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सत्यमेव जयते

भारत सरकार
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FOREWORD

India's textile and apparel (T&A) sector occupies a distinctive place in the country's economic, cultural and social landscape. Built upon centuries of craftsmanship and innovation, it continues to support millions of livelihoods while contributing significantly to manufacturing, exports and employment, driving sustainable industrial growth and strengthening India's position in global value chains.

While circularity has gained prominence as a global imperative, its underlying philosophy has long been embedded in India's traditional knowledge systems. What is today articulated through the 9R framework of the circular economy finds resonance in time-honoured textile practices such as rafugari, kantha embroidery and khesh weaving, where repairing, repurposing, reusing and extending the life of textiles have been integral to both craft traditions and community life. These practices reflect an enduring ethos of resource stewardship and demonstrate that sustainability has long been woven into India's textile heritage. As international markets increasingly emphasise sustainability, traceability and responsible production, circular economy principles present significant opportunities to enhance both environmental stewardship and economic competitiveness through circular product design, sustainable material innovation, digital traceability, efficient resource management, recycling technologies and responsible end-of-life solutions.

The tenth edition of the Journal on Circular Economy, devoted to the theme Circular Textiles: Designing India's Sustainable Textile Future, makes a timely and valuable contribution to this important agenda. The articles in this volume explore key dimensions of the circular textile ecosystem, including sustainable fibres, circular product design, digital technologies for traceability and transparency, textile waste management, recycling technologies and innovative circular business models. Collectively, they demonstrate how policy, technology, research and industry can work in concert to advance resource efficiency, innovation and sustainable growth across the textile value chain.

I commend the International Council for Circular Economy (ICCE), the editorial board, contributing authors and partner institutions for bringing together this valuable publication. By fostering informed dialogue and disseminating practical knowledge, it complements the Government's efforts to promote sustainability, innovation and resource efficiency within the textile sector. I am confident that this special edition will serve as a valuable reference for policymakers, industry, academia and researchers, while supporting India's continued journey towards a globally competitive, innovative and circular textile economy.

I extend my best wishes for the successful release of this special edition.

Arti Kanwar

(Arti Kanwar)

SHALINI GOYAL BHALLA

Managing Director
International Council for Circular Economy

Editor's

NOTE

It gives me immense pleasure to present the tenth edition of ICCE's Journal on Circular Economy, a publication that has steadily grown into a respected and prestigious voice in the circularity discourse. This edition, dedicated to the theme of textiles, comes at a particularly important moment and will be released during Bharat Tex in New Delhi.

India's textile sector stands at the intersection of tradition, livelihoods, global trade and industrial transformation. The Government of India's 5F vision — Farm, Fibre, Factory, Fashion and Foreign provides a powerful framework to reimagine the sector not only for scale and competitiveness, but also for sustainability and circular transition.

Circularity can strengthen each stage of this value chain. At the farm level, it can promote regenerative practices, responsible fibre cultivation and better resource use. At the fibre and factory stages, it can drive material innovation, recycling, cleaner production, waste reduction, traceability and resource efficiency. In fashion, it can encourage design for durability, repair, reuse and recyclability and in foreign markets, circular credentials can become a strong driver of export competitiveness, market access and global leadership. This edition brings together valuable insights from authors, researchers,

practitioners and contributors who have examined textile circularity through diverse lenses — from materials and business models to recycling systems, policy frameworks, informal value chains and green skills. The Bharat Tex concept note also emphasises circular design, sustainable materials, Digital Product Passports, traceability, circular business models, green skills and cross-border collaboration as core priorities for the sector's transition.

I extend my sincere thanks to the Ministry of Textiles for its encouragement and support, to our co-editor for shaping this edition with care and commitment, to all the authors and contributors for enriching the journal with their knowledge, and to the dedicated ICCE team for making this release possible.

As India advances its 5F priority, the textile sector has the potential to become a global example of how circular economy principles can create value, reduce environmental impact, strengthen livelihoods and position the country as a leader in sustainable industry.

Happy reading.

GIRIJA JHA

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Guest Editor's NOTE

Namaste!

This special issue on "Textiles of Tomorrow: Circularity, Innovation & the Sustainable Future of Fashion," captures the essence of sustainability in the Apparel Industry through multipronged approach of Material Innovation, Circular Business Models and Recycling. Today's textile happens to be yesterday's 'textiles of tomorrow' and has evolved with the confluence of innovation and traditional know-how. When in the past we imagined textiles of the future, little did we imagine fast fashion and slow fashion coexisting, alternate sustainable textile materials and unsustainable linear business models sharing the manufacturing spaces.

Material Innovation for integration of sustainability includes gamut of approaches spanning from spinning innovative bio-based fibres, smart textiles, regenerative materials, to resurrecting traditional materials like lotus silk, banana fibre etc.

Circular Business Model is the key driver as take-make-waste economy cannot be sustained. As the clock ticks, anthropogenic climate change requires critical climate action.

Novel models like resale, rental, take-back systems, 20-wear challenge etc. are gaining mass popularity not only on social media but in the real life as well.

Recycling and Scale up using mechanical, enzymatic and chemical recycling processes play a colossal role. DPP, Digital Product Passport and readiness and conformance to global standards like EU compliance opens up a plethora of opportunities for the apparel sector.

The World Bank's report "What a Waste 3.0", presents a global Snapshot of Solid Waste Management towards Circularity until 2050. Government initiatives like India's new Solid Waste Management Rules 2026 including Plastic Waste Management (Amendment) Rules, 2026 are a timely move in the right direction. As we engage in discussion, share our thoughts and strive to act, we are weaving the 'textiles of tomorrow' which are leaner, cleaner and greener.

READERS' SAY

Amit Dubey
Madhya Pradesh

The journal's diversity of themes and contributors, especially the insightful Tête-à-Tête with Mr. Shivam Verma, Municipal Commissioner of Indore, adds tremendous value to policymakers and practitioners alike. I look forward to future editions and continued engagement with ICCE's impactful work.

This dedicated journal on the circular economy published by the International Council for Circular Economy plays a vital role in advancing knowledge, policy, and practice in sustainable development. It serves as a credible platform for researchers, policymakers, industry leaders, and practitioners to share evidence-based insights on circular economy principles, resource efficiency, waste reduction, and regenerative economic models. By showcasing cutting-edge technologies, innovative circular business models, and progressive financial mechanisms, the journal stimulates innovation and supports systemic circular transitions. A must-read resource for stakeholders committed to sustainable and inclusive growth, it serves as a vital global knowledge infrastructure, accelerating the shift from linear to circular economic models across regions and sectors.

Mr. Heer Desai
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It was a pleasure to be part of this publication, which is playing an important role in advancing dialogue and knowledge-sharing on such a critical theme.I found the publication process to be very smooth and supportive. The journal serves as a valuable platform that brings together diverse voices and perspectives, and I am glad to have been able to add to that collective effort.I look forward to seeing the journal grow further in reach and impact, and I hope it continues to inspire more practitioners and researchers to engage with the circular economy agenda.

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THE CIRCULARITY ILLUSION: WHY FASHION'S LINEAR LOGIC OUTLASTS ITS SUSTAINABILITY PLEDGES

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Abstract

Despite growing environmental urgency and constant sustainability messaging, the global fashion industry still largely operates on a linear take make and dispose model. This article looks at why circularity, even though it is widely discussed, is still missing at the design stage of most fashion products. Using industry data, policy analysis and brand case studies, it argues that this is not accidental. The continued focus on disposable design comes from economic priorities, weak regulation and a larger system that does not reward circular outcomes.

The article also places this issue within a global policy context. It compares stronger regulatory frameworks in the European Union with the lack of binding circularity policies in major producing countries like India. The contrast highlights how uneven policy enforcement allows linear practices to continue. The article concludes by suggesting structural changes for policymakers, brand managers and fashion management professionals to move circularity from discussion to actual implementation.

1. Introduction

Every second, the equivalent of one garbage truck of textiles is either landfilled or burned somewhere in the world. According to the Ellen MacArthur Foundation, less than one percent of clothing is recycled into new fibre, and nearly 85 percent of all textiles end up as waste each year. These numbers do not reflect the past. They describe the fashion industry as it exists today, even after years of sustainability conversations and branding built around terms like conscious, responsible and eco forward.

The idea of a circular economy offers an alternative to this system. It focuses on keeping products and materials in use for as long as possible, rather than following a linear path of production and disposal. In fashion, this would mean designing garments that can be repaired, resold, rented or recycled without creating waste at the end of their life.

However, the reality of fashion production tells a very different story. Most garments are still designed in ways that make circularity difficult or even impossible. Blended fibres cannot be easily separated for recycling. Non removable trims contaminate recycling processes. Chemical finishes reduce the quality of recycled materials. Seasonal collections continue to encourage short product lifecycles. The result is a system where products are effectively designed to be thrown away.

This creates a clear contradiction. The industry increasingly speaks the language of circularity, but its design practices remain firmly linear. This article examines why that gap exists. It argues that the issue is not a lack of technology or knowledge. The tools to enable circular fashion already exist. The real problem lies in misaligned incentives, limited

regulation and an industry culture that continues to prioritise newness and speed over longevity.

Understanding these structural barriers is essential. Without addressing them, circularity will remain a concept rather

Fig 1: Fashion Designed for Disposal

than a standard practice. The shift requires not only better design decisions, but also stronger policy frameworks and a change in how value is defined within the fashion industry.

2. Why Brands Fail at Circularity: A Structural Critique

2.1 The Economics of Disposability

People, Planet, Profit. Out of the three major pillars that sustainable development stands on, Profit is given the most favor. This favoritism has a crippling effect on the People and the Planet. Virgin synthetic fibres like polyester, nylon, acrylic which are derived from petrochemicals remain significantly cheaper than their recycled counterparts. This is in large part because of the global subsidization of fossil fuel extraction. An estimation from the International Monetary Fund (IMF) states that the total global subsidies for fossil fuels surged to a record of $7 trillion USD in 2022, which represented 7.1% of global GDP.

The explicit subsidies i.e., direct government support, comprises $1.3 trillion USD in this figure and the rest, $5.7 trillion USD is for implicit subsidies i.e., undercharging for environmental, climate, and health costs (International Monetary Fund Report, 2023). The vast majority of these subsidies being implicit, result from the failure to account for the environmental damages caused due to the extensive burning of fossil fuels. The distortion created in material pricing, due to these subsidies, veil the true environmental cost of virgin polyester; portraying an artificial image of its inexpensiveness in the market and creating a major roadblock for the development of circular infrastructures. For a fashion brand working on thin margins and rapid inventory cycles, the smallest differences in price is also decisive.

Case studies of brands adopting remanufacturing, rental and resale models do show significant revenue generation, but these adoptions are in bits and pieces. An entire systemic restructure will incur substantial investment and maintenance cost, something that most publicly traded fashion companies will not prioritize over their lump-sum quarterly earnings; choosing a structural short-termism instead of the economically unattractive, but environmentally necessary, investment into circularity.

2.2 Linear Supply Chain Lock-In

"Old habits die hard". This idiom is hardly used in the context of the fashion industry but one such detrimental habit is fashion supply chains' paramount purpose of cheap and quick production.

This decades-long optimization has resulted in a deep structural 'lock-in' that makes pivoting into circular systems extraordinarily difficult. Supplier relationships, manufacturing models, logistics networks and quality control systems have all been calibrated for forward, linear movement from raw material to retail, with little to no space for reverse channels.

The supply chain architecture is fundamentally different for circular design. At the start itself, products need to be designed with disassembly in mind, so raw materials, construction techniques and finishing processes all need to be recalibrated by suppliers and manufacturers. A specialized team trained in such techniques will be vital. Reverse logistics framework establishment with touchpoints like collection points, sorting facilities, and partnerships with recyclers, for take-back programs will also be an important requirement.

A case study of a 2019 investigation by Swedish broadcaster SVT into H&M's Garment Collecting Initiative, launched in 2013 and often cited as an example of a brand attempting circularity at scale, revealed that a significant proportion of the garments collected through this initiative were either being incinerated or down-cycled, rather than fulfil their purpose of being recycled into regenerated fibres; displaying a gap between communication and reality of circularity.

Brands like Patagonia, Eileen Fisher, and MUD Jeans show that circular supply chains and models of take-back, repair and resell are possible and profitable but these companies had prioritized circular infrastructure as a core tenet from their outset. Restructuring systems designed for linear output is a complex and expensive undertaking.

2.3 The Policy Vacuum: Voluntary Pledges vs. Binding Regulation

Several frameworks in recent years have recognized a fourth pillar of sustainable development, which is essential for coordinating the traditional three: governance or policy (EVS Institute, 2025). And this fourth pillar is a most pressing issue; linear design systems are being enabled by the near- global absence of binding regulatory requirements for circular design in fashion. The brands' voluntary sustainability commitments, in the absence of legal obligations, often go unverified, unenforced and without consequences even if routine failure occurs.

The EU's Eco-design for Sustainable Products Regulation (ESPR), adopted in 2024 and France's The Anti-Waste for a Circular Economy (AGEC) Law, enacted in 2020 are global mandates to bring circular design under legal empowerment. The ESPR regulation empowers the European Commission to make Digital Product Passports and eco-design mandatory for brands exporting to the EU, covering durability, recyclability, reparability and the DPP discloses a product's full material composition and end-of-life instructions.The AGEC Law introduced mandatory Extended Producer Responsibility (EPR) for the textile sector, requiring mandatory funding by brands for the collection, sorting and recycling of their products at the end-of-life stage.

Yet, as the world's second-largest textile exporter and home to one of the largest domestic fashion markets globally, India has no binding national policy on textile circularity, no mandatory EPR framework for fashion, and no eco-design standards for garments in the domestic market.

This imbalance in global regulation has led to multinational brands developing a circular line of products bound for regulated markets, with the majority of their linear output products are released in the unregulated ones. Without an internationally binding framework, circularity in fashion might be doomed to remain as a compliance practice in minor markets, instead of becoming a global design principle.

2.4 Greenwashing as a Structural Barrier

In the fashion industry, there is an observed speed disparity between the adoptions of circular design language and circular supply chains and frameworks. Without authentic certifications, most of the claims are marketing gimmicks at best, riding the 'new' trend wave of going green. As another result of this, MSMEs or brands that are genuinely striving for a better future for the industry, but might not have the provisions for either the certifications or the branding and marketing, often face distrust and dismissal from consumers on grounds of 'greenwashing'.

The Synthetics Anonymous report's analysis of the circularity claims of major fashion brands revealed that a significant proportion of the claims were vague, misleading and unsubstantiated; Zara's 'Join Life' collection, H&M's 'Conscious' range and more (The Changing Markets Foundation, 2021). The rapid increase in claims, like "eco design", "conscious collections", "sustainably designed", have negatively affected the gravity of the situation, by portraying the fashion industry as one that is consistently shifting towards sustainability and circularity and hence, downplaying the urgency of regulatory actions.

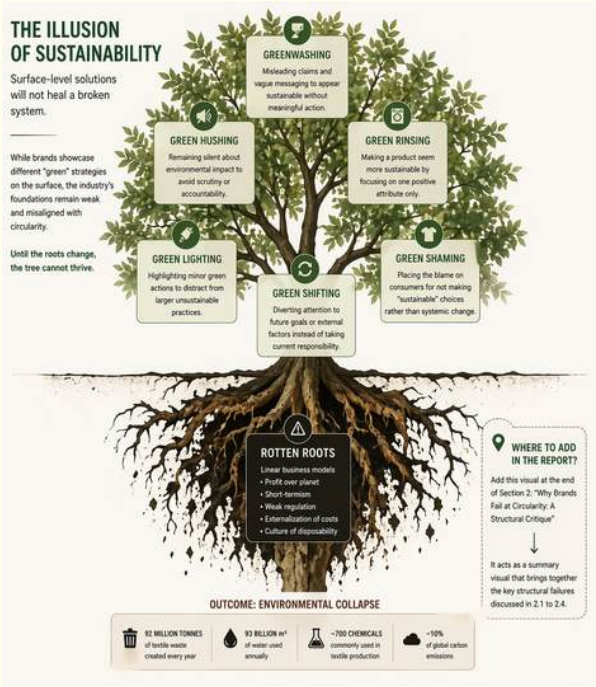

FIG 2: THE ILLUSION OF SUSTAINABILITY

FIG 3: CIRCULAR DESIGN PRINCIPLES

3. The Way Forward: From Aspiration to Obligation

The evidence discussed here leads to one clear takeaway: voluntary efforts alone are not enough to drive circular design at scale in the fashion industry. If real change is the goal, structural interventions are necessary to move the industry from intent to accountability.

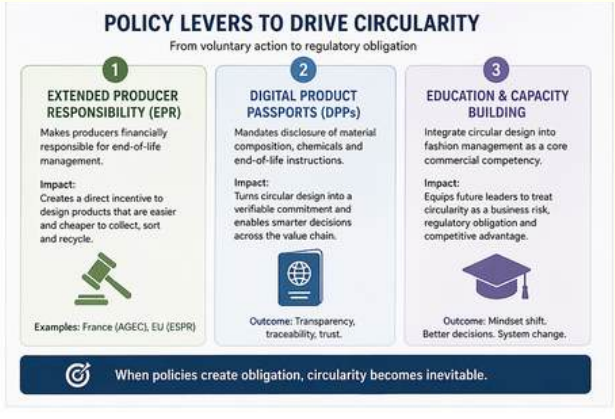

Fig 4: Policy Levers

To begin with, Extended Producer Responsibility (EPR) needs to become mandatory across major fashion markets. When producers are made financially responsible for what happens to products at the end of their life, it naturally pushes them to design better, products that are easier to collect, sort, and recycle. Existing models like France's AGEC law and the EU's ESPR framework already show that this can work, and countries like India have strong reasons to adopt and adapt similar systems.

Next, Digital Product Passports (DPPs) should be introduced as a standard requirement for all garments in regulated markets. If brands are required to clearly disclose material composition, chemical use, and disposal instructions at the point of sale, circularity becomes something that can be verified, not just claimed. It also helps recyclers and resale platforms handle products more efficiently at the end of their life.

Finally, circular design needs to be treated as a core skill in fashion management education, not something optional or limited to CSR discussions. The people studying today will soon be making key decisions around sourcing, merchandising, and product development. If they are trained to see circularity as a business risk, a regulatory requirement, and even a competitive advantage, then the internal priorities of brands will begin to change in a meaningful way.

Fig 5: Circular Fashion In Practice

4. Conclusion

Disposal-focused design in fashion isn't accidental, and it's definitely not because the industry lacks the technical know-how. It's simply the result of how the system is set up; the incentives, the rules, and the long-standing mindset all favor linear production because it's easier and cheaper.

The tools for recycling already exist. Circular models have already been tested and scaled by some brands. Even the design knowledge needed to create durable, repairable, and returnable products is already there.

So the issue isn't a lack of knowledge; it's a lack of pressure. The industry hasn't changed through goodwill or voluntary commitments, and the past 20 years prove that. Real change will happen only when regulations make linear production costly, when mechanisms like EPR turn waste into a financial burden, and when people working in the industry, including students learning fashion management today, start seeing circularity not as a moral choice, but as a business necessity.

At the end of the day, disposal is a decision made at the design stage. Once the industry, and the policies around it, start treating it that way, moving towards circularity won't just be an option, it'll be the obvious path forward.

References

Brydges, T. (2021). Closing the loop on take, make, waste: Investigating circular economy practices in the Swedish fashion industry. *Journal of Cleaner Production, 293, 126245.*

Changing Markets Foundation. (2021). Synthetics anonymous: *Fashion brands' addiction to fossil fuels.*

Ellen MacArthur Foundation. (2017). *A new textiles economy: Redesigning fashion's future.*

European Commission. (2024). *Ecodesign for sustainable products regulation (ESPR). Official Journal of the European Union.*

French Government. (2020). *Loi anti-gaspillage pour une économie circulaire (AGEC). Journal Officiel de la République Française.*

International Monetary Fund. (2023). *Fossil fuel subsidies.*

Ministry of Textiles, Government of India. (2022). *National textile policy draft.*

MUD Jeans B.V. (2024). *Impact report 2023.*

Patagonia, Inc. (2023). *Worn wear programme: Annual impact report.*

REFASHION. (2023). *Annual report on extended producer responsibility in the French textile sector.*

From Forests to Fabrics: Circular Economy Strategies for Sustainable Textile Value Chains in India

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TERI -SAS

Abstract

India's textile sector is the second-largest employer in the country and one of the highest contributors to industrial pollution. Conventional cotton and synthetic fibre production generate enormous water, chemical, and carbon footprints. Forest-based fibres—principally bamboo (Bambusa spp., Dendrocalamus spp.) and hemp (Cannabis sativa)—offer structurally superior ecological credentials and present untapped opportunities for circular economy (CE) integration. This paper examines the full value chains of bamboo and hemp textiles in India, from cultivation through processing, manufacturing, end-of-life recovery, and livelihood generation. Drawing on secondary data, policy analysis, and illustrative case evidence, we identify seven systemic barriers to circularity and propose a multi-layered intervention framework encompassing agroforestry, industrial symbiosis, producer responsibility, bio-based dyeing, and community enterprise models. Findings suggest that scaling forest-based fibre value chains through CE principles could reduce India's textile-sector water consumption by up to 35 percent, improve rural household incomes among forest-dependent communities, and contribute meaningfully to national climate commitments under the Paris Agreement. The paper concludes with policy and investment recommendations directed at national and state governments, development finance institutions, and the private sector.

Introduction

The global textile and apparel industry contributes approximately 10 percent of annual anthropogenic carbon dioxide emissions and is responsible for roughly 20 percent of industrial water pollution (Ellen MacArthur Foundation, 2017; UNEP, 2019). In India, the sector directly employs over 45 million people and accounts for approximately 2.3 percent of GDP, yet its environmental liabilities—comprising dye effluent, pesticide run-off from cotton cultivation, and mounting post-consumer waste—are increasingly incompatible with sustainable development objectives (Ministry of Textiles, Government of India, 2022; Textile Exchange, 2023).

Circular economy (CE) frameworks offer a systemic alternative to the dominant linear model of 'take-make-dispose.' Grounded in principles of design for longevity, resource cycling, and elimination of waste (Ellen MacArthur Foundation, 2013; Stahel, 2016), CE approaches have gained traction across manufacturing sectors. Their application to textiles, however, remains partial and predominantly focused on post-consumer recycling in high-income country contexts (Payne, 2015; Morley et al., 2009). The upstream dimensions of fibre choice and land-use practice receive comparatively little attention, particularly in the Indian development context.

Forest-based fibres represent a compelling entry point. Bamboo is among the fastest-growing plants on earth, sequesters carbon at rates of 12–17 tonnes per hectare per year, requires no replanting after harvest, and produces a soft, durable fibre with natural antimicrobial properties (Lobovikov et al., 2007; Yueping et al., 2010). Hemp, cultivated legally in several Indian states following regulatory relaxation, is naturally pest-resistant, improves soil health through phytoremediation, and yields fibre of high tensile strength (Raman, 2019; Cherrett et al., 2005). Both crops are historically embedded in Indian agricultural and craft traditions, and both sustain significant populations of tribal and rural artisans, particularly in the Northeastern states, Uttarakhand, Himachal Pradesh, and the Western Ghats.

Yet the value chains that connect these forest ecologies to consumer markets remain fragmented, technologically underinvested, and insufficiently integrated with CE principles. This paper seeks to address that gap. The objectives are threefold: (i) to characterise the current structure and environmental performance of bamboo and hemp textile value chains in India; (ii) to identify leverage points for circular economy intervention; and (iii) to propose an actionable framework for stakeholders across policy, finance, and industry.

2. Methodology

This study adopts a qualitative mixed-methods design combining systematic literature review, secondary data analysis, and policy document analysis. A structured review of peer-reviewed literature published between 2000 and 2023 was conducted using Scopus, Web of Science, and Google Scholar, employing the search terms: 'bamboo fibre India', 'hemp textile value chain', 'circular economy textile India', 'forest-based fibre livelihood', and 'sustainable fashion South Asia.' Eighty-three articles, reports, and policy documents were selected for full review on the basis of relevance and methodological quality.

Secondary data on Indian textile production, fibre yield statistics, water consumption benchmarks, and employment figures were sourced from the Ministry of Textiles (2022), Textile Exchange (2023), the Food and Agriculture Organization of the United Nations (FAO, 2021), and the National Bank for Agriculture and Rural Development (NABARD, 2020). Life cycle assessment (LCA) data were drawn from peer-reviewed comparative studies (van der Werf & Turunen, 2008; Bacci et al., 2011; Oeko-Institut, 2014) to support the comparative analysis presented in Table 1.

The value chain analysis framework applied here follows Kaplinsky and Morris (2001), adapted for circular economy applications as proposed by Geissdoerfer et al. (2017). Circular intervention opportunities were mapped against the nine R-framework (Potting et al., 2017)—ranging from Refuse and Reduce at the design stage through to Recover and Recycle at end-of-life—and scored against feasibility, impact potential, and alignment with existing Indian policy instruments.

3. India's Textile Sector and Its Environmental Footprint

3.1 Scale and Structure

India is the world's second-largest textile producer and third-largest exporter, with an industry valued at approximately USD 153 billion in 2022 (Ministry of Textiles, 2022). The sector spans a highly heterogeneous production landscape: large integrated mills in Gujarat and Maharashtra coexist with millions of small and micro enterprises, handloom weavers, and artisan clusters dispersed across 28 states. Cotton alone accounts for nearly 60 percent of fibre consumption; synthetic fibres (polyester, nylon) constitute approximately 35 percent; and all natural non-cotton fibres—including silk, jute, wool, bamboo, and hemp—together account for less than 6 percent (Textile Exchange, 2023).

3.2 Environmental Liabilities

Cotton cultivation in India consumes an estimated 22,500 litres of water per kilogram of finished fabric—among the highest of any agricultural commodity (WWF, 2013). The sector accounts for approximately 16 percent of global insecticide use despite cotton occupying roughly 2.5 percent of global agricultural land (Kooistra & Termorshuizen, 2006). Textile dyeing and finishing operations discharge an estimated 200,000 tonnes of dyes into water bodies annually in India (Kant, 2012), many of which are toxic azo compounds that persist in ecosystems and bio-accumulate in aquatic food chains. Post-consumer textile waste, estimated at over 7.5 million tonnes annually, is overwhelmingly landfilled or incinerated (FICCI, 2021).

These liabilities are increasingly scrutinised under India's National Action Plan on Climate Change (NAPCC), the Plastic Waste Management (Amendment) Rules 2022, and emerging Extended Producer Responsibility (EPR) frameworks for textiles. The transition to forest-based and low-impact fibres is explicitly referenced in India's Intended Nationally Determined Contribution (INDC) submissions and the National Forest Policy 2018 vision of linking forest conservation with rural livelihoods (MoEFCC, 2018).

4. Forest-Based Fibre Value Chains: Characterisation and Comparison

4.1 Bamboo Textiles

India possesses the second-largest bamboo resource base in the world, with approximately 13.96 million hectares under bamboo cultivation, primarily in the Northeastern states (Assam, Meghalaya, Tripura, Manipur) and parts of Maharashtra, Odisha, and Andhra Pradesh (FSI, 2019). The National Bamboo Mission (NBM), restructured under the Ministry of Agriculture and Farmers Welfare in 2018, has allocated INR 1,290 crore for plantation, processing, and enterprise development, yet penetration into textile value chains remains limited.

The primary processing pathway for bamboo textiles involves mechanical retting and

crushing of bamboo culms into fibre bundles —the 'bast fibre' method—or, in the dominant industrial route, a closed-loop lyocell-type chemical process that dissolves bamboo pulp in sodium hydroxide and carbon disulfide to produce viscose bamboo fibre (Yueping et al., 2010). The mechanical route yields a coarser, linen-like fabric (sometimes marketed as 'bamboo linen') with superior biodegradability but limited softness; the chemical route produces a fine, silky fabric widely sold as 'bamboo fabric' but with a process footprint analogous to conventional viscose if the solvent loop is not closed (Oeko-Institut, 2014).

4.2 Hemp Textiles

Hemp cultivation in India has a documented history dating back over 3,000 years, with references in Ayurvedic texts and evidence of use in traditional weaving in the Kumaon hills of Uttarakhand, Kullu valley of Himachal Pradesh, and Manipur (Raman, 2019). Commercial cultivation under the NDPS (Narcotic Drugs and Psychotropic Substances) Act is permitted for industrial hemp (THC $\leqslant$ 0.3%) in Uttarakhand, Madhya Pradesh, Himachal Pradesh, and Uttar Pradesh following state-level policy relaxation between 2016 and 2023.

The hemp fibre value chain involves field retting (or water retting), decortication, hackling, spinning, and weaving. Value addition is constrained by a near-absence of industrial decortication capacity in India: most processing occurs by hand in artisan clusters, limiting output volumes and fibre consistency.

Yarn and fabric import from China (which processes over 70 percent of the world's hemp fibre) undermines domestic processing investment (Cherrett et al., 2005). Several social enterprises and start-ups—including Bombay Hemp Company (BOHECO), The Avani Project (Uttarakhand), and Himalayan Hemp—have made notable progress in demonstrating integrated value chains from farm to finished fabric.

4.3 Comparative Environmental Performance

Table 1 presents a comparative analysis of key environmental parameters across bamboo, hemp, conventional cotton, and viscose/rayon, drawing on life cycle assessment literature. The data reveal a clear ecological advantage for forest-based natural fibres, particularly with respect to water consumption and pesticide avoidance.

Parameter	Bamboo	Hemp	Conventional Cotton	Viscose/Rayon
Water Consumption (L/kg fiber)	70–140	300–500	7,000–29,000	~400 (process water)
CO_2 Sequestration (tonne/ha/yr)	12–17	0.67–1.0	0.15–0.45	N/A (wood pulp-based)
Pesticide Requirement	None	Very low	High (~16% of global use)	Moderate (forestry inputs)
Biodegradability	High (natural fiber)	High (natural fiber)	High (natural fiber)	Low–Moderate (chemical process)
India Production Base	Strong (NE & W Ghats)	Nascent (Uttarakhand, MP)	Very large (~6M ha)	Limited (primarily imported pulp)

Table 1. Comparative Environmental Parameters of Selected Textile Fibres (per kg of processed fibre). Sources: van der Werf & Turunen (2008); Bacci et al. (2011); Oeko-Institut (2014); FAO (2021); Yueping et al. (2010).

The comparison makes clear that bamboo and hemp hold decisive advantages in water efficiency and chemical intensity. The caveat for bamboo viscose—that its process water footprint can rise if solvent recovery is incomplete—underscores the importance of process-level circularity alongside raw material choice.

5. Circular Economy Framework for Forest-Based Textile Value Chains

5.1 Mapping CE Opportunities Across the Value Chain

CE Strategy	Application in Value Chain	Key Actors	Estimated Impact	Barriers
Closed-loop fiber recycling	Post-consumer bamboo/hemp textile collection and mechanical/chemical recycling into new yarns	Brands, municipalities, recyclers	Reduces virgin fiber demand by 20–30%	Technology readiness; consumer collection
Industrial symbiosis	Textile dyeing effluent treated and reused; agricultural residues (stalks) converted to biochar or packaging	Textile clusters, agri-cooperatives	30–50% wastewater reduction	Coordination, investment costs
Bio-based dyeing	Forest-extracted natural dyes (lac, indigo, tannin) replace synthetic azo dyes in bamboo/hemp fabrics	SHG artisans, KVIC, design firms	Eliminates toxic effluent from dye stage	Colour fastness, scale, consistency
Producer responsibility (EPR)	Mandatory take-back of textile products containing forest-based fibers; deposit-refund schemes	Brands, MoEFCC, State PCBs	Formalises reverse logistics	Regulatory enforcement
Agroforestry integration	Bamboo/hemp intercropped with food crops on degraded land; dual livelihood from fibers and food	Tribal communities, FPOs, NABARD	Doubles per-hectare income; sequesters carbon	Land tenure, extension services

Table 2. Circular Economy Interventions Across the Forest-Based Textile Value Chain in India. Sources: Authors' compilation based on Potting et al. (2017); Ellen MacArthur Foundation (2017); FICCI (2021); Geissdoerfer et al. (2017).

Applying the R-framework (Potting et al., 2017) to the bamboo and hemp textile value chain reveals intervention opportunities at every node: from cultivation design (Reduce, Rethink) through processing (Reuse, Remanufacture) to end-of-life (Recycle, Recover). These are summarised in Table 2, which also identifies key actors, estimated impact ranges, and systemic barriers for each intervention category.

5.2 Agroforestry and Landscape-Level Circularity

The most upstream CE opportunity lies in the deliberate integration of bamboo and hemp into agroforestry systems on degraded, revenue, and tribal community lands. Intercropping bamboo with food or horticultural crops on degraded lands has been demonstrated to double per-hectare income while simultaneously sequestering carbon and stabilising soils (Lobovikov et al., 2007; NABARD, 2020). Under Joint Forest Management (JFM) frameworks, Gram Sabhas in Jharkhand, Odisha, and Chhattisgarh have successfully established bamboo enterprises; scaling these models requires secure land tenure, extension services, and market linkages that currently remain fragmented.

Hemp's phytoremediation properties—its capacity to extract heavy metals including cadmium, lead, and arsenic from contaminated soils—offer additional circular value in contexts where agricultural soils have been degraded by prior chemical use (Cherrett et al., 2005). Pilot programmes in Uttarakhand have documented soil regeneration alongside fibre yield over three-year crop cycles,

presenting an integrated case for investment in hemp cultivation on degraded land.

5.3 Industrial Symbiosis in Textile Processing Clusters

India's major textile clusters—Tiruppur, Surat, Bhilwara, Ludhiana—generate enormous flows of water, heat, chemical residues, and fibre waste that, under industrial symbiosis models, could be systematically exchanged and reused. The concept of eco-industrial parks (EIPs) applied to bamboo and hemp processing involves connecting: (i) water treatment effluent with irrigation supply for surrounding bamboo plantations; (ii) bamboo processing residues (culm waste, leaf biomass) with biochar or packaging material producers; and (iii) hemp stalk waste (hurds) with building material manufacturers or insulation producers (Cherrett et al., 2005; Geissdoerfer et al., 2017).

Tiruppur's Common Effluent Treatment Plants (CETPs), developed under the Supreme Court's 2011 directive, provide an institutional foundation for such symbiosis, though their application to natural-fibre processing clusters remains underdeveloped. The BioRegional model pioneered in the United Kingdom's Eco-towns initiative has been cited as a relevant template (BioRegional, 2013), and UNIDO's cluster development programmes in India offer a practical delivery mechanism.

5.4 Bio-based and Natural Dyeing

The dyeing stage represents the most chemically intensive node of the textile value chain and the principal source of toxic effluent. Forest and agri-based natural dyes—including lac (Kerria lacca), indigo (Indigofera tinctoria), madder (Rubia cordifolia), and tannin-rich barks—offer a circular substitute that creates upstream value for forest-fringe communities who harvest and process these inputs (Kumar et al., 2015). India's 'Rang De' and 'Natural Dye Network' initiatives, and the revival of Bagru and Ajrakh craft traditions in Rajasthan, demonstrate the commercial viability of natural dyeing at artisan scale.

The principal barriers to scaling are colour fastness, batch consistency, and price parity with synthetic alternatives. Research by Kumar et al. (2015) and the Central Institute for Research on Cotton Technology (CIRCOT) has identified mordant optimisation and standardised extraction protocols as critical technological needs that remain underfunded in India's textile research system.

5.5 End-of-Life Recovery and Extended Producer Responsibility

India's draft EPR notification for textiles (2022–2023) proposes mandatory take-back obligations for branded textile producers, creating a regulatory foundation for closed-loop fibre recovery. For forest-based fibres, whose natural structure is more amenable to mechanical recycling than synthetics, EPR creates the upstream incentive for product design choices—labelling, mono-material construction, avoidance of chemical finishes—that enable downstream recyclability (Payne, 2015; Morley et al., 2009).

A deposit-refund scheme modelled on beverage container recovery in Germany—applied to premium bamboo and hemp textile products—could provide the financial incentive for consumer participation in reverse logistics. Self-Help Groups (SHGs) and Farmer Producer Organisations (FPOs), already active in collection and sorting under the Swachh Bharat Mission, offer a ready institutional platform for last-mile textile collection in rural India.

6. Livelihood Enhancement and Social Circularity

The circular economy literature has been criticised for its inadequate engagement with distributional justice and labour (Hobson & Lynch, 2016). In the Indian context, forest-based textile value chains are inextricable from questions of Scheduled Tribe (ST) rights, women's employment, and the governance of common forest resources under the Forest Rights Act 2006 (FRA). A genuinely circular value chain must be designed to return value to the communities at its ecological foundation.

NABARD's 2020 review of bamboo enterprise clusters documents average annual household income increases of INR 35,000–65,000 among tribal artisan families engaged in bamboo craft production in Tripura and Assam, compared to wage labour in conventional agriculture. The Avani Project in Uttarakhand has documented similar livelihood gains for women's weaving cooperatives working with Uttarakhand has documented similar livelihood gains for women's weaving cooperatives working with hemp, wild silk, and natural dyes. These cases share common enabling factors: secure raw material access (land tenure or community forest rights), functional producer organisations, technical training, and direct market linkages that bypass exploitative intermediary chains.

Scaling these models requires policy coordination between the Ministries of Tribal Affairs, Textiles, Environment, and Agriculture—a cross-departmental challenge that the National Forest Commission (2006) and the National Bamboo Mission have not yet fully resolved. Development finance institutions such as NABARD, SIDBI, and international impact investors can play a catalytic role in providing patient capital to community enterprises during the period of market development.

7. Systemic Barriers to Circularity

Seven systemic barriers impede the transition to circular forest-based textile value chains in India:

(i) Regulatory fragmentation: Hemp cultivation, bamboo harvesting, and forest produce commercialisation are governed by at least four overlapping legislative regimes (NDPS Act, Indian Forest Act, Forest Rights Act, and state forest regulations), creating compliance uncertainty for investors and enterprises.

(ii) Technology gaps: Lack of industrial-scale mechanical decortication for hemp and closed-loop solvent recovery for bamboo viscose limits both environmental performance and cost competitiveness.

(iv) Finance: Risk-averse commercial banks and absence of blended finance instruments for early-stage community enterprises leave most natural fibre initiatives dependent on grant funding, constraining scale.
(v) Weak EPR enforcement: Existing EPR frameworks for plastics have demonstrated enforcement limitations; their extension to textiles requires significant institutional capacity building at State Pollution Control Board level.
(vi) Land tenure insecurity: Unresolved community forest rights under the FRA 2006 leave tribal communities without the tenure security needed to invest in bamboo plantation development.
(vii) Supply chain traceability: Absence of digital traceability systems prevents brands from substantiating circularity and sustainability claims, limiting premium market access for genuinely circular products.

8. Policy and Investment Recommendations

8.1 For National and State Governments

Regulatory harmonisation for hemp and bamboo should be treated as an urgent priority: a single-window clearance mechanism under the Ministry of Agriculture, covering cultivation, processing, and trade, would substantially reduce transaction costs. The National Bamboo Mission should be expanded to include textile processing infrastructure f—specifically mechanical fibre extraction units—as eligible investments. State governments in Uttarakhand, Himachal Pradesh, and Northeastern states should prioritise resolution of pending FRA claims to unlock tribal land for bamboo and hemp agroforestry.
The draft EPR notification for textiles should be finalised with fibre-specific provisions that create incentives for forest-based, biodegradable materials in product design. Labelling standards for 'bamboo' and 'hemp' textiles should be aligned with the Bureau of Indian Standards (BIS) and international norms to eliminate misleading marketing and support informed consumer choice.

8.2 For Development Finance Institutions

NABARD and SIDBI should develop dedicated blended finance instruments—combining concessional loans with technical assistance grants—for community enterprises in bamboo and hemp value chains. Investment readiness support for tribal FPOs and women's SHGs is a critical gap. Green bond frameworks should be extended to cover natural fibre enterprise clusters, allowing institutional investors to participate in the transition.

8.3 For the Private Sector

Brands sourcing from Indian natural fibre suppliers should invest in supply chain traceability platforms—leveraging blockchain or distributed ledger technologies—that authenticate claims of

circularity, livelihood benefit, and environmental performance. Corporate-community partnership models, in which brands co-invest in upstream plantation and processing infrastructure in exchange for assured supply, offer a mutual value proposition that reduces supply risk while improving smallholder income security.

Conclusion

India's forest-based textile value chains—anchored in bamboo and hemp—represent one of the most promising, and currently most underexploited, pathways toward a circular economy in one of the world's most polluting industrial sectors. The ecological case is compelling: both crops deliver superior water efficiency, carbon sequestration, and chemical footprint compared to dominant alternatives. The social case is equally strong: when value chains are designed to return economic benefit to forest-fringe communities, they generate livelihoods, preserve traditional knowledge, and strengthen the governance of common ecological resources.

Realising this potential requires simultaneous action across regulatory, financial, technological, and market dimensions. No single intervention is sufficient; the systemic nature of the barriers demands systemic responses. The circular economy framework—with its emphasis on designing out waste, keeping materials in use, and regenerating natural systems—provides both the analytical lens and the normative commitment required to navigate this complexity.

fFuture research should prioritise primary field studies on the financial viability of specific circular interventions at scale; rigorous comparative LCA studies under Indian production conditions; and governance analyses of the political economy of EPR implementation in the Indian textile context. The transition from forests to fabrics, and back again, is not only ecologically necessary—it is economically achievable and socially imperative.

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References

Bacci, L., Di Lonardo, S., Albanese, L., Mastromei, G., & Perito, B. (2011). Effect of different extraction methods on fibre quality of nettle (Urtica dioica L.) and hemp (Cannabis sativa L.). Textile Research Journal, 81(8), 827–837.

BioRegional. (2013). One Planet Living in Practice: A Global Framework for Sustainable Living. BioRegional Development Group, London.

Cherrett, N., Barrett, J., Clemett, A., Chadwick, M., & Chadwick, M. J. (2005). Ecological Footprint and Water Analysis of Cotton, Hemp and Polyester. Stockholm Environment Institute, Stockholm.

Ellen MacArthur Foundation. (2013). Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition. Ellen MacArthur Foundation, Isle of Wight.

Ellen MacArthur Foundation. (2017). A New Textiles Economy: Redesigning Fashion's Future. Ellen MacArthur Foundation, Isle of Wight.

FAO. (2021). Global Forest Resources Assessment 2020: Main Report. Food and Agriculture Organization of the United Nations, Rome.

FICCI. (2021). Sustainability in Indian Textiles: Industry Roadmap 2030. Federation of Indian Chambers of Commerce and Industry, New Delhi.

Raman, A. (2019). The Hemp Industry in India: Policy, Practice and Potential. Economic and Political Weekly, 54(22), 34–42.
Stahel, W. R. (2016). The circular economy. Nature, 531(7595), 435–438.

Textile Exchange. (2023). Preferred Fiber and Materials Market Report 2023. Textile Exchange, Lamesa TX.

UNEP. (2019). Putting the Brakes on Fast Fashion. United Nations Environment Programme, Nairobi.

van der Werf, H. M. G., & Turunen, L. (2008). The environmental impacts of the production of hemp and flax textile yarn. Industrial Crops and Products, 27(1), 1–10.

WWF. (2013). Water Risk Filter: Cotton. World Wide Fund for Nature, Gland.

Yueping, X., Rong, G., Xiaodong, L., Jian, C., & Luoxin, W. (2010). Structure and properties of bamboo fibers for textiles. Textile Research Journal, 80(4), 334–343.

Forest Survey of India (FSI). (2019). India State of Forest Report 2019. Ministry of Environment, Forest and Climate Change, Dehradun.

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy—a new sustainability paradigm? Journal of Cleaner Production, 143, 757–768.

Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: Radical social transformation in a resource-scarce world. Futures, 82, 15–25.

Kant, R. (2012). Textile dyeing industry: An environmental hazard. Natural Science, 4(1), 22–26.

Kaplinsky, R., & Morris, M. (2001). A Handbook for Value Chain Research. Institute of Development Studies, Brighton.

Kooistra, K., & Termorshuizen, A. (2006). The Sustainability of Cotton: Consequences for Man and Environment. Wageningen University Report, Wageningen.

Kumar, V., Dey, A., Hadimani, M. B., Prasad, T., & Georget, M. (2015). A review of characterization of natural dyes used in textile dyeing. International Journal of Textile Science, 4(1), 1–8.

Lobovikov, M., Paudel, S., Piazza, M., Ren, H., & Wu, J. (2007). World Bamboo Resources: A Thematic Study Prepared in the Framework of the Global Forest Resources Assessment 2005. FAO, Rome.

Ministry of Textiles, Government of India. (2022). Annual Report 2021–22. Government of India, New Delhi.

MoEFCC. (2018). National Forest Policy, 2018 (Draft). Ministry of Environment, Forest and Climate Change, New Delhi.

Morley, N., Bartlett, C., & McGill, I. (2009). Maximising Reuse and Recycling of UK Clothing and Textiles. Department for Environment, Food and Rural Affairs, London

NABARD. (2020). Report of the Expert Committee on Bamboo Enterprise Development. National Bank for Agriculture and Rural Development, Mumbai.

Oeko-Institut. (2014). Criteria for the Öko-Tex Standard 100 and the Öko-Tex Standard 1000 with Respect to Bamboo Fibres. Oeko-Institut, Freiburg.

Payne, A. (2015). Open and closed loop recycling of textile and apparel products. In J. Muthu (Ed.), Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing (pp. 103–123). Woodhead Publishing, Cambridge.

Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2017). Circular Economy: Measuring Innovation in the Product Chain. PBL Netherlands Environmental Assessment Agency, The Hague.

Scaling Up Post-Industrial and Pre-Consumer Textile Waste Unlocking Circular Economy Potential

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Abstract

This article explores the potential of scaling up the secondary materials industry within the textile sector, with the focus on post-industrial and pre-consumer waste streams. By integrating these materials into organized circular models, the conventional supply chain can evolve into a verified value chain that supports both profitability and regulatory compliance. The study demonstrates how circular economy practices are not merely environmental imperatives but can also be leveraged as profitable business opportunities. Furthermore, the paper emphasizes the critical role of digital traceability platforms and circular product design in enabling visibility across the textile supply chain. By embedding textile-to-textile circularity into product design, discarded materials are prevented from entering landfills and instead re-enter production cycles as valuable inputs. This approach ensures that waste is transformed into wealth, reinforcing sustainability while driving economic growth.

Introduction

Textile sector generates vast volumes of post-industrial and pre-consumer waste — from cutting scraps to unsold inventory. Yet only a fraction is reintegrated into the production cycle and mostly discarded. Scaling up this secondary materials industry is not just an environmental imperative; it is a business opportunity that can transform the conventional supply chain into a value-driven circular ecosystem. This article explores how scaling up this supply chain can make circular economy models profitable, formalize informal sector, design to close the loop and embed into textile compliance frameworks.

The Untapped Potential of Secondary Materials

Post-industrial waste (e.g., cutting room scraps, off-spec yarns) and pre-consumer waste (e.g., unsold garments, sample rejects) are often discarded or downcycled. Very few are recycled or upcycled that lacks visibility and traceability.

Landfilling dominates: Nearly three-quarters of textile waste ends up in landfills, contributing to methane emissions and soil contamination.

Incineration: Around 15% is burned, often for energy recovery, but this still releases CO_2 and toxins.

Recycling gap: Less than 10% is recycled, and only a fraction of that is true textile-to-textile recycling (most is discarded and downcycled).

There are many resources can be saved by promptly tracking and utilising this world's seventh resource. These textile wastes retains high utility and can be scale up into high value

create new revenue streams for manufacturers and recyclers. Hence, Cutting scraps and unsold inventory are cleaner streams that could be scaled up for circular business model more easily than post-consumer waste.

Figure.1. Post-Industrial and Pre-Consumer Textile Waste

3. Circular Economy as a Profitable Business Model

The global economy has long relied on a linear model of "take, make, dispose." This approach has driven growth but at the cost of resource depletion, environmental degradation, and mounting waste. The circular economy offers a transformative alternative — one that not only addresses sustainability but also unlocks profitability. By designing products for reuse, recycling, and regeneration, businesses can reduce costs, create new revenue streams, and strengthen resilience.

Linear model Circular Model

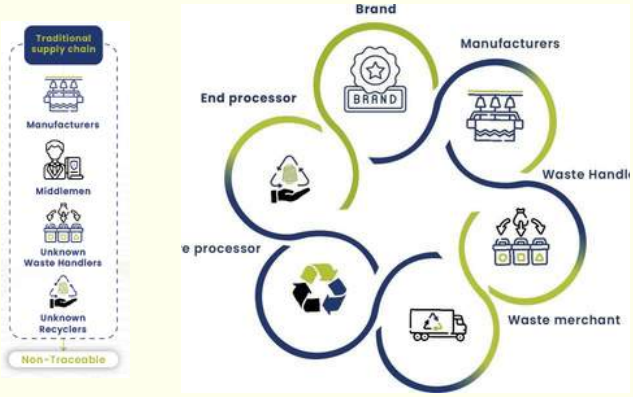

Figure.2. Linear model to Circular Model

3.1. Renovating End of Life as Strategic Design

In traditional supply chains, waste is treated as a liability. In a circular model, waste becomes a resource. Secondary materials (post-industrial scraps, pre-consumer rejects) can be reintegrated into production cycles by transparent traceability systems. This tracking systems can trace from form the origin of waste generated till closing the loop. This give confidence and the waste was diverted instead of disposed. It will reduce the reduce dependence on virgin raw materials and lowering procurement costs. When secondary materials are integrated into mainstream production compliance burden can be turned into a business enabler.An innovative eye mask crafted entirely from textile and plastic waste. The discarded materials are transformed into a functional product, redefining waste as a resource. This initiative demonstrates how circular design can embed sustainability into everyday items,

ensuring that what was once destined for landfill re-enters the value chain as a valuable, traceable product.

4. Formalizing the Informal Sectors

India's secondary textile material ecosystem is largely driven by small-scale, informal players who form the backbone of waste collection and recycling. Despite their critical role, these workers and enterprises remain invisible in policy frameworks. Their operations are often financially underfunded, running on thin margins with limited access to credit or investment. Many facilities operate without proper licenses or compliance with safety and labor standards, making them vulnerable and excluded from formal support systems. Additionally, the sector is predominantly trading-oriented, focusing on the buying and selling of textile scraps rather than investing in value-added recycling or sustainable innovation. Formalizing this informal sector is essential to building a resilient, inclusive, and circular textile economy.

4.1. Challenges Faced by Workers in the Informal Sectors

Workers in India's informal textile recycling sector face a range of serious challenges that threaten their health, safety, and livelihoods. Daily exposure to dust, dyes, and chemicals without protective gear puts them at risk of respiratory illnesses, skin conditions, and injuries from sharp textile waste.

Their workspaces are often overcrowded and poorly ventilated, lacking basic fire safety measures, sanitation, and access to clean drinking water. Economically, these workers are highly vulnerable — typically paid by weight, often below minimum wage, and excluded from social security, insurance, or pension schemes. Socially, they remain marginalized and stigmatized, despite their vital contribution to sustainability. Women and children are disproportionately represented in this sector, frequently facing exploitation and unsafe conditions. Addressing these challenges is essential to building a just and inclusive circular textile economy.

4.2. Why Scaling up Matters

Scaling up the secondary textile material ecosystem matters because it can fundamentally reshape the sector from an informal, fragmented supply chain into a structured and sustainable circular economy. By expanding operations, challenges can be transformed into opportunities: workers gain welfare through standardized wages, health insurance, and safe working conditions; facilities achieve compliance with labor laws, environmental standards. The industry can move beyond mere trading to organized recycling, upcycling, and secondary material scaling. With greater access to finance, technology, and training, productivity and profitability can rise, driving economic growth while ensuring dignity, recognition, and resilience for the workers who sustain textile recycling.

Fig.4. Workers safety of Informal Sector

5.Circularity Begins from Product Design

The global textile industry faces increasing pressure to address its environmental footprint, particularly in relation to waste management, resource depletion, and carbon emissions. Despite growing awareness and regulatory attention toward circular economy practices, textile waste remains difficult to recover and reuse at scale.

One critical but often overlooked reason is that many textile products are not designed with circularity concept. Instead, they are optimized for performance, aesthetics, and cost, frequently at the expense of end-of-life considerations.

5.1. Challenges of Material Complexity in the Textile Sector

One of the most significant barriers to circularity in textiles is the widespread use of products composed of multiple blended materials. Modern garments and textile products often combine different fiber types, coatings, finishes, and accessories within a single component to achieve specific functional properties such as stretch, water resistance, or aesthetic appeal. However, these multi-material compositions create major challenges for recycling infrastructure. Mechanical and chemical recycling processes typically require material homogeneity to function efficiently.

Figure.5. Material Complexity Barriers

When fibers such as cotton, polyester, elastane, and various chemical finishes are inseparably blended, the recovery of high-quality secondary materials becomes technically complex, economically unviable, or both. Consequently, a large portion of textile waste that could theoretically be diverted is instead sent for disposal. This issue highlights a fundamental disconnect between product design and waste management systems. While recycling technologies continue to advance, design complexity often outpaces the capacity of existing circular solutions.

5.2. Redefining Product Design for Circular Textile Systems

To overcome the limitations of current linear production models, textile product design must be redefined. This redefinition requires a shift in design priorities from complexity and novelty toward intentional simplicity and longevity.

Designers should carefully evaluate the necessity of each material input and component. For example, instead of blending fibers for marginal performance gains, designers can explore mono-material alternatives that offer comparable functionality while remaining recyclable. Similarly, surface treatments and finishes should be assessed for their compatibility with recycling processes and their environmental impact throughout the lifecycle.Digital design tools and material innovation can further support this transition.

Design for circularity can be enhanced through lifecycle assessment, digital material passports, and modular product architectures. These approaches allow designers to make informed decisions about how materials will behave not only during use, but also at the end of life.

5.3. Meaningful End-of-Life Outcomes

A core objective of circular design is to ensure that products have a meaningful end of life. In the textile context, this may include reuse, repair, remanufacturing, recycling, upcycling, downcycling into new textile products, or, in certain cases, safe biodegradation. Meaningful end-of-life outcomes reduce environmental harm by minimizing landfill disposal, conserving resources, and lowering greenhouse gas emissions. When design aligns with circular systems, waste becomes a resource. This alignment creates opportunities for closed-loop production, secondary material markets, and new business models based on product longevity and material recovery.

Figure.6. Attention required to Secondary materials for meaningful End of Life

Conclusion

Scaling up the secondary materials industry from post-industrial and pre-consumer textile waste is more than an environmental necessity — it is a transformative business opportunity. By embedding circular economy principles into the textile sector, we can reduce its dependence on virgin resources, unlock new revenue streams, and strengthen compliance regulations. The challenges of fragmented textile waste ecosystem reveal a critical need for visibility and integration. By identifying and connecting stakeholders who traditionally remain outside the circular economy, we can establish them as verified value chain partners, ensuring transparency and accountability. This approach empowers waste producers to track, control, and redesign their own waste streams, converting liabilities into profitable business models. By scaling this value chain globally, these wastes will be recognized and utilized as wealth, creating economic and social benefits for all stakeholders, including workers at the grassroots level. Recognizing circularity begins at product design, ensures that every waste has a meaningful end-of-life, reinforcing sustainability while driving profitability. Ultimately, digital innovation, traceability, and design can converge to make circularity both visible and viable worldwide, benefiting industries, communities, and the environment alike.

References

- Sharma, R., Yadav, V., Gaur, T. S., & Dixit, P. (2025). A systematic review on circular economy practices in the textile industries. Discover Applied Sciences, 7(1153). Springer.
- Parnell, K., Rolston, A., Hilton, B., & Luccitti, A. (2025). Circular Economy in the Textile Industry: A Review of Technology, Practice, and Opportunity. Recycling, 10(6), 225. MDPI.
- Systematic literature review of circular economy in the textile industry. (2025). Highlights CE as a framework for closed-loop production.
- Textile Traceability: End-to-End Guide for Manufacturers. (2026). Discusses compliance frameworks and digitization for supply chains.
- PSQR (2024). How to approach the Digital Product Passport (DPP) & traceability in textiles. Explains lifecycle data capture and compliance with ESPR.
- UNECE (2021). Traceability and Transparency in the Textile and Leather Sector. UN/CEFACT Business Requirements Specification.
- Your Colors Knowledge Base (2025). Circular Fashion: Designing for End-of-Life Textiles. Explores design strategies to retain material value.
- Conceição, M. E. J., Santos, J. R. L., Magalhães, C. F., & Franzato, C. (2025). Monomaterial Design as Circular Fashion Strategy for End-of-Life Recycling. Advances in Fashion and Design Research III. Springer.
- End-of-Life Management in Textiles. (2025). Academic review highlighting systemic issues of overproduction and consumption.

Digital Product Passports: Enabling Transparent Textile Supply Chains in India

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Abstract

The global order today is increasingly complex, with frequent disruptions to global supply chains. At the same time, rising emphasis on climate action, sustainability, and the circular economy has made transparency across supply chains more important than ever. The textile supply chain in India today largely functions as a 'black box', where data on materials is either heavily dispersed, opaque, or undigitised.

In response, digital product passports (DPPs) are rapidly emerging as trade requirements, driven by regulatory developments such as the European Union's Ecodesign for Sustainable Products Regulation, which mandates product-level information disclosure. For major textile-exporting countries like India, the resultant compliance requirements for DPPs necessitate supply-chain-level preparedness to ensure competitiveness. If implemented strategically, this can also strengthen sustainability and resilience at the domestic level.

This paper analyses how DPPs can function as a critical enabler and common digital backbone that can help bring transparency in India, particularly in fragmented sectors such as textiles. A DPP stores comprehensive data on product composition, origin, environmental impact, and end-of-life handling, covering the entire lifecycle of a product. The defining feature of DPPs is product-based digitisation of information that is independent of the company, its size, or revenue. This minimises the scope for conflation of product-level environmental performance with broader corporate greening claims and enables supply-chain substitutability towards lower-footprint inputs and processes.

The paper further explores the role of DPPs in addressing critical data gaps that impede effective implementation of the extended producer responsibility framework by facilitating transparency for producers, consumers, regulators, and recyclers.

Using a systems approach, the paper carries out a readiness assessment for adopting DPPs as a policy instrument in India, including elements of comparative policy analysis, stakeholder mapping, and risk analysis. The paper ultimately proposes a roadmap for systemic DPP adoption in India—a sequenced pathway in which governance preconditions are identified for scaled implementation.

Key words: digital product passport, circular economy, circular supply chains, textile industry, resource efficiency

1. Introduction

India's textile and apparel sector is a cornerstone of its economy, valued at USD 179 billion, with exports contributing nearly 15% (Press Information Bureau, 2025b; India Brand Equity Foundation, 2022). As the sixth-largest exporter of textiles globally, India exports to over 220 countries, with major market shares in the United States (US) and the European Union (EU), accounting for approximately 47% (Press Information Bureau, 2025a; Press Information Bureau, 2025c).

With the aim of achieving an ambitious target of USD 100 billion by 2030, India has actively engaged in free trade agreements (FTAs) with the EU, which has a market twice the size of the US, to expand its global footprint. This growth aligns with the government's broader goals of net zero targets, the National Circular Economy Framework (NCEF; United Nations Industrial Development Organization, 2025), Aatmanirbhar Bharat (self-reliant India), and the '5F' framework—farm to fibre to factory to fashion to foreign—to strengthen domestic value addition and enhance India's global brand in textiles (Press Information Bureau, 2025b).

However, this growth brings significant challenges, as the textile industry largely relies on conventional resource-intensive production and a highly fragmented supply chain acting as a 'black box', where information is inaccessible. This has led to increasing regulatory scrutiny and growing demand for transparency to support circular economy practices and greater accountability across supply chains.

In this context, the digital product passport (DPP) has emerged as a transformative tool.

A DPP is defined as 'a structured collection of product-related data with pre-defined scope and agreed data management, and access rights conveyed through a unique identifier and that is accessible via electronic means through a data carrier' (CIRPASS, 2023). DPPs move beyond brand-level transparency and enable product-level information, offering granular data for individual products.

From a global trade perspective, DPPs are more than just another tool—they are a critical compliance mechanism, especially for countries that are major exporters. The EU Ecodesign for Sustainable Products Regulation (ESPR) and initiatives such as CIRPASS mandate the disclosure of product-level data (European Parliament, 2024). These regulations emerge as green trade barriers, necessitating the adoption of DPPs, where compliance with sustainability and transparency requirements will increasingly determine market access.

For India, while non-compliance can hinder global market access and impact the country's export economy, early adoption can support the transition towards a circular economy, operationalise extended producer responsibility (EPR), and promote compliance with global sustainability standards. This paper posits that DPPs can serve as a critical digital backbone to strengthen supply chain transparency in India, particularly in fragmented sectors such as textiles. It further presents a policy and institutional roadmap for the effective adoption of DPPs.

1.1 How a digital product passport works

The anatomy of a DPP includes the entire lifecycle of a product, from sourcing, manufacturing, sale, and use to end-of-life management and circular reuse (Figure 1). The first level is the product identifier layer, where a physical product is linked to its digital record through technologies such as quick response (QR) codes, radio frequency identification (RFID), or near field communication (NFC) tags.

These tags and scanners provide a unique product identity containing information related to model, batch number, serial number, and product ID. This is one of the most important layers of the DPP, as it enables traceability of a product digitally.

The next layer is the core of the DPP; it forms the central information repository. It includes key data from the beginning of product development, such as raw material origin and composition, environmental impacts, chemicals or dyes used, recycled content, user manuals, repairability, compliance certificates, and end-of-life instructions (Figure 2). This information makes the sustainability impacts of the product transparent to stakeholders and hence pushes manufacturers to adopt ecodesign principles through market regulation or competition.

DPPs highlight the importance of data sovereignty, indicating how different users report (Figure 3) and access (Figure 1) data. Consumers can verify sustainability claims, regulators can audit compliance, circular operators can access information for safe disassembly, and manufactures can update product information and monitor supply-chain data.

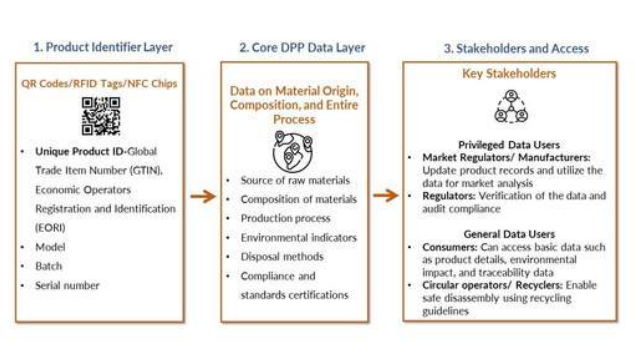

Figure 1: Core Layers of DPP (sources: The Textile Think Tank, 2025; EcoWise, 2025)

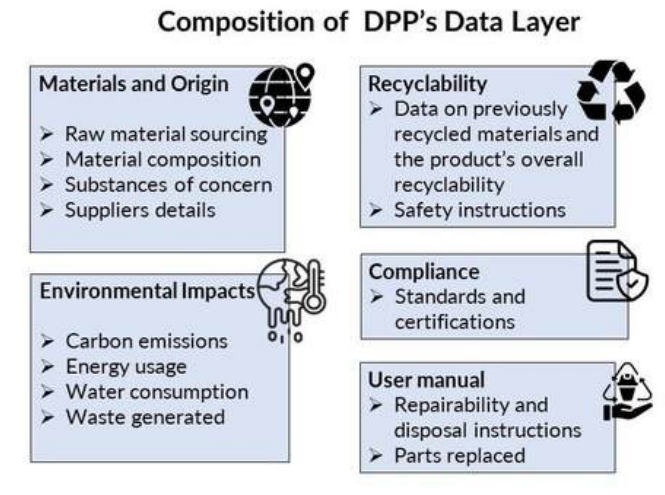

Figure 2: Anatomy of DPP (source: The Textile Think Tank, 2025)

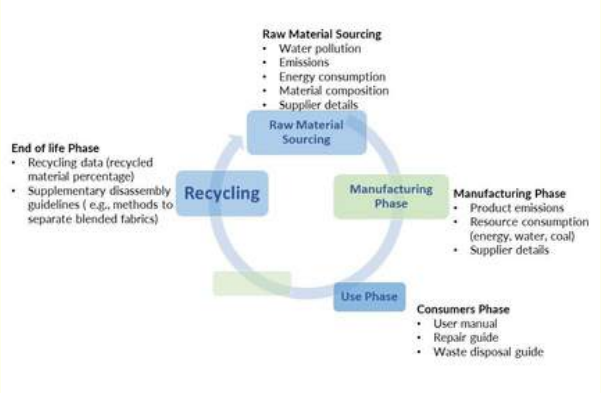

Figure 3: Data points for DPP in a lifecycle (source: The Textile Think Tank, 2025)

2. Global digital product landscape for textiles

Countries are responding to DPP mandates not only as a compliance checkbox but also as a strategic economic lever to gain a competitive edge (KPMG, 2025). The EU, one of the largest garment importers, has instituted DPP regulations and is therefore pushing other countries to align with sustainability standards. This is increasingly shaping global trade access, where exporting countries must meet strict environmental disclosure and traceability standards to enter global markets. Several countries, both exporters and regulators, are actively preparing to implement DPP or considering it to remain competitive and avoid green trade barriers (EcoWise, 2025); India has yet to take action in this space (Figure 4).

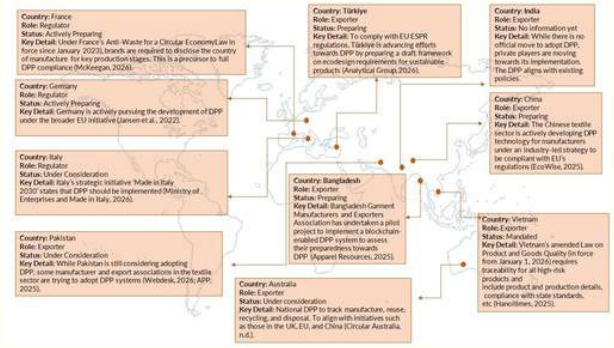

Figure 4: Global landscape of DPP

2.1 Policy landscape

The ESPR came into effect on 18 July 2024, following the 2020 Circular Economy Action Plan and the broader European Green Deal roadmap. It is a crucial component of the EU's sustainability efforts (European Parliament, 2024).

This regulation creates a legal framework for implementing ecodesign standards that products must meet before they can be sold or used. Its primary objectives are to establish sustainable products as the market standard, minimise environmental and carbon impacts throughout a product's lifecycle, and ensure that compliant goods can be traded freely across the internal market (European Union, 2024).

It replaces the previous Ecodesign Directive of 2009 and introduces major additions, including the establishment of the DPP and a framework to prevent the destruction of unsold consumer goods. It also establishes a framework for product-specific mandatory green public procurement requirements. The DPP is intended to support the broader vision of the regulation by promoting traceability, repairability, circularity, and sustainability across value chains, including textiles and apparel. While it is understood that the DPP will serve as a digital record of a product's sustainability profile, the exact criteria and requirements will remain unclear until the adoption of delegated acts (expected in 2027, with 18 months until adoption; KPMG, 2025).

2.2 Implications for India's exports

The proposed India–EU FTA is expected to benefit Indian industries, including those in the textile sector, subject to their ability to comply with the ESPR and its associated DPP mandate. The rules under the ESPR will apply to all products entering the EU market, regardless of their place of production (Haldar, 2026). This effectively requires all exporters to the EU, including India, to adopt DPP systems.

While industries operating within standardised global identification systems may be able to integrate their products through existing infrastructure with DPP systems, smaller players are likely to find compliance more difficult (Haldar, 2026). Smaller businesses will need to navigate an additional non-tariff barrier to remain competitive and retain access to export markets.

3. Implementing the DPP: Opportunities and bottlenecks

Early adoption of the DPP is increasingly viewed as a strategic advantage, as it offers improved market access and global competitiveness. The primary benefit of the DPP lies in its ability to consolidate fragmented data into a standardised digital format. Currently, data remains fragmentary and inconsistent, and the DPP addresses this gap by facilitating structured data collection, thereby promoting interoperability and operational efficiency. As highlighted earlier, this digital code contains embedded information on material specifications, recycling, and repairability, which can inform strategies for second-life use and resource recovery (Tech Mahindra Ltd, 2026). Beyond facilitating end-to-end lifecycle traceability, such datasets can serve as a foundation for EPR frameworks. Material composition details within a DPP can optimise resource efficiency and recycling processes, enabling recyclers to segregate materials effectively and thereby improve resource recovery rates. This, in turn, can help retain materials within the loop and reduce dependence on raw materials (Hakola et al., 2025). It can also support manufacturers in integrating ecodesign principles into their production processes.

While there are many benefits associated with the adoption of DPP, its implementation in India presents several challenges, including data-related, technological, institutional, and firm-level constraints, as well as gaps in stakeholder integration and governance models.

First, data collection could be difficult because of the informal nature of the textile industry and manufacturers' potential reluctance to share upstream data owing to confidentiality concerns. Additionally, maintaining and updating dynamic data within centralised platforms poses operational challenges. Variations in data formats, digital standards, and technological platforms across industries further hinder seamless interoperability across the value chain (Tech Mahindra Ltd, 2026).

Second, the absence of well-defined governance structures that allocate clear roles and responsibilities across stakeholder groups complicates implementation. Many existing studies tailor DPP architecture around region-specific legislation, with limited consideration for global applicability. This raises concerns about the emergence of fragmented regulatory regimes or 'regulatory islands' and parallel frameworks, which could be particularly problematic for industries with complex, multi-jurisdictional supply chains such as fashion (The Textile Think Tank, 2025). A nodal agency is therefore necessary to oversee the governance of the DPP system and maintain data standardisation and accountability

within operational structures. For instance, in the case of the proposed Battery Pack Aadhar (or Battery Passport), the Ministry of Road Transport and Highways functions as the apex body responsible for a centralised data system that enables compliance and monitoring (Ministry of Road Transport and Highways, 2026). A comparable institutional framework would be critical for sectors such as textiles.

Third, micro, small, and medium enterprises (MSMEs) may be disproportionately burdened by DPP requirements. Businesses with established identification systems, technical capacity, adequate workforce, and IT infrastructure may be able to integrate their products into DPP systems with relative ease. However, smaller manufacturers and recyclers may face significant operational and capital constraints. These include investments in digital systems, workforce training, and compliance requirements, which may limit their participation in such frameworks (Haldar, 2026).

Fourth, gaps persist in stakeholder integration and governance models. The role of end-users and recyclers remains marginalised in discussions on DPP, despite their importance in closing the loop. In addition, critical lifecycle data may be inconsistently recorded or updated—preventing continuity across the product lifecycle and undermining system effectiveness (The Textile Think Tank, 2025).

While these challenges are significant, they do not diminish the transformative potential of DPPs. With technological adoption, coordinated governance frameworks, targeted policy support for MSMEs, and stakeholder alignment, DPPs can unlock new opportunities for innovation, competitiveness, and regulatory compliance while accelerating the transition towards a more transparent and circular economy.

4. Implementation roadmap

The DPP requirement marks a major transition for the textile sector. A gradual rollout and built-in support mechanisms will help ease the adjustment. To remain viable in the EU, countries must proactively enable manufacturers and recyclers to upgrade their digital infrastructure and ensure thorough traceability across supply networks. The following roadmap outlines transitional arrangements and support mechanisms that India needs to put in place to implement DPPs.

I. Governance and regulatory frameworks

- Establish a nodal body (e.g. under the Ministry of Textiles, with representation from the Ministry of Environment, Forest and Climate Change and the Ministry of Commerce and Industry) to consolidate guidelines and interface with EU institutions. This would support the evolution of DPP requirements in a manner that streamlines and avoids duplication of compliance processes for Indian industries.

- Develop India-specific DPP rules for textiles following core ESPR principles while accounting for domestic production structures. This should include clear rules on data ownership and liability for incorrect or missing data.

II. Readiness assessments

- Evaluate existing capacity and systems for capturing and storing product data, supply chain information, and environmental metrics. This will help distinguish segments that can integrate quickly from those requiring additional support for data collection, process optimisation, or system upgrades.

- Engage stakeholders, including exporters, MSME clusters, industry associations, recyclers, technology providers, and logistics firms through targeted consultations to assess current practices, confidentiality concerns, data fragmentation, gaps in compliance with sustainability standards, and operational and technological capacity. These assessments should inform the design of incentive schemes, training modules, and DPP templates.

III.**Onboarding digital systems**

- The nodal agency should publish minimum technical specifications and certify or empanel a pool of technology providers, including open-source options, that offer solutions compatible with EU DPP systems. This can reduce transaction costs and ease adoption for MSMEs.

- Establish interoperable digital systems to support DPP implementation, ensuring secure management, storage, and sharing of information across the value chain.

IV. Standardisation of data

- Design standardised formats for data reporting in consultation with manufacturers and recyclers, covering product origin and composition, environmental footprint, processing methods, chemical safety information, certifications, repairability and recyclability, and end-of-life data.

- Adopt uniform data templates and taxonomies for both regulatory compliance and procurement. This will improve consistency, support interoperability, and enable automated data exchange.

V. Awareness and capacity building workshops for manufacturers and circular operators

- Issue clear guidelines and build capacity among industries and circular operators to ensure clarity in roles and responsibilities related to DPP adoption.

- Prioritise MSMEs by addressing gaps in infrastructure and operational capacity. Shared support services, such as common data-entry facilities, can help smaller firms participate effectively in DPP systems.

VI. Pilot projects

- Launch pilot projects across selected value chains that reflect the diversity of textile exports to identify gaps, test interoperability, validate workflows, and align stakeholders.

- Use pilot outcomes to refine data standards, platform design, and governance arrangements. The workflow must be iterated as per the feedback before full-scale roll-out, with particular attention to cost, ease of use, and the distribution of responsibilities.

VII. Scalability

- Introduce time-bound tax incentives or interest subvention schemes to support investments in DPP-related infrastructure, such as traceability software, tagging hardware, and training systems. Public credit guarantee schemes and blended finance instruments targeted at MSMEs can help mitigate financing risks.

- Establish shared digital hubs within textile clusters to provide services such as data entry, DPP registration, compliance advisory, and IT support. These hubs can act as key enablers for MSMEs to adopt DPPs.

Conclusion

The adoption of DPPs can strengthen India's standing as a major exporting nation by ensuring compliance with emerging EU regulations and supporting businesses operating in India. However, the DPP should not be viewed merely as a regulatory requirement but as a strategic tool to enhance transparency, competitiveness, traceability, and value chain efficiency.
DPPs also can potentially accelerate India's transition towards a circular economy.

India's circular economy could generate a market value of over USD 2 trillion and 10 million jobs by 2050 (Press Information Bureau, 2025). In addition, DPPs can support enable circular business models and expand employment in the circular operation space. Furthermore, DPP can act as an enabler for effective implementation of the EPR framework.
By facilitating better resource management and enabling circular supply chains, DPPs can contribute to broader national goals, including the 2070 net zero targets and the NCEF. If implemented effectively, DPP can help India move from compliance-driven adjustment to a more resilient, resource-efficient, and globally competitive circular economy.

References

- Analytical Group. (2026, February 2). Turkey: Ecodesign requirements and the digital product passport (DPP). Analytical Group. https://analytical-group.com/en/news-en/turkey-ecodesign-requirements-and-the-dpp
- Apparel Resources. (2025, October 15). Bangladesh gears up for the digital product passport era. https://bd.apparelresources.com/business-news/sustainability/bangladesh-gears-digital-product-passport-era/
- APP. (2025). Pakistan to introduce Digital Product Passport for textile exports, says commerce coordinator. Profit. https://profit.pakistantoday.com.pk/2025/08/13/pakistan-to-introduce-digital-product-passport-for-textile-exports-says-commerce-coordinator/
- Bhupender Yadav. (n.d.). [Press release]. https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2108165&reg=3&lang=2
- Carbon Trail. (n.d.). Digital product passport software in Germany. https://carbontrail.net/digital-product-passport-software/germany/
- Circular Australia. (n.d.). Circular Australia Welcomes Australian Government Digital Product Passport Proposal. Circular Australia Welcomes Australian Government Digital Product Passport Proposal - Circular Australia
- Haldar, S. (2026). Is the India-EU FTA equitable? Europe's Digital Product Passport raises questions on that score Down To Earth. https://www.downtoearth.org.in/economy/is-the-india-eu-fta-equitable-europes-digital-product-passport-raises-questions-on-that-score
- Hakola, L., Abedi, F., Nordman, S., Smolander, M., & Paltakari, J. (2025). Leveraging digital product passports to derive circular strategies. Procedia Manufacturing. https://doi.org/10.1016/j.promfg.2025.08.042
- KPMG. (2025). What textile brands need to know about the Digital Product Passport. KPMG. https://kpmg.com/dk/en/esg/digital-product-passport--dpp-/what-textile-brands-need-to-know-about-the-dpp.html
- Ministry of Enterprises and Made in Italy. Made in Italy 2030. (2026). https://www.mimit.gov.it/images/stories/documenti/Made_in_Italy_2030_-_Per_una_nuova_strategia_industriale.pdf
- CIRPASS. (2023). Digital product passport (DPP) in a nutshell. https://cirpassproject.eu/dpp-in-a-nutshell/
- Deutsche Recycling editorial team. (2026, March 23). The digital product passport for textiles explained. Deutsche Recycling. https://deutsche-recycling.com/blog/the-digital-product-passport-for-textiles-explained/
- EcoWise. (2025). Chinese textile sector DPP strategy white paper.
- European Union. (2024). Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC. http://data.europa.eu/eli/reg/2024/1781/oj
- Hanoitimes. (2025). Vietnam moves toward mandatory digital traceability for textile products. Enternews. https://en.diendandoanhnghiep.vn/vietnam-moves-toward-mandatory-digital-traceability-fornbsp-textile-products-n44265.html
- India Brand Equity Foundation. (2022, September 30). The textile and apparel exports of India. https://www.ibef.org/blogs/the-textile-and-apparel-exports-of-india
- Jansen, M., Gerstenberger, B., Bitter-Krahe, J., Berg, H., Sebestyén, J., & Schneider, J. (2022). Current approaches to the digital product passport for a circular economy: An overview of projects and initiatives (Wuppertal Paper No. 198). Wuppertal Institute for Climate, Environment and Energy.
- McKeegan, D. (2026). The digital product passport: What every textile printing business needs to know. FESPA. https://www.fespa.com/en/news-media/the-digital-product-passport-what-every-textile-printing-business-needs-to-know/#:~:text=Specifically%2C%20the%20DPP%20will%20mandate,DPP%20compliance%20across%20the%20EU.
- Ministry of Road Transport & Highways, Government of India. (2026). Guidelines for implementation of battery pack Aadhaar system (Draft). https://psa.gov.in/CMS/web/sites/default/files/publication/Battery%20Pack%20Aadhaar%20Guideline.pdf
- Press Information Bureau. (2025b, July 21). Government initiatives to boost India's textile sector and exports. Government of India. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2156220
- Press Information Bureau. (2025c, August 12). Export target for textiles 2030. Government of India. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2155461
- Tech Mahindra Ltd. (2026). Unlock the Future with Digital Product Passports: Transforming Product Lifecycle Transparency. https://insights.techmahindra.com/assets/unlock-the-future-with-digital-product-passports.pdf
- The Textile Think Tank. (2025). Ultimate guide to digital product passport for textiles. https://thetextilethinktank.org/wp-content/uploads/2025/01/Ultimate-Guide-to-Digital-Product-Passport-for-Textiles.pdf
- United Nations Industrial Development Organization. (2025). Digital product passport readiness assessment study for the textile industry in the Global South (Version 1.6).

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Closing the Loop: The Human Behaviour Imperative in Textile Circularity

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Head External Relations, Media & Sustainability
Bharat Soka Gakkai

Introduction: Circularity Is Not Just a Systems Problem; It Is a Human One

Circularity is often discussed as a systems challenge, but in reality, it is deeply connected to human behaviour. The textile and apparel sector is among the most resource-intensive and emissions-heavy industries in the global economy. Current estimates suggest that fashion contributes roughly **8–10 percent of global greenhouse gas emissions** (Apparel Impact Institute, 2023; IFC, 2023).

Despite the global policy push around the **United Nations Sustainable Development Goals (SDGs)** since 2015, consumption levels have continued to grow rapidly, largely driven by the expansion of fast fashion business models. The global fashion system now produces **tens of millions of tonnes of textile waste every year**, much of which ends up in landfills or is exported to countries that often lack the infrastructure required to manage it responsibly (EEA, 2023; Ellen MacArthur Foundation, 2017; PACE, 2021).

In response to these challenges, the circular economy has emerged as a powerful framework for rethinking how textiles are designed, produced, used, and recovered. Innovations in fibre-to-fibre recycling, chemical recovery technologies, and circular business models have expanded significantly over the past decade.

At the same time, second-hand and resale markets are growing faster than traditional retail channels, signalling a potential shift in the way clothing circulates within society (Future Market Insights, 2024; McKinsey & Company, 2024; Statista, 2024).

Governments and international organisations are also beginning to develop regulatory roadmaps that aim to reduce textile waste and introduce Extended Producer Responsibility (EPR) mechanisms for the fashion industry (EEA, 2023; PACE, 2021).

However, despite these technological advances and policy frameworks, the gap between circular ambition and practical outcomes remains significant. This gap is no longer purely technological or regulatory. It is also behavioural. Within Bharat Soka Gakkai (BSG), this missing dimension is described as Sustainable Human Behaviour, referring to how individuals emotionally relate to clothing and how everyday choices influence consumption patterns (BSG, 2025; RCA, 2023).

The future of circular textiles will therefore depend not only on technological innovation but also on reshaping the social habits, cultural norms, and identities that influence what people wear and how they use it. As **Daisaku Ikeda** observes, “The future we want can be achieved only when there is a deep personal awareness that we ourselves must bring it into being” (Ikeda, 2012).

Fashion brands and retailers have increasingly designed business strategies around this psychology. New collections appear at an accelerated pace, and garments are often produced with limited durability, creating a cycle of perceived obsolescence well before the physical lifespan of the product ends (Ellen MacArthur Foundation, 2017).

Because revenue growth is still closely tied to sales volume, even advanced recycling infrastructure struggles to compensate for the environmental impact generated by rapidly increasing consumption. A circular system that tolerates unlimited growth in consumption becomes difficult to sustain in material and mathematical terms.

For this reason, the first loop that must slow down is not the recycling loop but the **loop between desire and purchase.**

The Disposal Dilemma

Another critical behavioural challenge appears at the **end of a garment's life cycle.**

Globally, approximately **92 million tonnes of textile waste** are generated each year. Only a small proportion of this material is recycled effectively. A significant share is landfilled, incinerated, or exported to other regions (EEA, 2023).

Households play a central role in determining whether garments enter circular systems. However, low levels of textile segregation, uncertainty about fibre composition, and limited access to convenient collection systems often result in garments being discarded in mixed waste streams.

Convenience also strongly influences behaviour. When responsible disposal requires additional effort, time, or specialised knowledge, people tend to choose the simplest option available. Consequently, behavioural factors such as awareness, moral framing, and accessibility often shape disposal outcomes more strongly than infrastructure alone (RCA, 2023).

Cultural perceptions also present obstacles. Repairing clothing has historically been associated with financial constraint or lack of fashion awareness. Habits formed during decades of abundance are difficult to change, even when circular alternatives become available.

Circular systems frequently fail when the **behavioural friction associated with sustainable choices becomes higher than the effort required for familiar habits.**

If behaviour represents the main bottleneck, then behavioural science must become central to circular policy and innovation rather than an afterthought.

Behavioural Circularity Matters for Environment and Society

Environmental Consequences of Behavioural Patterns

The environmental footprint of fashion arises less from any single garment and more from the cumulative patterns of production, purchase, use, and disposal.

The textile and apparel sectors contribute approximately **8–10 percent of global greenhouse gas emissions,** partly due to the increasing use of **virgin polyester fibres** (Apparel Impact Institute, 2023).

What Is a Circular Economy?

Traditional textile production has largely followed a **linear "take-make-dispose"** model, where environmental impacts are treated as external costs rather than core design constraints. Circular economy thinking challenges this approach by viewing economic systems as **regenerative rather than extractive** (Ellen MacArthur Foundation, 2017; PACE, 2021).

Three core principles guide the circular economy:

1. Designing out waste and pollution
2. Keeping products and materials in use at their highest value
3. Regenerating natural systems

Circularity begins when value is created not only at the point of sale but throughout the entire lifecycle of a product. This includes longevity, reuse, repair, sharing, and material recovery. In theory, such a model enables economic activity to grow without proportionally increasing resource extraction, thereby aligning industrial systems with planetary boundaries (Ellen MacArthur Foundation, 2017).
Within the textile sector, circularity strategies generally focus on four domains.

First, **design for durability and longevity**, where garments are created using construction techniques and aesthetics that allow repeated wear and repair.

Second, **material innovation**, where fibres are engineered to enable mechanical or chemical recycling without excessive degradation.

Third, **material recovery systems**, which involve collection, sorting, and processing technologies capable of handling post-consumer textiles at scale.

Fourth, **circular business models**, including repair services, rental platforms, resale markets, and take-back programmes designed to extend the useful life of garments (ScienceDirect, 2024).

Despite this progress, far less attention has been devoted to the **human dimension** that ultimately determines how garments are used in everyday life. Circular strategies often overlook consumption psychology, disposal habits, identity formation, and social norms surrounding fashion trends and status. In reality, circularity depends not only on material loops but also on what may be called **"people loops"** and **"social loops."** These refer to the cultural meanings, emotional attachments, and behavioural patterns that shape how clothing moves through society (RCA, 2023; ACR+, 2023).

The Visible Behavioural Gap in Textile Circularity

Overconsumption as a Cultural Pattern

Today, clothing functions as a powerful language of identity. It communicates mood, aspirations, belonging, and social status. Social media platforms have amplified this dynamic by encouraging highly visible consumption practices, including the widely discussed "haul culture," where individuals showcase large volumes of newly purchased clothing online (Nature Sustainability Studies,2025).

Water consumption within the industry is also substantial. Producing a single cotton T-shirt may require approximately **2,700 litres of water**, while the lifecycle of a pair of jeans can involve roughly **1,000 gallons of water** when cultivation, processing, and consumer laundering are included (IFC, 2023).

Textile waste that enters landfills or open dumping sites can release methane and leach chemicals, dyes, and microplastics into surrounding ecosystems. Washing synthetic garments also releases large numbers of microfibres into waterways, contributing to an estimated **200,000 to 500,000 tonnes of textile microplastics entering oceans each year** (European Environment Agency, 2023).

These impacts demonstrate that environmental outcomes are closely tied to behavioural patterns such as purchasing frequency, washing habits, and disposal practices. Resource efficiency therefore depends not only on technological innovation but also on everyday consumer behaviour.

Culture of Consumption and Social Norms

Textile circularity is closely connected with issues of status, identity, and social justice.

Fast fashion has become widely accessible due to its low prices and rapid production cycles. As a result, frequent purchasing has become normalised, even though the environmental costs often remain hidden within supply chains.

At the same time, visible repair or repeated use of clothing can sometimes be interpreted as a sign of limited financial means, particularly for women and socially marginalised groups who face strong expectations around appearance.

On a global scale, textile waste flows also reflect economic inequality. Large volumes of discarded clothing from wealthier nations are exported to countries in the Global South, where limited waste management infrastructure can transform these imports into environmental burdens for local communities.

If circularity focuses solely on technological solutions while overlooking these social dynamics, it risks producing outcomes that resemble **greenwashing rather than genuine transformation.**

Communities as Engines of Change

While overconsumption is socially shaped, behavioural change can also emerge through collective action.

Communities often serve as powerful environments for social learning. When individuals observe peers repairing clothing, participating in clothing swaps, or proudly repeating outfits, behaviours that once appeared unconventional can gradually become normalised.

Initiatives such as **repair cafés, mending circles, clothing swaps, and youth climate movements** are not only extending garment lifespans but also reshaping cultural narratives around fashion. Clothing choices increasingly reflect broader ethical values related to sustainability and social responsibility.

Importantly, this shift reframes the issue away from individual guilt and towards collective cultural redesign.

Circular Textiles and the Future Human Role

From Consumers to Custodians

The future of circular textiles may depend on a fundamental shift in identity. Individuals may need to move from viewing themselves primarily as consumers toward understanding their role as **custodians of resources.**

In this perspective, garments are not disposable commodities but products that embody energy, water, labour, and cultural meaning. Emotional durability therefore becomes as important as physical durability.

When individuals develop deeper attachments to fewer garments, clothing becomes something that evolves alongside personal identity rather than being replaced continuously.

Repair practices may also take on new symbolic value. Visible mending, creative patchwork, and upcycling can communicate care, individuality, and environmental awareness. In such a culture, the most admired wardrobe would not necessarily be the largest but rather the most thoughtfully used.

Behaviour-Integrated Circular Business Models

Future circular business models will likely incorporate behavioural insights at their core.

Technologies such as **digital product passports**, accessible through QR codes or embedded tags, can provide information about fibre composition, environmental impact, repair options, and recycling pathways. This transparency allows users to make more informed decisions throughout a garment's lifecycle.

Some companies have already introduced initiatives that encourage garment longevity. For example, **Patagonia's Worn Wear programme** promotes repairing and extending the life of clothing rather than replacing it.

Incentive systems can also influence behaviour. Store credits or discounts offered in exchange for returning garments may encourage participation in repair, resale, or recycling schemes.

Digital tools could further support circular behaviour. AI-driven wardrobe applications might track how frequently garments are worn and suggest new styling combinations, encouraging repeated use. Community-based textile libraries, where garments are shared and maintained collectively, may also emerge in dense urban areas.

In such systems, the user becomes an active participant in the circular economy rather than a passive endpoint.

Education as Infrastructure

Education must play a central role in supporting behavioural circularity.

Circular literacy can be integrated into school curricula, vocational training programmes, and university education. Skills such as sewing, garment repair, and understanding care labels can complement broader knowledge about supply chains, labour conditions, and planetary boundaries.

Initiatives such as **BSG's SDG Clubs** demonstrate how youth engagement can support sustainability awareness and

encourage responsible consumption practices.

Experiential learning is particularly powerful. When students understand the complex journeys of fibres and dyes across multiple continents, the true environmental cost of inexpensive clothing becomes more visible.

Young people already play a central role in climate advocacy. Their influence on family purchasing choices, social media narratives, and brand accountability may become a powerful driver of behavioural change.

Behavioural Design in Policy

Policy frameworks may also benefit from incorporating behavioural insights.

Simple design interventions can guide more sustainable decisions. Online shopping platforms could prioritise durable or second-hand garments in search filters. Clear durability labels could help consumers evaluate product lifespan. Repair services might be offered alongside garment sales.

Extended Producer Responsibility schemes could reward companies that actively engage consumers in care, repair, and return processes.

Deposit-return systems for garments represent another possible approach. Consumers would pay a small deposit when purchasing clothing and receive it back when the garment is returned for reuse or recycling.

Social incentives may also encourage participation. Public recognition programmes, tax incentives, or community-level rewards could motivate collective engagement with circular practices.

In such policy environments, advanced technologies such as artificial intelligence, blockchain traceability, and digital twins could support behavioural change rather than merely optimising production processes.

Metrics Beyond Material Recovery: Measuring Behavioural Circularity

If behaviour is central to circular textiles, measurement frameworks must also evolve.

Current metrics often focus on material flows such as recycling rates, collected textile volumes, or the percentage of recycled fibres in production. Although these indicators are important, they do not fully capture how garments are actually used.

New indicators could therefore include:

- Garment lifespan extension indices
- Average repeat-wear rates
- Repair frequency statistics
- Consumer participation rates in circular programmes

Such behavioural indicators could be tracked at city, national, or brand levels.

These metrics could also be linked to carbon accounting models to estimate the emissions avoided when garment lifespans increase or when repairs replace new purchases.

Without addressing consumption growth, **Net Zero targets within the textile sector will remain difficult to achieve**, even if production processes become more efficient. Behavioural circularity therefore represents

not a peripheral concept but a critical driver of decarbonisation and resource efficiency.

Case Signals and Emerging Shifts

Early signs suggest that behavioural change in fashion may already be underway.

The global second-hand apparel market has expanded rapidly and is projected to exceed 200 billion USD by 2025 (Future Market Insights, 2024; Statista, 2024). Online resale platforms and peer-to-peer marketplaces have helped normalise the purchase of pre-owned clothing, particularly among younger consumers.

Repair cafés, community mending groups, and visible mending movements have also gained popularity in many cities, indicating renewed interest in repair culture as both a creative and social practice.

Youth-driven thrift culture has redefined second-hand fashion as unique and expressive rather than inferior. Social media platforms now frequently celebrate vintage styling and garment longevity.

At the policy level, several governments are strengthening textile regulations by introducing separate textile collection targets, Extended Producer Responsibility schemes, and stricter waste management policies.

Although promising, these developments remain incomplete. Resale markets often exist alongside continued fast fashion consumption, and many policies still focus primarily on waste collection rather than demand reduction.

Nevertheless, these trends provide valuable **signals of change** that may inform future circular strategies.

Conclusion: Circularity as a Cultural Transition

The challenge of circular textiles is often framed as an engineering problem. Significant attention is devoted to designing recyclable fibres, improving recycling infrastructure, and optimising reverse logistics.

These efforts are necessary, yet they are not sufficient on their own.

The deeper challenge is cultural. A system built on constant novelty, disposability, and status-driven consumption cannot become sustainable through recycling alone. Even the most advanced recycling technology cannot fully compensate for continuous growth in production and ever-shorter garment lifespans.

True circularity therefore requires alignment across several dimensions. Material systems must prioritise durability and reuse. Economic incentives must reward longevity rather than sheer volume. Policy frameworks must incorporate environmental and social costs in ways that protect both ecosystems and communities.

Most importantly, human values must evolve to appreciate care, repair, sharing, and moderation.

Such a transformation invites a reconsideration of how prosperity and self-expression are defined. Instead of equating fulfilment with constant acquisition, societies may gradually move toward values that emphasise meaning, sufficiency, and responsible stewardship.

In this sense, the future of circular textiles will be determined not only by what industries manufacture but also by how people value, use, and relate to their clothing.

References

- ACR+. (2023). The future of textiles: Understanding consumer behaviour in a circular economy.
- https://www.acrplus.org/en/agenda/the-future-of-textiles-understanding-consumer-behaviour-in-a-circular-economy-757
- Apparel Impact Institute. (2023). Fashion industry sees emissions spike driven by overproduction and polyester use.
- https://apparelimpact.org/resources/fashion-industry-sees-7-emissions-spike-driven-by-overproduction-and-polyester-use/
- Bharat Soka Gakkai. (2025). Sustainability initiatives and sustainable human behaviour. https://www.bharatsokagakkai.org/bsg-for-society/sustainability/
- Boston Consulting Group. (2025). Global trends reshaping the resale market. https://www.bcg.com/press/9october2025-new-report-from-bcg-and-vestiaire-collective-reveals-global-trends-reshaping-the-resale-market
- COSH! (2023). Plastic in the oceans: Textile microplastics and environmental impact. https://cosh.eco/en/articles/plastic-in-the-oceans
- Ecomena. (2023). *Environmental impact of the global textile industry and transition toward circular economy*.
- HHC Earth. (2023). The environmental impact of the textile sector. https://www.hhc.earth/knowledge-base/articles/the-environmental-impact-of-the-textile-sector
- International Finance Corporation. (2023). Strengthening sustainability in the textile industry. https://www.ifc.org/en/insights-reports/2023/strengthening-sustainability-in-the-textile-industry
- McKinsey & Company. (2024). State of fashion report. https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion
- Nature Portfolio. (2025). Consumer behaviour and sustainable fashion transitions. https://www.nature.com/articles/s41599-025-05813-9
- PACE (Platform for Accelerating the Circular Economy). (2021). Circular economy action agenda for textiles. https://pacecircular.org/action-agenda/textiles
- Royal College of Art. (2023). NICER insights report on human behaviour and the circular economy. https://textilescircularity.rca.ac.uk/resource/nicer-insights-report-on-human-behaviour-and-the-circular-economy/

https://www.ecomena.org/environmental-impact-of-global-textile-industry-and-jordan-transition-toward-circular-economy

- Ellen MacArthur Foundation. (2017). *A new textiles economy: Redesigning fashion's future.* https://www.ellenmacarthurfoundation.org/fashion-and-the-circular-economy-deep-dive
- European Environment Agency. (2023a). *Textiles and the environment: The role of design in Europe's circular economy*. https://www.eea.europa.eu/en/analysis/publications/textiles-and-the-environment-the-role-of-design-in-europes-circular-economy-1
- European Environment Agency. (2023b). *Microplastics from textiles: Towards a circular economy for textiles in Europe*. https://www.eea.europa.eu/en/analysis/publications/microplastics-from-textiles-towards-a-circular-economy-for-textiles-in-europe
- Future Market Insights. (2024a). *Second-hand apparel market report*. https://www.futuremarketinsights.com/reports/secondhand-apparel-market
- Future Market Insights. (2024b). *Second-hand fashion market outlook.* https://www.futuremarketinsights.com/reports/second-hand-fashion-market
- Greenpeace. (2024). *What are microfibres and why are our clothes polluting the oceans?*
- ScienceDirect. (2024). Advancing circular economy strategies for textile waste management.https://www.sciencedirect.com/science/article/pii/S2352550924001398
- Seaside Sustainability. (2023). *Plastic in our closets: Addressing microfiber pollution*. https://www.seasidesustainability.org/post/plastic-in-our-closets-addressing-microfiber-pollution
- Statista. (2024). *Apparel resale market value worldwide*. https://www.statista.com/statistics/826162/apparel-resale-market-value-worldwide/
- Wiley Online Library. (2023). *Consumer behaviour and sustainable fashion transitions*. https://onlinelibrary.wiley.com/doi/full/10.1002/casp.70217

The Hidden Backbone of Textile Circularity in India: Recognising Informal Workers in Policy Frameworks

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Introduction

A textile circular economy represents a significant shift from the conventional "take-make-dispose" linear model to a system where materials and products are utilised as long as possible. According to this concept, textiles are made to be long-lasting, repairable and recyclable. The ultimate goal is to "close the loop" and decouple industrial growth from the use of finite virgin resources by ensuring that textile fibres are collected and reincorporated into new production cycles at the end of their life.

As India is the world's 2nd largest producer of textiles & garments and the 3rd largest exporter, India faces a mounting waste crisis. According to the Ministry of Textiles' 2026 report, India generates approximately 70.73 lakh tonnes of textile waste every year. Of this, 58% is post-consumer waste and 42% is pre-consumer waste, also known as manufacturing waste. This scale of production directly translates into a growing waste burden, with an estimated 17% to 43% of post-consumer textile waste currently ending up in landfills or being incinerated. At the same time, India continues to be a major hub for recycling second-hand clothing and industrial rags, importing around 584 kilotonnes of textile waste from global markets.

However, what is often overlooked in mainstream policy discussions is that circularity in India is not a new concept. For decades, it has functioned through a vast informal ecosystem comprising kabadiwalas, itinerant traders such as the Waghris, and small-scale sorting units. Nearly 4 million informal waste pickers across the country play a critical role in recovering & sorting materials from streets, dumpsters, landfills, and material recovery facilities.

Despite serving as the functional backbone of material circularity, these actors remain largely invisible within formal policy frameworks, operating without recognition, social protection, or institutional support. This article examines the structural divide between formal policy & informal practice, arguing that true circularity in India cannot be achieved without the professional integration and protection of its most essential workers.

1.Existing Textile Circular System in India

India's textile waste management sector is remarkably well-integrated yet remains unorganised. The system operates through a multi-layered network comprising three main streams: pre-consumer waste, imported waste and post consumer waste. Within this structure, textile waste flows have a complex five-stage process that operates largely through informal expertise.

1	Collection of textile waste	Textile waste comes from manufacturers and households. It is collected through informal waste collectors, kabadiwalas, NGOs, and local body door-to-door collection systems.
2	Aggregation and sorting	After collection, the waste is taken to transfer stations or dry waste collection centres, where workers manually sort it by colour, size & fibre type and separate wearables from non-wearables.
3	Pre-processing of non-wearable waste	Non-wearable textiles are prepared for recycling by removing trims like buttons & zippers and then processed through methods such as garnetting, willowing, or bleaching.
4	Reuse and recycling pathways	Better-quality textiles are reused or resold in domestic and export markets, while recyclable materials are converted into yarn and other new products in recycling hubs like Panipat.
5	Downcycling and energy recovery	Lower-quality or non-recyclable textile waste is used in allied industries for products like insulation and stuffing, or as fuel for energy recovery in small industries such as brick kilns.

2.A System Built Without Blueprint

India generates approximately 70.73 lakh tonnes of textile waste every year, but long before circular economy discourse, the country had already built one through economic necessity and informal labor. At the heart of this system is the Bartanwali, the itinerant collector who moves door-to-door, exchanging utensils for textiles. Alongside them are waste pickers who recover textiles from landfills and mixed waste streams. Together, they form the primary entry point of textile waste into the circular chain. Once collected, these textiles move into godown-based sorting hubs, where skilled workers, predominantly women, manually grade fabrics into reusable, recyclable, or shoddy categories, a tacit experience-based knowledge that often rivals advanced automated fiber-sorting technologies. From here, high-quality grade A (excellent) & B (very good) garments re-enter the market through iconic second-hand bazaars like Sarojini Nagar, Delhi and Chor Bazaar, Mumbai.

At the recycling stage, materials that cannot be reused are processed through some of the world's most concentrated textile recovery clusters. Panipat in Haryana processes over 100,000 tonnes of textile waste annually, employing nearly 300,000 workers across 20,000 industrial units to convert textiles into recycled shoddy fiber for blankets and yarn. Surat handles 1,800-2,200 tonnes of synthetic fabric waste per day, while Tiruppur converts cotton knitwear offcuts into open-end spun yarn within a USD 4 billion export cluster.

Meanwhile, Dharavi's informal recycling micro-economy turns over an estimated USD 1 billion across all material streams. Despite operating at such a scale, this entire system functions without formal design: there is no Extended Producer Responsibility (EPR) mandate, no government cluster strategy and no dedicated formal circularity policy. As Doron and Jeffrey (2018) argue, India's waste economy represents a civilisational relationship with material reuse that predates industrialisation. The implication for policy is clear: India does not need to build a circular textile system from scratch; it needs to see, support, and formalise the one that already exists.

3.Role of Informal Workers

India's waste system plays a critical role in sustaining material circularity, particularly in contexts where municipal systems fall short. In many cities, waste generation exceeds the collection and processing capacity of Urban Local Bodies (ULBs), leading to dumping in landfills and open spaces. Waste pickers bridge this gap by recovering materials directly from mixed waste streams, identifying and sorting recyclables such as paper, plastic, metal, textiles, etc., contributing to India's high recycling rates. More than 70% of the total textile waste is currently recovered by extending material lifecycles, reducing demand for virgin resources, and lowering waste accumulation and health risks while easing pressure on formal waste management systems.

Yet this contribution remains largely invisible in national accounting, policy documents, and EPR frameworks.

*4.*Policy gaps

The management of solid waste and plastic waste has been the main focus of India's waste governance framework. The Solid Waste Management (SWM) Rules of 2016, which mandated source segregation, door-to-door collection, and decentralized processing, were a major development. These regulations focused on the integration of informal waste workers, mandating that ULBs register waste pickers, give them identity cards, and incorporate them into official waste management systems. However, mandate and implementation are two different things. Across most Indian cities, this integration remains unachievable. The SWM Rules do not extend specific protections or mechanisms to the textile-specific informal sector, which includes the kabadiwalas, sorters and recycling cluster workers who form a distinct sub-system within the broader waste sector.

In terms of EPR, India has developed a strong framework for plastic packaging under the Plastic Waste Management Rules, 2016 (Modified in 2022). To monitor EPR compliance, the Central Pollution Control Board (CPCB) has created a centralised website that is updated depending on feedback from local, regional, and national stakeholders.

However, there isn't a comparable EPR framework for textiles.

This gap is particularly consequential given that India is the world's second-largest textile producer and third-largest exporter: without EPR obligations, producers bear no formal responsibility for the post-consumer lifecycle of their products, leaving the full burden of recovery on the informal sector. While EPR for textiles is being deliberated in the developing stage, with regulatory measures under discussion by the European Commission and efforts by countries like the Netherlands, Sweden, and the UK, India's textile EPR remains undeveloped.

Therefore, the fundamental policy gap is structural: India's waste governance is built for a formal system, with accountability portals, registration requirements, and compliance processes that presume formal sector participation. Within this framework, the actual system functioning on the ground, the informal textile circular economy, lacks an institutional home. Informal workers are not officially recognised as contributors to circular economy objectives and are therefore unable to access benefits or participate in compliance mechanisms. Policies have been designed for an economy that does not reflect ground realities.

5.Need for integration

The marginalisation of informal workers from formal policy frameworks has quantifiable systemic and economic costs, making it more than just a social justice issue.

There is an efficiency cost first. Because it is integrated into pre-existing social networks, local knowledge, and adaptive route-based systems, the informal textile circular economy has low costs.

It would be expensive to replace or avoid it with formal mechanisms, such as corporate-led EPR compliance, municipal contracts, or new collection infrastructure, without ensuring equal recovery rates.

Second, there is a material loss cost. Without integration, the informal system remains fragmented, unable to access capital, certifications, or technology. Industry actors in Panipat note that if the largely informal sector is able to come together to create synergies and efficiencies of scale, India's potential for both global and domestic recycling is enormous. That potential is currently unrealised because the policy ecosystem does not create pathways for informal actors to participate in formal circular economy markets.

Third, there is a social cost. Informal textile workers disproportionately women, Dalits, and migrant workers perform hazardous labour without social protection. More than 200,000 people work in Panipat's textile sector, many pulling long shifts in suffocating conditions, with coughing, skin rashes, and respiratory illnesses being routine. Their exclusion from formal frameworks perpetuates this vulnerability.

The argument for integration is therefore both economic and normative. A circular economy that systematically excludes the workers who sustain it is neither circular nor equitable.

6.Policy Recommendations

India's textile circularity challenge is not the lack of a recovery system; rather, it is the absence of a policy framework capable of

recognising, governing, and financing the one that already exists. The following recommendations form a sequenced, mutually reinforcing architecture to address this gap.

6.1 Legal Recognition

Rather than constructing a parallel system, India should extend the e-Shram portal to create a Textile Recovery Registry (TRR), subclassifying textile circular economy workers such as waste pickers, kabadiwalas, sorters, & recyclers by function, geography, and material flow. Launched in 2021 and seeded with Aadhaar, e-Shram has registered over 30.48 crore unorganised workers. It has also integrated 12 Central Government schemes, including Ayushman Bharat and PM Suraksha Bima Yojana._The SWM Rules 2016 already mandate registration of waste pickers and their integration into formal waste management systems, yet implementation remains uneven and excludes textile-specific workers entirely. The TRR would close this gap, shifting recognition from a welfare gesture to economic actor status within circular value chains.

6.2 Textile-Specific EPR with Mandatory Informal Integration

India's forthcoming textile EPR framework must incorporate informal integration from the outset. The Ellen MacArthur Foundation's 2024 global EPR analysis highlights that the labor market of the reuse and recycling economy, along with the job impacts of a circular economy transition, remain poorly understood and require further policy attention. This gap is particularly acute in India, where the informal sector already performs the bulk of first-mile recovery yet remains structurally excluded from compliance mechanisms. To address this, the framework should mandate that producers meet a defined share of their collection targets through registered informal actors, establish a First-Mile Recovery Credit system through which informal collectors generate traceable compliance credits, and direct EPR financing toward decentralised, ward-level collection and sorting infrastructure.

6.3 Social Eco-Modulation of EPR Fees

The OECD (Organisation for Economic Co-operation) & Development) defines fee modulation as adjusting fees paid by producers in EPR schemes based on product design criteria, providing stronger design incentives while adding system complexity. India should extend this principle by incorporating social performance criteria: producers sourcing through registered informal networks or investing in worker safety would receive fee reductions, while those relying solely on formal-sector intermediaries would face higher obligations, making labor inclusion a compliance parameter rather than a voluntary commitment.

6.4 Cluster-Based Textile Circularity Zones (TCZs)

India should formally designate existing

recycling hubs such as Panipat, Tirupur, Ludhiana, and Indore as Textile Circularity Zones. These hubs should be supported through Common Facility Centres for sorting and fiber recovery, shared infrastructure, and environmental compliance assistance adapted to ground realities. Much of the recycling activity in these clusters is carried out by MSMEs (Micro, Small & Medium Enterprises), which often lack the financial and technical capacity to invest in experimentation or adopt new technologies at scale. Policy must therefore respond to these constraints rather than impose compliance burdens that small actors cannot absorb. Since these clusters already process textile waste at a significant scale through deeply integrated, largely informal networks, formal designation can help unlock coordinated investment, improve market access, and enable technological upgradation without disrupting the labor ecosystems that currently sustain them.

6.5 Cooperative and Worker-Led Enterprise Models

The SWaCH model in Pune offers a replicable format. With over 3,700 member owners, SWaCH recycles more than 200 tonnes of waste daily and saves the local government approximately Rs. 20 crore in waste management fees annually, while providing formal livelihoods to a predominantly female and Dalit workforce.

Policy should mandate ULB facilitation of textile-specific worker cooperatives and enable three-way partnerships between ULBs, producers, and worker collectives with viability gap funding to make these cooperatives viable EPR collection partners.

6.6 Social Protection and Occupational Safety

Recognition without protection risks formalising vulnerability. A dedicated framework must include national health insurance coverage, accident and disability protection, pension access through unorganised worker welfare boards, and mandatory OHS standards for sorting units. In Panipat, more than 200,000 workers operate in conditions where respiratory illness and skin disorders are routine, few can access medical care, and trade shocks have recently pushed the industry into its most difficult period in decades. Addressing these conditions is not peripheral to circular economy policy, it is central to its legitimacy.

6.7 Digital Traceability with Inclusive Design

A layered digital platform that connects mobile reporting by informal workers with formal compliance systems can make textile waste flows more transparent, help companies with ESG reporting, and improve pricing, without burdening small actors. This can turn informal, unclear systems into more organised and inclusive circular markets.

6.8 Fiscal Incentives and Green Public Procurement

Tax benefits for companies sourcing from registered informal networks, mandatory recycled textile procurement targets for government purchases, and low-interest credit lines for aggregators and micro-enterprises would collectively reframe circularity as a shared economic opportunity. The OECD identifies green public procurement as one of the vital levers for the circular economy transition, though adoption remains limited even where strong policy commitments exist. India's scale of government procurement represents a significant, currently untapped demand lever.

6.9 Material Value Guarantee (MVG) Mechanism

To address price volatility that directly affects informal workers' income stability, India should introduce minimum price benchmarks for key textile waste categories, funded through EPR contributions. This would stabilise scrap markets relied upon by collectors and sorters, while ensuring a consistent supply of materials to recycling clusters

6.10 National Textile Circularity Mission

A mission-mode institutional body under the Ministry of Textiles should coordinate EPR, waste governance, and industrial policy; align CPCB, State Pollution Control Boards, and ULBs; and set measurable targets for reuse, recycling, and worker integration. It should formally classify informal textile workers as Primary Resource Recovery Agents, a designation that carries entitlements, not just recognition. The Textile Policy 2024 already identifies sustainability, skill development, and employment generation as central sectoral objectives;_a National Textile Circularity Mission would provide the implementation structure through which those objectives reach the workers at the base of the recovery chain.

Policy Must Follow the Economy That Already Exists

India stands at a pivotal moment in the development of its textile circularity pathway, which will impact not only the environment but also millions of people's livelihoods and the credibility of its circular economy governance. The central argument of this article is clear: India does not lack a textile circular economy; it lacks a policy framework capable of recognising and supporting the one that already exists. Informal actors like kabadiwalas, waste pickers, sorters, and small-scale recyclers are not peripheral to this system.

They are its operational foundation, enabling first-mile recovery, material segregation, and value circulation at a scale that formal systems cannot match. Yet, their exclusion from policy frameworks creates systemic inefficiencies. Bypassing these actors in EPR mechanisms runs the risk of producing compliance without circularity,

and investments in parallel formal infrastructure could undermine effective, current networks.

Instead of building new systems, the solution is to match policy with actual conditions on the ground. Institutional recognition, inclusive EPR design, cluster-based support, and social protection are not welfare measures- they are prerequisites for building an efficient and resilient circular economy. Integrating informal workers into formal value chains can unlock material efficiency, reduce costs, and ensure equitable distribution of value.

Ultimately, the question is not about building a circular textile economy in India, it already exists. The challenge is whether policy can adapt to recognise, institutionalise, and fairly finance the system its workers have sustained for decades.

REFERENCES

- https://www.ibef.org/industry/indian-textiles-and-apparel-industry-analysis-presentation#:~:text=India%20is%20the%20world's%20second,year%20increase%20in%20Q1%20FY26.
- https://www.pib.gov.in/PressReleasePage.aspx?PRID=2237779&reg=3&lang=2
- Sorting-for-Circularity-Wealth-in-Waste-2.pdf Pg.9&26
- Sorting-for-Circularity-Wealth-in-Waste-2.pdf Pg.29
- https://www.britsafe.in/safety-management-news/2025/india-s-waste-pickers-indispensable-but-invisible#:~:text='Up%20to%20four%20million%20waste,as%20electricity%20generation%20from%20waste.
- Sorting-for-Circularity-Wealth-in-Waste-2.pdf Pg.35
- https://www.pib.gov.in/PressReleasePage.aspx?PRID=2237779®=3&lang=2
- https://special.ndtv.com/clothes-with-a-conscience-100/news-detail/how-the-waghri-community-indias-invisible-recyclers-help-keep-old-clothes-away-from-landfills-4188856/7#:~:text=The%20effectiveness%20of%20the%20Waghri,cities%20and%20meager%20economic%20returns.
- https://thewire.in/rights/the-invisible-labour-of-women-in-delhis-textile-recycling-sector
- https://timesofindia.indiatimes.com/life-style/travel/10-cheapest-markets-in-india-and-why-they-are-a-must-visit/photostory/123585936.cms
- https://ijrpr.com/uploads/V6ISSUE10/IJRPR53788.pdf
- https://www.theguardian.com/global-development/2025/oct/07/indian-factory-workers-fast-fashion-recycling-panipat-discarded-clothing
- https://india.mongabay.com/2024/02/stitching-sustainability-amidst-climate-change-challenges/#:~:text=World%20over%2C%20around%20215%20trillion,boilers%20of%20textile%20processing%20industries.
- https://tea-india.org/news-board/16473-what-to-learn-from-tirupur-model-4th-august-2022
- https://www.circularinnovationlab.com/post/dharavi-to-davos-informal-circularity#:~:text=This%20informal%20economy%20generates%20an,denser%20than%20New%20York%20City.
- https://www.researchgate.net/publication/326027052_Waste_of_a_Nation_Garbage_and_Growth_in_India
- https://thewire.in/rights/the-invisible-labour-of-women-in-delhis-textile-recycling-sector

- https://india.mongabay.com/2024/02/stitching-sustainability-amidst-climate-change-challenges/#:~:text=World%20over%2C%20around%20215%20trillion,boilers%20of%20textile%20processing%20industries.
- https://tea-india.org/news-board/16473-what-to-learn-from-tirupur-model-4th-august-2022
- https://www.circularinnovationlab.com/post/dharavi-to-davos-informal-circularity#:~:text=This%20informal%20economy%20generates%20an,denser%20than%20New%20York%20City.
- https://www.researchgate.net/publication/326027052_Waste_of_a_Nation_Garbage_and_Growth_in_India
- https://timesofindia.indiatimes.com/life-style/travel/10-cheapest-markets-in-india-and-why-they-are-a-must-visit/photostory/123585936.cms
- https://ijrpr.com/uploads/V6ISSUE10/IJRPR53788.pdf
- https://www.theguardian.com/global-development/2025/oct/07/indian-factory-workers-fast-fashion-recycling-panipat-discarded-clothing
- https://www.pib.gov.in/PressReleasePage.aspx?PRID=2237779®=3&lang=2#:~:text=Shri%20Giriraj%20Singh%20stated%20that,networks%20across%20the%20value%20chain.
- https://cpcb.nic.in/uploads/MSW/SWM_2016.pdf
- https://www.intechopen.com/chapters/88770
- https://sourcingjournal.com/sustainability/sustainability-news/india-textile-waste-recycling-laudes-tirupur-panipat-fashion-for-good-459187/
- https://atmos.earth/fashion-and-design/the-high-price-of-circular-fashion-in-indias-recycling-capital/
- https://www.pib.gov.in/PressReleasePage.aspx?PRID=2086193®=3&lang=2
- https://socialjustice.gov.in/public/ckeditor/upload/86351727949710.pdf#:~:text=There%20are%20several%20existing%20rules%20and%20policies,including%20door%20to%20door%20collection%20of%20waste.%E2%80%9D
- https://circulareconomy.europa.eu/platform/sites/default/files/2024-08/Pushing%20the%20boundaries%20of%20EPR%20policy%20for%20textiles.pdf#:~:text=reuse%20and%20recycling%20economy%2C%20and%20potential%20job,well%20understood%20today%20and%20require%20further%20exploration.

Visual Merchandising for Sustainability: Can Responsible Purchasing Be Affected by Store Design?

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Introduction

Consumer interaction with retail spaces has changed. Previously, retail spaces were constructed with the intention of making things visible, creating a hurry mentality, and generating more sales within the shortest time possible. This was done by illuminating the space well, filling it with merchandise, and bombarding potential customers with information.

As people become increasingly conscious about the need for sustainability, however, the above approach is slowly becoming obsolete. People now know that overconsumption has been one of the main drivers behind environmental destruction, especially when talking about consumer goods such as clothes and accessories. This means that the priority has shifted from maximizing sales to ensuring sustainable consumption practices.

With the rise of the above trend, visual merchandising emerges as a potent force. This practice goes beyond organizing merchandise; it involves creating a mental perception, controlling customer speed, and influencing decision- making. Thus, retail spaces communicate more than their contents.

An observation of Fabindia stores provides a useful lens to understand how design can support sustainability. The store does not rely on aggressive selling techniques. Instead, it creates an environment that encourages customers to slow down, observe, and engage more thoughtfully with products.

The Beginning of a Sustainable Retail Approach

It should be noted that in the case of sustainability in retail, it may not always be obvious. The message regarding sustainable aspects of retailing is usually delivered via subtle cues rather than direct marketing. In the case of the products sold at Fabindia stores, sustainability becomes part of the whole experience, and is not promoted directly.

One of the aspects that can reveal the presence of sustainability in Fabindia stores can be considered the application of natural materials for creating an interior of the store. One can say that the predominant colors of the stores are associated with the wooden shelves and other interior objects that are used inside stores.

This type of design creates a certain impression in customers, as they start perceiving products as high-quality and durable items.

Key observed characteristics:

- Employment of wood as well as other natural materials rather than man- made ones
- Rare employment of plastics in exhibit displays
- Man-made visual cues that convey artisan identity
- Earth-like color tones

These elements collectively communicate sustainability without the need for direct explanation.

Designing for Slower Consumption

One of the most noticeable differences between Fabindia and fast- fashion retail environments is the pace of shopping. The store layout is intentionally designed to reduce urgency.
Products are displayed with space around them rather than being tightly packed. Each section is clearly organized, allowing customers to navigate easily without feeling overwhelmed. This minimalistic approach reduces visual clutter and encourages focus.

From observation, it is evident that customers:

- Spend more time per section
- Touch and examine products more carefully
- Compare options before making decisions

This behavior suggests a shift from impulsive buying to more considered purchasing. By slowing down the shopping process, the store indirectly promotes responsible consumption.

Storytelling as a Visual Strategy

Instead of relying heavily on promotional signage, the store uses storytelling as a core element of visual merchandising. Products are presented in a way that highlights their origin, craftsmanship, and cultural context.
This storytelling is subtle.
It may appear through: Product descriptions and tags.

- Thematic arrangement of collections
- Visual references to traditional crafts

Such elements create an emotional connection between the customer and the product. When consumers feel connected to what they are buying, they are more likely to value it and less likely to treat it as disposable.
This emotional engagement plays an important role in sustainable consumption. It shifts the focus from quantity to meaning.

Lighting, Ambience and Consumer Behavior

Lighting is often overlooked in discussions about sustainability, but it has a strong influence on how consumers behave within a store.
In Fabindia, the lighting is warm and soft rather than bright and intense. This creates a calm and relaxed atmosphere. Unlike high-energy retail environments that encourage quick movement, this space invites customers to take their time.

The ambience contributes to:

- Reduced shopping pressure
- Increased comfort and ease
- Longer browsing time
- More thoughtful decision-making

The absence of urgency-driven cues further reinforces this experience. There are no loud sale signs or time- sensitive offers pushing immediate action. Instead, the environment supports a slower, more reflective shopping process.

Observational Insights from Store Experience

Direct observation within the store reveals several behavioral patterns that are influenced by the design:

- Customers move at a slower pace compared to fast-fashion stores
- There is higher engagement with individual products
- Fewer items are picked up impulsively
- Shoppers appear more selective in their choices These patterns indicate that the retail environment plays a role in shaping how consumers interact with products.
- Additional insights include:
- Minimal displays reduce decision fatigue
- Natural materials enhance perceived product value
- Storytelling increases emotional attachment
- Calm ambience supports mindful consumption

Balancing Design and Consumer Reality

While the influence of visual merchandising is significant, it is important to recognize its limitations. Consumer behavior is shaped by multiple factors, including price sensitivity, personal taste, and social influences.

Not all customers entering the store are driven by sustainability concerns. Some may still make decisions based on convenience or aesthetics rather than ethical considerations.

However, the store environment acts as a guiding framework. It does not force behavior but subtly encourages certain patterns. Over time, such environments can contribute to a shift in consumer mindset.

Toward a Circular Retail Experience

The concept of a circular economy emphasizes reducing waste and extending the lifecycle of products. Retail spaces play a crucial role in this system as they connect production with consumption.

By encouraging customers to buy fewer but more meaningful products, visual merchandising can support circular principles. The store becomes a space where consumption is not just transactional but intentional.

Fabindia's approach demonstrates that sustainability can be integrated into retail design without compromising the shopping experience. Instead of overwhelming the consumer, it creates a sense of balance between aesthetics, functionality, and ethics.

Conclusion

Store design has the potential to influence responsible buying, not through direct instruction but through experience. Visual merchandising shapes how consumers feel, how they interact with products, and ultimately how they make decisions. The observation of Fabindia stores shows that elements such as minimal displays, natural materials, storytelling, and calm ambience can encourage more mindful consumption patterns. While these factors do not completely determine behavior, they create an environment that supports sustainable choices.

As retail continues to evolve, the role of visual merchandising will become increasingly important. It offers a unique opportunity to align commercial goals with environmental responsibility, making the store not just a place of purchase, but a space of influence.

References

- Journal of Retailing | ScienceDirect.com by Elsevier
- How can consumers behave sustainably in the fashion industry? A systematic literature review of determinants, drivers, and barriers across the consumption phases - ScienceDirect
- Sustainability Champions: How Fabindia Is Changing the Game - Jobs for Fashion Designers, Stylist, Models

India–EU FTA: Rewriting the Rules of Trade for a Circular Economy

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Circular Textile Systems

1.Trade, Industrialisation, and the Making of a Linear World

The word trade is derived from Middle English, where it meant a "path" or "course of conduct." At its core, trade implies movement: the crossing of paths, the exchange of goods, and the circulation of ideas.

For centuries, trade has been a force for connection and progress. From early transcontinental routes linking Asia and Europe to maritime exchanges across continents, commerce enabled economic growth and the sharing of knowledge, culture, and innovation. Nations prospered through specialization and exchange. Over the past three decades, global economic integration has contributed significantly to poverty reduction across emerging economies, underscoring trade's foundational role in prosperity[1].

The Industrial Revolution amplified this momentum. Mechanized production and fossil-fuel energy enabled manufacturing at unprecedented scale. In the late twentieth century, trade liberalisation and globally integrated supply chains accelerated this expansion further. Between 1990 and 2019, global GDP more than tripled, and international trade volumes expanded sharply[1]. By the mid-2010s, nearly half of global trade was linked to global value chains, with goods crossing borders multiple times before reaching final consumers[2].

Yet this success came with structural imbalances. Supply chains stretched across continents, optimised for cost efficiency and speed. Production and consumption became geographically separated: cotton grown in one country, spun in another, woven elsewhere, stitched in yet another, and sold thousands of kilometres away. Roughly one-quarter of global CO_2 emissions are embodied in traded goods[3]. Environmental costs were shifted outward, while economic gains became increasingly concentrated. Accountability dispersed across borders.

The textile and fashion sector epitomizes this linear architecture of take-make-dispose, scaled to global proportions[4].

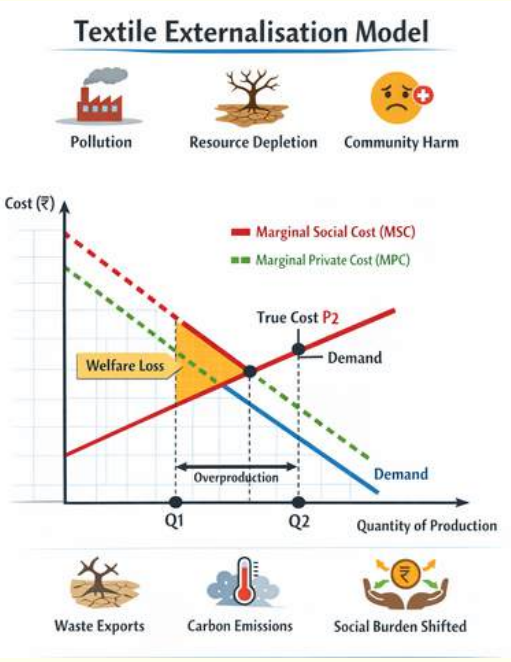

Figure 1. Textile Externalisation Model: Adapted from standard welfare economics models of negative production externalities (Pigou, 1920). Author's illustration.

2.Fast Fashion and the Externalisation of Environmental Cost

With the rise of fast fashion in the 1990s, this linear model intensified[5]. What had once been seasonal production cycles evolved into high-frequency, globalised supply chains engineered for speed and volume.

As logistics improved and production timelines shortened, major brands began introducing between 16 and 24 collections annually[7]. Speed and turnover became core performance indicators.

Global clothing production has roughly doubled since 2000, while garment utilisation rates have declined[7]. The world now produces over 100 billion garments annually[7]. The equivalent of one truckload of textiles is landfilled or incinerated every second[6].

The environmental footprint is substantial. Of the approximately 51 billion tonnes of CO_2-equivalent emissions generated globally each year, fashion contributes an estimated 8 percent[8]. Yet only around 1 percent of textile waste globally is recycled into new fibre-to-fibre applications[10].

Design theorist Jonathan Chapman describes this dynamic as a breakdown in the product–person relationship, where goods are engineered for rapid replacement rather than durability[14].

These pressures are unfolding within an already stressed climate system.

In Europe, warming winters have required increasing reliance on artificial snow for events such as the Milano–Cortina Winter Olympics[11].

In India, extreme heatwaves exceeding 45°C have disrupted labour productivity and water systems across multiple states[12]. Glacier retreat in high mountain regions intensifies long-term water security risks[13].

The global textile system operates within these planetary constraints.

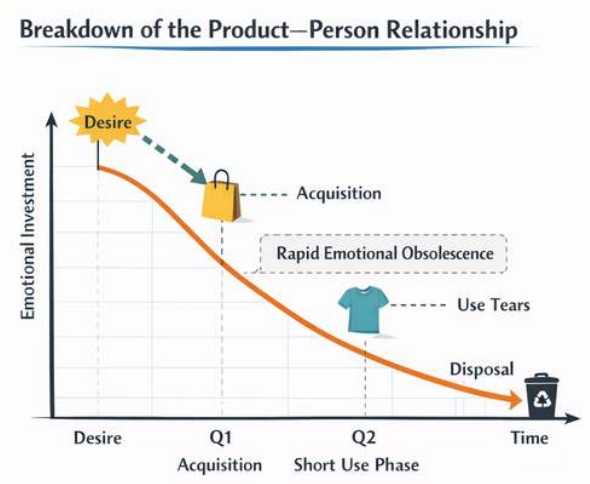

Figure 2. Breakdown of the Product–Person Relationship: Adapted from Chapman (2005), illustrating how reduced emotional durability accelerates disposal and intensifies linear textile consumption.

3.Europe's Regulatory Shift: Circularity as Market Condition

The European Union's textile and apparel ecosystem employs approximately 1.3 million people and generates more than €170 billion in annual turnover[15]. It remains an important pillar of European manufacturing and export capacity.

Yet the environmental footprint of the sector is substantial.

Textiles rank third among consumption domains in water and land use, and fifth in raw material use and greenhouse gas emissions[16]. The EU generates approximately 12.6 million tonnes of textile waste annually, of which only about 20 percent is reused or recycled[17].

Recognising this imbalance, the European Union has adopted one of the most comprehensive sustainability frameworks globally for textiles. Rather than relying solely on voluntary corporate commitments, the EU has embedded circularity into binding legislative instruments.

The foundation was laid through the EU Strategy for Sustainable and Circular Textiles (2022)[17], which establishes that by 2030 textile products placed on the EU market should be durable, repairable, recyclable, and increasingly made from recycled fibres. The strategy signals a systemic shift — from downstream waste management to upstream product design.

This ambition is operationalised through multiple legal instruments.

Revisions to the Waste Framework Directive require Member States to establish separate collection systems for textiles and implement Extended Producer Responsibility (EPR) schemes[18]. These measures formalise the "polluter pays" principle, whereby producers placing textiles on the EU market are financially responsible for the post-consumer phase of their products. Waste management costs are thus embedded within pricing, product design, and material selection.

The Ecodesign for Sustainable Products Regulation (ESPR) significantly expands ecodesign requirements beyond energy-related goods to include textiles.

The regulation introduces durability and recyclability criteria, restricts hazardous substances, and establishes the legal basis for the Digital Product Passport (DPP).

The DPP addresses a structural weakness of global fashion supply chains: opacity. A garment's journey often spans multiple countries and production tiers. As supply chains stretch, accountability fragments. Through standardized digital product identities, the DPP enables access to verified information on material composition, environmental performance, repairability, and end-of-life pathways[19]. Transparency becomes regulatory infrastructure rather than voluntary disclosure.

In addition, the ESPR introduces restrictions on the destruction of unsold consumer textiles, effective July 2026[19]. Overproduction can no longer be absorbed through disposal. It must be addressed at the source.

Taken together, these measures reflect a structural recalibration. Waste, transparency, durability, and lifecycle accountability are no longer peripheral considerations. They are increasingly conditions for operating within the European market.

4.Circularity as a Way of Life: India's Textile Continuum

As the world's second-largest textile producer, India's textile sector contributes approximately 2.3 percent to GDP, accounts for nearly 12 percent of exports, and provides direct employment to roughly 45 million people[20].

The ecosystem spans the full value chain: from cotton cultivation and spinning to weaving, processing, garmenting, and technical textiles, giving India rare vertical depth at scale.

Yet India's relationship with textiles cannot be understood through production metrics alone.

Long before the term "circular economy" entered policy discourse, material stewardship was embedded in everyday life across large parts of India. Traditional garments such as sarees, dhotis, and lungis are constructed from uncut lengths of fabric, minimizing cutting waste and avoiding standardized sizing systems[21]. Draped clothing traditions in South Asia have historically privileged adaptability over discard, allowing garments to move fluidly across contexts and bodies[22].

Clothes often had a first life, then a second, and sometimes even a third; passed down, repurposed, repaired, and reused within households shaped by frugality and material respect[23].

At a philosophical level, Indian thought traditions articulate collective responsibility toward society and nature. The concept of lok sangraha, articulated in the Bhagavad Gita as action undertaken for the welfare and stability of the world, reflects an ethic of continuity rather than individual accumulation[24]. Agricultural rhythms and seasonal cycles historically reinforced patterns of production and consumption aligned with ecological constraints[25].

Industrial circularity, too, has long-standing roots. The Panipat cluster in Haryana has for decades processed post-consumer textiles into blankets and yarns[26].

India reports PET recycling rates exceeding 90 percent, with recycled PET converted into polyester fibre that re-enters textile production chains[27]. Informal recovery networks have sustained material circulation long before Extended Producer Responsibility became legislative vocabulary.

Thus, while regulatory frameworks and terminologies may differ, both the European Union and India converge on a shared principle: value embedded in materials must be respected and carried forward, not cast aside.

5.The India–EU FTA: Convergence Beyond Tariffs

On paper, the India–EU Free Trade Agreement, often described as the "mother of all deals," is a trade instrument focused on tariff reduction, regulatory alignment, and expanded market access. The scale is significant: together, India and the European Union represent over two billion people and nearly a quarter of global GDP[28].

Yet trade in today's geopolitical context carries deeper implications. It unfolds amid supply-chain shocks, strategic realignments, climate pressures, and rising protectionism. In such a landscape, agreements between large economies do more than reduce duties; they shape production norms and define competitive standards.

When two of the world's largest democratic economies deepen economic integration at this historical moment, the agreement becomes more than a commercial negotiation. It becomes an opportunity to redefine what trade stands for.

Early signals of alignment are already visible. European brands such as H&M and IKEA are not only sourcing from India but co-developing circular supply chain models, testing recycled materials, strengthening traceability systems, and supporting initiatives that formalise informal waste workers into structured recovery networks[29]. At the same time, Indian manufacturers are integrating global recycling technologies into mainstream production. Companies such as Birla Cellulose and Arvind Limited are working with international innovators to test and scale recycled fibre integration[30].

On one side, recyclers scale technology within India's manufacturing ecosystem. On the other, Indian producers integrate circular inputs into global supply chains. Sustainability transitions from siloed experimentation to institutionalised practice, building infrastructure that is scalable, repeatable, and transferable.

Figure 3. India–EU FTA: Convergence Beyond Tariffs. Illustrating the shift from tariff reduction to circular supply chains, traceability, and sustainable trade integration.

6.From Extraction to Interdependence: Redefining Value

The deeper opportunity of the India–EU FTA lies in resetting what "value" means within global trade.

For the planet, it means transitioning from linear extraction: take, make, waste, toward circular systems that retain material worth and reduce pressure on primary resources.

For people, it means strengthening traceability and visibility across supply chains , improving labour transparency, accountability, and safety standards.

For prosperity, it means ensuring that sustainability does not become the privilege of large corporations alone. Both India and the European Union are fundamentally SME economies. The EU hosts approximately 32 million enterprises, over 99 percent of which are small and medium-sized firms[31]. India counts more than 73 million MSMEs, contributing roughly 30 percent of GDP[32].

This agreement is therefore not merely "EU large corporations meeting Indian conglomerates." It is an economic bridge between two ecosystems built on millions of small firms. If that backbone can participate, through accessible standards, usable compliance systems, and transparent market pathways, prosperity becomes shared progress rather than concentrated gain.

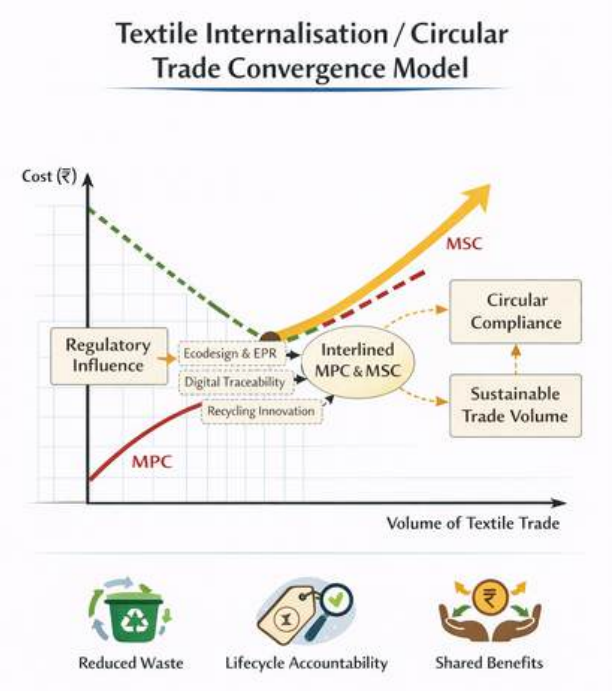

Figure 4. Textile Internalisation Model: Illustrating regulatory convergence of marginal private and social costs through circular compliance mechanisms in India–EU trade.

Choosing the Path Forward

The word trade once meant a path: a course of conduct. It implied direction, intention, and shared movement. For much of the past century, that path was defined by expansion, efficiency, and scale. Speed and cost became the dominant measures of competitiveness, even when they externalised environmental harm, fragmented accountability, and relied on opaque supply chains. The India–EU Free Trade Agreement arrives at a moment when that course can be consciously redirected. This agreement is not merely about lowering duties. It is about aligning markets with planetary boundaries. It is about ensuring that transparency travels across borders as seamlessly as goods do. It is about enabling small enterprises, not only large corporations, to participate in sustainable trade. If we get this right, we do not just grow trade. We upgrade the logic behind it; which was always meant to create 'prosperity' for people, planet, and future generations.

References

- World Bank. (2023). World Development Indicators.
- OECD. (2020). Trade in Value Added Database; World Bank. (2020). Global Value Chain Development Report
- Peters, G. P., et al. (2011). Growth in emission transfers via international trade. Proceedings of the National Academy of Sciences; Global Carbon Project. (2023).
- Ellen MacArthur Foundation. (2017). A New Textiles Economy: Redesigning Fashion's Future; UNEP. (2022). Sustainability and Circularity in the Textile Value Chain.
- Sandin, G., & Peters, G. (2020). Environmental impact of textile reuse and recycling. Journal of Cleaner Production.
- UNEP. (2022). The environmental costs of fast fashion (citing EMF "truckload per second" statistic).
- McKinsey & Company. (2020). Fashion on Climate.
- UNEP. (2025). Five Ways to Reduce Waste in the Fashion Industry.
- IUCN. (2017). Primary Microplastics in the Oceans.
- Ellen MacArthur Foundation. (2017). A New Textiles Economy.
- Climate Central. (2026). Milano-Cortina 2026: Warming Winter Olympics.
- CEEW. (2025). Mapping Climate Risks and Impacts of Extreme Heatwaves in Indian Districts.
- IPCC. (2022). AR6 Working Group II, Chapter 4: Water.
- H&M Foundation. (2023). Circular Innovation Initiatives in India; IKEA. (2023). Sustainability Report.
- Circ. (2023). Strategic partnerships with Birla Cellulose and Arvind Limited; Company sustainability disclosures.
- European Commission. (2023). SME Performance Review.
- Ministry of MSME, Government of India. (2023). Annual Report 2022–23.
- Chapman, J. (2005). Emotionally Durable Design: Objects, Experiences and Empathy. Earthscan.
- European Commission. (2023). Textiles Ecosystem Factsheet.
- European Environment Agency. (2023). Textiles and the Environment in Europe.
- European Commission. (2022). EU Strategy for Sustainable and Circular Textiles.
- Directive (EU) 2018/851 amending Directive 2008/98/EC (Waste Framework Directive revisions; textile EPR obligations).
- Regulation (EU) 2024/1781 establishing a framework for ecodesign requirements for sustainable products (ESPR, Digital Product Passport, and prohibition on destruction of unsold textiles).
- Ministry of Textiles, Government of India. (2023). Annual Report 2022–23.
- Lynton, L. (1995). The Sari. Thames & Hudson.
- Tarlo, E. (1996). Clothing Matters: Dress and Identity in India. University of Chicago Press.
- Appadurai, A. (1986). The Social Life of Things. Cambridge University Press.
- Bhagavad Gita, Chapter 3, Verses 20–25 (concept of lok sangraha).
- Gadgil, M., & Guha, R. (1992). This Fissured Land: An Ecological History of India. Oxford University Press.
- Haryana Industry Cluster Reports; Ministry of Textiles documentation on the Panipat recycling cluster.
- Central Pollution Control Board (CPCB). (2023). Status of PET Recycling in India.
- European Commission & Government of India. (2023–2024). Bilateral Trade Statistics and FTA Negotiation Briefings.

Where do the offcuts from textile sector end up in India
A Circular Economy Practitioners lens

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Introduction

A life cycle of a wearable clothing in Gautam Buddha times – A Robe became a bedsheet then a curtain, a mitten, a doormat, a mop and then the tattered pieces were used as a wick in the oil lamps burnt to ashes. That was innately circular, with a probable life of about 100 years.
Those were the times where offcuts were non-existing.
Fast forward to current times, the textile sector as part of their Cut-Make-Trim (CMT) process of producing apparels and home furnishing products generates the residual, inevitable offcuts, to cater to the end consumer needs.
In the bustling garmenting hubs of India — from the knitwear capital of Tirupur to the industrial stretches of Surat and Bengaluru —the "cutting floor" or the “cutting table” is where the story of a garment truly begins. India generates approximately 7.8 million tonnes of textile waste annually, of which the Pre-consumer waste accounts for approximately 42% (Refer Pg 21, line 3 – pre consumer waste Sorting-for-Circularity-Wealth-in-Waste.pdf) of total textile waste which is about 3.28 million tonnes that primarily consist of fabric offcuts and trimmings that never make it to the retail shelf.
These scraps are fresh as they are offcuts of a production activity and yet are deemed “trash”, despite having already consumed substantial resources in their production – including the incurred manual labour, water, dyes, chemicals, power & energy.
These are actually unused Materials that are reaching end-of-life (Eol) long before their actual Eol that effectively become “stranded resources” whose embedded value cannot be recovered under the current business-as-usual (BAU) systems.

The route map of offcuts is based on their source of generation which broadly falls into industrial & non-industrial categories, as per general understanding –

1. **Industrial** – Small, medium to large size factories engaged in stitching, knitting, and surface embellishments as the major activities of garment and/or home-furnishing products that are known to generate homogenous kind of offcuts by shape, size, fabric type and composition. Such units are either part of the sectoral clusters or SEZ s or the Supply and Value Chains of the brands. They are integrated as associations, have a collective voice, and are able to enjoy the benefits of schemes offered by state and central governments.

2. **Non-Industrial** – Are tailoring units also known as Boutique units that typically operate with 1-3 sewing machines, engaged in bespoke tailoring services that spring up as soon as a residential locality comes alive.

Such units operate in local, independently owned modes offering discrete nature of services. The offcuts generated are discretely heterogenous by size, shape, fabric material and composition.
The offcuts from such units are considered insignificant, ignored equally by the textile and the Solid Waste Management sectors, hence never been measured.

Samposhan® - An upcycling initiative from Chennai has attempted to measure this category and has derived by extrapolation that they are at least 50% of the post-consumer waste of per day collection, as mentioned by city Municipality the Greater Chennai Corporation - Greater Chennai Corporation set to recycle textile waste | Chennai News - Times of India.

Quoting a snippet from the The neighbourhood tailor | The Big Shift | Data For India
"

In 2005, there were less than 4 million custom tailors in India, and they made up just 7% of all manufacturing jobs. By 2024, there were 12 million custom tailors, and their share in the manufacturing workforce had climbed to 17%. Of the 14 million new manufacturing jobs added between 2018 and 2024, five million were in custom tailoring alone, Nileena finds.

The increase in bespoke tailoring leaves no room for ignoring the offcuts anymore and it's time to turn the perspectives from W to M – the Waste to the Material.

3. **Uncategorised** - This discovered category of units are ones that operate with 5-10 sewing machines, they take up bulk stitching orders of uniforms, apparels, et al and are colloquially known as stitching/embroidery job work units. They do not get accounted in the industrial category but certainly generate the industrial kind homogenous offcuts to an extent.

Observations & Findings – offcuts & the disposal mechanisms

1. **Industrial offcuts** - India is a global heavyweight in mechanical recycling, with Panipat in the North and Tirupur, Erode, Coimbatore textile belt serving as the primary hubs.The collection process is largely driven by an unorganised and informal network of brokers, agents, and aggregators who collect waste directly from factories. The pathway from factory gates to the Panipat hub or South belt is via the aggregators scattered across India, who are closely connected with either the major aggregators or the local micro recyclers who primarily deploy fibre opening machines which are largely used as fillers in mattresses, pillows/cushions. These micro recyclers generally work on specific feedstock comprising of cotton, or mixed with

cotton and is considered a Linear Downcycling as the resultant fibre ends up as a filler instead of a yarn again to be woven into a garment – as the original value of the fabric is reduced.

The garment factories sell their offcuts starting at Rs.8 to 10 per kg bearing the transport cost and the down-cyclers sell the mechanically converted fibre starting at Rs. 20 per kg in cities and Rs. 12 /- in tier 2 cities. The prices mentioned are for South India.

2. N**on-Industrial offcuts** – As per the on-ground waste map activity by the author, these offcuts are entering landfills due to the systemic gaps. The Solid Waste Management Policy 2026, and even earlier – this category waste is governed by the Shop & Establishment Act and there is an umbrella dry waste policy due which the bespoke tailoring shops are supposed to source segregate waste which means at least 2 bins – unfortunately this is not enforced by any Municipality across India and hence these offcuts end up nowhere but landfills via the kerbside bins.The Practitioners survey in Chennai with about 70 non-industrial units, 3 of them uncategorised, identified a minimal few (just 2) who are voluntarily upcycling the offcuts at source. None were found segregating their offcuts from used tea-cups except the 2. While there is always a need for clean cotton scraps, the mixed heterogenous nature of the offcuts coupled with lack of affordable sorting machines for this non-industrial category- some of them get into the trap of open burning or sent to the co-processing units via the city-wide Recyclers. Some portion of such offcuts are aggregated and sent to Panipat for mechanical recycling – based upon surveying the city aggregators that handle part of the industrial offcuts.
As per the Practitioner's findings, as part of their collection and sorting activities of 1800+ kgs of heterogenous scraps so far - the offcuts constitute at least 40% of cotton scraps. And this observation poses an opportunity and a gap of conserving the precious resources like water used in bringing the 1 kg cotton to life that needs at least 2000 litres of water.

3. **Uncategorised** – Some of the offcuts from this category that work in informal cluster fashion and are connected with the micro recyclers or the aggregators, who collect the offcuts and are routed to either of the national hubs. There is a sizeable amount that reaches the landfills from the units which are either disconnected, or in suburbs unable to bear the transport costs to send to local aggregators or recyclers. With the rising rent and land costs, these units are mostly scattered and hence majorly ending up landfilling their offcuts.

Case Studies –

Find below the observations & findings of the Practitioner as part of their rescuing travails, conversion pilots & and a few more third-party observations gathered enroute:

- **Pilot project of Upcycling by Weaving offcuts in Bangalore -**

Practitioner had rescued 100 kgs from a recycler, technically a down-cycler operating in the suburbs of Bangalore as part of their Weaving long strips "scraps to rugs" feasibility project. The Recycler was in practice of buying the offcuts from about 10+ garmenting units, made pillows and sold in local market.

Rescued long strips offcuts from a Down-cycler for weaving & sorting in progress

i). Of the rescued 100 kgs, 30 kgs were used to be woven as weft in the traditional pit looms and made into meditation rugs, seating mats popularly known as "Aasans" across India.

a woven meditation rug

Scraps being woven in the pit loom & a woven floor seating mat

ii) Of the rest 70 kgs, about 20 kgs was paper, thermocol, plastic and paper packaging discards, bubble wrap, thread cone discards, polypropylene sheets, etc.

iii) A 20 meters long, of uniform width cloth amidst a few cuts, about 8" wide and weighing about 10 kgs as shown in picture below – was upcycled to spectacles pouches, pencil boxes, and zipper pouch.

long 8" strip with few amidst cuts upcycled into pouches

What may have caused these offcuts – had no answer untill another case study indicated a probable cause.

iv) A sleeve shaped offcut in 3 colors of rayon, weighing about 5 kgs – upcycled into a kids half-pants.

v) The remnant long strip offcuts are waiting to be woven in Chennai, to be upcycled to high value products.

defective sleeve cuts upcycled to kids half pants

- **Tirupur garmenting offcuts converted to woven doormats by the Chenni Malai Cooperative Society –**

The knitwear waste from the Tirupur export sector, which is predominantly cotton based and is woven into the doormats by the cooperative society that deploys weaving activity at household level, and is a pet project of the Tamil Nadu state, which are sold via the State Governments handloom marketplace Co-optex. It has set a great example of a close-knit association of a textile industrial cluster & the cottage sector.

The woven door mat by Chenni Malai society

How many years are they in use in the doormat form?
What happens to the cotton rich doormats at their Eol?
Do they have an after-life or is it the landfill again?

Are a few circularity probes that demand further research for identifying higher value products woven within the same ecosystem.

- **There are few open-loop circular initiatives across India, converting industrial offcuts to tree-free paper, infused in tiles/bricks, mannequins et al that do demand probes as to what happens upon their end of life?**

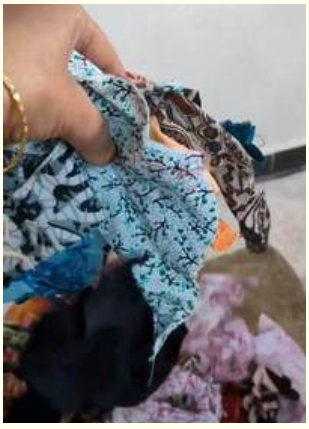
A Tirupur based Circular, sustainable initiative works on feedstock of white cotton offcuts from local & nearby clusters, converts them to paper and allied products used in packaging of textile sector. If Cotton has the capacity of living multiple lives circularly, is an open-loop upcycling that is based on cotton only, an environmentally viable one?

- **Another 100 kgs rescued from a woman-led, apparel exporter from Bangalore –**

offcuts pile and winded before cutting

These offcuts were generated due to the reason that fabric was wider than the cutting table available at the unit.

- **One of the uncategorised bulk nighties stitching unit in Chennai generates slightly homogenous kind of offcuts which can be converted to Cloth Carry bags, of various kinds –**



Offcuts from a Bulk Nightie Stitching unit sorted to be patchworked to a fabric again

Upcycled patchwork yardage converted into cloth carry bags of variant models

Conclusion & Next Steps

While there is no possibility of designing out the offcuts in the current times, there is certainly a scope for reducing their quantum by interventions. The case studies indicate enough room for optimization on the Cutting floor or cutting table, and indicate a need on the Textile sector to go Upstream to solve the currently shortened life of the materials and bring them to usage loop for longevity and for ever, as possible.
Interventions in an integrated manner that can help conserve expensive resources & circulate materials -

1. **Education & Curricula**

- Increased Quality checks of CMT processes can directly reduce the quantum of offcuts and increase produced units as well – a great win-win.

- The Academic institutions into training of Garment Designing & stitching must consider Upstream interventions on optimization & zero-waste techniques as part of the curricula, especially for Small MSME s who cannot afford the CAD/CAM and/or automated garmenting tools.

2. **Policy & Enforcement**

- Need for Policy on Standardization by not limited to the table sizes, bale sizes and probably many such unknown parameters in the context of Cut-Make-Trim.
- The SWM Policy gap needs to be plugged with clear mention of textile waste as part of dry waste, and educate the ULB as well.
- Including Textile as a material to be conserved as part of Circular Economy list of materials by Niti Aayog, shall spiral the necessary actions in the Textile & the SWM sectors.
- Tailoring as Skilling is a norm – bringing in Upcycling into Skilling fold especially in Urban India
- Segregation and conversion at source or near-source as an idealistic solution – can be a game changer in handling the offcuts menace in the non-industrial category pan India, as Localised Livelihood Projects integrated with State Livelihood Mission.

3. **Research Gap**

- There can be multiple pathways to Conserving the expensive Cotton natural fibre offcuts locally – this needs an in-depth local, regional research with baselining of quantum that is lost to downcycling, open-loop circularity initiatives.

- The offcuts from the non-industrial category need an immediate attention – funds to be pumped into the Research of mechanical solutions for sorting are needed for futuristic circularity. As an immediate workaround, the mixed scraps downcycling can be made the local norm and needed ecosystems, policy interventions to be identified.

4. **Infrastructure & Logistics**

- The centralized hubs of Panipat in North and Tirupur in the South – this model adds immensely to the carbon footprint in the Recycling value chain as offcuts travel from source to the hubs that are at least 1000 s of kms afar. Local and decentralized Recycling Parks or hubs at 100km ranges is the need of the hour.
- Provision of local drop-off centres at 5 km range will certainly discourage non-industrial category unit owners from burning & dumping practices.

Local, decentralized Upcycling of offcuts of all identified categories have a great potential towards creating newer green jobs, providing livelihoods to the marginalized, and reduce pollution with landfilling or incineration or downcycling, and avoid the negative damage caused by the emissions from the existing dumping or burning practices.

Digital Product Passport Readiness in Circular Fashion: A Multi-Dimensional Regulatory & Compliance Assessment for Commercialization

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Abstract

The transition toward a circular economy in the fashion industry is increasingly driven by regulatory frameworks, particularly the European Union's Ecodesign for Sustainable Products Regulation (ESPR), which introduces Digital Product Passports (DPP) as a key mechanism for product transparency and lifecycle accountability. This paper assesses the readiness of circular fashion business models to implement DPP through a multi-dimensional lens encompassing regulatory compliance, data architecture, and organizational preparedness. Drawing on policy analysis and global standardization frameworks such as those developed by the United Nations Economic Commission for Europe (UNECE) and the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), the paper identifies critical data requirements, regulatory-to-data mapping processes, and digital infrastructure needs.

The paper outlines the benefits of DPP and identifies key implementation challenges. It further proposes mitigation strategies with actionable recommendations, supported by an industry action framework. The insights highlight key considerations to circular economy research by positioning DPP as both compliance instruments and strategic enablers of circular business models in the fashion industry.

The analysis demonstrates that DPP signify a systemic shift in how sustainability is measured, managed, and regulated, with proactive alignment of compliance and digital transformation.

(Keywords: Digital Product Passports, Circular Fashion, ESPR, Regulatory Compliance, Traceability, Circular Economy, DPP Implementation)

Introduction

The fashion industry, characterized by resource-intensive production and short product lifecycles, is under increasing scrutiny for its environmental and social impacts (Ellen Macarthur Foundation, 2017). The transition from a linear "take-make-dispose" model to a circular economy has emerged as a critical pathway toward sustainability. In this context, Digital Product Passports (DPP) are gaining prominence as regulatory and technological tools that enable transparency, traceability, and lifecycle accountability. The European Union, through the Ecodesign for Sustainable Products Regulation (ESPR), is mandating DPP as part of its broader circular economy strategy. The European Commission is advancing Digital Product Passports implementation through rules on identifiers, data carriers, access rights, and the development of a centralized registry and web portal (European Commission - Green Forum , n.d.).

A DPP functions as a digital twin of a physical product, containing structured information on material composition, environmental impact, and lifecycle attributes. By enabling data sharing across value chains, DPP facilitate circular practices such as repair, reuse, and recycling. Growing concerns over the environmental, labour, and social impacts of fragmented textile value chains have led to global efforts to improve traceability. In support of the United Nations Sustainable Development Goals (Goal 12 on responsible consumption and production), the United Nations Economic Commission for Europe is developing digital systems to improve sustainability and ensure compliance (United Nations Economic and Social Council, 2023).

However, implementing DPP presents challenges in aligning regulatory requirements with organizational capabilities. This paper assesses the readiness of circular fashion models and goes beyond regulatory summarization by translating DPP requirements into actionable insights. It positions DPP as both a compliance obligation and a strategic enabler of transparency and competitive advantage.

2. Regulatory Compliance Landscape Assessment

2.1 EU ESPR and Digital Product Passports

Digital tools play a crucial role in advancing the circular economy by improving information availability across value chains and enabling lifecycle-oriented decision making.

In this context, Digital Product Passports (DPP) provide structured information on products, materials, production conditions, and sustainability performance, supporting responsible consumption and circular business models (United Nations Economic Commission of Europe, 2024).

The Ecodesign for Sustainable Products Regulation (ESPR) establishes a comprehensive framework for improving product sustainability by introducing requirements related to durability, repairability, and environmental performance. DPP are central to this framework, enabling standardized access to product information across stakeholders.

Digital Product Passports (DPP) also support key policy objectives, including environmental sustainability, circularity, and legal compliance. As a core enabler of economic digitalization, the DPP system is designed to provide interoperable product information across regulatory frameworks. It builds on international best practices while remaining adaptable to emerging technologies and evolving legislative contexts (European Commission, 2022).

UNECE and UN/CEFACT Standards

The United Nations Economic Commission for Europe has played a pivotal role in advancing DPP-related frameworks through the UN/CEFACT.

DPP are conceptualized as:

- Digital representations of products (digital twins)
- Tools for traceability and transparency
- Enablers of circular business models

UN/CEFACT standards provide:

- Harmonized data structures
- Interoperability across systems and geographies
- Code-based data exchange enabling machine readability

These standards are essential for global fashion supply chains, which operate across multiple jurisdictions.

2.2 Identification of Mandatory Data Requirements

DPP systems consist of two key components:

(a) Product Data ("What")

- Product identifiers (SKU, GTIN)
- Material composition
- Environmental footprint
- Chemical substances
- Durability and repairability metrics

(b) System Infrastructure ("How")

- Data exchange protocols
- Interoperable IT systems
- QR codes and digital interfaces
- Data registries

Product and System-Level Data Requirements in DPPs

(a) Product Data ("What")

Product data refers to the core, product-specific information captured within a Digital Product Passport (DPP). This data forms the foundation for transparency, traceability, and regulatory compliance across the product lifecycle.

- **Product Identifiers:** These are unique codes enabling accurate traceability across a product's lifecycle and supply chain. These include SKU for internal inventory management, GTIN for global standardization, and batch numbers for production tracking, collectively forming the foundation of Digital Product Passport functionality.

- **Material Composition and Recycled Content:** This refers to the breakdown of materials used in a product, including the percentage of each component. It covers primary and secondary materials and shows recycled or bio-based content. It may also indicate material origin. This information enhances transparency and sustainability disclosure.

- **Environmental Footprint (Carbon, Water, and Energy):** This data quantifies a product's lifecycle impacts, including carbon emissions, water consumption, and energy use across production and supply chains. Often derived from Life Cycle Assessment (LCA), it supports environmental reporting, regulatory compliance, and informed decision-making.

- **Chemical and Hazardous Substance Information:** This information identifies regulated or potentially harmful substances in a product. It supports compliance with safety and environmental standards, ensures alignment with chemical regulations, and enhances transparency for consumers and regulators regarding product safety and sustainability.

- **Performance indicators (Durability, Repairability):** These indicators such as durability and repairability measure a product's lifespan and usability. Durability reflects resistance to wear, while repairability assesses ease of repair. They support circular economy goals by extending product lifecycles, reducing waste, and enabling sustainability compliance.

(b) System Infrastucture ("How")

System architecture refers to the technological and infrastructural framework that enables the creation, storage, exchange, and accessibility of Digital Product Passport (DPP) data. It defines how product information is structured, transmitted, and utilized across stakeholders within the value chain.

- **Data Exchange Protocols and IT Standards:** These define how DPP data is shared across systems. They ensure data is secure, consistent, and machine-readable, and enable systems across platforms and regions to work together. This supports accurate, reliable data exchange and helps meet regulatory requirements through standardized formats and coding systems.

- **Interoperable Systems for Data Sharing:** They enable different digital platforms to connect, communicate, and exchange data seamlessly. DPP implementation requires integration across PLM, ERP, and supply chain systems. This enables stakeholders—including manufacturers, suppliers, retailers, and regulators—to access and update product data, reduce silos, enhance visibility, and support scaling across global value chains.

- **Digital Interfaces such as QR codes:** These provide access to Digital Product Passports by linking physical products to digital records. They provide real-time information to stakeholders through mobile apps, portals, or APIs, enhancing transparency, accessibility, and user engagement across the value chain.

- **Centralized or Decentralized Data Registries:** They store, manage, and retrieve DPP information. Centralized systems offer control and governance, while decentralized approaches, such as blockchain, enhance transparency and integrity. The choice depends on scalability, security, interoperability, and regulatory requirements. These systems ensure data is accessible, verifiable, and secure throughout the product lifecycle.

2.3 Regulatory-to-Data Mapping

A regulation requires disclosure of key product data to ensure transparency, sustainability, and lifecycle traceability, including material composition, recycled content, carbon footprint, repairability score, and supply chain visibility, supporting compliance and informed decisions under the EU Ecodesign for Sustainable Products Regulation.

2.3.1 Mapping Regulatory Requirements to Data Fields

Example :

Regulatory Requirement	Data Field
Recycled content disclosure	Recycled material percentage
Type of recycled material	Recycled material type
Certification	Recycled material certificate

2.3.2 Linking Data to Digital Architecture

Example :

Data Field	Data Source	Storage
Material composition	Supplier declaration	Blockchain ledger
Carbon footprint	LCA system	Sustainability database
Repairability score	Product engineering	DPP interface

2.3.3 Regulatory Traceability Matrix

A Regulatory Traceability Matrix (RTM) shows:

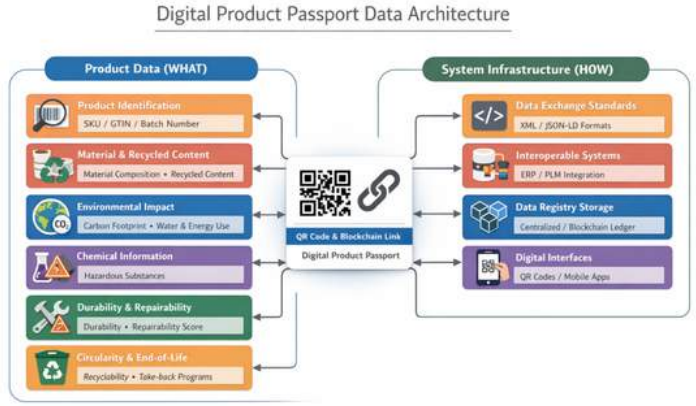
Regulation Clause	Required Data	System Field
ESPR Art. 7	Material composition	Material composition
ESPR Art. 9	Durability	Durability rating
ESPR Art. 10	Repairability	Repairability score

This ensures every regulation is traceable to actual product data.

The EU Ecodesign for Sustainable Products Regulation (ESPR) is the European Union's central framework for making products more sustainable, durable, repairable, and traceable across their lifecycle.

2.4 Digital Product Passport Data Architecture

A comprehensive DPP system typically includes structured data across multiple dimensions:



Typical Data Architecture Overview

A DPP system usually includes 50–70 structured fields across categories:

Data Field	Example	Data Source	Storage	Interface
SKU, GTIN, Batch Number	GTIN: 123456789	Manufacturer / ERP	Database	QR code / API
Material composition	Cotton 70%, Polyester 30%	Supplier declaration	Database / Blockchain	QR code
Recycled material percentage	40% recycled polyester (GRS certified	Supplier input	Sustainability database	API
Hazardous substances	Azo dyes (restricted) – compliance report (scanned)	Supplier / Compliance reports	Database	API
Carbon footprint, Water footprint	CO_2 per garment – LCA report (PDF)	LCA system	Sustainability database	QR code
Supplier ID, Facility location	Tier 1 supplier – India (ISO certification – scanned)	Supply chain systems	Blockchain ledger	API
Durability rating, Repairability score	50 wash cycles; replaceable zipper (technical sheet)	Product engineering	Database / DPP interface	QR code
Recyclability, Takeback program	Recyclable fabric; brand take-back (policy document)	Brand / Sustainability team	Database	API
Lifecycle event log	Manufactured → Sold → Recycled (timestamped records)	IoT / supply chain systems	Blockchain	API
QR code ID, Blockchain hash	QR linked to DPP page with certifications (PDF access)	System generated	Blockchain / Database	QR code / Web
XML, JSON-LD formats	JSON-LD file	IT systems	Interoperable platforms	API
ERP, PLM integration	SAP ERP integration	Enterprise systems	Cloud platforms	API
Centralized / Blockchain storage	Blockchain ledger entry with certification hash	System architecture	Distributed ledger / Database	API
QR code / Mobile app	Scan QR to view product info + certifications	User interface systems	Web / Mobile platforms	Consumer interface

2.5 Benefits of Digital Product Passports for Industry

Digital Product Passports (DPP) extend beyond regulatory compliance and offer significant strategic, operational, and market-oriented benefits for businesses operating within the fashion value chain.

Enhanced Transparency and Traceability: DPP enable end-to-end visibility across the product lifecycle, from raw material sourcing to end-of-life. This improves traceability across multi-tier supply chains, reduces information asymmetry, and supports compliance with sustainability and due diligence requirements.

Improved Regulatory Compliance and Risk Reduction: By structuring and standardizing product data, DPP systems facilitate efficient compliance with evolving regulatory frameworks such as the EU Ecodesign for Sustainable Products Regulation. This reduces the risk of penalties, product recalls, and restricted market access.

Operational Efficiency and Data-Driven Decision-Making: The integration of DPP with enterprise systems (e.g., ERP, PLM) enhances internal data flows and enables real-time monitoring of product information. This supports better inventory management, production planning, and lifecycle optimization.

Circular Business Models and New Revenue Opportunities: DPP act as key enablers for circular economy strategies, including repair, resale, refurbishment, and recycling. Access to reliable product data enhances the feasibility and scalability of these models, creating new revenue streams.

Strengthened Consumer Trust and Brand Differentiation: Providing transparent and verifiable sustainability information through DPP improves consumer confidence and supports informed purchasing decisions. This can enhance brand reputation and position companies as leaders in sustainability.

Supply Chain Collaboration and Standardization: DPP implementation encourages the adoption of standardized data formats and reporting practices across stakeholders. This improves coordination, reduces inefficiencies, and fosters long-term partnerships within the value chain.

Competitive Advantage and Market Access: Early adoption of DPP systems allows organizations to anticipate regulatory requirements and gain first-mover advantages. Compliance readiness is increasingly a prerequisite for access to key markets.

2.6 Challenges in Implementing Digital Product Passports

Despite their potential, the implementation of Digital Product Passports presents several structural, technological, and organizational challenges for industry stakeholders.

Data Availability and Quality Constraints: A significant challenge lies in the availability of

accurate, complete, and standardized data, particularly across complex and fragmented supply chains. Inconsistent or missing data across the supply chain can hinder effective DPP implementation.

Supplier Readiness and Engagement: Many suppliers, particularly small and medium enterprises (SMEs), lack the technical capabilities and resources required to generate and share standardized sustainability data. This creates dependencies and bottlenecks in data collection.

Additional Implementation Costs: The adoption of DPP requires substantial investments in digital infrastructure, system integration, data management tools, and workforce training. These costs may be prohibitive, especially for smaller firms.

Technological Integration and Interoperability Complexities: Integrating DPP systems with existing enterprise platforms (e.g., ERP and PLM) and ensuring interoperability across stakeholders and jurisdictions remains complex.

Regulatory Uncertainty and Evolving Requirements: As DPP-related regulations continue to evolve, organizations face uncertainty regarding future compliance requirements. This makes long-term planning and investment decisions more challenging.

Data Governance and Security Concerns: Ensuring data accuracy, ownership, and secure sharing across multiple stakeholders raises governance challenges. Concerns related to data confidentiality and competitive sensitivity may limit data transparency.

Organizational Readiness and Change Management: DPP implementation requires cross-functional alignment, new workflows, and cultural shifts toward data-driven decision-making. Resistance to change and lack of internal expertise can delay adoption.

3. Key Analytical Insights and Strategic Implementation

Shift toward Data-Driven Compliance: Regulatory requirements increasingly prioritize structured, verifiable product data —such as material composition, environmental footprint, and repairability— over qualitative claims. This transition necessitates robust data infrastructure and standardized reporting systems.

DPP as Integrated Digital Infrastructure: DPP function as system-level enablers, connecting product data, supply chain inputs, and consumer interfaces. They act as a digital backbone for lifecycle transparency, rather than a standalone compliance tool.

Supply Chain Data Dependency and Supplier Integration: A significant share of DPP data originates from upstream suppliers, making traceability a critical challenge. Strengthening supplier integration through standardized data frameworks enhances coordination, reduces compliance risks, and improves value chain transparency.

Compliance, Market Access, and Competitive Positioning: Regulatory alignment is increasingly linked to market access and competitiveness. Compliance readiness is no longer optional but a strategic requirement for sustained participation in global markets.

Data Readiness and Governance as Strategic Capabilities: Structured data management, clear ownership, and governance frameworks improve data reliability, support audit readiness, and enable accurate compliance reporting. Organizations that invest early in data readiness gain operational and strategic advantages.

Technology Enablement and Digital Transformation: Integration of DPP with enterprise systems such as ERP and PLM, along with technologies like blockchain and APIs, enables real-time data access, lifecycle tracking, and cross-functional integration.

DPP as a Driver of Circular Business Models: By embedding lifecycle data into products, DPP enable circular strategies such as repair, resale, and recycling, transforming compliance into a driver of value creation and innovation.

Phased Approach to Implementation

A structured, phased strategy supports effective adoption:

- Phase 1: Foundation & Data Readiness
- Phase 2: Integration & Pilot Implementation
- Phase 3: Scaling & Ecosystem Expansion
- This approach reduces complexity while enabling progressive capability building.

3.1 DPP Implementation: An Industry Action Framework

Phase 1: Foundation & Data Readiness

Step 1: Assess Readiness

• Audit product lifecycle data and evaluate digital systems across teams and suppliers
• Identify DPP compliance gaps
• Select pilot product category

Step 2: Build Data Infrastructure

• Define DPP data fields and standardize formats across stakeholders
• Integrate PLM/ERP/sustainability systems
• Establish internal governance for data ownership and management

Output:

• Data maturity and system readiness assessment with identified DPP compliance gaps
• Defined pilot product category for implementation
• Structured data governance model with clear ownership and management framework

Phase 2: Integration & Pilot Implementation

Step 3: Engage Supply Chain

• Integrate DPP data capture into product development and sourcing
• Align and onboard suppliers for upstream data sharing and traceability
• Validate supplier readiness against DPP requirements and standards

Step 4: Deploy Technology

• Generate Digital Product Passports (QR codes or digital IDs per product)
• Implement enabling technologies (APIs, blockchain, digital interfaces)
• Pilot DPP access across select product lines or regions, testing usability

Output:
• Functional Digital Product Passports for selected products
• Supplier participation and traceability model established
• Validated data quality, gaps, and system friction points
• Tested consumer and stakeholder access to DPP via digital interfaces

Phase 3: Scaling & Ecosystem Expansion
Step 5: Leverage for Business Value
• Expand DPP across products and automate data capture
• Integrate DPP with resale, repair, recycling, ensuring interoperability
• Enhance transparency, engagement, and support circular strategies
Output:
• Full DPP coverage with end-to-end lifecycle traceability
• Enabled circular ecosystems (resale, repair, recycling)
• Scalable, interoperable, and compliance-ready system

3.2 Real-World Examples: Fashion Brands Implementing DPP

While large-scale implementation of Digital Product Passports is still evolving, several fashion brands and industry initiatives have begun piloting traceability and transparency systems that align closely with DPP principles. These examples provide insight into how DPP can be operationalized in practice.

Stella McCartney – (Conscious Luxury & Sustainable Fashion)
Stella McCartney has implemented Digital Digital Product Passports to enhance transparency and traceability across its product lifecycle.
• Enables access to detailed product information, including material sourcing and environmental impact
• Supports traceability and responsible sourcing across the supply chain
• Impact: Advances circularity through informed purchasing and sustainability-driven practices

Dondup – (Italian Denim & Craftsmanship)
Dondup has implemented DPP to enhance transparency and ethical manufacturing in its denim products.
• Uses QR codes on labels to provide a "digital birth certificate" detailing the product's supply chain
• Enables access to information on material composition, production processes, care instructions, and end-of-life guidance
• Impact: Highlights ethical production and product longevity through informed use and recycling guidance

4. Discussion and Industry Recommendations

A key insight is the variation in DPP readiness between large organizations and small and medium enterprises (SMEs). While larger firms benefit from established digital infrastructure and resources, SMEs face constraints such as limited technological capabilities, lack of standardized data practices, and reliance on upstream suppliers. This uneven readiness highlights the need for targeted support and capacity-building initiatives.

The adoption of global standards enhances interoperability across systems and stakeholders; however, effective implementation requires alignment across the value chain. Increasing regulatory momentum is expected to accelerate DPP adoption and reshape transparency and sustainability practices across the industry.

To support effective implementation, the following industry actions are recommended:

- **Establish a Data-Centric Compliance Strategy:** Map regulatory requirements to internal data structures, standardize product and sustainability data across systems, align internal processes, and implement robust data validation and verification mechanisms to ensure accuracy and compliance.

- **Strengthen Supply Chain Integration:** Develop supplier data reporting frameworks and templates. Enable traceability across the supply chain. Conduct training and build supplier capabilities.

- **Invest in Interoperable Digital Infrastructure:** Integrate DPP with ERP and PLM systems. Adopt standardized data exchange formats. Explore blockchain for scalable traceability solutions.

- **Implement a Phased Approach:** Progress from core compliance data such as identifiers and material composition, to sustainability metrics, and finally full lifecycle tracking and circularity integration.

- **Leverage DPP for Strategic Value Creation:** Enable circular business models such as resale, repair, and take-back, use transparency for competitive advantage,and align with ESG and sustainability strategies.

- **Adopt Governance and Continuous Monitoring:** Define data ownership and accountability, establish compliance and audit systems, and continuously monitor evolving regulatory requirements to ensure ongoing alignment and control.

5. Conclusion

This paper examines the role of Digital Product Passports in enabling the transition toward circular and transparent fashion systems under increasing regulatory pressure and global sustainability mandates such as the EU Ecodesign for Sustainable Products Regulation. The findings position DPP as a foundational shift in how product-level data is generated, shared, and governed across value chains.

The analysis highlights that DPP introduces a new paradigm of lifecycle accountability, where sustainability information becomes structured, verifiable, and embedded within digital ecosystems. This reflects a broader transformation in regulatory design, moving from fragmented disclosures to integrated data-driven governance systems that support circular economy objectives.

At the same time, the paper underscores that DPP implementation is not uniform across the industry. Differences in digital maturity, supply chain complexity, and data governance capacity shape the extent to

which organizations can fully operationalize DPP frameworks.

Importantly, DPP should be understood as an evolving infrastructure rather than a static compliance tool. Its long-term value lies in its ability to connect regulation, technology, and business model innovation, thereby reshaping how sustainability performance is measured and operationalized.

Overall, the paper contributes to the understanding of DPP as a systemic enabler of circular economy transformation, bridging regulatory intent with operational and strategic shifts in the global fashion industry.

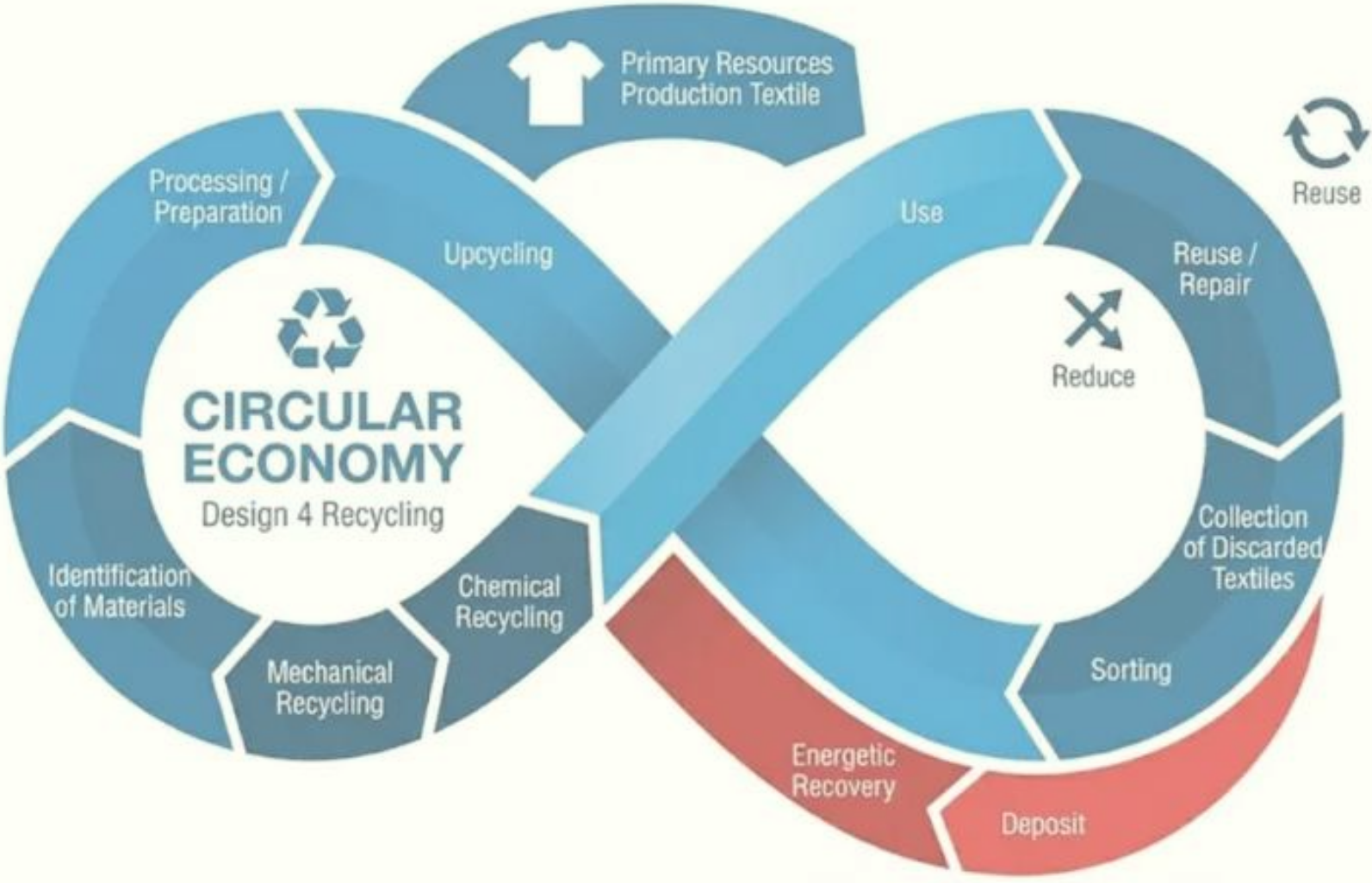
Limitations and Future Research

This paper is based on secondary data and conceptual analysis of Digital Product Passports frameworks, limiting empirical validation of real-world implementation outcomes. It primarily reflects early adoption cases and regulatory developments, which may not capture full supply chain complexity or regional variations.

Future research should include empirical and comparative studies across regions, firm sizes, and industries to assess adoption barriers and effectiveness. Further work could explore the role of emerging technologies such as AI and blockchain, and conduct longitudinal studies on DPP's impact on circular business models and sustainability performance over time.

References

- Ellen Macarthur Foundation, 2017. *A New Textiles Economy: Redesigning fashion's future.*[Online] https://www.ellenmacarthurfoundation.org/a-new-textiles-economy
- European Commission - Green Forum , n.d. *Implementing the Ecodesign for Sustainable Products Regulation.* [Online] https://green-forum.ec.europa.eu/implementing-ecodesign-sustainable-products-regulation_en [Accessed 13 April 2026].
- European Commission, 2022. *Ecodesign for Sustainable Products Regulation (ESPR) and Digital Product Passport (DPP).*[Online] https://unece.org/sites/default/files/2023-12/09Nov_APIWorkshop_am_item%20II_No.1_EU_P.Migliorini.pdf
- United Nations Centre for Trade Facilitation and Electronic Business, 2021. *Business Requirements Specification.* [Online] https://unece.org/sites/default/files/2021-03/BRS-Traceability-Transparency-TextileLeather-Part1-HLPDM_v1.pdf
- United Nations Economic and Social Council, 2023. Updated Report on the Blockchain Pilots Project for the Garment and Footwear Sector. [Online] https://unece.org/sites/default/files/2023-11/ECE-TRADE-C-CEFACT-2023-19E.pdf
- United Nations Economic Commission of Europe, 2024. UN/CEFACT Solutions in Support of Digital Product Passports (ECE/TRADE/481). [Online]



From Silk Routes to Source Code: The Hidden Barrier to Circular Textiles

Building Textile Knowledge Infrastructure for an AI-Enabled and Circular India

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Abstract

India's textile sector supports more than 45 million livelihoods and is central to the country's circular economy ambitions. India is also investing in artificial intelligence and digital infrastructure through initiatives such as the IndiaAI Mission, AIKosh, Tex-RAMPS, and Kasturi Cotton Bharat. This paper argues that both agendas depend on a shared but underexamined policy layer: textile knowledge infrastructure. Circular textile systems require materials and products to be classified, traced, and verified. AI systems depend on the datasets and taxonomies through which textile knowledge becomes visible and actionable. Both rest on how textiles are named and categorised. If Indian textile systems are represented mainly as heritage or craft rather than as sources of design innovation and circular value, they risk being under-recognised within future procurement, traceability, investment, and Digital Product Passport architectures.

The paper proposes a National Textile Knowledge Infrastructure connecting existing policy foundations across IndiaAI, AIKosh, Tex-RAMPS, Kasturi Cotton Bharat, NIFT, state textile departments, GI authorities, industry bodies, and artisan clusters. India does not need to build this from zero. The components exist. The challenge is integration. Strengthening textile knowledge infrastructure can advance circular economy outcomes while positioning India as a leader in AI-enabled textile governance.

(Keywords: Circular economy; Textile knowledge infrastructure; AI classification; Digital Product Passport; Indian textiles; Traceability; AI governance)

1.Introduction

For decades, discussions about circularity in the textile sector have focused on materials. The dominant questions have been how to reduce waste, increase recycling, improve resource efficiency, and extend product lifecycles. These are important objectives. Yet they share a common precondition that often remains invisible. Before materials can be recycled, they must first be identified. Before supply chains can be traced, products must be classified. Before sustainability can be measured, information must be organised. Every circular economy system depends upon underlying knowledge systems that determine what becomes visible, measurable, and actionable.

This paper begins from a simple proposition: the first circular economy decision is not recycling. It is classification.

The argument is particularly relevant to India. India's textile and apparel industry is the country's second-largest employer after agriculture, directly supporting more than 45 million livelihoods. The sector contributes approximately US$165 billion to the economy,

accounts for around 13 per cent of export earnings, and is projected to reach US$350 billion by 2030 (Ministry of Textiles, 2025a; Press Information Bureau, 2024a). Alongside this economic significance sits an extraordinary diversity of textile knowledge embodied in handloom traditions, craft clusters, regional production systems, technical textile innovation, and contemporary manufacturing networks.

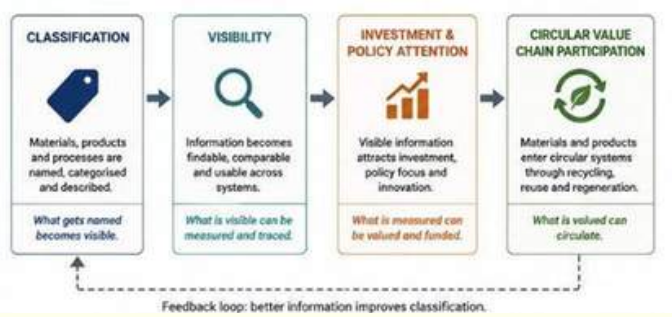

Figure 1. Classification influences visibility, which shapes investment and ultimately affects participation in circular value chains.

At the same time, India is pursuing ambitious goals in both artificial intelligence and circular economy development. Through the IndiaAI Mission, the Government of India has committed more than ₹10,300 crore towards compute infrastructure, datasets, foundational models, innovation ecosystems, and trusted AI development (Ministry of Electronics and Information Technology, 2024). Within the textile sector, programmes such as Tex-RAMPS and Kasturi Cotton Bharat are introducing new forms of monitoring, traceability, certification, and data-driven governance. These initiatives reflect a broader shift in which information itself is becoming a strategic resource.

This transformation is occurring against a rapidly changing international landscape. Emerging frameworks such as Digital Product Passports, enhanced traceability requirements, and sustainability disclosure obligations are reshaping expectations across global textile value chains. Increasingly, competitiveness depends not only on what a country can produce, but also on what it can demonstrate, verify, and communicate about production processes, material origins, environmental impacts, and product lifecycles.

Yet despite significant investment in both circularity and AI, these agendas are often discussed separately. Circular economy policies focus on materials, waste streams, and resource efficiency. AI policies focus on datasets, compute capacity, and innovation ecosystems. What receives far less attention is the knowledge infrastructure that connects them.

Importantly, this paper does not argue that India lacks such infrastructure. On the contrary, initiatives such as Tex-RAMPS, AIKosh, Kasturi Cotton Bharat, and the wider IndiaAI Mission demonstrate that many of the necessary foundations are already being established. The challenge is no longer invention but integration. The policy question is how these emerging systems can be connected into a coherent textileknowledge architecture capableof supporting circular economy goals, AI-enabled innovation, and future competitiveness in global markets.

By examining recent developments across India's textile, AI, and circular economy landscape, the paper proposes a framework for understanding textile knowledge infrastructure as a strategic national asset. Strengthening this infrastructure can improv

sustainability outcomes while enabling more representative AI systems and strengthening India's position in an increasingly data-driven global textile economy.

2. India's Textile Knowledge Landscape

India's textile sector is often described in terms of production, exports, employment, and manufacturing capacity. While these measures are important, they tell only part of the story. The textile economy is also a knowledge economy. Behind every fibre, fabric, technique, and product lies a system of accumulated knowledge developed across generations, regions, institutions, and industries.

This knowledge exists in multiple forms. Some of it is embodied in traditional practices such as weaving, dyeing, embroidery, block printing, spinning, and fabric finishing. Some exists within contemporary manufacturing systems through technical specifications, quality standards, production processes, and supply-chain management. Other forms are embedded within research institutions, design schools, testing laboratories, certification systems, and emerging technical textile ecosystems. Together, these form a diverse textile knowledge landscape.

The scale of this landscape is significant. Within this broader sector, the Fourth All India Handloom Census reports31.45 lakh households engaged in handloomactivities, including 26.73 lakh weavers and 8.48 lakh allied workers.

Table 1. India's Textile Ecosystem at a Glance

Indicator	Value
Industry size	US$165 billion
Target by 2030	US$350 billion
Employment supported	45+ million
Export contribution	~13%
Handloom workers (Fourth All India Handloom Census)	~35.2 lakh (≈ 3.5 million)
IndiaAI Mission outlay	₹10,300+ crore
Tex-RAMPS outlay	₹305 crore

Note. Figures drawn from Ministry of Textiles (2025a), Press Information Bureau (2024a), and the Fourth All India Handloom Census (Office of the Development Commissioner for Handlooms, 2019).

This gives a total of approximately 35.2 lakh handloom workers across weavingand allied activities. The same census also shows the sector's strong rural and genderedcharacter, with a large shareof handloom households located in rural areas and women forming a major part of the workforce (Office of the Development Commissioner for Handlooms, 2019; People's Archive of Rural India, 2019).

This diversity is also reflected in India's Geographical Indication ecosystem. Products such as Banarasi brocades, Kanchipuram silks, Chanderi weaves, Pochampally ikat, Bhagalpuri silk, and many others show how textile value is often inseparable from local knowledge systems. These products are not merely commodities. They embody information about materials, processes, cultural histories, and place-based expertise.

Yet this knowledge remains fragmented. Information is distributed across multiple institutions, databases, certification systems, ministries, research centres, industry associations, andprivate enterprises. Export data may sit in one system, handloom census data in another,sustainability metrics in a third, and traceability records in a fourth. Research outputs, design archives, production statistics, testing standards, and craft documentation often exist within separate administrative and technical environments.

This fragmentation creates growing challenges in a data-driven economy. Circular economy systems require reliableinformation about materials, composition, provenance, and product lifecycles. AI systems require datasets that can meaningfully represent the sectors they seek to model. In both cases, he effectiveness of the systemdepends upon the quality and accessibility of underlying knowledge.

The challenge is not a lack of knowledge. India possesses an extraordinary depth of textile expertise. The challenge is that this knowledge is often dispersed across disconnected systems. Recognising textiles as a knowledge ecosystem rather than solely a manufacturing sector changes how policy challenges are understood.

What knowledge is collected? Which forms of textile expertise become visible within digital systems, and which remain invisible?

These questions are becoming increasingly important as India expands its ambitions in circular economy development and artificial intelligence. Both agendas depend upon the ability to transform fragmented information into shared, reliable, and actionable knowledge. Understanding the existing textile knowledge landscape is therefore an essential first step towards understanding the infrastructure required to support the sector's future development.

3. AI, Circularity, and the Emerging Policy Context

The growing importance of textile knowledge infrastructure cannot be understood in isolation from broader changes in India's policy landscape. Over the past decade, three developments have begun to reshape how the textile sector is governed and how value is created within it. The first is the rise of artificial intelligence and data-driven decision-making. The second is the transition towards circular economy models. The third is the increasing importance of traceability and transparency within global value chains. Although these developments are often discussed separately, they are becoming increasingly interconnected.

India's approach to artificial intelligence illustrates this shift clearly. Throughthe IndiaAI Mission, the Government of India has committed more than ₹10,300 crore towards building national AI capabilities across seven pillars: compute infrastructure, innovation centres, datases, application development,

future skills, startup financing, and safe and trusted AI (Ministry of Electronics and Information Technology, 2024). The mission reflects a growing recognition that AI is not simply a technological tool but a foundational infrastructure that will influence economic development, industrial competitiveness, public services, and innovation ecosystems.

A particularly significant aspect of the mission is its emphasis on datasets. The success of AI systems depends not only on computing power or algorithmic sophistication but also on the quality and diversity of the information used to train them. For this reason, IndiaAI places substantial attention on data infrastructure and the development of AIKosh, a national repository designed to support datasets, models, and AI resources across multiple sectors (IndiaAI, 2025b).

The same principle applies to textiles. If AI systems are expected to support textile innovation, sustainability, forecasting, traceability, or policy analysis, then textile knowledge must be represented within the data infrastructures that support those systems.

At the same time, circular economy policy is undergoing a similar transformation. Historically, circularity was often framed primarily as a waste management challenge. Policy discussions focused on recycling rates, landfill diversion, material recovery, and resource efficiency. While these remain important concerns, recent developments suggest a broader understanding is emerging. Increasingly, circularity is also becoming an information challenge.

The reason is simple. Circular systems requirevisibility. Materials must be identified before they can be recovered. Products must be tracked before they can be repaired, reused, or recycled. Sustainability claims must be verified before they can be trusted. As circular economy systems become more sophisticated, they become increasingly dependent on information about products, materials, processes, and supply chains.

This trend is visible internationally through the growing emphasis on traceability and transparency. Emerging Digital Product Passport requirements under the European Union's Ecodesign for Sustainable Products Regulation are reshaping expectations around product information, traceability, and circularity. The regulation entered into force in 2024, while product-specific obligations for sectors including textiles are expected to follow through delegated acts (European Parliament & Council of the European Union, 2024). Future products are increasingly expected to carry structured information relating to material composition, origin, environmental performance, repairability, and lifecyclecharacteristics. In effect,products are becoming data-bearing entities.

This shift has important implications for countries seeking to remain competitive within global textile markets. Competitiveness no longer rests on labour costs and production volumes alone. The ability to generate, verify, and communicate information is becoming a strategic asset alongside traditional industrial strength.

India's textile policy has alreadybegun to recognise this reality. Programmes such as Tex-RAMPS reflect an explicit commitment to reducing information asymmetries, strengthening research capacity, modernising data systems, and supporting evidence-based policymaking.

Through initiatives such as the Integrated TextilesStatistical System, supply-chain mapping, and support for AI-enabled innovation, Tex-RAMPS signals a movement towards more knowledge-intensive forms of sector governance. Similarly, initiatives such as Kasturi Cotton Bharat demonstrate how digital traceability, certification, and verification can be integrated into textile value chains.

Taken together, these developments show that textile governance is becoming increasingly dependent on information infrastructures. IndiaAI foregrounds datasets and AI capability. Circular economy policy increasingly depends on traceability and verified product information. Textile programmes such as Tex-RAMPS and Kasturi Cotton Bharat are already moving towards data-led monitoring and certification. The next section argues that the policy layer connecting these developments is textile knowledge infrastructure.

Figure 2. Textile knowledge infrastructure acts as the connective layer between existing policy agendas.

4.The Missing Layer: Textile KnowledgeInfrastructure

The previous sections have shown that three major policy agendas are increasingly converging. India's textile sector is becoming more data-intensive. Circular economy systems are becoming more dependent on traceability and verified productinformation. Artificial intelligence systems are becoming more important in decision-making, forecasting, compliance, and innovation. Yet there remains no common framework for understanding how textile knowledgeitself should be organised within this emerging landscape.

This paper proposes that the missing layer can be understood as textile knowledge infrastructure.

Textile knowledge infrastructure refers to the institutional, technical, and governance systems through which textileinformation is collected, organised, verified, shared,and made usable across different domains. It includes datasets, classification systems, traceability frameworks, research repositories, certification mechanisms, statistical systems, governance standards, and the institutions responsible for maintaining them. Its purpose is not merely to store information, but to make knowledge visible, interoperable, and actionable across multiple contexts.

This distinction is important because knowledge infrastructure differs from physical infrastructure. Physical infrastructure moves materials. Knowledge infrastructure moves information. Both are necessary for modern economic systems.

A road networkallows goods to travel between locations. A knowledge infrastructure allows information to travel between institutions, industries, technologies, and policy domains.

The importance of this layer becomes apparent when considering how circular systemsactually operate. A recycled fibre cannot enter a certified supply chain unless its characteristics are known. A sustainability claim cannot be verified unless supporting information is available. A Digital Product Passport cannot function without structured data. A forecasting model cannot identify patterns if relevant categories are absent from the dataset. In each case, the effectiveness of the system depends on prior decisions about how information is represented and organised.

This is why classification matters.

Classification is often treated as a technical or administrative task. In reality,it performs a much more significant function. It determines what becomes visible within systems of measurement, governance, and investment. Categories shape what is counted, what is compared, what is monitored, and what receives attention. As a result,classification plays a constitutive role in the production of economic visibility.

A simple example illustrates the point. Consider two textile systems that possess comparable levels of technical sophistication and economic potential. If one is represented throughdetailed datasets, certification systems, recognised standards, and traceability mechanisms, while the others remains dispersed across fragmented local records and undocumented practices, the first is likely to be more visible to investors, policymakers, researchers, and technology developers. This does not necessarily mean the first system is superior. It means it is easier to see.

This is not only an abstract problem. In commercial forecasting environments, categories that are richly documented through standardised datasets are often easier to identify, compare,and track than equally complex practices that remain dispersed across local archives, informal knowledge networks, or non-standardised records.

Visibility matters because contemporary governance increasingly operates through data. What can be measuredcan be monitored. What can be monitoredcan be evaluated. What can be evaluated can attract investment and policy support. Conversely, forms of knowledge that remain poorly represented may struggle to enter systems of planning, innovation, and governance even when they possess significant economic or sustainability value.

This observation helps explain why textile knowledge infrastructure matters for both circularity and artificial intelligence. Circular economy systems depend upon reliable information about products, materials, and transformation pathways. AI systems depend upon structured representations of reality. Neither can function effectively in the absence of appropriate knowledge infrastructures.

Importantly, the argument is not that textile knowledge should be reduced to data. Textile systems contain forms of expertise that cannot be fully capturedin databases or digital records. Skills embodied in artisans, production communities, designers, enginers

and manufacturers remain essential. The objective is not to replacehuman knowledge but to create infrastructures capable of making relevant aspects of that knowledge visible and usable within contemporary governance systems.

Nor does the argument imply that India lacks the foundations for such infrastructure. On the contrary, many of the necessary components already exist. The challenge is not whether these components exist, but how they can be connected into a coherent architecture capable of supporting circularity, AI development, traceability, and future textile competitiveness.

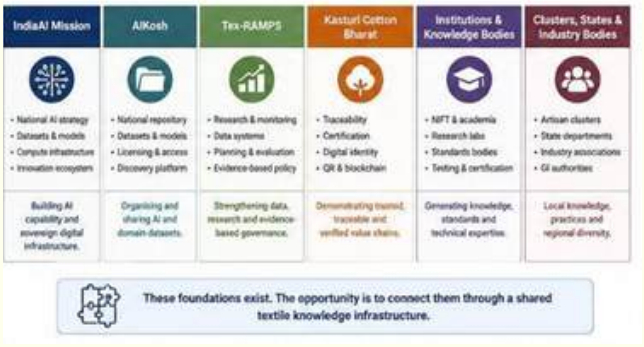

Figure 3. Existing initiatives already provide many of the building blocks required for a national textile knowledge infrastructure.

5.From Traceability Infrastructure to Textile Knowledge Infrastructure

If textile knowledge infrastructure is the missing layer connecting India'sAI, textile, and circular economy ambitions, the next question is practical: where should such an infrastructure begin?

The answer proposed by this paper is practical

where should such an infrastructure begin?

The answer proposed by this paper is interoperability. Datasets, traceability systems, research outputs, certification frameworks, and statistical tools should not be treated as isolated resources. They should be understood as components of a larger knowledge architecture.

The goal would not be centralisation for its own sake.Nor would it require all information to be stored in a single repository. Instead, the objective would be to ensure that information generated in one part of the system can be discovered, understood, and used in another.

For example, data generated throughtraceability systems could support sustainability reporting. Research datasets could contribute to AI applications. Monitoring systems developed through Tex-RAMPS could inform circular economy planning. Classification frameworks developed for certification could support Digital Product Passport requirements. In each case, value is created not only by the information itself but by its ability to move between systems.

Learning from Kasturi CottonBharat

Kasturi Cotton Bharat provides perhaps the clearest illustration of what such integration might look like in practice.

The initiative combines quality assurance, certification, traceability, and digital verification within a single governance framework. Through QR-enabled systems and blockchain-supported traceability mechanisms, cotton is no longer treated merely as a physical commodity. It becomes a

data-bearing asset carrying information about origin, quality, and movement through the supply chain (Press Information Bureau, 2024b).

The significance of this development extends beyond cotton. It demonstrates that textile materials can be embedded within digital information infrastructures capable of supporting trust, verification, and governance. In effect, Kasturi Cotton transforms textile identity into a structured and traceable form of knowledge.

This is highly relevant to circular economy policy. Circular systems depend on knowing what materials are, where they originate, how they have been transformed, and how they can be recovered or reused. Traceability therefore becomes more than a compliance tool. It becomes part of the knowledge infrastructure required for circularity itself.

The policy question is whether similar principles can be extended beyond cotton to the wider textile ecosystem.

The Role of AIKosh and IndiaAI

The same logic applies to AI infrastructure.

AIKosh has been designed as a national platform for datasets, models, and AI resources. Its architecture supports multipledata types, licensingstructures, visibility settings,and domain-specific applications. Importantly, the platform reflects a recognition that knowledge must be organised before it can be mobilised.

From the perspective of this paper, the most important implication is that textiles can be understood as a knowledge domain in their own right.

Agriculture has datasets. Healthcare has datasets. Language technologies have datasets.Textile systems increasingly require the same treatment. This does not mean creating a single textile database. Rather, it means developing the classifications, standards, metadata structures, and governance frameworks that allow textile knowledge to become visible within AI ecosystems.

Such an approach would support multiple objectives simultaneously. Researchers would gain access to better datasets. Policymakers would gain access to more reliable evidence. Industry could develop more targeted AI applications. Circular economy initiatives could benefit from richer information about products, materials, and production systems.

Towards a Textile Knowledge Domain

A practical next step would be the creation of a dedicated textile knowledge domain within India's emerging AI ecosystem.

This domain could bring together information relating to fibres, manufacturing systems, technical textiles, sustainability indicators, traceability records, repair practices, recycling pathways, regional clusters, GI products, and innovation initiatives. Importantly, it would not be limited to heritage documentation. Contemporary manufacturing, technical innovation, material science, and circular economy knowledge would be represented alongside traditional systems.

The objective would not be preservation alone. It would be capability.

As global markets move towardsgreater transparency, traceability, and sustainability disclosure, the ability to organise and mobilise textile knowledge becomes a source of competitive advantage. Countries that can generate reliable information about products and processes will be better positioned to meet emerging regulatory requirements, support innovation, attract investment, and strengthen export competitiveness.

The challenge is therefore organisational rather than technological. India possesses the building blocks: textile expertise, emerging AI infrastructure, traceability initiatives, research institutions, and circular economy ambitions. What remains underdeveloped is the connective architecture that allows these resources to work together.

A National Textile Knowledge Infrastructure would address this gap by enabling information to move more effectively across institutions, technologies, and policy domains. In doing so, it would strengthen not only textile governance, but also the broader objectives of sustainability, innovation, competitiveness, and digital transformation.

Table 2. ExistingInitiatives and Remaining Gaps

Initiative	Existing contribution	Remaining gap
IndiaAI Mission	National AI infrastructure	Textile-specific AI ecosystem
AIKosh	Datasets and AI resources	Textile knowledge visibility
Tex-RAMPS	Monitoring, research, planning	Cross-sector integration
Kasturi Cotton Bharat	Traceability and certification	Extension beyond cotton
DPP readiness	Compliance and transparency	Representation of Indian textile
Circular economy initiatives	Waste reduction and recycling	Upstream knowledge infrastructure

Note. Current initiatives provide strong foundations but remain institutionally fragmented.

6.Policy Recommendations

The argument of this paper is not that India requires an entirely new policydirection. Rather, it suggests that existing investments in AI, textiles, traceability, and circularity can generate greater value if they are connected through a shared knowledge infrastructure. The recommendations below are therefore designed to build upon initiatives already underway while addressing the integration challenges identified in previous sections.

Recommendation 1: Establish a National Textile Knowledge Infrastructure Taskforce

The first priority should be institutional coordination.

At present, textile-related knowledge is distributed across multiple organisations, including the Ministry of Textiles, IndiaAI, AIKosh, NIFT, research institutions, industry bodies, certification agencies, state governments, and cluster-level organisations.

Each institution generates valuable information, but there is no dedicated mechanism for coordinating these efforts around a common strategic objective.
A National Textile Knowledge Infrastructure Taskforce could provide this coordination function. Rather than creatinga new bureaucracy, the taskforcewould act as a convening mechanism, bringing together stakeholders responsible for textile data, traceability systems, AI development, sustainability reporting, and circular economy initiatives.
Its mandate should include identifying existing knowledge assets, reducing duplication, promoting interoperability, and developing a long-term roadmap for textile knowledge governance.

Recommendation 2: Create a Textile Knowledge and Circularity Domain within AIKosh

The second priority is visibility.
IndiaAI has already recognised the importance of domain-specific ddatasets through AIKosh. However, textiles have not yet emerged as a clearly defined knowledge domain within the national AI ecosystem.
A dedicated Textile Knowledge and Circularity domain should therefore be established within AIKosh. This domain would not simply function as a repository. It would provide a structured framework for organising textile-related datasets, models, documentation, and use cases.

Potential categories could include:

•Fibre and materialdatabases
•Textile waste and recycling datasets
•Technical textile research
•Traceability and certification records
•Sustainability metrics
•Cluster and GI information
•Repair and reusepractices
•Supply-chain and logistics data
•Innovation and startupcase studies

The objective would be to improve discoverability, interoperability, and reuse across the textile ecosystem.

Recommendation 3: Develop a National Textile Taxonomy Framework

The thirdpriority is standardisation.
Many of the challenges identified in this paper stem from the absence of shared classification frameworks. Different organisations frequently describe similar textile systems using different categories, terminology, and metadata standards. This creates barriers to data integration, traceability, AI development, and policy analysis.
A National TextileTaxonomy Framework would provide a common languagecapable of supporting multiple policy objectives simultaneously.

The frameworkshould be developed collaboratively and includeparticipation from:

•Ministry of Textiles
•NIFT and academic institutions
•Industry bodies
•GI authorities
•Standards organisations
•State governments
•Artisan and cluster representatives

The purpose would not be to impose a rigid classification system. Rather, it would be to improve interoperability across existing systems while allowing regional and sectoral diversity to remain visible.

Such a framework would also help position India for future Digital Product Passport requirements and international traceability standards.

Recommendation 4: Extend Traceability Beyond Fibre-Level Certification

Kasturi Cotton Bharat demonstrates the valueof combining traceability, certification, and digital identity within a unified framework.

The next stage should involve extending similar principles beyond fibre-level traceability towards broader textile-system traceability.

This does not imply that every textile product requires blockchain or advanced digital infrastructure. Instead, it suggests developing scalable approaches through which information about production methods, material origins, sustainability characteristics, and transformation processes can travel alongside products throughout their lifecycle.

Such systems would support circular economy objectives, export competitiveness, and Digital Product Passport readiness.

Most importantly, they would strengthen the informational foundations upon which future AI and circularity systems depend.

Recommendation 5: Recognise Knowledge Infrastructure as Economic Infrastructure

The final recommendation is conceptual but arguably the most important.

Infrastructure policy has traditionally focused on physical assets such as roads, ports, logistics networks, industrial parks, and manufacturing facilities. These investments remain essential. However, the emergence of AI-enabled and data-driven economies requires a broader understanding of infrastructure itself.

Knowledge infrastructures increasingly shape competitiveness, innovation capacity, regulatory compliance, and market access. Datasets, classification systems, traceability architectures, standards, and governance frameworks are becoming as important to economic performance as physical infrastructure.

For the textile sector, this means recognising that future competitiveness will depend not only on what India can produce,but also on what it can document,verify, classify, and communicate.

As global markets move towards greater transparency, sustainability reporting, and digital compliance requirements, countries with stronger knowledge infrastructures may enjoy significant advantages in investment attraction, innovation ecosystems, export positioning, and circular economy performance.

The roadmap below does not require a wholesale redesign of existing policy.It builds on programmes that already exist and seeks to improve their ability to work together.

India has already begun building the components of a textile knowledge infrastructure. The next step is to connect them.

Implementation Roadmap

Timeframe	Priority action	Lead stakeholders
Short term (1–2 years)	Establish Taskforce and map existing textile knowledge assets	Ministry of Textiles, IndiaAI
Short term (1–2 years)	Create Textile Knowledge and Circularity domain within AIKosh	IndiaAI, AIKosh
Medium term (2–4 years)	Develop National Textile Taxonomy Framework	Ministry of Textiles, NIFT, industry bodies
Medium term (2–4 years)	Integrate Tex-RAMPS, traceability, and AI datasets	Ministry of Textiles, state governments
Long term (4–6 years)	Align textile knowledge systems with DPP and global compliance frameworks	Government, industry, export bodies

Conclusion

India stands at an important moment in the development of its textile,sustainability, and digital economies. The country is simultaneously investingin one of the world'slargest textile sectors, expanding its commitment to circular economy principles, and building sovereign artificial intelligence capabilities through the IndiaAI Mission. Each of these agendas is ambitious in its own right. Together, they create an opportunity that extends beyond any single policy domain.

This paper has argued that an importantbut often overlooked connection exists betweenthem: knowledge infrastructure.

Contemporary discussions of circular textiles rightly focus on waste reduction, recycling technologies, traceability systems, Extended ProducerResponsibility frameworks, and emerging Digital Product Passport architectures. These initiatives are essential to achieving a more resource-efficient and sustainable textile economy. Yet they depend upon a prior condition. Materials, products, and production systems must first become visible within the information infrastructures that increasingly organise economic activity.

Visibility does not occur automatically. It is produced through datasets, classifications, taxonomies, standards, certification systems, and digital architectures. These forms of organisation influence what can be measured, traced, certified, invested in, and ultimately circulated.

As AI systems become more deeply integrated into forecasting, procurement, innovation, compliance, and governance, the importance of these knowledge infrastructures will only increase.

India has already recognised the strategic importance of information in several areas of policy. Through the IndiaAI Mission, the country is investing in datasets, foundational models, and domain-specific AI capabilities. Through AIKosh, it is creating mechanisms for organising and sharing knowledge resources. Through Tex-RAMPS, it is strengthening research, monitoring, planning, and evidence-based policymaking across the textile sector. Through Kasturi Cotton Bharat, it is demonstrating how traceability, certification, and digital identity can support trusted value chains.

The argument of this paperis not that these initiatives are insufficient. Rather,it is that their full potential depends upon the ability to connect them through a shared knowledgeinfrastructure.

For this reason, the paper has proposed the concept of a National Textile Knowledge Infrastructure: not a new bureaucracy or standalone programme, but an enabling framework that improves coordination between existing initiatives. Its purpose would be to make textile knowledge more visible, interoperable, and actionable across AI systems,traceability platforms, research programmes, sustainability frameworks, and circular economy initiatives.

This shift matters beyond textiles. Policymakers increasingly recognise that knowledge infrastructures are becoming as important as physical infrastructures in shaping economic development.

Roads move goods. Knowledge infrastructures move information. As Digital Product Passports, enhanced traceability requirements, and transparency demands reshape global value chains, future competitiveness will increasingly depend on the ability to provide trusted information about materials, origins, environmental impacts, and transformation processes. Knowledge infrastructure becomes economic infrastructure.

India possesses an extraordinary advantage. It is home to one of the richest and most diverse textile knowledge ecosystems in the world, encompassing handloom traditions, technical textiles, manufacturing expertise, research capabilities, regional production systems, and globally recognised craft knowledge. The challenge is not the absence of knowledge. It is ensuring that this knowledgebecomes visible within the systemsthat will shape future markets.

In a data-driven economy, what is not represented cannot be governed, measured, financed, or circulated fairly.

The first circular economy decisionis therefore not recycling. It is classification. Before materials can be traced, they must be identified. Before they can be certified, they must be represented. Before they can circulate through future value chains, they must become visible within the systems that govern economic attention, technological development, and policy action.

India has already begun building those systems. The next opportunity is to ensure that textile knowledge has a meaningful place within them.

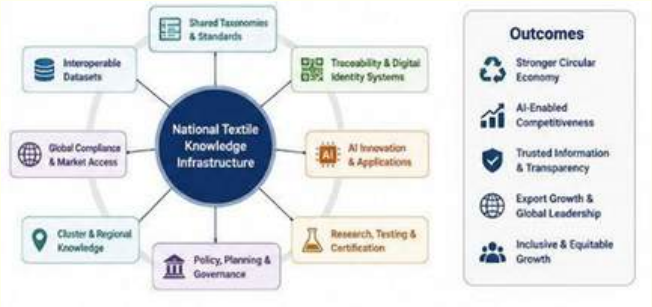

Figure 4. An integrated knowledge infrastructure can supportinnovation, circularity, traceability, and competitiveness simultaneously.

References

- Bhalla, S. G. (2025).Textiles: Need of a systemicchange. International Councilfor Circular Economy.
- Circle Economy. (2025).Circularity gap report:Textiles. Circle EconomyFoundation.
- Dutt, P., & Gandhi, A. (2025). Advancing circular economy in textile waste management: Integrated strategies for technology, policy,and market transformation. International Council for Circular Economy.
- Ellen MacArthur Foundation. (2024). Extendedproducer responsibility for textiles. Ellen MacArthur Foundation.
- European Commission. (2022). EU strategyfor sustainable and circular textiles(COM(2022) 141 final). European Commission.
- European Parliament & Council of the EuropeanUnion. (2024). Regulation (EU) 2024/1781 establishing a framework for the settingof ecodesign requirements for sustainable products (Ecodesign for Sustainable Products Regulation). Official Journal of the European Union.
- IndiaAI. (2025a).Building India's foundational AI models: IndiaAIinnovation initiative. Ministry of Electronics and Information Technology.
- IndiaAI. (2025b).AIKosh: National datasetsand AI resources platform. Ministryof Electronics and Information Technology.
- International Councilfor Circular Economy.(2025). Repurposing textileindustry for human well-being and transition to net-zero. ICCE Journal.
- Ministry of Electronics and Information Technology. (2024). Cabinet approvesover ₹10,300 crore for IndiaAI Mission. Press Information Bureau.
- Ministry of Textiles.(2025a). Annual report2024–25. Government of India.
- Ministry of Textiles. (2025b).Mapping of textilewaste value chain in India. Press Information Bureau.
- Ministry of Textiles. (2026a).Tex-RAMPS: Textiles focusedresearch, assessment, monitoring, planning and start-up scheme. Government of India.
- Ministry of Textiles. (2026b).MoUs signed with 15 states for data integration under Tex-RAMPS. Press Information Bureau.
- Office of the Development Commissioner for Handlooms. (2019). Fourth all India handloom census 2019–20. Ministry of Textiles, Government of India.
- People's Archiveof Rural India. (2019). Fourth all India handloom census 2019–2020. PARI Library.
- Press Information Bureau. (2024a). India'stextile industry expectedto reach US$350 billion by 2030. Government of India.
- Press Information Bureau. (2024b). Empowering ginners to produce Kasturi Cotton Bharat brand: Traceability and certification of Indian cotton.Ministry of Textiles,Government of India.

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