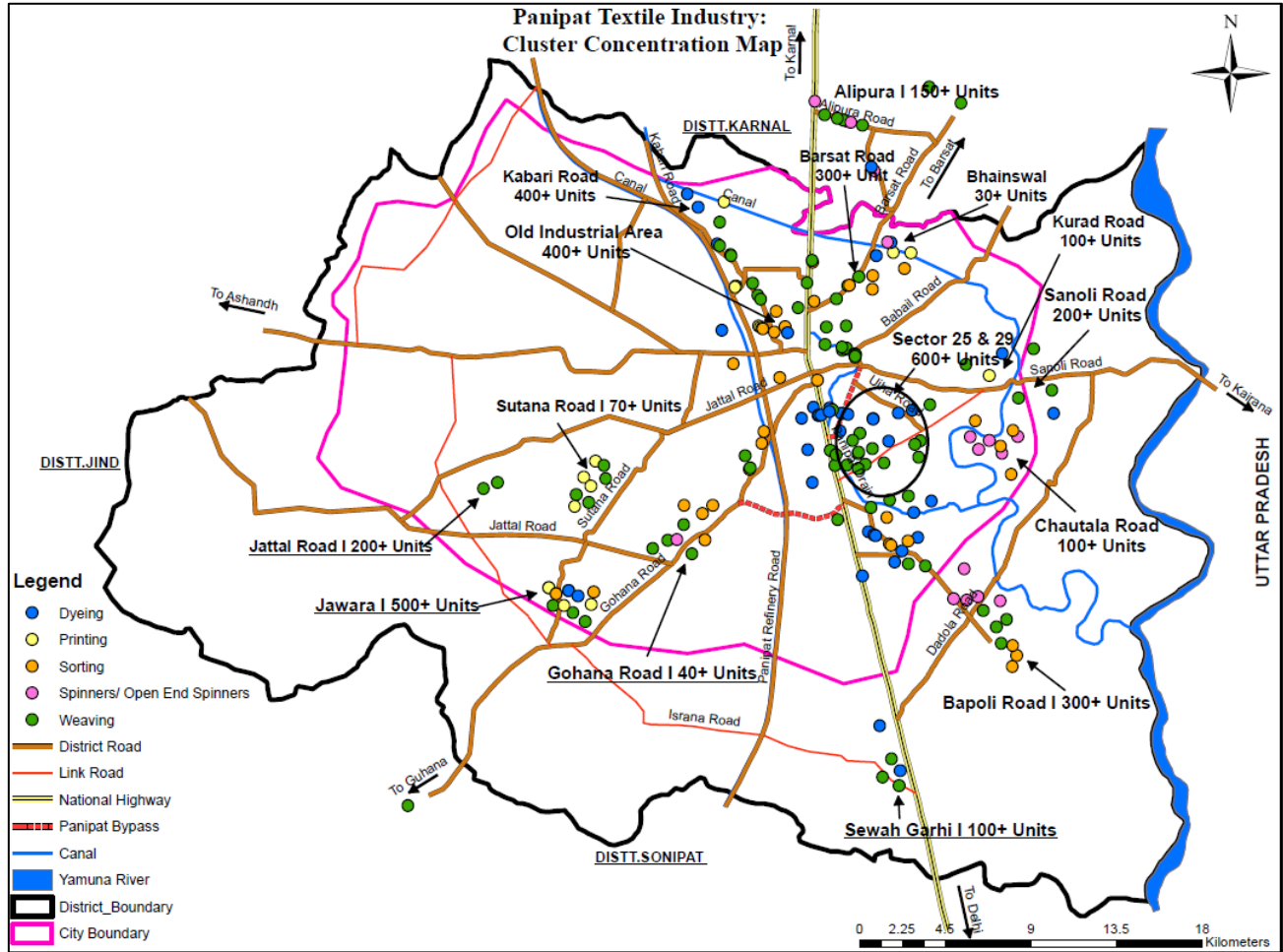
Today, Panipat is more than a recycling hub-it is a critical node in the global circular textile economy. The cluster processes post-consumer textile waste from developed countries and exports recycled yarns, fabrics, and home textiles back to international markets, including those that generated the waste. In doing so, it extends the lifecycle of textile materials that would otherwise end up in landfills.

Through recycling, re-spinning, and repurposing, Panipat demonstrates how industrial ecosystems can embed circularity into production, optimising resource use and reducing environmental impact. The cluster stands as a symbol of resilience and adaptive innovation, a story of people, perseverance, and purpose woven into the fabric of sustainability.

3.2. Geographic Spread and Cluster Boundaries

Though formally anchored in the Panipat city of Haryana, the recycled textile cluster pulses far beyond its administrative borders. It extends in all directions-urban and semi-urban zones alike forming an industrial corridor that spans around the city, infiltrating into the neighbouring districts of Rohtak, Sonipat, Kaithal and Karnal as well. Each neighbourhood and village contribute a unique thread to this fabric, specializing in different parts of the recycling value chain. A geographical map of the cluster is placed below, that is further explained in the paragraphs thereafter.

Figure 2: Geographical Map of Panipat Textile Recycling Cluster



Each region within this expansive cluster has evolved its own industrial character, shaped by local expertise, infrastructure, and decades of specialization.

In the localities of Bhaiswal, Kabari Road, Old Industrial Area (outer), and Barsat Road in Panipat district, skilled workers meticulously sort piles of discarded garments. These areas serve as the primary **rag-sorting zones**, marking the starting point of the textile recycling process. A similar level of activity defines Gohana Road, and Jattal Road, key clusters where vast quantities of used textiles are systematically categorized by colour, fabric type, and reuse potential.

In the newer industrial townships of Sector 25 and Sector 29, the air carries the distinctive scent of dyes. These areas constitute the principal **dyeing hubs** of Panipat, housing facilities where stripped yarns and fabrics are revitalized with new colour and texture. The Old Industrial Area and stretches along the GT Road corridor also house several dyeing, printing, and sorting units.

The **spinning units** are concentrated along Alipura Road, Dadola Road, and Sanoli Road, extending toward Chautala Road. These areas serve as the cluster's production backbone, where shredded fibres are spun into shoddy and recycled yarn.

Further west and south, Jattal road, Sutana Road, Jawara, and Bapoli Road host clusters engaged in weaving, printing, and dyeing. These zones integrate both small-scale family workshops and medium industrial units, ensuring flexibility and diversity in production capacity.

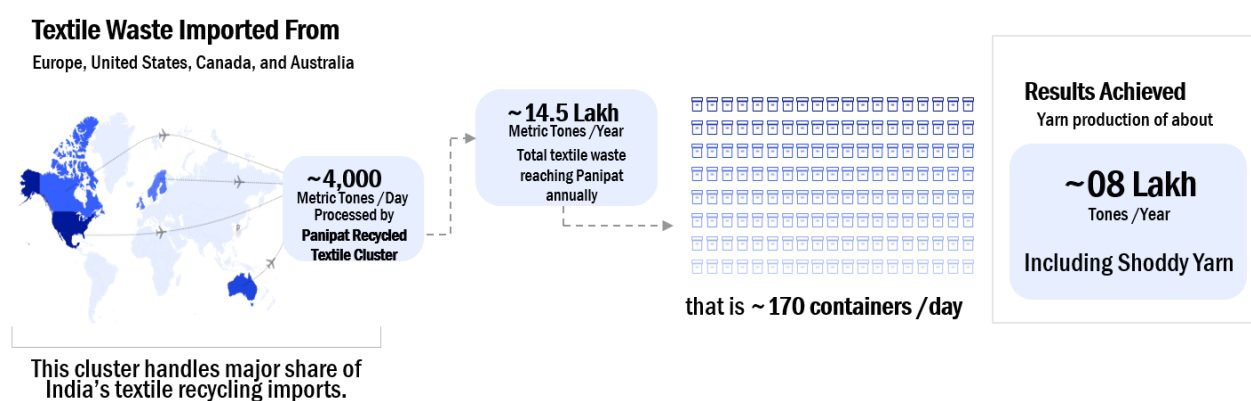
The final stage of the recycling chain thrives in Sector 15, Sector 28, Mohit Nagar, Kishanpura, Chawla Colony, and Shiv Nagar, where dense networks of looms and artisans transform recycled yarns into home furnishings, upholstery, *durries* (floor coverings), and *khes* (cotton throws) for global markets.

3.3. Scale of Operations and Diversity of the Cluster

3.3.1. Scale of Operations

Every day, the Panipat Recycled Textile Cluster processes approximately 4,000 metric tonnes of textile waste, imported and domestic both. This single cluster accounts for a substantial share of India’s total imported textile recycling volume, underscoring its national and global significance in circular textile economies. An average inflow of approximately 170 containers per day, with each container carrying around 22 tonnes of all type of textile’s waste, the estimated annual inflow to Panipat, which equals around 14.5 lakh tonnes per year. This results in the recycled yarn production of about 08 lakh tonnes per annum, including the shoddy yarn.

Figure 3: Scale of Operations



The cluster also processes a smaller volume of PET (polyethylene terephthalate) polyester staple fibre materials, with industry estimates suggesting 54,000+ metric tonnes of PET fibre spun into yarns annually for carpets, blankets, and mattress or pillow fillings. The PET-based recycled fibre segment represents a market valued at INR 500-600 crores per annum, indicating a nascent but growing synthetic recycling capacity that contrasts with China’s more advanced polyester recycling infrastructure, where recycled polyester accounts for 14% of the fibre market.

The table below outlines the approximate scale and functional segmentation of the cluster economy.

Table 1: Segment-wise distribution of MSMEs with Turnover in the Cluster

Segments	Product Manufacturing Units	Spinning Units (Shoddy & Open-End)	Sorting & Grading Units	Dyeing Units	Value Addition, Stitching & Finishing Workshops / Vendors
Approx. No. of Units	4,850+	147+	575+	355+	73,000+
Typical Annual Turnover Range (INR Crores)	0.5 – 500+	10 – 500+	0.5 – 50	0.5 – 50	0.05 – 10

The table below presents the turnover-wise distribution of textile units within the Panipat Recycled Textile Cluster, illustrating the variation in economic scale across functional segments. The majority of enterprises

fall within the INR 1–5 crore and 50-100 crores turnover segments, reflecting the dominance of micro and small-scale units. Manufacturing units form the largest segment with 4,850 establishments, followed by dyeing, sorting and grading, and spinning units. A smaller proportion of medium-scale enterprises operate in the INR 10–50 crore range, while large-scale units (INR 100 crore and above) are primarily concentrated in spinning and manufacturing, including several export-oriented firms. The pattern underscores a highly diverse industrial base, dominated by MSMEs with limited capitalisation and scope for scaling through targeted finance and technology interventions.

Table 2: Turnover Distribution Across Textile Segments

Turnover range/ annum (in INR. crores)	Only Manufacturing Units	Manufacturing and Export Units	Dyeing Units	Spinning Units	Sorting & Grading Units
0.5-1	500		150	-	250
1-2.5	300		100	-	100
2.5-5	200	400	60	-	140
5-10	150	340	40	-	75
10-50	210	600	5	50	5
50-100	130	1,250	-	90	5
100-500	50	700	-	3	-
500+	10	10	-	4	-
Total	1,550	3,300	355	147	575

Concentration of textile units by turnover range: **High**  **Low**

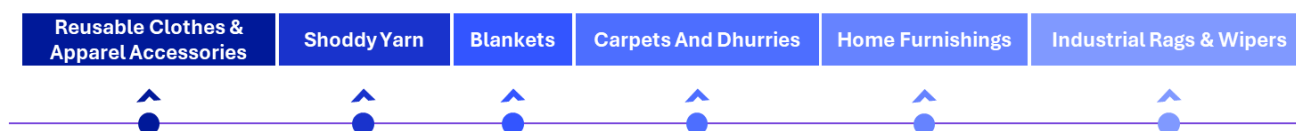
3.3.2. Diversity of Major Recycled Products

The cluster specializes in a wide range of recycled textile products tailored for both domestic consumption and export markets, including:

- ▶ **Limited re-processing items and apparel accessories** (e.g. zips, chains, buttons etc.): During sorting and grading, a portion of textile waste is re-processed and sold to downstream markets, while apparel accessories are separated beforehand and sold by weight in the domestic market.
- ▶ **Shoddy yarn** is produced by tearing old woollen and acrylic rags into fibres and re-spinning them into new yarn. In Panipat, it is primarily associated with woollen and acrylic-based recycled yarns used in blankets, rugs, and durries, making the city India's largest producer of shoddy yarn. The term recycled yarn more broadly refers to yarn made from re-used fibres-wool, cotton, or synthetics-through newer technologies. While often used interchangeably with "shoddy," recycled yarn typically offers a lower carbon footprint, requiring less energy and fewer virgin raw materials. By reusing existing textile waste, the process avoids energy-intensive raw material extraction and reduces associated emissions, making it a more resource-efficient and climate-friendly alternative.
- ▶ **Blankets:** Recycled fibre-based blankets produced in Panipat cater to government procurement (e.g., disaster relief, defence, railways and others) and international humanitarian aid agencies such as the Red Cross and UNHCR.
- ▶ **Carpets and Dhurries:** Waste cotton and synthetic fibres are woven into low-cost floor coverings. These products are in demand in both domestic low-income housing and export markets in Africa, Latin America, and the Middle East.

- ▶ **Home Furnishings:** Includes rugs, mats, cushion covers, and throws, primarily manufactured using leftover fabric and yarn blends. These products are exported widely and have growing acceptance in sustainable home décor markets.
- ▶ **Industrial Rags and Wipers:** Textile waste is also converted into cleaning cloths, rags, and wipers used in automotive, oil and gas, and heavy industries.









Figure 3: Major Recycled Textile Products Produced in the Panipat Cluster



3.4. Employment Dynamics and Production Structure of the Cluster

The Panipat textile recycling cluster is one of the largest employment generators in Haryana’s manufacturing landscape, engaging an estimated 4.50 lakh workers across its diverse value chain. Employment is spread across sorting and grading, shoddy yarn production, blanket and carpet weaving, home furnishing, finishing, and a vast network of stitching and packaging vendors. A majority of these jobs are concentrated in micro and informal enterprises, particularly in sorting, stitching, and finishing activities that rely heavily on migrant and women workers. It is estimated that around 30–40% of the total workforce are women, most of whom are engaged in low-income, labour-intensive activities such as sorting, stitching etc. The overall employment pattern reflects a complex but interdependent ecosystem, where both formal and informal enterprises contribute to livelihoods across production, logistics, and allied services.

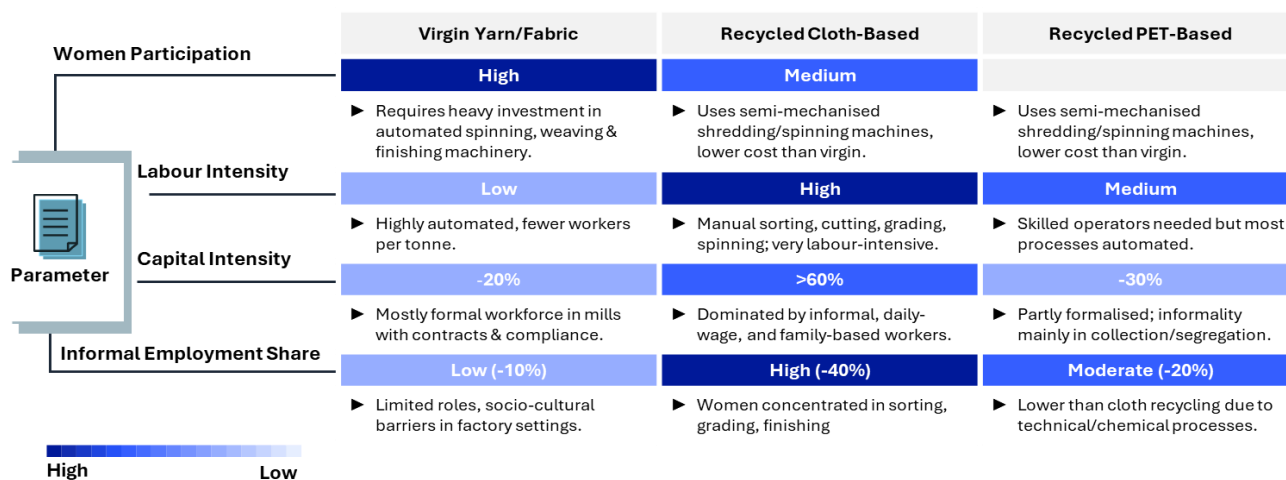
Table 3: Estimated Employment Spread Across Units

Segment	Nature of Employment	Estimated Workers
Support and Logistic Services	Driver, Loader, Warehouse, Traders, Labours	65,000 
Vendors	Raw Material Supplier, Dyes & Chemicals, Machinery & Spare Parts, Allied Services	45,000 
High End Furnishings & Finishing	Stitching, Automatic Tufting, Weaving, Embroidery, Packaging	1,10,000 
Carpet and Rugs Weaving	Home-based & Loom Operators, Manual Tufting	70,000 
Dyers	Skilled, Semi-Skilled, Un-Skilled	45,000 
Yarn Manufacturing	Skilled, Semi-Skilled, Un-Skilled	80,000 
Reaped Material Waste Handling	Informal	10,000 
Sorting & Grading	Mostly Women	25,000 

The production structure of the Panipat cluster reflects clear distinctions between virgin textile manufacturing and recycled cloth-based processes, both in terms of capital requirements and labour intensity. Virgin yarn and fabric production is capital-intensive and highly automated, relying on advanced spinning and weaving machinery that demands significant investment but employs relatively fewer workers. In contrast, Panipat’s recycled cloth-based industry is far more labour-driven, depending on manual sorting, cutting, grading, and open-end spinning. This segment provides large-scale employment, much of it informal and daily-wage based, with a high concentration of women workers, particularly in sorting and finishing operations. Overall, the recycled cloth-based model remains a low-capital, high-

employment system, representing a distinctive labour-intensive pathway within India’s broader circular textile economy.

Figure 4: Capital, Labour, and Employment Dynamics Across Textile Production Types



4. Cluster Stakeholder Landscape

The Panipat Recycled Textile Cluster represents one of India's most dynamic circular economy ecosystems, integrating diverse stakeholders across the textile value chain. The cluster's strength lies in its complex interlinkages between traditional skills, industrial innovation, and sustainability-driven entrepreneurship. Effective stakeholder engagement and inclusive practices are essential to sustaining this ecosystem's growth while ensuring equitable social and economic outcomes for all participants.

4.1. Key Value Chain Stakeholders

The Panipat textile recycling cluster is one of largest clusters of India that is primarily composed of Micro, Small, and Medium Enterprises (MSMEs), which form the backbone of its local industrial ecosystem. There are very few large enterprises (less than 10) operating in the cluster, particularly in the export segment, with integrated manufacturing systems in house. All the other enterprises are MSMEs that specialise in a diverse range of activities starting from sorting, ginning, spinning, dyeing, weaving and finishing a range of recycled home textiles. Some of these enterprises are very small, typical of the processes that they are engaged in, while others are relatively bigger with higher economies of scale and bigger investment requirements. The enterprise size typically varies based on the product type, level of technological advancement, and target markets (domestic vs. export).

Table 4: Size-Based Classification of Cluster Units and Their Typical Production Processes

Micro Units				Investment	Turnover
Post consumer textile waste sorting yards including manual tearing	Home-based stitching units	Handlooms	Carpet weaving units	< INR 1 Cr	< INR 5 Cr
Small Units				Investment	Turnover
Ginning & Spinning	Dyeing	Power-loom based weaving units		< INR 10 Cr	< INR 50 Cr
Medium Units				Investment	Turnover
Semi-mechanized yarn production	Blankets making units	Contract manufacturers of final products		< INR 50 Cr	< INR 250 Cr
Large Enterprises				Investment	Turnover
Fully integrated exporters	Automated blanket/ carpet exporters			> INR 50 Cr	> INR 250 Cr

Open End and Shoddy yarn production, the cluster's core activity, is dominated by medium and small units operating mechanised setups that supply yarn across the value chain. Blanket manufacturing is led by medium and large enterprises, many with export and institutional buyers, while carpets, rugs, and home furnishings are produced mainly by micro and small units, often using power looms or handlooms and engaging women workers in stitching and finishing. Sorting and grading operations remain largely informal and family-run, whereas finishing and packaging units function as subcontracted value-add extensions. Export houses, typically medium or large - manage integrated design, production, and quality control, linking the cluster to global markets.

Figure 5: Panipat Recycled Textile Cluster Map

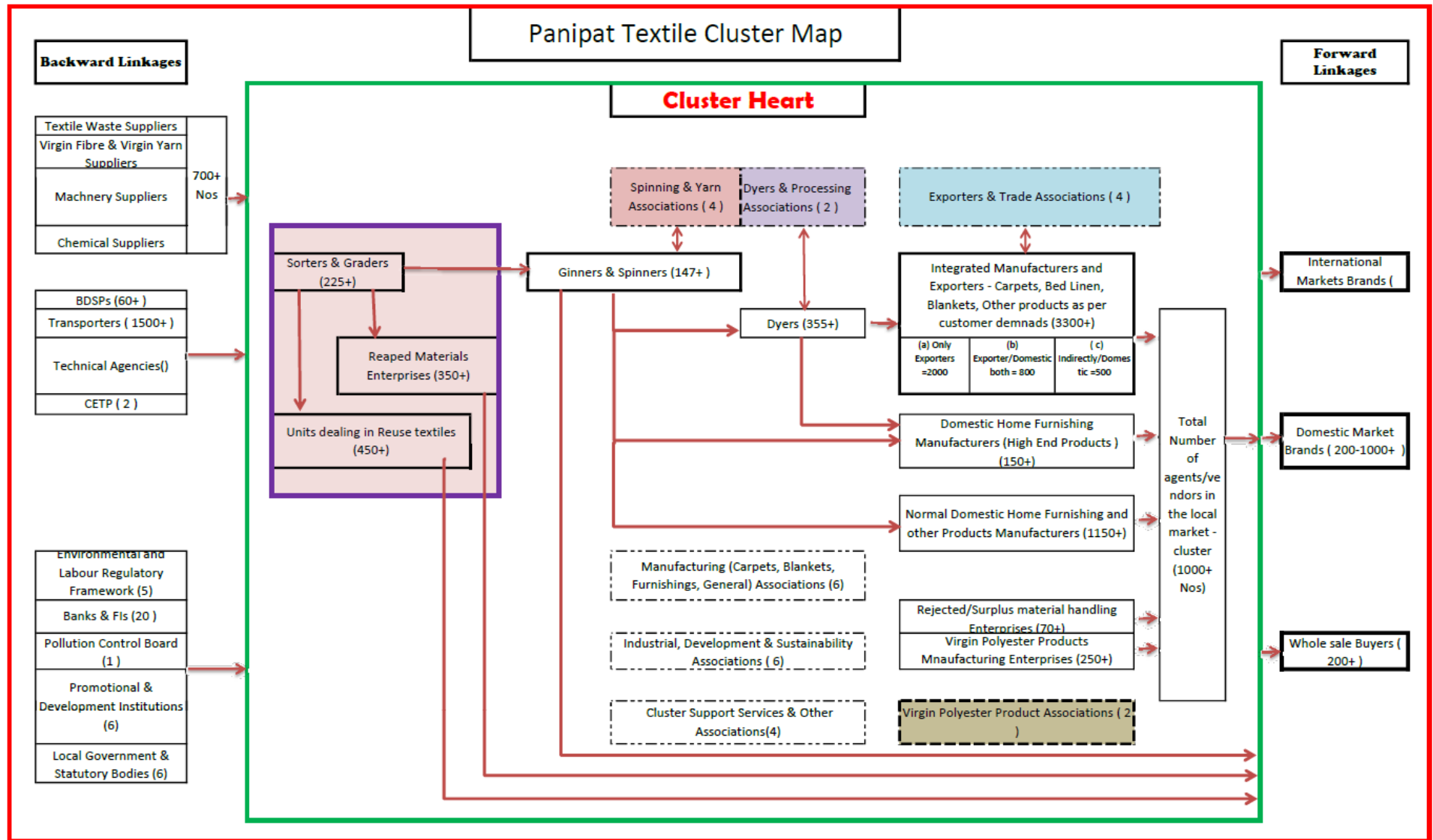


Figure 6: Typical Products and Dominance of Enterprises as Per Size of MSMEs

Shoddy Yarn		Blankets		Carpets & Dhurries		Home Furnishings	
Size Dominance	Key Characteristics	Size Dominance	Key Characteristics	Size Dominance	Key Characteristics	Size Dominance	Key Characteristics
<p>Medium & Small</p>	<ul style="list-style-type: none"> Mechanized Cluster-wide demand Core to recycling 	<p>Medium & Large</p>	<ul style="list-style-type: none"> Export focus Government & aid buyers 	<p>Micro & Small</p>	<ul style="list-style-type: none"> Low-capital Power loom & handloom mix 	<p>Micro & Small</p>	<ul style="list-style-type: none"> Patchwork Stitching Dyeing; women-centric
Sorting & Grading		Finishing & Packing		Export Houses			
Size Dominance	Key Characteristics	Size Dominance	Key Characteristics	Size Dominance	Key Characteristics		
<p>Micro (informal)</p>	<ul style="list-style-type: none"> Mostly informal Family-run setups 	<p>Micro & Small</p>	<ul style="list-style-type: none"> Subcontracted Value-add processes 	<p>Large & Medium</p>	<ul style="list-style-type: none"> End-to-end exporters With in-house QC & design 		

4.2. Industrial Associations & their Relevance

Panipat’s textile recycling sector is supported by a strong network of industry associations and cooperatives, representing a diverse base of micro, small, medium, and informal enterprises. These organisations facilitate collective representation, policy advocacy, skill development, and market access, helping create a more coordinated and resilient industrial ecosystem.

Prominent associations include the Panipat Exporters Association (PEA), Panipat Dyers Association, Haryana Chamber of Industries and Commerce, and All India Woollen & Shoddy Mills Association. They serve as key platforms for advocacy, capacity building, and trade facilitation, with some maintaining formal representation and regular engagement with government departments. Many enterprises are affiliated with multiple associations depending on their business focus. In total, there are about **30 business membership organisations (BMOs)**, locally known as industrial associations in Panipat. Together, they form the institutional backbone of Panipat’s textile recycling ecosystem.

Table 5: Key Industry Associations in the Panipat Textile Recycling Cluster²

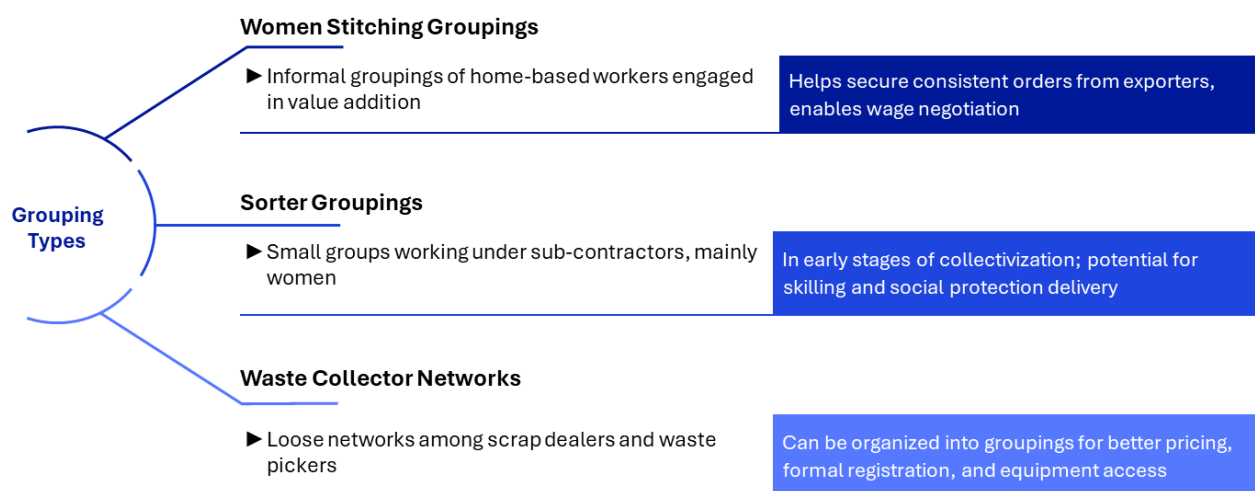
S.no	Name of Association	Membership base and Representation	Major Services Rendered
1	Haryana Chamber of Commerce and Industries	All industry associations	As per the scope provided in the HCCI Charter
2	Panipat Exporters Association (PEA)	Export-oriented textile and home furnishing firms typically registered under the Handloom Export Promotion Council (HEPC)	Facilitates export promotion, certification, market intelligence
3	Panipat Dyers Association	Yarn and fabric dyeing units	Resource efficiency programs, CETP participation, regulatory compliance, and technology support

² Government of India, Ministry of MSME. *Brief Industrial Profile of Panipat District*. MSME-Development Institute Karnal, 2015-16. <https://dcmsme.gov.in/dips/2016-17/DIPS%20PANIPAT%202015-16.pdf>.

S.no	Name of Association	Membership base and Representation	Major Services Rendered
4	Textile Machinery Manufacturers Association	Members include textile machinery producers, suppliers, and engineering workshops	Coordinates on machinery sourcing, maintenance, and technology upgradation.
5	Northern India Rotors and Spinners Association	Includes shoddy yarn and woollen recycling mills	Advocacy on import policy, quality standards, and cluster competitiveness.
6	Handloom Exports Manufacturing Association	Comprises handloom exporters and weaving enterprises	Export promotion, market facilitation, and participation in trade fairs.
7	Industrial Area Manufacturers Association	Members from industrial zones across Panipat	Policy advocacy, infrastructure coordination, and common services.
8	Kambal Manufacturing Association	Blanket and kambal producers (mostly medium-scale)	Represents sector interests, facilitates market and supplier coordination.
9	Young Entrepreneurs Society (YES)	Young entrepreneurs, exporters	Addresses technical and export related issues, raw material access, and industry standards.
10	Haryana Carpet Manufacturers Association	Carpet, rug, and floor-covering manufacturers	Trade promotion, export facilitation, and quality compliance.
11	Global Alliance for Textile Sustainability	Industries oriented towards sustainable production	Trade promotion and compliance towards sustainability
12	Haryana Environment Management Society	Collective actions on Environmental Impact and Conservation	Addresses environment related technical issues

In recent years, Panipat’s textile recycling ecosystem has witnessed the gradual emergence of **informal and semi-organised groupings/societies**, particularly among **sorting, stitching, and value-addition workers**. These include women’s stitching groups, sorter groupings, waste picker networks, and artisan-led weaving units, typically operating within neighbourhood clusters or family-run enterprises that pool labour, space, and resources to manage fluctuating workloads and shared procurement needs. The average size of such groupings ranges from 20 to 50 members, smaller for stitching and finishing groups and larger for sorting and collection units. They function as mutual-support networks, especially for migrant and women workers, offering social and economic security within an otherwise informal work environment. These groupings are largely self-organized and operate in informal or semi-formal structures, formed through mutual association or sub-contractor facilitation. At present, there is no direct institutional fostering under dedicated government programs. However, several groups have linkage potential with ongoing initiatives like DAY-NRLM, MSE-CDP, or Haryana Textile Cluster Development Scheme, should they formalize and register. Their emergence reflects a community-driven model of collectivisation, strengthening resilience, inclusiveness, and livelihood security within the recycling value chain.

Figure 7: Emerging and Informal Groupings in the Panipat Textile Recycling Cluster



4.3. Financial Institutions and their Contribution

The textile recycling industry in Panipat, comprising of a large number of MSMEs and informal players depends significantly on financial institutions (both banking and non-banking) for working capital, machinery upgradation, export financing, and credit support. Despite the presence of several commercial and cooperative banks, access to formal credit remains limited for smaller units, informal players, and women-led enterprises due to inadequate collateral and weak documentation. The cluster, however, benefits from a wide network of financial institutions and multiple public credit schemes accessible through government departments in partnership with banks. While the financing needs of established enterprises are largely met, a notable credit gap persists for micro and informal units outside the formal financial system.

Table 6: Financial Institutions Supporting MSMEs

Type of Institution	Institutions	Primary Role in the Cluster
Public Sector Banks (PSBs)	State Bank of India, Punjab National Bank, Bank of Baroda, Canara Bank, UCO Bank etc.	<ul style="list-style-type: none"> ▶ Working capital loans and term loans for machinery ▶ Export finance & LC handling ▶ Mudra/CGTMSE loans for small units

Type of Institution	Institutions	Primary Role in the Cluster
Private Banks	HDFC, ICICI, Axis Bank etc.	<ul style="list-style-type: none"> ▶ Commercial loans for medium and large enterprises including exporters ▶ Digital lending and supply chain finance
Regional Rural Banks (RRBs)	Haryana Gramin Bank	<ul style="list-style-type: none"> ▶ Micro-credit for home-based workers and artisans ▶ Support for smaller units in peri-urban areas
Co-operative Banks	Panipat Urban Co-op Bank, District Central Co-op Bank	<ul style="list-style-type: none"> ▶ Small business and trader credit ▶ Finance for sorters, home-based and informal enterprises
NBFCs (Non-Banking Financial Corporations)	Bajaj Finserv, Indifi, LendingKart, IIFL, Hero FinCorp etc.	<ul style="list-style-type: none"> ▶ Unsecured business loans for MSMEs ▶ Short-term working capital & invoice discounting
Microfinance Institutions (MFIs)	Bandhan Bank, Fusion Microfinance, Svatantra etc.	<ul style="list-style-type: none"> ▶ Group-based lending to women workers ▶ Informal finance for PET collectors and sorters
SIDBI (Small Industries Development Bank of India)	Government Bank lending for MSME Sector only	<ul style="list-style-type: none"> ▶ Technology upgradation (CLCSS) ▶ Co-financing clean energy and sustainability interventions ▶ Cluster development and capacity building support
NABARD (National Bank for Agriculture and Rural Development)	Government Bank for nano and household enterprises	<ul style="list-style-type: none"> ▶ Credit linkages for SHGs, waste picker cooperatives ▶ Support for rural women-led micro-enterprises near Panipat

Enterprises within the Panipat textile recycling cluster can leverage a range of central and state-level financial support schemes aimed at strengthening MSME competitiveness, sustainability, and inclusion. These programmes address diverse enterprise needs - from capital investment and credit access to technology upgradation, energy efficiency, and social inclusion. While mainstream schemes such as PMEGP, CGTMSE, and MUDRA provide collateral-free or subsidised credit for micro and small units, specialised initiatives like CLCS-TUS and ADEETIE support technology and energy-efficiency upgrades in textile processing. Similarly, emerging frameworks such as SPICE and GIFT promote green finance and social inclusion, aligning well with Panipat's recycling-based value chain. However, awareness and uptake of these schemes remain limited, particularly among informal and women-led enterprises, indicating the need for targeted outreach and facilitation through local industry associations and financial institutions. Some of these schemes and programmes are listed in the table below.

Table 7: Supportive Financial Schemes and Programs Applicable to the Cluster

PMEGP	KVIC	+	Banks	▶ Capital subsidy for new units including recycling-linked activities		
Credit Guarantee Scheme (CGTMSE)	SIDBI	+	Banks	▶ Collateral-free loans up to INR 2 crore for MSMEs		
Stand-Up India	SIDBI	+	PSBs	▶ Loans for women/SC/ST entrepreneurs (underused in the cluster)		
MUDRA Loans	PSBs	+	MFIs	▶ Micro loans for informal and nano businesses (INR50K-10 lakh)		
CLCS-TUS	MoMSME	+	SIDBI	▶ Machinery subsidy for tech upgradation in textile processing		
ADEETIE Scheme	Bureau of Energy Efficiency (BEE)			▶ Financial support for MSMEs deploying energy-efficient technologies in MSME's		
GIFT Scheme	SIDBI			▶ Facilitates access to green finance for sustainable MSME operations		
SPICE Scheme	MoMSME	+	GIZ	+	SIDBI	▶ Promotes social inclusion and climate-responsive investments among informal and small actors
ZED Certification-linked Incentives	Quality Council of India (QCI)			▶ Interest subsidy and handholding support for adopting quality/environmental standards		

Financial institutions are essential enablers of growth, modernisation, and inclusion in the Panipat textile recycling cluster. Yet, a gap persists between formal finance and the realities of small, informal, and socially excluded enterprises. Strengthened partnerships among MSMEs, financial institutions, and government agencies are needed to unlock the cluster's inclusive growth potential.

Enterprises seeking green finance for technology upgradation, resource efficiency, or traceability often lack awareness of public support schemes. While business development service providers (BDSPs) and financing consultants are skilled in financial assessments, they lack technical and scheme-specific knowledge, limiting outreach. Building the capacity of both bankers and BDSPs to integrate technology and sustainability considerations into credit delivery is crucial to expand green and inclusive financing in the cluster.

4.4. Government Institutions and Regulatory Bodies Framework

The Panipat Recycling Textile Cluster operates within a multi-tiered governance ecosystem involving central, state, and local authorities. These institutions play key roles in regulation, compliance enforcement, infrastructure development, and policy-linked promotion of sustainability, formalization, and competitiveness. The table below provides a landscape for the local government and statutory bodies.

Table 8: Roles of Local Government and Statutory Bodies in Cluster Governance

Institution	Jurisdiction & Role	Relevance to Recycling Cluster
Panipat Municipal Corporation (PMC)	Urban local body for Panipat city	<ul style="list-style-type: none"> ▶ Regulates land use and infrastructure within city limits ▶ Waste management coordination, basic urban services ▶ Issues trade licenses and construction permit
District Industries Centre (DIC), Panipat	Under Haryana Department of Industries	<ul style="list-style-type: none"> ▶ Registration of MSMEs/Udyam ▶ Scheme facilitation (PMEGP, CLCS-TUS) ▶ Cluster development projects ▶ Acts as nodal agency for MSME data and incentives
Haryana State Pollution Control Board (HSPCB)	Regional Office in Panipat	<ul style="list-style-type: none"> ▶ Environmental clearances (Consent to Establish/Operate) ▶ Monitoring effluents, emissions, and solid waste disposal ▶ Regulation of dyeing and PET units under Water & Air Acts
Labour Department, Haryana (Panipat Division)	Regulatory oversight on employment	<ul style="list-style-type: none"> ▶ Enforcement of labour laws ▶ Registration under BOCW (Construction Workers) ▶ ESIC/EPFO linkages ▶ Safety audits in factories
Factories Department (Panipat)	Under Directorate of Industrial Safety & Health	<ul style="list-style-type: none"> ▶ Factory licensing ▶ Inspection of working conditions, safety, hazardous operations
Skill Development Mission – Haryana (HKRNL/District Skill Committee)	District skill and livelihood planning	<ul style="list-style-type: none"> ▶ Oversees RPL (Recognition of Prior Learning), PMKVY schemes ▶ Coordination with skilling partners, ITIs ▶ Special focus on women and informal workers in textiles

The cluster is supported by a network of promotional and development institutions that provide technical, financial, and infrastructural assistance to MSMEs and informal enterprises. These institutions, ranging from national agencies such as SIDBI and KVIC to state-level bodies like HSIIDC play a key role in Infrastructure development, cluster upgradation, capacity building, and access to finance. Their programmes address the cluster’s evolving needs in areas such as technology modernisation, infrastructure support, skill development, environmental compliance, and social inclusion. The landscape of promotional and development institutions relevant to the cluster requirements is given in the table below:

Table 9: Promotional & Development Institutions

Institution	Relevant Schemes/Initiatives	Linkage to Panipat Cluster
MSME-Development & Facilitation Office (MSME-DFO), Karnal	<ul style="list-style-type: none"> MSE-CDP (Cluster Development) ZED Certification Credit-linked Capital Subsidy (CLCSS) 	<ul style="list-style-type: none"> Provides handholding for upgrading cluster units, testing, marketing
SIDBI (Small Industries Development Bank of India)	<ul style="list-style-type: none"> SMILE Scheme CLCS-TUS (Tech Upgradation) 	<ul style="list-style-type: none"> Funding for clean tech, energy efficiency, common facilities
KVIC (Khadi & Village Industries Commission)	<ul style="list-style-type: none"> PMEGP Scheme 	<ul style="list-style-type: none"> Some small units are linked via PMEGP financing
Haryana State Industrial & Infrastructure Development Corporation (HSIIDC)	<ul style="list-style-type: none"> Infrastructure Estate management 	<ul style="list-style-type: none"> Development of industrial areas Land allotment, industrial sheds, CETP
National Safai Karamchari Finance & Development Corporation (NSKFDC)	<ul style="list-style-type: none"> Skill training Finance for sanitation workers 	<ul style="list-style-type: none"> Relevant for informal PET collectors and waste pickers from Dalit communities
District Legal Services Authority (DLSA), Panipat	<ul style="list-style-type: none"> Awareness and legal aid 	<ul style="list-style-type: none"> Informal workers’ rights Legal literacy campaigns in industrial belts
Haryana Renewable Energy Development Agency	<ul style="list-style-type: none"> Subsidy on renewal energy installations of equipment/ machineries 	<ul style="list-style-type: none"> Scope renewable energy sources
National Handloom Development Corporation	<ul style="list-style-type: none"> Various type of support to handloom industries 	<ul style="list-style-type: none"> Technical support Logistical support
Weaver’s Service Centre (MoT)	<ul style="list-style-type: none"> Technical, marketing, skill development support 	<ul style="list-style-type: none"> Supports the local handloom industry

Rooftop solarisation in the Panipat recycling cluster is a clear example of how coordinated public-private action can translate policy into practical, scalable outcomes. National and state programmes, channelled through central government (Ministry of New & Renewable Energy, Govt. of India and Indian Renewable Energy Dev Agency Ltd) and state subsidy mechanisms, and concessional and project-level finance from development lenders like SIDBI have together lowered implementation barriers and made investments viable for MSMEs. A functional delivery chain of local vendors, EPC contractors and energy service providers have enabled assessment, procurement and installation, with industry associations and cluster facilitators driving outreach and demand aggregation. This demonstrates both progress in renewable adoption and the significant untapped potential for energy transition in the cluster.

The experience offers concrete lessons for wider green upgradation across the cluster: align subsidy routes with concessional finance, simplify estate approvals and interconnection processes, and strengthen local vendor and BDSP capacity to prepare bankable projects. Equally important is building

technical capability among bankers and BDSPs and resolving regulatory/open-access constraints so renewables can move beyond early adopters. As a replicable model of public-private collaboration, the solarisation drive shows how finance, regulation and local delivery can be coordinated to deliver cost-effective, resilient sustainability interventions for MSME clusters.

4.5. Non-Governmental Organizations and Sustainability Advocates

Non-Governmental Organizations (NGOs), civil society institutions, and sustainability alliances play a critical role in enabling Panipat's textile recycling cluster to adopt environmentally sustainable, socially inclusive, and circular practices. Acting as technical partners, conveners and capacity builders, these actors work across resource efficiency, regulatory compliance, skills development, responsible sourcing and product traceability, helping translate high-level sustainability goals into practical interventions on the ground.

Key organisations including the **Foundation for MSME Clusters (FMC)**, **Solidaridad**, **GATS**, **GIZ**, and the **Haryana Environmental Management Society (HEMS)** have introduced clean technologies, promoted ESG compliance, and supported improvements in water and energy use and pollution control. Solidaridad led a nationally recognized initiative on water savings in dyeing units, with support from the Ministry of Water Resources through Namami Gange programme, while GATS is driving ESG and traceability solutions. HEMS focuses on pollution control and environmental awareness at the local level. These initiatives are illustrative of the technical and operational support NGOs provide. To align cluster production with international market expectations, NGOs have piloted tools such as digital product passports, and QR-code traceability, while also supporting uptake of recognised sustainability standards.

A parallel stream of NGO activity targets people-centred outcomes: organisations such as **Save the Children**, **Pratham**, **Fair Wear Foundation**, **Bachpan Bachao Andolan** and **Smile Foundation** work on worker welfare, occupational health and safety, child-labour prevention and inclusion of women and migrant workers; HUMANA provides early-childhood services for workers' children. CSR-funded projects have delivered skilling and safety programmes covering occupational health and safety, fire safety and rights awareness, especially for women sorters and migrant labourers. Industry bodies and NGOs (e.g. TEXPROCIL, FMC, CUTS International, GATS and HEMS) have supported child-labour awareness drives, policy advocacy, and dialogues with regulators. These NGOs are often backed by international partnerships with organisations such as Ministry of Foreign Affairs of Denmark (Danida), GIZ, SWITCH-Asia, Laudes Foundation, CRB, UNIDO and also enable technical assistance and knowledge transfer. Together, these efforts are pivotal in bridging the formal-informal divide and positioning Panipat's cluster for responsible participation in global supply chains.

4.6. Informal Actors and Migrant Workers

The informal workforce plays a critical role in Panipat's recycling textile ecosystem, particularly in early-stage processes such as waste aggregation, manual sorting, tearing, and resale. Despite their contributions, most remain undocumented and unprotected, making formalization efforts vital for inclusive and sustainable development.

Figure 8: Key Informal Actor Categories

Waste Aggregators and Traders	Operate small godowns or open yards, sourcing and distributing of textile waste; often family-run and unregistered
Manual Sorters	Largely women and migrants, they sort waste by fibre, colour, and condition; typically, piece-rated, with no social benefits
Middlemen/ Subcontractors	Facilitate informal labour supply; manage payments and coordination, though sometimes exploitative
Home-based Workers	Involved in stitching, trimming, and finishing for home furnishing units; semi-formal, with irregular wages and poor coverage

4.6.1. Role and Challenges of Migrant Workers

The Panipat textile recycling cluster relies heavily on a workforce composed of women and migrant workers, who form the backbone of activities such as sorting, stitching, dyeing, and finishing. Despite their central contribution to production and value creation, these workers often remain on the margins of formal recognition and protection. Their participation is shaped by a mix of economic necessity and limited livelihood alternatives yet constrained by barriers to inclusion, including legal informality, restricted access to financial services, and low awareness of rights and entitlements. As a result, many continue to work under informal arrangements with limited job security, low wages, and minimal access to welfare or capacity-building initiatives. Understanding their role and the challenges they face is essential to building a more equitable, gender-responsive, and socially inclusive recycling ecosystem in Panipat.






Figure 9: Roles of Women and Migrant Workers

Sorting & Grading	Women, mostly from migrant or marginalized communities, dominate manual sorting of textile waste based on fibre, colour, and usability
Stitching, Weaving & Finishing	Many women work as home-based labourers, undertaking trimming, embroidery, and packaging of recycled products
Machine Support and Loading	Migrant men are primarily employed in physically demanding tasks such as tearing, fibre extraction, and loom operation

Women and migrant workers in the Panipat textile recycling cluster face a range of systemic and interlinked barriers that limit their economic security and social inclusion. Most workers lack formal job contracts or identity documentation, leaving them outside the ambit of key labour protections such as the Factories Act (1948) and Minimum Wages Act (1948). They depend on irregular, piece-rated payments with little access to formal credit, savings, or insurance mechanisms, reinforcing cycles of vulnerability. Social and gender-related barriers persist through wage disparities, absence of safe and sanitary workplaces for women, and limited opportunities for skill advancement. The cluster assessment indicates partial social security coverage (ESIC, PF) and varying levels of workplace safety compliance, which together influence workers' health and livelihood security.

These challenges are compounded by low awareness of rights, entitlements, and grievance redressal mechanisms, which further restrict access to government schemes and institutional support. Collectively, these barriers entrench the informal status of women and migrant workers, constraining their ability to benefit equitably from the cluster’s economic growth.

Figure 10: Challenges Faced by Women and Migrant Workers

Category				
 Legal	 Financial	 Social & Gender	 Occupational	 Awareness
Challenges				
▶ Lack of formal job contracts or identity documents	▶ Irregular and piece-rated payments	▶ Gender wage gaps	▶ No social security (ESIC, PF)	▶ Limited knowledge of entitlements, grievance redressal, or government schemes
▶ Exclusion from labour protections under Factories Act, 1948, Minimum Wages Act, 1948, Minimum Wages Act, 1948	▶ No access to formal credit or savings mechanisms	▶ Lack of safe and sanitary working conditions for women	▶ Unsafe and unregulated work environments	

4.6.2. Social Inclusion and Sustainability Interventions

Some efforts have been initiated to improve worker welfare, social protection, and gender inclusion within the Panipat recycling cluster, particularly for informal and migrant workers. Initiatives such as the Labour Department’s e-Shram registration drives have facilitated partial enrolment of workers into national databases, enabling limited access to social security schemes. In parallel, outreach activities including ESIC facilitation and periodic health camps, undertaken in collaboration with industry associations, have attempted to extend basic health and occupational safety coverage. Additionally, select state-level initiatives, such as linkages with the Haryana Mahila Vikas Nigam and Self-Help Group (SHG) programmes under DAY-NULM, have begun supporting women engaged in sorting, stitching, and home-based activities. While these interventions mark important progress, their coverage and depth remain limited, indicating the need for more structured and scalable approaches to social inclusion within the cluster.

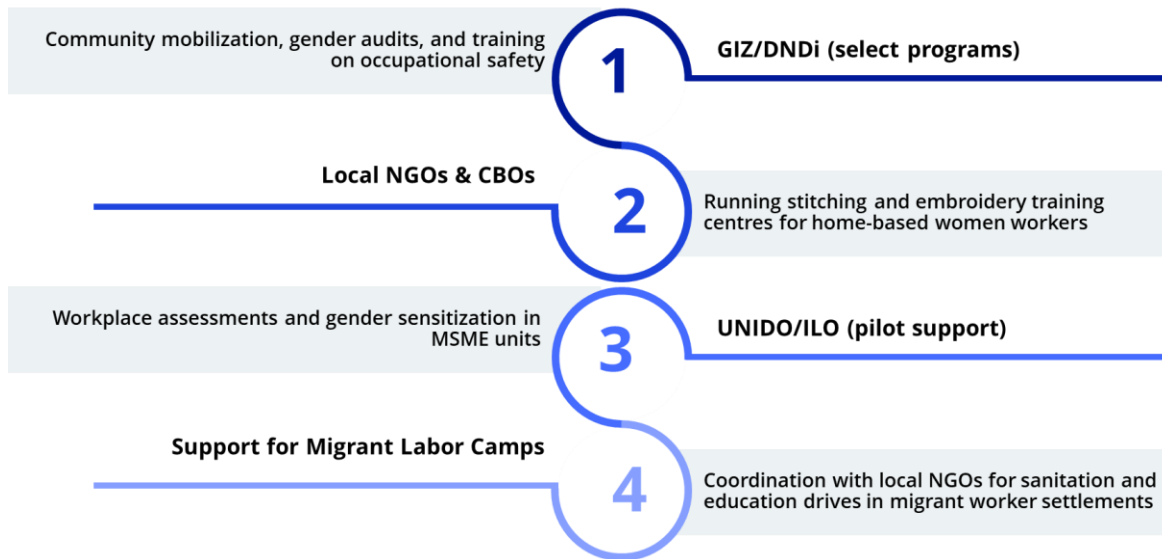
Table 10: Key Government-Led Interventions in the Panipat Recycling Cluster

Initiative	Description
e-Shram Registration Drives	Labour department-led registration of unorganised workers for social security linkage
ESIC & Health Camp Outreach	Mobile camps organised with factory associations to increase coverage under health insurance
Women Empowerment Schemes (State)	Linkages to Haryana Mahila Vikas Nigam and SHG formation under DAY-NULM

A range of social and institutional initiatives have been implemented in the Panipat recycling cluster through partnerships between international agencies, NGOs, and local organisations to enhance worker welfare, inclusion, and workplace safety. Programmes by International Donors have focused on community mobilisation, gender audits, and occupational safety training, while local NGOs and CBOs operate stitching and embroidery training centres that equip home-based women workers with employable skills. UNIDO and ILO pilot projects have introduced workplace assessments and gender sensitisation in MSME units, promoting fair and safe working environments. Additionally, coordinated

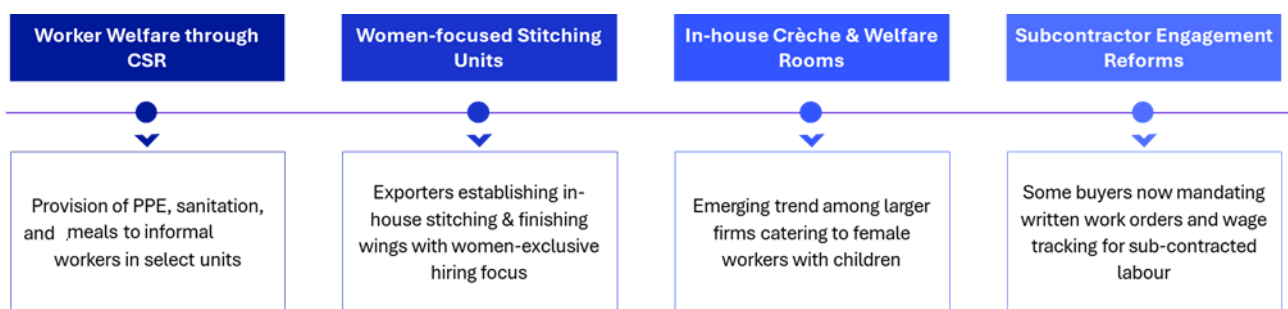
efforts with local NGOs have supported migrant labour camps, conducting sanitation, health, and education drives for worker families.

Figure 11: Social and Institutional Interventions in the Panipat Recycling Cluster



Within the cluster, industry associations and leading enterprises are increasingly integrating social welfare and inclusion measures into their operations. Several units have introduced CSR-driven initiatives, such as the provision of PPE kits, and sanitation facilities, and meals for informal and contract workers, improving basic workplace welfare. A growing number of exporters are establishing women-focused stitching and finishing units, creating safe and secure employment opportunities for female workers. Some larger firms are also setting up in-house crèches and welfare rooms to support women with children, signalling gradual progress toward gender-responsive workplaces. In parallel, some buyers and exporters have initiated subcontractor engagement reforms, requiring written work orders and wage tracking to improve accountability and transparency within the extended value chain.

Figure 12: Industry & Cluster-Level Practices



Collectively, these initiatives indicate a gradual shift toward improved social accountability within the Panipat textile recycling cluster, particularly in relation to worker registration, access to welfare schemes, and basic labour protections. However, these efforts remain limited in scale and largely fragmented, with most informal workers still operating outside formal social security and labour governance frameworks. Yet, most initiatives remain scattered and pilot-scale, with limited reach across the informal segments. A coordinated roadmap that integrates formalisation, skilling, social protection, and worker rights is needed to scale these efforts and embed sustainability and inclusion across the entire value chain.

4.7. Technology and R&D Landscape

The Panipat recycling textile cluster, known for its large-scale reuse of pre- and post-consumer textiles waste, has grown with limited formal R&D support from the national or local institutions. However, with an increasing demand for sustainability issues such as resource efficiency, de-carbonisation, traceability, digital product passport, green financing, statutory and non-statutory compliances, the cluster requires technological upgradation, product innovation, sharing of learnings, sourcing public financing and building institutional partnerships. Based on industry interviews, it can be ascertained that the existing technology landscape is based on organic evolution devoid of any special interest and interventions by any R&D or technology institution. The following table provides a snapshot of existing technology landscape and the key observations that could help draw up future course of action with engagement of relevant institutions in this regard.

Table 11: Existing Technology Landscape Across Key Process Areas

Area	Current Technology Used	Key Observations
Yarn Manufacturing (Shoddy/Open-End)	Modified ring and rotor spinning	Largely mechanical, semi-automated, limited fibre-specific adjustments
Sorting & Grading	Manual sorting	Labor-intensive, inconsistent quality, ergonomic challenges
Tearing/Shredding	Italy-imported tearing machines (1980s–1990s), domestic variants	Low throughput, high noise, fibre loss
Dyeing & Processing	Conventional water-based processes	High chemical/water consumption, pollution load
Value Addition (Finishing/Printing)	Manual or semi-mechanized	Lack of uniformity, quality issues in export lots

4.7.1. Key R&D and Technical Institutions

There are several national institutions that have varied levels of technical knowledge along with physical facilities and technical staff that can be engaged with to explore options for partnerships with the cluster stakeholders at individual or collective level. There is only one relevant institution in the vicinity of the cluster at Sonipat while others are more distant in the neighbouring states and even farther, each with their own niche area of their specialisation.

Table 12: Key R&D and Technical Institutions Engaged or Relevant to the Cluster

Institution	Location(s)	Relevance/Contribution
Northern India Textile Research Association (NITRA)	Ghaziabad	R&D in textile processes, eco-friendly dyes, testing labs; potential for collaboration on fibre testing, circular product development
AIC IIT Delhi Sonipat Innovation Foundation	Sonipat	R&D for recycled Textile Sector and Incubation centre
Wool Research Association (WRA)	Thane (Maharashtra)	Expertise in woollen and blended fibres; relevant for blanket and carpet innovations
Textile Committee (Ministry of Textiles)	HQ at Mumbai with 8 Regional Offices at Amritsar, Noida, Indore, Kolkata, Bengaluru, Coimbatore, Navi Mumbai & Ahmedabad.	Compliance testing, BIS standards, product certification for exporters
CSTRI – Central Silk Technological Research Institute	Bengaluru	Limited direct relevance, but techniques for sustainable dyeing and finishing can be adapted

Institution	Location(s)	Relevance/Contribution
CSIR-National Institute for Interdisciplinary Science and Technology (NIIST)	Thiruvananthapuram	Polymer recycling and bio-based material R&D; applicable in PET segment
IIT-Delhi (Dept. of Textile Technology)	Delhi	Research on circular textiles, nanofibers, smart textiles; scope for industry-research collaborations
CIPET (Central Institute of Petrochemicals Engineering and Technology)	Sonipat	Expertise in PET recycling, extrusion, polymer waste upcycling; relevant for plastic textile blends and fibre-to-fibre R&D
ICT (Institute of Chemical Technology)	Mumbai	strong research capabilities in polymer science, fibre science, textile chemistry, and waste-to-material innovations.

4.7.2. Opportunities for Strengthening R&D and Technology Support

Based on the comparison between the cluster requirements and what is available among different known R&D and technical institutions, it can be assessed that the matchmaking is feasible only to a limited extent, particularly in the areas of dyeing, and product development. But there are no institutions currently known for having contributed to the machinery development, use of technology for improving sorting, traceability enhancement, water reduction and energy efficiency. Specialised programmes may need to be designed to target assistance in these areas and seek public funding support for the same. Some of these opportunities that the industry stakeholders have identified are given as under:

Table 13: Opportunities for Strengthening R&D and Technology Support in the Cluster

Opportunity	Suggested Actions
Technology Upgradation	Facilitate access to ATUFS, ZED, and MSME tech support schemes for machinery modernization
Cluster R&D Centre	Establish a common R&D and testing facility on yarn/ fabric specifications, like count, tensile strength, fibre composition, twist level, GSM etc. in collaboration with NITRA/IIT under a PPP or SPV model
Sustainable Process R&D	Partner with WRA and IITs for low-water dyeing, zero-waste finishing, and chemical recycling of PET
AI/Machine Learning in Sorting	Collaborate with startups and IITs for piloting automated sorting using vision-based classification
Skill-Based Tech Training	Leverage CITRA, NIFT-TEA, or DGT for running technician-level courses on modern textile machinery
Product Innovation	Support incubation of startups for upcycled products (e.g., felt, insulation, geo-textiles from textile waste)

4.7.3. Government Schemes and R&D Linkages

In order to fund such initiatives, a number of public schemes and funding mechanisms can be leveraged to strengthen innovation, sustainability, and competitiveness within the Panipat textile recycling cluster. Key among these are the MoT- Textile Development Fund (TDF), which supports R&D and innovation-led projects; the PM MITRA Parks Scheme, which could extend infrastructure and technology support if Panipat is included under its integrated textile development initiative; the Cluster Development Programme (CDP-MSME), which provides scope for establishing shared technology or testing centres; and the ZED (Zero Defect Zero Effect) Scheme, which encourages eco-innovation, process efficiency, and quality compliance among MSMEs.

To future-proof the cluster & its growth, it is essential to align these government schemes with an active R&D and institutional support ecosystem. Stronger linkages with technical institutes, the development of customized machinery suited for recycled fibre processing, and the creation of accessible cluster-level facilities can accelerate technological modernisation and product diversification. Together, these interventions will help Panipat’s recycling enterprises enhance productivity, meet global sustainability standards, and sustain long-term competitiveness in the evolving textile value chain.

4.8. Business Development Service Providers (BDSPs) and Institutional Capacity

Panipat’s recycled textile cluster is supported by a growing yet underdeveloped ecosystem of Business Development Service Providers (BDSPs) and Business Membership Organisations (BMOs). Despite increasing buyer expectations and policy emphasis on sustainability and traceability, significant institutional and technical capacity gaps persist across three key areas - sustainability integration, traceability systems, and resource efficiency (RE) audits.

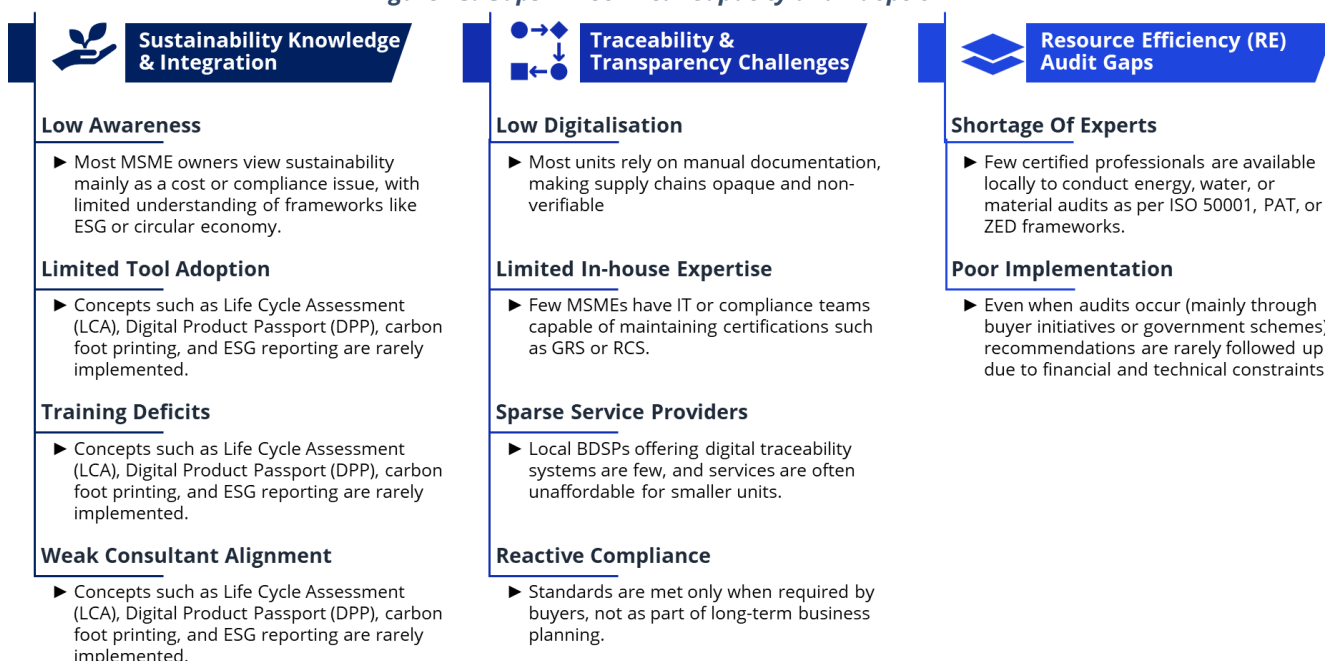
4.8.1. Existing BDSP Ecosystem and Key Gaps

While several local consultants, non-profits, and government schemes provide advisory and audit services, their outreach and technical depth remain limited. The cluster faces persistent challenges in:

- Integrating sustainability practices beyond compliance.
- Building traceable, verifiable supply chains.
- Conducting and acting upon resource efficiency audits.

These constraints limit Panipat’s ability to move up the value chain, access premium markets, and align with international buyer standards.

Figure 13: Gaps in Technical Capacity and Adoption



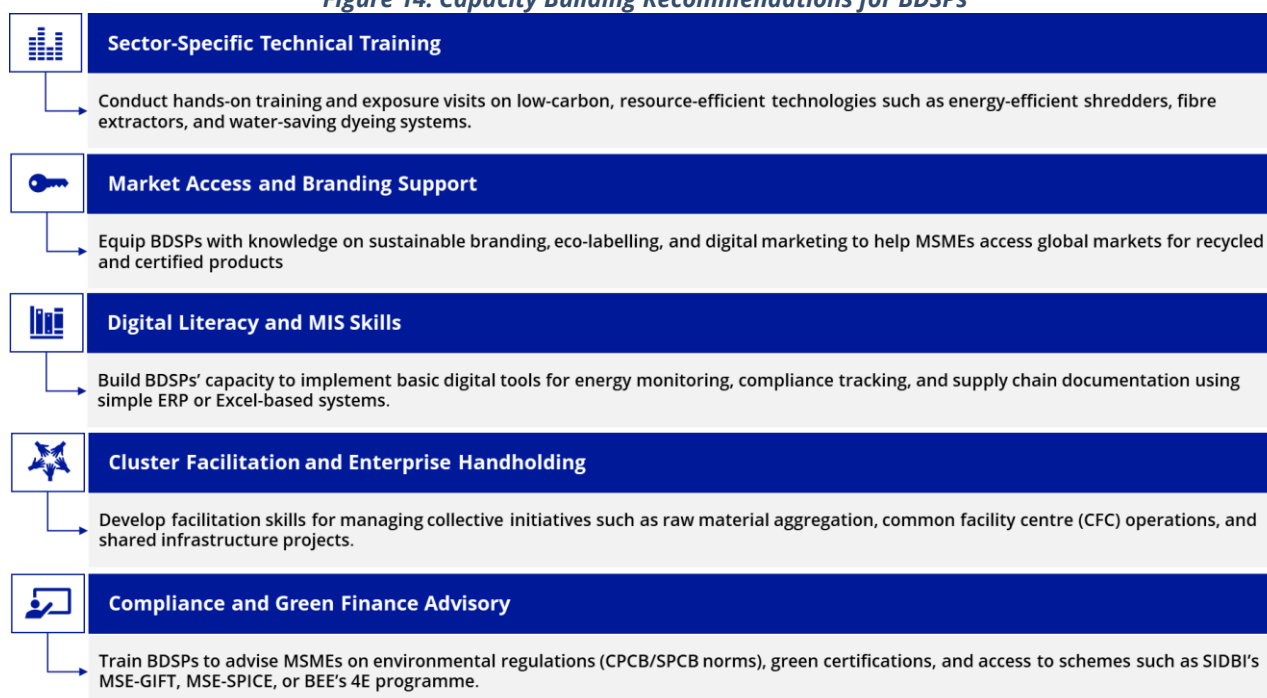
4.8.2. Recommendations for Capacity Building of BDSPs and BMOs

To strengthen the long-term sustainability and competitiveness of the Panipat recycling cluster, capacity building efforts must focus on equipping both BDSPs and BMOs with the technical, managerial, and collaborative skills needed to drive clean and circular transformation.

4.8.2.1. Capacity Building for BDSPs (Business Development Service Providers)

The effectiveness of BDSPs in Panipat and the Delhi NCR is closely linked to their capacity to support MSMEs in navigating technological upgradation, compliance enhancement, and improved market access. Strengthening their technical know-how and operational capacity is therefore critical to achieving cluster-wide sustainability outcomes.

Figure 14: Capacity Building Recommendations for BDSPs



4.8.2.2. Capacity Building for BMOs (Business Membership Organisations)

BMOs play an important intermediary role in connecting cluster enterprises with policymakers, buyers, and financial institutions. Enhancing their institutional capacity will enable them to deliver better services to members, coordinate sustainability initiatives, and represent MSME interests effectively.

Figure 15: Capacity Building Recommendations for BMOs

Policy Advocacy and Representation	Strengthen BMOs' ability to engage with regulators, SPCBs, and export councils through evidence-based policy advocacy using cluster data and case studies.
Institutional Capacity for Service Delivery	Enhance BMO staff capacity to conduct member needs assessments, organise training, and manage common facilities (e.g., CETPs, dyeing units).
Decarbonisation Awareness and Roadmapping	Support BMOs in developing cluster-level decarbonisation and circularity roadmaps, engaging members through workshops, peer learning, and shared sustainability targets.
Partnership and Networking Development	Facilitate linkages between BMOs and technical institutions such as NITRA, ATIRA, and TERI, and promote participation in national-level sustainability and MSME forums.

4.8.2.3. Role of Technical Institutions and Training Partners

Technical institutions and training partners serve as the backbone of knowledge and innovation transfer for the cluster. Their continued engagement is vital to bridge the gap between research and practice, and to ensure that MSMEs, BDSPs, and BMOs are aligned with emerging global standards. Institutions like **NITRA, ATIRA, TERI, Weavers' Service Centre (WSC), MSME Technology Centres etc.** can:

- ▶ **Validate and adapt technologies** such as fibre recovery systems and low-temperature dyeing units for Panipat's context.
- ▶ **Train workers and entrepreneurs** via ITIs and sector skill councils on energy-efficient machinery, safe chemical handling, and quality assurance for recycled products.
- ▶ **Develop BDSP/BMO training modules** on circular economy principles, carbon foot printing, and environmental compliance.
- ▶ **Create knowledge repositories** and digital tools for traceability, energy tracking, and sustainability reporting.
- ▶ **Support financing linkages** by guiding MSMEs and BMOs in accessing green funds through SIDBI, BEE, and international development banks.

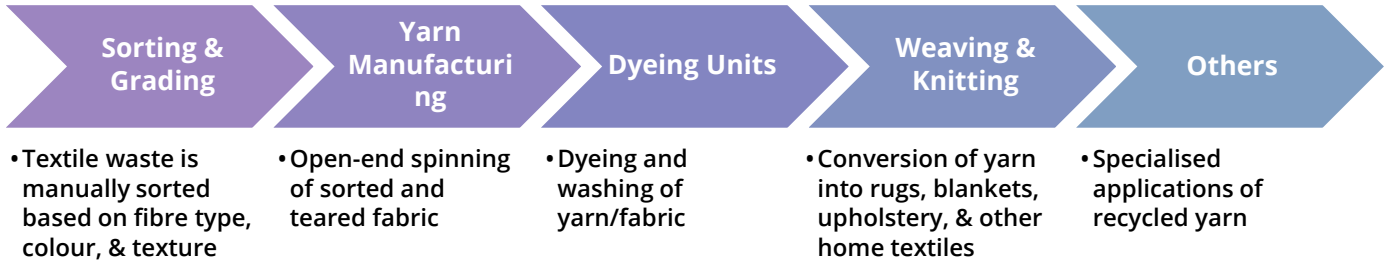
Despite the presence of capable technical institutions, progress remains limited due to low awareness among MSMEs, weak demand for technical support, and fragmented coordination between institutions, industry, and financiers. Many enterprises prioritise short-term operational survival over long-term capacity building, while existing training and support programs are often not tailored to cluster-specific needs. Limited access to affordable finance and a lack of demonstration models further constrain adoption. Addressing these gaps requires coordinated institutional engagement, demand-driven training, integrated financing mechanisms, and practical demonstration of technology benefits at the cluster level.

5. Production Processes and Energy Assessment

5.1. Overview on the Production Processes

The Panipat textile recycling cluster integrates a complex sequence of interdependent processes - sorting, yarn manufacturing, weaving and knitting, dyeing, and finishing - that together transform pre & post-consumer textile waste into high-demand recycled products such as blankets, carpets, and home furnishings. The technological composition of these processes varies widely across the cluster, reflecting the coexistence of mechanised MSMEs and manual, labour-intensive units.

Figure 16: Production Processes in the Panipat Textile Recycling Textile Cluster



The cluster has made notable technological advancements across production processes. Sorting units have introduced basic mechanical shredders and conveyor systems to enhance efficiency, though manual labour remains the backbone of sorting. Yarn manufacturing is evolving with the adoption of semi-automated blending systems, online fibre cleaners, and advanced rotor drives, which have improved productivity and yarn consistency. Weaving units are increasingly using high-speed looms, including rapier, dobby, and jacquard looms, which offer enhanced design capabilities and minimize yarn wastage. In dyeing, resource-efficient systems like jet dyeing and soft flow machines have been implemented, reducing water and chemical consumption significantly. For specialized production, such as carpets and mink blankets, there has been a shift to upgraded tufting machines, enhancing design flexibility and fabric quality. Despite these technological strides, challenges remain in energy optimization and skill gaps, especially among smaller enterprises, highlighting the need for continued investment in training and capacity-building.

Figure 17: Summary of Production Processes, Technology Features, and Operational Challenges in the Panipat Recycling Cluster

	Process Stage	Key Activities	Technology Profile	Resource / Energy Use	Key Issues and Upgradation Needs
▼	Sorting & Grading	Sorting & grading of imported textile waste by fibre type, colour, and texture	Predominantly manual; limited use of mechanical shredders and conveyor-fed tables by large GRS-compliant units	Labour-intensive; minimal mechanisation	High informality, low skill levels, and limited access to technology
▼	Yarn Manufacturing (Open-End Spinning)	Blending, carding, and open-end spinning of recycled fibres	Many upgraded with semi-automated blending systems, online fibre cleaners, and 'Generation 6' rotor drives	Improved efficiency and yarn quality after modernisation	Remaining older machinery; skill and energy optimisation gaps
▼	Dyeing / Printing	Dyeing & washing of recycled yarn/fabrics	Mix of conventional jigger machines and newer soft-flow and jet dyeing systems	High water use; large thermal energy demand via biomass and LPG boilers	High water and energy intensity; ETP performance and skill shortages
▼	Weaving / Knitting	Conversion of recycled yarn into blankets, durries, mats, towels, and home furnishings	Combination of handlooms, power looms, and high-speed rapier, dobby, and jacquard looms	Reduced yarn breakage and improved design precision with advanced looms	Many small units still operate second-hand machines; limited capital and technical training
▼	Other Specialized Products (Carpets, Minks, Bedsheets)	Production of carpets, mink blankets, and bedsheet fabrics using recycled yarn	Tufting, warp-knitting, and backing machines; partial shift to computer-controlled systems	High thermal load from backing ovens and dryers; minimal effluent generation	Suboptimal heat recovery, limited insulation, and need for energy-efficient retrofits

5.1.1. Sorting

Each day, around 4,000 tonnes of textile waste is processed in Panipat. Waste from multiple sources is routed to the Barsat Road hub, the cluster's primary aggregation points for garments and mill waste destined for recycling. The imported material, sourced primarily from the USA, UK, Canada, Japan, and the EU, is procured through exporters and auction systems. Mixed post-consumer lots are priced around INR 20–22 per kg, while premium fibres such as Kashmiri wool or angora can fetch up to INR 1,200–1,300 per kg, depending on purity and yield.

Sorting and grading remain manual, labour-intensive processes, undertaken largely by informal and migrant workers with limited formal training. Garments are separated by fibre type, colour, and texture. These further cuts using simple cutting tools to remove accessories such as zippers, buttons, though a few larger units employ mechanical shredders and conveyor-fed tables to increase throughput and comply with Global Recycle Standard (GRS) norms. Despite gradual mechanisation, manual sorting continues to underpin the cluster's recycling operations.

5.1.2. Yarn Manufacturing

Open-end spinning forms the backbone of Panipat's yarn production and is widely regarded as the most efficient method for processing recycled fibres. The cluster hosts around 147+ spinning mills, each producing average of 20 tonnes per day, together yielding close to approximately 3,000 tonnes of recycled yarn daily out of around 4000 Tonnes of textile waste.

Traditionally dependent on refurbished or second-hand machinery, the sector has undergone significant technological modernisation in recent years. The number of carding machines has reduced from nearly 1,200 in 2001–02 to about 250 today, with several older units shifted to Bikaner as operations consolidated around more efficient systems. Many mills have introduced semi-automated blending equipment, online fibre cleaning systems, and energy-efficient 'Generation 6' rotor drives, resulting in higher productivity, better yarn uniformity, and reduced energy consumption. In parallel, several former shoddy yarn producers have diversified into other-value segments such as tufted carpets, shoddy blankets, mink blankets, and home furnishings, reflecting both technological adaptation and a gradual movement toward product specialisation within the cluster.

5.1.3. Dyeing

Dyeing units in Panipat serve as a critical downstream operation, offering services for both woven and knitted recycled fabrics, as well as limited virgin material-based products. The cluster largely relies on conventional dyeing systems, especially jigger dyeing machines, which are known for their high liquor ratio, significant water consumption, and extensive use of dyes and auxiliaries. These legacy systems remain widespread due to their low initial investment and compatibility with small-batch processing. However, they are increasingly under scrutiny for inefficient resource use, high effluent loads, and energy intensity, especially when viewed against global benchmarks for sustainable textile processing.

In response to mounting regulatory and buyer-driven sustainability demands, some larger units in Panipat have transitioned to resource-efficient dyeing technologies, such as soft flow dyeing machines, jet dyeing systems, and low-liquor-ratio dyeing equipment. These technologies can significantly reduce water consumption (by up to 40%) and chemical loads (by up to 30%), while improving dye fixation rates and colour uniformity. Additionally, pilot demonstrations of stenter frame insulation, jet machine cladding, and variable frequency drive (VFD) installation facilitated under programs by Solidaridad and other development partners, have led to notable energy savings of up to 15–20% in steam and electricity usage.

The cluster's dyeing units discharge nearly 50 million litres of water daily³, while effluent treatment plants (ETPs) exhibit varying levels of operational performance, with scope for improvement through enhanced operator training, process optimisation, and strengthened operations and maintenance practices. Energy-wise, the dyeing and finishing units collectively rely on more than 400 boilers, most of which were earlier coal-fired. Following NCR emission norms by the National Green Tribunal, around 70% of units have now transitioned to agri-biomass briquettes, while the remaining use Liquefied Petroleum Gas (LPG), especially those located within designated industrial zones. This transition has contributed to a substantial reduction in particulate emissions and operational GHG footprint, though challenges in biomass quality and boiler efficiency still persist. While the segment has made meaningful strides toward resource efficiency and environmental compliance, its widespread scalability remains hindered by structural gaps in finance, skills, and infrastructure.

5.1.4. Weaving

Weaving units in Panipat employ a diverse combination of handlooms, power looms, and semi-automatic machines to transform recycled yarn into a broad range of products, including blankets, durries, mats, towels, cushion covers, and home furnishings. Traditional setups-particularly pit and frame looms-remain common among household and micro-enterprises, while medium and large-scale units have steadily transitioned to high-speed weaving technologies such as rapier, dobby, and jacquard looms. These advanced systems have significantly improved fabric design precision, yarn utilisation, and production efficiency, marking a gradual technological shift within the cluster.

The adoption of advanced looms has reduced yarn breakage rates, a persistent issue in recycled yarn processing, and enabled manufacturers to meet complex pattern and quality specifications demanded by international buyers, particularly in Europe and North America. However, a large proportion of small and micro-enterprises continue to rely on second-hand or refurbished machinery, constrained by limited access to capital and technical expertise. Addressing these gaps through targeted financing schemes and skill development support remains essential to achieving cluster-wide modernisation and competitiveness.

5.1.5. Others (Carpets, Minks, etc.)

The carpet, mink blanket, and bedsheet manufacturing segments in Panipat represent specialized and high-volume applications of recycled yarn. These product lines not only contribute significantly to the region's economic output but also demonstrate the vertical integration of recycling into value-added textile goods. The carpet segment alone accounts for approximately INR 10,000 crore in annual turnover, with products exported extensively to North America, Europe, and the Middle East.

Carpet manufacturing in Panipat is dominated by tufted carpet units, which use tufting machines, patterning heads, and latex-backing ovens. These machines have been gradually upgraded in some units to include multi-colour loop pile and cut pile attachments, allowing manufacturers to offer greater design flexibility and match complex export specifications. However, a large proportion of the units still operate manual or semi-automatic lines, particularly those catering to domestic markets or working on a job-order basis. From a technical standpoint, there is clear scope for optimizing thermal systems used in backing ovens, which are currently powered by biomass or conventional fuels, and often operate with sub-optimal heat recovery systems. This leads to unnecessary energy loss and elevated operational costs.

³ <https://www.tribuneindia.com/news/haryana/to-keep-yamuna-clean-panipat-units-to-shut-till-chhath-puja/>

The mink blanket segment, with about 200 operational units each producing an average of 15 tonnes per day. These units have become increasingly prominent in the past decade, especially after many traditional spinning and shoddy yarn facilities were repurposed. Technology-wise, mink manufacturing involves warp knitting machines, embossing lines, and brushing machines, with recent investments in computer-controlled knitting systems for design reproducibility and improved fabric hand-feel.

Bedsheet and curtain fabric production, on the other hand, is driven by around 100 active weaving units, which together manufacture nearly 100,000 metres of fabric daily. These units, while less energy-intensive than dyeing or spinning, still face challenges related to machine downtime, inconsistent yarn quality, and lack of trained machine operators, especially in the power loom segment.

From an environmental perspective, most of these specialized units generate dust, yarn lint, and minor solid waste but generally do not discharge effluents, since finishing and dyeing are typically outsourced to dedicated processing units with ETPs systems. However, the energy footprint, especially in carpet latexing and blanket finishing, is substantial, and limited thermal insulation or waste heat recovery measures are in place. As Panipat seeks to position itself as a low-carbon textile hub, interventions in machine retrofitting, process energy audits, and operator training will be critical for this segment's sustainable growth.

5.2. Energy Consumption and Efficiency Patterns

The energy consumption patterns within Panipat's textile recycling cluster vary considerably by process. Spinning and weaving are highly energy-intensive but have low water requirements, whereas dyeing and processing units consume significant amounts of both energy and water. The table below provides a comparative overview of energy use across different types of units and processes.

Figure 18: Energy and Resource Consumption Patterns in Panipat Textile Recycling Cluster

Process	Water Use	Energy Use	Material Loss	Chemical Use	Emission Profile
Sorting & Grading	Negligible Only for cleaning if at all	Very low Manual work dominant	Moderate Losses from dust/fibre residue ~10-15% unusable	Negligible	Low Overall Dust/fibre fugitive emissions
Spinning (Open-End)	Negligible Only cooling water	High Electricity usage: 1.6-2.0 kWh/MT yarn grid dependent. A small fraction of biomass usage and diesel generators for power backups.	Moderate Fibre losses in carding/rotor cleaning ~8-12%	Negligible No dyes/chemicals used	High Scope 2: high CO ₂ from grid electricity; no direct thermal emission dust/fibre fugitive emissions
Dyeing/ Processing	Very High Highest water user (80-120 L/kg fabric); ~42 MLD cluster-wide	High High electricity (pumps, dryers)+ high thermal energy (biomass/PNG boilers)	Low-Moderate Fabric rejection/rework 5-10% due to uneven dyeing	Very High Dyes, auxiliaries, finishing chemicals used	High Scope 1: direct emissions from biomass/LPG combustion (CO ₂ , PM _{2.5} , VOCs); Scope 2: electricity load; high wastewater load
Printing/ Washing	High Hot water demand high	High Electricity + thermal energy for water heating	Low Print defects: ~5% material wastage	High Printing inks, solvents, fixatives	High Combustion emissions+ wastewater COD/BOD load
Weaving/ Knitting	Very low Not water-intensive unless wet finishing integrated	Moderate Moderate-high electricity (0.3-0.5 kWh/m fabric)	Low-Moderate Yarn wastage in warping/loom breakages ~5-8%	Negligible	Low Scope 2: Indirect CO ₂ from electricity
Finishing (Stitching/ Embroidery)	Low Minimal	Moderate Electricity for stitching/ironing	Low Fabric/yarn wastage ~3-5%	Negligible	Low Indirect CO ₂ from electricity

Source: Field surveys conducted with textile units in Panipat and desk research



5.2.1. Spinning Units (Yarn Manufacturing/Spinners)

Open-end spinning is mechanically intensive, driven by high-speed rotors, carding machines, and blending systems. According to the energy efficiency survey data, 100% of sampled spinning units reported using grid electricity as their primary source of power. A smaller fraction also uses biomass and diesel generators (1 unit each), likely for backup. These units tend not to use natural gas or coal. The energy consumption in spinning is predominantly electricity-driven, primarily for motorized carders, blowers, rotor frames, and conveyor systems.

Studies confirm that open-end spinning consumes **approximately 1.6-2.0 kWh per kg of yarn** produced, making it a high-energy segment⁴. However, unlike dyeing, it consumes negligible water, mostly for cooling.

5.2.2. Processing Houses (Dyeing/Printing Units)

The dyeing and printing units within the Panipat recycling cluster exhibit the most diversified and energy-intensive operational profile among all production segments. Field data indicates that all of these units rely on grid electricity to operate pumps, dryers, and motor controls, while a substantial number also depend on biomass- or gas-fired boilers to meet their high thermal energy requirements. A smaller share uses diesel generators as supplementary sources. This energy mix reflects the heavy dependence of processing houses on both electrical and thermal energy for heating water, running steam-based dyeing machines, and operating stenter frames and dryers-core activities that define the energy footprint of the sector.

In parallel, these units record the highest levels of water consumption across the cluster. Estimates suggest a daily water withdrawal of about 50 million litres, much of it attributable to dyeing and finishing operations. On average, textile dyeing consumes between 80 and 120 litres of water per kilogram of fabric, contributing significantly to both chemical load and wastewater generation. This reinforces the need for greater investment in water-efficient technologies, cleaner production systems, and zero-liquid-discharge (ZLD) measures to reduce the environmental burden of processing operations within the cluster.

This confirms field observations that processing houses not only depend on electricity for pumps, dryers, and motor controls but also consume large volumes of thermal energy via biomass- or gas-fired boilers. These are required for heating water, steam-based dyeing machines, stenter frames, and dryers.

5.2.3. Weaving Units

Weaving units are also electricity-dependent, with all surveyed units reporting grid electricity usage. Diesel and biomass are used minimally, while few units reported using LPG, possibly for thermal finishing or process heating.

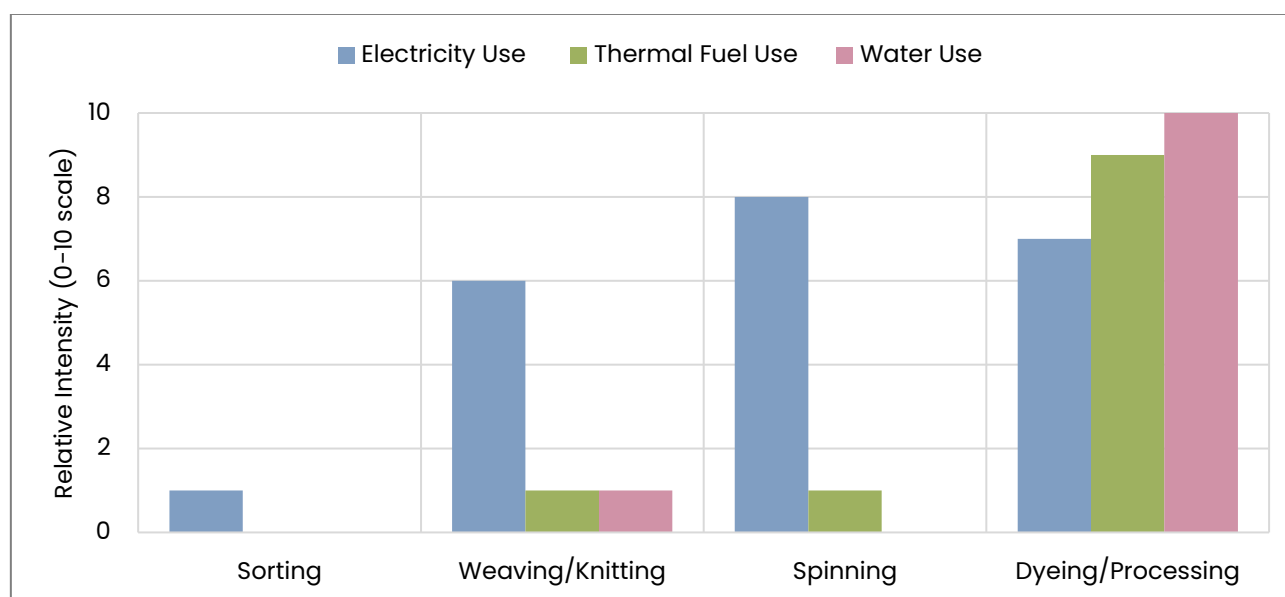
These units run power looms, rapier looms, dobby machines, and warping systems, all of which are motorized and require stable 3-phase electricity supply. Based on industry benchmarks, weaving consumes **approximately 0.3-0.5 kWh per metre**. Like spinning, weaving is not water-intensive unless it is integrated with wet finishing.

⁴ Kaplan, E. and Erdem Koç. "Investigation of Energy Consumption in Yarn Production with Special Reference to Open-End Rotor Spinning." *Fibres & Textiles in Eastern Europe*, vol. 18, no. 2 (79), 2010, pp. 7-13.

5.3. Energy Cost Share

When asked to estimate the share of energy costs in their total production expenses, most respondents reported that energy accounts for 20–30% of overall costs in dyeing, spinning, and mechanised weaving units. A few dyeing units indicated even higher proportions-exceeding 30%-underscoring the energy-intensive nature of thermal and electrical processes in this segment. In contrast, sorting and grading units reported negligible energy expenses, generally below 2%, since their operations are largely manual with minimal reliance on mechanised equipment.

Figure 19: Energy & Resource Consumption Patterns in Panipat Textile Recycling Cluster



5.4. Energy Management Awareness and Practices

Awareness and implementation of structured energy management practices in the Panipat textile recycling cluster remain at a nascent stage. While certain efficiency measures, such as LED lighting and VFD installations, have gained traction, most enterprises continue to operate without formal systems for monitoring, optimisation, or renewable integration. Most units indicated the need for energy audits, awareness workshops, and access to technology demonstrations. Financial assistance, especially in the form of soft loans or capital subsidies, was cited as critical for scaling adoption of EE technologies like stenter retrofits, boiler upgrades, VFDs, and renewable power systems.

The following points summarise key observations on current practices, capacities, and barriers related to energy management in the cluster:

- ▶ **Energy Audits:** Fewer than 10% of enterprises have undergone any form of energy audit, either internal or external. This indicates limited awareness of energy benchmarking and the absence of systematic mechanisms for identifying inefficiencies or potential savings.
- ▶ **In-House Technical Capacity:** More than 90% of the surveyed units reported not having a dedicated technical or energy management team. Most rely on informal, experience-based maintenance practices rather than structured monitoring or preventive maintenance systems.
- ▶ **Energy-Efficient Equipment:** Only a small number of enterprises have adopted energy-efficient (IE3/IE4) motors, while several respondents were uncertain about their equipment ratings. This reflects low technical awareness and limited guidance from equipment suppliers or service providers.

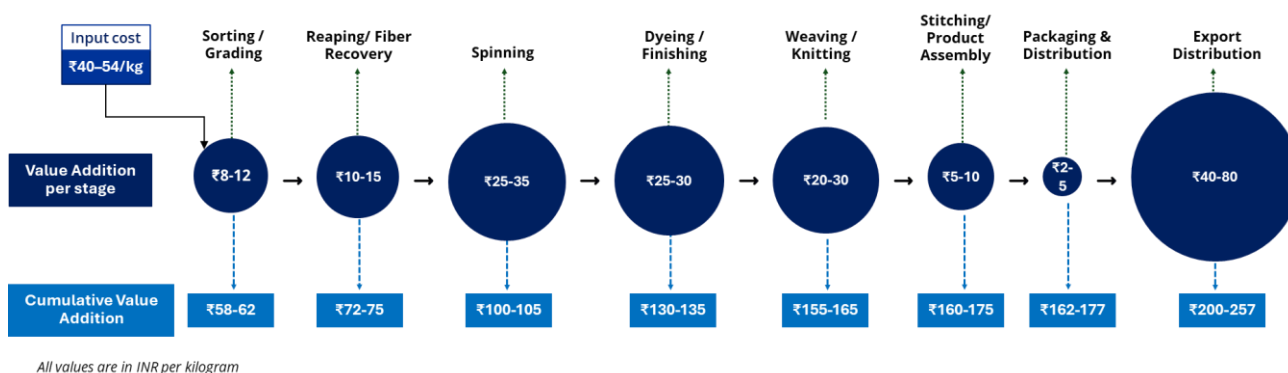
- ▶ **Variable Frequency Drives (VFDs):** Approximately 30% of the surveyed units, mainly in dyeing and high-speed spinning operations, have installed VFDs to optimise motor performance. These installations have typically been driven by the need to reduce motor load fluctuations and electricity costs.
- ▶ **Lighting Efficiency:** The adoption of LED lighting is relatively high, with over 70% of units having completed full or partial replacement of conventional lights. Many reported noticeable reductions in electricity bills and improved lighting quality in workspaces.
- ▶ **Renewable Energy Integration:** A limited but growing number of enterprises have adopted rooftop solar systems or participated in shared renewable energy arrangements. However, several units cited lack of roof space, high upfront investment, and administrative delays as major constraints to broader adoption.

6. Value Chain Analysis

6.1. Value Chain Analysis with Node-Wise Valuation

The Panipat textile recycling cluster operates through a complex yet highly integrated value chain, transforming discarded garments and textile waste into usable home furnishings, yarns, and industrial fabrics. This chain involves multiple stages, each adding value in varying degrees and engaging distinct actors, from informal workers to export-oriented businesses.

Figure 20: Value addition at each stage of the Textile recycling value chain



The value chain begins with waste collection, where post-consumer garments are sourced both domestically and through imports, primarily via Kandla Port. Input costs in the Panipat recycling cluster span a wide range and are costed at range of **INR 20-40 per kg**, depending on fibre composition and grade. These inputs collectively account for an annual procurement value of INR 5,476-5,483 crore at the sorting stage. **Sorting** contributes a fixed 22% margin on input value, equivalent to only **INR 8-12 per kg**, despite being labour-intensive and foundational for downstream quality. This limited margin compared to the incoming material cost indicates a value bottleneck: a stage with high workload but low economic capture. Because the margin does not scale with processing complexity or variability in input composition, the stage structurally underperforms relative to its importance in controlling quality across the rest of the chain.

Following sorting, the waste enters the **fibre recovery or tearing phase**, where fabric is mechanically opened to extract spinnable fibres. This stage earns a 5% margin, giving a **INR 10-15 per kg** value addition. Around 350 micro-units are performing this activity, yet the margin remains small and does not vary across material types or grades. The gap between the input cost and the low realised margin points to a structural bottleneck where units cannot upgrade value proportionate to their operational effort.

The **spinning process**, primarily using open-end spinning technology, transforms the fibre into yarn. It represents one of the more significant value-add stages, contributing **INR 25-35 per kg**. However, yarn quality often varies due to inconsistent input materials. In addition, this stage generates large amount of air pollution from fibre dust. This is an area where the enterprises have shown different levels of maturity and readiness and thus offers scope for awareness creation and supporting the enterprises ready to improve their processes.

The yarn is then sent for **dyeing and finishing**, a thermally and chemically intensive stage that adds **INR 25-30 per kg** in value. Key activities include colouration, washing, and softening, often using biomass-fired boilers and effluent treatment units. This is followed by **weaving or knitting**, where fabric is produced for rugs, blankets, or upholstery, generating **INR 20-30 per kg** in value. Loom operators and small weavers

primarily perform this function. This is a highly fragmented but low-yield segment, where production volume is high but realisation per kilogram is structurally low.

Subsequent steps include **stitching or product assembly**, typically done by tailors or informal labour in household units. This stage contributes a modest **INR 5–10 per kg** in value. **Packaging and distribution** add the least, around **INR 2–5 per kg**, as most products are sold in bulk or generic packaging, with limited branding. The lack of brand equity and quality certification prevents premium pricing, trapping the cluster in a volume-over-value business model.

Finally, the retail or **export sale stage** captures the highest value, approximately **INR 40–80 per kg**, depending on product type, destination, and compliance credentials. Exporters, traders, and institutional buyers, such as government procurement agencies play a critical role at this end of the chain.

The concentration of value here, following multiple low-margin manufacturing steps, shows a systemic imbalance: upstream producers bear operational load while downstream traders capture the highest incremental value. This underscores the need for better integration, fair distribution mechanisms, and investment in quality, branding, and sustainability across the chain.

Table 14: Value Chain of the Panipat Textile Recycling Cluster

Stage	Key Activities	Main Actors	Approx. Value Addition (INR/kg)
Waste Collection	Sourcing of post-consumer garments (domestic and imports via Kandla Port)	<i>Kabadiwalas</i> , importers, aggregators	8–12
Sorting & Grading	Manual segregation by colour, fibre type, and quality	Women and migrant workers in informal setups	6–10
Fibre Recovery (Tearing)	Mechanical opening of fabric to extract fibres	MSMEs, machine operators	10–15
Spinning	Conversion of recovered fibres into yarn (mainly open-end spinning)	Spinning units, small manufacturers	25–35
Dyeing & Finishing	Colouring, washing, softening using biomass boilers and ETPs	Dyeing units, processors	15–20
Weaving / Knitting	Conversion of yarn into fabric for rugs, blankets, upholstery	Loom operators, small weavers	20–30
Stitching / Product Assembly	Sewing and assembling finished products	Tailors, home-based units	5–10
Packaging & Distribution	Bulk or generic packaging for shipment	Local packers, distributors	2–5
Retail / Export Sales	Sale to exporters, traders, or institutional buyers	Exporters, traders, procurement agencies	40–60

6.2. Input Supply and Raw-Material Chain

6.2.1 Primary Inputs

Panipat's mills are fed by a heterogeneous mix of post-consumer garments, pre-consumer off-cuts, and speciality fibre wastes. Roughly 60% of the feedstock now arrives as mutilated, second-hand clothing imported through Kandla and Mundra ports, moved onward approx. 22 tonnes in each container to different sorting yards. Typical bales contain wool-rich winterwear from North America and Europe, cotton T-shirts from Japan and the Gulf, and polyester fleece off-cuts from East Asian garment plants.

Domestic supply covers the 30% of the waste processed, sourced from Tiruppur-Coimbatore knitwear trimming, Ludhiana hosiery waste, and PET-yarn off-grades from Surat.

Table 15: Feedstock Categories and Utilisation in the Cluster

Feed category	Dominant fibres	Average purchase price	Typical use in cluster
Post-consumer winterwear	60–80 % wool/ acrylic blends	INR 20–22 kg	Garneted into shoddy yarn, relief blankets
Knitwear off-cuts	90% cotton	INR 35–40 kg	Low-count rotor yarn, wiping cloth
PET bottle flakes & rPET dope	100 % polyester	INR 55–70 kg	rPET staple, insulation pads

Contaminants (zips, buttons, PVC prints) average 3–5% by weight, requiring additional manual removal before mechanical opening. The high variability in fibre length, colour, and residual chemical finishes remains the single biggest quality risk for spinners aiming at higher-count yarns.

6.2.2 Collection Networks and Waste Aggregators

The physical flow of textile waste into Panipat originates through two parallel channels-domestic collection networks and imported textile waste aggregators. On the domestic side, a vast informal ecosystem of informal waste pickers and rag-dealers in cities like Delhi, Mumbai, and Kolkata segregate usable lots, which are sold to *kabaadi* yards where larger traders consolidate five- to ten-tonne truckloads. On the import side, textile waste aggregators procure discarded garments through auction systems in the Kandla Special Economic Zone, where Panipat-based commission agents' pre-book lots and organise, daily convoys transporting material to the cluster.

Once in Panipat, the waste flows through a structured yet informal hierarchy of actors. **Primary sorters** located along Barsat Road, Jatal Road, Ghana Road, Saundhapur, and Kabari Road manually segregate material by fibre type and colour, typically under piece-rate contracts. **Secondary godown owners** then bale the homogeneous lots and auction them each afternoon to spinning mill representatives, with daily prices - announced by loud-hailer - serving as the benchmark for the entire cluster. **Specialised recyclers**, including felt manufacturers, PET-fibre blenders, and industrial-wiper cutters, compete for niche grades such as Kashmiri wool or towel selvage. Most transactions remain cash-based, though larger exporters are gradually adopting e-invoicing to meet traceability and compliance requirements.

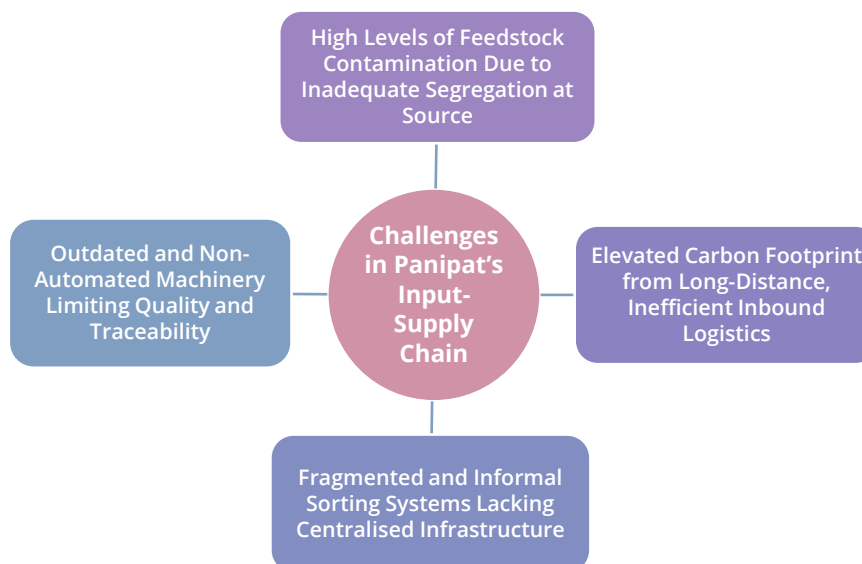
This tightly coordinated chain enables exceptional raw-material velocity - turning waste from port gate to mill hopper in as little as four days, a speed unmatched by rival recycling hubs in Turkey or China. Despite achieving operational efficiencies, the value chain remains vulnerable to several external risks. Port inspection delays, monsoon-related transport disruptions on NH-44 affected further value chain processes. To mitigate these risks, cluster actors are increasingly exploring buffer warehousing, digital bale traceability systems, and diversification into domestic Extended Producer Responsibility (EPR)-linked waste streams-steps crucial for building a more resilient and future-ready input supply ecosystem.

6.2.3 Challenges in Input-Supply Chain

The efficiency and competitiveness of Panipat's textile recycling ecosystem are increasingly constrained by weaknesses in its input-supply chain. Despite its scale and integration, the cluster relies on a highly fragmented and largely informal system for sourcing, transporting, and preparing waste materials. Poor segregation at origin, long-distance logistics, and outdated sorting practices contribute to high contamination rates, elevated carbon emissions, and inconsistent feedstock quality, all of which undermine productivity and reduce value capture. The absence of centralised sorting infrastructure and limited access to modern, contamination-smart machinery further prevent the cluster from achieving the quality and traceability benchmarks demanded by global buyers. Addressing these systemic challenges is

essential not only to enhance operational efficiency but also to align Panipat's recycling processes with emerging ESG and circular economy standards, enabling cleaner inputs, stronger yarn quality, and improved market credibility.

Figure 21: Key Challenges in the Panipat Recycled Textile Input-Supply Chain



6.2.3.1. Contamination Caused by Inadequate Segregation At Source

A major challenge in Panipat's textile recycling input chain stems from the poor segregation of post-consumer textile waste at source. Most imported and domestic bales arrive as mixed packs containing non-textile elements such as PVC prints, metal fasteners, multi-material linings, and even small electronic components. Mill gate inspections frequently reveal 3–5% non-textile impurities and an additional 10–12% fibre cross-contamination—such as poly-cotton blends in “wool” lots or acrylic fibres in “cotton” batches. These contaminants slow down the garning process, increase noil extraction, and weaken yarn strength. Downstream, they cause colour bleeding and uneven dye absorption in blended fibres, leading to high rejection rates and reduced product quality. The absence of pre-sorting and contamination control systems at the source significantly erodes both material value and operational efficiency across the cluster.

6.2.3.2. High Carbon Footprint of Inbound Logistics

The cluster's heavy reliance on long-distance transport adds considerably to its environmental and cost burden. Imported textile waste travels over 1,200 kilometres by road from ports such as Kandla and Mundra to Panipat, while domestic off-cuts from textile hubs like Tiruppur, Surat, and Kolkata often cover even greater distances. Each 40-foot container, typically carrying approx. 22 tonne of material, emits an estimated 4–5 tonnes of CO₂ over this journey. Empty return legs further increase both emissions and per-tonne freight costs. As global buyers move toward Scope 3 emission accountability, this dependence on carbon-intensive transport weakens Panipat's sustainability positioning and raises the landed cost of recycled inputs.

6.2.3.3. Fragmented Sorting and Segregation Systems

Sorting operations in Panipat are highly fragmented, conducted in hundreds of small, unventilated sheds along Barsat Road and nearby industrial lanes. Workers manually pick and segregate textiles from floor-level heaps, without access to mechanised conveyors, dust extraction systems, or fibre-type detection tools. This structure leads to inconsistent recovery of high-value fibres such as cashmere or merino, while dust and micro-lint emissions pose serious environmental and health hazards in surrounding neighbourhoods. The sorting and material recovery practices within the cluster are not digitally enabled to record key traceability parameters such as batch-level identification, fibre composition, and country of origin. This limits the availability of verifiable data on recycled inputs, thereby affecting buyer assurance and the cluster's positioning in export markets where traceability is a critical requirement.

6.2.3.4. Outdated and Non-Automated Machinery

The lack of modern, contamination-smart machinery further constrains efficiency and quality in the recycling process. Most sorting units and mills rely on manual inspection and outdated mechanical equipment that cannot effectively detect elastomeric or PVC-coated materials before tearing. Introducing optical sorters, near-infrared (NIR) fibre scanners, and colour-sorting conveyors could substantially improve material purity, raising single-shade lots from the current 65% to over 90%, while extending card-cloth life and enhancing process traceability. However, such upgrades remain financially out of reach for most MSMEs. Establishing a shared sorting park under a Special Purpose Vehicle (SPV), supported by green finance mechanisms (through SIDBI, ADEETIE, or CSR channels) and pay-per-use models for advanced scanners, could make technology adoption viable at scale. Upgrading to these systems would not only improve yarn quality and reduce contamination but also integrate the cluster into emerging digital product passport and life-cycle assessment frameworks, strengthening its global competitiveness.

6.3. Key Stakeholders and Leakage Analysis

6.3.1 Key Stakeholders

The Panipat cluster plays a pivotal role in India's recycled textile value chain, transforming imported second-hand garments and pre-consumer textile waste into recycled yarns and home textile products. Understanding who captures value along this chain is essential for identifying opportunities to increase incomes, enhance competitiveness and strengthen the cluster's position in international trade.

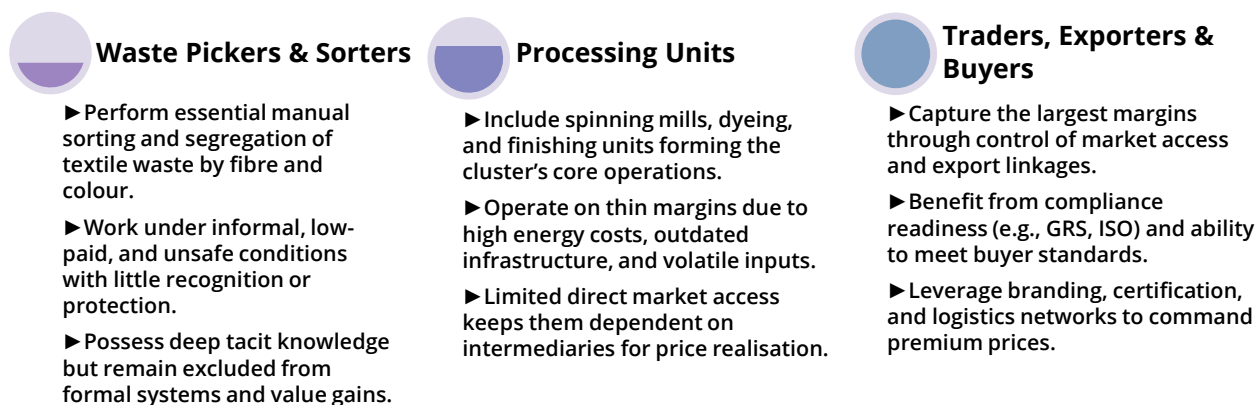
Figure 22: Key stakeholders for value capture in the Panipat Textile Recycling Cluster

Importers and Aggregators	A significant share of Panipat's raw material originates from Europe, the US, and the Middle East, where used garments are collected, sorted, and shipped to India. Importers and aggregators earn margins through large-volume procurement and bulk handling but add limited value beyond basic sorting and baling.
Recyclers and Processing Units	Core value creation occurs at recycling and spinning units that convert waste into recycled yarn and fabric. Those investing in technology and quality control capture higher margins through superior product quality and access to premium buyers, while smaller informal units often remain limited by scale and efficiency constraints.
Traders and Exporters	By consolidating production and managing logistics, traders and exporters enable access to international markets and capture substantial value through price negotiation, compliance management, and certification handling.
International Buyers and Brands	At the downstream end, global brands and retailers capture significant share of value by leveraging brand equity, market reach, and sustainability credentials. Their stringent sourcing norms can marginalize smaller producers but also create opportunities for those who can meet these standards.

6.3.2 Value Share Analysis

Value capture in Panipat's recycled textile cluster is highly skewed, with the largest margins accruing to those who control volume aggregation and market access, moderate shares to the core processors, and the smallest returns to the informal workforce at the base of the chain.

Figure 23: Value Capture Dynamics within the Panipat Recycling Ecosystem



6.3.2.1. High Value Share – Traders, Exporters & Buyers

At the upper end of Panipat's textile recycling value chain, traders, exporters, and international buyers capture the largest share of value owing to their control over market access, compliance, and pricing. Exporters consolidate production from multiple processing units, ensure product standardisation, and manage logistics and buyer relationships. Their ability to secure large export orders and meet international quality and sustainability standards positions them as key intermediaries linking Panipat's informal production base with organised global markets.

Firms dealing with European and North American buyers particularly benefit from the growing demand for certified and traceable recycled textiles, commanding premium prices for GRS- or ISO-certified products. However, achieving and maintaining these certifications requires investments in auditing, documentation, and infrastructure - costs that smaller or informal producers often cannot afford. As a result, value tends to concentrate among a few compliant and export-oriented firms.

International brands and retailers further reinforce this concentration by leveraging their global reach, brand equity, and sustainability narratives to capture downstream profits. Their sourcing standards drive improvements in quality and compliance across the cluster but also exclude smaller, non-compliant players. Overall, the high-value segment's advantage lies in **scale, compliance readiness, and buyer connectivity**, making it both the most profitable and the most influential tier in shaping Panipat's recycled textile trade.

6.3.2.2. Moderate Share: Processing Units

Processing units, comprising open-end **spinning mills, dyeing houses, and finishing facilities** - form the operational backbone of Panipat's textile recycling cluster, converting recovered fibres into yarns, blankets, and home furnishings. Despite their central role, these units capture only a moderate share of value due to thin margins, high input costs, and limited market leverage. Most operate as MSMEs, burdened by volatile raw material prices, steep energy expenses, and outdated infrastructure. Dyeing units can face up to 20-30% energy costs in total production costs, while biomass-fuelled boilers and significant labour costs further strain profitability.

Environmental compliance adds to operational pressure, as smaller units struggle to meet effluent and emission norms or invest in efficient machinery. Dependence on intermediaries for market access, coupled with inconsistent fibre quality and weak quality control systems, further constrains value realisation. Though these processors are vital to the circular economy, they remain stuck in a low-margin, high-risk segment. Strengthening their position will require targeted investments in technology upgrades, energy efficiency, quality assurance, and digital traceability to move them from price takers to value creators in the recycled textile value chain.

6.3.2.3. Least Value Share: Waste Pickers and Sorters

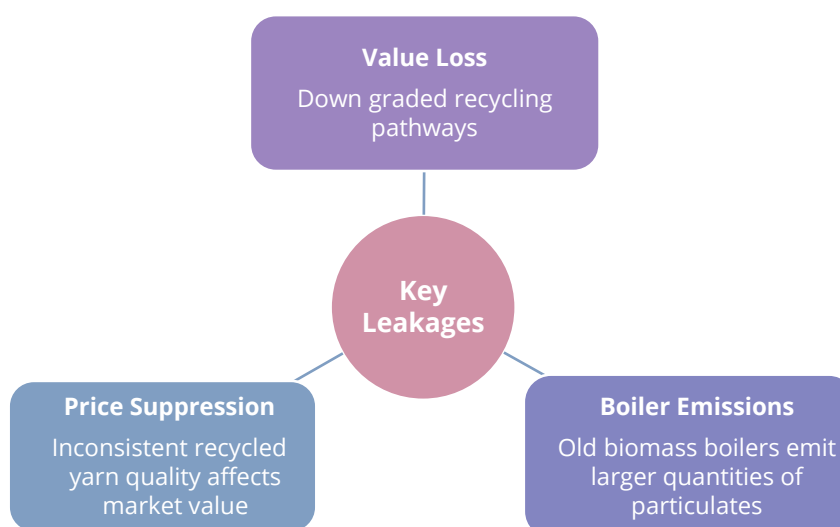
At the base of Panipat's textile recycling value chain, waste pickers and sorters perform the most labour-intensive yet least rewarded work, capturing only a fraction of the total value generated. This predominantly female and migrant workforce is responsible for manually segregating discarded garments by fibre type, colour, and condition-tasks that directly determine the quality of material entering the recycling process. Despite their crucial role in sustaining the cluster's efficiency, their share of value capture remains negligible.

Operating almost entirely within the informal economy, these workers earn low and irregular wages, often under piece-rate systems without contracts, social security, or safety provisions. Their workplaces-typically open yards or unventilated godowns-lack basic amenities such as protective gear, sanitation, or clean drinking water, leaving them exposed to textile dust, chemical residues, and infections. Yet, these workers possess deep tacit expertise, honed over years of experience, enabling them to distinguish fibre blends and assess recyclability with remarkable accuracy-a skillset that remains unrecognised and unrewarded.

The invisibility of this workforce highlights a major inequity in the cluster's value distribution. Even as international buyers demand ethically sourced and traceable products, the foundational layer of the recycling system continues to operate outside formal systems of accountability and welfare. Integrating them into formal systems, through cooperatives, training, certification, and welfare measures, would not only promote equity but also enhance the overall efficiency and quality of Panipat's textile recycling value chain.

6.3.3 Leakages of value chain

Figure 24: Key Leakages in the Recycled Textile Value Chain



The Panipat textile recycling cluster faces critical value leakages that undermine both its economic and environmental performance. At the material level, a significant portion of usable fabric is lost to downgraded recycling pathways due to inadequate sorting and limited fibre recovery efficiency. Operationally, outdated biomass boilers in dyeing and finishing units emit high levels of particulates, driving up fuel costs and exposing units to compliance risks. On the market front, inconsistent yarn quality—stemming from variable fibre inputs and limited quality control—leads to price suppression and weakens buyer confidence. Together, these leakages reduce the cluster’s overall value capture potential, highlighting the need for improved sorting systems, cleaner production technologies, and stronger quality assurance mechanisms to enhance efficiency and competitiveness.

6.3.3.1. Unutilised Waste Sent to Landfill

A minor proportion—estimated at 0.3 to 0.5%—of recycled textile value chain waste in Panipat is either underutilized or entirely discarded, primarily due to inconsistent waste segregation, limited uptake of fibre-to-fibre recycling technologies, and inadequate infrastructure for handling low-value residuals. Common forms of leakage include:

- ▶ Reject material from dyeing and cutting operations, often contaminated or improperly blended.
- ▶ Fabric trimmings and damaged yarns that fall below spinning-grade quality.
- ▶ Sludge from effluent treatment plants (ETPs) and ash generated from biomass boilers.

These waste streams frequently end up in landfills, are used as fuel within or outside the cluster, as low-grade industrial fuel. There is scope to reduce this amount by improving the quantity of recoverable material and embedded value through better practices, technology upgradation but also contributes to lesser air and soil pollution, ensuring the cluster’s circularity goals and green branding potential.

6.3.3.2. Inefficient Boilers and Generators

Many dyeing and finishing units in Panipat continue to depend on agro-waste biomass fuels such as mustard husk, sawdust, and rice husk, alongside Liquefied Petroleum Gas (LPG) where infrastructure exists. Biomass remains a cost-effective energy source, yet most boilers in use are aging and inefficient, consuming excessive fuel and operating with outdated combustion systems. The lack of modern emission-control equipment, like electrostatic precipitators, scrubbers, or chimney filtration, leads to energy wastage and localised air quality issues. In medium-sized units, daily biomass consumption of 5–6 tonnes is common during peak operations, reflecting significant thermal demand and rising carbon intensity.

Adoption of cleaner, energy-efficient boilers, including fluidized bed combustion (FBC), hybrid, or gas-fired systems, is still minimal due to high capital costs, limited awareness, and restricted access to concessional finance. Many MSMEs also lack the technical capacity to operate or maintain advanced systems. Strengthening green financing, technology demonstrations, and cluster-level shared utilities could accelerate cleaner energy transitions, improving both cost efficiency and environmental compliance across Panipat’s textile processing ecosystem. Several units are progressively aligning with statutory norms through phased investments, technical support, and regulatory facilitation.

6.3.3.3. Price Suppression Due to Quality In-consistencies

Quality inconsistency, once a key challenge in Panipat’s recycled yarn sector, is being addressed through better awareness, process upgrades, and collaborative efforts. As the cluster processes diverse post-consumer waste, variability in fibre type, colour, and fabric construction can affect yarn strength and finish, especially when lower-grade inputs are used.

Very few progressive units now invest in improved pre-sorting, traceable sourcing, and structured blending to enhance uniformity. The adoption of fibre scanners, standardised testing, and digital quality systems is gaining traction among export-oriented mills, marking a shift from manual to data-backed production.

Panipat's adaptability positions it well to meet global buyer expectations. Rising demand for GRS-certified yarns and traceability pilots signals stronger quality assurance. With targeted upskilling, digital integration, and cluster branding, Panipat can meet international benchmarks and establish itself as a leader in sustainable recycled yarns, turning past constraints into competitive strengths.

6.3.4 Impact of International Trade Dynamics

Panipat's recycled textile industry is deeply intertwined with global trade flows, where shifts in demand, sustainability regulations, and price competition shape how value is distributed across the chain. As one of the world's largest hubs for recycled yarn and home textiles, Panipat operates at the intersection of low-cost bulk markets and increasingly demanding premium markets in Europe, Middle East and North America. These trade linkages determine not only the margins available at each production stage but also the capacity of local actors to upgrade technologically and organisationally. Over the past decade, the global push for circular economy standards, traceable supply chains, and ethical sourcing has amplified both opportunities and pressures for Panipat's producers. While larger and more formal units are beginning to benefit from compliance-led differentiation, smaller informal units often struggle to keep pace with the requirements of international buyers. Exchange rate volatility, policy shifts, and evolving trade norms further influence competitiveness, underscoring the need for strategic adaptation across the cluster.

Figure 25: International Trade Dynamics Affecting Value Capture

Price Pressures and Market Segmentation	The global recycled textile trade is divided between price-sensitive bulk markets in Africa and the Middle East and premium markets in Europe and North America that demand certified, traceable, and high-quality products. This segmentation influences which actors capture value and the margins available at each level.
Compliance and Certification Costs	Adhering to international ESG norms and certifications such as GRS or BSI increases operational costs but enables access to premium buyers. Larger, formal units benefit from compliance capacity although they might face entry barriers, while smaller informal players are often priced out.
Fragmented Supply Chain and Informality	The predominance of intermediaries and informal operations erodes margins and limits collective bargaining power, leaving primary processors with a reduced share of export revenues.
Currency Fluctuations and Trade Policies	Volatile exchange rates and changing tariff regimes affect export competitiveness and profitability, particularly for smaller exporters with limited financial buffers.
Technology and Innovation Adoption	Investments in advanced recycling, digital traceability, and product diversification can enhance compliance, improve quality, and unlock higher-value market segments.

6.4. Technological Gaps and Innovation Opportunities

The Panipat textile recycling chain adds value through several interconnected stages, each with unique constraints and emerging opportunities for innovation. The collection and sorting stage, which sets the foundation for the entire process, still relies heavily on manual methods-leading to inefficiencies and contamination. Recent global trends, such as automated sorting using **AI and hyperspectral imaging**,

are transforming this stage by enabling highly accurate fibre identification and colour recognition, which in turn improve downstream yarn quality. Initiatives like the **Sort to Sustain** project demonstrate how dedicated infrastructure for colour and composition-based sorting can significantly enhance the quality of feedstock entering the recycling process.

In the cleaning and fibre recovery phase, traditional mechanical tearing and scouring remain labour- and energy-intensive, often producing inconsistent fibre quality. However, global innovations such as **enzymatic cleaning**, **advanced mechanical shredding**, and **chemical depolymerisation** are opening pathways for higher-grade fibre recovery, particularly for polyester or blended textiles that dominate post-consumer waste streams. The spinning stage, which converts these fibres into recycled yarn, continues to face challenges of variable input quality and low realisation values-issues that can be mitigated through improved blend control, modern carding systems, and quality assurance protocols.

Weaving and knitting processes largely produce utilitarian textiles such as rugs and mats, with limited design differentiation. Upgrading to Jacquard or tufting technologies could enhance both product appeal and market positioning. Similarly, dyeing and finishing, while adding critical value in colour and texture, remain constrained by high effluent loads and thermal inefficiencies. Cleaner dyes, energy recovery systems, and compliant effluent treatment plants are now central to aligning with global sustainability benchmarks. Finally, packaging and dispatch stages continue to underplay product value due to weak presentation and traceability. The adoption of **eco-friendly packaging**, stronger **branding**, and **QR-coded trace systems** could help Panipat's recycled products compete more effectively in both domestic and international markets.

Table 16: Process Stages & Value Drivers

Stage	Main Output / Value Add	Key Constraints	Innovation Levers
Collection & Sorting	Segregated fibre by type/colour	Visual/manual, high error rate	AI-based sorting, infrastructure hubs
Cleaning & Fiber Recovery	Scoured and opened fibrous mass	Labor-intensive, energy-heavy	Enzymatic scouring, mechanical shredding
Spinning	Recycled shoddy yarn	Variable yarn quality, low realisation	Advanced carding, blend control, QA protocols
Weaving / Knitting	Utility textiles (rugs, mats)	Basic designs, opaque craftsmanship	Jacquard patterns, tufting upgrades
Dyeing / Finishing	Finished coloured textiles	High effluent load, thermal inefficiencies	Cleaner dyes, compliant ETP, energy recovery
Packaging / Dispatch	Market-ready bundles	Poor presentation, low traceability	Eco-packaging, branding, QR trace codes

7. Traceability, Digital Readiness and Green Product Branding Readiness

7.1. Importance and Drivers of Traceability

Traceability refers to the systematic ability to track the journey of a textile product, component, or raw material throughout its lifecycle - from the point of origin (such as post-consumer or post-industrial waste) to manufacturing, use, end-of-life and potential recycling. In the context of Panipat's textile recycling cluster, which depends heavily on imported second-hand garments and post-consumer waste, traceability plays a pivotal role in ensuring **environmental responsibility, ethical sourcing, legal compliance and material integrity**.

As global regulations increasingly demand verifiable data on product origin and recycled content, traceability has emerged as a strategic differentiator rather than a mere compliance requirement. Frameworks such as the EU Strategy for Sustainable and Circular Textiles, Ecodesign for Sustainable Products Regulation (ESPR), and the upcoming Digital Product Passport (DPP) mandate full lifecycle visibility for textiles entering European markets. Similarly, India's draft Extended Producer Responsibility (EPR) Guidelines for Textiles signal a domestic shift toward accountability in waste sourcing and processing. These developments directly impact Panipat's exporters and MSMEs, who supply to international buyers that now expect proof of responsible sourcing and transparent recycling processes.

Figure 26: Global and National Regulatory Drivers for Traceability

EU Ecodesign Regulation for Sustainable Products (ESPR):	Mandates traceability of environmental attributes via Digital Product Passports
Corporate Sustainability Reporting Directive (CSRD):	Requires large brands to report on supply chain sustainability, including material provenance
Extended Producer Responsibility (EPR):	Being rolled out across Indian states and in the EU for textiles, requiring producers to take responsibility for post-consumer waste
India's Draft EPR Guidelines for Textiles (MoEFCC):	Indicate upcoming mandates for producers and recyclers to document waste flow

Despite being India's largest hub for recycled yarns, blankets, and home textiles, Panipat's recycling ecosystem remains constrained by informal sourcing practices, limited relevant customised digital infrastructure, and weak data management systems at enterprise level. Most material flows-whether imported through Kandla Port or sourced domestically-lack verifiable documentation linking input waste to output products. This opacity not only limits access to premium ESG-conscious markets but also exposes the cluster to risks such as contamination, greenwashing claims, and loss of buyer trust.

Strengthening traceability within the cluster is therefore essential to improving supply chain transparency, compliance readiness, and global competitiveness. A robust traceability framework would enable Panipat's MSMEs to demonstrate verified recycled content, build credibility with international buyers, and align with emerging global sustainability norms.

7.2. Stakeholders and Incentives for Traceability

The effectiveness of traceability in Panipat's textile recycling ecosystem depends on the coordinated participation of diverse actors-ranging from informal sorters and MSME recyclers to large exporters and certifying agencies. Each stakeholder contributes to and benefits from a transparent, data-driven supply

chain in distinct ways. A well-designed traceability system therefore needs to align incentives across all levels, ensuring both compliance and competitiveness.

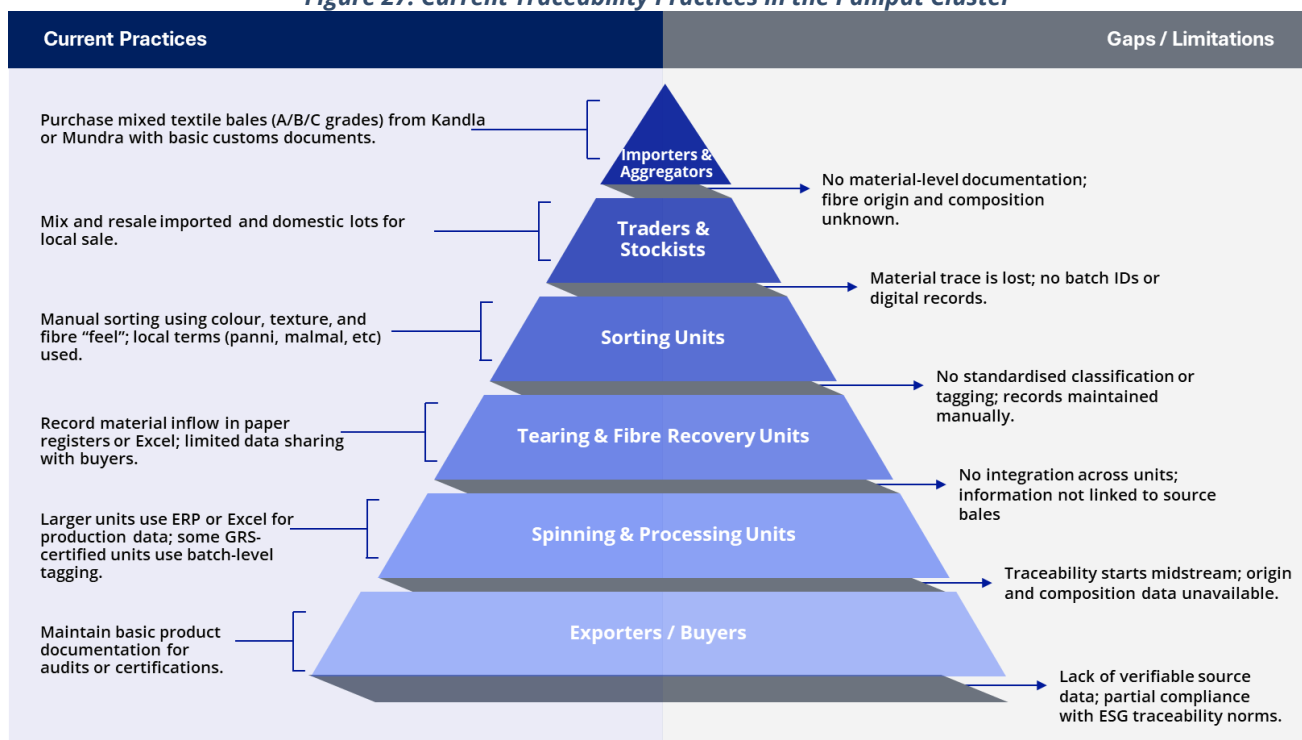
Table 17: Key Stakeholders and Their Incentives for Traceability

Stakeholder Group	Primary Role in the Value Chain	Key Incentives and Benefits from Traceability
Recycling Units / MSMEs	Convert textile waste into yarns, fabrics, and home furnishings	Access to premium buyers; eligibility for green certifications; improved process efficiency and reputation
Traders and Aggregators	Source, grade, and supply textile waste to processors	Ability to demonstrate legal sourcing and material integrity; stronger buyer confidence
Exporters / Agents	Connect MSMEs to global markets	Enhanced credibility with ESG-focused buyers; long-term contracts and higher price realisation
Brands / Retailers	Source recycled textiles for domestic and global markets	Compliance with ESG norms; consumer trust, verifiable sustainability claims
Government and Regulators	Oversee EPR and trade compliance for recycling sector	Reliable data for monitoring waste flows, enforcing standards, and reporting on circular economy targets
Certifying Agencies	Audit and certify recycled content (e.g., GRS, OEKO-TEX)	Depend on verified data to ensure credible certification and reduce audit discrepancies
Consumers	Purchase final recycled textile products	Greater confidence in sustainability claims and ethical sourcing through verified product data

By aligning the economic and compliance interests of these actors, a robust traceability ecosystem can transform Panipat’s recycling sector from a largely volume-driven, informal system into a data-driven, transparent, and ESG-compliant cluster.

7.3. Current Traceability Practices in the Cluster

Figure 27: Current Traceability Practices in the Panipat Cluster

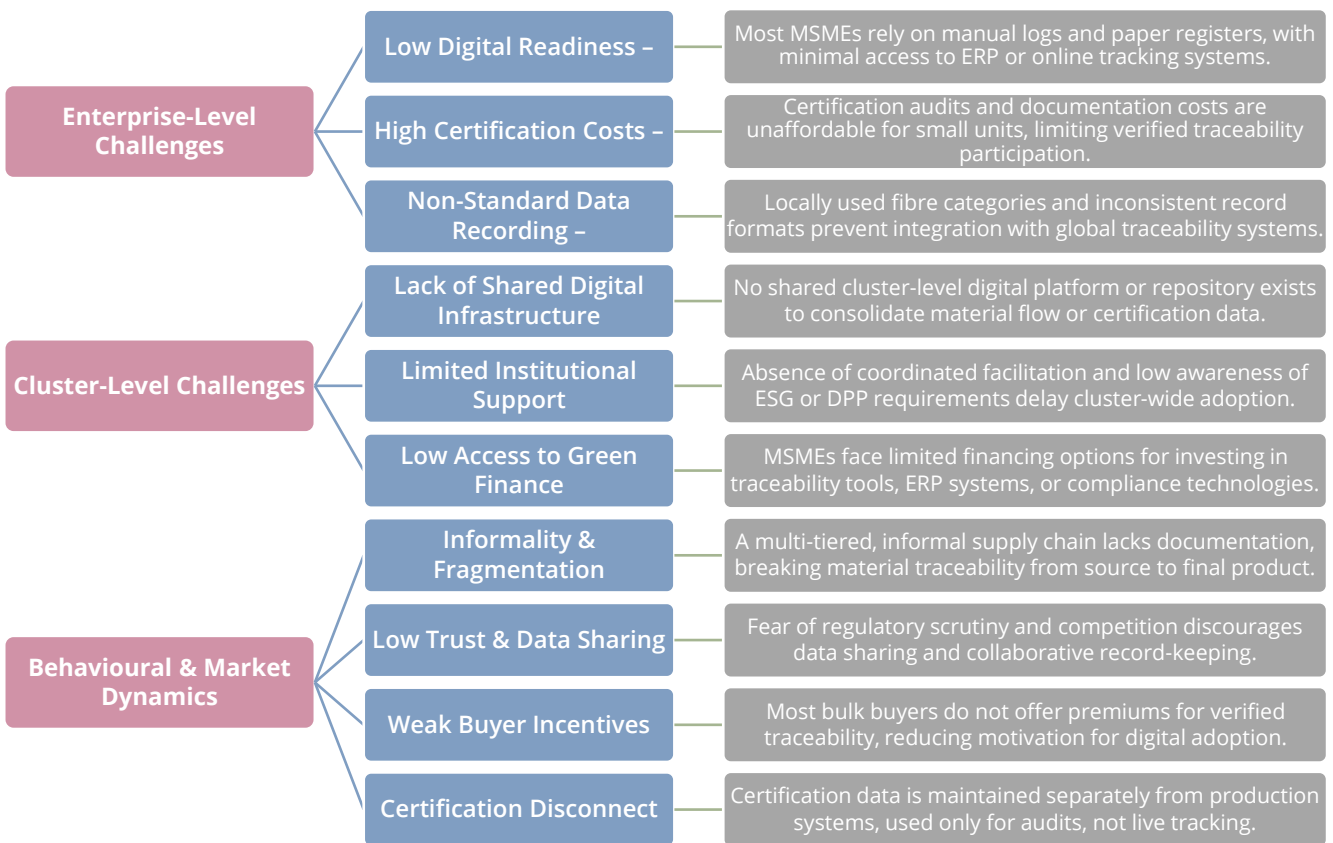


Traceability practices within Panipat’s textile recycling cluster are largely informal, fragmented and inconsistent, functioning through experience-based, manual systems with very limited use of digital systems for tracking material origin or movement. Most waste flows through multiple intermediaries without documentation, and existing record-keeping depends heavily on manual registers and worker experience. The traceability system is highly dependent on individual unit practices, size, and market orientation (domestic vs export).

7.4. Challenges in traceability across supply chain actors

Despite Panipat’s scale and maturity as India’s leading textile recycling hub, the cluster continues to face several interrelated challenges that limit the development of a transparent and digitally traceable value chain. These barriers span structural, technological, behavioural, and institutional dimensions, and collectively constrain the cluster’s readiness to align with emerging international standards. As global markets, especially Europe demand traceable and ESG-compliant sourcing, Panipat must address these gaps to remain competitive.

Figure 28: Systemic Challenges Affecting Traceability in the Panipat Recycling Cluster



7.5. Digital Readiness of MSMEs

Digital readiness among Micro, Small, and Medium Enterprises (MSMEs) in Panipat’s textile recycling cluster remains **limited and uneven**, reflecting wide disparities in capacity, awareness, and investment ability. While a handful of medium-sized, export-linked enterprises have begun experimenting with basic ERP systems or digital tagging, the majority of smaller units continue to operate with manual, paper-based processes that offer minimal data integration or traceability value.

Current Level of Digitalisation

Most MSMEs record procurement and production data in notebooks or Excel files, capturing only basic details such as quantity and vendor name. Fibre type, source, and process information are rarely noted. ERP systems, used by a limited number of larger units, remain internal and disconnected from supply chain partners. As a result, traceability data does not extend beyond enterprise boundaries.

Infrastructure and Connectivity Constraints

Infrastructure gaps are a major deterrent to digital adoption. Power fluctuations and weak internet connectivity in older industrial zones make cloud systems unreliable. Many MSMEs operate with minimal IT hardware—often a single shared desktop—and lack secure data backup or maintenance systems. Even when there is intent to digitise, physical infrastructure remains a constraint.

Human Resource and Digital Literacy Gaps

Digital skills are limited among both owners and workers. Many entrepreneurs prefer traditional supervision and verbal reporting to structured data management. Line workers, largely migrant labourers, have little exposure to digital tools or documentation protocols. Without local training mechanisms, digital adoption remains dependent on individual initiative rather than institutional support.

Financial and Operational Barriers

For most small enterprises, digitalisation is seen as a cost rather than an investment. Limited access to credit and the informal nature of operations make software or system upgrades financially unviable. Since few buyers offer premiums for traceability, the incentive to digitise remains weak. The result is continued dependence on low-cost, manual systems. Despite these challenges, gradual change is visible. E-invoicing under GST and certification audits have increased familiarity with digital documentation. Some exporters and certified mills now maintain basic digital records for buyer compliance. Interest in shared ERP or pay-per-use traceability hubs suggests a willingness to adopt collective solutions if costs and training support are provided.

Panipat's MSMEs display **low-to-moderate digital maturity**, with readiness concentrated among export-oriented firms. Most small units lack the infrastructure, finance, and skills needed for digital traceability. A cluster-wide approach, focused on shared platforms, training, and financial facilitation, will be essential to build inclusive digital readiness and prepare the ecosystem for traceability and ESG compliance.

7.6. Adoption Readiness for Digital Traceability and Blockchain-Based Solutions

As global textile supply chains move toward greater transparency and accountability, digital traceability has emerged as a critical enabler of decarbonisation and market access. For Panipat's textile recycling cluster - where material flows are complex and dominated by MSMEs - traceability systems offer a pathway to strengthen credibility, meet buyer compliance, and integrate into emerging frameworks such as the EU's Digital Product Passport (DPP) and Carbon Border Adjustment Mechanism (CBAM).

While awareness of these shifts is growing, particularly among export-oriented enterprises, adoption across the wider cluster remains limited. MSMEs recognise the inevitability of traceability but remain hesitant due to cost, technical complexity, and uncertainty over commercial returns. A few progressive exporters are beginning to explore blockchain- and SaaS-based traceability tools, but widespread adoption will require a combination of financial incentives, demonstration pilots, and sustained handholding support.

Figure 29: Digital Traceability Readiness at a Glance

Dimension	Current Status in Panipat Cluster	Implications for Decarbonisation and Market Access
Awareness Level	Moderate to high among exporters; low among domestic-focused and informal units.	Exporters are driving the transition, but the cluster lacks collective readiness.
Adoption Drivers	Buyer compliance (GRS, RCS, DPP), ESG alignment, market credibility, and traceability-linked premiums.	Directly supports low-carbon verification, transparency, and access to regulated markets.
Key Barriers	High setup and subscription costs, lack of technical capacity, limited digital infrastructure, and data privacy concerns.	Without support, smaller units risk exclusion from traceable and certified value chains.
Technology Readiness	Blockchain/SaaS platforms piloted by a few exporters; minimal adoption in micro and small enterprises.	Potential to ensure product traceability and verified recycled content but needs simplification and cost-sharing.
Institutional Support Needs	Cluster-level pilots, government/donor subsidies, technical training, and local language user interfaces.	Critical to achieving scalable adoption and cluster-wide decarbonisation compliance.

- ▶ **Cautious but Emerging Willingness:** Overall, MSMEs in Panipat express cautious but growing interest in adopting digital traceability tools. Most enterprises acknowledge that such systems will soon become essential for maintaining export relationships, yet they are reluctant to invest without financial or technical assistance. The current sentiment is one of *pragmatic interest* – driven by compliance and buyer pressure rather than intrinsic motivation for sustainability.
- ▶ **Growing Awareness among Exporters and Brands:** Export-oriented spinning mills and larger processors show greater awareness of traceability frameworks such as Global Recycled Standard (GRS) and Recycled Claim Standard (RCS). These firms recognise clear business benefits: premium pricing, stronger buyer retention, and enhanced credibility in ESG-conscious markets. Several global brands – including H&M, IKEA, and European buyers – are already piloting systems that integrate QR code tracking, Digital Product Passports (DPPs), and blockchain-based fibre tracing, signalling a top-down market push for verified sustainability.
- ▶ **Limited Preparedness among Smaller Units:** Smaller and informal enterprises, particularly those engaged in sorting, tearing, and basic fibre recovery, remain hesitant or unprepared for digital adoption. Their resistance stems from the perceived costs of new tools, lack of digital infrastructure, and fear of exposing sensitive sourcing data. Many rely on manual documentation or verbal transactions, making the transition to real-time digital tracking systems challenging. In some cases, mistrust regarding data usage and potential regulatory exposure further discourages participation.
- ▶ **Cost and Complexity as Key Barriers:** Even among interested units, cost and complexity are major deterrents. High initial setup expenses, recurring subscription fees, and complicated user interfaces make these systems seem inaccessible. MSMEs are also uncertain whether such investments will translate into tangible commercial advantages or buyer incentives, leading to a wait-and-watch approach.
- ▶ **Conditional Openness to Blockchain and SaaS Platforms:** Medium-sized spinning and tearing units show cautious openness toward blockchain or SaaS-based traceability tools, provided they are affordable, intuitive, and adaptable to local contexts. MSMEs are more likely to adopt when platforms feature simplified dashboards, local language options, and cost-sharing arrangements. However, most

informal units still lack the basic digital infrastructure – computers, smartphones, and stable internet required for participation.

- **Need for Demonstration and Cluster-Level Support:** Across stakeholder consultations, there is consensus that pilot projects and handholding support are essential to overcome hesitation. Demonstration initiatives – facilitated by industry associations, government agencies, or development partners – could showcase operational feasibility and build confidence. Co-funded or subsidised onboarding, coupled with buyer-backed pilots, would help prove business value and accelerate wider adoption across the cluster.

7.7. Green Product Branding Readiness

As global textile markets move toward sustainability-led procurement, the ability to establish a credible green product brand has become a key determinant of competitiveness. Buyers in Europe, North America, and Japan are increasingly demanding verifiable evidence of environmental and social performance, extending beyond recycled content claims to include transparency, traceability, and ethical production. For Panipat’s textile recycling cluster, one of the world’s largest centres for recycled yarn and home furnishings, this transition presents both an opportunity and a challenge: while the cluster already produces inherently circular products, its current operations lack the systems and visibility required to position them as “green” in the global marketplace.

Green product branding in this context refers not only to marketing or labelling, but to a verified performance identity built on traceable sourcing, certified production processes, and demonstrable environmental benefits. A credible green brand allows exporters and MSMEs to access premium markets and ESG-aligned buyers, while strengthening the overall image of the cluster as a responsible and future-ready manufacturing base. However, to achieve this, Panipat must bridge several gaps - limited traceability, low digital readiness, inconsistent compliance, and lack of coordinated brand positioning - that currently prevent its products from being recognised as sustainable beyond domestic and low-cost export markets.

7.7.1. Current Buyer Expectations and Market Trends

In the global textile and apparel market, buyers especially from Europe, North America and other developed regions have heightened expectations regarding Environmental, Social and Governance (ESG) compliance and green product certifications. Buyers expect suppliers to provide comprehensive documentation, including traceability from raw materials through processing, along with third-party verified certifications.

Table 18: Buyer Expectations and Market Trends in Sustainable Textiles

Dimension	What Buyers Expect	Typical Certifications / Mechanisms	Relevance to Panipat Cluster
Material Traceability	Verified recycled content with documentation across the value chain	Global Recycled Standard (GRS), Textile Exchange, OEKO-TEX, Cradle-to-Cradle	Limited upstream traceability; only a few certified mills maintain batch-level data
Process Sustainability	Evidence of low-impact dyeing, reduced water and energy use, and ETP compliance	Higg FEM, ISO 14001, ZDHC MRSL	Many MSMEs lack data or infrastructure to demonstrate compliance
Social & Ethical Standards	Worker safety, fair wages, gender inclusion, and audit readiness	SA8000, Sedex SMETA, BSCI	Predominantly informal labour; limited audit documentation








Dimension	What Buyers Expect	Typical Certifications / Mechanisms	Relevance to Panipat Cluster
Transparency & Reporting	Digitised data, online disclosure, and lifecycle tracking	Digital Product Passport (DPP), Blockchain traceability	No digital linkage between waste source, yarn, and final product
Green Branding & Market Storytelling	Clear sustainability claims supported by data and certifications	Sustainability reports, QR-based labels	Weak cluster-wide branding; limited storytelling despite circular heritage

7.7.2. Cluster Capacity for Green Branding

While Panipat has established itself as a global hub for recycled textiles, its ability to translate this advantage into a credible green brand identity remains limited. The cluster's strength lies in its circular production model and deep recycling expertise, yet it struggles with low visibility, fragmented compliance, and weak communication of sustainability credentials. Green branding readiness therefore depends not only on the adoption of eco-friendly practices but also on the ability to measure, document, and market these efforts in a consistent, verifiable way.

The following table presents a snapshot of Panipat's current green branding capacity, mapped across key dimensions relevant to sustainable market positioning.

Table 19: Cluster Capacity for Green Branding

Dimension	Current Status in Panipat Cluster	Desired / Benchmark Level	Readiness Level
Recycled Content & Circular Production	Strong recycling base; extensive fibre recovery and open-end spinning	Verified traceability and waste-source documentation	
Environmental Compliance (ETP, Energy, Water)	Partial compliance; a few units have ETPs, most rely on shared or informal systems	Universal compliance and documented environmental performance	
Certifications & Standards (GRS, OEKO-TEX)	Limited certification coverage; mainly among exporters and large mills	Wider participation across MSMEs with multi-tier certification support	
Digital Traceability Systems	Minimal; mostly manual or Excel-based data entry	Integrated digital traceability linked to DPP or blockchain	
Cluster-Level Brand Visibility	Individual exporter branding; no unified sustainability narrative	Cluster-level green identity and marketing platform	
Buyer Engagement & Market Access	Concentrated in bulk and low-compliance buyers	Diversified base with ESG-focused, premium buyers	
Institutional Support & Coordination	Limited facilitation by associations; no sustainability roadmap	Cluster-wide sustainability council and digital facilitation hub	

7.8. Readiness for Digital Product Passports (DPP)

The Digital Product Passport (DPP) is an emerging tool that enhances transparency and traceability within textile supply chains. It provides digital records on product origin, material composition, processing history, and compliance status, helping brands, regulators, and consumers verify sustainability claims. By enabling data-driven decisions, DPPs also promote circular economy practices such as recycling, reuse, and responsible disposal. The European Union, under its Sustainable Textiles Strategy and Green Deal, is spearheading mandatory disclosure of traceability and environmental impact.

For Panipat’s recycling cluster, which exports large volumes of recycled yarns, home furnishings, and industrial textiles, the DPP represents both a compliance challenge and a strategic opportunity. It offers a pathway to strengthen the credibility of “Made from Recycled Materials” claims, enhance buyer confidence, and access premium ESG-driven markets. However, achieving readiness will require upgrading digital systems, standardising data capture, and aligning documentation with global traceability protocols.

7.8.1. Current Level of DPP Readiness

While some export-oriented spinning and finishing units have begun digitising production and certification data, the majority of MSMEs remain far from DPP compliance. Presently, most units maintain paper-based registers or Excel sheets that record only basic procurement and dispatch details. Current implementation is limited to a few progressive companies.

- ▶ **Spinning mills/Manufacturers/Exporters** supplying European buyers through intermediaries have partial digital systems (often linked to GRS-certified documentation).
- ▶ **Dyeing and finishing units** record batch-level data manually, with minimal environmental tracking.
- ▶ **Sorting and tearing units**, which handle raw textile waste, are almost entirely undocumented.

This fragmented data landscape means that Panipat’s traceability begins only midstream, typically from spinning onwards, rather than at the material source. To achieve DPP compliance, traceability must extend end-to-end, from waste input to finished export.

7.8.2. Cost Structure of DPP Implementation

Implementing a DPP system entails initial setup costs, recurring maintenance fees, and data compliance expenses. The cost burden varies depending on enterprise size and system sophistication.

Table 20: Cost Considerations for Digital Product Passport Implementation

Cost Component	Description	Remarks
Digital Setup / Platform Subscription	Licensing or subscription to DPP-compatible traceability software	Indicative range for MSMEs is INR 2–10 lakh depending on scope and customisation; could be lower under shared models
Hardware and QR / Tag Integration	Label printing, scanners, barcoding, or RFID integration	Costs vary but are non-trivial for smaller units.
Data Management & Documentation	Training, data entry, and reporting support	Can be pooled through cluster-level service
Certification & Audit Alignment	GRS or equivalent certification integration into DPP	Required for credibility and verification
Maintenance / Cloud Storage	Platform upkeep and cloud-based storage of product data	recurring line items that must be budgeted annually

For small and informal units typical in Panipat’s recycling cluster, these costs can pose significant barriers without financial assistance or cluster-level collaborative models that distributes expenses and provides collective training.

7.8.3. DPP Technology and Service Providers

A growing ecosystem of technology providers now offers turnkey DPP and traceability solutions tailored for the textile sector. These range from blockchain-enabled platforms to lightweight SaaS systems compatible with existing ERP setups.

- ▶ **Global Platforms** such as *CircularID*, *Everledger*, and *SourceMap* provide **blockchain-enabled systems** ensuring tamper-proof data and transparency.
- ▶ **GS1 India**, a national standards organisation, supports **barcode-based product identification** and interoperable data-sharing frameworks suitable for MSMEs.
- ▶ **InDitex**, an Indian textile-industry platform, is developing integrated traceability tools and DPP concepts tailored to cluster realities.
- ▶ Collaborations between **Textile Exchange** and **CII** are piloting DPP-aligned traceability frameworks for Indian textile clusters.
- ▶ **Green Story DPP platform** is a sustainability intelligence solution that helps textile and apparel companies create and manage Digital Product Passports (DPPs).
- ▶ **TrusTrace**: A software provider that has been recognized by Gartner for its DPP readiness and is working with brands on pilot programs.
- ▶ **Intertek**: A global leader in quality assurance and compliance that offers DPP solutions, including verification, risk assessment, and LCA support for the fashion industry.
- ▶ **Inriver PIM**: Offers a Product Information Management (PIM) system that helps companies centralize and manage the complex product data required for DPP compliance.
- ▶ **Carbon Trail**: Provides guidance and solutions for implementing DPPs in the textile sector, including AI-driven insights.
- ▶ **Worldfavor**: Has partnered with Nilörn to offer a solution supporting supply chain transparency for the textile industry, including DPP requirements.

These initiatives emphasise localised, scalable digital tools and cluster-level pilots to keep adoption affordable and practical.

7.8.4. Indian Adaptations and Support Mechanisms

Recognising the fragmented nature of Indian textile clusters, DPP frameworks are being customised for local scalability. Pilot initiatives focus on shared digital systems allowing multiple units to use common infrastructure for data storage and compliance reporting. Government schemes under the Ministry of Textiles-including the Sustainable Textiles Mission and upgraded Technology Fund Schemes-are exploring incentives to promote digital traceability and export competitiveness.

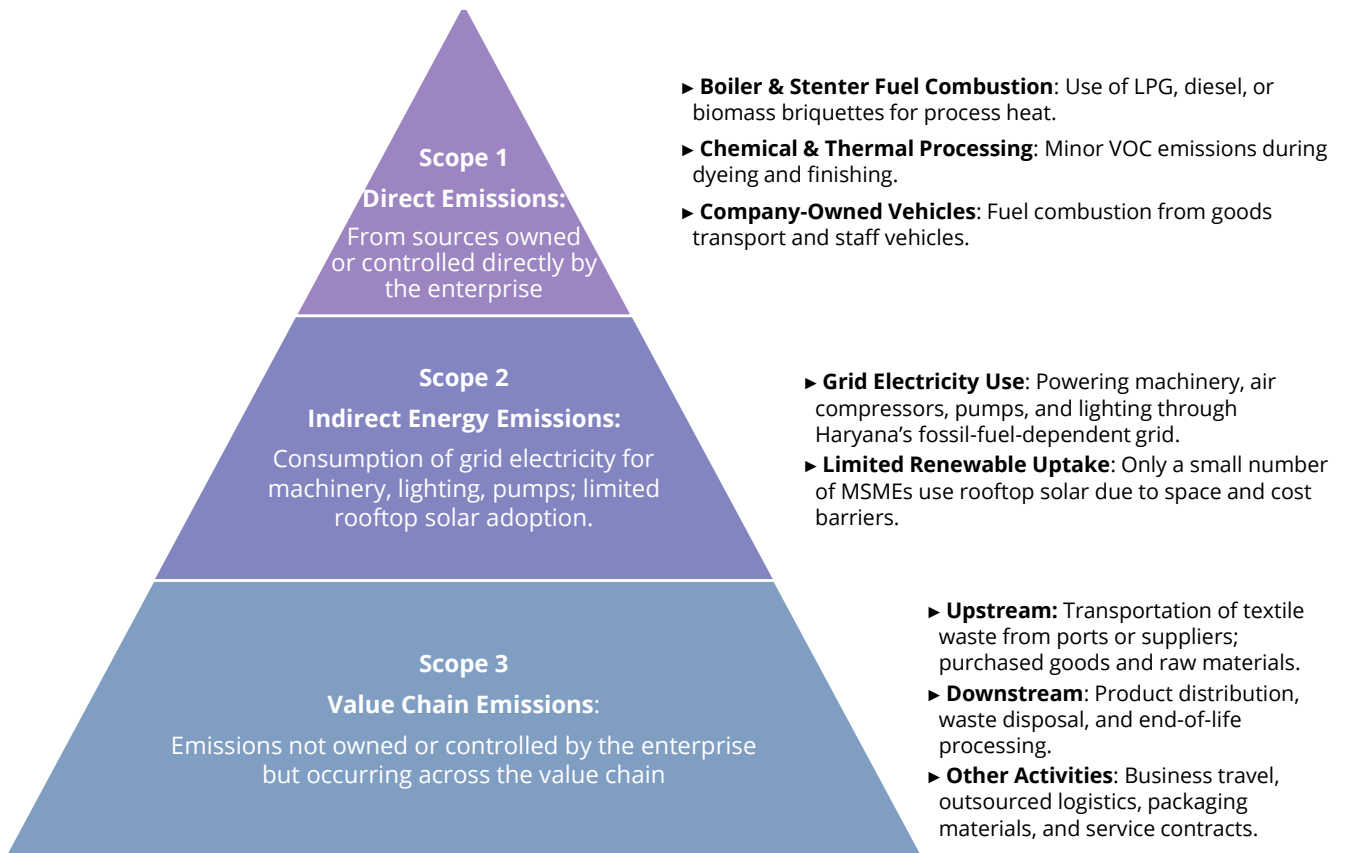
8. Environmental Footprint and Decarbonisation Baseline

8.1. Current GHG Emissions Profile

Panipat’s sizable concentration of MSMEs active in recycling, spinning, dyeing, and finishing results in substantial greenhouse gas (GHG) emissions. The cluster’s annual emission is estimated at approximately 1.4 million tonnes (~14 lakh tonnes)⁵ of CO₂. This emission volume is considered high for an industrial cluster dominated by MSMEs. For comparison, such emission levels are typical of larger, urbanised industrial districts in India and exceed the total annual CO₂ output of many smaller or less industrialised cities. Given Panipat’s sectoral mix and overall size, this figure indicates that the district’s industrial activities have a significant climate impact, well above average for a typical MSME cluster.






Greenhouse gas (GHG) emissions within Panipat’s textile recycling cluster arise from a combination of **direct fuel use, grid-based energy consumption, and broader value chain activities**. Understanding the distribution of emissions across Scope 1, Scope 2, and Scope 3 categories is important for identifying decarbonisation priorities and aligning with emerging sustainability reporting standards. While most enterprises have limited formal accounting of emissions, the dominant sources are fuel combustion in boilers and stenter machines, electricity consumption from the fossil-fuel-dependent state grid, and transport-related activities within the extended supply chain. The following table summarises the principal emission sources under each scope and highlights the key areas contributing to the cluster’s carbon footprint.

Figure 30: Sources of GHG Emissions across Scopes 1, 2 and 3 in the Panipat Textile Recycling Cluster



⁵ https://c4rb.org/demonstrating-decarbonisation-pathways-through-pilots-in-textile-smes/?utm_source=chatgpt.com

Table 21: GHG Emissions Contribution by Sector in Panipat

Sector	Estimated Share	Major Sources/ Key Activities	Key Gases
Textile & Industrial		Combustion of fossil fuels for process heat (boilers, stenters), use of diesel and biomass briquettes, chemical processing emissions, and industrial waste handling.	CO ₂ , SO ₂ , N ₂ O
Transport		Movement of raw materials, goods, and workers by road; diesel-based freight and local logistics.	CO, N ₂ O
Power Generation		Electricity generation from Haryana's largely fossil fuel-based grid; limited renewable penetration.	CO ₂ , SO ₂ ,
Residential/ Commercial		Household electricity and LPG use for cooking, heating, and lighting.	CO ₂
Land Use Change		Urban expansion, construction activities, and limited vegetation cover change.	CO ₂

8.2. Waste Generation and Disposal Practices

The textile recycling and processing activities in Panipat generate a wide range of solid, liquid, and semi-solid wastes across different stages of production. These include fibre residues, dye sludge, boiler ash, packaging plastics, and contaminated non-recyclables—each posing distinct environmental management challenges. While the cluster has made progress in regulatory compliance through the installation of Effluent Treatment Plants (ETPs) and linkage with Common Effluent Treatment Plants (CETPs), a large proportion of waste still enters informal disposal streams. Inadequate segregation, poor record-keeping, and limited infrastructure for recycling or recovery continue to constrain effective waste management.

8.2.1. Types of Waste Generated

► Textile Residues and Fibre Dust:

Textile residues and fibre dust are generated during the shredding, tearing, and carding of cotton, wool, and synthetic fibres. When disposed of in open landfills or mixed with municipal solid waste, these residues undergo anaerobic decomposition, releasing methane (CH₄)—a potent greenhouse gas. Informal burning of fibre dust and textile scraps, still observed in some areas of Panipat, emits carbon dioxide (CO₂), black carbon, and particulate matter, worsening air quality. Improved segregation, fibre recovery, and recycling could significantly reduce the cluster's carbon footprint and local air pollution.

► Sludge and Effluent:

Dyeing, washing, and finishing operations in Panipat generate large volumes of sludge and high-COD/BOD effluents, especially from bathmat dyeing units. The sludge typically contains dye residues, salts, and heavy metals, contributing to environmental pollution and greenhouse gas emissions during treatment or disposal. Within Panipat, around 355+ industrial units generate 7,684.71 tonnes per annum potential hazardous ETP chemical sludge from their standalone effluent treatment plants⁶. According to the Haryana State Pollution Control Board (2023-24), in Panipat - 3,012.11 tonnes were disposed of in secured landfills and 183.43 tonnes incinerated, while recyclable or utilizable remains around 4489.18. The GEPIL facility manages the collection, transportation, and safe disposal of this waste from CETPs and individual industrial units.

► Boiler Ash and Combustion Waste:

⁶ Haryana State Pollution Control Board. District Environment Plan, Panipat 2023. HSPCB, 30 June 2023, https://hspcb.gov.in/uploads/pages/panipat_669be14e7fbc3.pdf

Combustion residues, including ash and particulates, are by-products of thermal energy generation. The use of coal for industrial boilers and dyeing operations was prohibited across the National Capital Region (including Panipat) from October 2022, following directives of the Commission for Air Quality Management (CAQM). Most industries have transitioned to cleaner fuels, including LPG and biomass (briquettes/pellets), approximately 20 units have shifted to LPG, and the remaining on biomass. However, ash and particulate waste continue to be generated, often disposed of informally or mixed with solid waste.

► **Plastic and Packaging Waste:**

Polybags, bale wrappings, and packaging films used in the transport of imported and domestic textile waste form a growing secondary waste stream. These materials, mostly low-grade plastics, are either sold to informal recyclers or disposed of unsafely.

► **Contaminated or Non-Recyclable Waste:**

Items that are heavily contaminated or unsuitable for mechanical recycling are often discarded or burned informally. Reports indicate the presence of unauthorised dumping sites in parts of Panipat where such materials accumulate.

8.2.2. Current Waste Disposal Practices

Waste disposal in the Panipat textile cluster combines regulated systems with widespread informal practices. While many units operate ETPs or connect to CETPs as per HSPCB norms, smaller enterprises often rely on unregistered vendors and open dumping. Weak segregation, poor tracking, and inconsistent compliance continue to cause material leakages, underscoring the need for stronger monitoring and circular waste management systems.

8.2.2.1. Solid Waste Disposal:

A large portion of unrecyclable waste and fibre dust is either dumped in open land or sold to informal waste handlers. Inadequate segregation leads to mixing of recyclable, non-recyclable and often hazardous waste streams. Informal burning of solid waste in some parts of the cluster has been reported, contributing to air pollution.

8.2.2.2. Effluent and Sludge Disposal:

Industrial units are required to obtain Consent to Operate (CTO) from the HSPCB under the Water and Air Act, contingent upon the installation of functional Effluent Treatment Plants (ETPs), particularly in those MSMEs engaged in effluent-generating processes such as dyeing, washing, bleaching meeting prescribed discharge standards. In-house ETPs exist in medium-scale units however proper functioning of these ETPs, and sludge handling is inconsistent and lacks traceability. Sludge is often handed over to third-party vendors without proper tracking, and in some cases, informally disposed.

CETP (Common Effluent Treatment Plant) – HUDA Sector 29 is the main industrial hub for dyeing and finishing units in Panipat. Most enterprises in this zone are connected to two CETPs with a combined treatment capacity of 42 MLD (21 MLD + 21 MLD). The CETPs form an essential component of the cluster's wastewater management system and are aligned with regional initiatives such as the Yamuna Action Plan-I & II and local irrigation reuse schemes. The Haryana Shahari Vikas Pradhikaran (HSVP) carries out periodic sampling and compliance audits, and units found violating discharge norms are liable to penalties or court-imposed fines.

8.2.2.3. Air Emissions and Particulates:

Air pollution from biomass-fired boilers, particularly during winter months, remains a serious concern. While the use of coal and pet coke has been banned under CAQM regulations, most units have yet to adopt advanced emission control systems such as bag filters, electrostatic precipitators, or wet scrubbers. Stack emissions often exceed permissible Suspended Particulate Matter (SPM) limits, reflecting gaps in operational control and maintenance.

8.2.3. Institutional Gaps and Awareness

Panipat lacks a cluster-wide waste management protocol. Most units operate independently, without standardised procedures for waste segregation, collection, and disposal. While the cluster generates an estimated x and residues, there is no centralised collection system for these materials. Small units, which constitute 70% of the textile units, cannot afford individual dust collection systems (INR 5-15 lakh capital cost). As a result, informal burning and open disposal continue.

Tracking mechanisms are largely absent, with units failing to maintain waste management records. Only 3012.11 tonnes disposed in secured landfills with 183.43 tonnes incinerated. The remaining ~4489.18 tonnes are recyclable and utilizable. Moreover, Panipat recyclers have no formal mechanism to access domestic post-consumer textile waste, remaining dependent on imported waste.

While regulatory frameworks are well established, effective enforcement can be further supported through enhanced monitoring systems and improved compliance facilitation. Units are required to submit scrubber performance data and maintain waste records, yet numerous facilities neglect compliance. 181 out of 413 grossly polluting industries (GPIs) in Haryana are in Panipat (43.8%)⁷ - highest concentration statewide.

Given the fragmented practices, there is strong potential to establish a centralised waste management service at the cluster level to help reduce unit-level compliance costs, improve environmental performance, and strengthen traceability. Such a system could handle the collection, segregation, and treatment of key waste streams, including fibre dust, dye sludge, and non-recyclable waste, through shared infrastructure and service models.

8.3. Water and Energy Use Intensity

The textile recycling and dyeing industry in Panipat is both water- and energy-intensive, contributing substantially to the cluster's overall carbon footprint. High water demand in washing and dyeing, coupled with reliance on fossil and biomass fuels for process heat, creates significant environmental pressure on local water tables and air quality. Assessing these resource flows is critical to identifying decarbonisation opportunities and promoting cleaner production across the cluster.

8.3.1. Water Usage

Water is a key input in all stages of the textile recycling process-washing, scouring, bleaching, dyeing, and finishing. Dyeing and processing is the most water-intensive stage. At the cluster level, Panipat's industrial **water consumption is estimated at 50 million litres per day, out of which 18 MLD is supplied from the canal network**, which amounts to nearly 45% of the total demand and remaining comes from other sources.

⁷ Singh, Rahul. "Panipat's Pollution Surges Amid Industrial Boom." *The Tribune*, 12 Oct. 2025, <https://www.tribuneindia.com/news/haryana/panipats-pollution-surges-amid-industrial-boom/>

Effluents from dyeing units continue to pose contamination risks, with elevated nitrate, fluoride, and heavy-metal levels detected in several monitoring zones. Adoption of PLC-based dyeing automation has shown potential to reduce both water and energy use, but uptake remains limited. The cluster must now transition from chemical-heavy to biological wastewater treatment, supported by technical collaboration with expert agencies such as the Textile Committee.

8.3.2. Energy Usage

Energy use in Panipat’s textile industry is dominated by thermal energy for dyeing and finishing operations. Following the CAQM coal and pet-coke ban in 2022, all industrial boilers in NCR shifted to approved fuels - biomass briquettes, PNG and Liquefied Petroleum Gas (LPG). Currently, about 70% of boilers in the Panipat operate on biomass and 30% on LPG in Panipat.

While PNG offers cleaner combustion, its high cost (INR 60 per SCM; calorific value ≈ 9000 kcal/kg) limits its viability for small units. Biomass, costing around INR 6 per kg (calorific value ≈ 2400 kcal/kg), remains the preferred option but has variable quality and lower efficiency. The cluster is also adapting to stricter stack-emission norms, reduced from 800 SPM to 80 SPM - which most enterprises find technically challenging to meet.

Electricity is sourced from the state grid, where supply reliability is high, reducing dependence on diesel gensets. Industrial tariffs average INR 8.0–10 per unit (Including fixed charges). A typical dyeing or open-end spinning unit consumes 1.5–2 lakh kWh per month, costing around INR 16 to 18 lakh. Energy intensity is highest among dyeing and spinning enterprises, which therefore offer the greatest potential for efficiency improvements through waste-heat recovery, motor upgrades, and process optimisation.

8.4. Processing Chain and Key Emission Points

A review of energy use and process operations in Panipat’s recycled textile value chain reveals four major emission hotspots spanning thermal, electrical, air-quality, and transport dimensions. Together, these processes account for most of the cluster’s direct (Scope 1), indirect (Scope 2), and value-chain (Scope 3) emissions. Thermal energy use in dyeing and finishing remains the cluster’s largest emission source, followed by electricity use in spinning, fugitive dust from tearing, and inefficiencies in packaging logistics.

Table 22: Processing Chain, Key Emissions and Mitigation

Sorting and Grading	Tearing, Carding and Boiler Operations	Spinning and Carding	Dyeing, Washing and Finishing	Weaving and Knitting	Packaging and Transport
Scope					
Minimal direct emissions	Scope 1 Fugitive dust & incomplete combustion	Scope 2 Electricity-related CO2 emissions	Scope 1 Thermal fuel combustion	Scope 2 Electricity	Scope 3 Logistics & waste
Key Emissions					
Dust and lint during manual handling	PM2.5, lint, CO	Indirect CO2 from grid power, noise, heat	CO2, PM2.5, CO, VOCs	Indirect CO2 operational noise	CO2 from diesel trucks, plastic packaging waste
Impact					
Impacts worker health and indoor air quality	Dust > 5 mg/m2: repeated PM breaches risk NCR	Spinning consumes- 1.6-2.0 kWh/kg yarn;	Dyeing & finishing account for >60 % of direct	Continuous loom operation adds to grid demand	40 ft container uses 70-90 kg plastic; 35 %

Sorting and Grading	Tearing, Carding and Boiler Operations	Spinning and Carding	Dyeing, Washing and Finishing	Weaving and Knitting	Packaging and Transport
	compliance penalties		emissions ; 5-6 t biomass or LPG/day per unit		empty return trips raise tonne-km CO ₂
Mitigation					
Dust extraction units, enclosed sorting bays, use of masks/gloves	Bag filters, cyclones, ESPs, improved biomass quality, sealed work zones	IE4/IE5 motors, VFDs, energy audits, waste-heat recovery	Economisers, oxygen-trim controls, low-liquor jet dyeing (1:4). insulation, steam recovery	High-efficiency looms, power-factor correction, machine maintenance	Reusable pallet boxes, shared freight platforms, route optimisation

8.4.1. Thermal Energy Hotspot - Steam Generation in Dyeing and Finishing

Dyeing, washing, and stenter drying operations together contribute **over 60% of the cluster's direct (Scope 1) emissions**. A medium-sized blanket line typically consumes 5–6 tonnes of biomass or LPG per day to generate steam at around 130 °C.

Outdated fire-tube boilers run at only 60–65% efficiency, producing high CO₂, CO, and particulate (PM) emissions. Stack measurements from several units show exceedance of the 80 mg/m³ SPM limit, particularly in winter. Volatile agro-residue prices also destabilise input costs, sometimes adding INR 4–5 per kg of finished fabric, impacting already slim margins.

Installing economisers and oxygen-trim controls can lift efficiency to >80%, saving roughly 25% fuel. Upgrading to low-liquor (1:4) jet dyeing machines halves steam, water, and effluent consumption compared to legacy models.

8.4.2. Electrical Energy Hotspot - Rotor Spinning and Carding

Spinning operations consume the bulk of Scope 2 (grid electricity) emissions, estimated at **1.3–1.6 Tonne of CO₂ per tonne of yarn**.

India's grid emits roughly 820 kg CO₂/MWh. Power costs contribute INR 14–18 per kg of yarn, which is substantial of mill-gate prices-creating both environmental and competitiveness pressure.

Adoption of IE5–IE7 motors and variable-frequency drives (VFDs) can yield 10–12% savings. Heat recovery from rotor housings for pre-heating boiler feed water can further improve cluster-wide energy integration.

8.4.3. Air-Quality Hotspot - Lint and Particulate Emissions

Mechanical tearing, opening and carding operations generate significant airborne lint and cotton dust, while biomass-fired boilers can add fine particulate emissions when they operate inefficiently. Elevated dust levels in older or poorly ventilated tear and card rooms have been documented in multiple studies and can exceed established occupational exposure limits, creating health risks for workers and raising compliance concerns.

Regulators in the National Capital Region (NCR) have strengthened scrutiny of industrial particulate emissions, and repeated violations can trigger corrective action or enforcement measures under existing air-quality regulations.

Installing appropriate dust-control systems—such as bag filters, fabric filters or cyclones—on tearing and carding machines can substantially reduce airborne lint and dust, improve workplace air quality and allow recovery of usable fibre waste. Likewise, multi-fuel or biomass boilers fitted with high-efficiency particulate-control equipment, including electrostatic precipitators (ESPs) or baghouses, are capable of meeting stringent particulate-matter emission limits when properly designed, operated and maintained.

8.4.4. Scope 3 Hotspot - Packaging and Transport

Cluster logistics and packaging practices also contribute significantly to indirect emissions. High volumes of disposable plastic packaging and low return-trip utilisation increase the carbon intensity of transport per tonne-kilometre. Empty back-hauls are a major driver: when outbound trucks return with little or no load, emissions per tonne-kilometre rise substantially.

Global buyers increasingly evaluate suppliers on packaging reduction, waste-minimisation and logistics efficiency, making these factors directly relevant to export competitiveness.

Replacing single-use packaging with reusable options—such as durable bale covers, returnable crates or foldable pallet boxes—can meaningfully reduce plastic waste and lower lifecycle emissions when supported by efficient return logistics.

Similarly, digital load-pooling and freight-matching platforms that connect outbound and return freight can improve truck utilisation and reduce transport-related CO₂ emissions by lowering empty-trip mileage.

8.5. Existing Environmental Compliance and Certifications

Existing environmental compliance reflects different stages of maturity across enterprises, with several units progressively aligning with statutory norms through phased investments, technical support, and regulatory facilitation. Environmental compliance among MSMEs in the Panipat textile cluster is a mix of mandated adherence to regulatory norms and voluntary adoption of sustainability standards. This section outlines the prevailing compliance landscape and uptake of environmental certifications across units.

8.5.1. Statutory Environmental Compliance

Most medium and large textile units are mandated to comply with environmental regulations as outlined by the Central Pollution Control Board (CPCB) and the Haryana State Pollution Control Board (HSPCB). Key statutory requirements include:

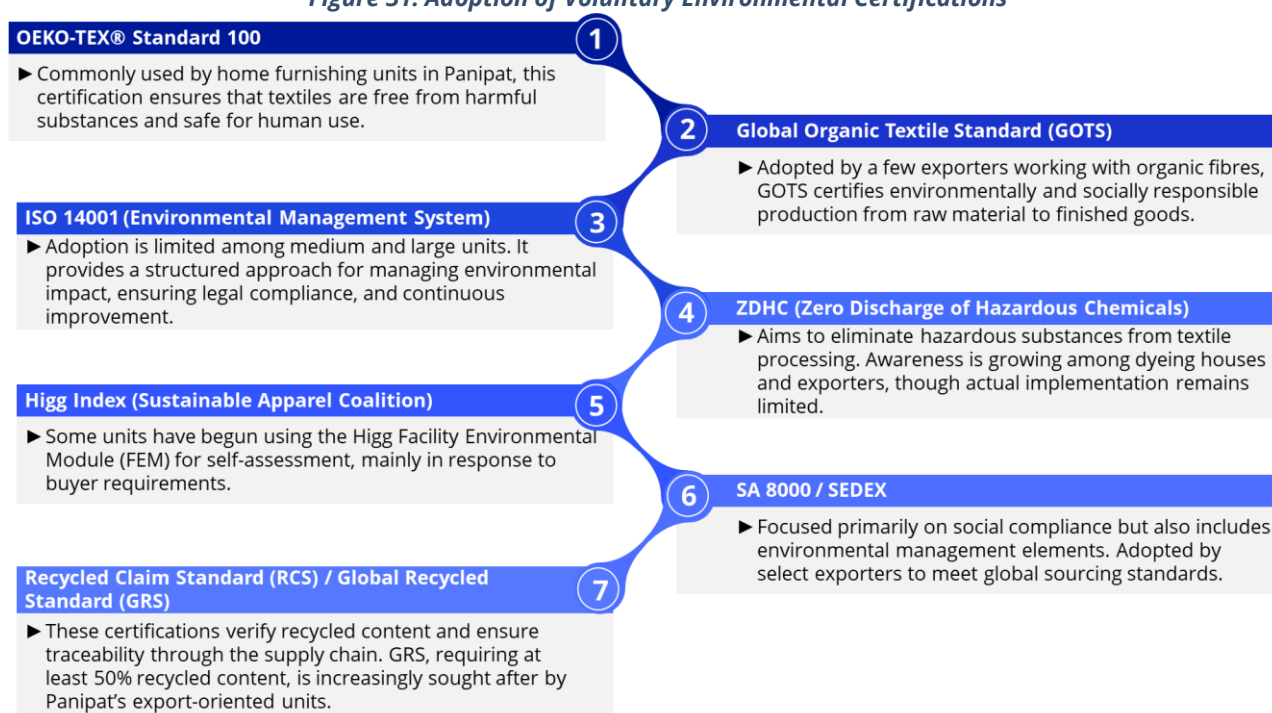
- **Consent to Establish (CTE) and Consent to Operate (CTO)** under the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981.
- Installation of **Effluent Treatment Plants (ETPs)** for process wastewater and participation in the Common Effluent Treatment Plant (CETP) where applicable.
- **Hazardous Waste Management compliance** under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.
- Maintenance of **air emission parameters**, especially from boilers and thermos-packs using fossil fuels.

However, a significant proportion of micro and small units operate informally or without complete regulatory compliance, primarily due to limited technical know-how, cost constraints, and absence of dedicated in-house EHS personnel.

8.5.2. Voluntary Environmental Certifications

Adoption of voluntary environmental standards and certifications in the Panipat textile cluster remains at an early stage. These frameworks serve as important tools for guiding best practices and aligning industry behaviour with broader sustainability goals. Though not legally binding, they encourage companies to adopt cleaner and more responsible operations as a means of differentiation and market access. Their global recognition provides a shared language for compliance and quality, while their collaborative development with industry stakeholders ensures practical relevance and credibility. As more enterprises adopt these standards to remain competitive, they collectively drive market transformation and indirectly advance policy objectives.

Figure 31: Adoption of Voluntary Environmental Certifications



9. Domestic and International Demand for Recycled Textiles

Panipat's circular textile economy is among the most mature and resilient recycling ecosystems in the Global South. With decades of experience, integrated operations, and growing policy and buyer engagement, the cluster continues to adapt to changing market and regulatory conditions. It is well-positioned for growth, provided it strengthens compliance with environmental, social, and digital standards. Global demand for low-cost, traceable recycled textiles is expected to rise under regulations like the Carbon Border Adjustment Mechanism (CBAM), ESPR and CSRD CSDD.

India's textile recycling market is expected to reach US \$375 million by 2028, with a CAGR of about 3.4% during 2023–2028⁸, with Panipat contributing most of the national output in recycled yarns, blankets, and home furnishings. Continued investments in technology, worker welfare, and traceability will be vital to sustaining competitiveness and long-term export potential.

9.1. Demand Market Snapshot

Panipat's textile recycling cluster derives its strength from its capacity to process large volumes of post-consumer and post-industrial textile waste, transforming them into a wide range of products across varying quality and price segments. The cluster's global standing is built on its flexibility to cater to humanitarian markets, domestic demand, and export-oriented sustainability-linked products.

- ▶ **Humanitarian and Relief Markets:** Panipat remains a leading supplier of disaster-relief blankets procured by organisations such as the United Nations, Red Cross, and international NGOs. These products, typically made using shoddy yarn and recycled wool, are preferred for their low cost and high-volume availability.
- ▶ **Domestic Blanket Dominance:** The cluster meets approximately 75% of India's demand for woollen and semi-woollen blankets, catering to agencies including Indian Railways, defence forces, and relief departments.
- ▶ **High-Volume Exports of Carpets and Mats:** Panipat exports to over 60 countries, with strong markets in Africa, North America, and Eastern Europe for rugs, durries, and carpets made from recycled fibres.
- ▶ **rPET Apparel and Yarns:** Rising regulatory mandates such as the EU Digital Product Passport (DPP) and GRS certification have created demand for traceable rPET yarns and blended fabrics. Exporters supplying brands like IKEA and H&M Home are aligning operations with these sustainability standards.
- ▶ **Denim and Hosiery Recycling:** Imported post-consumer denim and hosiery waste are reprocessed into low-GSM yarns, used in recycled denim, furnishing fabrics, and other budget home-textile applications.

9.2. Export Market Overview – Demand Dynamics and Buyer Profiles

Panipat's recycled textile cluster plays a crucial role in the global circular textile economy, supplying recycled yarns, fibres, and home furnishing products to diverse international markets. The cluster's exports rely heavily on **key destinations –Europe, America, Africa and Middle East–** each defined by distinct demand structures, buyer expectations, and compliance landscapes.

While African markets drive volumes for low-cost, second-hand or recycled textiles, the Middle East serves as a hybrid zone where traditional price-sensitive trade coexists with emerging interest in sustainability-

⁸ <https://www.openpr.com/news/3332910/india-textile-recycling-market-size-business-opportunity>

linked products. In contrast, European buyers represent the most advanced and regulation-driven segment, demanding full traceability, certified recycled content, and alignment with frameworks such as the EU Strategy for Sustainable and Circular Textiles, Extended Producer Responsibility (EPR), and Digital Product Passports (DPP).

Figure 32: Export Market Overview and Value-Compliance Mapping

	Africa	Middle East	Europe
Key Countries	Nigeria, Ghana, Kenya, Tanzania, South Africa	UAE, Saudi Arabia, Oman, Qatar, Bahrain	Germany, Netherlands, France, Italy, Spain, UK
Market Profile	High-volume, low-cost market driven by affordability and informal retail.	Transitional market combining consumption and re-export hubs; demand from diverse income groups.	Mature, regulation-driven market aligned with the EU Sustainable Textiles Strategy, EPR, and DPP.
Typical Buyer Type	Wholesalers, distributors, informal traders.	Retailers, re-export agents, distributors.	Brands, importers, retailers with sustainability mandates.
Compliance Intensity / Market Value	Low compliance, high volume / low margin. Minimal certification requirements; trade often outside formal channels. ▼	Moderate compliance, medium value. Growing focus on verified recycled content and traceable supply chains. ●	High compliance, high value. Requires certified recycled content, traceability (GRS, OEKO-TEX), and digital documentation. ▲
Strategic Implications for Panipat Exporters	Maintain cost advantage and volume reliability; strengthen logistics and explore exports of semi-processed yarns to offset policy risks.	Invest in traceable recycled yarn production; enhance quality control and supply chain coordination; engage in regional green procurement networks.	Develop cluster-wide certification systems, DPP readiness, and consolidated export platforms to meet EU buyer standards and retain market access.

Panipat’s export landscape spans a wide spectrum – from volume-driven low-compliance markets to value-driven, regulation-intensive destinations. The cluster’s long-term competitiveness will depend on its ability to transition toward compliance-intensive European markets, where traceability, certification, and digital readiness are fast becoming entry requirements. Developing cluster-wide certification systems, digital product passport (DPP) infrastructure, and sustainable production practices can position Panipat as a credible global supplier in the emerging circular textile economy.

9.3. Domestic Low-Cost Blanket and Carpet Demand

In the domestic market, Panipat’s recycled textile industry plays a crucial role in serving mass utility segments, particularly through state government procurement, budget retail chains, and rural distribution networks. The most in-demand products in these channels include:

- ▶ **Winter relief blankets** supplied to disaster management departments and welfare schemes
- ▶ **Low-cost rugs and floor mats** sold through informal and semi-formal retail outlets
- ▶ **Basic household items** such as bedsheets, pillow covers, and towels aimed at low-income consumers

Despite high volumes, product pricing has remained largely stagnant over the past six years, particularly for key items like mink blankets and shoddy woollen covers. This stagnation is driven by market saturation, tender-based procurement price ceilings, and fierce price competition, leaving little room for producers to invest in quality enhancements.

As a result, many units forego value-adding processes such as final washing, shrinkage control, or branded packaging. These steps that could otherwise improve product finish, durability, and consumer appeal. The focus on output quantity over presentation and quality often diminishes the perceived value of Panipat-made goods in both wholesale and consumer-facing markets.

This trend has also impacted the cluster’s brand identity and pricing power, with many products sold as generic, unbranded commodities. However, there is untapped potential to differentiate even in the

domestic market through low-cost design innovation, regional branding, better packaging, and retail partnerships, particularly as sustainability and quality consciousness grow among Indian consumers.

9.4. Demand Drivers

Panipat’s rise as Asia’s largest mechanical textile recycling hub is underpinned by a unique combination of domestic cost advantages, policy recognition, and growing international demand for sustainable textiles. Processing nearly 14,50,000 tonnes of textile waste annually, the cluster converts imported and domestic textile waste into a wide range of recycled yarns, fibres, and home furnishings. At the domestic level, resource constraints, raw material price differentials, and increasing sustainability commitments among Indian brands have accelerated demand for recycled inputs. Internationally, regulatory momentum in the EU, coupled with retailer-driven sustainability goals, is reshaping buyer expectations toward traceability, certified recycled content, and verifiable ESG performance.

Together, these domestic and global forces are positioning Panipat as a strategic player in the global circular textile economy - where cost efficiency, compliance readiness, and technological modernisation are emerging as the key determinants of competitiveness.

Figure 33: Key Demand Drivers for the Panipat Recycled Textile Cluster



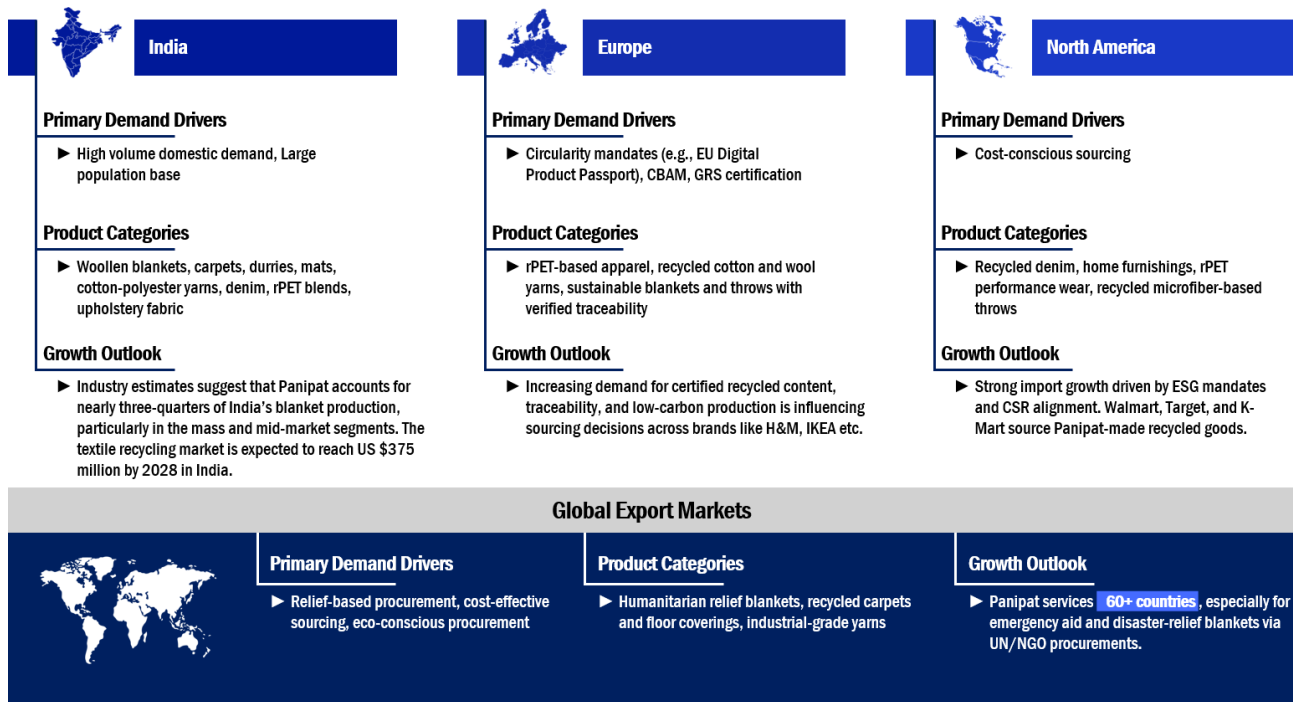
- ▶ **Policy Recognition & Export Orientation:** Panipat is designated a “Town of Export Excellence,” which brings policy and infrastructural benefits to the cluster. Its textile export turnover is approximately INR 29,000 crore, and it serves global buyers such as IKEA, Walmart, Kmart, and H&M Home.
- ▶ **Resource Constraints and Virgin Raw Material Volatility:** Virgin polyester and recycled PET yarn is priced at INR 100–110/kg– driving widespread adoption of recycled fibres in local manufacturing. Moreover, disruptions in global cotton and polyester supply chains have further incentivised recycling as a cost-effective alternative.
- ▶ **Technology Adoption and Mechanical Recycling:** Over 147+ spinning mills in Panipat engage in open-end spinning, producing around 4,000 tons of recycled yarn per day. While many SMEs still use outdated equipment, larger units have upgraded to semi-automated and energy-efficient systems, with some sourcing refurbished machinery from Europe.

- ▶ **Environmental Regulations and International Compliance:** Upcoming EU regulations like the ESPR, CSRD, CSDDD and the Carbon Border Adjustment Mechanism (CBAM) are pushing exporters to invest in traceability, GHG accounting, and life-cycle impact documentation. Mapping of Scope 1, 2, and 3 (Partial) emissions has already started in pilot units.
- ▶ **Buyer and Consumer Demand:** Domestic and international brands – including Reliance Trends, Monte Carlo, and Ed-a-Mamma – are increasingly sourcing from Panipat for its recycled product offerings. Exporters also supply to global labels that demand sustainability credentials like GRS, OEKO-TEX, and ISO 14001.
- ▶ **Digital Traceability and Branding:** Panipat-based units are piloting Digital Product Passport (DPP) systems to meet traceability requirements and appeal to environmentally conscious buyers.
- ▶ **Waste Valorisation and Circular Market Models:** Around 80% of textile waste processed in Panipat is reused. Residuals such as trimmings and threads are diverted to secondary applications – e.g., carpet backing, mats, and fillers – minimising landfill dependence.

9.5. Product-Wise Demand Across Domestic and International Markets

Panipat’s textile recycling cluster is defined not only by its scale, but also by the diversity of products it generates and the demand drivers that shape its domestic and international markets. A unique combination of resource constraints, sustainability regulations, humanitarian aid needs, and policy incentives has positioned Panipat as a critical node in both the domestic and global circular textile economy.

Figure 34: Product-Demand Matrix by Region



9.6. Buyers’ Sustainability Requirements and Compliance Challenges

As global supply chains tighten their sustainability requirements, textile exporters in Panipat are under mounting pressure to align with Environmental, Social, and Governance (ESG) expectations. International buyers – especially from the EU and North America – now demand traceability, carbon footprint

transparency, and demonstrable improvements in labour and environmental practices. These demands are not just limited to Tier 1 suppliers but extend deep into the value chain, including fibre recyclers, dyers, and processors. While several leading Panipat-based exporters have made strides toward compliance, the cluster as a whole faces structural, operational, and knowledge-based constraints in meeting these evolving standards.

► **ESG Reporting and Traceability:**

Major buyers are seeking digitised, auditable ESG disclosures through platforms like the Higg Index, ZDHC Gateway, and the forthcoming EU Digital Product Passport (DPP). However, most MSMEs still rely on manual recordkeeping, with limited understanding of ESG reporting formats or data requirements. Adoption of digital traceability tools such as Textile-Genesis, Reverse Resources etc. remains low due to high costs and a lack of trained personnel, constraining participation in sustainability-led global supply chains.

► **Carbon Labelling and Emission Disclosure:**

Growing regulatory pressure – through mechanisms like the EU Carbon Border Adjustment Mechanism (CBAM) and product-level carbon standards (PAS 2050, ISO 14067) – is pushing buyers to demand detailed GHG accounting. Yet, high testing costs and limited technical expertise deter most Panipat exporters. Only a few have initiated pilot GHG mapping exercises, typically covering Scope 1 and 2 emissions, while smaller units struggle with the financial and operational burden of compliance.

► **Certifications and Audits:**

Global certifications such as GRS, and OEKO-TEX etc. have become essential for market access. Larger exporters integrate these into regular audit cycles, but Micro and small units often face audit fatigue, cost pressures, and documentation gaps, leading many to view certification primarily as a procedural requirement rather than a value driver. However, where compliance capabilities are strengthened, certification has the potential to enable access to higher-value markets, including export-oriented supply chains, and to support price realization, brand visibility, and longer-term buyer relationships. Nonetheless, certified units increasingly command price premiums, brand visibility, and long-term buyer trust, reinforcing the strategic importance of proactive compliance.

9.6.1. Compliance Gap Matrix

While some units have begun investing in effluent treatment plants, mechanised operations, and worker training, challenges persist due to the legacy of informality and dependence on migrant labour. The fragmented industrial structure also limits shared compliance infrastructure, though common facility centres (CFCs) for chemical testing and documentation are being proposed by industries

Table 23: Diagnostic overview of the primary sustainability compliance gaps in the cluster

Compliance Area	Buyer Expectation	Supplier Challenge
ESG Reporting	Full, auditable disclosure on environment and labour	Manual records, lack of digital infrastructure, limited awareness
Carbon Foot-printing	Lifecycle-based emissions data (ISO 14067)	High costs of testing; lack of carbon-literate staff; fragmented data
Certifications	Chain-of-custody, social and chemical safety audits	Cost barriers, audit fatigue, limited SOPs and documentation
Chemical & Labour	ZDHC alignment, gender equity, safety protocols	Informal labour systems, insufficient OHS training, low effluent compliance

9.7. Emerging Market Incentives for Low-Carbon Products

As global climate regulations tighten, Panipat's textile recycling cluster is increasingly positioned to benefit from market incentives favouring low-carbon and circular products. Buyers and policymakers increasingly signal preference for suppliers demonstrating reduced emissions, verified recycled content, and transparent supply chains. However, in the absence of robust documentation and traceability at the unit level, these preferences do not translate into improved price realization. Strengthening compliance documentation, impact quantification, and sustainability communication is therefore critical for enabling unit owners to convert sustainability performance into tangible commercial benefits.

► Carbon Pricing and Climate Taxation

Global shifts toward carbon markets and emission trading systems are reshaping cost competitiveness. In India, the Bureau of Energy Efficiency (BEE) is developing a national carbon market framework that may soon include sectoral caps and offset trading. Though recycled textiles are currently exempt from direct levies, the creation of carbon credit mechanisms could enhance Panipat's cost advantage over virgin fibre producers. Similarly, the EU's Emissions Trading System (ETS) and Carbon Border Adjustment Mechanism (CBAM) will increase import costs for carbon-intensive products, indirectly favouring Panipat's low-carbon recycled exports – provided exporters can disclose verifiable carbon data.

► Green Public Procurement (GPP)

Governments in the EU, Canada, and Japan are increasingly mandating minimum recycled or low-carbon content in public contracts. This creates an emerging market for eco-certified textiles – a segment Panipat can tap into through verified environmental claims and certification alignment.

► Green Finance and Concessional Credit

Access to low-interest sustainability finance is expanding through institutions like SIDBI, IREDA, and multilateral banks. MSMEs that can demonstrate measurable improvements, such as energy savings or emission reductions, are eligible for concessional loans for machinery upgrades, solar heating systems, or ZLD installations. Several MSMEs and exporters in Panipat have begun availing these schemes to upgrade to low-liquor ratio dyeing machinery, solar-powered heating systems, and ETPs. However, limited data systems and formal documentation remain barriers to participation for many small units.

► Carbon Labelling and Eco-Disclosure

Voluntary carbon labelling programs in the UK (Carbon Trust), France (ADEME Eco-Score), and India's upcoming national scheme are promoting transparency in product emissions. While uptake in Panipat is still limited due to verification costs and lack of trained assessors, such schemes could enhance access to premium retail markets and reinforce cluster-level branding for “low-carbon recycled textiles.”

► Export Incentives for Eco-Certified Goods

Markets such as the EU, USA, and UK are offering tangible trade advantages for certified sustainable products – ranging from GSP duty waivers to reduced inspection frequencies and preferred buyer partnerships for suppliers contributing to Scope 3 emission reductions. To leverage these benefits, Panipat's exporters must strengthen third-party certification systems and adopt digital chain-of-custody traceability.

9.8. Opportunities for Green Product Branding

As sustainability becomes a defining axis of global trade, green branding has emerged as a critical strategy for Panipat's textile recycling cluster to differentiate its products, access premium markets, and build long-

term buyer trust. International retailers and institutional buyers now look beyond cost competitiveness to traceability, environmental impact, and ethical production narratives. Within this evolving landscape, Panipat’s recyclers are taking significant strides – though still in early stages – toward building credible, values-driven brand identities anchored in circularity and sustainability.

9.8.1. Branding Pillars for Panipat

As sustainability becomes central to global trade, green branding offers Panipat’s textile recycling cluster a powerful avenue to move beyond cost-based competition toward value-driven market differentiation. International buyers now prioritise transparency, environmental performance, and ethical production, making sustainability-linked branding essential for long-term competitiveness. Although still at an early stage, Panipat-based producers are beginning to adopt structured branding approaches that emphasize both product performance and sustainability credentials.

Figure 35: Green Product Branding Pillars

Branding Pillar	Buyer Appeal	Opportunities for Panipat
Traceability	Verified fibre origin & impact metrics	QR labels, DPP pilots, LCA reports
Performance Messaging	Durability and value	Testing-backed claims on strength, warmth, colourfastness
Certifications	ESG-secure sourcing	GRS, OEKO-TEX, Fair Trade logos = green procurement access
Storytelling	Ethical narrative engagement	“Waste to wealth” + community impact stories
Circular Services	Product lifecycle commitment	Take-back/repair programs for institutional clients
Material Innovation	Eco-material sourcing	rPET, hemp, organic cotton blends; zero-waste designs
Tech-Enabled Validation	Quality and transparency via tech	AI-backed sorting, fiber scanning, digital trace platforms
Regional Brand Identity	Cluster-level recognition	Position Panipat as a sustainable recycling hub globally

- ▶ **Traceability and Transparency:** Driven by upcoming mandates like the EU Digital Product Passport, select group of exporters are piloting QR-coded yarn labels and conducting Life Cycle Assessments (LCA) to provide verifiable data on product origin, carbon footprint, and water use.
- ▶ **Performance-Based Messaging:** Producers are shifting from low-cost narratives to performance-led positioning - highlighting product durability, colour fastness, and thermal retention of recycled goods such as shoddy blankets and denim.
- ▶ **Certification-Backed Claims:** Standards such as GRS and OEKO-TEX® are being used as trust signals and marketing tools, enhancing credibility with eco-conscious buyers and qualifying products for green public procurement channels.
- ▶ **Storytelling and Emotional Branding:** Several Panipat exporters are engaging in impact-driven storytelling to enhance emotional connection with buyers. These narratives revolve around the

“waste-to-wealth” transformation journey of post-consumer garments - collected from the Global North and reborn as blankets, carpets, or denim products in Panipat’s factories. Through digital marketing campaigns, brochures, and B2B communications, these stories aim to humanise recycled products and showcase their social and environmental value.

- ▶ **Circular Services and Take-Back Models:** A few pioneering firms now offer repair and take-back programs, particularly for institutional buyers and humanitarian agencies - reinforcing Panipat’s position as a circular textile hub focused on longevity and reuse.

Integrating traceability, certification, and sustainability narratives is enabling a gradual shift towards relationship-driven positioning. Although currently limited to a few exporters, such green branding is increasingly recognized as a pathway to better buyer retention, price realization, and regulatory resilience.

10. Infrastructures Enabling Environment

A robust enabling ecosystem is critical for Panipat’s textile recycling cluster to improve productivity, ensure environmental compliance, and foster innovation. Shared infrastructure such as Common Facility Centres (CFCs) and digital platforms can play a transformative role by enhancing resource efficiency, reducing operational costs, and supporting sustainability transition across MSMEs.

10.1. Availability and Condition of Common Facility Centres (CFCs)

Common Facility Centres (CFCs) play a pivotal role in strengthening the collective efficiency and sustainability of industrial clusters. In the Panipat textile recycling ecosystem, they serve as shared infrastructure nodes that help MSMEs overcome scale limitations by providing access to **common utilities, environmental management systems, and resource-sharing mechanisms**. Effective CFCs reduce operational costs, ensure regulatory compliance, and enable smaller enterprises to participate in cleaner production practices. Currently, Panipat’s CFC ecosystem is limited but evolving, centred around effluent treatment facilities, with emerging opportunities for digital resource exchange and workforce platforms to enhance cluster-wide productivity and coordination.

10.1.1. Existing CETP Infrastructure

At present, the **Centralised Effluent Treatment Plant (CETP)** remains the cluster’s only functional CFC, serving as the backbone of industrial wastewater management for Panipat’s dyeing and processing units. Located in **Sector 29**, the facility is owned by the **Haryana Shehri Vikas Pradhikaran (HSVP)**, which oversees planning, development, and compliance coordination.

The cluster hosts two CETP units, each with a capacity of 21 MLD, offering a combined treatment capacity of 42 MLD. Daily operations and maintenance are handled by private operators contracted through HSVP’s tendering system, while HSVP retains overall supervision and performance monitoring. Regulatory oversight is provided by the Haryana State Pollution Control Board (HSPCB), which conducts periodic sampling, inspections, and enforcement of discharge norms.

10.1.2. Cluster Exchange and Resource-Sharing Platforms

The establishment of an **Electronic Cluster Exchange Platform (CEP)** can significantly enhance resource efficiency within the Panipat textile cluster. Such a platform would enable member industries to trade surplus resources, including machinery, chemicals, raw materials, and finished goods. Additionally, it

could facilitate collaboration among manufacturers, exporters, and export houses by creating a structured marketplace for exchange of export surpluses.

Integrating a dedicated job portal within the CEP would further expand its utility, linking employers with skilled and semi-skilled workers, addressing workforce shortages, and improving overall cluster productivity. This digital ecosystem would serve as a centralised hub for material, knowledge, and human resource sharing, fostering a more connected and collaborative industrial environment.

10.2. Status of Renewable Energy Adoption

Energy use in Panipat's textile recycling cluster plays a defining role in its operational efficiency, cost structure, and environmental performance. The cluster's industrial ecosystem comprising spinning mills, dyeing units, processing houses, and finishing plants, relies heavily on both thermal and electrical energy to power production processes such as washing, bleaching, dyeing, drying, carding, and finishing. Traditionally, this demand has been met through coal-fired boilers and grid electricity, resulting in high carbon intensity, elevated production costs, and exposure to volatile fuel markets.

Over the past few years, a combination of regulatory mandates, policy incentives, and market pressures has catalysed a gradual but measurable shift towards renewable energy adoption. This shift is led primarily by two pathways, **solar power** for electricity and **biomass-based systems** for process heat generation. Together, these renewable energy sources are emerging as critical levers for achieving decarbonisation, cost savings, and environmental compliance across the Panipat textile cluster.

10.2.1. Policy Context and Strategic Drivers

Panipat's industrial area falls under the National Capital Region (NCR), where air quality management regulations are among the strictest in India. Following the Commission for Air Quality Management (CAQM) directive of June 2022, the use of coal and coke for industrial heating was banned effective January 2023. This regulation compelled textile units – particularly dyeing and finishing operations – to transition toward biomass and Liquefied Petroleum Gas (LPG) as compliant fuel sources.

Simultaneously, India's broader decarbonisation commitments under the Paris Agreement and the National Action Plan on Climate Change (NAPCC) have led to multiple incentives for renewable energy adoption under state and central schemes. The Haryana Aatmanirbhar Textile Policy (2022–25) specifically recognises renewable energy as a strategic enabler for cleaner textile production. It provides capital subsidies to encourage MSMEs to install solar energy systems and adopt low-emission technologies.

These subsidies can be availed for rooftop solar systems, energy-efficient dyeing equipment, and other renewable energy assets. Further, institutions such as IREDA and SIDBI are extending concessional financing and dedicated credit lines to promote renewable energy among MSMEs.

Beyond policy drivers, the global textile market is also exerting growing influence. Export buyers - particularly from Europe and North America - increasingly require suppliers to demonstrate Scope 1 and 2 emission reductions and renewable energy sourcing. Compliance with frameworks such as the EU Carbon Border Adjustment Mechanism, Digital Product Passport, and Higg FEM module is becoming integral to sustaining export competitiveness.

Against this backdrop, renewable energy is no longer viewed merely as a cost-saving measure, but as a strategic investment for market access, compliance readiness, and long-term industrial resilience.

10.2.2. Solar Energy Adoption

Solar energy adoption in Panipat has witnessed a steady upward trend, particularly since 2022, with the proliferation of rooftop photovoltaic (PV) systems across small and medium textile units. As of 2025, approximately **~150 units** have installed solar systems for captive power generation, contributing an estimated **6% of the cluster's total electricity demand**.

However, the potential capacity remains significantly higher – technical assessments suggest that if 1,000 additional MSMEs adopt solar systems, renewable energy could meet up to 35% of the cluster's total power requirement. Adoption is strongest in Category C and D industrial blocks, where higher subsidy levels and better technical outreach have accelerated implementation.

Table 24: Electricity Demand vs. Solar Generation

Parameter	Cluster Electricity Demand	Current Solar Installed	Potential Solar (1,000 Units)
Daily (lakh kWh)	~38	~1.52	~13
Annual (lakh kWh)	~13,500	~556	~4,700

10.2.2.1. Economic Viability and Financial Returns

At a benchmark cost of **INR 44,000 per kW**, rooftop solar remains one of the most cost-effective investments available to textile MSMEs.

A 500 kW system, costing approximately INR 2.2 crore, generates around INR 51 lakh worth of electricity annually, with a **payback period of ~5 years in subsidised zones** and around ~7 years without subsidy, considering all costs. The Aatmanirbhar Textile Policy offers between 30%–50% subsidy, depending on the block category, significantly improving return on investment.

Despite cost advantages, the RESCO model (Renewable Energy Service Company) has seen limited adoption, as most enterprises prefer direct investment for better returns. Around 10% of units seek financing, while others self-fund installations. SIDBI offers solar loans at 7.4% interest, lower than 9% from commercial banks, and is currently developing a cluster-level solar implementation strategy to accelerate adoption across 1,000 additional MSMEs, especially in Blocks A and B, where penetration remains low.

10.2.2.2. Environmental and Operational Benefits

Rooftop solar adoption provides both economic savings and measurable climate gains. A 500 kW system offsets approximately **600 tonnes of CO₂ annually**, contributing directly to cluster-level GHG mitigation.

Additionally, solar installations help:

- Reduce dependency on grid electricity, thereby lowering exposure to tariff volatility.
- Strengthen ESG compliance by demonstrating renewable energy use to buyers.
- Enhance brand positioning in sustainability-led export markets (EU, Canada, Japan).

The integration of solar energy also aligns with Haryana's State Solar Policy (2021), which encourages distributed renewable generation across industrial clusters.

10.2.2.3. Barriers to Wider Adoption

Despite proven benefits, several challenges hinder universal solarisation across Panipat:

- ▶ **High initial capital cost** for small and micro units.
- ▶ **Regulatory hurdles** related to grid connectivity, net metering, and taxation under Haryana's open-access renewable power framework.

- ▶ **Technical limitations**, including poor roof design and limited maintenance capabilities.
- ▶ **Awareness gaps** on subsidy procedures and payback advantages.

A cluster-level facilitation mechanism, possibly through SIDBI or the District Industries Centre, could address these barriers by providing technical handholding, vendor empanelment, and financial linkage support.

10.2.3. Biomass Energy Transition

The second major renewable pathway in Panipat has been the transition from coal to biomass-based boilers, following the CAQM's 2022 directive banning coal use in NCR industries from January 2023. This shift has transformed the thermal energy landscape of the cluster.

Currently, approximately 70% of dyeing and processing units operate on biomass-fired boilers, while the remaining 30% use Liquefied Petroleum Gas (LPG). The cluster's daily biomass consumption stands at roughly 1,950 metric tonnes, primarily in 355 active dyeing units.

While LPG provides cleaner combustion, its high cost renders it economically unviable for energy-intensive units. Biomass, by contrast, offers cost savings of 30–40% compared to pre-ban coal usage and ensures regulatory compliance with emission norms.

10.2.3.1. Environmental and Operational Impact

Biomass combustion produces lower CO₂ and negligible sulphur dioxide emissions compared to coal, contributing to improved air quality and reduced carbon intensity. However, efficiency challenges persist:

- Most boilers operate at 60–70% efficiency, leading to high fuel consumption. The optimal level feasible can reach up to 88% according to some of the secondary reports available by credible institutions.
- Lack of economisers, oxygen trim controls, and heat recovery systems further reduces performance.
- Manual feeding and suboptimal combustion conditions increase particulate matter (PM) emissions.

Technology upgradation, through modern combustion systems, electrostatic precipitators (ESPs), and waste heat recovery, can improve efficiency to >80% and reduce stack emissions below regulatory limits.

The shift also supports circular resource utilisation, as agricultural residues (mustard husk, paddy husk, walnut shells) are repurposed as industrial fuel, creating rural income linkages.

10.2.4. Cluster-Level Impact and Outlook

Together, solar and biomass adoption are enabling Panipat's textile cluster to make measurable strides toward energy efficiency, carbon reduction, and compliance alignment.

Table 25: Status of Solar and Biomass Energy Adoption across the cluster

Dimension	Solar Energy	Biomass Energy
Current Adoption	~150 units installed	Most of the dyeing units
Potential Adoption	Up to 1,000 MSMEs	Universal across process units
Primary Benefit	Reduced grid dependence, CO ₂ offset	Cleaner fuel, cost savings, air-quality compliance
Policy Support	Aatmanirbhar Textile Policy, IREDA, SIDBI	CAQM directive, MNRE Bioenergy Programme

Key Barriers	Capital cost, roof design, regulatory complexity	Fuel supply volatility, efficiency loss
Emission Reduction	~600 tonnes CO ₂ per 500 kW solar system	Lower PM, SO ₂ , CO ₂ emissions than coal

10.3. Transportation and Logistics Efficiency

The transportation network supporting Panipat's recycled textile economy is formal for inter-cluster movements and predominantly informal for intra-cluster movements, while remaining highly efficient. It enables the smooth flow of post-consumer textile waste - primarily imported from the UK, Germany, the Netherlands, the USA, and Canada - into the cluster's production cycle. Large consignments of baled used clothing and unsold garments arrive at Kandla (Deendayal) Port in Gujarat, one of India's busiest for second-hand goods and scrap materials. The port provides specialised customs clearance facilities for used textiles under stringent MoEF regulations.

After clearance, containers travel about 1,200 km to Panipat via the NH-27-NH-44 corridor, mostly in 40-foot containerised trucks. A critical link in this chain is ICD Patli in Gurugram, operated by CONCOR, which acts as a key consolidation hub for both inbound and outbound cargo. It serves Panipat's textile MSMEs by facilitating container movements to and from Kandla, Mundra, and Nhava Sheva ports - reducing reliance on Delhi-based ICDs and cutting lead times by 1-2 days.

Finished Goods Outflow: Panipat supplies both domestic markets (Delhi, UP, Punjab) and exports (Europe, America, Africa and Middle East). Deliveries to domestic buyers are largely by road to markets such as Karol Bagh and Gandhi Nagar in Delhi, while exports move via road or rail to Nhava Sheva and Mundra ports.

Cost Competitiveness: Logistics efficiency is central to Panipat's cost advantage.

The total landed cost of recycled raw material (~INR 20 to 40 /kg) remains far lower than virgin cotton (INR 70-INR 80/kg), sustaining Panipat's competitiveness in global markets - especially for low-cost yarns and home furnishings.

10.4. Policy Environment for Clean Technology Adoption

Panipat's textile recycling cluster operates within an evolving policy landscape that increasingly supports clean technology adoption. The policy drivers span international trade-linked obligations, national climate strategies, and state-level incentives. Together, these frameworks establish both the regulatory push and financial support needed for decarbonisation and energy-efficient modernisation.

10.4.1. International and Trade-Linked Drivers

- ▶ **EU Green Deal (ESPR, CSRD, CSDD and Carbon Border Adjustment Mechanism, CBAM etc.):** Export-oriented clusters like Panipat must reduce carbon intensity to retain access to European markets.
- ▶ **Global Climate Finance:** India can leverage concessional funding from the Green Climate Fund (GCF), World Bank, and Asian Development Bank to finance clean technology upgrades in industries such as textiles.
- ▶ **Technology Transfer and IPR Reforms:** International partnerships are expanding access to hydrogen, EV, and carbon capture technologies, complementing India's broader decarbonisation goals.

10.4.2. National Framework and Policies

India's commitment to achieve net-zero emissions by 2070 drives its national clean technology agenda, centred on renewable energy expansion, EV adoption, energy storage, and green hydrogen development. The National Action Plan on Climate Change (NAPCC) provides strategic direction through sectoral "missions" that promote renewable energy, energy efficiency, and sustainable industrial growth.

- ▶ **National Solar Mission:** Scales up solar power generation through subsidies and grid integration, contributing to India's target of 500 GW of non-fossil capacity by 2030.
- ▶ **Wind-Solar Hybrid Policy:** Encourages co-located hybrid projects to maximise land use and renewable power generation.
- ▶ **ADEETIE Scheme** (*Assistance in Deploying Energy Efficient Technologies in Industries & Establishments*): Targets MSMEs, including those in Panipat, with interest subvention (up to 5% for micro and small enterprises) on loans for energy-efficient and clean technology upgrades. The scheme also funds energy audits, project preparation, and post-implementation verification.

10.4.3. State-Level Policies and Incentives

- ▶ **Haryana Industrial Policy:** Simplifies approvals and provides incentives for renewable energy use, rooftop solar installation, and cleaner fuel adoption (PNG, LPG etc.), benefiting clusters like Panipat.
- ▶ **Haryana Renewable Energy Policy:** Promotes net metering, open access to green power, and participation in solar parks, enabling industries to lower both carbon emissions and power costs.
- ▶ **HSPCB Regulations:** The Haryana State Pollution Control Board enforces emission norms and supports effluent treatment plant (ETP) upgrades and cleaner fuel use through compliance-linked incentives.

10.4.4. Institutional and Implementation Support

To accelerate adoption, the government has streamlined regulatory processes through single-window clearance systems at both national and state levels. Platforms such as the National Single Window System (NSWS) and Haryana Udyam Portal reduce approval time, making it easier for industries in Panipat to access government schemes and financial incentives deploy clean technologies.

11. Workforce Readiness for Green Transition

Human capital is the backbone of Panipat's textile waste ecosystem. However, systemic gaps in skill development, occupational safety, gender equity, and readiness for green transitions pose a significant challenge to realising the cluster's full potential. This section explores workforce characteristics, gaps in green skilling, and opportunities for a more inclusive, skilled, and resilient workforce.

11.1. Workforce Profile in Recycling Units

The textile waste and recycling value chain in Panipat is highly labour-intensive. During field visits and stakeholder interactions, it was observed that each process stage including sorting, shredding, carding, spinning, weaving, dyeing, and finishing, is largely dependent on human effort rather than automation.

- ▶ **Worker Composition:** The majority of workers in the cluster are male interstate migrants from Bihar, Uttar Pradesh, and West Bengal. Most of them live in rented rooms or shared accommodations, often arranged by unit owners.
- ▶ **Employment Terms:** Work arrangements are largely informal, with most workers hired through contractors or employed on a daily-wage basis. There is minimal access to formal contracts, job security, or statutory benefits.
- ▶ **Women Workers:** Women are primarily engaged in low-skill, low-wage roles such as sorting post-consumer textiles, thread trimming, and finishing. These roles are perceived as less hazardous but offer limited opportunities for advancement or skill growth.
- ▶ **Turnover and Retention:** Worker attrition is high, particularly during festival seasons, which disrupts production timelines and affects product quality. Employers report difficulty in retaining experienced workers.
- ▶ **Skill Background:** Most workers acquire skills informally through on-the-job learning or family-based transmission. Only a small fraction has received structured or certified training.

11.2. Awareness of Energy Efficiency and Decarbonisation Practices

There is limited awareness among workers regarding energy-efficient operations or decarbonisation objectives. Conversations with unit owners and staff revealed that these topics are often perceived as technical or managerial concerns, not directly linked to the day-to-day roles of workers.

- ▶ **Limited Awareness:** Workers typically associate energy only with electricity consumption or power outages, without understanding its environmental or economic implications.
- ▶ **Knowledge Concentration:** Awareness of sustainability or energy efficiency practices is confined to owners or senior managers, primarily driven by buyer audits or export requirements.
- ▶ **Training Initiatives:** There are no training initiatives that connect workers' operational practices to outcomes such as energy savings or emission reduction.
- ▶ **Missed Potential:** Workers are not engaged as active contributors to sustainability goals, even though their actions – such as proper machine usage and maintenance – could significantly impact efficiency.

11.3. Skill Development and Green Job Training

Despite being one of India's leading textile clusters, Panipat lacks a formal and coordinated ecosystem for green skill development. Existing skilling activities are limited in scope, infrequent, and rarely aligned with circular economy principles.

- ▶ **Training Gaps:** There are no dedicated institutions offering structured training in green or sustainability-related domains. MSMEs that engage with NGOs or local institutes usually focus on basic skills such as dyeing or safety practices, which are not linked to environmental performance.
- ▶ **Lack of Green Job Pathways:** The cluster has not yet developed training programmes for emerging job roles such as energy auditors, process optimisers, traceability coordinators, or renewable energy technicians.
- ▶ **Recommended Training Areas:** Priority areas for workforce skilling include resource-efficient dyeing techniques, machinery maintenance for energy savings, environmental compliance and audits, and digital inventory and traceability systems.
- ▶ **Industry Relevance:** Structured, modular training aligned with cluster needs would enhance productivity and prepare the workforce for the industry's transition towards low-carbon, traceable production systems.

11.4. Occupational Health & Safety (OHS) and Worker Wellbeing

Occupational health and safety standards in Panipat's textile recycling value chain remain weak, particularly in smaller and informal units. The absence of structured OHS systems exposes workers to significant health and safety risks across different process stages, with limited institutional support for prevention, training, or healthcare access.

Common Health Hazards Across Process Stages -

- ▶ **Sorting Units:** Workers face continuous exposure to dust, allergens, and microplastics, leading to respiratory discomfort, eye irritation, and skin conditions.
- ▶ **Shredding/Carding Units:** Frequent risks arise from sharp blades, and excessive noise levels. Dust exposure adds to respiratory strain.
- ▶ **Spinning/Dyeing Units:** Workers are vulnerable to chemical inhalation, high temperatures, and repetitive motion injuries. Chronic back pain, joint stiffness, and breathing difficulties are common among long-serving employees.

11.4.1. OHS Interventions

Existing OHS interventions within the cluster are minimal and unevenly distributed. Most recycling units lack ergonomic design features, forcing workers to lift heavy textile bales manually or work for long hours on the floor. This contributes to fatigue, back injuries, and reduced efficiency. The installation of dust control systems, such as exhaust fans or air filters, is limited and often poorly maintained, particularly in smaller units where ventilation is inadequate.

The use of PPE varies widely across units. In export-oriented or GRS-certified facilities, PPE adoption is relatively higher due to compliance monitoring by international buyers. However, in most micro and small-scale units, PPE use remains voluntary and infrequent.

11.4.2. Awareness and Adoption of OHS Protocols

Across most facilities, there is a noticeable lack of structured OHS orientation or awareness. Workers typically receive no safety induction at the time of joining and learn through observation or peer guidance. The use of personal protective equipment (PPE) – such as gloves, earplugs, dust masks, and goggles – is inconsistent and often dependent on individual preference rather than company policy.

Employers, particularly in small or informal units, tend to perceive OHS as an additional expense rather than an operational requirement. This attitude results in minimal investment in preventive safety measures or training. Only a few export-oriented or certified units conduct regular safety drills or inspections, usually driven by buyer audits or certification requirements rather than internal motivation. Dedicated health or safety officers are rare, and safety signage or emergency response systems are often missing.

11.4.3. Existing Support for Social Security Schemes

Formal social protection and health coverage for workers are extremely limited. Most workers rely on personal savings or informal loans to manage medical expenses, as enrolment in schemes such as the Employees' State Insurance (ESI) remains negligible.

Safety training is sporadic, short-term, and often focused narrowly on basic machinery operation or fire safety. Comprehensive training on workplace ergonomics, dust exposure management, or chemical handling is rare. NGO-led or government-supported health awareness sessions are not common within the cluster, and no systematic programs addressing worker wellbeing were reported during field visits.

11.5. Gender and Youth Empowerment in Green Transition

The transition toward a circular and low-carbon textile economy offers a significant opportunity to promote greater inclusion of women and youth within Panipat's recycling cluster. However, systemic barriers - ranging from limited skilling opportunities to restrictive social norms - continue to constrain their participation and upward mobility.

11.5.1. Gender-Disaggregated Participation

Women and youth remain underrepresented in skilled and technical roles within the recycling value chain.

Women: Most women are employed in non-technical, manual tasks such as sorting, thread trimming, and stitching. These activities are perceived as low-risk and "suitable" for women but provide limited pay, recognition, or scope for advancement. Women are rarely seen in supervisory, dyeing, or spinning roles, where technical expertise and machine operation are required.

Youth: Young workers, both male and female, often enter the sector due to economic necessity rather than choice. With limited access to training or formal employment contracts, they experience low job satisfaction, minimal income security, and high attrition.

11.5.2. Potential for Promoting Leadership among Women in MSMEs

Women's representation in managerial and entrepreneurial positions remains negligible within the cluster. However, examples from other textile regions demonstrate that women's economic empowerment can be significantly enhanced through targeted interventions such as microfinance access, mentorship, peer networks, and business management training.

Encouraging women-led self-help groups (SHGs) and promoting recognition for women innovators in sustainable production can further inspire leadership. Developing tailored capacity-building programmes focusing on financial literacy, enterprise management, and negotiation skills will be crucial to supporting aspiring women entrepreneurs.

11.5.3. Barriers & Aspirations for Women and Youth Workers

Discussions with workers revealed clear aspirations for improved working conditions, stability, and skill development, particularly among young women. Many women expressed a desire for employment in safer, cleaner, and less physically demanding roles. However, a combination of **institutional and social barriers** prevents their greater participation.

Key barriers include the absence of local skilling centres, which limits access to relevant training, and inadequate sanitation facilities in many workplaces, which discourage women from joining or remaining in the workforce. Gendered social norms and mobility concerns further restrict women's ability to travel for work or pursue technical training.

Youth workers, on the other hand, showed strong interest in digital, machine-based, and sustainability-oriented roles, but lacked the necessary exposure and vocational training opportunities. The absence of structured career pathways contributes to frustration and frequent job turnover.

11.5.4. Green Skilling Needs and Opportunities

The move towards greener production systems creates demand for new skills, providing a pathway for both women and youth to participate in the green transition. Emerging areas include:

- ▶ **Renewable Energy Systems (RES):** With the growing installation of rooftop solar panels across the cluster, there is a rising need for trained technicians in solar installation, system maintenance, and energy audits. Smaller units are beginning to explore these options but often lack the skilled workforce to manage them.
- ▶ **Digital Traceability and Inventory Systems:** As global buyers increasingly require certifications such as GRS and RCS, there is growing demand for workers skilled in data management, barcode tagging, and traceability software. Training youth in these digital competencies can open up new, higher-value employment opportunities.
- ▶ **Eco-Certification and Audit Support:** Workers trained in sustainability documentation, record-keeping, and certification processes can play a crucial role in ensuring compliance and supporting audit readiness for MSMEs.
- ▶ **Sustainable Product Design and Upcycling:** Training programmes in creative reuse and upcycling of textile waste can empower women and youth to engage in product design, handmade goods, and zero-waste manufacturing – creating livelihood opportunities in crafts and small enterprises.

Despite these opportunities, Panipat currently lacks institutions or structured programmes that focus on green or sustainability-linked skills. There is an urgent need for **co-created training modules** developed in partnership between industry, government, and training institutions to bridge this gap.

12. Financial Ecosystem and Green Finance Readiness

While the cumulative investment across the cluster exceeds INR 20,000 crores, the share directed toward sustainable infrastructure, clean technologies, and environmental compliance remains marginal. This chapter assesses the financial ecosystem's readiness to support a green transition, examining access to both conventional credit and climate-aligned financing instruments, and identifying key constraints and opportunities for MSMEs.

The cluster comprises micro, small, and medium enterprises with wide variations in technology adoption, capital intensity, and formalisation, which directly influence access to finance and readiness for green investments. The table below outlines key process segments, operational characteristics, and formalisation levels to contextualise financing constraints and opportunities across the value chain.

Table 26: Process Segmentation, Unit Characteristics, and Formalisation Levels Relevant to Financing Readiness

Process Segment	Nature of Operations	Unit Type	Degree of Formalization
Sorting	Manual/visual classification of textile waste	Micro & Small	Semi-formal
Shredding/Carding	Mechanical fibre recovery & cleaning	Micro, Small, few Medium	Semi-formal
Spinning	Open-end spinning using waste fibre	Medium to Large	Formal, Export-oriented
Dyeing	Wet processing, coloration	Micro, Small, Medium	Formal
Processing/Finishing	Stentering, calendaring, brushing, washing	Medium to Large	Formal
Weaving/Stitching	Loom-based fabric weaving, stitching	Micro to Medium	Informal to Formal

Higher levels of formalisation and scale observed in downstream processes correspond with greater access to institutional finance, while upstream activities remain constrained in adopting green technologies due to limited formal credit access.

12.1. Access to Conventional Finance

Panipat has an established financial network comprising nationalised and private sector banks, regional rural banks, and NBFCs. Despite the availability of credit, the majority of MSMEs, particularly those in informal or semi-formal segments, struggle to secure term loans for capital investment. This is due to the sector's fragmented formalisation, collateral constraints, and weak financial documentation practices.

- ▶ Collateral-backed loans remain the norm, disadvantaging informal and small enterprises that lack fixed assets.
- ▶ Interest rates for conventional term loans currently range between 9–11%, which proves unaffordable for capital-constrained units.
- ▶ Very few units have previously availed institutional credit for modernisation or compliance-related capital expenditure.

12.2. Access to Climate and Green Finance

Green and climate-aligned finance mechanisms are emerging but remain underutilised in Panipat. Schemes such as SIDBI's 7.4% green loans for solar installations, the ADEETIE interest subvention (offering up to 5% for micro units), yet uptake is limited due to lack of awareness and documentation gaps.

For instance, a 500 kW rooftop solar installation subsidised by IREDA (30–50%) offers a payback period of just ~5 years and annual energy savings worth INR 51 lakhs. However, ~150 Units of the cluster have adopted solar systems, with most installations concentrated among larger export-oriented enterprises. Smaller firms cite the high upfront costs, lack of technical guidance, and absence of facilitation as major deterrents.

12.3. Financial Readiness of MSMEs





An analysis of cluster-level data reveals that overall financial readiness remains low across MSMEs. Only a handful of enterprises have accessed subsidies or soft loans for sustainability-linked investments. Completion of energy audits is very less and a few units possess detailed project reports (DPRs) aligned with green finance eligibility standards.

Readiness levels are relatively higher among export-oriented spinning units, which face greater compliance pressure from European buyers. These firms are more likely to engage consultants and financial intermediaries to prepare documentation and access concessional funding. Conversely, small sorting and finishing units remain excluded from green financing channels due to limited capacity and informality.

12.4. Fixed Capital and Working Capital Assessment

The scale of investment and financial preparedness varies widely across different segments of Panipat's textile recycling value chain. Capital-intensive processes such as spinning and dyeing demonstrate relatively higher financial readiness, driven by export linkages and access to formal credit, while smaller units engaged in sorting, shredding, and finishing operate with limited capital and low access to institutional finance. The table below summarises the typical capital requirements and observed levels of financial readiness across major process segments in the cluster.

Table 27: Capital Requirement and Financial Readiness across Textile Recycling Processes in Panipat

Process Segment	Capital Requirement per Unit	Observed Financial Readiness
Spinning (OE/Ring Frame)	INR 5–20 crore	
Dyeing/Processing	INR 3–12 crore	
Stitching/Finishing	INR 50 lakh – INR 2 crore	
Sorting/Shredding	INR 5–25 lakh	

12.4.1. Adoption Patterns and Investment in Clean Technologies

The adoption of clean and resource-efficient technologies across Panipat's textile recycling ecosystem varies significantly by technology type, reflecting differences in cost, scalability, and technical maturity rather than firm size or ownership structure. Technologies such as effluent treatment plants (ETPs) and solar rooftops have achieved moderate traction due to clear regulatory or economic incentives, while others like zero liquid discharge (ZLD) systems, IE4/IE6 motors, and water reuse technologies remain at a pilot or low-adoption stage.

The variation is shaped by multiple factors, including technology affordability, return on investment, policy incentives, and access to technical expertise. High-capital interventions like ZLD and common boiler systems require collective investment models or blended finance mechanisms, whereas relatively low-

cost, quick-return technologies such as efficient motors and dust control systems are hindered mainly by lack of awareness rather than feasibility.

The table below presents an overview of key technology segments, their current level of adoption, estimated investment ranges, and key observations regarding feasibility and challenges within the cluster.

Table 28: Technology Specific Investment Segments

Technology Type	Observed Adoption Level	Investment Range (INR) per unit	Observations
ETP (Effluent Treatment Plant)	Moderate in larger dyeing units	INR 25–100 lakh	Common in large units; less viable for MSMEs without CETP linkage
ZLD (Zero Liquid Discharge)	Rare – pilot stage	INR 1.5–3 crore	Cited as unaffordable for most MSMEs; CETP-ZLD hybrid suggested
Solar Rooftop (Rooftop PV)	~150 units adopted	INR ~220 lakh	500 kW system offers ROI within ~5 to 7 years
Common Boiler Systems	Proposed, not yet implemented	INR 3–4 crore (shared for 10-12 units)	Pilot proposed for 10 to 12 dyeing units; land acquisition pending
IE4 / IE6 Motors	Very low	INR 3–5 lakh/ motor	Lack of awareness; high ROI when included in energy audit
Gensets (Gen 3/Gen 4)	Aging units still in use	INR 5–15 lakh	Used primarily as backup; rarely energy efficient
Air Compressors	Moderate adoption	INR 4–12 lakh	Major contributor to energy bills in finishing units
Air Handling Units (AHUs)	Absent in most units	INR 3–6 lakh	Rarely installed; contributes to indoor air quality and process cooling
Ventilation & Dust Control Systems	Very low	INR 1–5 lakh	Lacking in most units; leads to health issues and safety concerns
Water Reuse Systems	Limited, mostly experimental	INR 50–75 lakh	Solidaridad pilot: 80% reduction in freshwater usage possible

12.5. Utilisation of Government Subsidies and Carbon Credit Mechanisms

The transition toward a sustainable and resource-efficient textile ecosystem in Panipat requires not only technological and operational improvements but also significant financial support. To address this, a range of government subsidies, fiscal incentives, and emerging carbon finance mechanisms have been introduced at both state and national levels. However, the actual utilisation of these schemes across the Panipat cluster remains limited, fragmented, and heavily skewed toward larger, export-oriented units.

Table 29: Key Schemes Supporting Green Finance and Clean Technology Adoption

Scheme/Policy	Administering Body	Key Benefit	Status in Panipat
ADEETI Scheme (Accelerated Development of Energy Efficiency in Textile Industry)	Bureau of Energy Efficiency (BEE), Ministry of Power	5% interest subvention for micro units, 3% for medium units; requires energy audit & DPR	Poor awareness and low uptake among MSMEs
SIDBI Green Loan Products	SIDBI	Concessional loans (7.4%) for 700+ pre-approved green technologies	Accessed by a few solar adopters; most MSMEs unaware of eligibility
Textile Policy 2035 (Haryana)	Government of Haryana	Incentives for solar energy adoption, ZLD, and common CETPs	Underutilised due to lack of implementation clarity and facilitation

12.6. Key Barriers to Finance

Despite the growing need for sustainability-linked investments, enterprises across Panipat's textile recycling cluster face persistent barriers in accessing both conventional and green finance. These challenges are rooted in structural informality, weak financial documentation, and low awareness of available schemes and instruments.

A large share of MSMEs operates without bankable financial records or fixed collateral, limiting their eligibility for institutional credit. Even where concessional green financing is available – through schemes such as SIDBI Solar, ADEETIE, or UNIDO Clean Tech – uptake remains minimal due to lack of information, facilitation support, and readiness to meet documentation or compliance requirements.

In addition, digital and carbon readiness remain extremely low. Very few units use traceability or monitoring platforms, and almost none have conducted GHG assessments necessary for carbon credit validation or disclosure frameworks such as CBAM. Some large units are preparing for CBAM-aligned disclosures, but majority of the cluster has not initiated Scope 1, 2, or 3 mapping. Informal employment structures further weaken the financial credibility of enterprises and restrict their participation in formal credit systems.

Figure 36: Key Barriers to Finance

Collateral & Formality	Over 60% of units lack bankable financial records, audited statements, or mortgageable assets, limiting their ability to access term loans.
Documentation	Most enterprises do not prepare Detailed Project Reports (DPRs), financial projections, or cost-benefit analyses required by lenders for green technology proposals.
Awareness	Knowledge of concessional finance mechanisms – such as SIDBI Green Loans, ADEETIE interest subvention, or UNIDO Clean Tech – is very limited among MSMEs.
Digital Traceability	Uptake of traceability and certification platforms like GRS, TextileGenesis, or Reverse Resources remains low, reducing eligibility for sustainability-linked finance.
Carbon Readiness	There is no structured GHG mapping at the unit level, and carbon validation costs are prohibitively high for MSMEs.
Informality	Over 70% of employment in the cluster is contractual or informal, which restricts enterprises from formal registration and access to institutional finance.

12.7. Potential for Blended Finance and CSR Integration

Achieving the scale of investment required for Panipat's textile recycling cluster to transition into a resource-efficient, low-carbon, and globally competitive ecosystem will require financing models that go beyond traditional credit mechanisms. Given the limited creditworthiness of MSMEs among the formal lenders in particular and the high capital intensity of clean technologies, blended finance and Corporate Social Responsibility (CSR) integration emerge as viable pathways to mobilise both public and private capital for sustainable transformation.

Blended finance combines concessional public or philanthropic funds with private investment to de-risk green projects and make them financially viable. This approach can help overcome MSME constraints such as lack of collateral, limited cash flows, and high upfront costs for technology adoption. CSR partnerships, on the other hand, can support complementary interventions, such as worker skilling, environmental awareness, and compliance capacity building, that may not yield immediate financial returns but are essential for the long-term sustainability and social inclusiveness of the cluster.

While a few CSR- or donor-backed pilots in Panipat have demonstrated success, they remain fragmented, small-scale, and largely non-replicable. Institutionalising such blended approaches across the cluster is now critical to unlock scalable and sustained investment flows.

12.7.1. Relevance of Blended Finance for MSMEs in Panipat

Most MSMEs in Panipat, particularly in dyeing, finishing, and sorting segments, operate on thin profit margins and within informal or semi-formal structures, limiting their ability to absorb the high capital costs of sustainable technologies such as ZLD systems, rooftop solar, or high-efficiency IE4/IE6 motors. At the same time, financial institutions are often reluctant to lend to these enterprises due to lack of collateral, weak documentation, and uncertain repayment capacity.

Blended finance mechanisms can bridge these gaps by combining different forms of capital and risk-sharing instruments, including:

- ▶ **De-risking private investments** through guarantees, interest subventions, or first-loss capital provisions.
- ▶ **Crowding in concessional finance** from development financial institutions (DFIs) such as SIDBI, NABARD, and IREDA.
- ▶ **Leveraging donor and CSR capital** to fund technical assistance, pilot demonstrations, and viability gap funding (VGF) for high-cost sustainable technologies.

Such models can make sustainability-linked investments more attractive for MSMEs, while also building long-term financial and institutional resilience across the cluster.

12.7.2. Opportunities for Blended Finance in Panipat

Several priority intervention areas within Panipat's textile recycling ecosystem are well-suited for blended finance structures. These initiatives combine public sector support for infrastructure and subsidies with private participation in operations and maintenance, creating sustainable, shared value.

Table 30: Potential PPP Models for Green Infrastructure and Capacity Building

Intervention Area	Public/Donor Role	Private Sector Role	Potential Financing Sources
ZLD- Common Effluent Treatment Plants (CETPs)	Provide capital subsidy and allocate land	Contribute to O&M and monitoring	MoT, MoEFCC, SIDBI
Cluster Solar Rooftop Programme	Offer capital buy-down or Viability Gap Funding (VGF)	Purchase power under long-term PPA arrangements	IREDA, MNRE, CSR funds
Shared Common Boiler Infrastructure	Fund infrastructure development and utilities	Bear fuel and maintenance costs	State Government, CSR
Traceability Platforms & DPP Compliance	Support platform development and onboarding costs	Input and manage transaction-level production data	GIZ, EU, Global Brands
Worker Skilling & Financial Literacy	Cover training costs and curriculum design	Ensure worker participation and retention	CSR (FMCG, Apparel Sectors), NSDC

Each of these blended initiatives can be structured under a **Public-Private-Community Partnership (PPCP)** model or implemented through a **cluster-level Special Purpose Vehicle (SPV)** supported by local industry associations. Such institutional structures would ensure transparent governance, accountability, and efficient fund utilisation – enabling Panipat to mobilise long-term green investments while driving inclusive and sustainable industrial growth.

13. SWOT Analysis with Decarbonisation Lens

Panipat's textile recycling cluster stands at a critical juncture - balancing its established circular economy foundation with the need to transition toward low-carbon, resource-efficient production. The cluster's strengths lie in its scale, experience, and circularity-driven business model, yet its dependence on fossil fuels, limited digitalisation, and low decarbonisation readiness pose key challenges.

This SWOT analysis examines the cluster's internal capacities and external environment through a decarbonisation lens, highlighting areas where Panipat can leverage existing advantages, address systemic weaknesses, and align more closely with global climate and trade imperatives and emerging ESG-linked financing frameworks.

Figure 37: SWOT Analysis for Decarbonisation in the Panipat Recycled Textile Cluster



13.1. Strengths

- ▶ **Established Circular Recycling Ecosystem:** Panipat's large-scale recycling base inherently reduces textile waste and supports low-carbon production, providing a strong foundation for climate-aligned manufacturing.
- ▶ **Experience and Process Maturity:** Decades of expertise in waste fibre recovery and reprocessing offer practical potential to integrate energy efficiency and cleaner production technologies.
- ▶ **Early Renewable Energy Adoption:** Around ~150 units have installed rooftop solar systems, demonstrating initial progress toward decarbonisation and self-reliant energy generation.
- ▶ **Integration with Global Value Chains:** Engagement with international buyers such as IKEA, H&M, Primark etc. exposes the cluster to international climate disclosure and ESG compliance standards, pushing gradual change.
- ▶ **Policy and Institutional Support for Greening:** Recognition as a *Town of Export Excellence* and eligibility for schemes such as ADEETIE, SIDBI Green Loans, Haryana Renewable Energy Policy etc. facilitate access to clean technology finance and regulatory incentives.

13.2. Weakness

- ▶ **High Carbon Dependence:** The cluster remains reliant on biomass, coal, and diesel-based boilers, with limited transition to low-emission fuels or electrified systems.
- ▶ **Low Carbon Literacy:** Most MSMEs have limited understanding of decarbonisation frameworks, emission monitoring, or energy management systems.

- ▶ **Insufficient Technical and Financial Preparedness:** Only few units have completed energy audits or prepared project documents aligned with green finance eligibility.
- ▶ **Weak Traceability and Digital Systems:** Low adoption of digital monitoring tools prevents reliable measurement of carbon footprints and hinders participation in traceability-driven export markets.
- ▶ **Institutional Fragmentation:** Absence of a dedicated sustainability facilitation cell or local BDSPs limits access to technical assistance for energy transition or carbon accounting.

13.3. Opportunities

- ▶ **Cluster-Wide Renewable Energy Transition:** Expanding rooftop solar adoption and shared clean energy infrastructure (e.g., community solar, biomass gasifiers) could offset up to 35% of grid power demand.
- ▶ **Deployment of Low-Carbon Technologies:** Wider use of energy-efficient dyeing, waste heat recovery, and electric boiler systems can significantly reduce Scope 1 and 2 emissions.
- ▶ **Access to Emerging Climate Finance:** Instruments such as SIDBI Green Loans, ADEETIE, GCF, and blended finance mechanisms can lower barriers to technology adoption for MSMEs.
- ▶ **Digital and Carbon Traceability Systems:** Integrating platforms for DPP can enable verified low-carbon exports and compliance with upcoming EU trade standards.
- ▶ **Green Workforce and Innovation:** Targeted upskilling in energy management, circular design, and digital compliance can strengthen the cluster's human capital and innovation capacity for green transformation.

13.4. Threats

- ▶ **Stringent Climate Trade Regulations:** Non-compliance with CBAM, EPR, CSRD, CSDDD etc. requirements may lead to export losses or tariff penalties.
- ▶ **Rising Energy Costs and Fuel Volatility:** Dependence on fossil and biomass fuels exposes MSMEs to fluctuating input prices and potential carbon taxes.
- ▶ **Limited Financial Inclusion:** Smaller or informal enterprises risk exclusion from green funding due to poor documentation or lack of creditworthiness.
- ▶ **Market Concentration and Compliance Burden:** The cost of certifications, audits, and emission disclosures may push smaller firms out of supply chains.
- ▶ **Climate and Resource Risks:** Increasing water scarcity, temperature rise, and waste disposal constraints could disrupt production processes and threaten cluster sustainability.
- ▶ **Rising Competition:** Panipat's textile recycling cluster faces competition from both domestic and international hubs that are advancing in traceability and compliance. Within India, clusters such as Surat, and Tiruppur compete for buyers and green investments. Internationally, organised recycling ecosystems in Prato and manufacturing hubs in Turkey and Bangladesh offer stronger certification and brand linkages, underscoring the need for Panipat to strengthen traceability and compliance.

14. Key Issues and Constraints for Decarbonisation

For Panipat, decarbonisation primarily depends on transitioning from conventional fuels to cleaner alternatives such as biomass and solar energy, improving boiler and process efficiency, and adopting low-carbon technologies including waste heat recovery and advanced dyeing systems.

The overarching objective is to establish a low-carbon, resource-efficient production ecosystem that strengthens the cluster's competitiveness in both domestic and export markets. However, persistent barriers – such as limited technical awareness, inadequate financing mechanisms, and outdated process infrastructure – continue to slow this transition.

14.1. Technological Barriers

Although awareness of sustainability has grown, most MSMEs in Panipat still face persistent technological challenges that limit their ability to adopt low-emission and energy-efficient practices.

Obsolete and Energy-Intensive Machinery

The majority of units continue to rely on manual or semi-mechanised machinery for shredding, carding, spinning, and dyeing. These older systems consume excessive energy, lack thermal efficiency, and are incompatible with automation or renewable energy integration.

Limited Access to Cleaner Production Technologies

Boilers and stenters are predominantly powered by solid fuels such as biomass, briquettes, and rice husk. Cleaner alternatives – like LPG -fired boilers, electric steam generators, and solar dryers – remain underused. Retrofitting costs ranging from INR 20–30 lakhs, fuel price volatility, and infrastructure gaps have constrained wider adoption.

Poor Process Optimisation

Energy consumption is rarely monitored at the machinery level. Uninsulated pipelines, poor steam management, and batch-wise operations result in significant energy losses. Waste heat recovery systems are seldom implemented despite their cost-saving potential.

Weak Technical Support Ecosystem

The cluster has a shortage of reliable vendors, clean-tech service providers, and trained technicians. The lack of electronics professionals for PLC troubleshooting often discourages MSMEs from investing in automated or digital systems due to fear of downtime and maintenance costs.

Technology Gaps and Obsolescence

Panipat's recycled textile cluster has achieved global recognition for scale and productivity, yet its technological base remains outdated relative to international standards. Processes in sorting, spinning, dyeing, and traceability remain resource-intensive and inefficient. These gaps lead to value losses but also present opportunities for technology transfer, cluster-level upgrades, and capacity-building.

Table 31: Comparative Overview of Technological Benchmarks and Gaps

Process Stage	Global Benchmark (Best Practices)	Panipat – Current Status	Gap / Notes
Sorting & Grading	Automated optical/NIR sorting, conveyORIZED lines, dust extraction, traceability/DPP integration	Manual sorting, limited mechanisation, no optical sorters	Large efficiency, yield, and traceability gap

Process Stage	Global Benchmark (Best Practices)	Panipat – Current Status	Gap / Notes
Fibre Recovery (Tearing/Garneting)	Modern garnet lines with dust capture, low fibre breakage, high throughput	Legacy Italian/domestic machines, noisy, high breakage	Outdated → lower fibre quality
OE (Rotor) Spinning – Energy	0.8–1.1 kWh/kg yarn (Gen-6 rotors)	1.6–2.0 kWh/kg yarn	Higher energy intensity
OE Yarn Counts	Ne 10s–30s possible with clean fibre prep	Mostly Ne 6s–20s	Limited product range
Spinning Quality Control	Online contamination sensors, clearers, auto doffing	Spot testing, limited sensors	Quality inconsistency
Weaving/Knitting	Shuttle-less looms (rapier/air-jet), CAD/CAM integration	Mix of handlooms/ power looms; rapier/dobby in some units	Lower productivity, design limitations
Dyeing Technology	Low-liquor ratio (1:4–1:6) soft-flow/jet, digital printing	Jigger dominant (1:10–1:15 liquor ratio); partial soft-flow	Very high water/energy/chem use
Water Use (Processing)	30–60 L/kg fabric	80–120 L/kg fabric	High consumption; reuse low
Wastewater Treatment	ETPs with membranes, 60–80% reuse; ZLD where required	CETPs/ETPs exist, O&M inconsistent, partial ZLD	Compliance + reuse gap
Boilers/Fuels	High-efficiency boilers, O ₂ trim, condensate recovery >70%, LPG/biomass with controls	Biomass/LPG mix, varying efficiency, very few condensate recovery	Efficiency gap, controls missing
Heat Recovery/VFDs	Standard (condensate recovery, stenter insulation, VFDs)	Partial adoption	Quick ROI opportunity
Traceability/DPP	ERP-integrated, blockchain-ready, buyer-standard	Manual/spreadsheets, pilot initiatives	Needed for EU compliance
Testing & Labs	In-cluster accredited labs, fastness/REACH compliance	Limited advanced labs	Bottleneck for exports
Energy Management	ISO 50001, metered sub-lines, real-time monitoring	Audits sporadic, rooftop solar emerging	Cluster-wide EMS absent
GHG Intensity	OE spinning <1.2 kg CO ₂ e/kg yarn; low-LR dyeing reduces further	1.5–2.5 kg CO ₂ e/kg yarn; dyeing higher	Cleaner energy + low-LR adoption needed

14.2. Financial and Capacity Gaps

The technological lag in Panipat's textile recycling cluster is reinforced by limited financial access and weak institutional capacities, particularly among small and micro enterprises. Transitioning to cleaner fuels or upgrading to energy-efficient machinery entails high capital investment – costs that most units cannot afford due to low profit margins and limited cash flow.

Although multiple green financing schemes exist through SIDBI, BEE, MoMSME, and NABARD, awareness among enterprises remains minimal, and procedural delays discourage participation. Most MSMEs rely on self-financing, as formal credit access is constrained by collateral requirements, lack of proper documentation, and limited credit history.

Loan applications are frequently rejected due to insufficient guarantees or the absence of detailed project reports and energy audit data, which are prerequisites for concessional loans. Even where awareness exists, investments in energy efficiency are often postponed unless there is a clear link to productivity or cost reduction.

Institutional and technical capacity further hinder progress. There is a shortage of qualified energy auditors and consultants who can guide MSMEs through the financing process or prepare investment-grade proposals. A review by CEEW (2018) of the *Technology & Quality Upgradation Support for MSMEs*

Scheme found that nearly 71% of the allocated funds remained unused, underscoring the systemic challenges in scheme uptake and implementation.

Overall, the cluster's ability to adopt low-carbon technologies depends not only on affordable financing but also on improving financial literacy, developing tailored credit products, and strengthening technical support for project preparation and execution.

14.3. Institutional and Governance Challenges

Panipat's textile recycling cluster operates within a loosely organised and fragmented institutional framework, limiting coordinated climate action. While associations such as the *Panipat Dyers Association* and *Panipat Exporters Association* exist, their roles are confined to basic advocacy and dispute resolution. These bodies lack dedicated staff, technical capacity, and financial resources to drive decarbonisation, technology upgrades, or energy standardisation across the cluster.

Participation in association-led meetings is irregular, and activities are often managed by busy business owners, leaving little focus on sustainability. This has resulted in weak, uncoordinated cluster-wide initiatives. Moreover, associations lack capacity to help MSMEs access government schemes, subsidies, or clean technology support, which are often seen as overly bureaucratic and time-consuming by small enterprises.

The absence of a strong institutional anchor also restricts engagement with green finance providers, technology vendors, and training agencies, who typically require organised local partners. Shared infrastructure – like CETP upgrades, renewable systems, or common fuel facilities – thus remains underdeveloped.

To strengthen governance and enable low-carbon transition, Panipat needs:

- ▶ **Dedicated sustainability cells** within BMOs to coordinate decarbonisation projects.
- ▶ **Collaboration frameworks** linking associations, financiers, and technical experts.
- ▶ **Training and staffing support** for BMOs to handle compliance, scheme facilitation, and sustainability reporting.

Improved institutional capacity can turn fragmented efforts into a coordinated, cluster-wide movement toward decarbonisation and resilience.

14.4. Behavioural and Awareness Barriers

A major constraint to decarbonisation in Panipat's textile cluster lies in behavioural attitudes and limited awareness among unit owners and workers. Most MSME owners adopt a risk-averse, short-term outlook, prioritising immediate production and cost efficiency over long-term sustainability. There is a strong inclination to continue using existing machinery, conventional fuels, and familiar processes – even when cleaner, more efficient options are available. This reluctance stems from concerns about production downtime, upfront capital costs, and uncertainty regarding the financial returns of new technologies.

Many owners come from non-technical backgrounds, with limited understanding of environmental management or energy systems. The absence of formal training restricts their ability to evaluate emission impacts, interpret energy data, or identify potential savings from efficiency measures. Technical consultants and energy auditors are scarce and often unaffordable for small enterprises, while cluster-level knowledge exchange or peer learning remains weak.

Even where monitoring systems exist, most unit heads lack the capacity to interpret performance data, making it difficult to base decisions on evidence or justify green investments. Complex environmental

norms, compliance procedures, and government incentives are poorly understood, leading to underutilisation of available support schemes.

Worker training on sustainability topics – such as energy conservation, effluent treatment, or safety management – is nearly absent, particularly among micro and small units. This reinforces a perception that environmental performance is a management issue rather than a shared responsibility. Collectively, these behavioural and awareness barriers create inertia, slowing down the transition toward a low-carbon and energy-efficient production system in Panipat.

14.5. Strategic Pathways for Decarbonisation

The constraints outlined above indicate that the transition to low-carbon operations requires a multi-level approach -

- ▶ **Upgrading Core Production Systems** - Investment in high-efficiency boilers, low-liquor dyeing, condensate recovery, improved tearing systems, and electric or hybrid heating can substantially reduce emissions and production costs.
- ▶ **Strengthening Monitoring and Data Systems** - Introducing digital energy meters, steam flow meters, and wastewater quality sensors can help units optimise processes and reduce inefficiencies across dyeing, finishing, and spinning.
- ▶ **Building Technical Support Structures** - Cluster-level technical advisory cells, accredited energy auditors, and design labs can support MSMEs throughout the transition—technology evaluation, financing applications, training, and process troubleshooting.
- ▶ **Collaborative Financing Mechanisms** - Group-based procurement, cluster credit guarantees, and industry-association-mediated loan facilitation can expand access to green finance for small units.
- ▶ **Capacity Development** - Training programmes focused on operators, supervisors, and enterprise owners can strengthen technical competence, safety standards, and readiness for more advanced technologies.

15. Proposed Vision for a Low Carbon Recycling Cluster & Recommendations

15.1. Vision Statement

Panipat's recycling ecosystem is uniquely positioned to demonstrate how a traditional MSME cluster can transition toward a low-carbon future while maintaining high productivity and employment. This transformation will be achieved by optimising resource use, improving energy efficiency, integrating renewable energy, and promoting a circular economy.

To transform Panipat's textile recycling cluster into a globally competitive, circular, and carbon-neutral ecosystem by 2035 — driven by energy efficiency, resource optimisation, sustainable production technologies, inclusive skilling, green financing, and climate-resilient infrastructure that together ensure long-term environmental and economic sustainability.

Achieving this vision will require a just and inclusive transition that balances environmental ambition with economic resilience. It calls for coordinated action from industry associations, government agencies, financial institutions, and development partners to enable technology upgrading, green finance mobilisation, and capacity building across the recycling value chain. Establishing strong institutional frameworks and shared infrastructure will be critical to ensure that low-carbon practices become both viable and scalable, positioning Panipat as a model for sustainable cluster transformation in India and beyond. While many of these steps lie in the future, a draft vision for Panipat's Recycling Cluster has been formulated, drawing upon stakeholder consultations, site assessments, and sustainability evaluations.

15.2. National and Global Relevance of the Cluster Vision

The vision for transforming Panipat into a low-carbon recycling cluster holds significant national and global importance. Its successful implementation will enable the cluster to meaningfully contribute to both India's sustainability targets and the global climate and circular economy agenda.

15.2.1. National Significance

At the national level, Panipat's transformation directly supports *India's Net Zero Target (2070)* by demonstrating the feasibility of decarbonisation in a traditionally polluting MSME sector and establishing a replicable model for other industrial clusters. The shift toward renewable energy and circular production practices will help advance India's *Nationally Determined Contributions (NDCs)*, particularly the goal of reducing the emission intensity of GDP by 45% by 2030.

Enhanced adoption of rooftop solar systems under the *National Solar Mission* and *Rooftop Solar Programme* will reduce dependence on grid electricity while integrating renewable energy into the cluster's operations. Moreover, the promotion of circular economy practices through *Extended Producer Responsibility (EPR)* and *Circular Economy Missions* will align Panipat with India's material recovery and recycling goals.

Equally important is the focus on workforce development and skilling. Training in areas such as occupational health and safety, energy efficiency, and digital traceability directly supports the *Skill India* and *Green Jobs Mission*, contributing to the national goal of generating one million green jobs. These measures not only enhance productivity and safety but also build a skilled workforce capable of sustaining long-term green growth.

Together, these interventions will ensure that Panipat's progress contributes to India's broader industrial and climate strategy - integrating renewable energy adoption, sustainable production, and workforce transformation into a cohesive model of low-carbon growth.

15.2.2. Global Relevance

From a global perspective, Panipat's low-carbon vision is closely aligned with multiple international sustainability frameworks. It resonates strongly with the United Nations Sustainable Development Goals (SDGs), particularly:



By promoting digitisation and emissions tracking, Panipat's recycling units can gradually align with international benchmarks such as the *Science-Based Targets initiative (SBTi)*, preparing the cluster for export readiness in line with global best practices.

As sustainability and traceability become central to international trade, especially under frameworks like the EU Green Deal, Panipat's ability to demonstrate low-carbon sourcing and transparent production practices will be a decisive factor in maintaining and expanding its global market share.

Additionally, the adoption of global measurement frameworks such as the *Higg Sustainability Index* will enhance transparency, traceability, and competitiveness - positioning Panipat as a global leader in sustainable textile recycling.

15.3. Strategic Recommendations for Achieving the Vision

Achieving the vision of a low-carbon and circular textile recycling cluster in Panipat will require a coordinated set of actions spanning technology, infrastructure, workforce, and governance. The following steps outline the key focus areas that industries and supporting institutions must prioritise to realise this transformation.

Key Action Areas -

- **Strengthen Circular Economy Practices:** Panipat's recycling operations must transition from energy-intensive to resource-efficient processes. By 2035, at least 40% of total energy consumption in the cluster should come from renewable sources such as solar, biomass, and waste heat recovery systems. At least 1000 MSMEs are expected to adopt rooftop solar or biomass boilers, supported by digital energy monitoring across units. These measures are expected to collectively reduce energy intensity by 30% (kWh/kg output), contributing significantly to cluster-wide decarbonisation.

- ▶ **Modernise Machinery and Processes:** Replacing outdated equipment with modern, energy-efficient machinery and low-liquor dyeing systems will cut down emissions and resource use. Shared investments in ZLDs and CETPs can ensure that 100% of wastewater is treated and 80% reused within the cluster by 2035. A 20% reduction in chemical usage per unit fabric can be targeted through adoption of sustainable chemical formulations and condensate recovery systems.
- ▶ **Deepen Circular Economy Integration:** To move towards a zero-waste cluster, Panipat must implement automated sorting, grading, and fibre recovery systems, coupled with waste traceability mechanisms. The goal is to achieve 85% material recovery efficiency by 2035. At least 10% MSMEs should adopt eco-design and upcycling practices, supported by an annual progress assessment.
- ▶ **Build a Climate-Competent and Inclusive Workforce:** Dedicated Green Skill Centres (at least 5 by 2030) will prioritise women and youth, aiming for a 30% increase in their participation in technical roles and 20% formalisation of the informal workforce. A 50% retention rate among trained workers is targeted to sustain capacity.
- ▶ **Strengthen ESG Compliance, Traceability, and Market Access:** Less than 5% of Panipat's units currently hold global sustainability certifications, excluding remaining units from a EUR 15–20 billion European sustainable textile procurement market. By 2030, 50% of cluster units are expected to achieve international certifications, and by 2035, 100% of export-oriented products should be digitally traceable (QR/blockchain). This could enable a targeted 25% increase in sustainable export share to the EU and other regulated markets.
- ▶ **Develop Shared Infrastructure and Services:** Shared sustainability infrastructure will be central to enabling MSMEs' transition. By 2030, at least three cluster-level facilities, a renewable energy pooling hub, common testing and R&D laboratory, ZLD-CETP should be operational. These facilities will aim for 70% utilisation by MSMEs, benefiting over 500 enterprises by 2030 and reducing the cost of compliance by 15% per unit by 2035. Shared waste logistics and recycling systems will further streamline material recovery.
- ▶ **Enable Green Finance and Investment Access:** Financial enablement will accelerate the cluster's sustainability transition. Through collaboration with SIDBI, NABARD, and multilateral funds, at least INR 1000 crore in green and concessional finance should be mobilised by 2035. A minimum of 10% MSMEs should access these instruments for clean technology adoption. Targeted incentives and risk-sharing mechanisms will ensure an average payback period of ≤ 4 years for clean technology investments.
- ▶ **Institutionalise Governance, Monitoring, and Collaboration:** A dedicated Decarbonisation and Resource Efficiency Cell (DREC) should be established by 2030 to coordinate policy, capacity building, and data management. Multi-stakeholder platforms involving industry, academia, government, and development partners will guide the transition. A digital sustainability dashboard (live by 2027) will track 50+ key performance indicators, with quarterly stakeholder reviews and biannual progress reports ensuring accountability. The goal is to achieve $\geq 80\%$ of decarbonisation and circularity targets by 2030.

A more detailed representation of the proposed measures across different segments of the textile recycling industry is presented below. While not exhaustive, this framework highlights the potential for significant emission reductions and efficiency gains. Establishing a baseline of current energy and emission levels will be essential to guide targeted interventions. Only with such data-driven benchmarking can appropriate technologies and practices be identified to meet the cluster's strategic goals.

Table 32: Indicative Action Framework

Strategic Goal	Action Points	Measures of Performance (MoP)
Decarbonisation of Energy & Processes	<ul style="list-style-type: none"> Transition 40% of total energy to renewables by 2035. Retrofit 1000 MSMEs with rooftop solar. Implement digital energy monitoring across 70% of units. 	<ul style="list-style-type: none"> ▶ ≥40% of cluster energy from renewables by 2035. ▶ ≥1000 MSMEs equipped with renewable systems. ▶ 30% reduction in energy intensity (kWh/kg output). ▶ ≥70% of units with digital energy systems.
Water & Chemical Management	<ul style="list-style-type: none"> Shared ETPs and ZLD infrastructure. Use of low liquor dyeing and safer chemical formulations. Introduce condensate recovery systems. 	<ul style="list-style-type: none"> ▶ 100% wastewater treatment and ≥80% reuse by 2035. ▶ 25% reduction in liquor ratio. ▶ 20% reduction in chemical usage per unit fabric.
Circular Economy Integration	<ul style="list-style-type: none"> Introduce automated sorting, grading, and recycling systems. Promote reuse and upcycling of generated waste. Promotion of eco-design and upcycling. 	<ul style="list-style-type: none"> ▶ 90% of the current landfill textile waste diverted by 2035. ▶ 85% material recovery efficiency. ▶ ≥200 MSMEs adopting eco-design/upcycling.
Green Jobs & Workforce Transition	<ul style="list-style-type: none"> Establish 5 Green Skill Centres by 2035. Prioritise women and youth in skill development and formalisation. Introduce certification programs for green skills. 	<ul style="list-style-type: none"> ▶ >20% workers trained by 2035. ▶ 50% increase in women/youth in technical roles. ▶ 30% formalisation of informal workers. ▶ 70% retention rate of trained workers.
Digitalisation & Transparency	<ul style="list-style-type: none"> Implement QR/blockchain-based traceability. Promote GRS/OEKO-TEX and other sustainability certifications. Onboard MSMEs onto national sustainability dashboards. 	<ul style="list-style-type: none"> ▶ ≥50% of cluster units certified by 2035. ▶ 100% of export products digitally traceable by 2035. ▶ 25% increase in sustainable export share (Europe market).
Shared Infrastructure & Services	<ul style="list-style-type: none"> Develop 3 shared cluster-level facilities (renewable hub, testing lab, pollution control unit) by 2026. Enable shared logistics and recycling systems. 	<ul style="list-style-type: none"> ▶ ≥70% utilisation of shared infrastructure. ▶ 500 MSMEs benefiting by 2035. ▶ 15% reduction in compliance cost per unit.
Green Finance & Investment Access	<ul style="list-style-type: none"> Partner with SIDBI, NABARD, and multilateral funds to mobilise green finance. Design concessional loans and risk-sharing mechanisms for MSMEs. 	<ul style="list-style-type: none"> ▶ ≥INR 500 crore in green finance mobilised by 2035. ▶ ≥10% MSMEs accessing concessional finance. ▶ Average payback ≤4 years for clean tech adoption.
Institutional Governance, Monitoring & Collaboration	<ul style="list-style-type: none"> Establish Decarbonisation & Resource Efficiency Cell (DREC) by 2035. Launch digital sustainability dashboard by 2028. Conduct quarterly reviews and publish biannual progress reports. 	<ul style="list-style-type: none"> ▶ DREC operational by 2035. ▶ Dashboard tracking ≥50 KPIs live by 2028. ▶ ≥2 stakeholder reviews/year. ▶ ≥80% of decarbonisation & circularity targets achieved by 2035.

15.4. Roadmap for Transition

Decarbonising the Panipat textile cluster is both an ambitious and achievable goal. Production processes currently generate considerable waste — from fabric scraps to dyeing effluents — highlighting the need for integrated interventions. The cluster's adoption of energy-efficient technologies, renewable energy,

sustainable material sourcing, and circular economy frameworks presents a clear pathway to low-carbon growth.

By embedding sustainability at every stage of production and promoting collective action among enterprises, Panipat can gradually transition toward carbon neutrality and global competitiveness.

The decarbonisation journey should follow a **phased approach**:

1. **Phase I:** Focus on resource efficiency improvements.
2. **Phase II:** Shift toward low-carbon materials and closed-loop production systems.
3. **Phase III:** Explore next-generation technologies for deep decarbonisation.

Collaboration at the cluster level will be vital - enabling cost-sharing, technological diffusion, and joint branding under a unified identity as a **“Green Textile Recycling Hub.”**

Figure 38: Roadmap for Transition for Panipat Cluster

PHASE	KEY ACTIONS	EXPECTED OUTCOMES
Efficiency & Renewable Integration 1	<ul style="list-style-type: none"> Conduct energy and resource audits to establish baselines. Retrofit outdated machinery with energy-efficient systems. Promote rooftop solar and biomass-based boilers. Pilot waste heat recovery and digital energy monitoring systems. Initiate basic training and awareness sessions for MSMEs. 	<ul style="list-style-type: none"> Reduction in energy intensity (kWh/kg of output) Increased share of renewable energy in total consumption Established emission and process efficiency baselines. Improved energy management awareness across units.
Circular and Low-Carbon Systems 2	<ul style="list-style-type: none"> Develop shared infrastructure (ETPs, ZLDs, testing labs, etc.) Adopt eco-design and upcycling practices. Implement digital traceability (QR codes, blockchain). Expand training for green and technical skills. Facilitate access to green finance through partnerships. 	<ul style="list-style-type: none"> Increasing no. of units adopting resource-efficient practices. Improved wastewater and chemical management. Enhanced traceability and ESG compliance. Increased green jobs and upskilling.
Advanced Decarbonisation & Innovation 3	<ul style="list-style-type: none"> Adoption of next-generation technologies Cluster-wide digital monitoring and energy data integration. Establishment of DREC Facilitate industry-academia R&D partnerships. Participation in carbon markets & branding as a “Green Hub.” 	<ul style="list-style-type: none"> Reduction in cluster-level emissions. Widespread integration of renewable and clean technologies. Functional DREC driving continuous improvement. Improved export readiness and competitiveness in global markets

15.5. Enabling a Just Transition: Scope for Formalisation, Skilling, and Social Protection

A critical enabler of Panipat’s low-carbon and circular transition is the integration and empowerment of its large informal workforce, which forms the backbone of the cluster’s recycling operations. The textile recycling industry in Panipat relies heavily on informal, often home-based and migrant labour, especially women workers engaged in sorting, tearing, stitching, and value-addition processes. While these workers drive much of the cluster’s productivity, they remain outside formal systems - lacking legal identity, job security, and access to basic social protections.

Ensuring a just and inclusive transition is therefore central to achieving the cluster’s vision of sustainable growth. Formalisation, skill development, and social protection not only improve worker livelihoods and dignity but also strengthen the cluster’s long-term competitiveness, resilience, and compliance with national and global ESG standards.

15.5.1. Scope for Formalisation

Integrating informal workers and enterprises into formal and sustainable systems is essential to enhance worker welfare, transparency, and productivity. Strengthening formal linkages will also improve traceability and compliance — both of which are increasingly demanded by global buyers.

Table 33: Areas of Intervention for Worker Formalisation

Area	Potential Interventions
Worker Documentation	Register all informal workers under the e-Shram portal and link Aadhaar for verified identification. Develop a digital worker database integrated with cluster HR systems. Conduct quarterly registration drives to cover 100% workforce by 2035.
Legal Identity at Work	Issue standardised worker ID cards recognised by cluster associations. Introduce simplified bilingual employment contracts outlining wages, safety norms, and grievance mechanisms. Monitor compliance through periodic audits.
Financial Inclusion	Facilitate opening of zero-balance bank accounts and link them with UPI for digital wage payments. Partner with local banks for on-site account camps. Ensure 100% wage digitalisation by 2035 and integrate with social protection schemes (ESI/EPFO).
Unit Formalisation	Support micro and home-based units to register under MSME/Udyam or cooperative models through helpdesks and training. Offer tax or compliance incentives for first-time registrants. Aim for 50%-unit formalisation by 2030.
Mobility Inclusion	Develop a mobile-based worker registry for tracking seasonal and migrant labour. Collaborate with NGOs for language-accessible outreach. Ensure portability of benefits (ID, wages, health) across units and sub-clusters.
Awareness & Rights	Conduct cluster-level campaigns on labour rights, gender equity, and occupational safety through digital media and community workshops. Introduce mandatory induction sessions on workplace safety for new hires.
Labour Linkages	Create a digital labour exchange platform connecting verified workers to registered units. Establish local labour hubs for transparent recruitment and skill-matching. Integrate with training centres to bridge demand-supply gaps.

These measures can help create a structured, transparent labour ecosystem while improving compliance with buyer codes and government regulations.

15.5.2. Training and Skill Development

As the cluster moves toward low-carbon and circular systems, upskilling of the workforce is vital for improving quality, productivity, and compliance. The focus should be on providing technical and soft skills that enable workers to adapt to modern machinery, cleaner production processes, and digital systems.

Table 34: Training and Skill Development Opportunities

Segment	Suggested Interventions
Sorting & Grading	Training on fibre identification, colour sorting, safety practices, and ergonomic handling.
Machine Operators	Skill development for tearing, carding, and spinning machines under <i>NSDC</i> and <i>PMKVY</i> modules.
Home-based Workers	Training on finishing, quality control, stitching upgrades, and basic digital literacy.
Supervisory Roles	Upskilling women workers for supervisory or quality-check roles to promote gender leadership.
Recognition of Prior Learning (RPL)	Certification for existing workers to formally recognise skills acquired through years of informal work.

Such skill-building efforts will enhance employability, enable role progression, and ensure that the benefits of cluster modernisation are shared equitably.

15.5.3. Social Protection Access

Improving access to **social protection schemes** will help address vulnerabilities among informal workers and strengthen overall workforce resilience. This includes ensuring basic welfare benefits such as health insurance, accident protection, childcare support, and housing.

Table 35: Areas for Social Protection Linkages

Area	Potential Measures
Health & Insurance	Link informal workers to <i>ESIC</i> , <i>PM-JAY</i> , and state welfare boards for health coverage.
Accident Protection	Promote affordable group insurance schemes, Pradhan Mantri Suraksha Bima Yojana (PMSBY), Ayushman Bharat – PM-JAY
Childcare & Maternity Support	Establish cluster-level crèche facilities or community childcare centres near work zones.
Access to Financial Tools	Facilitate financial inclusion through bank account opening, microcredit access, and training in digital payments.
Housing & Mobility	Coordinate with local government to provide low-cost rental housing or dormitory models for migrant workers.

By embedding social protection within the cluster framework, Panipat can reduce worker precarity, improve retention, and enhance compliance with global social standards.

15.5.4. Opportunities to Enhance Income and Working Conditions

Panipat's recycling cluster employs more than 4.5 lakh workers across formal and informal setups. While the sector contributes significantly to India's circular economy goals, many workers — especially those in sorting, stitching, and value-addition activities — continue to face low and insecure incomes, poor working conditions, and exclusion from welfare schemes. Strengthening worker livelihoods is not only a social imperative but also a pathway to enhancing cluster productivity, ESG performance, and export competitiveness.

Table 36: Income Enhancement and Working Conditions Improvement Opportunities

Opportunity	Intervention/Example	Expected Impact
Skill Upgradation	Training in machine operation, finishing, and quality control under <i>PMKVY</i> , <i>DDU-GKY</i> , or cluster-led skilling initiatives.	Higher wage eligibility and transition to semi-skilled roles.
Recognition of Prior Learning (RPL)	Certification for experienced sorters, stitchers, and packers.	Improves employability and bargaining power.
Micro-Entrepreneurship	Support SHG-based or women-led stitching and finishing units for home furnishings.	Creates local employment and supplementary income.
Cooperative Work Models	Promote worker cooperatives for value-added products such as eco-rugs and bags.	Ensures fair wage distribution and profit-sharing.
Incentivised Waste Segregation	Introduce pay-linked incentives in sorting and PET collection.	Enhances quality, productivity, and worker earnings.
Occupational Safety & Health (OSH)	Provide PPE kits, ergonomic tools, and improve ventilation in godowns and sheds.	Reduces health risks and enhances worker retention.
Model Sorting Sheds & Workspaces	Develop cluster-level facilities with sanitation, drinking water, and lighting.	Creates dignified and safer work environments.
Childcare & Welfare Support	Establish crèche facilities within large units or industrial zones.	Enables women's full-time participation and reduces absenteeism.

Opportunity	Intervention/Example	Expected Impact
Sanitation & Housing for Migrants	Support low-cost housing and mobile toilet facilities in collaboration with local authorities.	Improves living standards and workforce stability.
Fair Wage Practices	Promote awareness of wage codes and ensure transparent, digital piece-rate payments.	Reduces exploitation and income fluctuation.

15.6. Strengthening Panipat's Identity as a Sustainable and Low-Carbon Recycling Hub

Despite being India's largest textile recycling cluster, Panipat currently lacks a unified identity and branding strategy that reflects its contributions to circularity and low-carbon production. Branding efforts are fragmented across individual exporters or certification-compliant firms, resulting in limited visibility in global markets and an under-leveraged reputation as a leader in textile recycling.

There is a clear strategic opportunity to develop a **Sustainable Cluster Brand (SCB)** for Panipat that links its circular economy strengths with measurable sustainability outcomes. Such an initiative would enhance international competitiveness, attract green investment, and create a replicable model for other industrial clusters.

15.6.1. Scope for Branding Opportunities

Panipat's cluster-level branding remains underdeveloped and largely reactive. While individual firms promote their environmental compliance through certifications such as GRS or OEKO-TEX, these efforts are isolated and compliance-driven, rather than part of a coordinated branding narrative. The absence of a cluster-wide identity around sustainability and circularity limits Panipat's ability to differentiate itself in global markets increasingly driven by ESG standards.

- ▶ Promote Panipat as a **"Sustainable Circular Textile Cluster."**
- ▶ Introduce **brand-led carbon labelling, QR-based traceability, and Digital Product Passport (DPP)** integration across producers.
- ▶ Establish **cluster-wide branding and certification platforms**, supported by industry associations, government agencies, and policy incentives.

A consolidated brand identity centred on sustainability and circularity can reposition Panipat as a credible, forward-looking global supplier of low carbon recycled textiles.

15.6.2. Building Cluster-Wide Capacity for Sustainability Claims

Cluster-wide capacity for developing sustainability claims remains nascent due to technological, financial, and institutional constraints. There is a need to:

- ▶ Facilitate **brand-led development** of shared digital infrastructure such as **Digital Product Passports (DPP) or carbon accounting platforms**, with cluster-level participation to standardize sustainability reporting. This approach would enable MSMEs to align with buyer requirements while reducing individual compliance costs and ensuring consistency in data capture and disclosure.
- ▶ Conduct **capacity-building programmes** for small and medium units on topics such as fibre tracing, life-cycle assessment, and carbon accounting.
- ▶ Introduce **recognition and incentive mechanisms** for sustainability leadership to encourage early adopters and innovators within the cluster.

By building digital and institutional capacity, Panipat can move beyond certification-based compliance toward credible, data-backed sustainability branding that enhances trust among global buyers.

15.6.3. Potential Benefits of Developing a Sustainable Cluster Brand (SCB)

Establishing a Sustainable Cluster Brand (SCB) offers a transformative opportunity to reposition Panipat from a high-volume, low-margin producer to a globally recognised hub for circular, traceable, and low-carbon textiles. A cluster-level brand, backed by verifiable sustainability data, can unlock a wide range of economic, market, and institutional benefits.

- ▶ **Market Access and Premium Pricing:** A unified sustainability brand would enhance access to high-value export markets that prioritise ESG compliance and carbon transparency. Alignment with frameworks such as the EU Digital Product Passport (DPP) and GRS/ISO certifications can help Panipat's producers command premium prices and improve margins.
- ▶ **Buyer Retention and Long-Term Partnerships:** A collective brand built on traceability and responsible sourcing can strengthen buyer confidence, improve supplier rankings, and support longer-term contracts with global brands seeking credible, low-carbon partners. Accordingly, existing brands should lead the introduction of common infrastructure to reduce the compliance burden on individual enterprises.
- ▶ **Access to Finance and Policy Incentives:** An SCB would increase the cluster's eligibility for green finance, CSR co-funding, and policy support. Verified sustainability data would make MSMEs more attractive for concessional financing through programmes such as SIDBI or ESG-linked investment funds.
- ▶ **Cluster-Wide Upgradation and Process Improvement:** Shared branding encourages enterprises to upgrade technologies, align standards, and adopt best practices. Brand-led common sustainability systems reduce audit duplication, improve peer learning, and enable economies of scale in compliance and infrastructure.
- ▶ **Export Differentiation in a Competitive Market:** In a tightening regulatory landscape, an SCB would distinguish Panipat from low-cost competitors by combining affordability with verified sustainability, reinforcing its position as a reliable supplier of circular, traceable, and low-impact textiles.

Developing a Sustainable Cluster Brand (SCB) for Panipat represents a long-term investment in both market differentiation and institutional credibility. A well-designed SCB would not only elevate Panipat's global profile but also reinforce internal transformation across MSMEs, financing systems, and workforce practices.

With sustained institutional support and stakeholder collaboration, Panipat can emerge as **India's first "Green Recycling Hub"** — a flagship example of how collective branding, traceability, and circular economy principles can drive inclusive industrial decarbonisation.

A successful SCB would deliver multiple dividends: improved market access, increased income for compliant producers, enhanced ESG standing, and greater resilience in global textile value chains. Importantly, it could serve as a replicable model for sustainable cluster branding across other industrial hubs in India and the Global South.

16. Panipat Textile Recycling Cluster's Resource Mapping & Material Flow Analysis (MFA) – Existing Ecosystem

The Panipat textile cluster operates as a vast, interlinked system where discarded fabrics from around the world are transformed into new products through a tightly woven network of micro-enterprises, manufacturers, traders and exporters. What begins as bales of mixed textile waste arriving daily in the cluster's yards gradually moves through a sequence of activities that extract value at every possible stage. It is a new concept tried for the first time as part of DSR where its data may not be the financial truth but can be said as the "Baseline Assessment" or "Existing Ecosystem" of Panipat Textile Recycling Cluster.

Importance of such analysis: This type of analysis provides a valuable directional overview of the Panipat cluster's scale, its 20% margin of error and reliance on heuristic averages make it a "low-fidelity" model. Hence it is best used for introductory understanding rather than precise financial or operational auditing. Such depiction may be appropriate in view of the following:

- a) **Captures Interconnectivity:** The analysis successfully links disparate parts of the cluster—from global waste arrival to micro-units recovering zips and buttons. This "cradle-to-grave" view is essential for understanding circular economy models.
- b) **Quantifies the "Invisible" Economy:** Much of the recycling sector is informal. By estimating the turnover of transporters, segregators, and micro-reapers (e.g., the ₹658 Cr from accessory recovery), the document brings visibility to value-added activities that are often overlooked in traditional industrial census data.
- c) **Scalability Assessment:** It provides a clear volumetric flow (e.g., approx. 4,000 tones daily), which is crucial for infrastructure planning, such as waste management, logistics, and power requirements.

However, such analysis has its own limitations as under:

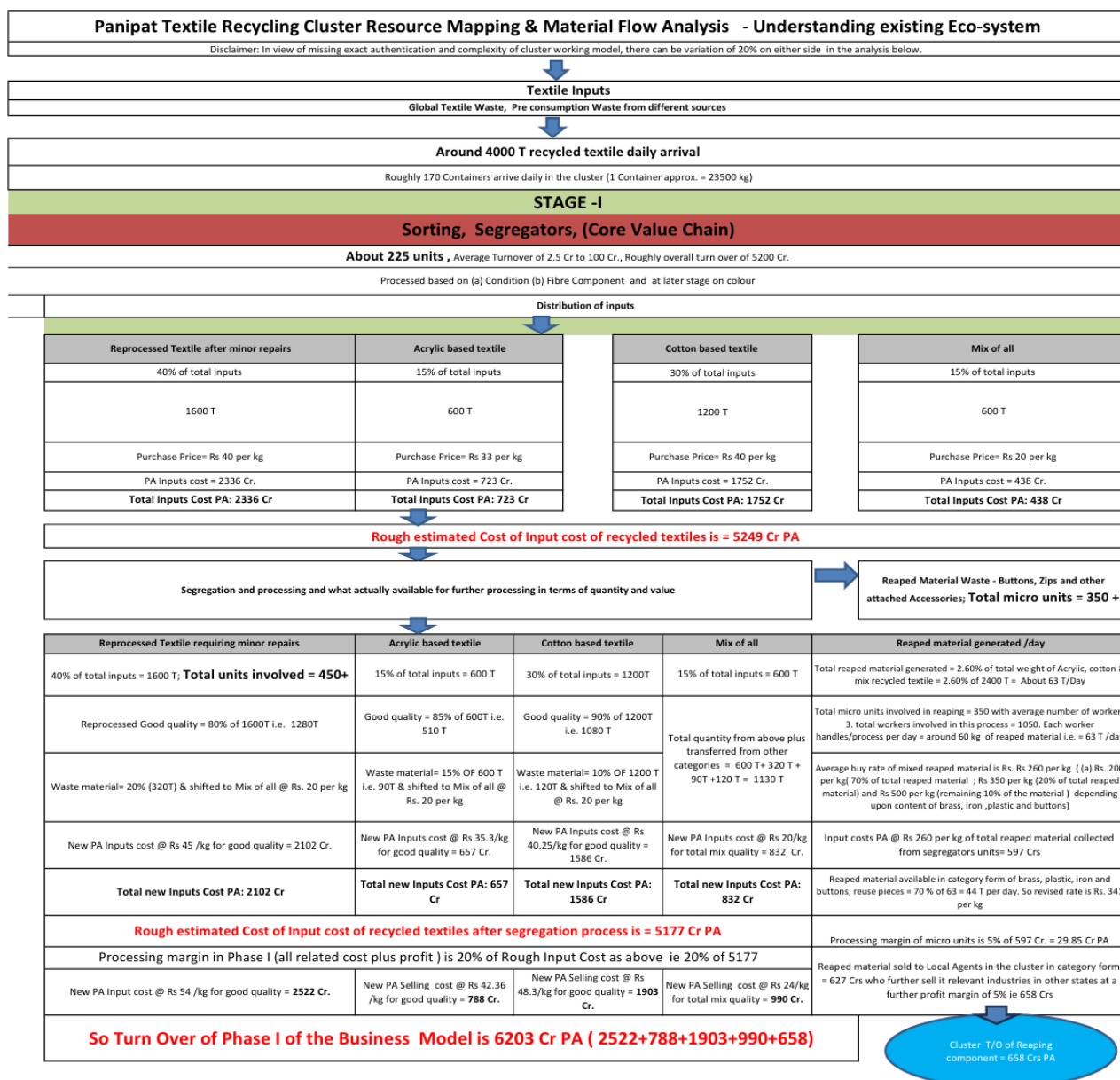
- a) **Lack of Empirical Authentication:** The figures are mostly based on heuristics, expert estimates, or informal observations rather than audited financial statements or official government data (like GST or tax filings).
- b) **Cascading Estimation Errors:** The analysis follows a linear flow where each subsequent figure depends on the previous estimate. If the initial figure is even slightly inaccurate, the error multiplies through the entire chain, leading to potentially significant deviations in the final turnover and profit figures.
- c) **Generalization of Wide Ranges:** Using a single "average" to represent businesses that are 40 times larger than others masks the diversity of the ecosystem and can lead to misleading conclusions about the "typical" business in the cluster.
- d) **Over-Simplified Profit Modeling:** Profitability in recycling depends heavily on operational efficiency, machinery age, labor costs, and energy prices. A "flat" average margin may ignore the reality that some units might be struggling while others are highly profitable.
- e) **Subjectivity and Approximation:** The frequent use of terms like "Roughly," "About," "Approx," and "i.e. Roughly" suggests that the analysis is a "back-of-the-envelope" estimation. While useful for a quick high-level understanding, it lacks the rigor required for capital-intensive investment decisions or formal policy formulation.
- f) **Aggregation Bias:** By treating the cluster as a uniform "Eco-system," the analysis may overlook Outliers, Niche Markets and Inter-dependencies.

This resource mapping & material flow analysis is not linear but layered, with multiple parallel markets operating simultaneously across processing after minor repairs, recycled fibre production, home

furnishings, carpets, industrial textiles and exports. Thousands of units participate in different phases of the chain, supported by extensive agent networks and market linkages. The result is an industrial environment where waste is continuously revalued, labour is intensively absorbed, and production capacity adapts to shifting domestic and global demand. This section provides a breakdown of this system tracing how material, labour and value move throughout the cluster.

16.1. Stage I: Waste Intake, Sorting, Segregation and Initial Value Capture

Figure 39: Resource Mapping & Material Flow Stage I: Waste Intake, Sorting, Segregation and Initial Value Capture



Stage I consists of all activities involved in receiving, opening, handling and classifying the large volumes of textile entering Panipat. This stage transforms an unorganised inflow into clearly segmented material streams that have defined commercial uses in later stages. The work spans bale opening, fibre identification, colour sorting, condition grading, accessory removal, material movement and early-stage price discovery. By the time materials exit Stage I, they have been reorganised into economically distinct categories including reprocessed textile after minor repairs, cotton-based inputs, acrylic-based inputs and mixed-material waste.

Daily Input Scale and Material Characteristics: Panipat handles approximately 4,000 tonnes of mixed textile waste per day, transported via approx. ~170 container loads or so with each container carrying around 22 tonnes of compressed waste. This represents a mix of:

- Post-consumer garments from international exporters
- Domestic household textiles (bedsheets, curtains, blankets)
- Pre-consumption garment factory waste (cut pieces, rejects)
- Industrial textile scraps
- Synthetic, acrylic, cotton-based and multi-fibre blends

The variation across fibre types, colours, fabric structures and contamination levels make Stage I a high-volume and high-complexity operation.

Structure and Economics of Sorting Units: Approximately **225 sorting and segregation units** operate across Panipat. They vary widely in scale, with annual turnover per unit ranging between INR 2.5 crore and INR 100 crore, culminating in an estimated **INR 6,200 crore** per year in combined turnover for the sorting segment alone.

Primary Material Segregation:

- ▶ **Cotton-Based Textiles (30% of inflow):** Approximately 1,200 tonnes/day of the incoming material is cotton-rich. Sorting determines which items are fit for fibre recovery and which must be diverted to mixed waste. Roughly 90% (about 1,080 tonnes/day) is classified as good-quality cotton waste suitable for spinning and yarn production, while 10% (120 tonnes/day) is too contaminated or heavily blended and is shifted into the mixed-material category. Cotton waste is purchased at INR 40.25 per kg, resulting in an annual input cost for good-quality cotton of **INR 1,586 crore**.
- ▶ **Acrylic-Based Textiles (15%):** Acrylic waste — roughly 600 tonnes/day — arrives mainly in the form of used blankets, jackets and acrylic knits. Around 85% (510 tonnes/day) is deemed good-quality material for acrylic yarn or shoddy blanket production. The remaining 90 tonnes/day move to mixed-material waste. Acrylic waste is purchased at INR 35.3 per kg, generating an annual input cost of INR 657 crore.
- ▶ **Mixed-Material Waste (15%):** About 600 tonnes/day directly enter the cluster as mixed waste. However, this category expands significantly as unsuitable fractions from other streams are added, and the total mixed-material volume reaches 1,130 tonnes/day. This includes poly-viscose blends, heavy knits, fleece, multi-fibre fabrics and textiles with inconsistent or degraded fibre profiles. Mixed waste is purchased at INR 20 per kg, leading to a direct annual input cost of INR 438 crore; after including transferred quantities, the total annual input cost reaches INR 832 crore.
- ▶ **Re-processed Textile (after minor repairs) Stream (40%):** The reprocessed textile category constitutes the largest single stream emerging from Stage I, amounting to 1,600 tonnes/day. These materials are diverted from recycling processes and reprocessed with minor repairs for absorption in the markets.

The reprocessed textile stream accounts for INR 2,522 crore annually in raw material value, making it a major contributor to Stage I revenue. These reprocessed textile feed markets both within India and through inter-state and export channels.

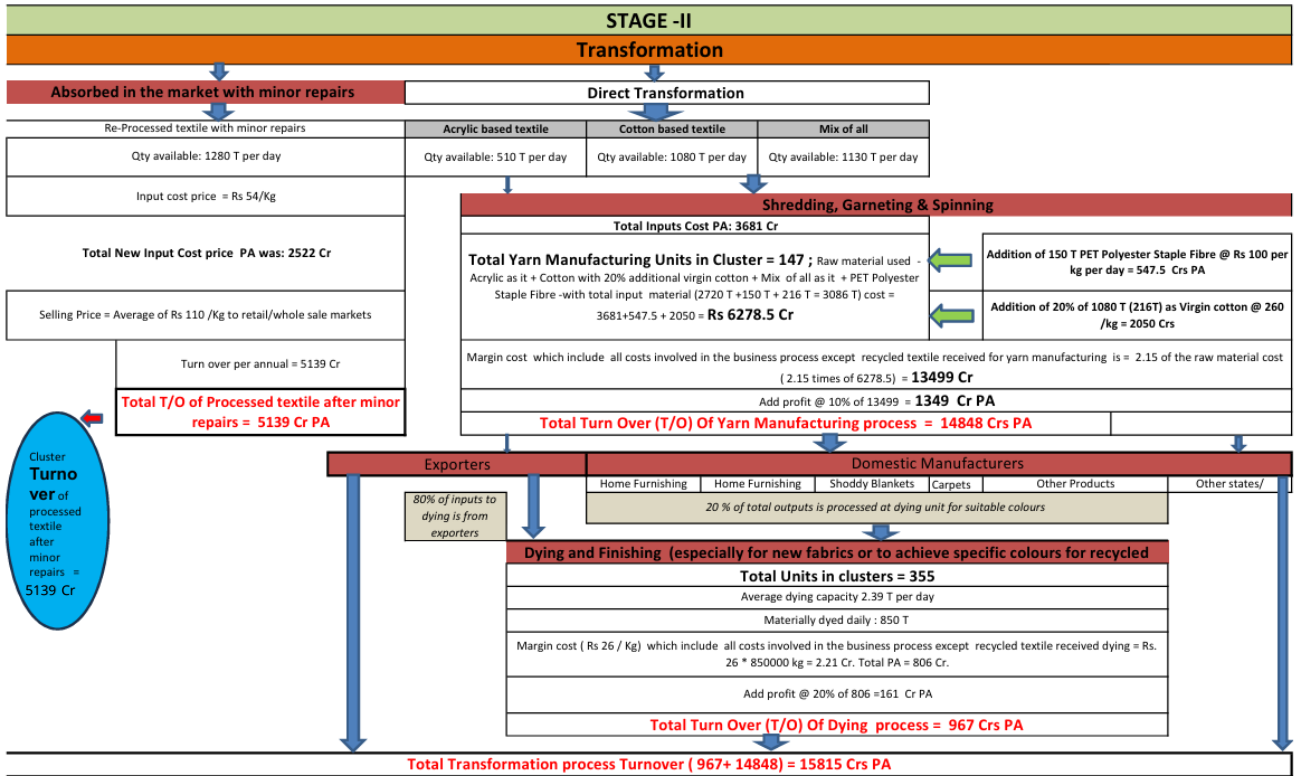
Accessory Removal (Reaping):

As part of sorting, garments undergo systematic removal of non-textile components such as buttons, zippers, rivets, hooks, elastics and trims. Although the document does not quantify the daily tonnage of accessories recovered, this activity creates a defined secondary material stream traded locally and beyond Panipat. Metal and plastic scraps from reaping are bought by specialised recyclers, adding another revenue source within Stage I operations.

When all types of textiles inputs are combined in the Stage I, handles INR 5,177 crore/year in textile input costs, a processing margin estimated at 20% of textile input costs. This results in an overall Stage I turnover of approximately **INR 6203 crore annually**,

16.2. Stage II: Fibre Preparation, Direct Sales, Spinning and Dyeing

Figure 40: Resource Mapping & Material Flow Stage II: Fibre Preparation, Direct Sales, Spinning and Dyeing



Stage II provides the industrial base of the Panipat cluster. It reorganises sorted waste from Stage I into spinnable fibres, recycled yarns and dyed materials. It ensures that recycled materials achieve the technical properties required for weaving and finishing in the next stage. It also generates a consistent supply of intermediate goods for domestic manufacturers and exporters. By the end of this stage, waste inputs have been substantially upgraded and made ready for their conversion into carpets, blankets, upholstery and home-furnishing items in the next stage of the cluster’s value chain.

Downstream Market of Limited Processing Textile Output:

A substantial portion is transferred to downstream channels followed by limited processing. The recorded quantities indicate daily movements of approximately 1280 tonnes materials. These flows are accounted for under Stage II material diversion, with an estimated annual value of INR 5,130 crore. This pathway reflects material circulation involving minimal reprocessing steps and diversion away from energy-intensive recycling processes.

Input Streams and Fibre Preparation:

Three primary textile streams feed into Stage II manufacturing: cotton-based waste, acrylic-based waste and mixed-material waste. Cotton-based inflow amounts to 1,080 tonnes per day, excluding unusable fractions diverted in Stage I. Acrylic-based waste available for processing stands at 510 tonnes per day, forming the base for acrylic yarn and blended shoddy yarns. Mixed-material inflow is 1,130 tonnes per day, consisting of blended fibres that require shredding and garneting before entering spinning lines.

Together, the total textile input processed in Stage II manufacturing is approximately 3086 tonnes per day.

Before spinning, sorted fibres undergo mechanical preparation. Cotton waste, acrylic waste and mixed materials are shredded, opened and blended to achieve fibre uniformity. This step ensures the fibre length, cleanliness and blend ratios required for downstream spinning. Mixed-material inputs are processed into lower-grade blends or incorporated into coarser yarn types. Cotton waste is prepared separately, with virgin cotton added at controlled ratios to stabilise strength. Acrylic waste is opened for use in acrylic yarns and shoddy blanket manufacturing. After preparation, the fibres are combined in specific ratios to meet yarn specifications, such as cotton waste is blended with 20% virgin cotton.

Spinning and Yarn Manufacturing:

Once fibres are prepared and blended, they enter the spinning mills. The raw-material cost of spinning, including all waste categories and virgin cotton, is INR 6,278 crore per year. The operational cost of spinning, which encompasses electricity, labour, equipment maintenance and overheads, is expressed as a 2.15× multiplier over raw materials. This results in INR 13,499 crore per year in processing costs. When combined, the raw-material cost, operating cost and 10% profit margin result in a total yarn-manufacturing turnover of **INR 14,848 crore per year**. This output supplies yarn for weaving, tufting, hosiery, non-woven production and various home-furnishing lines in the next stage.

Dyeing and Finishing Operations:

The cluster has 355 dyeing units, each operating at an average capacity of 2.39 tonnes per day, giving a total daily dye output of 850 tonnes. Most dyeing work – approximately 80% – comes from exporters, indicating that colour-standardisation is a prerequisite for export-quality goods. The total dyeing turnover comes to **INR 967 crore per year**.

Across spinning and dyeing, the entire transformation process creates combined turnover of INR 15,815 crore per year.

Stage III: Product Manufacturing from Recycled Textile

This stage encompasses all manufacturing activities in the Panipat textile cluster that convert yarn, polyester staple fibre, recycled fibres and mixed materials into finished textile products. This stage brings together multiple product categories, including virgin polyester products, exporter-driven outputs, high-end domestic home furnishing items and normal domestic home-furnishing products. The manufacturing base at this stage is extensive and includes spinning-derived materials from Stage II, virgin inputs sourced from external suppliers and recycled textile fibres on which the cluster's operations heavily depend.

This category consists of home-furnishing and filled-product lines such as pillows, cushions, quilts, duvets, mattresses, soft toys, fleece fabrics, upholstery fabrics, polyester velvet and non-woven materials. The cluster has 250 units dedicated to manufacturing virgin polyester-based products. The average production capacity of each unit is 12 tonnes per day, resulting in a combined cluster capacity of 3,000 tonnes per day. Virgin polyester is the principal raw material, priced at INR 100/kg, and the total polyester used per annum is valued at INR 10,950 crore. After adding raw-material cost, margin cost and profit (10%), the total turnover of virgin polyester products in the cluster is **INR 22,168 crore per year**.

Figure 41: Resource Mapping & Material Flow Stage III: Product Manufacturing from Recycled Textile

STAGE -III				
Product Manufacturing (The Output)				
Virgin Polyester Products	Exporters	Domestic Home Furnishing (High End Products)	Normal Domestic Home Furnishing and other Products	Recycled yarn directly sold in other states
Home Furnishings and Filled Products - Pillows and Cushions, Quilts and Duvelts, Mattresses, Soft Toys; Fleece Fabric; Upholstery Fabric; Polyester Velvet; Non-Woven Fabrics and Felt; Industrial Felt; Interlining; Apparel	Similar to domestic except as per the requirements of foreign buyers	Domestic Products: Blankets, Carpets and Rugs, Floor Mats and Doormats, Bedsheets and Bed Linen, Cushions and Cushion Covers, Curtains and Drapes, Upholstery Fabrics, Industrial Wipes and Cleaning Cloths, Filling Material for mattresses/quilts/pillows and soft toys		
Total Units = 250 +	Total units = 3300 + (a) Only Exporters =2000 (b) Exporter/Domestic both = 800 (c) Indirectly/Domestic =500	Total Units = 100 to 150 +	Total Units = 1150 with T/O from 0.5 to 50 Cr PA along with Numerous small-scale value (around 600+ units) addition enterprises working from local area	20% of the total Recycled yarn (20% of 14848) produced in the cluster = 2969 Crs PA
Average Production per unit per day = 12 T	Details of raw materials used/PA are as under:	Details of raw materials used/PA are as under:	Details of raw materials used/PA are as under:	
Total Production capacity of all per day = 3000 T	(a) Recycled textile - 35% of total raw material cost: 4200 Crs	(a) Polyester - 68% of the total raw material : 4216 Cr	(a) Warp Thread (Mostly Virgin Polyester or PET thread) = 12780 Cr	
Cost of virgin Polyester = Rs 100/kg	(b) Virgin Cotton - 40% of total raw material cost : 4800 Crs	(b) Virgin Cotton - 10% of total RM : 620 Cr	(b) Weft Thread (Mostly Recycled thread/ yarn) = 8520 Cr (c) PET Polyester Staple Fibre = 200 Crs	
Total polyester used /PA = Rs. 10950 Cr	(c) Micro Polyester - 20% of total RM: 2400 Crs (d) PET Polyester Staple Fibre - 5% of total RM :600 Crs Total cost of raw materials used = 12000 Crs	(C) P. Viscos -10% of total RM: 620 Cr (d) P. Cotton -10% of total RM : 620 Cr Recycled textile - 2% of the total RM : 124 Cr Total cost of raw materials used = 6200 Cr	(e) Total cost of raw material /PA = Rs. 21500 Cr	
Margin cost of production which include all costs involved in the business process except raw material as above and w/o profit margin is = 1.8 of the raw material cost i.e. 19710 Cr	Margin cost of production which include all costs involved in the business process except raw materials as above and w/o profit margin is = 2.15 of the raw material (as above) cost i.e. 25800 Cr	Margin cost of production which include all costs involved in the business process except raw materials as above and w/o profit margin is = 2.3 of the raw material (as above) cost i.e. 14260 Cr	Margin cost of production which include all costs involved in the business process except raw materials as above and w/o profit margin is = 1.8 of the raw material (as above) cost i.e. 38700 Cr	
About 700 Nos vendors/agents are contributing in value chain of Raw Material Suppliers i.e. Spinners, virgin polyester suppliers & other materials used in manufacturing processes and their actual users in manufacturing, these vendors / agents are working on the profit margins @ 2 to 2.5 % of raw material cost + production cost				
Production cost + Vendors/agents margin (19710 + 443) = 20153 Cr	Production cost + Vendors/agents margin (25800 + 580) = 26380 Cr	Production cost + Vendors/agents margin (14260 + 320) = 14580 Cr	Production cost + Vendors/agents margin (38700 + 870.75) = 39570 Cr	
Profit Margin @ 10% of above = 2015 Cr.	Profit Margin @ 10% of above = 2638 Cr.	Profit Margin @ 10% of above = 1458 Cr.	Profit Margin @ 20% of above = 7914 Cr.	
Total Turn Over (T/O) of Virgin Polyester products in cluster = 22168 Cr PA (20153+2015)	Total Turn Over (T/O) of Exporters in the cluster = 29018 Cr PA (26380+2638)	Total Turn Over (T/O) of Domestic Home Furnishing (High End) in the cluster = 16038 Cr PA (14580+1458)	Total Turn Over (T/O) of Domestic Home Furnishing (other than high end) in the cluster = 47484 Cr PA (39570+7914)	

STAGE -IV					
Distribution and Markets (The Sales Channels)					
Virgin Polyester Products		Domestic Home Furnishing (High End Products and Normal Products)		Exporters	
Sold Direct to its agents across the country (90% of total output)	Sold to agents /agency in the local city market which further sell it to across country local market	Sold to agents /agency in the local city market which further sell it to across country local market	Sold Direct to its agents across the country (85% of total output)	Sold to Export market	Rejected/Surplus material handling units (We do not have the value of total amount spent on purchase of 25000T since that has already been taken care at various level above. Here we are only considering their profit margins)
	Total Number of agents/vendors in the local market - cluster = 1000+ Nos % of turnover component being handled by them of virgin polyester products is 10% and that of Domestic Home Furnishing is 15 % i.e. Roughly 2216 Crores (10% of 22168 Cr) of Virgin Polyester products and 9528 Crores (15% Of 63522) of Domestic Products - with total of Rs = 11744 Cr PA Profit Margin @ 10% of above = 1761 Crs Total Turn Over PA = 13505 Cr				(a) Rejected /Surplus material sold to local warehouse agents in the cluster (b) Total Number of such units - 70 (c) Qty of surplus/rejected material handle by each such unit = 30 T PM (d) Total Quantity handled by all units PA = 25000 T (e) Profit margin is product wise and when reflected to Kg value may be between Rs 40 to 80 i.e. Ave Rs = 60 per kg = 150 Cr
Cluster T/O of this component = 19951 Cr PA	Cluster T/O of this (Virgin Polyester) component = 2549 Crs PA	Cluster T/O of this (domestic products) component = 10957 Crs PA	Cluster T/O of this component = 53994 Cr PA	Cluster T/O of this component = 29018 Cr PA	Cluster T/O of this component = 150 Cr PA
CLUSTER TURN OVER PA = 658 (Reapers) + 5139 (Processed textile with minor repairs) + 19951 (Virgin Polyester) + 2549 (Virgin Polyester agents) + 10957 (Domestic agents) + 53994 (Domestic) + 29018 (Export) + 2969 (Direct yarn sale) + 150 (Surplus/rejected) = Rs 125385 Crs					

Export Manufacturing (Exporters):

Stage III includes a large exporter segment producing goods tailored to the requirements of foreign buyers. The file identifies 3,300 exporting or export-linked units, consisting of:

- 2,000 pure exporters,
- 800 units serving both export and domestic markets, and
- 500 indirectly linked domestic-export units.

This category relies on a combination of raw materials: 35% recycled textile waste costing INR 4,200 crore per annum, 20% micro polyester costing INR 2,400 crore, 5% PET, costing INR 600 crore and 40% virgin cotton costing INR 4800 crore. Combined, the total raw-material cost for export-oriented manufacturing is INR 12,000 crore per year. Adding the raw-material cost, margin cost and profit (10%) gives a total exporter turnover of **INR 29,018 crore per year**.

Domestic Home Furnishing (High-End Products):

This category includes premium furnishings such as high-quality blankets, carpets, rugs, bed linen, curtains, upholstery fabrics, industrial wipes, fleece fabrics, non-woven felt, interlining and filled home products. There are **~150 units** operating in this high-end domestic segment. Annual raw-material use is mixed:

- Polyester: 68% of total raw materials, valued at INR 4,216 crore,
- Virgin cotton: 10% valued at INR 620 crore,
- P. Viscose: 10% valued at INR 620 crore,
- P. Cotton: 10% valued at INR 620 crore,
- Recycled textile: 2% valued at INR 124 crore.

The total turnover from these products is INR 16,038 crore per year.

Normal Domestic Home Furnishing and Other Products:

This is the largest domestic segment, with **1,150 units** producing blankets, carpets, rugs, floor mats, doormats, bedsheets, cushion covers, curtains, upholstery fabrics, filling materials and cleaning cloths. There are also numerous small-scale value-addition units operating informally or from residential areas. Annual raw-material use is defined in two components:

- Warp thread, mostly virgin polyester or PET thread, costing INR 12,780 crore,
- Weft thread, mostly recycled yarn, costing INR 8,520 crore.

Together, raw-material usage totals INR 21,500 crore per year. The resulting total turnover of this segment is INR 47,484 crore per year.

This entire stage handles a total output value of **INR 114,708 crore per year**.

The Resource Mapping & Material Flow Analysis (MFA) – Existing Ecosystem of the Panipat cluster demonstrates a highly structured progression in which each stage builds operationally on the one before it. Taken together, these stages illustrate how the cluster maintains continuity in material movement, cost formation and value addition. Inputs enter as mixed waste and exit as a diversified portfolio of goods without significant material loss between stages. The business flow also highlights how different material types—cotton, acrylic, blends, PET and virgin inputs—are integrated at specific points to achieve the necessary quality and volume for downstream production. The flows across the stages reflect this same progression, showing how input costs, processing margins and product-based returns align to sustain operations at scale.

The combined effect of these stages is a system in which resource conversion is organised, predictable and capacity driven. Each component operates with clarity on its function, throughput and output. By the end of the three-stage process, the cluster has channelled all viable fractions into productive uses, established the cost and value structure for the next cycle of activity and created a steady supply of goods for domestic and export markets. This integrated movement from waste intake to final product defines the operational backbone of Panipat's textile economy and is estimated approx. **INR 1,25,000 crores** per annum. This integrated analysis moves the understanding of the cluster from anecdotal stories to empirical, data-driven engineering and economics, turning it into a measurable system that can be optimized.

Annexure-I

List of Important Textile Certifications and Their Description:

S. No.	Standard / Certification	What it Explains / Scope	Why it is Important	Issuing / Governing Organization	Applicable To (Who Should Use)
1	GRS (Global Recycled Standard)	Verifies recycled content and tracks it through the supply chain, including social, environmental, and chemical practices.	Ensures credibility of recycled claims and supports circular economy.	Textile Exchange	Recyclers, spinners, fabric manufacturers, garment units
2	RCS (Recycled Claim Standard)	Confirms presence and amount of recycled material in a product.	Simple verification of recycled input without process requirements.	Textile Exchange	Manufacturers and brands using recycled materials
3	GOTS (Global Organic Textile Standard)	Covers organic fiber processing with environmental and social criteria.	Ensures organic integrity from farm to finished product.	Global Standard gGmbH	Organic textile producers, exporters, brands
4	OCS (Organic Content Standard)	Verifies organic material content in textile products.	Builds transparency in organic raw material usage.	Textile Exchange	Spinners, weavers, traders, brands
5	OEKO-TEX® Standard 100	Tests textiles for harmful substances.	Ensures consumer safety and chemical compliance.	OEKO-TEX® Association	All textile and apparel manufacturers
6	ISO 9001 (Quality Management)	Defines quality management system requirements.	Improves product consistency and customer satisfaction.	International Organization for Standardization (ISO)	All manufacturing and service organizations
7	ISO 14001 (Environmental Management)	Framework for managing environmental responsibilities.	Reduces environmental impact and regulatory risks.	International Organization for Standardization (ISO)	Manufacturing units, processors, exporters
8	ZDHC (Zero Discharge of Hazardous Chemicals)	Eliminates hazardous chemicals from textile supply chains.	Supports chemical compliance and safer production.	ZDHC Foundation	Dyeing, printing, processing units
9	OHSAS 18001 / ISO 45001	Occupational health and safety management system.	Reduces workplace risks and improves worker safety.	ISO	Factories, processing units, MSMEs

Annexure- II

References & their Sources:

References

Types and No of Industries

Cluster Turnover INR 1,25,000 crore & Cluster exports INR 29,000 Crore

Around 6400 MSMEs

Around 170 containers of approx. 22 tonne daily/4000 tonne textile waste/14.50 lakh tonnes yearly Textile waste Inflow

About 4.50 lakhs workers

30 Industry Associations/BMOs

Yarn Production 08 lakh tonnes/Year in the cluster

Process segment-wise distribution of MSMEs with Turnover

Turnover distribution across textile segment

Estimated Employment Spread Across value chain

Price of Material (Waste, reaped material, yarn, Fabric, finished goods etc.)

Category-wise production and turnover

Electricity consumption and emission per unit of material production

Value-added in each process of the cluster product

Underutilised waste percentage

3,000-7,200 tonnes/annum of fibre dust

No of Solar Installed

Cumulative investment in the cluster

Sources

DSR Primary Survey

DSR Primary Survey's based calculations

DSR Primary Survey

DSR Primary Survey & Material flow analysis's calculations

DSR Primary Survey

DSR Primary Survey

Material Flow analysis calculations

DSR Primary Survey

DSR Primary Survey

DSR Primary Survey

DSR Primary Survey

DSR Primary Survey & Material flow analysis's calculations

DSR Primary Survey's based calculations

DSR Primary Survey

DSR Primary Survey's based calculations

DSR Primary Survey's based calculations

DSR Primary Survey

DSR Primary Survey



About the Study

The Panipat Textile Recycling Cluster is a global hub for recycled yarn and textiles. This study assesses sustainability readiness and outlines pathways for environmental, social, and economic transition.

Prepared by Foundation for MSME Clusters (FMC)

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