



**Green Indian
Financial System**

Annual Research Report

Examining Climate Risks and Unlocking Green Finance in Ludhiana's Knitwear Cluster





Green Indian Financial System

initiative

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Executive Summary

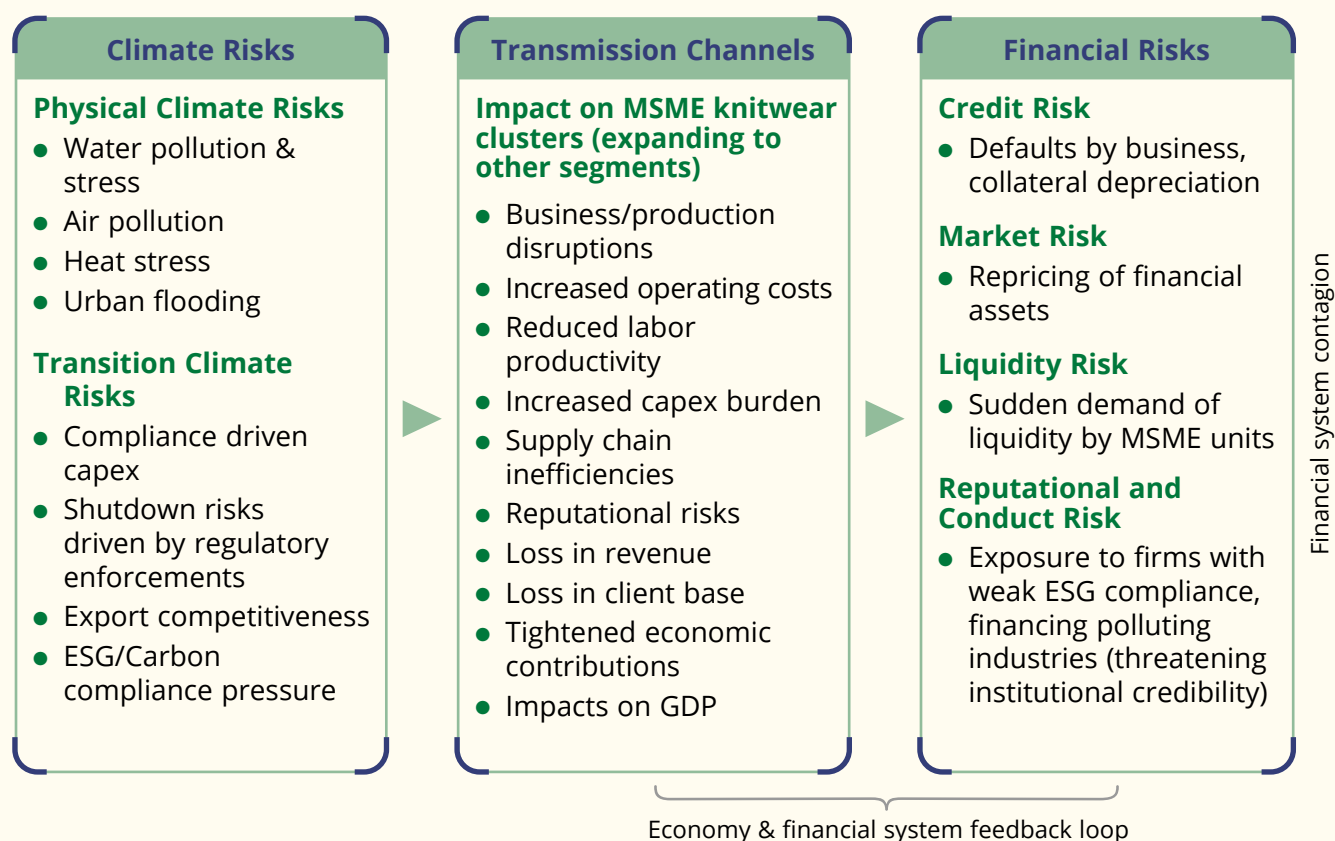
Ludhiana's knitwear cluster represents a core node in India's textile sector, driving domestic woolen production, exports, and micro, small, and medium enterprises (MSMEs)-led employment. The cluster accounts for approximately 95% of India's domestic woolen knitwear production (Punjab Bureau of Industries, 2019), supports direct and indirect employment of over 500,000 people, and operates an MSME-dominated ecosystem of 10,000-15,000 textile units¹. Within this ecosystem, the Small Industries Development Bank of India (SIDBI) Ludhiana branch holds 30-40% of its portfolio in the knitwear segment² (based on stakeholder consultation). Moreover, Punjab's textile and apparel industry carries an active credit exposure of USD 900 million to USD 920 million (The Tribune 2021). As a result, the cluster is exposed to two reinforcing forces: (a) a domestic financial architecture that is increasingly being oriented towards climate-aligned capital and (b) a tightening climate and regulatory environment that is reshaping the basis of competition for textile-based MSMEs.



Image Courtesy: Magnific

¹ Textile Economy, Focus Group Discussion, FMC, 2026) and The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, Focus Group Discussion, FMC, 2026)

² Stakeholder consultation (SIDBI)



Climate risks are becoming a core driver of financial risk for financial institutions lending into this cluster. Physical risks (water stress, air pollution, heat stress, and urban flooding) are transmitted into lender portfolios through credit, portfolio, liquidity, operational, and reputational risk channels. Transition risks, on the other hand, are also material and accelerating, driven by hazard-specific regulation, domestic disclosure, and capital allocation frameworks, and international market measures such as sustainability standards and carbon-related trade requirements. These factors increasingly influence both access to finance and continued participation in global value chains.

For banks and NBFCs, these risks are not isolated to individual borrowers but are highly correlated across firms operating within the same geography, supply chains, and production systems. As a result, climate-

related vulnerabilities can accumulate at the cluster level, creating systemic risks for lenders with concentrated exposure to the region. Addressing these challenges therefore requires a cluster-level approach. Many of the barriers to climate risks resilience in Ludhiana, including shared infrastructure deficits, common environmental externalities, information asymmetries, and limited technical capacity, cannot be effectively addressed through fragmented, firm-by-firm interventions. A coordinated cluster-based approach is therefore, better suited to aggregate demand, reduce transaction costs, standardize investments, and create a pipeline of bankable projects capable of attracting finance at scale.

However, the existing ecosystem is insufficient to deliver a coordinated, cluster-level response. India operates a well-developed set of MSME and textile-sector

schemes (including CGTMSE, CGSSD, SIDBI 4E, PRSF, ZED, and ATUFS). While these instruments provide important support, they share three structural gaps.

First, they are designed as sector-agnostic, firm-by-firm interventions. Each scheme targets individual enterprises in isolation. There is no mechanism to coordinate action, aggregate demand, or address shared infrastructure challenges across an interconnected cluster. This is a critical limitation in the context of Ludhiana. The climate risks facing knitwear MSMEs do not originate at the firm level, they stem from conditions that are common to all units operating within the cluster. For example, groundwater sources are uniformly overexploited across all 14 blocks in the district, drainage and effluent systems are inadequate at the cluster level, not just within individual units and buyer sustainability requirements apply uniformly across entire supplier bases. When regulatory tightening on groundwater extraction or industrial emissions occurs, it does not affect one firm. It affects every firm drawing on the same resource base at the same time. When flooding disrupts the Sutlej corridor, it does not shut down a single production unit. It shuts down an entire geography. Climate stress in Ludhiana is correlated and systemic. It requires a response mechanism that operates at the same level.

A cluster-level approach addresses this in ways that firm-level schemes cannot. It enables shared infrastructure investment. It aggregates small and dispersed MSME demand into viable project pipelines. It reduces per-unit transaction costs that make individual green investments uneconomical for smaller firms. It creates the standardized data and reporting frameworks that financial institutions need to lend at scale. State-

level or sector-level frameworks serve as important policy enablers but operate at too broad a level of aggregation. They cannot resolve the specific infrastructure deficits, technology gaps, and financing constraints that define the Ludhiana cluster's transition challenge.

Second, existing schemes do not incorporate physical or transition risk into their financing structures. Credit guarantees, concessional lines, and subsidy frameworks are calibrated to conventional MSME investment needs. They are not designed for firms facing water regulation deadlines, emissions compliance requirements, carbon-linked trade measures, or evolving buyer sustainability standards. As a result, financial institutions have limited tools to price or manage climate-related credit risk within their MSME portfolios. MSMEs, in turn, have limited incentive or structured support to undertake transition investments ahead of regulatory compulsion.

Third, technical assistance and financing are delivered through separate programs with no structural linkage between them. Project preparation, technology audits, and investment facilitation are not connected to financing channels in a way that converts identified opportunities into bankable proposals. This gap is particularly binding for MSMEs, which lack the internal capacity to bridge it on their own.

The resulting market barriers, including high upfront capital expenditure requirements, perceived technological risk, MSME prioritization of working capital over green investment, and weak ecosystem coordination, leave a financing gap that is structurally embedded and will widen as transition pressures intensify.

Global experience from peer textile clusters in Bangladesh, Vietnam, Cambodia, and

India demonstrates that effective transition pathways combine aggregating MSME demand into bankable pipelines, integrating finance with technical assistance, and standardizing investments and disclosures.

Based on these existing gaps and best practices, the report proposes three recommendations to translate these features into a Ludhiana-specific architecture.



- **Pillar 1: Cluster Green Transformation and Resilience Facility** proposes the establishment of a cluster-anchored financing architecture that intends to combine concessional refinance, risk-sharing, and embedded data and standards, anchored by NABARD or SIDBI and capitalized through India's emerging green capital pool and international climate finance.
- **Pillar 2: Project Pipeline Development and Investment Facilitation** proposes the operational mechanism that converts dispersed MSME demand into investment-ready pipelines through cluster-wide audits, buyer and brand engagement, and direct integration with financial institutions
- **Pillar 3: Awareness, Capacity Building, and Coordination** recommends the enabling ecosystem layer through MSME outreach, FI capacity-building, and stakeholder coordination, leveraging existing business membership organizations, sector training institutions, and regulatory anchors.

Each pillar intends to be implementable within existing Indian institutional structures. For financial institutions, the proposed architecture shifts climate risk from an external concern into an integrated dimension of portfolio management. For policymakers, the cluster-level model provides a template that can be replicated across other MSME-dominated industrial clusters facing similar climate risk exposures. For Ludhiana's MSMEs, it provides a credible pathway to access matched finance, comply with emerging disclosure expectations, and retain competitiveness in global value chains that are increasingly tied to climate performance.

The Ludhiana cluster presents a strong case for such an approach. A structured, cluster-specific transition pathway can de-risk financial institutions' portfolios, strengthen MSMEs' competitiveness, and unlock the scale of capital required for the transition. This report aims to create a replicable model for other MSME clusters in India where climate exposure and financial gaps converge.



Image Courtesy:

01

INTRODUCTION

1.1 | Economic Significance of India's Textile Sector

India's textile and apparel sector is a core pillar of the Indian economy. It contributes ~2.3% to India's Gross Domestic Product (GDP), 13% to industrial production, and 12% to total exports (Press Information Bureau, 2025). The sector is also the country's second-largest employer after agriculture. It provides direct employment to around ~45 million people and indirectly supports over 100 million livelihoods, especially among women and rural populations (Ministry of Textiles, 2025). India produces nearly 22,000 million garment pieces annually, reflecting the scale of its manufacturing ecosystem. Approximately 80% of production is concentrated in MSME-based clusters, making the sector highly decentralized and

regionally distributed (Press Information Bureau, 2025).

India's textile and apparel market is currently valued at ~USD 174 billion and is projected to reach USD 350 billion by 2030 (Press Information Bureau, 2025). In FY 2023-24, textile and apparel exports totaled USD 34.4 billion. Apparel contributed 42% of exports, followed by raw and semi-finished materials (34%) and non-apparel finished goods (30%) (Press Information Bureau, 2025). Export growth has remained moderate, increasing from USD 36.65 billion in 2022-23 to USD 37.75 billion in 2024-25 (Press Information Bureau, 2025a).

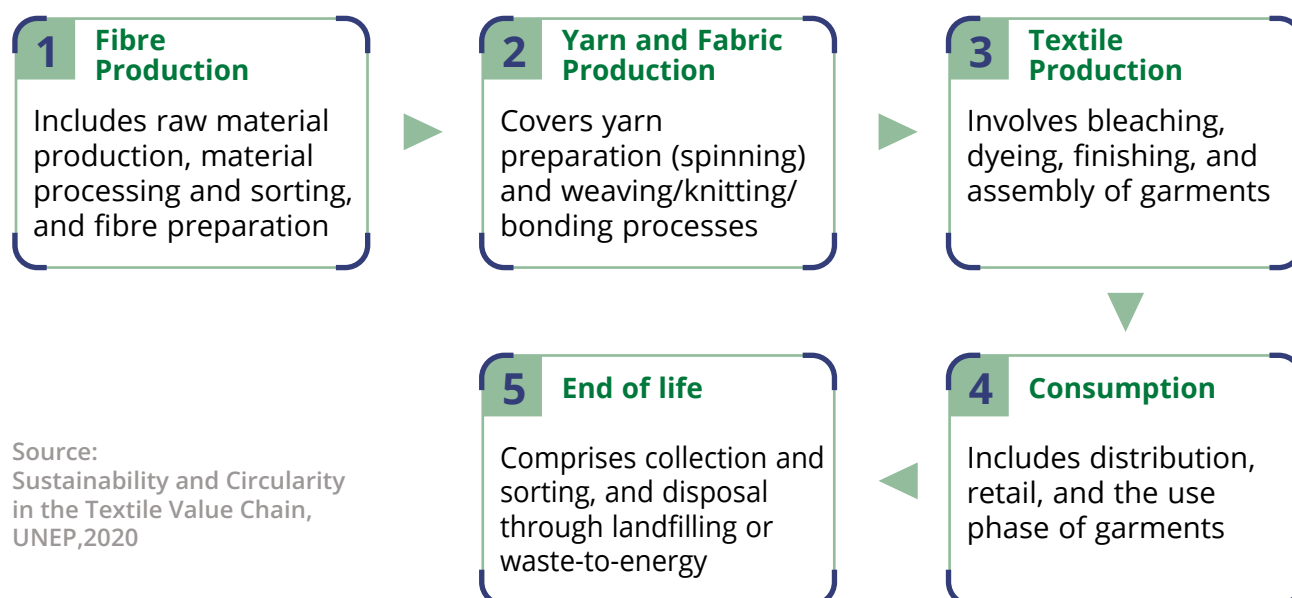
Table 1 Economic Profile of the Indian Textile Sector

Dimension	Key Insights
• Contribution to GDP	~2.3% of India's Gross Domestic Product
• Industrial Output	Contributes 13% to total industrial production
• Export Share	Accounts for 12% of India's total exports
• Employment Generation	~45 million direct jobs; over 100 million livelihoods indirectly (second-largest employer after agriculture)
• Market Size	~USD 174 billion (current domestic textile and apparel market)
• Growth Projection	Expected to reach USD 350 billion by 2030
• Production Scale	22,000 million garments produced annually
• MSME Dominance	80% of production capacity concentrated in MSME clusters
• Export Value (FY 2024-25)	USD 37.75 billion in textile and apparel exports
• Export Composition	Apparel (42%), raw & semi-finished materials (34%), finished non-apparel goods (30%)
• Recent Export Growth	7% growth (April–December 2024, YoY)
• Global Positioning	5th largest textile market globally
• Target Growth Rate	The government aims for 15–20% annual growth in the coming years
• Industry Structure	Cluster-based
• Economic Role of Clusters	Act as hubs of production, employment, ancillary industries, and financial linkages

Sources: Based on secondary literature and data sources referenced in this section

The textile value chain comprises five stages, from fiber production to end-of-life processes, as illustrated below. These stages provide a perspective on the lifecycle processes in the textile sector and will inform the discussion in this paper.

Figure 1 Production stages across the textile value chain



Source:
Sustainability and Circularity
in the Textile Value Chain,
UNEP, 2020

Within India's broader textile and apparel sector, knitwear represents a distinct and significant sub-segment,³ with Ludhiana emerging as a critical node in the country's textile landscape. The cluster accounts for nearly 95% of India's domestic woolen knitwear production and meets a substantial share of national apparel demand (Punjab Bureau of Industries, 2019). Over time, Ludhiana has evolved into one of Asia's most concentrated textile manufacturing ecosystems, particularly known for hosiery and woolen knitwear. Beyond its production significance, the cluster also plays a major role in regional economic development by supporting a dense network of enterprises and providing direct and indirect

employment to over 5 lakh people (Punjab Bureau of Industries, 2019).

The cluster also includes dedicated textile and apparel infrastructure, including the Ludhiana Integrated Textile Park, Punjab Apparel Park, Trident, and Rhythm Apparel Park. However, stakeholder consultations indicated that several of these parks currently face low occupancy levels due to unit closures and firm relocations.

The economic significance of the Ludhiana knitwear cluster is reflected across multiple dimensions, including its industrial structure, production scale, export ecosystem, financial linkages, and credit exposure. The table below provides an overview of these key characteristics.

³ However, due to limited availability of disaggregated data specific to knitwear, this analysis draws selectively on insights from the wider textile sector to contextualize production patterns, risk exposure, and financing dynamics, while maintaining a focused lens on Ludhiana.

Table 2 Overview of the Ludhiana Knitwear Cluster

Dimension	Key Insights
• Contribution to GDP	~2.3% of India's Gross Domestic Product
• Annual Turnover	Estimated at USD 1.7-1.8 billion (The Financial World 2020)
• Domestic Market Share	Meets 80% of India's woollen garment demand (TheFinancialWorld 2020)
• Export Value	USD 24 million worth of exports annually (direct exports) (TheFinancialWorld 2020)
• Number of Units	10,000–15,000 textile units; 7,000–8,000 engaged in apparel manufacturing (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, Focus Group Discussion, FMC, 2026)
• Industrial Ecosystem	Dense network of BMOs, including Knitwear Club (1,500 members), APPEAL, and other associations (Knitwear & Apparel Manufacturers), (Apparel Export Promotion Council)
• Spinning Capacity	188 units producing 3.6 lakh tons of fiber annually (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, Focus Group Discussion, FMC, 2026)
• Knitted Fabric Units	4,400 units (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, Focus Group Discussion, FMC, 2026)
• Processing Units	400 units involved in finishing and processing (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, Focus Group Discussion, FMC, 2026)
• Garmenting Units	5,600 units (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, Focus Group Discussion, FMC, 2026)
• Employment (Value Chain)	2.2 lakh workers across different stages of production (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, Focus Group Discussion, FMC, 2026)
• Export Ecosystem	800–1,200 direct exporters; an additional 25–30% indirect exporters in the value chain (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, FMC, 2026)

Dimension	Key Insights
Global Linkages	Supplies to brands such as Adidas, GAP, and Marks & Spencer (The Circular Loom, Ludhiana's Strategic Transition toward Waste-to-Wealth Textile Economy, FMC, 2026)
Loan Portfolio Exposure of the Small Industries Development Bank of India's (SIDBI) Ludhiana Branch to the Knitwear Cluster	30–40% (Stakeholder consultation with SIDBI)
Financial Exposure of the Punjab-based textile and apparel industry	USD 900 million to USD 920 million credit exposure; 15,000 active loan accounts (The Tribune 2021)
Regional Credit Concentration	The Ludhiana–Jalandhar–Amritsar region accounts for ~USD 900 million (The Tribune 2021)

Sources: As cited in the table



1.2 | Climate-Related Financial Risks and Transmission Channels

India's climate policy and financial architecture are evolving in tandem. The country's updated Nationally Determined Contributions (NDCs) include emissions-intensity reduction and the expansion of non-fossil energy capacity (Press Information Bureau 2026a). The financial system infrastructure to deliver on these commitments is also taking shape with:

- The draft Climate Finance Taxonomy establishes common definitions for green and transition activities (including a proportionality principle for MSMEs to support alignment and better uptake) (Press Information Bureau 2025b)
- The Sovereign Green Bond Framework channeling ~USD 5.7 billion into eligible projects (Department of Economic Affairs 2022)
- Reserve Bank of India's (RBI) Green Deposit Framework, enabling banks to mobilize capital earmarked for green activities

For MSME clusters, such as Ludhiana's knitwear cluster, these shifts create an enabling environment for allocating capital to climate and transition, as well as for market/financing access and competitiveness.

However, the textile sector and the knitwear segment remain highly exposed to climate risks as their production processes are resource-intensive and depend on climate-sensitive inputs such as cotton, wool, water, and energy. These activities also operate through complex, geographically distributed supply chains, making the units vulnerable to environmental disruptions.

Climate risks can be classified into 2 categories: physical and transition risks. Physical risks arise from climate hazards, including floods, heatwaves, and water stress. These impact assets, infrastructure, and operations. Transition risks arise from the shift to a low-carbon economy, including policy and regulatory changes, technology shifts, market expectations, and reputational pressures. Both risk categories interact. Physical disruptions increase regulatory and market responses. Transition pressures increase compliance costs and investment needs.

As a result, climate-related shocks can impact multiple stages of the value chain, affecting raw material availability, production processes, labor conditions, and market stability. For financial institutions, this exposure translates directly into financial risk. Disruptions at any stage of the value chain affect firm revenues, cost structures, and working capital cycles. In MSME-dominated clusters, these shocks spread quickly across firms, creating credit stress and portfolio concentration risks.

For financial institutions such as banks and NBFCs, climate change is increasingly recognized as a driver of traditional financial risks rather than a separate ESG concern. In textile clusters such as Ludhiana, physical and transition risks directly affect borrowers' operational and financial performance. These risks manifest as reduced productivity, supply chain disruptions, rising input and compliance costs, and asset damage, which, in turn, weaken borrower cash flows and balance sheets. Cluster-based lending amplifies these effects because firms are

interconnected through supply chains and shared infrastructure, thereby creating stress across borrowers during climate events or regulatory shifts.

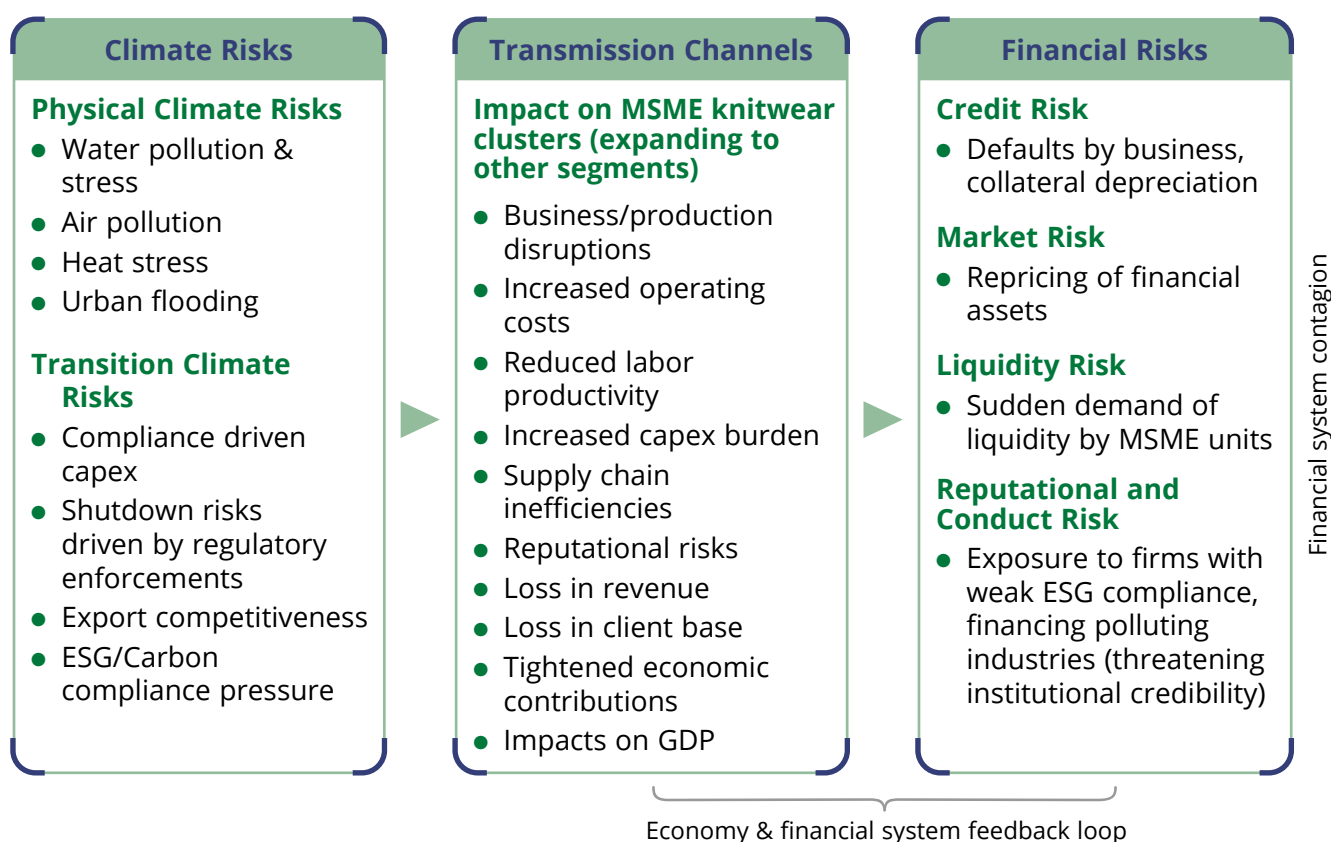
Regulatory frameworks in India are evolving to reflect these risks and developments. The Reserve Bank of India's Draft Disclosure Framework on Climate-Related Financial Risks requires regulated entities to integrate climate-related financial risks into their governance, strategy, and risk management systems (Reserve Bank of India 2024). Securities and Exchange Board of India's BRSR Core requires ESG disclosures (SEBI 2023). India's Carbon Credit Trading Scheme is establishing a domestic carbon market with sectoral coverage expected to expand

over time. Together, these frameworks are increasingly signaling a shift towards mandatory financial-system integration of climate risks.

For banks and NBFCs, this translates to increased default probabilities, market and liquidity risks stemming from correlated shocks across clusters, and reputational risks arising from exposure to environmentally unsustainable or non-compliant firms. As a result, climate risks are now emerging as systemic transmission channels that can impact asset quality, portfolio stability, and long-term financial performance.

The figure below illustrates the pathways by which climate risks are transmitted from

Figure 2 Transmission of climate risks to financial risks in the textile sector



sectoral and operational disruptions to financial risks, highlighting the link between real-economy impacts and financial-system exposure.

These dynamics are particularly acute for the Ludhiana cluster. Its production process remains energy-intensive and heavily dependent on coal-based processes, exposing firms to rising volatility in input costs, tightening environmental regulations, and sustainability-linked market pressures (Center for Study of Science, Technology & Policy 2024).

However, the adoption of cleaner, more resource-efficient technologies also remains constrained. While viable solutions such as energy-efficient machinery, cleaner fuel alternatives, and water management systems exist, high upfront costs, perceived technological risks, limited awareness, and a lack of well-structured financing mechanisms tailored to MSMEs hinder their uptake. Stakeholder inputs have validated these challenges.

This creates a structural financing gap: firms face increasing pressure to transition but lack access to finance aligned with their risk profiles and investment capacities. In the context of limited capital availability, MSMEs naturally prioritize immediate

business and operational requirements, such as working capital, production, and inventory management, before allocating resources toward green investments.⁶ As a result, sustainability-related investments are often deferred despite increasing transition pressures. Without adequate financial support, compliance with emerging environmental standards and market expectations may impose disproportionate costs, affecting competitiveness and potentially increasing credit stress within the segment.

In this context, there is a clear need for green and transition finance solutions that enable MSMEs to undertake incremental, scalable investments in low-carbon, climate-resilient production systems. The Ludhiana knitwear cluster, given its scale, concentration of MSMEs, and strong linkages with formal financial institutions, provides a high-impact, replicable case for examining how such financing solutions can be structured and deployed. Accordingly, this study focuses on how climate risks translate into financial risks for financial institutions lending to the cluster, assesses whether the existing financing ecosystem can mediate that response, and proposes a cluster-specific transition pathway to mobilize climate finance.

⁴ *Economy & financial system feedback loop: As climate risks increase operational and financial stress for firms, lenders may tighten credit conditions, increase risk premiums, or reduce sectoral exposure. Reduced access to finance can then constrain MSMEs' ability to invest in resilience, technology upgrades, and compliance measures, further increasing vulnerability to future climate and transition risks.*

⁵ *Transmission of climate-related financial stress across interconnected firms, lenders, and value chains due to concentrated exposure and systemic linkages.*

⁶ *Stakeholder inputs from the women entrepreneurs' webinar*

1.3 | Approach and Methodology

Building on this background, the scope of the report has three objectives: (a) to examine how physical and transition risks are transmitted into financial risks for banks and NBFCs lending to the Ludhiana knitwear cluster, (b) to assess the gaps in the existing climate finance ecosystem that constrain responses and (c) to propose a cluster-specific architecture that can catalyze climate finance for transition at scale.

Within this scope, the study undertakes key analytical tasks:

- **First**, it assesses the Ludhiana knitwear cluster's exposure to physical and transition climate risks and develops a transmission framework linking these risks to financial risks for banks and NBFCs, including credit, liquidity, concentration, and reputational risks. The analysis also incorporates emerging regulatory developments, particularly the RBI's Expected Credit Loss (ECL) framework, positioning climate risk as a core financial risk consideration.
- **Second**, the study examines global and domestic case studies from Bangladesh, Vietnam, Cambodia, and India to identify scalable financing mechanisms and transition pathways. Across these cases, three common features emerge: aggregation of MSME demand into investable pipelines, integration of technical assistance with finance, and standardized investment and disclosure frameworks.
- **Third**, it evaluates India's evolving policy and regulatory landscape, including frameworks such as CGTMSE, SIDBI 4E,

MSME GIFT, and ZED, to assess how they shape climate-aligned capital allocation and financial risk management. The analysis identifies key gaps that limit financial institutions' engagement at scale, including fragmented cluster-level support, limited climate integration in financing structures, and a weak linkage between technical assistance and finance.

- **Fourth**, the study proposes targeted recommendations on green and transition finance solutions through three interconnected pillars: a Cluster Green Transformation and Resilience Facility, an advisory-led Resource Efficiency and Resilience Program, and an Awareness, Capacity-Building, and Coordination mechanism. Together, these aim to strengthen climate resilience, improve access to finance, and support scalable green transition pathways for MSME textile clusters.

The report adopts a mixed-method research design, combining secondary data analysis with targeted expert consultations to ensure both analytical robustness and operational relevance. Secondary research draws on government statistics, climate datasets, policy documents, industry and consulting reports, multilateral publications, academic literature, environmental studies, and business news to identify climate risks and their financial implications. Primary research consists of 4–5 in-depth bilateral consultations with stakeholders across financial institutions, MSME finance, policymakers, and the knitwear ecosystem to capture financing patterns, risk perceptions, and institutional practices.

The study is relevant to financial institutions, including banks and NBFCs, and to regulators that need to integrate climate risk, manage portfolios, and promote green financing for MSME textile clusters. It is also relevant for policymakers, industry associations, and development partners seeking to align industrial transition, policy support, and climate finance mechanisms with cluster-level needs.

While the study adopts a structured and data-driven approach, certain methodological considerations and assumptions inform the scope and interpretation of the analysis:

- The mixed-methods approach helps partially address limitations in firm-level granularity by combining secondary datasets with stakeholder insights
- In the absence of uniformly available disaggregated data, the analysis relies on credible and triangulated sources to develop robust directional assessments of risk exposure and financial implications
- Forward-looking insights into climate impacts, regulatory developments, and market shifts are based on established secondary evidence and should be interpreted as indicative pathways rather than precise forecasts
- Where city-level data is unavailable, national and state-level datasets have been used as proxies, with the assumption that they are structurally representative of the Ludhiana cluster, given its alignment with broader sectoral trends
- Comparative insights from peer geographies are used as adaptable reference points, recognizing contextual differences while drawing relevant lessons for replication

The sections above outline the economic significance of the Ludhiana knitwear cluster and introduce the emerging climate risks relevant to MSME-dominated manufacturing systems. By mapping the linkages among industrial performance, financial-sector exposure, and potential investment needs, the report makes the business case for a cluster-anchored green transition and identifies potential pathways and mechanisms to enable it.





02

CLIMATE RISK EXPOSURE LANDSCAPE

Image Courtesy:

2.1 | Physical Risks to the Ludhiana Knitwear Cluster

2.1.1 Water Stress

Water stress is a material climate risk for Ludhiana. All 14 blocks in the district have remained over-exploited between 2022 and 2024 (National Bank for Agriculture and Rural Development 2025). Water intensity is highest in textile processing stages, particularly dyeing, washing, and finishing, which require large volumes of freshwater. Lifecycle assessments confirm that these stages account for the highest levels of water consumption and pollution in apparel manufacturing (UNEP, 2020). At

the cluster level, groundwater contamination has emerged as a primary environmental risk. Stakeholder consultations link this directly to dyeing activities. Inadequate wastewater treatment infrastructure remains a key constraint. Some units continue informal discharge practices due to cost pressures. This has accelerated groundwater degradation and increased regulatory exposure.

Adoption of treatment solutions remains limited. Capital-intensive systems, such as Zero Liquid Discharge (ZLD), entail high

upfront and operating costs. Financial institutions indicate that these costs affect firm competitiveness. Under such conditions, production may shift to alternative clusters with lower compliance costs. Even where Common Effluent Treatment Plants (CETPs) exist, performance concerns persist. Suboptimal treatment outcomes continue to affect water quality, reducing the effectiveness of shared infrastructure and sustaining environmental risk.

Upstream dependencies further increase exposure. Cotton and wool production are highly sensitive to water availability, and climate variability is expected to reduce yields and affect fiber quality. This creates input volatility and supply uncertainty for downstream knitwear units (Solidaridad, 2023) (Mubarak et al, 2022). These risks translate into operational and financial impacts: water scarcity disrupts production schedules and increases input costs, while energy costs rise due to pumping and treatment requirements. Smaller firms are more vulnerable due to limited access to alternative water sources or recycling systems.

For lenders, credit risk rises as borrowers' repayment capacity declines, driven in large part by capital expenditures on compliance that do not improve productivity (e.g., ZLD systems). Additionally, upstream input-price volatility affects working capital and the probability of default for firms that cannot absorb these costs, both of which contribute to credit risk. Portfolio and concentration risk also emerge, with almost every block in the district overexploited, and exposure to water-intensive sub-segments, such as dyeing, prompting active repricing considerations. Liquidity is also affected for

financial institutions with a concentration in Ludhiana, as simultaneous borrower stress further strains repayment inflows.

2.1.2. Air Pollution

Air pollution in Ludhiana is driven largely by the processes that anchor the knitwear value chain. Dyeing, finishing, and steam ironing rely on combustion boilers, many of which are still wood-fired because wood remains cheaper than industrial gas, and because CNG and PNG infrastructure in the cluster is limited and cost-prohibitive at the unit level. The dyeing sub-segment alone accounts for approximately 28–37% of PM₁₀ and 30–38% of PM_{2.5} emissions in the city across all seasons (Punjab State Council for Science & Technology, Chandigarh, PSCST and TERI, 2021), and Respirable Suspended Particulate Matter routinely exceeds 180 µg/m³, close to three times the regulatory limit (State Action Plan on Climate Change and Human Health, Punjab, 2022–27). Concentrated textile-waste storage adds acute, episodic exposure on top of this chronic baseline; warehouse fires release intense, localized pollution, force production stoppages, and have become a recurring incident category in the cluster.

These exposures translate into operational, regulatory, and market risks for firms. Chronic pollution increases worker absenteeism, accelerates equipment wear, and reduces product quality by accumulating particulates. Fire incidents have added an episodic layer of asset and inventory losses and have pushed up insurance premiums in exposed parts of the cluster. Export competitiveness is also affected as global buyers tie sourcing decisions to emissions performance and ESG compliance.

For banks and NBFCs lending into the cluster, these dynamics transmit into credit risk through two channels. First, compliance-driven capex on fuel switching, emissions control, and fire-safe waste storage raises borrowers' demand for capital that does not improve productivity, thereby compressing cash flows and elongating repayment cycles. Second, insurance costs rise, and collateral values weaken in fire-exposed and pollution-exposed units. At the portfolio level, this differentiates compliant and non-compliant borrowers and pushes lenders toward selective tightening and repricing for exposures in the highest-emitting parts of the cluster.

2.1.3. Heat Stress and Rising Temperatures

In Ludhiana, extreme heat events have become more frequent and intense over recent years, reflecting a broader warming trend across North India. In June 2025, temperatures in the city reached nearly 44°C during a severe heatwave episode (Hindustan Times 2025). Multi-year assessments further identify Ludhiana as one of India's most heat-vulnerable urban centers, with increasing exposure to prolonged heat stress and rising average summer temperatures (Sustainable Futures Collaborative 2025). Heat stress has important implications for upstream manufacturing processes within the textile value chain. The yarn and fabric production stage, particularly spinning, is highly energy-intensive and dependent on a continuous electricity supply. The heavy reliance on machinery, humidification systems, and compressors results in increased cooling requirements during elevated temperatures, thereby increasing electricity demand. This

increases operating costs and exposes firms to operational disruptions during grid instability, load-shedding, or voltage fluctuations (Imran et al. 2023).

These conditions directly impact labor productivity. Workers in dyeing, processing, and small workshops are exposed to prolonged heat. Health risks increase, including dehydration and fatigue. Productivity declines during peak summer months. Consultations indicate that workers continue to report to factories despite adverse conditions, as absenteeism is not a viable option. However, these conditions have negatively affected productivity, particularly for workers engaged in multi-stage operations such as stitching, cutting, and steam ironing.

Heat stress also affects market demand. Stakeholder consultations indicate a shortening of the knitwear demand cycle. Traditionally, the demand season extended from August to December; however, it has now shortened, beginning around mid-October due to warmer climatic conditions. Demand from regions such as East India and hill states has also declined, reflecting broader shifts in consumption. These changes affect revenue stability. Firms face reduced sales windows and demand uncertainty. Capacity utilization declines, affecting profitability.

Heat translates into credit risk along a different path than the other hazards. Margin compression (higher cooling-driven energy costs and lower labor productivity) steadily erodes borrowers' cash flows year-round. At the same time, the contraction of the knitwear season and demand attrition concentrate revenue into a narrower window and raise the risk of mistimed

repayments for MSMEs with thin buffers. Adaptation capex on ventilation, cooling, and energy back-up also generates small-ticket, high-volume financing demand across the cluster. Given that heat affects all firms simultaneously rather than selectively, exposures move together at the portfolio level: concentration is the dominant risk for lenders with material exposure to Ludhiana.

2.1.4. Urban Flooding

Urban flooding is an emerging and intensifying risk in Ludhiana. Rainfall patterns have become more erratic, with high-intensity events exceeding drainage capacity (World Resources Institute India 2025). The city faces a dual challenge of groundwater depletion and flood exposure, and proximity to the Sutlej River increases flood vulnerability. Heavy rainfall events have led to overflow and localized flooding in recent years, causing infrastructure damage and disrupting economic activity (The Tribune 2025, The Indian Express 2026).

Flooding directly disrupts industrial operations. During the 2025 flood events, dyeing and processing units were temporarily shut down to manage wastewater discharge, affecting production schedules and delaying downstream processes (The Indian Express 2025). Flooded roads and disrupted transport also reduce labor mobility, and even partial flooding has cascaded into production delays and logistical bottlenecks across multi-stage value chains.

The financial impact extends well beyond the disruption period itself. Firms continue to incur fixed costs (wages, rent, utilities) during the shutdown, while ingress-related inventory damage results in an immediate loss. Stakeholder consultations also indicate that recovery from a single flood can extend over multiple years. Working capital requirements rise as payments are delayed and orders go unfilled. However, the financing mechanisms available to MSMEs, such as insurance, risk transfer, and contingency lines, remain limited and are not systematically integrated into existing lending frameworks, leaving firms exposed to repeated shocks (The Tribune, 2025).

For lenders, flooding hits both flows and stocks. Recovery periods that span multiple years lengthen working capital cycles and push NPL recognition well beyond the event itself, with smaller firms most likely to default during recovery rather than at the point of impact. On the asset side, collateral values become location-sensitive: units close to the Sutlej or in low-lying parts of the cluster face structural impairment that is not yet routinely priced into loan-to-value assumptions. Limited insurance penetration compounds both effects, as the residual risk falls to the borrower and, by extension, the lender. At the portfolio level, geographic concentration within the flood-affected zones produces correlated stress across a subset of the cluster, narrower than for heat, but typically more severe per borrower.

2.2 | Transition Risks

2.2.1. Water Regulation

Groundwater stress is driving regulatory tightening across India. The policy focus is shifting from access to controlled extraction and to usage efficiency. In 2020, India's Central Groundwater Authority introduced stricter guidelines for groundwater extraction in over-exploited regions. These included restrictions on industrial use and penalties for non-compliance (India Water Portal 2020). While MSMEs are not fully covered, regulatory expansion remains likely.

State-level action is also accelerating. In February 2026, Punjab's notification designating 111 blocks as overexploited (including every block in Ludhiana) restricted new tube wells and brought industrial water use under closer scrutiny (Amar Ujala 2026). Precedents from other textile clusters indicate the direction of travel: in Tiruppur, mandatory Zero Liquid Discharge norms triggered large-scale, compliance-driven investment in wastewater treatment infrastructure (The Economic Times 2025).

For Ludhiana, similar regulatory pathways imply mandatory capital expenditure. Firms may need to invest in recycling systems, alternative sourcing, and shared treatment infrastructure. For financial institutions, this creates a dual impact: (a) credit demand increases due to compliance-related capex, and (b) credit risk increases for firms unable to finance these investments. At the portfolio level, regulatory tightening creates segmentation between compliant and non-compliant borrowers. This can lead to selective credit tightening and repricing within the cluster.

2.2.2. Air Pollution Compliance

Air pollution is moving from an environmental issue to a compliance and enforcement risk. Regulatory scrutiny on industrial emissions is increasing. Dyeing and processing units in Ludhiana are already under the oversight of the pollution control authorities and the National Green Tribunal. In January 2026, the National Green Tribunal issued non-compliance notices to dyeing units for using prohibited fuels and improper waste disposal (Times of India, 2026). Action by the CPCB and state pollution control boards has become more frequent, with penalties and shutdown orders no longer rare. Compliance requirements include fuel restrictions, emission monitoring, and boiler standards (Hindustan Times, 2026).

Future tightening is likely to focus on fuel switching and emissions control. This includes transitioning to cleaner fuels, installing emission control equipment, and upgrading processes. These requirements create direct cost pressures, with capital investment being required for equipment upgrades, and operating costs increasing due to cleaner fuel adoption and monitoring systems.

As global buyers increasingly incorporate environmental performance, emissions disclosures, and sustainability standards into procurement and sourcing decisions, supplier selection is likely to become more closely linked to firms' environmental compliance and reporting practices (Supply and Demand Chain Executive, 2020). This could create a growing divergence

between firms that successfully adapt to evolving requirements and those that do not. While compliant firms may be better positioned to retain access to ESG-sensitive markets and global value chains, non-compliant firms could face increasing risks of reduced competitiveness, higher compliance costs, or loss of market access. For financial institutions, these trends have the potential to influence both risks and returns. Over time, lenders may need to reassess exposure to environmentally intensive segments within the cluster, shaping sectoral lending strategies, portfolio composition, and capital allocation decisions.

2.2.3. Labor Standards Related to Heat Stress

Heat stress is being formalized as a transition risk for apparel supply chains through workplace safety standards that directly translate into market-access conditions for suppliers. In 2025, the International Accord for Health and Safety in the Garment and Textile Industry introduced a Heat Stress Protocol. This integrates heat-related safety into binding inspection and compliance systems across supplier factories (Climate Rights International 2025a). Major global apparel brands, including H&M group, Inditex, PVH, Mango, and Marks & Spencer, are signatories to the Accord, making these provisions legally binding across their supplier networks (Climate Rights International 2025a). These frameworks extend beyond voluntary standards, given that they are increasingly embedded in buyer contracts and audit systems. Within this context, compliance is linked to continued participation in global supply chains.

Parallel advocacy by labor organizations has also increased pressure for stricter workplace protections. Climate Rights International's 2026 report on Bangladesh's garment industry calls for mandatory work-rest ratios based on real-time environmental conditions, stop-work thresholds during extreme heat, acclimatization protocols for workers, and training programs for employers and healthcare providers. Such measures are increasingly being incorporated into buyer codes of conduct and supplier compliance frameworks (Climate Rights International 2025b).

India, one of the world's largest garment exporters, has been identified as one of the countries most exposed to heat stress, along with several major garment-producing countries, including China, Indonesia, Pakistan, Bangladesh, and Brazil (Clean Clothes Campaign 2025). In response, emerging buyer-led compliance frameworks and workplace safety standards increasingly include workplace modifications, such as ventilation systems, cooling infrastructure, hydration facilities, and monitoring mechanisms. These involve incremental, but widespread, capital investments across production units. For MSMEs, implementation is uneven because individual firms lack the scale to absorb costs on their own, leading to dependence on external financing and technical support.

For lenders, compliance capex on ventilation, cooling, hydration, and monitoring creates small-ticket, high-volume financing demand across the cluster. On the other hand, firms that cannot or do not invest face binary market-access risk as buyer relationships and order volumes become contingent on protocol compliance. The credit risk of non-compliance therefore concentrates in

the part of the cluster least able to absorb the cost. For banks and NBFCs lending in Ludhiana, heat-stress regulation is an active driver of borrower differentiation, with direct implications for credit quality, portfolio composition, and the urgency of deploying transition-aligned financing.

2.2.4. Infrastructure Standards and Insurance Frameworks around Urban Flooding

Transition risks specific to flooding are less developed than those for water stress or air pollution. However, they are emerging through two key channels: insurance market repricing and integration of physical risk into financial regulation.

Insurance markets are beginning to price climate risks more explicitly. Premiums are rising for flood-prone industrial assets, and conditional coverage tied to resilience measures (drainage upgrades, asset elevation, protective systems) is becoming more common (Indian PSU 2026). For MSMEs operating on thin margins, this either raises the operating cost base or shifts uninsured residual risk onto firms and, by extension, their lenders.

Financial regulation is moving in the same direction. The RBI draft disclosure framework on climate-related financial risks requires regulated entities to integrate physical risk (including flood exposure) into credit, market, and operational risk frameworks (RBI 2024a). For MSMEs, this is likely to mean tighter loan-to-value ratios, higher pricing, or restricted access in flood-exposed parts of the cluster; for lenders, exposure concentrates into the more resilient subset, reshaping portfolio composition and risk pricing across the Ludhiana book.

2.2.5. Financial Regulatory Drivers

India's sustainable finance ecosystem is being shaped by evolving regulatory frameworks that influence capital allocation, disclosure requirements, and risk management practices across financial institutions and corporations. These frameworks have both direct and indirect implications for Ludhiana's MSME knitwear cluster.

For example, as a consequence of the BRSR Core, large apparel brands and retailers are increasingly expected to collect environmental and social data from suppliers, including on energy use, emissions, water consumption, waste, and labor conditions (SEBI 2023). While most units in Ludhiana are unlisted MSMEs and therefore not directly subject to BRSR disclosure requirements, they are likely to become indirectly integrated into ESG and climate disclosure frameworks through buyer and supply chain requirements. This also increases expectations on financial institutions to generate climate-relevant data for their lending portfolios. Stakeholder consultations further indicate that while some climate risk tagging already exists, it remains limited and requires greater standardization and integration.

At the same time, RBI's Draft Disclosure Framework on Climate-related Financial Risks (2024) recognizes climate change as a major risk for regulated entities (RBI 2024b). For banks and NBFCs with exposure to Ludhiana's knitwear MSMEs, climate hazards such as heat stress, flooding, water scarcity, and air pollution are increasingly becoming core credit and portfolio risks. This makes climate-aligned financing and de-risking

mechanisms increasingly important for both compliance and risk management.

Complementing this, the RBI finalized its Expected Credit Loss (ECL) framework in April 2026, which will come into effect from April 1, 2027 (RBI 2026). The ECL framework represents a fundamental shift from the traditional loss-incurred model to a forward-looking approach, requiring banks to assess and provision for potential credit losses based on future risks rather than past defaults. Under this framework, banks must classify financial assets into three stages depending on credit risk and calculate provisions using parameters such as probability of default (PD), loss given default (LGD), and exposure at default (EAD) (RBI 2026). However, without complementary mechanisms to help MSMEs adapt and build resilience, it risks creating a financing

squeeze on climate-exposed firms. Banks may provision more heavily and lend more cautiously to Ludhiana's units without corresponding support for investments in emissions reduction, flood resilience, or operational adaptation. This makes climate-aligned financing and de-risking mechanisms increasingly important for both compliance and risk management.

2.2.6. International Market and Policy-Driven Transition Risks

The EU's Carbon Border Adjustment Mechanism (CBAM), implemented in January 2026, signals a shift toward carbon-linked trade measures. While textiles are not yet covered, expansion remains likely given sector emissions intensity (Down to Earth, 2026).

Case Study

EU Carbon Border Adjustment Mechanism (CBAM) and India-EU trade dynamics

The EU's Carbon Border Adjustment Mechanism (CBAM) entered its transitional phase in 2023 and currently covers emissions-intensive sectors such as steel, cement, aluminum, fertilizers, hydrogen, and electricity. While textiles and apparel are not presently included, there is a strong likelihood of future expansion, particularly as the EU depends on its climate policy architecture and supply chain regulations.

Relevance in the context of India-EU FTA

Ongoing negotiations around the India-EU Free Trade Agreement are expected to deepen trade integration. However, market access advantages may increasingly be contingent on compliance with sustainability and carbon-related requirements, effectively linking trade competitiveness with climate performance.

Sources: [European Commission], [2026a], [European Commission], [2026b]

Combined with CBAM's eventual expansion and growing buyer expectations around ESG performance, climate-related regulations are increasingly reshaping the competitive landscape for textile manufacturers. For export-oriented producers in Ludhiana, competitiveness is no longer determined solely by cost and quality, but increasingly by carbon efficiency, emissions transparency, product durability, and circularity. Firms that fail to measure and manage emissions across their supply chains may also face higher compliance costs where importers apply default emission values, making robust emissions measurement and reporting an increasingly important source of competitive advantage. Consequently, early investments in decarbonization can generate multiple benefits by lowering compliance costs, reducing CBAM exposure, strengthening market access, and improving long-term competitiveness.

Simultaneously, India's Carbon Credit Trading Scheme (CCTS) has designated textiles as an obligated sector, requiring larger units to meet greenhouse-gas emission intensity targets or procure domestic carbon credits to remain compliant (Press Information Bureau 2026b). This creates dual carbon-cost exposure for exporters: domestic compliance costs under the CCTS and potential residual CBAM liabilities in the EU. While CBAM allows importers to deduct the effective carbon price paid in a third country from their certificate obligations, such deductions are contingent on demonstrable payments under recognized carbon-pricing mechanisms (European Commission 2025).

At the domestic level, India's Carbon Credit Trading Scheme (CCTS) has designated textiles as an obligated sector, requiring

larger units to meet greenhouse gas emission intensity targets or procure domestic carbon credits to remain compliant (Press Information Bureau, 2026b). This extends carbon-related compliance beyond export-oriented firms to large domestic textile producers through mandatory emissions monitoring, reporting and verification (MRV), efficiency improvements, and, where necessary, the purchase of carbon credit certificates (International Carbon Action Partnership). For export-oriented firms, these requirements create dual carbon-cost exposure through domestic compliance obligations under the CCTS and potential residual CBAM liabilities in the EU. While CBAM permits importers to deduct carbon prices paid under recognised domestic carbon-pricing mechanisms, such deductions depend on credible emissions accounting and verification (European Commission, 2025).

These developments are also beginning to reshape firms' financial risk profiles. Climate-related regulations and transition requirements increase the risk of higher operating costs, asset impairments, and credit deterioration, while creating greater uncertainty for lenders assessing long-term repayment capacity. Emerging analyses suggest that 80% of India's textile CCTS exposure sits in MSMEs, indicating that the compliance burden is likely to fall disproportionately on smaller firms (Climate Decode, 2026). Given Ludhiana's prominence in both domestic and international textile supply chains, these converging regulatory and financial pressures reinforce preparation, and access to climate-aligned finance.

At the same time, these challenges also present a strategic opportunity. Early investments in low-carbon technologies, resource efficiency, and emissions management can reduce compliance costs, strengthen access to international markets, improve operational resilience, and enhance the long-term competitiveness of Punjab's textile sector.

Additionally, the EU's revised Waste Framework Directive, which entered into force in 2025, introduces mandatory Extended Producer Responsibility (EPR) schemes for textiles and footwear. Member States will have 30 months from that date to establish EPR schemes, with all EU Member States required to do so by April 2028, thereby changing the basis of competition fundamentally (EU 2025a). Under the new EPR rules, textile and footwear producers will pay a fee for each product they place on the market, with fees adjusted based on sustainability criteria, such as durability and recyclability, an approach known as eco-modulation that links the cost producers pay to the environmental and circular performance of their textiles. Non-EU exporters supplying the EU, including entities from India, will be required to comply with these schemes, participate in collection and recycling systems, and report annual data on volumes and composition (EU 2025b).

Another important dimension of this evolving risk landscape is the increasing integration of MSMEs into global supply chains. Emerging disclosure frameworks such as the EU's European Sustainability Reporting Standards under the Corporate Sustainability Reporting Directive (CSRD), along with the International Sustainability Standards Board

(ISSB) standards, are extending reporting requirements across value chains (European Financial Reporting Advisory Group 2023), (International Financial Reporting Standards Foundation 2023), (European Union 2022). As a result, MSMEs, though often not directly regulated, are increasingly required to provide structured ESG data to larger buyers, particularly around supply chain and Scope 3 (Accountancy Ireland 2024).

While these frameworks aim to enhance transparency and sustainability, they also impose significant compliance costs and reporting burdens on resource-constrained MSMEs. Firms that cannot provide credible data face implicit cost penalties and reduced market access, and they incur increased financing needs for emissions monitoring and reporting systems. Gaps in proportionate standards, simplified tools, and targeted capacity-building support for non-financial disclosures further undermine MSMEs' competitiveness.

The table below synthesizes how key physical and transition climate risks affecting the Ludhiana knitwear cluster translate into distinct financial risk channels for banks and NBFCs, including implications for credit quality, portfolio stability, and reputational exposure.

Table 3 Climate Risk Transmission and Financial Risk Channels:
 Ludhiana Knitwear MSME Cluster

Specific Physical and Transition Risks	Credit Risk	Portfolio and Market Risk	Reputational and ESG Risk	Bank Priority Considerations
Water Stress				
- Stressed groundwater sources are hitting water-intensive dyeing and processing - Tightening extraction regulation and effluent / CETP standards - Climate-driven supply volatility in upstream cotton and wool	- Revenue disruption from production stoppages - Compliance-driven capex on recycling and effluent treatment - Working capital strain from input price volatility	- Cluster-wide correlated stress across borrowers - Repricing of exposure to water-stressed sub-segments - Sector-wide deterioration in asset quality	- Exposure to unsustainable water use practices - Financing of non-compliant units	High Driven by regulatory tightening and systemic resource risk
Air Pollution				
- Regulatory tightening on combustion emissions and effluents is hitting boiler-based dyeing and finishing - Acute fire-hazard exposure from concentrated textile-waste storage - Buyer-led ESG and emissions-disclosure requirements	- Higher compliance costs and fuel-switching capex - Penalties, shutdowns, and stranded-asset risk - Revenue loss from buyer disengagement	- Repricing of exposure to high-emission sub-segments - Concentration risk in polluting units - Selective tightening for compliant vs non-compliant borrowers	- Association with polluting industries lacking transition pathways - Increased ESG scrutiny from regulators and buyers	High Driven by strong regulatory and reputational sensitivity

Specific Physical and Transition Risks	Credit Risk	Portfolio and Market Risk	Reputational and ESG Risk	Bank Priority Considerations
Heat Stress				
• Rising temperatures and heatwave frequency are hitting labor productivity and energy-intensive spinning operations • Shortened the knitwear demand cycle and demand attrition from East India and hill states • Emerging heat-safety compliance requirements in buyer codes and labor regulations	• Margin compression from higher energy costs and labor productivity loss • Revenue concentration into a narrower seasonal window, raising the risk • Adaptation capex demand for cooling, ventilation, and energy back-up	• Cluster-wide correlated stress during heatwaves; exposures move together • Simultaneous working capital demand across the cluster	• Exposure to firms with poor labor standards and inadequate heat-safety measures • Misalignment with the International Accord and buyer-led heat protocols	Medium-High (rising) Operational and labor impacts already visible; adaptation capex demand growing
Urban Flooding				
• High-intensity rainfall and drainage failure are hitting low-lying production units, asset stocks, and logistics • Sutlej River proximity raises baseline flood vulnerability • Rising insurance costs and emerging resilience-infrastructure requirements	• Asset damage reduces collateral value • Multi-year recovery cycles extend working capital strain and delay NPL recognition • Increased default probability for smaller firms during recovery	• Geographic concentration of stress in flood-affected zones • Insurance gap pushing residual risk onto lenders	• Exposure to climate-vulnerable assets without resilience measures • Limited engagement with flood-resilient infrastructure financing	Medium (high-severity, episodic) Low frequency but high per-event severity and multi-year recovery exposure

Specific Physical and Transition Risks	Credit Risk	Portfolio and Market Risk	Reputational and ESG Risk	Bank Priority Considerations
Cross-Cutting Transition Risks (Policy, ESG, Disclosures)				
• BRSR Core value-chain disclosure requirements • Buyer-led ESG and Scope 3 reporting expectations • Future direction on carbon-linked trade measures (e.g., CBAM expansion) • EU EPR Rules	• Compliance and reporting capex demand • Credit stress for non-compliant MSMEs losing market access	• Repricing of sectoral exposure • Portfolio risk concentrated in export-oriented segments	• Exposure to firms unable to meet ESG or disclosure expectations • Misalignment with India's draft climate finance taxonomy	Medium-High (rising) Driven by policy direction and global market shifts

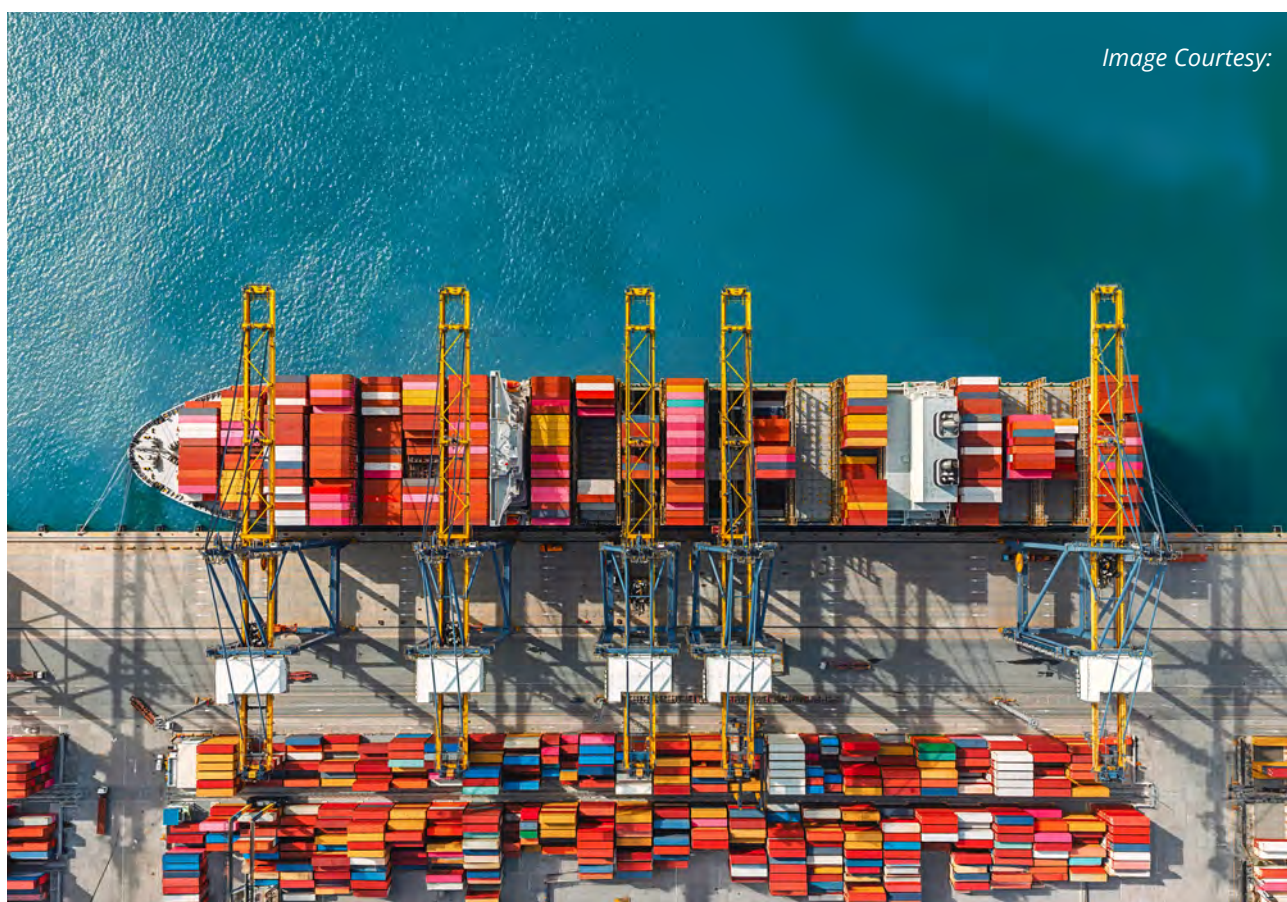


Image Courtesy:



Image Courtesy:

The Ludhiana cluster's response to the climate and transition pressures remains constrained on two fronts: 1) the limits of existing MSME-targeted schemes and 2) the market barriers that limit firm-level response. This section examines these constraints.

3.1 | Existing Ecosystem: Schemes and Structural Gaps

India has a well-developed ecosystem of MSME and textile-sector support schemes that can be leveraged to facilitate a green transition in Ludhiana's knitwear cluster. These include credit guarantees, concessional financing lines, technology upgradation subsidies, and sustainability certification frameworks. However, these schemes have largely been designed as

broad-based MSME or sectoral interventions. They are not explicitly tailored to address both cluster-specific climate risks or enable coordinated, cluster-level transition pathways. The table below summarizes the key schemes relevant to the Ludhiana knitwear cluster, along with their core features and limitations from a climate finance perspective.

Table 4 Key government schemes relevant for the Ludhiana knitwear cluster

Scheme	Type of Support	Features & Relevance	Key Limitations
Credit Guarantee Fund Trust for SMEs (CGTMSE 2020) (Credit Guarantee Fund Trust for Micro and Small Enterprises) (HDFC Bank, 2026) <i>Govt of India (Ministry of MSMEs) and SIDBI</i>	Credit guarantee	Key features: Collateral-free guarantees for term loans and working capital up to USD 600,000 (INR 5 crores), providing 75-85% coverage Green transition relevance: Can support financing of green capex, including energy-efficient boilers, ETPs, rooftop solar, and heat mitigation	No preferential terms or incentives for climate-aligned investments
Credit Guarantee Scheme for Subordinate Debt (CGSSD 2020) (National Institute for Micro, Small and Medium Enterprises 2020) <i>Under CGTMSE (Ministry of MSMEs)</i>	Credit guarantee (restructuring)	Key features: Guarantees up to 90% of subordinate debt, capped at 50% of promoter stake or USD 90,000 (INR 75 lakh) Green transition relevance: Can support compliance-driven environmental investments in stressed MSMEs	Primarily a restructuring tool; no explicit green or resilience focus
MSME Energy Saving Project (Phase III, 2025) (Bureau of Energy Efficiency) <i>Japan International Cooperation Agency (JICA) SIDBI</i>	Concessional finance	Key features: Loans for energy-efficient technologies (10% savings); tenors up to 7 years; slightly below-market rates Green transition relevance: Supports the adoption of energy-efficient technologies in MSMEs	Sector-agnostic and project-based; lacks cluster-level orientation needed to address shared infrastructure gaps, common climate risks, and financing barriers across interconnected MSME textile/knitwear units. This limits aggregation of demand, standardized project pipelines, and coordinated deployment of green technologies at scale

Scheme	Type of Support	Features & Relevance	Key Limitations
End-to-End Energy Efficiency (4E, 2024) (SIDBI 2023a) <i>SIDBI</i>	Blended (technical + financial)	Key features: Combines audits, DPRs, implementation support with concessional finance; up to 90% project cost finance; ~ 2.5% below market rates Green transition relevance: Strong model integrating technical assistance and finance for energy efficiency	Limited to energy efficiency; does not address broader climate risks (heat, flooding, water stress); not cluster-focused
Partial Risk Sharing Facility for Energy Efficiency, 2015 (SIDBI 2023b) <i>SIDBI</i> <i>World Bank</i>	Risk sharing + technical assistance	Key features: World Bank supported facility (~USD 43 million) providing partial credit guarantees (typically 40-75%) to banks/NBFCs lending to energy efficiency projects via ESCO models; includes technical assistance and standardization of contracts and appraisal frameworks Green transition relevance: Addresses lender risk perception and unlocks private capital for energy efficiency investments; supports development of the ESCO market and performance-based contracting	Limited to energy efficiency; dependent on ESCO-based models, which are still nascent in many MSME clusters; not cluster-specific or designed for broader climate risks
Zero Defect Zero Effect (ZED) Certification Scheme, 2022 (Press Information Bureau 2022) <i>Government of India (Ministry of MSMEs)</i>	Certification + subsidy	Key features: Promotes resource efficiency, waste reduction, improved environmental performance; subsidy-linked Green transition relevance: Improves process standards and market recognition; can support access to finance indirectly	Not linked to financing instruments; does not explicitly incorporate climate risk resilience

Scheme	Type of Support	Features & Relevance	Key Limitations
Amended Technology Upgradation Fund Scheme (ATUFS 2025) (Press Information Bureau 2025); (Bajajfinserv 2025) <i>Government of India (Ministry of Textiles)</i>	Capital subsidy	Key features: 10-15% subsidy for machinery modernization Green transition relevance: Indirectly supports cleaner production and energy efficiency	Not climate-tagged; no environmental performance tracking; does not address physical climate risks
Financing Mitigation and Adaptation Projects (FMAP) in Indian MSMEs (Green Climate Fund 2024) <i>Green Climate Fund via SIDBI, approved July 2024</i>	Blended finance (capacity building + concessional loans)	Key features: USD 215.6 million GCF funding providing nearly 10,000 concessional loans to MSMEs for climate mitigation and adaptation technologies. Green transition relevance: Directly supports the adoption of low-emission and climate-resilient technologies	Early-stage implementation (2024-2038 timeline) with limited on-ground deployment as of 2025; Scheme awareness among Ludhiana cluster MSMEs remains limited
MSME Green Investment and Financing for Transformation (GIFT) Ministry of Micro, Small and Medium Enterprises	Interest subvention + credit guarantee	Key features: Interest subvention on loans for the adoption of green technology. 80% credit guarantee eliminates the collateral requirement. Implemented by SIDBI through participating banks, SFBs, and NBFCs. Green transition relevance: Supports the adoption of energy efficiency, renewable energy, waste reduction, and other eco-friendly technologies	Active only for 2023-24 to 2025-26 (limited tenure, might be extended); limited awareness in clusters. Success is dependent on FI participation and MSME awareness of benefits

Overall, while existing schemes provide strong foundational elements such as guarantees, concessional credit, subsidies, and certification frameworks, they do not collectively translate into a coordinated or climate-aligned transition pathway for the Ludhiana MSME cluster. Three key structural gaps emerge:

- **Lack of cluster-level approach:** Most schemes are sector-agnostic and firm-level, with no mechanisms for aggregation, pipeline development, or coordinated cluster-wide transformation. This limits MSMEs' ability to access shared infrastructure and collective financing solutions, while increasing transaction costs and reducing scalability for financial institutions
- **Limited integration of climate risk considerations:** Instruments do not explicitly incorporate physical or transition risks into financing structures. As a result, MSMEs remain underprepared for emerging climate and market risks, while

financial institutions face challenges in assessing and managing climate-related portfolio exposure

- **Weak integration of finance and technical support:** Except for select programs (such as SIDBI 4E), technical assistance, project preparation, and financing remain fragmented. This constrains MSME adoption of climate-aligned technologies and reduces the pipeline of bankable green projects for financial institutions

As a result, while a strong policy and financial foundation exists, it is not yet aligned to support a coordinated, scalable, and risk-informed transition for Ludhiana's knitwear cluster. For financial institutions, these gaps contribute to higher perceived risks, weaker project pipelines, and limited ability to scale climate-aligned lending within MSME clusters. Addressing these gaps is therefore critical to enable effective deployment of green finance and resilience investments at scale.



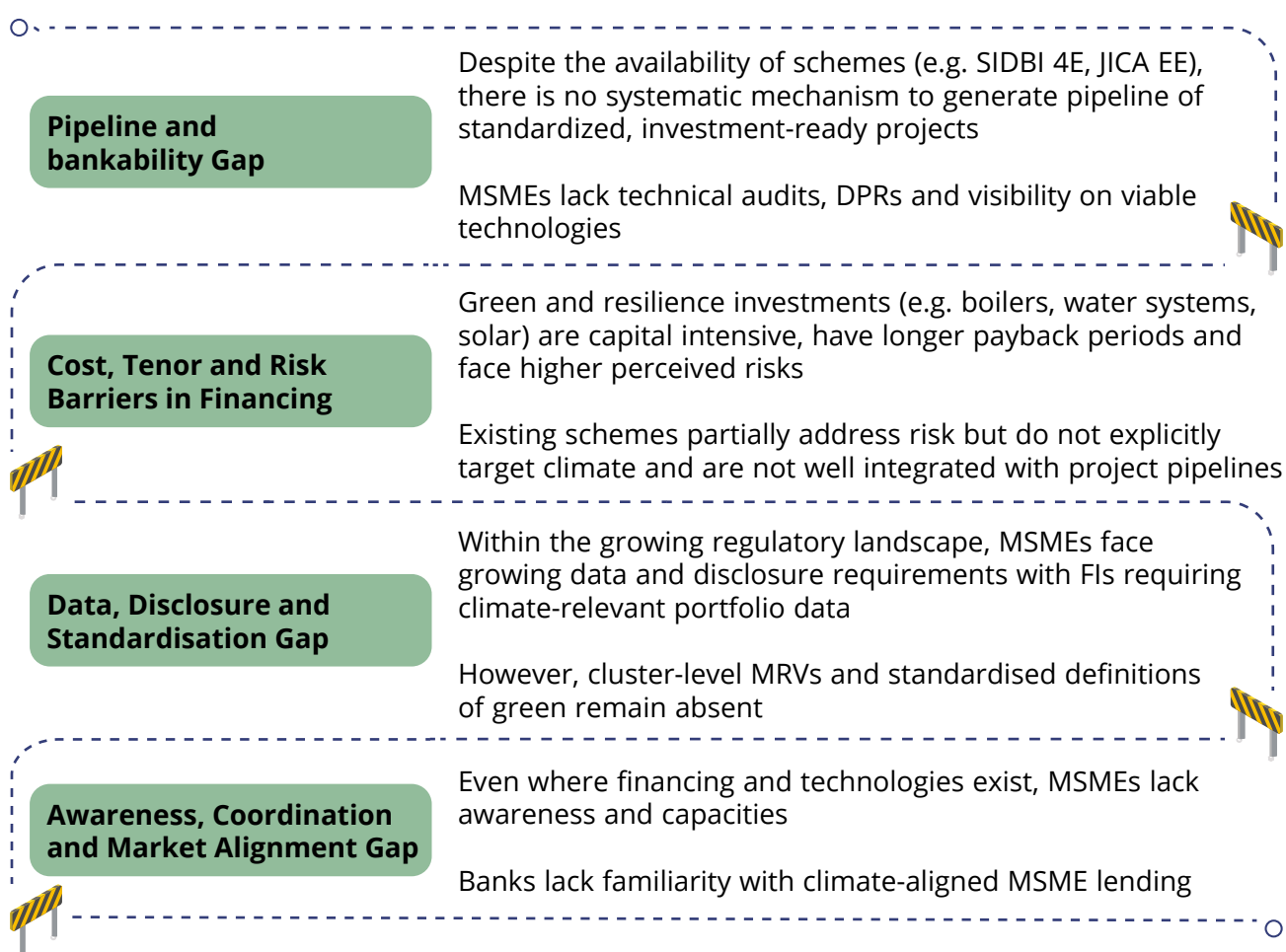
Image Courtesy:

3.2 | Transition Barriers

Despite increasing policy attention and the availability of sustainability-linked schemes, MSMEs in the Ludhiana knitwear cluster continue to face significant barriers in undertaking green transition measures. These constraints extend beyond access to

finance and encompass broader challenges, including information gaps, limited technical capacity, fragmented institutional support, and weak market incentives. As a result, transition efforts remain limited and uneven across the cluster. Four key barriers emerge:

Figure 3 Market barriers constraining MSME response



Taken together, these barriers indicate that the constraint is not the absence of schemes or capital, but the absence of an integrated, cluster-level financial architecture.

Given this landscape, a cluster-level transition model is required to align financial instruments, institutional mechanisms, and regulatory expectations for the Ludhiana knitwear cluster.



Image Courtesy:

04

GLOBAL BEST PRACTICES, LESSONS, & OPPORTUNITIES FOR THE LUDHIANA KNITWEAR CLUSTER

The previous section highlighted barriers that continue to constrain the climate-aligned transition in textile/knitwear MSME clusters. It also showed that while policy frameworks and financing instruments are evolving, existing systems remain fragmented and are not yet fully aligned to support coordinated, large-scale transition pathways. In this context, examining global and domestic experiences is important for understanding how similar barriers have been addressed in other textile and apparel clusters.

Global experiences from countries such as Bangladesh, Vietnam, Cambodia, and India show that coordinated action can support the transition to cleaner, more resource-efficient production systems. These models typically involve collaboration between governments, development finance institutions, financial institutions, and industry stakeholders. They use a mix of concessional credit lines, refinance facilities, blended finance structures, and technical assistance programs tailored to MSMEs operating in fragmented industrial clusters.

This section examines selected case studies to identify key design features, financing structures, and institutional arrangements that have enabled scale and replication. The objective is not to replicate these models directly, but to derive actionable insights for Ludhiana's knitwear cluster. In particular, the analysis focuses on approaches that address MSME-level constraints, align lender risk frameworks with transition investments, and

support aggregation and standardization within cluster-based industries.

While the focus of this report is Ludhiana's knitwear cluster, the evidence base for knitwear-specific transition finance remains limited. Accordingly, this section draws from the broader textiles and apparel sector, where more mature examples of cluster-level transition financing and programmatic interventions have emerged.

4.1 | Bangladesh: IFC Partnership for Cleaner Textile (PaCT) Program

IFC's Partnership for Cleaner Textile (PaCT) programme represents a sector wide, advisory-led transition model that integrates technical diagnostics, capacity building and investment facilitation. Moreover, an investment facilitation mechanism to support the adoption of cleaner production (CP) and climate smart practices across the textile value chain. Launched in 2013, PaCT is supported by the governments of Denmark and the Netherlands, and is implemented by IFC in partnership with the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) (Apparel Resources Bangladesh 2024).

A defining feature of PaCT is its multi-stakeholder structure, which brings together global apparel brands, manufacturers, and financial institutions. In 2016, VF Corporation, a global branded lifestyle apparel, footwear, and accessories company headquartered in Denver, Colorado, USA, joined PaCT alongside 12 other international brands (VF Corporation 2016). Under this partnership, IFC and VF Corporation committed to enhancing the long term competitiveness and sustainability of the textile wet

processing sector by reducing excessive groundwater extraction and surface water pollution, as well as energy and chemical use. PaCT engages VF's supplier factories through a structured 3-tiered approach:

- Awareness building on water, energy, chemicals, and process efficiency
- Basic cleaner production (CP) assessments to identify no and low cost efficiency measures
- In depth CP assessments providing factory level technical recommendations, technology adoption support, and strengthening of water and energy management systems, alongside facilitation of financing for capital-intensive interventions (VF Corporation, 2016)

Since its inception, PaCT has worked with over 450 textile and ready-made garment (RMG) factories in Bangladesh, supporting the adoption of measures such as process optimization, water recycling and reuse, installation of energy-efficient boilers and motors, waste-heat recovery, improved chemical management, and on site renewable energy.

The program has delivered significant, measurable gains in resource efficiency at scale. Participating factories collectively save approximately:

- 35 billion liters of freshwater per year
- 29 billion liters of wastewater discharge
- 3.8 million megawatt per hour (MWh) of energy annually and
- ~723,617 tons of CO₂-equivalent emissions per year

These interventions have also catalyzed ~USD 168.8 million in resource efficiency investments across 488 factories. IFC estimates that these savings are equivalent to meeting the annual water needs of more than 1.9 million people and removing ~160,000 cars from the road each year. Building on these outcomes, the next phase of PaCT is expected to focus on circularity and deeper decarbonization across the textile value chain, indicating a shift from

efficiency-led improvements to system-level transformation (Apparel Resources Bangladesh 2024; The Business Standard, 2025).

The PaCT programme demonstrates the importance of combining technical assistance, investment facilitation, and buyer engagement to drive resource efficiency at scale within textile clusters. For Ludhiana, a similar cluster-level model could help MSMEs identify bankable green investments through technical diagnostics, cleaner production assessments, and implementation support. The program also highlights the role of global brands in creating demand for sustainability-linked investments across supplier networks. For financial institutions, such approaches can improve the quality of project pipelines, reduce information gaps, and lower climate-related credit risks by improving operational efficiency and resilience among MSME borrowers.

4.2 | Bangladesh: Green Transformation Fund (GTF)

The Green Transformation Fund (GTF), launched in 2016 by Bangladesh Bank, is a central bank-led refinancing mechanism designed to address structural financing barriers to the green transition in the export-oriented textile and leather industries. With an initial corpus of USD 200 million, the fund provides long-tenor foreign currency financing, typically 5–10 years with a one-year grace period, through scheduled commercial banks, which on-lend to eligible firms for the import of green capital machinery and equipment (ICLEI South Asia, 2020).

Unlike conventional lending, the GTF is structured to address two critical constraints faced by textile exporters directly:

- Limited access to long-tenor, low-cost foreign currency finance for capital-intensive green investments; and
- High risk perception among banks, particularly for unfamiliar or technology-intensive sustainability investments

To mitigate these constraints, Bangladesh Bank provides refinancing to participating banks at highly concessional rates (approximately 1–2%), enabling end borrowers to access financing at capped

interest rates of around 5%, which are significantly below prevailing commercial lending rates of over 10%. This blended structure effectively reduces both firms' cost of capital and banks' credit risk exposure.

Institutionally, the fund is managed through a dual structure: the Sustainable Finance Department oversees project approvals and eligibility, while the Forex Reserve and Treasury Management Department handles disbursement and monitoring (ICLEI South Asia 2020). This separation ensures both technical scrutiny and financial discipline in deployment. The GTF supports a wide range of eligible investments aligned with resource efficiency and environmental performance, including (ICLEI South Asia 2020):

- Water-use efficiency and wastewater management in wet processing;
- Energy efficiency and renewable energy adoption
- Resource recovery, recycling, and waste management
- Heat management, ventilation, and workplace environment improvements

The scope of the fund has evolved. In 2019, eligibility was expanded beyond textiles and leather to include other manufacturing exporters, accompanied by an additional €200 million window. This Euro-denominated component also enabled financing for industrial raw materials alongside green

machinery, broadening its relevance across manufacturing segments.

To complement foreign-currency lending, Bangladesh Bank introduced a USD 410 million (Tk 5,000 crore) local-currency refinancing facility in December 2022, addressing exchange-rate risks and expanding access for firms with domestic revenue exposure. As of September 2023, cumulative disbursements under the GTF reached USD 140.94 million and €71.21 million. By March 2025, total disbursements had increased to approximately USD 147 million (Tk 1,800 crore), channeled to 63 clients through 20 participating banks, indicating sustained uptake and operational viability (The Business Standard 2025).

The GTF provides an example of how central bank-led refinancing mechanisms can address structural financing barriers to the green industrial transition. For Ludhiana, similar refinancing or credit enhancement structures through institutions such as SIDBI or NABARD could improve MSME access to long-term, lower-cost capital for climate-aligned investments. The standardized framework for eligible green investments also provides clarity for lenders and borrowers. For financial institutions, concessional refinance mechanisms can reduce perceived lending risks, diversify portfolios into green assets, and support alignment with emerging climate-risk and sustainable finance frameworks.

4.3 | Vietnam: Vietnam Improvement Program

The Vietnam Improvement Program (VIP), implemented by IFC since 2015, represents an integrated model that combines technical assistance with facilitated financing to support

resource efficiency and decarbonization in the textile and garment sector. The Clean Technology Trust Fund and the Korean Green Growth Trust Fund support the program.

It is designed to address fragmentation in industrial supply chains by aggregating demand for resource efficiency investments across firms.

A key feature of VIP is its brand-linked, supply chain approach, which engages global apparel companies and their supplier networks to drive adoption of cleaner production practices. By aligning factory-level interventions with buyer expectations, the program creates both demand and accountability for sustainability investments. In 2019, VIP was expanded to include 70 factories supplying major global brands such as VF Corporation, Target, Puma, New Balance, and Adidas. Through targeted interventions in water, energy, and chemical use, participating firms collectively achieved operating cost savings of approximately USD 24 million, demonstrating the commercial viability of resource-efficiency investments (Just Style, 2019).

Since then, IFC's industrial resource efficiency and clean energy team has extended the program's reach to 112 facilities. These facilities have received detailed technical diagnostics and implementation support across a range of interventions, including:

- Process optimization and no-cost/low-cost efficiency improvements
- Installation of energy-efficient boilers, motors, and process equipment
- Wastewater recycling and reuse systems
- Adoption of rooftop solar and other clean energy solutions

These interventions have been supported by over USD 51 million in financing facilitated by

IFC and its partner financial institutions (as of July 2023), highlighting VIP's role in bridging the gap between technical advisory and bankable investment pipelines (IFC, 2020).

At the firm level, the case of Phong Phu International (PPJ) illustrates the depth of impact achievable through this model. As a large supplier with 20 factories and approximately 14,000 workers, PPJ implemented a combination of process and technology upgrades under VIP. These included replacing low-efficiency boilers, recycling up to 80% of wastewater, and adopting advanced manufacturing technologies such as laser-based finishing and ozone washing systems. As a result, the company reduced annual energy consumption by nearly 7 million kilowatt-hours and water use by approximately 200,000 cubic meters, generating cost savings of around USD 700,000 per year (Just Style, 2019).

Vietnam's VIP demonstrates how buyer-linked transition programs can align MSME investments with evolving global value chain requirements. For Ludhiana, integrating financing with buyer expectations and ESG compliance requirements can strengthen incentives for adopting cleaner production technologies and improve export competitiveness. The model also shows the importance of combining technical diagnostics with financing facilitation to generate bankable projects. For financial institutions, stronger alignment with buyer-driven sustainability requirements can reduce transition risks related to market access, compliance pressures, and stranded assets in textile portfolios.

4.4 | Cambodia: Switch Garment

Cambodia's Switch Garment program (also known as the Promotion of Sustainable Energy Practices) represents a catalytic, ecosystem-building model for enabling green transition in the textile and garment sector. Implemented between May 2019 and April 2023 (with impact tracking extending into early 2024), the program was funded by the European Union under the SWITCH-Asia initiative and executed by a consortium led by GGFI, in partnership with Geres and the Garment Manufacturers Association in Cambodia (GMAC), in close coordination with government ministries (SWITCH-Asia Programme, 2021).

A distinguishing feature of the program is its role as an enabler of market development rather than a direct financier. It focused on addressing structural barriers to the adoption of energy-efficiency and renewable-energy solutions in garment factories, particularly limited awareness, weak project pipelines, and limited access to tailored financing.

The program adopted a phased approach combining technical assistance, institutional engagement, and financing facilitation. It began with baseline assessments and energy audits to identify investment opportunities and build awareness among factories and financial institutions. This was followed by targeted advisory support to approximately 50 garment factories, focusing on identifying and structuring viable investments in energy efficiency measures, such as compressed air systems and efficient lighting, as well as renewable energy solutions, particularly rooftop solar (SWITCH-Asia Programme, 2021).

To address financing constraints, the program worked closely with financial institutions to develop and align financing solutions for green investments. It also introduced tools such as the Model Green Factory Program (MGFP), which helped standardize sustainability practices, create demonstration effects, and improve the bankability of projects. Parallel policy engagement contributed to strengthening Cambodia's broader energy efficiency and climate policy ecosystem (SWITCH-Asia Programme 2021).

By the final phase, the program had translated these interventions into measurable outcomes. A total of 22 factories invested approximately USD 2.63 million in sustainable energy solutions, contributing to an estimated reduction of 5,734 tCO₂e by early 2024. Importantly, several additional factories adopted no-cost and low-cost efficiency measures, indicating wider behavioral shifts beyond directly financed investments (SWITCH-Asia Programme, 2021).

The Cambodia model underscores the importance of ecosystem-building interventions in early-stage green transitions. Cluster-wide audits, demonstration projects, and financing facilitation helped raise awareness, improve project pipelines, and attract private capital. For Ludhiana, similar approaches could help standardize sustainability practices and strengthen the enabling ecosystem for green finance. For financial institutions, these measures can improve data availability, reduce information asymmetries, and strengthen confidence in financing climate-aligned MSME investments.

4.5 | Tamil Nadu, India

Good Fashion Fund (GFF): Sri Kannapiran Mills

In addition to international examples, the Good Fashion Fund (GFF) provides a domestic illustration of blended finance-led industrial transition, targeting resource-intensive segments of the textile value chain. Initiated by Fashion for Good in collaboration with the Laudes Foundation, The Mills Fabrica, and FOUNT (fund manager), with Rabobank as a lending partner, the fund deploys long-term, USD-denominated debt alongside technical, environmental, and social expertise to textile manufacturers in Asia. With a blended capital structure and a fund size of approximately USD 19 million, GFF is designed to finance “impact equipment” that simultaneously enhances operational efficiency and environmental performance (Indian Textile Journal, 2023).

A notable investment under this model is the USD 2.5 million loan extended to Sri Kannapiran Mills in Tamil Nadu in 2023. The financing supported modernization across spinning and denim manufacturing units (KG Naidu Mill, Balaji Mill, and KG Fabriks), enabling the replacement of legacy systems and the deployment of advanced machinery, including auto blenders, high-speed rotor spinning machines, auto doffers, and high-speed winding systems. These upgrades targeted efficiency improvements across both pre- and post-spinning processes (Indian Textile Journal, 2023)

The investment demonstrates measurable environmental, social, and financial outcomes, underscoring the effectiveness of impact-oriented financing. As of Q2 2025, GFF-supported interventions delivered up to a 59% reduction in energy consumption

(approximately 886,439 kWh annually), a 95% reduction in cotton waste (approximately 4,756 kg annually), and emissions savings of around 1,272 tonnes of CO₂. Social outcomes include improved worker safety through automation (e.g., doffing), as well as strengthened environmental and social governance systems, grievance redressal mechanisms, and occupational health and safety practices (Good Fashion Fund 2025). From a financial perspective, the firm realized approximately USD 140,000 in annual savings from energy and waste efficiencies and an additional USD 115,000 from improved weaving productivity. These gains were accompanied by increased production capacity, with output reaching approximately 220,000 meters per month following the installation of additional air-jet looms (Good Fashion Fund 2025).

Importantly, GFF's model goes beyond capital provision by integrating technical assistance, ESG performance frameworks, and rigorous due diligence, thereby improving both the bankability and sustainability of investments. This is particularly relevant for small and medium-sized enterprises (SMEs) operating in deeper tiers of the textile value chain, which are often the most resource-intensive but remain undercapitalized and underserved by traditional financing and brand-led sustainability initiatives.

The GFF case demonstrates the role of blended finance and impact-oriented lending in supporting technology modernization within resource-intensive textile operations. For Ludhiana, integrating technical assistance, ESG due diligence, and long-term

financing could help MSMEs adopt cleaner, more efficient production technologies and improve operational performance. The model also illustrates how measurable efficiency gains can strengthen repayment capacity and investment viability. For financial institutions, this can reduce operational and transition risks by improving borrower resilience, strengthening ESG performance, and enhancing the overall quality of green lending portfolios.

Across Bangladesh, Vietnam, Cambodia, and India, a consistent set of design principles emerges to enable a climate-aligned transition in MSME-dominated textile clusters. These examples demonstrate that financing alone is insufficient; instead, effective models combine technical diagnostics, demand aggregation, and

institutional coordination to create a pipeline of bankable green investments. They also highlight the importance of de-risking mechanisms, including concessional refinancing, blended finance structures, and anchor support from brands or public institutions, to address MSME constraints related to high upfront costs and limited access to long-term capital. Importantly, aligning financing with global value chain requirements and regulatory drivers helps create sustained demand for cleaner production.

Together, these approaches point to a cluster-level transition model in which finance, technical assistance, and ecosystem partnerships operate in tandem to enable scalable, commercially viable adoption of resource-efficient, low-carbon technologies.

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05

RECOMMENDATIONS: PRIORITY PILLARS FOR CLUSTER-LEVEL TRANSITION

Previous sections of this report demonstrate that the physical and transition risks are translating into material financial risks for financial institutions lending to the Ludhiana knitwear cluster. On the other hand, the existing ecosystem (which remains fragmented at the cluster level) is unable to mediate a response at the required scale and speed. Successful international interventions and models converge on three design features: (a) aggregating MSME demand into investable pipelines, (b) integrating technical assistance with finance, and (c) standardizing investment categories and disclosures. In this context, it is evident that Ludhiana's knitwear cluster requires a coordinated, cluster-level financial architecture built on these features.

This section of the report presents recommendations to address these challenges, based on the success parameters of the previously outlined international case studies. Three reinforcing pillars are set out to deliver this architecture, each based on a cluster-level intervention. Pillar 1 anchors the cluster-level financing facility; Pillar 2 focuses on building an investable project pipeline; and Pillar 3 works to enable awareness, capacities, and coordination to sustain both.

Together, they are intended to shift the response from generic MSME finance instruments to a coordinated architecture built around the structural characteristics of the Ludhiana knitwear cluster.

Figure 4 Priority pillars for a cluster-level transition



5.1 | Pillar 1: Cluster Green Transformation and Resilience Facility

The existing government schemes provide important but fragmented support, including credit guarantees and concessional energy efficiency lines. However, the existing landscape lacks a dedicated, cluster specific, and climate-aligned financing architecture comparable to Bangladesh's GTF, particularly one that can address the combined challenges of cost, tenor, risk, and data standardization for MSME borrowers.

To address existing gaps, a dedicated Ludhiana Knitwear Green Transformation and Resilience Facility is proposed as a cluster-level financing anchor, designed to aggregate demand, reduce financing costs, enable risk-aligned lending, and standardize climate-linked investments and reporting frameworks. This facility could be anchored by NABARD/SIDBI and capitalized through a mix of domestic and international climate finance sources, including Multilateral Development Banks (MDBs) and the Green Climate Fund via SIDBI, creating a scalable

platform to channel green capital into MSME clusters. Importantly, the facility is conceptualized not only as a refinancing mechanism but also as an integrated financing architecture that combines capital, risk-sharing, and a cluster-level data and standards backbone.

The facility can be conceptualized around core functions, including cost reduction, targeted deployment, risk mitigation, and data and disclosure enablement, addressing the financial and structural barriers identified in the study.

1. Cost and tenor alignment

This would involve establishing refinance window(s) for participating banks and NBFCs and offering long-term (5-10-year) funding at concessional rates, thereby addressing the mismatch between MSME investment horizons and conventional lending structures.

2. Targeted deployment for climate-relevant investments

Financing would be directed toward standardized, taxonomy-aligned capex categories in MSME knitwear units, including:

- Water efficient dyeing and finishing, CETP (Common Effluent Treatment Plant), ETP (Effluent Treatment Plant), and ZLD (Zero Liquid Discharge) connections
- High efficiency, low emission boilers and thermic systems
- Rooftop solar and energy efficiency upgrades
- Ventilation, insulation, and workplace heat stress mitigation
- Basic flood resilience investments (elevating equipment, drainage)

3. Risk mitigation and credit enhancement

Existing guarantee mechanisms, such as CGTMSE and CGSSD, would need to be integrated with enhanced coverage and preferential pricing for climate-aligned investments. This would reduce perceived credit risks and enable greater lender participation.

Stakeholder consultations with financial institutions further highlight structural constraints in extending credit for climate-aligned investments. Lenders noted the need for lower-cost capital, particularly for smaller-ticket investments such as pollution control equipment (e.g., chimney filters), which are currently difficult to finance under prevailing terms. In addition, the absence of tangible primary collateral poses a key constraint, as such assets are often embedded within factory infrastructure and cannot be easily

repossessed or liquidated in the event of default.

In this context, stakeholder consultations also validated the strong case for integrating dedicated risk-sharing mechanisms, drawing on models such as the PRSF, implemented by SIDBI with support from the World Bank. This approach has been instrumental in unlocking lending for energy efficiency projects by improving bankability, standardizing transactions, and enabling participation from banks and NBFCs that would otherwise be constrained by risk considerations (SIDBI 2023a).

Adapting a similar mechanism within the proposed facility could significantly strengthen lender confidence, particularly for first-of-a-kind or non-collateralized climate investments in MSME clusters, while ensuring that risk is shared across public and private stakeholders.

4. Embedded data, standards, and disclosure framework

To address the lack of standardized climate data and reporting mechanisms, the facility would incorporate cluster-level data and a standards backbone as core design features. This would include:

- A tiered checklist-based 'green factory standard' for MSMEs covering key parameters such as energy, water, emissions, heat stress, and waste, co-developed with industry and technical partners
- A centralized data and reporting platform capturing baseline and post-investment performance metrics (kWh, m³, tCO₂e), enabling FIs to build climate-tagged MSME portfolios and meet RBI disclosure

requirements. This would also enable buyers to comply with BRSR Core value chain requirements and policymakers to track cluster-level transition progress

- Direct linkage between performance and finance, where compliance with the cluster standard (and ZED certification where applicable) becomes an eligibility criterion for concessional finance, guarantees, and subsidies

Crucially, this embedded standard approach operationalizes the proportionality principle under India's draft climate finance taxonomy, allowing MSMEs to comply through simplified, standardized, and cluster-level reporting mechanisms rather than complex firm-level disclosures.

5. Alignment with regulatory and taxonomy frameworks

The facility can be designed to embed climate risk disclosure and taxonomy alignment within its core architecture. This would involve standardizing eligible investment categories, reporting templates, and performance metrics in line with emerging RBI draft disclosure norms and India's climate finance taxonomy, thereby enabling participating FIs to classify exposures as climate-aligned without incurring significant additional reporting or data-collection costs.

By combining concessional refinancing, risk sharing, standardized investment categories,

and a cluster-level data infrastructure on a single platform, the facility addresses the core financial and informational constraints faced by MSMEs. This transforms the facility from a narrow financing instrument into a full-stack transition mechanism, aggregating small-scale investments, enabling disclosure compliance, and creating an investment-grade pipeline at the cluster level. This approach directly adapts and extends the GTF model to the Indian context, incorporating data, disclosure, and proportionality considerations relevant to Ludhiana's MSME ecosystem.

The implementation of a cluster-anchored facility in Ludhiana is feasible within existing Indian institutional structures. NABARD and SIDBI have established track records of operating concessional and blended finance instruments for MSMEs, providing established channels for international climate finance. Both entities are natural anchor candidates, with capital being sourced through India's emerging green finance pool. Risk-sharing mechanisms through the expanded CGTMSE/CGSSD coverage may also be leveraged. Key implementation considerations would include governance design and inter-ministerial coordination among the Ministry of Finance, the Ministry of Textiles, and the Ministry of MSMEs, as well as the development of cluster-level eligibility criteria that operationalize the proportionality principle.

5.2 | Pillar 2: Project Pipeline Development and Investment Facilitation

Unlike Bangladesh and Vietnam, Ludhiana lacks a structured, programmatic mechanism to translate climate risks into bankable investments, particularly one that integrates factory-level technical assistance with access to finance and market demand signals. As a result, even where viable technologies and financing schemes exist, the absence of a credible project pipeline remains a binding constraint for both MSMEs and lenders.

This gap can be addressed through a cluster-level project pipeline development and investment facilitation mechanism, drawing on the core design features of IFC's PaCT and Vietnam Improvement Program. This can be structured around three reinforcing functions – diagnose, de-risk, and deliver – to systematically convert climate risks into investable opportunities.

1. Diagnose: Standardized technical audits and investment planning

Conduct cluster-wide, standardized audits across knitwear and downstream processing units, covering energy, water, chemicals, heat stress, and pollution. These audits would generate investment-grade DPRs and pre-validated technology pathways, creating a pipeline of bankable projects similar to PaCT in Bangladesh and VIP's facilities in Vietnam.

Stakeholder consultations further indicate that existing adoption of cleaner technologies and infrastructure within the cluster is largely concentrated among a small subset of larger firms. As a result, current assessments of technology penetration and environmental performance may not

accurately reflect the conditions of the broader MSME base, which is predominantly composed of small and micro units. This creates a risk of overestimating baseline readiness and underestimating the scale of investment and support required. A standardized, cluster-wide diagnostic approach is therefore critical to generate representative data and ensure that investment pipelines are aligned with the actual needs and capacities of MSMEs.

2. De-risk: Brand and buyer alignment to anchor demand

Engage with leading domestic and international brands sourcing from Ludhiana to jointly signal demand for environmental improvements, thereby strengthening the business case for MSME investments and encouraging wider adoption of sustainable practices. As seen in PaCT and VIP (with brands such as VF, Target, Puma, and others), buyer alignment can reduce market uncertainty and enhance the creditworthiness of investments.

3. Deliver: Integration with financial institutions and schemes

Establish direct links with SIDBI, local banks, and existing financing lines (SIDBI's JICA EE scheme, SIDBI 4E, and the proposed cluster facility under Pillar 1), ensuring that identified projects are seamlessly routed into pre approved financing channels with concessional terms and standardized appraisal frameworks.

The MDB-IDFC Common Principles classify adaptation finance investments into three project types—Type 1, Type 2, and Type 3. Regardless of the project type, the process begins with a climate risk assessment, such as vulnerability mapping, hazard analysis, or another diagnostic exercise, to identify the relevant physical climate risks (e.g., heat stress, flooding, or drought) at the project location. While this assessment is a prerequisite for adaptation finance, it is common to all three project types and does not, in itself, determine the classification of an investment.

Type 1 refers specifically to investments that would proceed regardless of climate considerations — a standard piece of infrastructure or industrial asset — where the design is adapted, or the asset is retrofitted, to withstand an identified risk. In the Ludhiana cluster, this includes MSME factory buildings, industrial sheds, and internal access roads within industrial areas adapted through measures such as elevated floor levels to reduce flood risk, heat-resistant roofing or paving materials, improved site-level drainage, or re-orientation of structures based on local flood and heat-stress mapping. It also includes retrofits to existing factory operations to manage heat risk, such as process cooling and ventilation upgrades and energy-efficient cooling systems installed to reduce occupational heat stress, as well as urban greening and shade-creation measures within industrial estates (e.g., tree cover, shaded walkways, reflective or permeable paving) that reduce ambient and surface temperatures. Alternatively, where the investment itself is not physically modified, obtaining climate risk insurance tailored to the identified hazard is itself treated as the

adaptation measure. The adaptation finance component typically represents a smaller share of total investment or project cost, indicatively around 15%.

Type 2 investments comprise MSME projects in the Ludhiana cluster where the primary objective is another business driver—such as production economics, inventory management, or efficiency— and climate adaptation is an explicit secondary objective designed into the investment from the outset. In the Ludhiana textile context, this includes machinery upgrades that improve water-use efficiency in production, such as low-liquor-ratio dyeing machines or air-jet looms, where the primary driver is input-cost reduction and competitiveness, with reduced exposure to water scarcity risk as a secondary, explicitly designed-in benefit. It also includes new raw material or finished-goods storage and warehousing facilities — for yarn, cotton, wool, or finished textile stock — where the primary objective is inventory management and business continuity, and climate-resilient design features (such as moisture and humidity control, or flood-resilient siting) are built in to protect stock from increasingly erratic rainfall and humidity. Because adaptation is a documented secondary objective rather than an incidental feature, a larger share of project cost — indicatively around 50% — can typically be attributed to climate resilience, though this will vary by project.

These investments are well suited to blended finance mechanisms combining technical assistance with concessional and commercial capital, including SIDBI's JICA Energy Efficiency Line of Credit, the SIDBI 4E Programme, and the proposed Ludhiana MSME Cluster Transition Facility under Pillar 1. The MSME GIFT Scheme may also

be relevant, subject to confirmation of its continuation beyond FY2025–26.

Type 3 investments are those where climate adaptation and resilience is the primary objective — the investment would not otherwise be made but for the climate risk. Under the MDB-IDFC Common Principles, up to 100% of investment cost may qualify as adaptation finance, subject to the three-step methodology: a demonstrated climate risk context, an explicit adaptation objective, and a clear link between the identified risk and the financed activity. In the Ludhiana cluster, this includes industrial water recycling and reuse systems built principally for long-term water security, climate-resilient CETP/ETP upgrades and connectivity to ZLD systems where resilience is the principal driver, flood-resilient drainage and stormwater infrastructure, dedicated worker-cooling facilities and cool-roof retrofits installed primarily to manage heat stress, and cluster-level early warning systems and climate risk information platforms. These are well suited to adaptation-focused concessional finance, including resilience credit lines through SIDBI along with the concessional facility under FMAP.

Importantly, Pillar 2 is designed to operate in close coordination with the proposed cluster-level financing facility under Pillar 1. While the facility addresses constraints

on capital supply, this program focuses on generating a steady pipeline of investment-ready projects that can be financed through it. In this architecture, the advisory-led program performs the critical function of converting dispersed MSME demand into standardized, bankable opportunities, which are then aggregated and financed through the facility's refinance and risk-sharing mechanisms. This separation of functions - pipeline development and capital deployment - ensures both scalability and efficiency, while maintaining clear institutional roles across technical partners and financial institutions.

Implementation in Ludhiana can build on existing institutional capacity. The cluster's active business membership organizations (the Knitwear Club and APPEAL) already perform aggregation functions and may serve as delivery partners. Direct supplier relationships with global brands can provide immediate demand and domestic technical advisory capacity across programs such as the Green Indian Financial Systems Initiative (GIFS Initiative). The key implementation considerations would include a coordinating institution (SIDBI or Ministry of Textiles working through technical agencies) and ensuring that brand commitments translate into binding purchasing preferences rather than remaining voluntary.

5.3 | Pillar 3: Awareness, capacity-building, and coordination for credible transition pathways

Experiences from Bangladesh, Vietnam, Cambodia, and the Good Fashion Fund (GFF) consistently highlight that the availability of financing alone is insufficient to drive transition outcomes. Instead, information

asymmetries, capacity constraints, and coordination failures among stakeholders often bind, particularly in MSME-dominated clusters.

In Ludhiana, these challenges manifest as limited awareness of climate risks and financing options among MSMEs, limited institutional capacity within financial institutions to appraise such investments, and weak alignment between buyers, producers, and financiers. Stakeholder consultations further reveal persistent awareness gaps on both the demand and supply sides. MSMEs, particularly small and micro units, often lack familiarity with cleaner, advanced technologies, their associated costs and benefits, and available financing mechanisms. At the same time, lenders face capacity constraints in evaluating such investments. Financing remains a critical bottleneck for MSMEs, especially smaller firms, where limited awareness and technical understanding restrict access to appropriate financial products. As a result, even technically viable and financially feasible investments face delays or limited uptake.

Addressing these constraints requires a structured, cluster-level approach that focuses on informing stakeholders, enabling capability, and aligning incentives across the ecosystem.

1. Inform: Targeted MSME awareness and outreach

Implement cluster-wide awareness programs and on-site advisory support to build understanding of:

- Localized climate risks
- Emerging compliance requirements
- Available financing instruments and government schemes
- The business case for resource efficiency and resilience investments

2. Enable: Capacity-building for financial institutions and intermediaries

Strengthen the ability of banks, micro-finance institutions (MFIs), and NBFCs to identify, appraise, and scale climate-aligned MSME lending through:

- Training in standardized audit frameworks, technology benchmarks, and risk assessment tools
- Development of internal appraisal templates aligned with Pillar 2 pipelines and Pillar 1 standards
- Exposure to domestic and global case studies to improve institutional confidence and understanding of green MSME lending

3. Align: Stakeholder coordination and market signaling

Create structured engagement platforms that bring together MSMEs, financial institutions, brands, and policymakers to:

- Align on sustainability expectations and investment priorities
- Strengthening demand signals from buyers, reducing market uncertainty
- Facilitate co-development of financing solutions and implementation pathways with Pillar 1 facility stakeholders

4. Institutionalize knowledge through cluster platforms

Develop accessible, standardized knowledge products and tools (e.g., technology guides, cost-benefit calculators, financing pathways) hosted by industry associations and cluster bodies to support continuous learning and replication across MSMEs.

This pillar serves as the enabling layer that ensures the effectiveness of the broader transition framework. While Pillars 1-2 address structural constraints in finance, pipeline, and data, this pillar ensures that these mechanisms translate into actual adoption at the firm level.

Implementing this pillar in Ludhiana would be coordination-intensive. The infrastructure for outreach already exists through organizations such as:

- The Knitwear Club and APPEAL: to provide MSME-facing channels
- SIDBI and NABARD: which operate established capacity building interventions for FIs
- NIFT and NITRA: which provide sector-specific accredited technical training

A key consideration is ensuring coordination among these entities to implement this recommendation meaningfully. The Punjab Pollution Control Board and the Ministry of Textiles can also serve as regulatory anchors for stakeholder coordination. Other important considerations that would guide implementation include designing for institutional continuity beyond initial funding and grounding capacity building in the realities of MSME participation (short, frequent training sessions tied to immediate operational gains/benefits rather than abstract sessions that smaller firms cannot afford to attend). Given the low capital intensity, this pillar can be initiated quickly, while the financial and pipeline pillars are still being developed.





Image Courtesy:

The analysis of Ludhiana's knitwear cluster highlights a fundamental shift from viewing climate risks as external pressures to recognizing them as core drivers of financial performance and competitiveness for MSMEs and their lenders. While India's existing policy and financing ecosystem provides important building blocks, it remains fragmented, sector-agnostic, and insufficiently aligned with the specific risk profiles and structural characteristics of MSME clusters. At the same time, global experience demonstrates that effective transition pathways in textile clusters are

not driven by isolated interventions, but by integrated systems that combine finance, technical support, data infrastructure, and market alignment.

Taken together, the three pillars outlined in this section, spanning targeted finance, pipeline development, and stakeholder coordination, provide a coherent pathway to transition Ludhiana's knitwear cluster from a fragmented, compliance-driven approach to a systematic, investment-led model of climate resilience and competitiveness. This integrated framework addresses

both supply- and demand-side constraints that currently limit the uptake of green investments.

Importantly, this approach enables the cluster not only to manage emerging climate risks but also to unlock new sources of capital, strengthen buyer relationships, and future-proof its role within increasingly sustainability-linked global value chains. It also aligns with emerging regulatory expectations in India, including climate risk disclosures, value chain reporting, and the principle of proportionality under the evolving climate finance taxonomy, while anticipating future market shifts such as carbon-linked trade measures and supply chain due diligence requirements.

For financial institutions, this implies a shift from reactive risk management to proactive portfolio alignment, where MSME clusters such as Ludhiana are viewed not merely as risk exposures but as strategic opportunities

for climate-aligned lending and portfolio diversification. For MSMEs, it provides a pathway to access more appropriate and affordable capital, improve operational efficiency, and remain competitive in evolving export markets. While grounded in the specific context of Ludhiana, this framework has broader applicability across India's textile and MSME clusters, particularly those facing similar combinations of physical risks, regulatory pressures, and market transitions.

Ultimately, enabling this transition will require coordinated action across policymakers, financial institutions, industry associations, and global partners. By aligning incentives, reducing structural barriers, and strengthening institutional capacity, India can unlock scalable green finance flows into MSME clusters, supporting not only climate resilience and decarbonization but also long-term industrial competitiveness and inclusive growth.



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