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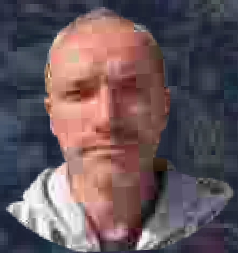
SPECIAL EDITION ON
WASTE MANAGEMENT

A TRANSITION TO ZERO WASTE : UNLOCKING THE CLIMATE, ECONOMIC, AND SOCIAL CO-BENEFITS OF WASTE SECTOR TRANSFORMATION



Mr Piotr Barzack
Guest Editor

Rethinking Religious Waste:
Circular Solutions for Sustainable Resource Renewal

Beyond Traditional Urbanism:
Adopting a Circular Economy for Sustainable and Inclusive Cities in India

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CIRCULAR ECONOMY

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EDITOR'S NOTE

MS SHALINI GOYAL BHALLA
Managing Director
International Council for Circular Economy

Dear Readers,

It is my pleasure to introduce the eighth edition of our Journal on Circular Economy, a special issue dedicated to waste management. Few topics test the circular economy more directly than the everyday materials we discard. The vivid, on-the-ground articles in this volume are not only insightful—they are immediately useful to practitioners, policymakers, and businesses seeking proven ways to design out waste, keep materials in circulation, and regenerate natural systems.

Across India's cities, we see both momentum and unmet potential. Nationally, India generated roughly 170,000 tonnes/day of municipal solid waste (MSW) in FY 2021–22; about 54% was treated and 24% landfilled, underscoring the distance we still need to travel from disposal to true circularity. At the same time, implementation is deepening: in the 2024–25 Garbage-Free Cities (GFC) assessment, more than 60,000 wards report >90% door-to-door collection and nearly 40,000 wards report >90% source segregation, while 1,700+ ULBs now have C&D waste facilities.

By the numbers (Urban India, 2022–25)

- Delhi: Municipal bodies report ~11,144 tonnes/day of MSW generation.
- Mumbai: ~6,330 tonnes/day (2022), with food waste comprising ~72.6% of the stream—an enormous opportunity for reduction, composting, and biomethanation.
- Chennai: ~6,150 tonnes/day collected daily by the Greater Chennai Corporation.
- Bengaluru: ~6,000 tonnes/day, with capacity gaps still visible between generation and scientific processing.
- Hyderabad: ~8,000 tonnes/day poses persistent treatment and landfill pressure, spurring plans for additional facilities and waste-to-energy.

These figures are not just statistics; they map where circular solutions can have the greatest impact.

For instance, Mumbai's organic fraction points to fast wins through source-segregated wet-waste systems, neighbourhood composting, and biogas—solutions that cut methane, return nutrients to soils, and lower transport and landfill costs. At a systems level, steady progress is visible in segregation, collection, and plant roll-outs, yet legacy dump remediation remains a national challenge—only ~38% of accumulated landfill waste had been bio-mined/processed as of late September 2024, reminding us that remediation and upstream waste prevention must advance together.

What this special issue offers:
The contributions in these pages span policy and practice: city-scale case studies on segregated collection and Material Recovery Facilities; design and operational lessons from composting and biomethanation projects; financing models for decentralised systems; C&D waste recycling pathways; and governance mechanisms—from SWM Rules, 2016 compliance to performance measurement—that make circularity stick at scale. Together, they translate the principles of the circular economy into the daily work of urban services—procurement, operations, inclusion of informal workers, market development for secondary materials, and climate co-benefits.

This edition has been a truly collaborative effort. I extend my heartfelt gratitude to our co-editor, Piotr Barczak, for his stewardship throughout the editorial process and to every author for their timely and valuable contributions. Your rigour, clarity, and generosity with data and field experience are what make this issue a practitioner's handbook rather than just a collection of essays.

If there is one theme that runs through this volume, it is that design and discipline—at source and across the service chain—unlock circular outcomes:

- Reduce avoidable waste (especially food) and promote reuse-first models in institutions and bulk generators.
- Segregate at source (wet/dry/sanitary) with consistent behaviour nudges and transparent feedback loops.
- Process locally where feasible—composting, biomethanation, and well-run MRFs—so cities move from "collection & dump" to "collection & recovery."
- Close the loop with market development for compost and recycled materials, and firm C&D recycling mandates.
- Remediate legacy landfills while preventing tomorrow's legacy through better contracts, data integrity, and outcome-based monitoring.

I hope this special issue equips you to accelerate what already works and to course-correct where needed. The circular economy is not a distant horizon; it is a set of choices we can implement in the next budget cycle, the next contract, the next ward. Thank you for reading, sharing, and—most importantly—putting these ideas to work in your city.

HAPPY READING!

GUEST EDITOR'S NOTE

MR. PIOTR BARCZAK

Guest Editor,
Journal on Circular Economy

Dear Readers,

It is my pleasure to welcome you to this edition of the *Circular Economy Journal*, where I invite you to delve deeper into the principles, practices, and real-world examples of circularity. We will explore not only the "big visions" of the circular economy but also the practical low-hanging fruits that cities and businesses can embrace today, particularly in waste management.

The #CircularEconomy is much more than the opposite of the "take–make–dispose" linear model. Circular loops must be designed with intention and with clear characteristics. When I speak with governments or businesses, I often ask them not only to compare circularity to linearity but to visualize the loops—the flow of products and materials through production, use, reuse, disposal, and reintegration. But true circularity is not about looping for its own sake. It is about looping with purpose:

- Slow loops → keeping products in use longer, through durability, repair, and reuse.
- Lean loops → reducing material throughput and consumption to essentials.
- Local loops → ensuring value circulates within communities, not exported as waste.
- Clean loops → eliminating toxics that pollute ecosystems and disrupt recycling.
- Sustainable loops → powered by renewable energy and regenerative materials.
- Regenerative loops → restoring ecosystems, improving livelihoods, and leaving societies stronger.

One area where these principles come vividly to life is in organic waste management. The article by GAIA highlights how cities can unlock transformative impact by addressing this often-neglected stream. Organic waste represents more than half of urban waste (by weight). If properly managed, it becomes a resource: compost to regenerate soils, biogas to produce renewable energy, and even proteins for animal feed through innovations like black soldier fly technology. Crucially, separating organics at source also improves the recyclability of all other waste streams by reducing contamination.

Managing organic waste is not just a technical fix—it is a regenerative action. It cuts greenhouse gas emissions, supports local livelihoods, and returns nutrients back to the environment. In a world struggling with climate, resource scarcity, and social inequalities, prioritizing organics is a clear low-hanging fruit with outsized benefits. Yet it remains too often deprioritized. It is time to change that.

In this issue, you will find perspectives and case studies from around the world—showcasing how cities, communities, and businesses are rethinking loops in housing, mobility, waste, and more. Each story reflects a growing truth: the circular economy is not an abstract vision, but a practical pathway for resilience, prosperity, and justice.

Let us design loops that are slow, lean, local, clean, sustainable, and regenerative. Loops that not only close waste streams but also open new possibilities for people and the planet.

HAPPY READING!

READER'S SAY

It was a wonderful experience and honour to contribute an article to the circular economy journal of ICCE. The expectation of the journal is not only to cover diverse aspects of circular economy, but also ensuring the contents to have substance and quality. I found the review and feedback process by the evaluators very positive, constructive and straight forward. I wish the journal a long and impactful journey ahead.

Soumya P Garnaik
Country Representative - India
GGGI

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.

Dhiraj Santdasani
Technical Advisor India
C40 Cities

It was truly an enriching experience to be part of a publication that is not only timely but also incredibly relevant in shaping India's journey toward circularity.The editorial process was seamless, collaborative, and thoughtful, reflecting the professionalism and dedication of the ICCE team. I deeply appreciate the platform provided to highlight the potential and practices of the circular economy in small towns and villages, an area that often goes underrepresented in mainstream sustainability discourse. 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.

Amit Dubey
SWM and Sanitation Consultant
Indore Municipal Corporation

READER'S SAY

Contributing to the ICCE journal was a deeply fulfilling experience. The journal is incredibly insightful, featuring perspectives that are both comprehensive and cutting-edge. The team maintained excellent communication and created a rare and vital platform for meaningful dialogue around the circular economy. I am grateful for the opportunity and for being part of this important journey

Tavishi Darbari
Manager
Primus Partners

I was delighted to see the final article submitted by Kushaagra Innovations Foundation presented so well by the ICCE team. On submission of the article from me, the team took care of final formatting and everything was well-organized and seamless. Such smooth coordination allows authors like me to focus fully on experience sharing, content and ideas.

Zigisha Mhaskar
Director
Kushaagra Innovations Foundation

What I enjoyed most was the journal's vision of fostering meaningful dialogue rather than simply collecting articles. Each edition feels carefully curated, with themes and perspectives that complement each other. Contributing to such a purposeful publication has been a privilege

Srikrishna Balachandran
Senior Director
Anubhuti Welfare Foundation

A TRANSITION TO ZERO WASTE :
UNLOCKING THE CLIMATE, ECONOMIC, AND SOCIAL CO-BENEFITS OF WASTE SECTOR TRANSFORMATION

Cecilia Allen
Global Zero Waste Cities Program Lead
GAIA

Introduction

As the climate crisis intensifies, the urgency of reducing greenhouse gas (GHG) emissions has never been greater. Among the various sources of emissions, the waste sector often remains underestimated, despite being the third-largest source of anthropogenic methane emissions globally. Methane, a potent greenhouse gas with over 80 times the warming potential of carbon dioxide (CO_2) over a 20-year period, is primarily generated in the waste sector from the decomposition of organic matter in oxygen-limited environments, such as landfills. The methane mitigation potential within the waste sector is significant and can be deployed quickly and with minimal investment compared to interventions in other sectors, thus posing a unique opportunity for climate action in the short term.

The Role of the Waste Sector in Greenhouse Gas Emissions

The importance of the potential impact of methane abatement has been reflected in initiatives such as the Global Methane Pledge signed in 2021, the ROW (Reducing Organic Waste) Declaration launched at COP29 and many other regional and national policies. These instruments provide a positive framework to raise ambition in climate action, and need to be translated into practice. The waste sector contributes approximately 20% of anthropogenic methane emissions, making it a significant driver of near-term climate change (UNEP and CCAC; 2021). Municipal solid waste (MSW)—especially food scraps, garden clippings, and paper products—is the primary contributor. In some regions, landfills are even the leading source of methane emissions.

Food and green waste pose a unique accessible opportunity for methane mitigation globally. Diverting organic waste from landfills through source separation, separate collection and processing through any of the diverse techniques for this waste stream - such as animal feed, composting, anaerobic digestion, cultivation of black soldier fly- should thus be a priority in waste management planning.

The Studies show that composting alone could reduce MSW methane emissions by 78%. When combined with bio-stabilization of residuals and biologically active landfill cover, reductions can reach as high as 95% (Tangri, N. et al; 2022).

These impacts can also extend to others if connected to overall food systems transformation, by connecting urban discards with food production through agroecological practices. Preventing food waste avoids emissions not only from decomposition but also from the production, processing, and transport of food. Globally, one-third of food produced is wasted, accounting for up to 10% of GHG emissions (Gikandi; 2021).

As reducing methane emissions becomes a global priority and national and local governments enact policies to address this, and international financial institutions increase their support to methane mitigation in the waste sector, it becomes imperative to keep a perspective of the big picture and avoid trade-offs between methane and other GHG emissions. A recent study analyzes the long-term global warming effect of three waste management strategies -waste disposal in dumpsites and landfills, incineration and zero waste- in three cities: Lagos, Nigeria; Barueri, Brazil; and Quezon City in the Philippines. The three waste approaches are compared by modeling temperature outcomes by 2060. In the three cities, zero waste (including practices such as source separation, separate collection collection and treatment of organic discards and recyclables) outperforms waste disposal and incineration. In Lagos, Nigeria and Quezon City, Philippines, the avoided warming resulting from zero waste interventions is up to nine times bigger than incineration (Ribeiro-Broomhead, J. and Tangri, N; 2025).

Moreover, measures taken in the waste sector have an impact that extends to the overall material economy. Seventy percent of global GHG emissions stem from the lifecycle of material goods—from extraction and manufacturing to disposal (Fraser, M. et al; 2024). These emissions are often categorized under industrial, agricultural, and energy sectors, but waste generation and management decisions directly influence them. Strategies like waste prevention, reuse and recycling reduce the need for virgin material extraction and energy-intensive manufacturing. This has a ripple effect across multiple sectors, amplifying the mitigation potential of waste management well beyond its direct footprint. As calculations show, zero waste systems can lead the waste sector to become a net negative source of greenhouse gas emissions (Tangri et al; 2022).

Transitioning to a Zero Waste Approach

Zero waste is an approach to waste prevention and management that differs from linear waste management in its essence. Zero waste is both a vision and a strategy. Defined by the Zero Waste International Alliance as "the conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning, and with no discharges to land, water, or air that threaten the environment or human health," it emphasizes systemic change away from disposal-dependent economies. As a vision, zero waste understands waste as a symptom of a broader systemic problem, and envisages a world where nothing and no one is wasted.

On a practical level, zero waste encompasses a combination of policies and programs that align with the waste hierarchy and can be organized by 5 overarching strategies:

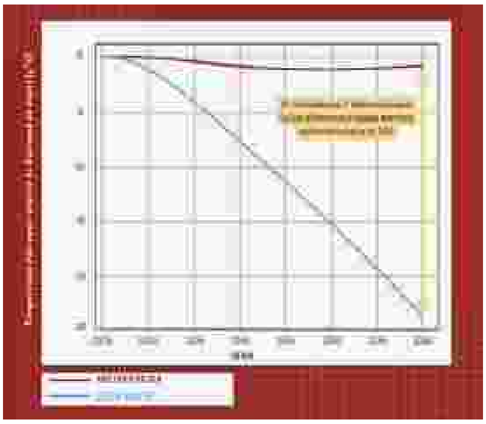
- Set the goal to end waste disposal in dumps, landfills, and incinerators. This provides a long term vision and goal to direct policies and programs.
- Industrial responsibility over production, accountability and redesign of products to minimize waste at source, design products for reusability, longevity, repairability, toxics-free, alternative delivery systems.
- Reorient consumption patterns around ecological limits. Promote values among society not based on material consumption but on solidarity, empathy and care for family, friends and the environment.
- Develop systems and infrastructure to safely recover resources at their highest and best use, avoiding harmful and toxic processes. This includes setting up systems for separate collection, reuse, composting, anaerobic digestion, use of black soldier fly reuse, recycling discards.
- Ensuring social and environmental justice by respecting and engaging all sectors on the frontlines of the resources ecosystem, with prioritization of the sectors most impacted by waste generation, such as local communities, waste pickers, and other waste workers.

Zero Waste Around the World

Zero waste is not theoretical—it is a practical approach. Over 550 municipalities worldwide are taking steps to transition to zero waste across diverse economic, cultural, and climatic contexts.

Zero waste provides a framework that is suitable to be adapted to diverse contexts, as the experience from around the world shows. Thiruvananthapuram, the capital of the state of Kerala in India, with a population of almost a million, runs a highly successful decentralized zero waste system.

The program includes an intensive program for organic waste, which represents 72% of the total municipal solid waste in Kerala.



BY 2060, Zero-waste is 30 time more effective in preventing global warming than waste incineration- Quezon City, Philippines

This includes promotion of source separation and separate collection of organic waste, extensive community outreach and education programs, and promotion of on-site treatment that greatly reduces waste collection. As part of this, the government provides subsidies to set up small-scale organic waste treatment units such as compost systems, micro-anaerobic digesters, bins, etc. These schemes achieved compliance rates for source separation of 80% in the residential sector and 88% in the commercial sector within five years (Ramachandran, K; 2019).

In Slovakia, the municipality of Partizánske has also implemented a decentralized system for organic waste which combines promotion of home composting for single-family households, and door-to-door separate collection of organic waste for apartment buildings. This program resulted in 95% of single-family households currently composting at home and a 18% city-wide reduction of residual waste since 2018. Moreover, this has had a positive impact on the public budget, bringing savings in waste management. (Moňok et al; 2024). 19 municipalities in Europe have been certified as Zero Waste Cities by Mission Zero Academy and dozens more are in the process to achieve the certificate.

In Tanzania, the organization Nipe Fagio has introduced the zero waste approach that is rapidly expanding throughout the country. Starting in 2019 in Bonyokwa ward in Dar es Salaam, the organization put in place a zero waste system that prioritizes community engagement, cooperative-led separate collection and decentralized waste management. The program has been instrumental to create a zero waste cooperative that handles separate waste collection, build a materials recovery facility to process dry-recyclables, composting of organics, cultivation of black soldier fly and a vegetable garden, develop a transparent fee payment system through an app that connects users and collectors, and intensive community awareness and engagement campaigns. The program has a source separation compliance rate of 95% and a composting, reuse and recycling rate of 85%. It is a hallmark of the implementation of context-grounded waste management system, and has not only expanded to other wards within Dar es Salaam but is also being replicated in Zanzibar and Arusha, with materials recovery rates of 82% in Zanzibar, and 75% in Arusha (Nipe Fagio, 2024).

Furthermore, the implementation of zero waste systems is faster than the processes to set up centralized technology such as landfills or incinerators. Based on their long-term experience, Zero Waste Europe estimates the average period for a municipality to implement a zero waste plan is between 2-3 years. In Dar es Salaam, the zero waste system implemented by Nipe Fagio in Bonyokwa achieved 95% compliance in source separation and reduced waste disposal by 75% in just two years. In San Fernando, Pampanga, Philippines, the zero waste plan boosted waste diversion from 12% to over 80% in six years. Sǎlacea, Romania went from near-zero recycling to 40% in only three months. Parma, Italy increased separate collection from 48.5% to 81% in seven years (Tangri et al, 2022, Nipe Fagio; 2024).

Co-Benefits of Zero Waste

Beyond reducing GHG emissions, zero waste generates a wide spectrum of environmental, social, and economic co-benefits. One of the most compelling co-benefits of zero waste systems lies in their potential for job creation and boosting local economies. The job creation hierarchy mirrors the environmental hierarchy: the strategies that are most beneficial for the environment also generate the most employment. According to a global study covering 16 countries, zero waste approaches—ranging from repair and reuse to composting and recycling—create significantly more jobs than disposal-based systems such as landfills and incinerators. For instance, repair activities generate an average of 404 jobs per 10,000 tonnes of waste managed, recycling creates 115 jobs, and remanufacturing generates 55. In stark contrast, incineration and landfilling produce only about 1–2 jobs for the same volume (Ribeiro-Broomhead, J. & Tangri, N.; 2021).

Moreover, zero waste jobs are often more diverse and higher quality than those in disposal systems. Employment opportunities range from technical roles in electronics repair and remanufacturing to community outreach, data analysis, and urban farming using compost. These jobs not only enhance local economic resilience but also support social equity by providing livelihoods to marginalized groups.

Job creation opportunities in global south countries also mean possibilities to recognize the work of waste pickers and integrate them into formal waste management systems through contracts, provision of infrastructure, payment for their services and integration in the overall planning and implementation of waste management. This alignment of environmental and economic goals highlights zero waste as an ideal investment for building resilient local economies.

Conclusion

The waste sector's role in methane and GHG emissions is both a challenge and an opportunity. Left unchecked, waste continues to fuel climate change and degrade ecosystems. Yet, with the adoption of zero waste strategies, the sector can become a net-negative source of emissions while generating substantial social and economic gains.

Zero waste is no longer an aspirational goal; it is a proven, scalable solution. As cities, governments, and industries grapple with the dual crises of climate change and unsustainable resource use, zero waste offers a transformative pathway—one that reduces emissions rapidly, enhances resilience, and creates thriving, just societies.

For environmental services professionals, business consultants, research organizations, community based organizations, and international development associations, the message is clear: zero waste is not simply about managing garbage—it is about rethinking systems, reclaiming resources, and redefining progress.

The stakes of inaction are too high to remain passive. It is time to bring commitments into action and to replicate successful systems that are operating across the world. The know-how is there, grounded in very diverse contexts, often lying in communities, waste pickers and zero waste champions. We encourage all waste management practitioners and governments to raise ambition and put zero waste at the center of climate action.

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RETHINKING RELIGIOUS WASTE: CIRCULAR SOLUTIONS FOR SUSTAINABLE RESOURCE RENEWAL

Dr. Ketna Atul Matkar
Founder & Managing Director
Cipher Environmental Solutions LLP, Thane

Fig. 1: Funerary Statues at Mesita B (Photograph by Benjamin Oswald, CC BY-NC-SA)

Abstract

Religious artefacts such as idols, photographs, and ornate frames hold deep spiritual significance in Indian society. When damaged, faded, or no longer in use, these items often enter water bodies or landfills, creating a unique waste stream that is both culturally sensitive and environmentally impactful. This article reviews the scale of the challenge, the environmental implications of current disposal practices, and highlights innovative circular economy solutions pioneered by organizations such as Sampurnam Seva Foundation (Nashik) and HelpUsGreen (Kanpur). It discusses similar initiatives, explores scaling through urban local body involvement, and offers recommendations to integrate religious waste into formal systems without compromising cultural values.

Keywords: Religious waste; Special Waste; Circular economy; Urban local bodies; Upcycling; Recycling

1. Introduction

Waste generated by religious practices is distinct, carrying sacred associations that make disposal culturally sensitive. Immersion of idols, photographs, and frames in water bodies has been customary in many parts of India. While tradition endows these items with divinity, increasing use of synthetic materials, chemical paints, laminated surfaces, and plastics in their making has introduced environmental concerns (CPCB, 2010). Items once honouring the divine may inadvertently become potential environmental pollutants if not managed appropriately. Globally, religious waste streams pose similar challenges. Japan's Hari-Kuyō (Festival of Broken Needles) ceremonially retires sewing tools, while parts of Latin America prefer to bury or store worn religious statues rather than discard them (Oswald, 2019). Given India's large population and frequent festivals, the scale of waste generation is substantial, presenting both environmental challenges and opportunities for sustainable circular solutions (UNEP, 2021). The circular economy approach offers a pathway to harmonise respect for tradition with environmental stewardship by closing material loops and creating economic opportunities through upcycling sacred waste.

2. Scale and Nature of the Problem

2.1 Annual Disposal Volumes

According to Toxics Link, over **100,000 idols** are immersed annually in India (Basu, 2013), excluding untracked photographs and frames. Major urban centres face disproportionate waste loads; in Mumbai, the Brihanmumbai Municipal Corporation reports that hundreds of thousands of idols are immersed annually during Ganesh Chaturthi, illustrating the scale of religious waste generated (The Indian Express, 2023). Kolkata immerses around **15,000 Durga idols** annually in the Hooghly River (Basu, 2013).

2.2 Composition of Religious Waste

Religious waste comprises a complex mixture of materials reflecting the diverse nature of artefacts used in spiritual practices.

- **Idols:** Idols, which form a significant portion of this waste, are primarily made from Plaster of Paris (PoP) or clay, often reinforced with metals, wood, and thermocol to enhance structural integrity and aesthetic appeal. However, many of these idols are finished with chemical paints that frequently contain toxic heavy metals such as lead, mercury, cadmium, and chromium, posing environmental and health risks during disposal.
- **Photographs & Frames:** Photographs and frames discarded as religious waste add another layer of material complexity. These typically consist of laminated prints for preservation, glass components, wooden frames, various plastics, and metallic foils used for decorative edging or embellishments. These multi-material compositions challenge conventional recycling processes due to the difficulty in separating components.
- **Associated Materials:** In addition to idols and framed photographs, religious waste includes numerous associated materials such as clothes used for draping idols, garlands made from plastic or natural flowers, artificial flowers crafted from synthetic materials, and a variety of other decorative items commonly employed during rituals and ceremonies.

The combined presence of biodegradable and non-biodegradable materials necessitates specially tailored waste management solutions that consider both environmental impact and cultural significance.

2.3 Environmental Impacts

The disposal of religious artefacts poses several environmental risks, particularly to water quality. Plaster of Paris (PoP) idols dissolve slowly in water, reducing dissolved oxygen levels critical for aquatic life and releasing harmful chemicals into water bodies (CPCB, 2010). In addition, paints used on idols often contain toxic heavy metals such as lead and cadmium, which leach into rivers and accumulate in aquatic organisms, threatening biodiversity and human health through the food chain (Environmental Science & Technology, 2021). Beyond water pollution, solid waste generated from discarded photographs and frames frequently ends up in open dumps or is incinerated, releasing hazardous emissions and contributing to land and air pollution.

3. Case Studies: Circular Solutions in Action

3.1 Sampurnam Seva Foundation (Nashik)

The Sampurnam Seva Foundation was established in 2021 by Advocate Trupti Gaikwad after she was moved by the sight of discarded religious photographs floating in the Godavari River (YourStory, 2022). This inspired the creation of a systematic process for collecting and respectfully repurposing religious artefacts.

The foundation's operational model involves multiple collection channels, including donations, strategically placed drop-off points, and direct pickups from households and communities. A distinctive feature of the process is the cultural respect maintained by performing a brief Uttar pooja ritual to honour each item before it enters the recycling stream, ensuring adherence to religious sentiments.

Other strategies include Reducing Plastic Consumption:

- Supporting the development and use of sustainable packaging options such as biodegradable or compostable materials to promote eco-friendly packaging.

- These materials offer a viable alternative to traditional plastics, reducing landfill waste and reliance on fossil fuels. The market for these sustainable options is growing,

The foundation's processing methods focus on material-specific reuse: Plaster of Paris idols are crushed and combined with cement to produce bird feeders and bowls primarily used for stray animals; wooden frames are creatively transformed into birdhouses and furniture pieces; recovered metals are responsibly sold to recyclers; and plastics are upcycled into toys and small household items. These upcycled products are marketed under the 'Sampurna' brand, establishing an identity that links sustainability with cultural values.

Fig. 2: (a) Performing uttar pooja ritual; (b) Sampurnam Foundation's upcycled products

As a result of these efforts, Sampurnam has recycled over 350 tons of religious materials and conducted 141 clean-up drives. The initiative notably provides employment and skills training opportunities for women and individuals with autism, promoting inclusive economic empowerment. Revenue generation is sustained through the sale of recycled products and donations.

3.2 HelpUsGreen (Kanpur)

HelpUsGreen was established in 2015 with the mission to prevent temple floral waste from polluting the Ganges River and nearby urban environments (UNEP, 2021). The organization operates a large-scale collection system, gathering approximately 2.5 tonnes of discarded flowers daily from temples, mosques, and other religious sites. These flower petals undergo a cleaning process to remove pesticides and other contaminants, after which they are dried and blended with natural binders to create a variety of sustainable products. These include charcoal-free incense sticks, biodegradable floral foam known as "Florafoam," organic compost, and seed paper packaging.

By providing steady employment to 23 rural women, HelpUsGreen has contributed to significant socioeconomic benefits, empowering these women with improved incomes and financial independence. Environmentally, the organisation has successfully offset 210 metric tonnes of chemical pesticides annually by diverting floral waste from waterways. Its products have found markets both within India and internationally, supported by partnerships with prominent brands. The organisation's impactful work has earned recognition, including designation as a UNEP Young Champion of the Earth and inclusion in Forbes Asia's 30 Under 30 list.

Fig. 3: Floral waste processed by rural women at HelpUsGreen

3.3 Other Initiatives

Several other innovative projects across India exemplify culturally sensitive and circular approaches to religious waste management.
Murthyshodhana (Bengaluru): The Murthyshodhana initiative in Bengaluru operates through strategically placed drop-off points where communities can responsibly deposit old idols and photographs. This program integrates respectful disposal rituals, ensuring religious sentiments are honoured throughout the process (Sri, 2025).
Sampoorna (Delhi): In Delhi, the Sampoorna project focuses on upcycling idol clothes into marketable products, empowering women artisans and facilitating skill development while reducing textile waste (Agarwal, 2025).
Punaravartan Campaign (Pune): The Punaravartan Campaign in Pune recovers clay sludge from idol immersion sites and reutilizes it for new idol production, contributing to material circularity and waste minimization (eCoexist Foundation, n.d.). These diverse models highlight creative pathways for scalable, community-anchored circular solutions across urban India.

4. Lessons from the Field

Experience from these initiatives reveals several critical success factors that can inform broader replication.
Cultural Sensitivity: Integrating rituals and honouring religious sentiments before recycling fosters community acceptance and participation.
Community Engagement: It emerges as essential, with active involvement of local stakeholders building trust and enhancing collection efficiency. Active involvement builds trust and collection efficiency.
Value Addition: The creation of *value addition* through upcycled products not only generates revenue but also supports the financial sustainability of these programs.
Social Inclusion: plays a pivotal role by providing employment and skills training specifically targeting women and marginalised groups, thereby linking environmental objectives with socioeconomic empowerment.

5. Pathways for Scaling and Policy Integration

5.1 Role of Urban Local Bodies (ULBs)

Urban local bodies (ULBs) are central to scaling circular religious waste management solutions. They can facilitate this by providing a designated space near religious sites for collection and processing infrastructure. Collaborative partnerships between ULBs and civil society organisations or NGOs enable efficient post-festival waste recovery, leveraging local networks and expertise. Crucially, integrating religious waste streams into formal municipal solid waste management frameworks ensures systematic handling and monitoring at scale.

5.2 Policy Recommendations

Policy initiatives can significantly accelerate the adoption and impact of circular systems. Mandating the use of eco-immersion tanks can improve material capture and reduce pollution. Extending Extended Producer Responsibility (EPR) frameworks to idol makers could incentivise the use of eco-friendly materials and create take-back systems. Public awareness campaigns are essential to educate citizens on the environmental consequences of traditional disposal methods and to promote the adoption of sustainable alternatives.

5.3 Economic Incentives

To catalyze operational viability, governments could offer grants dedicated to establishing recycling and upcycling facilities specializing in religious waste. Tax benefits aimed at donors contributing to registered religious waste management NGOs would encourage philanthropy and investment in this niche sector. Such financial mechanisms can underpin a sustainable ecosystem for sacred waste circularity.

6. Global Parallels and Opportunities

The challenges and solutions relating to religious waste management are not unique to India; global parallels enrich the understanding and offer opportunities for cross-cultural learning.

- **Japan:** In Japan, *Kuyō* ceremonies respectfully honor and retire worn tools and religious paraphernalia through temple-led disposal practices, exemplifying a model that blends reverence with material recovery (Oswald, 2019).
- **Philippines: I**n the Philippines, community-led recycling initiatives effectively divert waste generated from festival decorations, mirroring approaches found in Indian contexts (UNEP, 2021).

These examples illustrate the potential for cultural exchange and adaptation of best practices that integrate tradition with sustainability, fostering a global movement towards circularity in culturally significant waste streams.

Conclusion

Religious artefact waste embodies both an environmental challenge and an opportunity. Unmanaged, it fuels pollution and resource depletion. Managed via circular economy principles, it can yield livelihoods, preserve culture, and regenerate ecosystems. The efforts of Sampurnam Seva Foundation, HelpUsGreen, and similar NGOs exemplify sustainable, culturally respectful solutions. Scaling such solutions through ULB support, policy backing, and public engagement can transform this neglected waste stream into a regenerative sector.

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TOWARDS A ZERO WASTE TO LANDFILL FUTURE: *COMMUNITY-DRIVEN MODELS FOR WASTE MANAGEMENT IN INDIA*

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Introduction

By 2050, the world is expected to generate 3.4 billion tonnes of waste every year—a staggering figure that highlights the scale of our global waste crisis. Yet, as of today, less than one-third of this waste is managed in ways that are safe for people and the planet. The rest ends up in overflowing landfills, polluting rivers, choking ecosystems, and contributing to climate change.

In India, the challenge is even more urgent. Rapid urbanisation, changing lifestyles, and a dependence on single-use plastics have dramatically increased the waste burden in cities and towns. Landfills are reaching dangerous levels, municipal systems are overstretched, and the environmental and health impacts are being felt most severely by vulnerable communities.

Traditional approaches, focused largely on collection and disposal, are proving inadequate. What is needed is a paradigm shift: from linear "take-make-dispose" systems to circular, community-driven solutions where waste is not discarded but continuously reused, recycled, or composted. This is where the idea of Zero Waste to Landfill (ZWL) becomes critical. ZWL is not about managing waste at the end of its journey—it is about redesigning systems so that very little, or ideally nothing, reaches the landfill in the first place.

Over the last few years, through the Why Waste Wednesdays Foundation (WWWF) and the Navjeevan Residents Welfare Association (RWA), I have been working to translate this vision into practice. Together with citizens, schools, markets, hospitals, and institutions, we have piloted and scaled innovative models of Zero Waste to Landfill. These models show that when people participate actively, when systems are transparent and accountable, and when circularity is made visible, change is not only possible—it is replicable.

The following case studies highlight different approaches we have implemented: a colony that became a Zero Waste model, a city-wide "borrow-a-bag" movement to replace single-use plastics, waste-free festivals and cultural events, recycle melas that turn households, colonies, schools, colleges, and offices into sustainability champions, and PaperLoop, which closes the cycle on office paper. Together, they demonstrate that Zero Waste to Landfill is not a dream—it is a scalable reality that communities can achieve today.

Case Study 1: Navjeevan Vihar – A Zero Waste Colony

Navjeevan Vihar, a South Delhi colony once struggling with the everyday challenges of urban waste, has today transformed into a model Zero Waste community.

The journey began with 100% household-level segregation, ensuring that every bit of waste had a defined pathway. Wet waste was treated locally through composting units and leaf composters in parks.

The effort didn't stop at composting. A dedicated RRR (Reduce, Reuse, Recycle) Centre was set up within the colony to channelise waste that could not be composted. This centre became a hub where residents could drop off old clothes, books, plastics, and even e-waste. To date, the RRR Centre alone has diverted more than 65 tonnes of material away from landfills and into productive reuse streams.

A key driver of success was the focus on social inclusion and incentives. Female domestic helpers were provided with biodegradable sanitary napkins for themselves and their daughters—an intervention that addressed both waste reduction and menstrual health.

Children, often the most enthusiastic change agents, were engaged through puppet shows, Paint-a-Bag workshops, and interactive waste-awareness games that turned learning into fun. These efforts ensured that waste management became a community movement rather than a top-down directive.

The results speak for themselves: over 7 lakh kilograms of waste have been diverted from landfills, and the colony has been recognised by MoHUA and GIZ as a national best practice in community-led waste management.

Today, Navjeevan Vihar is not just a cleaner colony—it is a living example of how urban neighbourhoods can take ownership of their waste, embed circular practices, and inspire replication across India.

Case Study 2: Project Vikalp – Borrow a Bag

Delhi's markets are drowning in single-use plastic bags. But with Project Vikalp, we introduced a simple yet transformative solution: borrow, don't buy.
Through more than 1,000 stalls set up across MCD, NDMC, and Delhi Cantt markets, shoppers now have access to 1.75 lakh cloth bags available on a deposit-refund basis.

Fig. : women's self-help groups using upcycled fabric

These sturdy, reusable bags are stitched by women's self-help groups using upcycled fabric, turning textile waste into both a resource and a livelihood opportunity.

To make participation seamless, each bag carries a QR code that directs citizens to the nearest Vikalp stall, embedding digital access into a grassroots movement. The impact has been game-changing: over 1 crore plastic bags have been prevented from entering the waste stream, while a circular textile market has been created—one that not only reduces plastic but also empowers women through sustainable employment.

Case Study 3: Zero Waste to Landfill Events

Festivals and large public gatherings in India often generate mountains of mixed waste, much of which ends up in landfills. To change this narrative, the Why Waste Wednesdays Foundation developed a robust framework to make events truly Zero Waste to Landfill.

At these events, the approach is hands-on: teams go stall-to-stall and table-to-table, engaging with vendors and visitors to prevent food wastage and littering. Continuous public announcements keep sustainability at the forefront, while volunteers at every disposal point ensure strict segregation through real-time bin monitoring.

Disposables are replaced with steel thalis, compostable cutlery, and matka-water, proving that tradition and sustainability can go hand-in-hand. The system is backed by rigorous monitoring, reporting, and follow-up, ensuring that commitments translate into measurable results.

Fig: real-time zero waste monitoring and public engagement at a large event in India

The outcomes have been remarkable. High-footfall events like Rashtrapati Bhavan Udyam Utsav 2025, Gurupurab 2022, and Nirjala Ekadashi 2024—together hosting over 3.5 lakh visitors—were conducted without adding to landfill burden, with more than 15 tonnes of waste diverted.

Currently, the team is managing the month-long Amrit Udyan Festival at Rashtrapati Bhavan (2025) as a Zero Waste to Landfill event, setting a powerful precedent for embedding sustainability into India's national cultural spaces.

Case Study 4: Recycle Melas & Educational Engagement

Urban communities often lack clear, structured ways to recycle their waste, leading to valuable materials being lost to landfills. To bridge this gap, the Why Waste Wednesdays Foundation pioneered Recycle Melas—community fairs that make recycling simple, accessible, and even fun.

At these melas, citizens can drop off their e-waste, plastics, expired medicines, and paper in exchange for useful items like notebooks, cloth bags, and stationery made from recycled materials. This exchange model reinforces the idea of circularity—waste is not just discarded, it comes back to the community in a new form.

Education plays a central role. The Students vs Plastics Toolkit, rolled out to more than 2,600 schools nationwide, equips young people with practical activities and awareness tools, empowering them to become champions of sustainability in their own communities.

The results have been both tangible and cultural: over 10 tonnes of waste have been safely channelized to authorized recyclers, while thousands of students and families now see recycling not as a burden but as a responsibility—and an opportunity.

Case Study 5: PaperLoop – Closing the Circular Paper Cycle

Office desks, schools, and hospitals generate mountains of paper waste every day, but most of it rarely finds its way back into the supply chain. To tackle this, the Why Waste Wednesdays Foundation launched PaperLoop, a pioneering program that closes the loop on paper usage.

Through PaperLoop, institutions like Safdarjung Hospital, schools, and offices deposit their waste paper into a structured collection system. In return, they receive recycled copier paper at a fixed exchange rate—creating a direct, visible incentive to recycle.

The initiative is backed by transparent reporting, which tracks the amount of paper collected, recycled paper distributed, and the environmental savings achieved. This accountability has built trust and encouraged more organisations to participate. In just two weeks, PaperLoop managed to channelise over 4 tonnes of paper into recycling loops, effectively creating a market for recycled paper. By turning waste into a commodity, PaperLoop proves that circularity is not only possible but also practical and scalable.

Replicating Zero Waste to Landfill Models

What began as a single colony-level transformation in Navjeevan Vihar has now evolved into a scalable model that is being replicated across diverse defence and institutional spaces.

Some of the notable replications include:

- Northern Railways Officers Enclave, S.P. Marg
- Northern Railways Officers Enclave, San Martin Marg
- DID Lines, Delhi Cantonment
- Taurus Officers Mess & Annexe, Delhi Cantt
- Albert Ekka Institute, Delhi Cantt

Fig: Community members and officials at a Zero Waste to Landfill replication site in Delhi

These prove that Zero Waste to Landfill is not a one-off success but a transferable framework that can be adapted to housing colonies, cantonments, markets, schools, and hospitals. Each replication strengthens the case that when systems are community-driven and accountability-driven, sustainability can scale.

Key Learnings

From these initiatives, several key lessons stand out that can guide others working towards a Zero Waste to Landfill future:

- Community engagement is essential. Sustainable systems thrive when citizens—especially children and women—are active participants. Their involvement ensures that practices like segregation and composting become part of daily life.
- Incentives drive participation. Small but meaningful rewards, such as biodegradable sanitary pads, recycled notebooks, or cloth bags, motivate people to stay committed and see value in their actions.

Conclusion

Waste management in India cannot be reduced to the question of where our garbage goes; it is fundamentally about how we as a society choose to live. At its core, it is about ownership, dignity, and community building. Every discarded item tells a story—not of waste, but of wasted opportunity—unless we reimagine it as a resource waiting to be transformed.

The journey from Navjeevan Vihar's Zero Waste colony model to Project Vikalp's fight against single-use plastics, from waste-free festivals at Rashtrapati Bhavan and Gurupurab to Recycle Melas and PaperLoop has shown us something profound: when citizens, institutions, and governments come together, Zero Waste to Landfill is not only possible, it is practical and replicable.

These initiatives prove that waste management is not just a municipal responsibility; it is a collective responsibility. Communities thrive when people see the benefits of their actions—compost turning into fertile soil, old clothes becoming useful again, or paper being reborn as notebooks. Incentives, accountability, and transparency make the system not just functional but inspirational.

The next step is clear: scale and collaboration. India cannot afford isolated success stories; it needs a movement. Replication across RWAs, schools, markets, hospitals, defence enclaves, and cultural institutions is already underway, but to truly reach scale, we must integrate Zero Waste principles into policy frameworks and everyday citizen habits.

This is not simply about reducing landfill loads; it is about building resilient communities, protecting public health, reducing greenhouse gas emissions, and safeguarding the future for generations to come. The global waste crisis may seem overwhelming, but India has the opportunity to show the world what is possible when community participation meets innovation and accountability.

As we stand at this crossroads, the message is simple: waste is not a burden—it is a resource. When circularity becomes our default and landfill our last resort, we will not only have solved a pressing environmental crisis, we will have created a society that values sustainability, equity, and dignity.

The time to act is now. Each colony, each school, each market, and each event that embraces Zero Waste to Landfill brings us closer to a future where nothing is wasted—and everything has value.

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NATURE AND TECHNOLOGY-BASED SOLUTIONS TO DROUGHT REVERSAL:

CASES OF FARMER-FRIENDLY SPECIES (VETIVER ZIZANOIDES AND OTHER FIBRES)

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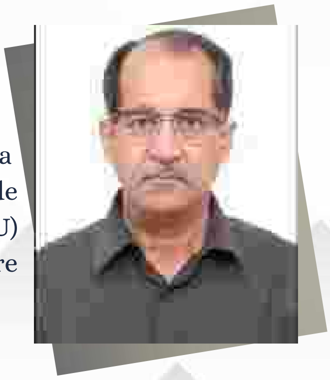

Humans have stuck to cotton since it was a ready crop that provided fibres, ready on its plant. Over millennia, humans have harvested this crop without any issue. Then came the Industrial Revolution and its woes. Climate change stresses added to the woes of farmers. With climate change, this cash crop became the bane of Indian farmers' existence.

Abstract:
Climate change has made the indigenous people adapt and continue to survive. But then came the industrial revolution and the desires (greed) associated with it. What was a basic human right, clothing, became a profitable business. With businesses exploiting agriculture over time, and the quest for maximum profits through high yields at source (farms), has given rise to genetic or bioengineering of cotton seeds.
Mother Nature has a whole host of solutions for humanity, but nothing to cure the need for a quick buck / fast money and an insatiable greed.

Keywords:
Natural Fabrics, Alternative to cotton, Argo waste, Climate change adaptation, Sustainability, Circular economy, Green moral economy, Livelihood options, Healthy fabrics

Introduction:
The history of clothing dates back to the evolution of humans on Earth. 100,000 to 500,000 years ago, humans used grass, fur, leather and then fabrics for clothing. Humans have always imitated Mother Nature. The weaverbird wove leaves to create her nest. Humans used bones and thin strips of leather to sew clothing. Over time, the patterns of nature were observed. Fabrics were created using many fibres from the coconut, jute and other hemp plants. These innovations were shared via the travails of tribes and communities over the sea and land routes. [1], [2]

Clothing for a tribe of a community meant the advancement and skill levels achieved. In Mobaim (the indigenous name for Bombay), the tribes advanced weaving methods over millennia, where they could even create a piece of pure gold into a thread and weave it into the cloth fabric. [3] Many tribes in India have always advanced their skills in thread making and weaving patterns, along with creating clothing of various styles and combinations traditionally.

Clothing among traditional communities is mostly for the coverage of vital body parts, serves as protection from the weather and is used to court partners among tribes.

Problem cited

The industrial revolution moved people from close-knit communities into industries and communities that produced goods. This prompted producers of threads and fabrics to scale their operations so that they could cope up with the demand. Cotton was the most time-tested crop and this crop was the ‘go to’ for farmers. Cotton accounted of 82% of the global fibre use. China is the largest producer of cotton followed by India and America. [4]

Cotton is produced in 80 countries and it is estimated that 25.6 million tonnes were produced in the year 2024/2025. The market for Indian textiles and apparel is projected to grow at a 10% CAGR to reach US$ 350 billion by 2030. (ICAC) [5]

Climate change and its impacts on the collective whole has also added a whole lot of stress to our farmers depending on this cash crop and to soils.

Global climate change affects everyone globally. The rising heat, water stress, and unseasonal rain reduce the farmers' harvest, in most cases destroying the farmers' cotton harvest. Small holding farmers are at risk from drought, flooding and extreme heat, which impact the cotton plants' flowering patterns and their survivability, affecting the overall productivity of the cotton farmer, the supply chains and global markets. [6]

Cotton, on the other hand, is grown by farmers all over the world. The patenting of plants by Western multinational companies in 1992 in India gave way to patenting the worm-resistant cotton seed. The soil bacterium BT (Bacillus thuringiensis) is an insecticidal gene, which is genetically modified. This gene makes the plant produce a toxic protein that repels certain insects and pests. This cotton variety is called BT (Bacillus thuringiensis) cotton. These patented seeds could not be re-harvested by the farmer. The farmer has to constantly purchase new seeds to continue to farm cotton. [7], [8]

Presently, the farmers have been introduced to illegal genetically modified cotton seeds that have proliferated due to weak regulation. These genetically modified seeds have been targeted to naïve farmers who do not know the effects of the seeds on the soil. [9]

Several recent studies have indicated that GM crops may cause changes in both the invertebrate and microorganism soil biota associated with these crops, with some laboratory-based experiments even revealing the transfer of genes from GM plants to native soil bacteria.

In many soils, fungi constitute a high proportion of the microbiome mass. These fungi interact with the plant rhizomes (root systems) in nutrient exchange. (Domsch et al. 1980)
The soil microbiome helps in plant growth, and the plant, in turn, helps the microbiome interaction through nutrient and protein exchange.

The GM plant's natural function to facilitate the exchange is hindered since the modified plant affects the soil microbiome negatively. The chemical environment of the soil, such as the NPK and pH, is affected by the plant and the microbiome present in that soil.]

Market forces (Money) are directly connected with the flooding of the markets with genetically modified cotton seeds.

The following are a few GM seeds that are illegal, but due to a lack of regulation mechanisms, these seeds end up causing havoc in Indian soils. Most GM seeds have Indian names, but this, too, is something Western corporations are responsible for. You get a willing Indian distributor, and the rest is easy. [14]

Image Source: Down to Earth Website

Circular Economy

Circular economy is an economic system that is designed to eliminate waste and pollution, reduce stresses to existing ecosystems by keeping resources in use within the human ecosystem for as long as possible, as opposed to the destructive economic model of, use and dispose linear model.

Collaborating with the indigenous communities, the global markets could benefit through access and benefit sharing, as well as learn from the sustainable ways of the indigenous communities [15]

Agriculture creates a lot of waste. This waste can be transformed into clothing through a mechanical or natural process called fibre separation and cottonization. Various agricultural wastes like cornstalks, banana stems, orange peels, oat husks, pineapple leaves, and cactus leaves of the agave plant can be turned into fibres for clothing.

SOLUTIONS

Hemp – Cannabis

1.Hemp

Hemp is one of the oldest cultivated crops, dating back over 10,000 years, with its use in textiles. Hemp fabric can be dated to ancient Mesopotamia, where it was used to create ropes, sails of ships and clothing. Over time Hemp spread to ancient China and India, playing an important role in the respective countries' culture and civilisation. In ancient India, the versatile hemp was used for making ayurvedic medicines and its fibers used in textiles. The word 'canvas' is derived from cannabis. [16]

Hemp is an herbaceous annual plant in the family Cannabaceae. Its botanical name is Cannabis Sativa. While Cannabis indica has the following amount of psychoactive THC, dried flower: Usually contains 15-25% THC, but can go higher. Hash and Kief: Can range from 50-80% THC. Concentrates (e.g., wax, shatter, rosin): Often contain 60-90% THC, hemp has only 0.3% THC, and because of its leaves that look similar to Cannabis indica, this plant is frowned upon by non-traditional, non-indigenous communities and governments who do not know the difference between the two plant species. Hemp is a non-psychoactive plant.

Hemp grows from 4 feet to 15 feet in height. While cannabis indica grows only 4 to 5 feet in height. The stigma attached to this species got the hemp plant banned in many countries. Long fibres derived from the stem of the hemp plant is what fabrics are made of. The hemp fabric protects the wearer from the harmful UV rays of the sun and it is anti-fungal too. [17],

Soils and Hemp

Hemp helps revive degraded or poor soils through phytoremediation. Hemp's structure and its root systems continue to grow unaffected in polluted soils with heavy metals in them. [18]

Flax

2. Flaxseed plant - Linen

L. usitatissimum, also known as common flaxseed, or linseed, is one of around 200 plants in the Linum genus, part of the flowering plant family Linaceae.

The fibres from the stem of this plant are naturally smooth and long, ideally used for fabrics and clothing. The seeds contain a large amount of omega-3 fatty acids and is a good dietary supplement for vegans and others. The oils from the seed are used to polish wooden surfaces to protect the wooden surfaces of furniture and musical instruments from moisture.

Linen is one of the oldest fabrics known to humans, dating back thousands of years. The ancient Egyptians used it extensively for mummification and clothing. The linen fabric was the fabric of choice for the Egyptians, the Greeks and the Romans, because of its purity, breathability and sustainability. With the onslaught of the industrial revolution and mechanised production, synthetic fibres became the norm, and these ancient fibres were ignored. [19]

Flaxseed plant and Soil

The flaxseed plant promotes healthy soil in crop rotations. They require minimum irrigation, pesticides and fertilisers. Flaxseeds are a fast-growing, renewable plant that uses minimal water and other resources. Since the plant does not require fertilisers or pesticides, it has less potential for groundwater pollution. [20]

Pineapple – Pina

3. Pineapple – Pina

The pineapple (Ananas comosus) belongs to the Bromeliaceae family, is indigenous to South America, where it has been cultivated for centuries and was brought to the Philippines and Asia, including India, by the Portuguese.

Pineapple is a generic name derived from the words 'Pinas' or 'Pomme de Pin', which translates to 'Apple of Pine' in the language of the indigenous people of Brazil and by Gonzalo Hernandez Oviedo, who described the words pinas in 'Hispaniola' around the year 1540. [21] The pineapple plant's long leaves offer fibres for fabric. These leaves that were once discarded have been used by the Philippines to make their national clothing, the 'Barong Tagalog' which often resembles silk in its texture and drape. The Barong Tagalog is the national formal shirt of the Philippines, made from pineapple (pina) or abaca, a banana species endemic to the Philippines. Pina is a fabric is carefully extracted from the leaves of the pineapple plant as soon as the pineapple is harvested. The process of extracting the fibres is called decortication. By repurposing the leaves, this reduces waste and supports the circular economy.

Pineapple and Soil

Pineapple's root system being dense, protects the soil from erosion, specially on slopes and on degraded lands. After the harvesting of all elements of the leaves and fruit, the mulch remaining is used as compost. This compost rejuvenates soils by adding macronutrients like potassium, calcium and magnesium and micronutrients like zinc, copper and manganese.
The compost residue can also increase beneficial soil bacteria and actinomycetes. [22]

4. Abacá (Musa textilis)

Also known as Manila hemp, is a species of banana, endemic to the Philippines. Indigenous people of the Philippines handloom this fabric into indigenous garments or abaca cloth, also known as medrinaque. The native abaca textiles have survived into the modern era among various indigenous ethnic people, namely the t'nalak of the T'boli people and the dagmav of the Bagobo people. Since the fibre is naturally stronger than hemp and salt-tolerant, this fabric is used in maritime shipping. [23]

Abaca and Soil

Abaca prevents soil erosion and needs healthy, well-drained soils to thrive. Agroecosystems are when two or more plants are planted next to each other, like Abaca and coconut, there is a nutrient exchange and the abaca leaves provide shade for the soil surrounding it thus preventing quick evaporation of moisture in the soils.

Fig: Workers processing Banana silk from Musa fabrics

The indigenous have preserved this fabric since centuries and this fabric is now a national pride of the Philippines, South America and Asia.

Fig: The indigenous people of Mobaim *(mob-People, Aim-Mother means People's Mother (Mother Nature) Indigenous name for Bombay) with their 9-yard lugra made from silk or cotton pod silk*

Fig: Tree located in Mobaim (indigenous name for Bombay)

5. Cotton Pod (Ceiba pentandra), Bombax ceiba

This tree was brought to Mobaim (indigenous name for Bombay) by the Portuguese from South America in the 1500s to 1700s. Since the Khapri (East Indian weavers of Mobaim) tribe are skilled in ancient weaving methods, this silk was introduced to these indigenous people, and the fabric from this cotton pod is superior to cotton and similar to silk, which was used by the indigenous. Silk was always traded in Mobaim (Indigenous name for Bombay) through the Silk Route that came towards Sopara, the Italian port in the 1st century, currently called Maharashtra. There was no state or nation of India back then. Just traders and small kingdoms are protected by the international trader community. [24]

The Cotton pod, which grows once a year, dries up and falls to the ground. This cotton pod is collected by the indigenous people of the 7 islands of Mobaim, and over time, the 9-yard Lugra (nav Vari Lugra) is woven with this cotton pod silk fabric. [25], [26]

(Photo Source: Wikipedia)

6. Vetiver zizanioides

Is another miracle plant that Mother Nature provides. Vetiver z. heals the soil and its long roots help stabilise soils on river embankments, slopes and lake boundaries. Vetiver z. removes heavy metals from the soil, and also being a high heat-tolerant plant, it can help reverse drought using holistic methods (not just plant and leave). Vetiver z. helps reverse drought as it traps rainfall and stores water deep within its root systems. Vetiver z. Plants on the border of the main cotton crop and other climate-stressed plants will help reduce stress and improve the survivability of the vulnerable plant. Vetiver z. helps provide livelihoods too, with its aromatic oils extracted from its roots. Vetiver z is a plant that is the most farmer-friendly. (The PhD thesis on Vetiver z. and drought reversal will be available soon at TDU - Bangalore)

Summary

Since the global fabrics market will touch 1 trillion USD in the year 2030, the stresses will continue to be felt by farmers who would want a slice of this pie. These stresses will translate to the degradation of land, leading to drought conditions in the long run, affecting the food security of India. [27] With the availability of so many fibres that have been used for millennia, why has this sector (industry) not yet organised itself? Why do weak regulations continue to harm the farmers and the soil?

Mother Nature (Mai Maati, Nisarga, Prakriti, Kudarat) offers solutions, provided people are willing to listen and follow.

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ADVANCING CIRCULAR ECONOMY IN TEXTILE WASTE MANAGEMENT:
INTEGRATED STRATEGIES FOR TECHNOLOGY, POLICY, AND MARKET TRANSFORMATION

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Abstract

The global textile industry generates substantial waste across production, pre-consumer, and post-consumer stages, contributing to greenhouse gas emissions, resource depletion, and pollution. Transitioning to a circular economy (CE) offers a pathway to mitigate these impacts by closing material loops, extending product lifespans, and promoting resource recovery. This study synthesises recent literature to examine waste streams, recycling technologies, and the barriers, drivers, and opportunities shaping CE adoption in textile waste management.

The analysis identifies persistent technological challenges such as mixed fibre compositions and limited composite recycling alongside economic constraints, policy gaps, and low consumer participation. At the same time, regulatory momentum, technological innovation, and emerging circular business models present opportunities for large-scale adoption. A five-pillar strategic framework is proposed, integrating technological scaling, policy alignment, market development, capacity building, and consumer engagement.

This integrated approach emphasises the need for harmonised Extended Producer Responsibility (EPR) schemes, guaranteed offtake agreements, decentralised sorting hubs, and targeted R&D in underserved waste streams like technical textiles and composites. Findings suggest that coordinated action among stakeholders, supported by financial incentives and behavioural change strategies, is essential for achieving a sustainable circular textile economy. The framework provides researchers, industry leaders, and policymakers with practical strategies to support the transition of textile waste management from a linear model to a more circular system.

Keywords
"Circular economy, Textile waste management, Recycling technologies, Sustainable textiles, Policy and governance"

1. Introduction

The global fashion and textile industry generates more than 100 million tonnes of waste each year, making it a significant contributor to environmental degradation. Much of this waste is either incinerated or disposed of in landfills, practices that accelerate pollution, deplete valuable resources, and release large volumes of greenhouse gases (Niinimäki et al., 2020; Papamichael et al., 2023). The rise of fast fashion has intensified these problems by promoting rapid product turnover and reducing the average lifespan of garments (Shamsuzzaman et al., 2025).

In response, the principles of the circular economy (CE) offer a restorative alternative. By prioritising practices such as resource recovery, recycling, remanufacturing, reuse, and repair, the CE seeks to maximise material utility while minimising waste (Kirchherr et al., 2017; Papamichael et al., 2023). The adoption of CE models not only reduces reliance on virgin resources but also mitigates environmental pressures and opens new economic opportunities (Geissdoerfer et al., 2017; Dissanayake & Sinha, 2015).
Nevertheless, the transition to circular textile systems faces persistent challenges.

Consumer behaviour, market volatility, fragmented policy frameworks, and technological limitations remain substantial barriers (Shirvanimoghaddam et al., 2020; Tura et al., 2019; Shamsuzzaman et al., 2025). Addressing these obstacles requires coordinated action among stakeholders, investment in advanced recycling technologies, and the establishment of robust governance mechanisms (Mahdi et al., 2021; European Commission, 2022).

Against this backdrop, the present study explores the opportunities, constraints, and enabling factors within the CE landscape, and proposes a strategic framework to accelerate circular textile waste management.

2. Literature Review

The application of circular economy (CE) principles in textiles focuses on systemic redesign, product longevity, and closed material loops (Kirchherr et al., 2017; Geissdoerfer et al., 2017). In practice, this translates into designing for recyclability, improving production efficiency, and advancing recovery strategies that retain material value (Dissanayake & Sinha, 2015; Papamichael et al., 2023).

Global textile waste continues to rise, driven by fast fashion and shortened garment lifespans. Fewer than 20% of discarded textiles are recycled, with most landfilled or incinerated, leading to microplastic release, toxic leachate, and greenhouse gas emissions (Niinimäki et al., 2020; Sandin & Peters, 2018; Papamichael et al., 2023).

Recycling technologies offer mixed progress. Mechanical methods are low-cost but limited by contamination and fibre weakening (Shirvanimoghaddam et al., 2020; Xie et al., 2021). Chemical recycling enables fibre-to-fibre recovery from blends but is capital-intensive and complex (Mahdi et al., 2021). Biological processes remain promising yet early-stage (Payne, 2015; Papamichael et al., 2023). Policy instruments such as Extended Producer Responsibility (EPR), eco-design standards, and bans on destroying unsold goods have advanced CE adoption in the EU (European Commission, 2022; Watson et al., 2020). However, weak standards and enforcement in many developing economies constrain impact (Tura et al., 2019; Shamsuzzaman et al., 2025).

Behavioural and market barriers further slow adoption. Consumers show low participation in take-back schemes due to price sensitivity, convenience, and awareness gaps (Niinimäki et al., 2020; Papamichael et al., 2023). On the supply side, volatile demand for recycled fibres and absence of offtake agreements discourage investment (Krauklis et al., 2021; Shamsuzzaman et al., 2025).

Despite extensive research on CE principles and recycling technologies, few studies integrate technological, policy, and behavioural perspectives. Moreover, technical textiles and composites remain underexplored despite their growing environmental relevance (Krauklis et al., 2021; Papamichael et al., 2023).

3. Methodology

This study adopts a systematic literature review (SLR) approach to synthesise existing research on textile waste management within the circular economy (CE) framework. The method ensures a comprehensive and transparent analysis by following a structured process for identification, selection, and synthesis of relevant sources (Shamsuzzaman et al., 2025; Papamichael et al., 2023).

3.1 Search strategy and selection criteria

Academic databases, including Scopus, Web of Science, and ScienceDirect, were searched using keywords such as "*textile waste management*", "*circular economy*", "*recycling technologies*", and "*sustainable textiles*".

Studies published between 2010 and 2025 were considered, with a focus on peer-reviewed journal articles, industry reports, and policy documents.

The inclusion criteria were:
1. Direct relevance to textile waste management in the context of CE.
2. Coverage of at least one thematic area, technological, policy, market, or behavioural aspects.
3. Availability of full text in English.

Exclusion criteria were:
1. Studies unrelated to textiles or CE.
2. Conference abstracts without full papers.
3. Non-English sources.

3.2 Data extraction, synthesis, and analytical framework

The selected studies were coded and thematically analysed to capture patterns in waste generation, recycling technologies, policy frameworks, market dynamics, and behavioural aspects. Manual coding ensured contextual accuracy, with data management tools used to maintain an audit trail (Shamsuzzaman et al., 2025; Papamichael et al., 2023). To complement this, a descriptive statistical overview mapped the distribution of research themes, geographic focus, and methodological approaches. This combined strategy highlighted critical gaps, especially in linking technological, policy, and behavioural dimensions of textile waste management (Shamsuzzaman et al., 2025).

4. Waste Streams and Their Environmental Impacts

Textile waste is generated throughout the value chain, from fibre production to end-of-life disposal, and can be categorised into production waste, pre-consumer waste, and post-consumer waste (Nyika and Dinka, 2022; Papamichael et al., 2023; Shamsuzzaman et al., 2025). Each waste stream presents distinct challenges for collection, treatment, and recycling, with associated environmental consequences.

4.1 Production waste

Production waste includes fibre sweepings, fabric offcuts, selvedges, trimmings, and defective parts generated during spinning, weaving, dyeing, finishing, cutting, and sewing operations (Nyika and Dinka, 2022; Kant, 2012). Wastewater sludge from dyeing and finishing processes often contains toxic dyes, heavy metals, and auxiliaries, which contribute to soil and water contamination if inadequately treated (Kant, 2012; Muthu, 2020).

4.2 Pre-consumer waste

Pre-consumer waste arises from unsold stock, quality control rejects, and style discontinuities before products reach consumers (Dissanayake and Sinha, 2015; Papamichael et al., 2023). Brand protection policies sometimes lead to incineration or shredding of unsold goods, while limited reverse logistics capabilities prevent reuse or recycling at scale (Watson et al., 2020; Shamsuzzaman et al., 2025).

4.3 Post-consumer waste

Post-consumer waste consists of garments and household textiles discarded after use. Globally, less than 20% of post-consumer textiles are collected for reuse or recycling, with the majority ending up in landfills or incinerators (Papamichael et al., 2023; Niinimäki et al., 2020). Landfilled natural fibres release methane as they decompose, while synthetic textiles contribute to microplastic pollution (Belzagui et al., 2019; Muthu, 2020).

4.4 Environmental impacts

- Water pollution: Dye sludge and process effluents containing heavy metals and organic compounds can contaminate surface and groundwater (Kant, 2012; Muthu, 2020).
- Greenhouse gas emissions: Incineration of synthetic textiles releases CO_2, nitrous oxide, and other harmful emissions (Papamichael et al., 2023; Belzagui et al., 2019).
- Resource depletion: Discarded textiles represent embedded water, energy, and raw materials that are permanently lost if unrecovered (Niinimäki et al., 2020; Shamsuzzaman et al., 2025).
- Land use pressure: Landfilling consumes valuable space and can cause soil contamination (Nyika and Dinka, 2022; Muthu, 2020).

Waste Stream	Sources	Common Materials	Environmental Impacts	Potential CE Interventions
Production	Fibre production, spinning, weaving, dyeing, finishing, cutting, sewing	Sludge, fabric offcuts, trimmings, packaging waste	Toxic leachate, microplastic pollution, GHG emissions	Mechanical/chemical recycling, eco-design, sludge treatment
Pre-consumer	QC rejects, unsold stock, discontinued styles	Finished garments, fabrics	Landfill waste, resource loss	Reverse logistics, reuse, recycling
Post-consumer	Household disposal, take-back schemes	Used clothing, home textiles	Methane emissions, air pollution, microplastics	Repair, resale, upcycling, fibre-to-fibre recycling

Table1 – Textile Waste Streams, Sources, and Environmental Impacts

5. Recycling Technologies in the CE Context

Recycling technologies for textiles can be categorised into mechanical, chemical, thermal, and emerging biological processes, with a growing focus on specialised methods for technical textiles and fibre-reinforced composites. Each pathway differs in feedstock compatibility, output quality, technological readiness, and environmental trade-offs (Papamichael et al., 2023; Shirvanimoghaddam et al., 2020; Shamsuzzaman et al., 2025).

5.1 Mechanical recycling

Mechanical recycling involves processes such as cutting, shredding, carding, and re-spinning, commonly applied to mono-material textiles and clean production waste (Wang, 2010; Pensupa et al., 2017). While cost-effective and well-established, it results in fibre shortening and quality loss, leading to downcycling into nonwoven products, insulation, or wiping cloths (Shirvanimoghaddam et al., 2020; Papamichael et al., 2023). A common strategy for increasing yarn strength is to blend recovered cotton with virgin polyester (Pensupa et al., 2017).

5.2 Chemical recycling

Depolymerisation for synthetic fibres, solvent-based separation for cellulosics, and hydrolysis/glycolysis procedures are examples of chemical recycling (Haule et al., 2016; Mahdi et al., 2021). These techniques can handle mixed materials and create virgin-equivalent fibres, but they come with significant operating and capital costs and need high feedstock purity (Papamichael et al., 2023; Shamsuzzaman et al., 2025). To lessen environmental effects, green chemistry techniques and efficient solvent recovery are crucial (Mahdi et al., 2021).

5.3 Thermal recycling and energy recovery

Thermal methods such as pyrolysis and gasification convert textiles into syngas, oils, and char, offering a solution for contaminated or complex material streams (Czajczyńska et al., 2017; Strähle and Philipsen, 2017). However, these processes do not maintain fibre loops and require robust emission control systems (Papamichael et al., 2023; Shamsuzzaman et al., 2025).

5.4 Biological recycling (emerging)

Biological methods use enzymatic or microbial processes to break down natural fibres such as cotton, viscose, wool, and silk under mild conditions (Payne, 2015; Papamichael et al., 2023). While potentially reducing energy and chemical requirements, current limitations include slow reaction rates and challenges in processing blended materials.

5.5 Technical textiles and fibre-reinforced composites

End-of-life management for composites (e.g., carbon or glass fibre reinforced polymers) remains underdeveloped, with current options focusing on mechanical size reduction or pyrolysis, often with loss of fibre quality (Krauklis et al., 2021; Chatziparaskeva et al., 2022). Solvolysis offers higher-quality fibre recovery but faces cost and solvent recovery challenges (Mativenga et al., 2017; Wondmagegnehu et al., 2021).

Route	Typical Inputs	Outputs	Advantages	Limitations	References
Mechanical	Mono-material cotton/polyester; production waste	Recycled yarn; nonwovens	Scalable, low CAPEX	Fibre damage, downcycling	Wang, 2010; Pensupa et al., 2017; Papamichael et al., 2023
Chemical – PET	PET textiles, PET blends	Monomers (DMT/MEG)	Virgin-like quality	High CAPEX, solvent needs	Mahdi et al., 2021; Haule et al., 2016
Chemical – Cellulosics	Cotton, viscose blends	Regenerated cellulose fibres	High quality, closed loop	Solvent recovery required	Haule et al., 2016; Papamichael et al., 2023
Thermal	Mixed/contaminated textiles	Syngas, oils, char	Handles complex waste	No fibre retention, emissions	Czajczyńska et al., 2017; Strähle and Philipsen, 2017
Biological	Cotton, viscose, wool, silk	Sugars/oligomers, regenerated fibres	Mild conditions	Slow rates, blend issues	Payne, 2015; Papamichael et al., 2023
Composites	CFRP, GFRP	Secondary fibres, fillers	Valorises high-value waste	Fibre quality loss	Krauklis et al., 2021; Chatziparaskeva et al., 2022; Wondmagegnehu et al., 2021

Table 2 – Textile Recycling Technologies in a Circular Economy

6. Barriers, Drivers, and Opportunities

Adoption of circular economy (CE) principles in textile waste management is influenced by interlinked technological, economic, policy, organisational, and behavioural factors. Evidence from recent studies highlights that while policy frameworks and technological advances are gaining traction, structural challenges continue to impede large-scale implementation (Papamichael et al., 2023; Shamsuzzaman et al., 2025).

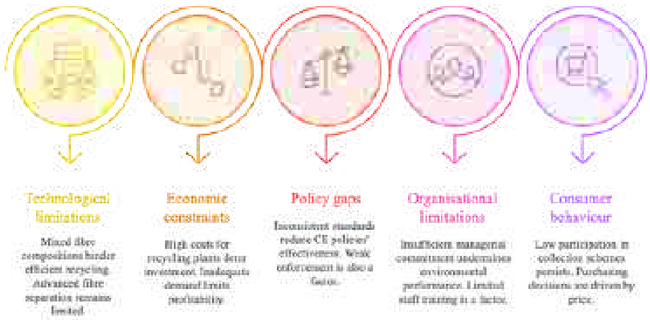

Image 1:- Barriers of Circular Textile Waste Management

6.1 BARRIERS

Technological and infrastructural limitations:

Mixed fibre compositions, elastane content, and chemical finishes hinder efficient recycling, reducing both yield and quality. Advanced fibre separation and automated sorting remain limited in many regions, particularly in developing economies (Shirvanimoghaddam et al., 2020; Mahdi et al., 2021; Shamsuzzaman et al., 2025). Biological recycling, while promising, faces challenges in reaction rates, blend selectivity, and industrial scalability (Payne, 2015; Papamichael et al., 2023).

Economic and market constraints:

High investment and operational costs for chemical recycling plants, coupled with volatile secondary material markets, deter investment. Inadequate demand for recycled fibres, especially in technical textiles and composites, further limits profitability (Mahdi et al., 2021; Krauklis et al., 2021; Shamsuzzaman et al., 2025).

Policy and governance gaps:

Inconsistent standards, weak enforcement, and a lack of harmonised Extended Producer Responsibility (EPR) schemes reduce the effectiveness of CE policies in emerging economies (Tura et al., 2019; European Commission, 2022; Shamsuzzaman et al., 2025).

Organisational capacity limitations.

Insufficient managerial commitment, limited staff training, and gaps in operational control, such as inadequate monitoring in effluent treatment plants, undermine environmental performance (Shamsuzzaman et al., 2025; Papamichael et al., 2023).

Consumer behaviour.

Low participation in collection and take-back schemes persists, with purchasing decisions still largely driven by price, convenience, and style over sustainability considerations (Niinimäki et al., 2020; Papamichael et al., 2023).

6.2 DRIVERS

- **Regulatory momentum:** The EU Strategy for Sustainable and Circular Textiles mandates eco-design requirements, digital product passports, and bans on the destruction of unsold goods, setting a global benchmark for policy design (European Commission, 2022; Watson et al., 2020). EPR pilots have shown potential to encourage design-for-recycling and improve collection rates (Tura et al., 2019).

- **Technological advancements:** Deployment of AI-enabled sorting, IoT-based waste tracking, and blockchain-enabled traceability has improved feedstock quality and supply chain transparency (Kumar et al., 2021; Xie et al., 2021). Chemical recycling technologies capable of handling blended textiles are becoming more viable with better pre-sorting and green chemistry processes (Mahdi et al., 2021; Papamichael et al., 2023).

- **Brand and market initiatives:** Circular business models, such as garment take-back, resale, and rental, are expanding globally. These models, when integrated with logistics partners, enhance collection volumes and build secondary markets (Papamichael et al., 2023; Shamsuzzaman et al., 2025).

- **Collaborative networks:** Partnerships between brands, recyclers, municipalities, and NGOs facilitate knowledge sharing, risk reduction, and faster technology adoption (Shamsuzzaman et al., 2025; Papamichael et al., 2023).

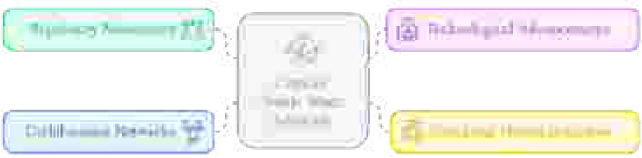

Image 2:- Key Drivers of Circular Textile Waste Adoption

- **Standardised metrics and transparency.** Adoption of unified KPIs, regular life cycle assessments, and third-party verification can increase consumer trust and comparability across markets (Papamichael et al., 2023; Tura et al., 2019).
- **Financing mechanisms.** Blended finance models and targeted public–private partnerships can de-risk investment in recycling technologies and infrastructure (Shamsuzzaman et al., 2025; Krauklis et al., 2021).
- **Under-addressed waste streams.** Technical textiles and composites represent a growing challenge; scaling solvolysis and improved pyrolysis could enable higher-quality secondary materials (Krauklis et al., 2021; Papamichael et al., 2023).
- **Health and environmental co-benefits.** Strengthening effluent treatment and chemical management reduces environmental pollution and improves worker and community health (Kant, 2012; Shamsuzzaman et al., 2025).

6.3 OPPORTUNITIES

- **Material and product innovation.** Mono-material textiles, recyclable blends, and design-for-disassembly can significantly improve recyclability and fibre recovery rates (Dissanayake and Sinha, 2015; Papamichael et al., 2023).
- **Decentralised processing hubs.** Local pre-sorting facilities reduce contamination and transport emissions, making recycling more economically viable (Nyika and Dinka, 2022; Shamsuzzaman et al., 2025).

Image 3:- Advancing Circular Textile Waste System

Barrier	Matching Driver	Opportunity	References
Mixed fibres and finishes limit yields	AI sorting + design-for-disassembly	Mono-materials, recyclable blends	Shirvanimoghaddam et al., 2020; Papamichael et al., 2023
High CAPEX and uncertain markets	EPR + blended finance	Public–private partnerships	Mahdi et al., 2021; Krauklis et al., 2021
Weak enforcement, fragmented standards	EU-style regulatory frameworks	Unified KPIs, third-party verification	European Commission, 2022; Tura et al., 2019
Limited organisational capacity	Training and collaborative networks	Upskilling and operational audits	Shamsuzzaman et al., 2025; Papamichael et al., 2023
Low consumer participation	Circular business models	Deposit-refund or loyalty incentives	Niinimäki et al., 2020; Papamichael et al., 2023
Lack of composite recycling options	R&D investment	Solvolysis and pyrolysis scaling	Krauklis et al., 2021; Papamichael et al., 2023

Table 3 – Barrier–Driver–Opportunity Matrix for Circular Textile Waste Management

7. Strategic Framework for Advancing Circular Textile Waste Management

A successful transition to circular textile waste management requires an integrated framework that aligns technology, policy, markets, skills, and consumer behaviour (Papamichael et al., 2023; Shamsuzzaman et al., 2025).

On the technological front, priority investments include AI-enabled sorting, chemical recycling for blended fabrics, and emerging biological processes. Specialised methods for technical textiles—such as solvolysis and pyrolysis—also need targeted R&D and pilot-scale support (Mahdi et al., 2021; Krauklis et al., 2021; Chatziparaskeva et al., 2022). Policy measures must work in tandem, with harmonised Extended Producer Responsibility (EPR), eco-design standards, and digital product passports helping to standardise requirements across markets. Effective governance will also require clear metrics, independent verification, and penalties for non-compliance (European Commission, 2022; Watson et al., 2020; Tura et al., 2019).

Market stability can be fostered through guaranteed offtake agreements, green public procurement, and financial incentives for recycled fibres. Blended finance models—combining public subsidies, concessional lending, and private capital—can further de-risk large infrastructure investments (Papamichael et al., 2023; Shamsuzzaman et al., 2025). Strengthening capacity is equally critical, particularly through training for plant operators, inspectors, and designers, alongside multi-stakeholder platforms that facilitate technology transfer and knowledge exchange.

Image 4:- Strategic Framework For Circular Textile Waste Management

Finally, behavioural change remains a cornerstone of CE adoption. Public campaigns, deposit-refund systems, and retailer-led take-back schemes can drive participation, while transparent labelling and third-party certifications build consumer trust and combat greenwashing (Niinimäki et al., 2020; Papamichael et al., 2023).

8. Discussion

The findings emphasise that transitioning to a circular textile waste management system requires systemic change rather than incremental adjustments. Current recycling technologies, while advancing, remain insufficient to address blended fibres, elastane-rich fabrics, and technical composites (Shirvanimoghaddam et al., 2020; Mahdi et al., 2021; Krauklis et al., 2021).

Technological solutions such as AI-based sorting, solvent recovery, and decentralised pre-sorting hubs can enhance recovery rates, but without aligned policies—including Extended Producer Responsibility (EPR), eco-design standards, and recycled content targets—economic viability is limited (European Commission, 2022; Watson et al., 2020). Similarly, financial barriers persist due to volatile secondary fibre markets and high capital costs, which could be mitigated through blended finance models and guaranteed offtake agreements (Mahdi et al., 2021; Shamsuzzaman et al., 2025).

Collaboration among brands, recyclers, NGOs, municipalities, and research institutions is vital to accelerate CE adoption, supported by capacity-building programmes for operators, inspectors, and designers (Papamichael et al., 2023; Shamsuzzaman et al., 2025). At the consumer level, low participation in take-back schemes highlights the need for economic incentives such as deposit-refund systems, loyalty rewards, and transparent labelling to build trust and counter greenwashing (Niinimäki et al., 2020; Tura et al., 2019).

Finally, unaddressed waste streams such as technical textiles and composites represent a frontier for innovation. Expanding solvolysis and pyrolysis, along with hybrid recycling technologies, could deliver significant sustainability benefits if coupled with coordinated R&D and supportive market incentives (Krauklis et al., 2021; Chatziparaskeva et al., 2022).

Conclusion

The transition to circular textile waste management is essential for reducing environmental impacts, conserving resources, and building sustainable value chains. This study reviews recent research to identify the main barriers, opportunities, and motivators, focusing on technological readiness, policy alignment, market mechanisms, and stakeholder engagement.

Emerging solutions such as chemical recycling of blends, biological recovery processes, and AI-enabled sorting hold promise for closing material loops. However, in the absence of standardised frameworks such as Extended Producer Responsibility (EPR) schemes and eco-design requirements, their impact remains constrained.

Market development through blended finance and offtake agreements can stabilise demand for recycled fibres while lowering investment risk.

At the same time, collaboration, capacity building, and consumer participation facilitated by deposit-refund schemes, transparent labelling, and third-party certification are critical to scaling adoption. Technical textiles and composites represent an underutilised waste stream and a frontier for innovation requiring targeted R&D investment.

Overall, a strategically integrated approach that combines innovation, coherent policy, market incentives, and behavioural change can accelerate the shift to a circular textile industry while creating new economic opportunities.

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INDIA'S STRUGGLE WITH WASTE: *A CRISIS OF SYSTEMS, PLASTIC, AND CIVIC SENSE*

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Walking through Indian cities today often leaves one with a heavy heart. Streets that should be vibrant public spaces are marred by scattered plastic, open garbage dumps, and stray animals chewing on polythene in search of food. The pungent mix of rotting matter and plastic has become a daily reality across urban and peri-urban landscapes. The earth suffers silently while society grows indifferent to the consequences of unchecked consumption.

This is not simply an environmental issue. It is a systemic, social, and civic crisis. Waste mismanagement in India reveals not only the fragility of infrastructure but also deeper challenges of inequality, governance, and public behaviour.

The Magnitude of the Problem

According to the Central Pollution Control Board (CPCB), India generates nearly 62 million tonnes of municipal solid waste each year. Of this, only about 70% is collected, and just 20–25% is processed. The rest finds its way to open dumps, rivers, or unscientific landfills.

The scale of neglect is staggering. The Ghazipur landfill in Delhi, often compared in height to the Qutub Minar, stands as a monument to systemic failure. Year after year, unmanaged waste piles higher, poisoning the air, soil, and groundwater.

Plastic remains the most stubborn part of the problem. India consumes over 14 million tonnes annually, much of it in the form of single-use plastics like bags, cutlery, and packaging that persist despite bans. Microplastics now infiltrate rivers, soil, and even human bodies. The issue extends beyond cities. Rural India, too, is witnessing rising volumes of plastic and non-biodegradable waste, driven by consumerism and e-commerce penetration. Lacking formal collection systems, villages often resort to burning plastic waste in the open, releasing toxic fumes directly into the atmosphere.

Waste and Social Justice

Waste is not only an environmental and economic concern; it is also a profound social justice issue. In almost every Indian city, it is the poorest and most marginalised communities who live closest to landfills or work with waste.

They breathe toxic air, drink water contaminated by leachate, and face chronic health risks. While wealthier citizens can retreat into gated communities with purifiers and bottled water, the poor are left to endure the daily hazards of society's negligence.

There is also a strong gender dimension. A large proportion of informal waste pickers are women, who begin work before dawn, combing dumps for recyclables. Their labour recovers up to 30% of materials that would otherwise end up in landfills, yet they remain invisible and underpaid. Most lack safety gear, healthcare, or social security. Many suffer respiratory illnesses, injuries, and chronic diseases from constant exposure to toxic materials.

Children, too, are pulled into this cycle, robbed of education and dignity. Waste picking in India is deeply tied to caste hierarchies—historically relegated to specific communities.

Though outlawed, these stigmas endure, embedding waste management within broader struggles of equity and human rights.

The inequality is stark. Those who generate the most waste—affluent households and commercial establishments—rarely suffer its consequences. Meanwhile, the poorest, who generate the least, bear the heaviest burden.

Globally, injustice deepens. Wealthier nations export large volumes of plastic and electronic waste to India under the guise of "recyclables." These shipments often end up in informal dumps, handled by vulnerable workers with no protection. The Global South thus absorbs the risks created by the Global North's overconsumption.

A just waste system must recognise and empower waste workers by providing fair wages, protective equipment, healthcare, and pathways to more dignified employment. Encouragingly, some Indian cities have begun integrating waste picker cooperatives into municipal systems. Such models both improve efficiency and restore dignity to an often-overlooked workforce.

From Minimal Waste to Waste Mountains

Ironically, India's waste crisis is a relatively recent phenomenon. For centuries, society functioned with minimal waste, sustained by traditions of reuse and recycling. Food was sold loose in markets, containers were refilled repeatedly, clothes were upcycled into quilts or rags, and scrap dealers (kabadiwalas) recycled broken goods. Most waste was organic and returned to the soil through composting or feeding animals.

The culture of "throwaway" consumption barely existed. What little waste was produced was easily absorbed back into natural cycles.

The past three decades, however, have seen rapid urbanisation, consumerism, and the flood of cheap plastics. The shift has been dramatic: from a low-waste society rooted in traditional wisdom to one overwhelmed by non-biodegradable waste.

When you stand at the edge of Delhi's Ghazipur landfill, the stench hits you before the sight does.

A mountain of garbage, taller than Qutub Minar, towers over the horizon, its slopes crawling with birds, stray dogs, and desperate humans.

Now shift your gaze to Indore. Here, garbage trucks move with precision, neighbourhoods stay clean, and not a single plastic bag floats in the wind. The contrast is so stark it almost feels like two different countries. Both are India—but one shows what neglect creates, the other what discipline can achieve.

Indore's transformation did not come easily. It began with something as simple—and as difficult—as making households segregate waste. Municipal officials knocked on doors, community leaders held street meetings, and fines were enforced. Today, Indore processes nearly all its waste, a feat unimaginable in most Indian cities. It proves a simple truth: the waste crisis is not a curse of fate, but a failure of will.

In Pune, the story is written not by officials but by women who once lived in the shadows. For decades, waste pickers worked barefoot in toxic dumps, sifting through filth for recyclables that earned them barely enough to survive. Their labour kept cities running, yet society saw them as untouchables. Then came SWaCH—a cooperative that gave them identity cards, contracts, and dignity. Now, these women knock proudly on doors, collecting segregated waste and charging user fees. One waste picker told researchers, "Earlier, people closed their doors on us. Now, they greet us with respect." Pune reminds us that waste management is not just about technology—it is about justice.

New Waste Streams: Modern Challenges

1. Plastic Waste – The Persistent Pollutant

Single-use plastics—bags, bottles, straws, packaging—dominate the waste stream. They clog drains, choke rivers, and take centuries to degrade. Along the way, they fragment into microplastics, which infiltrate food chains, harming animals and eventually humans. Open burning worsens the damage, releasing dioxins and furans, among the most toxic substances known.

2. Electronic Waste (E-Waste) – The Hidden Hazard

E-waste is the fastest-growing waste stream globally. Discarded electronics leach heavy metals like lead, mercury, and cadmium, contaminating soil and groundwater. Informal recycling often involves burning wires or acid leaching, practices that expose workers and communities to deadly toxins.

3. Organic Waste – The Methane Machine

Food and garden waste, if composted, could return nutrients to the soil. But when dumped in landfills, it decomposes anaerobically, producing methane—a greenhouse gas 84 times more potent than CO_2 in the short term. India's overflowing landfills are now among the nation's largest methane emitters.

4. Biomedical and Hazardous Waste – A Silent Menace

Hospitals and industries generate biomedical and chemical waste that can be lethal if mishandled. In India, biomedical waste is often mixed with municipal garbage, exposing sanitation workers and ragpickers to infection and toxic exposure.

5. Construction and Demolition Waste – The Bulky Polluter

Rapid urbanisation has created millions of tonnes of construction debris annually. While less toxic than plastics or e-waste, its sheer volume overwhelms cities, clogs drains, and fuels dust pollution.

Why Waste Management Fails:

The crisis is the result of multiple interconnected failures:

- **Lack of segregation at source** – More than 80% of households still mix wet and dry waste, undermining recycling.
- **Inadequate infrastructure** – Composting plants, material recovery facilities (MRFs), and waste-to-energy units are scarce.
- **Over-reliance on landfills** – Cities continue to dump waste in overflowing sites rather than treating it scientifically.
- **Weak enforcement** – The Solid Waste Management Rules (2016) mandate segregation, but penalties are rarely enforced.
- **Dependence on the informal sector** – Waste pickers save cities millions, yet work without protection, recognition, or support.
- **Civic apathy** – Waste remains an "out of sight, out of mind" problem for many citizens, seen as the municipality's sole responsibility.

Health, Environment, and Climate Costs

The true cost of waste is not just what municipalities spend on collection and disposal—it is what communities, ecosystems, and the planet silently pay every day. When unmanaged waste piles up in landfills, rivers, or streets, its impacts ripple through public health, environmental stability, and the climate system.

1. Health Costs – A Silent Epidemic

Waste is a breeding ground for mosquitoes, flies, and rats, spreading diseases such as dengue, malaria, and cholera. Burning waste releases fine particulate matter (PM2.5), which enters lungs and bloodstream, causing asthma, heart disease, and even premature death. Informal waste pickers—many of them women and children—work without gloves or masks, handling toxic waste daily. Studies show they face higher risks of tuberculosis, skin disorders, and respiratory illnesses. Communities living near dumpsites like Ghazipur (Delhi) and Deonar (Mumbai) report shorter life expectancies due to continuous exposure to toxic air and contaminated water.

2. Environmental Costs – The Earth Suffers Too

Plastics in soil reduce fertility, affecting farmers' crop yields. Leachate (the toxic liquid from landfills) seeps into groundwater, contaminating drinking water sources for thousands of families. Rivers and oceans choke with plastic, killing marine life, turtles, dolphins, and fish that mistake waste for food. Biodiversity loss accelerates when habitats are poisoned or blocked by human-generated waste.

3. Climate Costs – Waste as a Hidden Driver of Global Warming

Organic waste in landfills generates methane, a greenhouse gas far more potent than CO_2. India's landfills are now among the largest methane emitters in South Asia. Burning mixed waste emits black carbon, which settles on glaciers in the Himalayas, speeding their melting and altering monsoon patterns.

The energy wasted in producing goods that end up as garbage adds to global emissions. For example, every ton of recycled paper saves 17 trees and 7,000 gallons of water, reducing both emissions and resource stress. According to the World Bank, mismanaged waste contributes up to 10% of total global greenhouse gas emissions from the waste sector.

The Invisible Bill

When we add it all together, the bill for mismanaged waste is enormous. India spends billions annually on healthcare linked to pollution-related diseases. Cities lose money when tourism declines due to dirty surroundings. Flood damages rise when plastic clogs drains during monsoons. And yet, much of this cost remains invisible because it is paid by the poorest communities and by future generations who inherit a damaged environment.

Why This Matters

By viewing waste through the lens of health, environment, and climate costs, the urgency becomes clear. Waste is not merely a municipal problem; it is a public health crisis, an environmental emergency, and a climate threat rolled into one. Addressing it through segregation**,** recycling, composting, and reducing consumption is not charity—it is survival.

Innovation and Youth-Led Change

Amidst the crisis, innovation is emerging. Youth-led startups and organisations are pioneering creative solutions:

- **Phool** converts temple flowers into incense and compost.
- **Banyan Nation** uses AI-driven systems for plastic recycling.
- **TrashCon** develops automated segregation machines.

NGOs, student groups, and community campaigns are promoting zero-waste lifestyles, organising beach clean-ups, and building awareness. Many schools have begun teaching segregation as part of daily routines. This new generation represents India's greatest hope for shifting cultural attitudes towards sustainability.

Global Lessons for India

Other nations offer valuable models. While India struggles with mounting garbage and overflowing landfills, many countries have demonstrated that with political will, strict enforcement, and citizen participation, waste can be transformed from a burden into a valuable resource.

Sweden – Turning Waste into Power

Sweden is a global leader in waste-to-energy innovation. Less than 1% of its waste is sent to landfills. Instead, Sweden operates advanced waste-to-energy plants that incinerate trash under controlled conditions, generating electricity and district heating for millions of households.

Astonishingly, Sweden now imports waste from neighbouring countries to keep its plants running, because it does not produce enough waste domestically. The system is backed by strict laws that prohibit the landfilling of organic and recyclable waste. What India can learn is that with technology, even garbage can become a reliable source of clean energy, reducing both landfill pressure and fossil fuel dependence.

Germany – Extended Producer Responsibility (EPR)

Germany has one of the highest recycling rates in the world, thanks to its Extended Producer Responsibility (EPR) system. Under this framework, manufacturers are legally required to take responsibility for the packaging they put into the market.

This has forced companies to design eco-friendly packaging, invest in recycling infrastructure, and reduce unnecessary plastics. German households follow a colour-coded bin system with remarkable discipline, ensuring that recyclables are separated at source. The result is a recycling rate of over 65%, compared to India's current rate of less than 20%. The key lesson for India is accountability—producers must be part of the solution, not just consumers and municipalities.

Japan – The Discipline of Segregation

Japan treats waste management almost as a civic ritual. Citizens are expected to segregate waste into dozens of categories, including burnable, non-burnable, plastics, cans, bottles, and hazardous items. Each municipality has a detailed waste calendar, and violations are socially unacceptable. This cultural discipline ensures that recycling and composting systems function flawlessly. Beyond rules, there is also a mindset: waste belongs to the community, and every resident shares responsibility. For India, where segregation at source remains a challenge, Japan offers a powerful lesson in behavioural change and citizen participation.

South Korea – Pay-As-You-Throw System

South Korea has successfully tackled food waste—one of the most challenging categories to manage—with remarkable success. It introduced a "pay-as-you-throw" system where households are charged based on the amount of food waste they generate. This is measured using special biodegradable bags or smart bins with weighing sensors. The result has been a dramatic reduction in food waste, coupled with large-scale composting and biogas production. South Korea now recycles more than 95% of its food waste. For India, where food waste makes up over 40% of municipal solid waste, such economic incentives could be a game-changer.

The Common Thread

Across these diverse countries, one principle stands out: waste is not an afterthought; it is a resource managed with care, responsibility, and innovation. Whether through technology (Sweden), regulation (Germany), cultural discipline (Japan), or economic incentives (South Korea), success comes from a combination of policy, enforcement, and public participation.

Pathways Forward

For India, change must happen on multiple fronts simultaneously:

- **Strengthen Source Segregation** – Every household and institution must separate wet, dry, and hazardous waste. Non-compliance should carry clear penalties.
- **Empower the Informal Sector** – Recognize waste pickers through cooperatives and partnerships, providing safety gear, healthcare, and fair wages.
- **Invest in Infrastructure** – Expand composting plants, biogas units, MRFs, and waste-to-energy facilities. Use digital tools like AI, IoT, and blockchain for tracking and efficiency.
- **Enforce Extended Producer Responsibility (EPR)** – Hold producers of plastics, electronics, and hazardous waste accountable for recovery and recycling.
- **Civic Education** – Build responsibility through schools, campaigns, and media, framing waste as a shared duty, not just a municipal task.
- **Policy Reform** – Adopt stricter landfill bans, set zero-waste targets, and reward cities leading in sustainable practices. Provide tax incentives for recycling enterprises and circular economy businesses.

Toward a Circular Economy

Waste management cannot be solved in isolation. India must embed it within the broader framework of a circular economy, where materials are reused, repaired, recycled, and kept in circulation for as long as possible.

For India, this would mean:

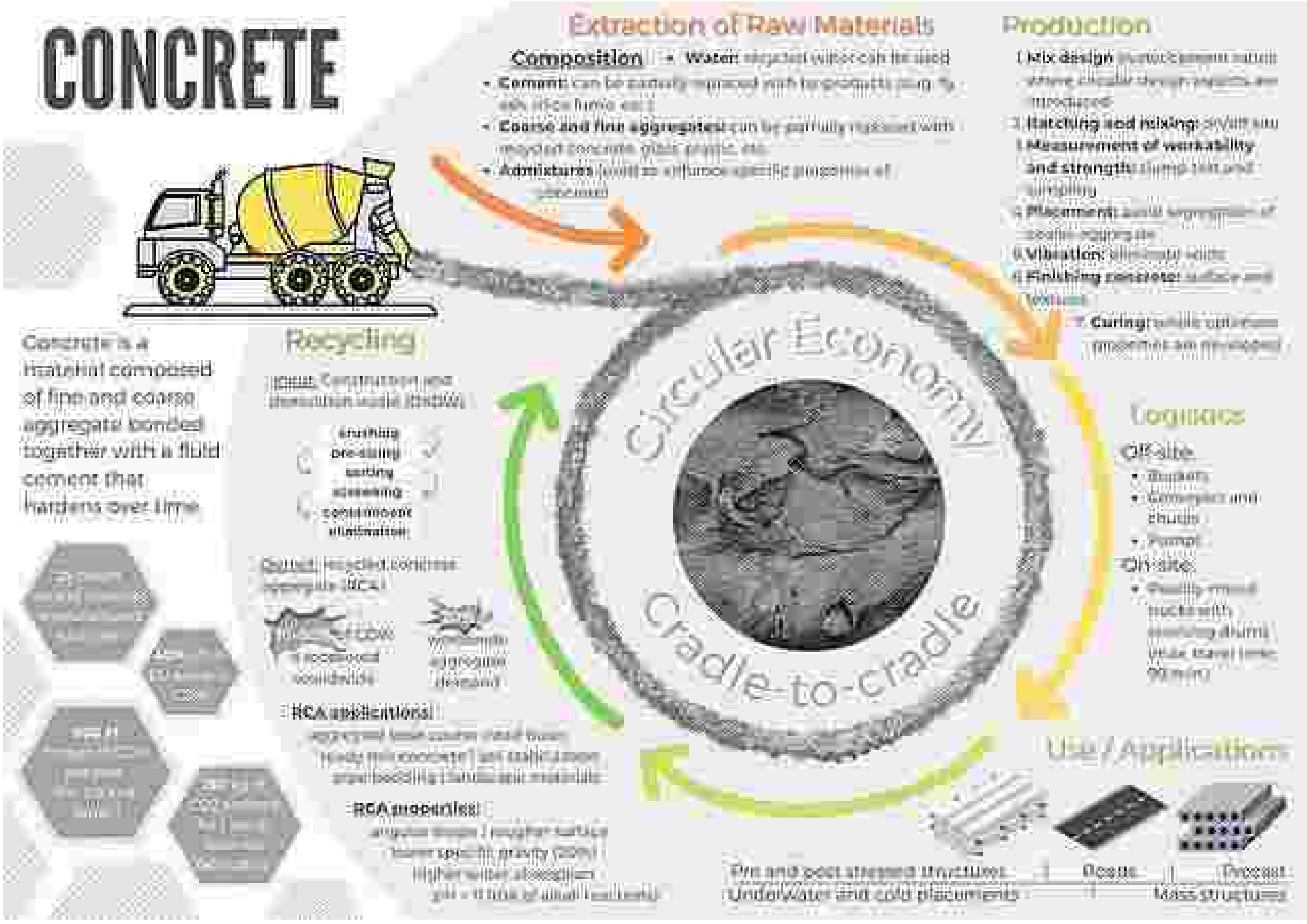
- Designing packaging and products with recovery in mind.
- Encouraging industries to adopt closed-loop production.
- Creating marketplaces for secondary raw materials.
- Supporting innovations like refill stations, compostable packaging, and zero-waste retail.

A circular economy transforms waste from a liability into an opportunity—generating jobs, spurring innovation, and advancing sustainability.

Conclusion

India's waste crisis is not just about sanitation. It is a test of governance, civic sense, and ecological wisdom. The mountains of garbage rising across cities symbolise both systemic failure and the urgent need for transformation.

The solutions are known: segregation, infrastructure, innovation, accountability, and a circular economy. What remains is the collective will of government, industry, and citizens to act. If India can integrate global lessons with local innovations, empower its waste workers, and nurture civic responsibility, it can turn from one of the largest waste generators into a leader in sustainable resource management.
The path forward is challenging, but essential—for the dignity of workers, the health of citizens, the survival of animals, and the future of the planet.



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STUDY ON FACTORS INFLUENCING CONSUMERS SUSTAINABLE FASHION CONSUMPTION AND DISPOSAL BEHAVIOUR

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Abstract

The increasing demand for textile-based goods in the apparel and non-apparel industries has led to pollution emissions from manufacturing and post-manufacturing processes, which have depleted natural resources and degraded the environment. As a result, the sustainability analysis now includes the pre-consumer and post-consumer activities of textiles and clothing. By implementing resource-saving techniques like recycling, reuse, and repair, the said issue can be addressed. Therefore, this study aims to examine the influence of the Attitude towards Slow Fashion (ASF) on Sustainable Disposable Behaviour (SDB) and Sustainable Fashion Consumption (SFC). Theory of Planned Behaviour (TPB) was extended by adding Environmental Awareness towards Sustainable Fashion (EASF) and Knowledge on Sustainable Fashion Practices (KSFP) as ASF predictors and Self-expressiveness (SE) as a predictor for SFC. Through the use of an online survey questionnaire, data were gathered at random from 272 customers across the State of Tamil Nadu, India. Partial Least Squares structural equation modelling has been used for carrying out the data analysis. According to the results, knowledge of sustainable fashion practices, environmental awareness of sustainable fashion, and sustainable fashion consumption are all mediated by attitudes towards slow fashion. Furthermore, this actual interaction leads to a favourable correlation with Sustainable Disposable Behaviour. According to research findings, customers favour eco-friendly apparel since they care about and are conscious of contemporary environmental problems. As a result, their perception of sustainable fashion is influenced by their understanding of sustainable fashion practices and environmental awareness, which leads to a growing desire to purchase more sustainable clothing and engage in sustainable disposable behaviour in an effort to lessen their impact on the environment. The findings of the study could benefit the policy makers to pave the way for improving the consumer to adopt suitable practices towards sustainable fashion.

Keywords

Environmental Awareness, Knowledge on Sustainable Practices, Sustainable Fashion Consumption, Slow Fashion, Sustainable Disposable Behaviour, Partial least squares structural equation modelling.

1. Introduction

The growing population and concepts like fast fashion, fresh look and trend in the lifestyle have resulted in tremendous clothing production and consumption in recent years [1]. The rise in new clothes sales has also led to a variety of clothing disposal techniques, including littering, reusing, recycling, and burning. The impact due to waste disposal by the clothing and other industries has created a significant environmental impact and has become an important concern for the ecological balance.

In developed countries, the disposed garments end up either in landfills or incinerators. In recent years, repurposing, recycling the used materials, and slow fashion are gaining momentum [2]. Nowadays, various solid management methods like landfilling, incineration, composting, etc, are practised by the different industries for improving the sustainable environment [3]. The landfilling method is easy, adjustable with a lower cost than the rest of disposal methods due to activities such as disposal, compression and embankment filling by waste at the specified sites [4,5].

But, the gas emissions, waste or dust blown by the wind from landfill sites have alarmed the government to create awareness on sustainability measures like recycling, circular economy, slow fashion, instant fashion, environmental conservation, etc, to the consumers [6]. Consumer awareness of the environment is influenced by sustainable practices in controlling land pollution, water pollution, air pollution, product development and disposal, etc. [3,7].

However, there is a lack of research in sustainable fashion consumption with regard to knowledge, attitude, personal interest and disposal. So the study is carried out to explore the process by which a consumer may adopt sustainable fashion consumption and disposal behaviour. In this context, the conceptual framework and definition of the construct for the proposed model, along with a structured questionnaire, are framed by using the findings of earlier research work. Afterwards, the collected data was analysed and the results and findings with limitations were discovered in this study. The result of this research will address the requirement for improving consumers' sustainable fashion consumption and sustainable clothing disposal behaviour.

2.Theoretical Framework and Hypothesis

According to theory of reasoned action (TRA), a person's attitude towards a behaviour and subjective norms determine their behavioural intention [8,9]. Behavioural intention assesses a person's relative ability to engage in a behaviour [10]. Beliefs on the repercussions of engaging in a behaviour include attitude. A person is more likely to exhibit good behavioural intention towards a behaviour if they have a positive attitude towards it [9,14]. A person's perceived expectations from pertinent individuals and their intention to live up to these expectations are considered to be the two main components of a subjective norm [8]. Therefore, it is believed that a person will be more inclined to engage in a behaviour if they feel that others want them to and are motivated to follow [15].

2.1. Attitude towards Slow Fashion and its impact on Sustainable Fashion Consumption

The clothing business has made environmental sustainability an important concern in recent years [9]. Globally, consumers are growing increasingly conscious of the environmental damage caused by their consumption patterns as well as the methods and locations used to make their clothing [10]. Only 15% of the 16 million tonnes of textile and clothing waste produced annually by Americans is recycled, according to the U.S. EPA [14]. The majority of trash from clothing and textiles ended up in landfills. As the environment continues to deteriorate, slow fashion has been identified as one of the most effective strategies to reduce trash production and resource usage [15].

The necessity of switching to slow fashion is also emphasised in order to curb excessive consumption and achieve sustainable growth. Slow fashion goods are becoming more and more popular as consumers become more conscious of environmental and social sustainability issues [15].

As a result, consumers now want to surpass rapid fashion methods. Slow fashion advocates advise people to acquire high-quality, long-lasting, sustainably manufactured goods rather than advising them to "don't buy" [17]. Therefore, the present hypothesis is proposed:

H1: There is a positive association between Attitude towards Slow Fashion and its impact on Sustainable Fashion Consumption

2.2. Knowledge on Sustainable Fashion Practices and their influence on Attitude towards Slow Fashion

The risks of using garments in an unsustainable manner go beyond the dangers of doing laundry [18]. Intensifying and extending the usage of clothing is one of the most effective ways to reduce the environmental impact [19].

Three key dimensions—wear, care, and repair—have been used to describe sustainable garment use practices. [21]. The concept of sustainable wear is based on the regular interaction between clothing users and the organisation of their wardrobes, which enables the discovery of various methods to wear underutilised garments [22]. Sustainable clothing practices emphasise a higher degree of awareness and thoughtful decision-making while actively maintaining and interacting with one's wardrobe [23].

Finally, the consumer can extend the lifespan of their wardrobe by having learnt the fundamentals of clothing repair [24]. Invisible or visible mending, whether done by oneself or an expert, to patch holes, replace buttons, or fix seams, is an example of sustainable repair practices [25]. As a result, sustainable wear, maintenance, and repair methods are viewed as key aspects that gauge sustainable use practices, leading to a reduction in the amount of clothing consumed. Therefore, the hypothesis is suggested as follows

H2: There is a positive association between Knowledge of Sustainable Fashion Practices and its influence on Attitude towards Slow Fashion

2.3. Sustainable Fashion Consumption and its relationship with Sustainable Disposable Behaviour

A behavioural response in any situation is influenced by various factors, such as a person's intention, past experience, and the inherent constraints of the context [26,27].

A person's behaviour depends on the situation. Human behaviour in social contexts such as emotional components, could be described by using the Theory of Interpersonal Behaviour (TIB). Furthermore, behavioural performance is strongly impacted by habit, supportive environments, and behavioural intention. Consequently, both cognitive and emotional factors have influenced the decision [28-31].

A habit turns into a routine when the routine activity gets more frequent and the consciousness level decreases [30-32]. The several stages of sustainable fashion production and consumption include textile production, apparel manufacture, distribution, after-sales service, and clothing disposal. In the apparel supply chain, the success of the transition to sustainable consumption is contingent upon responsible consumption and disposal after use.

Therefore, understanding how to properly dispose of clothing is crucial to eventually lowering landfill waste. Certain behaviours, like reusing, recycling, gifting to charities, selling used clothes at second-hand stores, or throwing them away, can change how people get rid of their clothes [33,34]. Thus, the hypothesis is proposed as follows-

H3: There is a positive association between Sustainable Fashion Consumption and its relationship with Sustainable Disposable Behaviour.

2.4. Environmental Awareness towards Sustainable Fashion and its Attitude towards Slow Fashion

Consumer perceptions of items that aim to protect the environment are positively impacted by environmental concern [35-37]. Consequently, it must be examined in light of pro-environmental concerns [38–40]. The relationship between environmental knowledge and attitude is mediated by environmental concern [41-43].

Generally, environmental concern is related to views on a variety of ecological issues [44]. This characteristic has grown in significance for academics and professionals throughout time. Because environmental concern is measured by various factors, which include a broad set of environmental ideas and attitudes [45]. The study has shown that people who are more concerned about the environment are more likely to take action to protect it by consuming more sustainable products. This suggests that this variable can have a significant impact on consumer behaviour [45-46].

However, this guarantees that environmental concern has a direct effect on the repercussions faced for the actions during the specific events [47]. Furthermore, it is noted that extremely high scores have been obtained when assessing attitudes that support the environment. These findings suggest that the environmental concern variable gains weight when other factors, such as finances and health, are taken into account. According to the findings of the earlier study, the purchase of sustainable fashion items is steadily increasing among consumers towards sustainability. As a result, understanding the consumer perspective regarding sustainability in fashion products is essential for meeting domestic and international market competitiveness [48].the

Hence, the hypothesis is proposed below regarding environmental concerns and consumer attitudes.

H4: There is a positive association between Environmental Awareness towards Sustainable Fashion and its Attitude towards Slow Fashion.

2.5. Self-Expressiveness and Sustainable Fashion Consumption

Self-expressiveness refers to a person's belief that they can wear and purchase sustainable apparel as a means of expressing who they are [49]. It is especially significant in the fashion industry and is associated with the desire to show one's own attitude in order to attract attention and receive approval from others. Consequently, the potential to be seen as an environmentally conscientious individual may be enhanced by using sustainable materials [50]. An individual's compassionate behaviour originates from an internal structure of principles and a moral imperative [51].

Thus, personal rules and moral obligations may be closely related. Those with lower personal norms may resist pro-environmental behaviour and vice versa. Growing awareness about environmental degradation in the fashion business has resulted in the customers' personal values moving from being self-centred to more society-centred [52].

It has been found from the earlier research findings that there is a positive correlation between personal apparel consumption and personal norms [53]. Hence, the hypothesis is proposed as follows.

H5 : There is a positive association between Self-Expressiveness and Sustainable Fashion Consumption

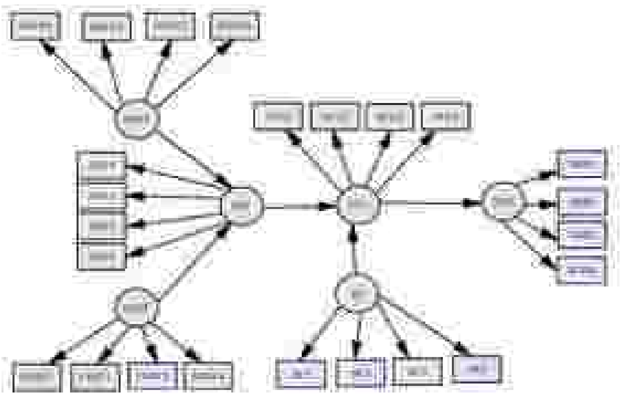

Figure 1. Proposed Theoretical model and Knowledge on Sustainable Fashion Practices (KSFP)

Environmental Awareness towards Sustainable Fashion (EASF), Attitude towards Slow Fashion (ASF), Sustainable Fashion Consumption (SFC), Self-Expressiveness (SE), Sustainable Disposable Behaviour (SDB).

3. Methodology

3.1 Research Design and Sample Collection

This study is carried out in the context of consumers' sustainability fashion behaviour from consumers randomly in different parts of the State of Tamil Nadu, India, through online. Quantitative non-experimental research has been used without changing independent variables. Online questionnaires have been used to collect data from consumers.

The questionnaire has been developed based on the literature review and validated through experts from the respective domain. The questionnaire comprises a few demographic information and 24 items associated with the six factors namely, Sustainable Fashion Consumption, Environmental Awareness towards Sustainable Fashion, Attitude towards Slow Fashion, Knowledge on Sustainable Fashion Practices, Sustainable Disposal Behaviour, Self-Expressiveness.

In order to prevent non-response bias, the online questionnaire first explained the study's purpose before stating: "Your participation requires about ten minutes." Your involvement is anonymous and entirely voluntary. As a result, the data collected is private and will only be utilised for study. In order to guarantee the ethical element of the research, two questions were then developed, each with a yes or no response: "I understand that my participation is by choice," and "I understand the objectives of this research." Participants who answered "yes" to the two questions were taken into consideration for the study.

A component of the survey sought for sociodemographic data, including age, gender, marital status, education, and residential area. Five point Likert scale (1 = Strongly disagree, 2 = Disagree, 3= Neutral, 4 = Agree, 5= Strongly agree) is employed for all the statements in the questionnaire. So that, highest scores revealed a more positive response for all of the items.

3.2 Sample :

A non-probability sampling technique was used to get the data because the researchers chose the respondents based on their judgement. As a minimum, responses were required to examine the relation between the variables presented, taking into account a 95% confidence range, 5% margin of error, and population percentage of 0.8. Nonetheless, 272 legitimate responses from State of Tamil Nadu, Indian customers participated the survey. The survey link has been distributed by email and social media and followed the snowball technique further.

3.3 Data Analysis :

The responses had been cleaned and encoded using Microsoft Excel because this is a quantitative study. The link between the constructs was then measured by analysing the data using the SmartPLS tool. PLS-SEM, or variance-based SEM, was employed because it is an exploratory analysis. In the present work, PLS-SEM was employed for samples that do not have a normal distribution and necessitate a non-parametric analysis.

Further, the model's performance is illustrated by using PLS-SEM, which provides the R2 values and highlights the significance of relationships between the variables. Moreover, PLS-SEM may manage numerous independent variables concurrently [54]. Cronbach's alpha reliability coefficient, construct and discriminant validity, and internal consistency through composite reliability have been used to assess the subscales' internal consistency [55]. The loads of each indicator were measured to assess its reliability. The model's fit was examined by using the average extracted variance. Additionally, the discriminant validity was calculated by using the Fornell–Larcker criterion [56,57].

4. Results

The demographic information of the consumers is presented in Table 1. Of these 272 consumers,

Most of the respondents (51.1%) are in the age category of 21 to 30 years, and a small number of respondents (4.4%) are in the age category of 41 to 50. The other age group categories, 31 to 40 years and above 50 years, are 27.2 % and 17.3 %, respectively.

In the gender category, the maximum respondents are female (65.44%) and the rest are male (34.43%). On the marital status, 43.38% of respondents are married, and 56.62% are unmarried.

Based on the educational qualification, the maximum respondents (56.25%) have an undergraduate education, and a small number of respondents (18.38%) have a graduate education.

It is also revealed based on the residential area that the respondents of Rural, Town and Urban areas are 8.8%, 36.4% and 54.8%, respectively.

Demographic Variable	Classification	No. of respondents	Percentage
Age	21–30	139	51.1%
	31-40	74	27.2%
	41-50	12	4.4%
	Above 50	47	17.3 %
Gender	Male	94	34.43%
	Female	178	65.44%
Marital Status	Married	118	43.38 %
	Unmarried	154	56.62%
Education	Higher Secondary	69	25.37 %
	Undergraduate	153	56.25 %
	Postgraduate	50	18.38 %
Residential area	Rural	24	8.8%
	Town	99	36.4%
	Urban	149	54.8%

Table 1: Demographic Analysis

4.1. Measurement Model Assessment

The PL-SEM was used with 300 iterations in order to assess the correlative relationship between each item and construct with regard to factor loadings [54]. It has been observed that, except for the items ASF2 and SDB4, others have the factor loading value more than 0.7, which is considered satisfactory. The items, construct and factor loading are mentioned in the Table

It has been observed from the common method bias analysis that the model was free of common method bias, as variance inflation factors were less than 3.3. As the Cronbach's alpha value is more than 0.6, internal consistency is good [58]. Convergent validity is satisfactory as the AVE is more than 0.5, as mentioned in Table 3.

Construct	Item	Description	Factor Loading
Knowledge on Sustainable Fashion Practices (KSFP)	KSFP 1	I wear my clothing items multiple ways to increase their use	0.863
	KSFP 2	I organize my wardrobe regularly to find ideas about how to mix and match my clothes	0.855
	KSFP 3	I utilize many items in my wardrobe	0.797
	KSFP 4	I re-sew buttons, patch holes, or make other repairs to damaged garments	0.845
Environmental Awareness towards Sustainable Fashion (EASF)	EASF 1	I do not mind giving up certain fashion design elements for environmental protection purposes.	0.798
	EASF 2	I only buy fashion garments from companies that are ethically or sustainably certified	0.787
	EASF 3	I only buy garments from companies that protect the environment	0.845
	EASF 4	I am concerned about the long-term environmental consequences of unsustainable behavior	0.889
Attitude towards Slow Fashion (ASF)	ASF1	I buy apparel from stores that promote slow fashion garments	0.859
	ASF2	I have a favorable attitude towards clothes for using long time periods	0.691
	ASF3	I purchase sustainable clothes even if they are more expensive than conventional clothes	0.742
	ASF4	I like to buy slow fashion clothes instead of conventional clothes to contribute to environmental protection	0.79
Self Expressiveness (SE)	SE1	I prefer to buy a product which can represent me	0.916
	SE2	I typically wear clothing that fits my personal style for a long time.	0.905
	SE3	The products of this brand help me to express myself	0.868
	SE4	A main benefit of the products of this brand is the ability for customers to express their own beliefs, values, or personalities	0.865
Sustainable Fashion Consumption (SFC)	SFC1	People should consider resource conservation when they buy clothes.	0.853
	SFC2	I will not buy products that have excessive packaging	0.806
	SFC3	If I understand the potential damage to the environment that some products can cause I do not purchase them	0.862
	SFC4	If there is no difference in style between the two garments, I will choose the one with the eco-tag	0.827
Sustainable Disposal Behaviour (SDB)	SDB1	I give away unwanted clothing to family/friends.	0.819
	SDB2	I swap clothing with family members and friends	0.799
	SDB3	I sell old clothing for environmental reasons	0.783
	SDB4	I give used clothing to charity or needy people	0.681

Table 3. Internal Consistency, Reliability and Convergent Validity

Latent Variable	Items	Mean (SD)	Cronbach's Alfa	Construct Reliability	Average Variance Extracted
KSFP	4	3.901(0.821)	0.727	0.813	0.623
EASF	4	3.592(0.693)	0.816	0.856	0.678
ASF	4	3.975(0.917)	0.713	0.805	0.514
SE	4	3.291(0.864)	0.855	0.925	0.742
SFC	4	3.467(0.892)	0.843	0.896	0.692
SDB	4	3.286(0.983)	0.859	0.931	0.824

Discriminant validity has been checked and analysed by using Fornell-Larcker criteria and Heterotrait-Monotrait (HTMT) ratio. It is noted from Table.4 that shared variants are not significant than their respective AVE's.

Latent Variable	KSFP	EASF	ASF	SE	SFC	SDB
KSFP	0.793					
EASF	0.378	0.813				
ASF	0.492	0.364	0.715			
SE	0.662	0.478	0.616	0.854		
SFC	0.486	0.582	0.462	0.468	0.832	
SDB	0.348	0.294	0.415	0.326	0.382	0.894

Table 4. Discriminant Validity

The Discriminant validity of the items is assessed by using the heterotrait-monotrait ratio of correlation approach due to its higher specificity and sensitivity rates in comparison to cross-loading criterion and Fornell–Larcker criterion [53,54], where all values were less than 0.9 (Table 5).

atent ariable	KSFP	EASF	ASF	SE	SFC	SDB
SFP						
ASF	0.648					
SF	0.552	0.492				
E	0.762	0.478	0.386			
FC	0.816	0.892	0.812	0.468		
DB	0.448	0.512	0.515	0.398	0.522	

Table 5. HTMT ratio

The global model fitting criterion is the Standardized Root Mean Squared Residual (SRMR), and the SRMR value for an adequate fit is less than 0.08. The values of the saturated model and estimated model for d-ULS and d_G should be close for a good fit of the model. An NFI close to 1 means a good fit (Table 6).

	Saturated Model	Estimated Model
SRMR	0.071	0.094
d_ULS	1.624	2.82
d_G	0.365	0.404
Chi-Square	864.442	903.072
NFI	0.684	0.752

Table 6. Goodness of fit

4.2 Structural Model Assessment

Regarding the formative evaluation of the model, the variance inflation factor (VIF) is analyzed. Values range from 1.204 to 2.830, demonstrating collinearity issues since these last values are below three [51]. The last step relates to statistical significance and relevance using Bootstrapping with 5000 iterations. As shown in Table 7, all the relations were significant (p-values < 0.05).

	Hypothesis	Original Sample	Mean Sample	Standard Deviation	T-Statistics	p-Value	Test
1	ASF → SFC	0.546	0.548	0.042	15.604	0	Support
2	KSFP → ASF	0.234	0.255	0.062	2.62	0.018	Support
3	SFC → SDB	0.706	0.709	0.038	16.485	0	Support
4	EASF → ASF	0.508	0.509	0.054	7.135	0	Support
5	SE → SFC	0.085	0.097	0.042	2.63	0.014	Support

Table 7. Hypothesis Testing

Table 8 shows the total effects of each relationship, which are the sum of the direct effect and specific indirect effects. As we can see, all of them remained significant and thus supported. For instance, Environmental Concern and Perceived Environmental Knowledge affect attitude. Moreover, this last variable influences Purchase Intention.

Scale	Original Sample	Mean Sample	Standard Deviation	T- Statistics	p- Value
ASF → SDB	0.389	0.391	0.05	9.563	0
ASF → SFC	0.632	0.634	0.045	15.604	0
KSFP → ASF	0.158	0.159	0.066	2.53	0.017
KSFP → SDB	0.064	0.065	0.027	2.374	0.024
KSFP → SFC	0.098	0.099	0.042	2.346	0.02
SFC → SDB	0.612	0.614	0.038	16.384	0
EASF → ASF	0.411	0.412	0.059	7.124	0
EASF → SDB	0.158	0.159	0.032	5.125	0
EASF → SFC	0.259	0.262	0.042	6.240	0
SE → SFC	0.062	0.064	0.025	2.534	0.016
SE → SDB	0.098	0.099	0.039	2.63	0.014

Table 8. Total Effects

Table 9 shows specific indirect effects related to mediation. All of them are significant. For instance, we corroborate that Attitude towards Slow Fashion acts as a mediator between Environmental Awareness towards Sustainable Fashion, Knowledge on Sustainable Fashion Practices, and Sustainable Fashion Consumption.

Furthermore, adding Sustainable disposal behaviour in this relation is also valid, demonstrating that Sustainable Fashion Consumption influences behavior, corroborating the Theory of Reasoned Action.

Scale	Original Sample	Mean Sample	Standard Deviation	T-Statistics	p-Value
EASF → ASF→SFC→SDB	0.169	0.162	0.034	5.563	0
KSFP →ASF→ SFC	0.098	0.099	0.042	2.604	0.02
EASF→ASF→ SFC	0.258	0.259	0.042	6.153	0
ASF →SFC→ SDB	0.384	0.394	0.04	9.374	0
KSFP → ASF →SFC→ SDB	0.068	0.069	0.026	2.346	0.024
SE →SFC→ SDB	0.062	0.064	0.028	2.384	0.016

Table 9. Specific Indirect Effects.

Figure 2 shows the model tested, indicating the relation between the variables and showing that the model explains 36.7% of the dependent variable Sustainable Fashion Consumption.

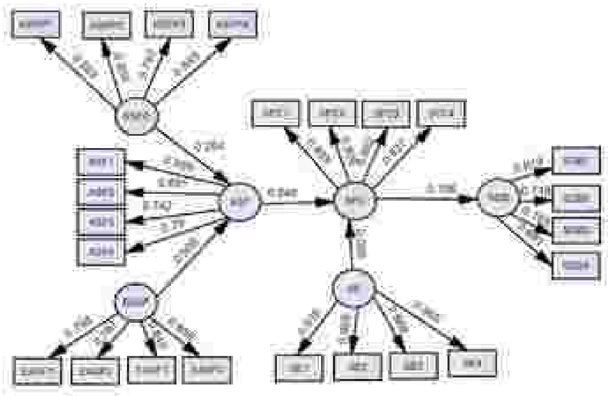

Figure 2. Tested Research model, and Knowledge on Sustainable Fashion Practices (KSFP), Environmental Awareness towards Sustainable Fashion (EASF), Attitude towards Slow Fashion (ASF), Sustainable Fashion Consumption (SFC), Self-Expressiveness (SE), Sustainable Disposable Behaviour (SDB).

5. Discussion

The current study evaluated the effect of Environmental Awareness towards Sustainable Fashion (EASF) and Knowledge on Sustainable Fashion Practices (KSFP) on Attitude towards Slow Fashion (ASF), as well as the effect of ASF and Self-Expressiveness (SE) on Sustainable Fashion Consumption (SFC), and finally the effect of SFC on Sustainable Disposal Behaviour (SDB).

The outcomes showed that consumers the relationship between the study variables was significant (p-value < 0.05). The reported relationships allow us to recognize that a greater attitude towards environmental care can be achieved if EASF is increased as has been reported previously [59].

Likewise, it has been reported that an increase in KSFP has a positive effect on the ATT [56]. The effect of ASF on Sustainable Fashion Consumption (SFC)coincides with previous reports, as well as the effect of Self-Expressiveness (SE) on Sustainable Fashion Consumption (SFC [60].

Following the Theory of Reasoned Action, the results corroborated the effect of Sustainable Fashion Consumption on Sustainable Disposal Behaviour (SDB) as previously reported [61]. Focusing on the mediating role of attitude towards sustainable fashion reflects how consumers evaluate the actual Environmental Awareness towards Sustainable Fashion, and Knowledge on Sustainable Fashion Practices [62]. Moreover, some researchers found that the specific indirect effect between Environmental Awareness towards Sustainable Fashion and Sustainable Fashion Consumption through Attitude towards Slow Fashion was higher than a simple direct relationship [63].

This is due to the current influence of Environmental Awareness towards Sustainable Fashion on Attitude towards Slow Fashion. It has been reported that if consumers are aware of the impact of conventional products, they will more likely turn to an eco-friendly consumption pattern and enhance their attitude towards sustainable products [64]. The specific indirect effects allowed us to show that the attitude and the Sustainable Fashion Consumption had a mediating effect in the model. This verification is of practical use because it can help companies to know the different variables that could influence, in a cascade, the consumption and disposal behaviour of sustainable fashion.

6. Conclusion :

The model for Consumer's Fashion Sustainability behaviour is developed through the Structural Equation Modelling approach, which provides a guideline for improving sustainable consumption and disposal for fashion clothing. The continuous degradation of the environment by clothing increases the environmental awareness towards sustainable fashion and their genuine concerns regarding the impact of human behaviours on the earth.

This study provides important information regarding the actual predictors of sustainable clothing consumption. Furthermore, we extended the TRA by adding environmental antecedents currently considered relevant. The study findings would be helpful for policymakers, textile and garment manufacturers, and retailers to develop strategies for improving the consumer's awareness and knowledge towards sustainable fashion.

6.1. Theoretical Implications

The contribution of this research to the academic literature is in the application of theories previously demonstrated in other situations and contexts [65]. Indeed, the extension of the TRA by adding predictors such as environmental concern and perceived environmental knowledge showed how consumers care about their environmental impact, resulting in the adoption of sustainable consumption behaviours [66,67].

Consumers with a high degree of environmental concern are more willing to act and reduce their environmental impact. Consequently, they tend to buy and consume green products, corroborating what other researchers have stated [68]. This last variable can be complemented with perceived environmental knowledge, in which the high degree of awareness of current ecological issues and the impact of human actions on the ecosystem is reflected in the adoption of sustainable consumption [69].

As stated earlier, green purchase behaviour is related to the actual consumption of products with a minimum impact on the ecosystem[70]. Indeed, Environmental Awareness towards Sustainable Fashion through Attitude towards Slow Fashion affects consumption behaviour [71]. Moreover, knowledge on environmental sustainable fashion practices, self-expressiveness, and sustainable consumption influence sustainable disposable behaviour [72]. Nonetheless, the small beta coefficient between self-expressiveness and sustainable fashion consumption validates the previous literature [73].

6.2.Practical Implications

The research findings suggest that customers prefer eco-friendly apparel due to their heightened environmental awareness and knowledge of sustainable fashion practices.

As a result, their attitude towards slow fashion leads to a greater desire for sustainable fashion consumption and disposal behaviour. By creating eco-friendly, multipurpose clothing, brands may leverage these findings to create a sustainable strategy. Hence, transparency regarding the actual production process is crucial, as consumers are searching for and confirming sustainable clothing.

The findings indicated that the textile and garment manufacturing sector should support environmental campaigns and develop value propositions that integrate environmental qualities, as consumers' attitudes have been found to have the strongest correlation with the consumption of sustainable fashion.

Retailers should create efficient marketing efforts for sustainable fashion because this generation is increasingly purchasing sustainable clothing [68]. The purpose of this is to make sure that customers are aware of the options that are now available on the market and how industries are constantly coming up with new ways to reduce their water consumption and carbon footprint. Customers who care about the environment are aware of ways to protect it and, consequently, begin to purchase sustainable clothing [69].

6.3. Limitations and Future Research

One of the main limitations of this study is the collection of data through online throughout the State of Tamil Nadu, India, while it might be subsequently broadened to include more states, regions, and nations and also face-to-face surveys. As a result, the issue can be effectively addressed, and the field of study can be opened for further investigation. As a result, other researchers may find its application to be limited. In order to test a more comprehensive model, future research may include more variables. Retailers' social responsibility and social influence could be included in the model to assess how sustainable fashion consumption and disposal practices are affected.

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BEYOND TRADITIONAL URBANISM: *ADOPTING A CIRCULAR ECONOMY FOR SUSTAINABLE AND INCLUSIVE CITIES IN INDIA*

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1. Introduction

Today, India is at a decisive moment in its urban development. Cities are not just the engines of economic growth, innovation and cultural transition, but also centres of climate resilience, resource management and social inclusion. According to the World Bank report, the urban population of India was about 480 million in 2020, which would almost double to 951 million by 2050. Due to this rapid urbanisation, India would be at the forefront of the world (worldbank.org).

This expansion will enhance improved service priority, economic opportunities and connectivity potential; however, it will also intensify serious challenges such as degradation of air quality, reduction in groundwater stock, and degradation of ecosystems due to unplanned urban expansion. The pressure on land, energy and infrastructure in metros like Delhi and Mumbai is pushing urban life to volatility.

Moreover, the effects of urbanization are not limited to metropolitan cities. Small and medium-sized cities are also rapidly transforming. However, given their limited resource potential, institutional capacity, and financial possibilities, without sustainable planning, these cities are also in danger of repeating the mistakes of metropolitan cities. This underlines the need for a systematic and long-term approach at all levels.

In this context, the concept of circular cities is becoming of special importance internationally. As opposed to the conventional 'tech-make-disposal' model, the circular approach is based on close-loop systems where emphasis is laid on recycling, reuse and reproduction of resources. According to the UNECE guideline, such urban systems need to evolve within the framework of material flow analysis, recycling management, local participation, and strategic coordination (unece.org). In the Indian context, the promise of this approach is particularly impressive. The outlook is particularly optimistic for India, with the IBEF reporting that its waste management indicators were better on the poverty line by 2021 than the 2014 baseline, and with the potential for the circular economy to generate US$624 billion in revenue by 2050 (ibef.org).

In line with this, it is important to highlight that today, globally, we have diverse approaches such as the Sustainable Development Goals (SDGs), Circular Economy (CE), as well as ESG (Environmental, Social, Governance) frameworks. With the help of these tools, developing countries can outline national, regional and urban development and can achieve more sustainable development than developed countries by taking appropriate policy decisions. But unfortunately, most of the developing nations are still running behind rapid and Unilateral development. In such a scenario, adoption of circular economy at the right time and with rigour can set the tone for all-round sustainable development.

However, sustainable transition cannot be achieved by relying solely on policy frameworks and technological interventions. The day-to-day behaviour of urban citizens - consumption patterns, transport choices, waste management, and resource use - is a determinant of change. Research shows that without large-scale behaviour change, approaches to circular urban systems can only be limited to conceptual or policy documents (UN-Habitat, 2020; OECD, 2022). Therefore, the vision of circular cities is difficult to materialise without the active involvement of socio-cultural factors and citizen participation.

This article, therefore, explores India's urban future through three interconnected dimensions:

1. The scale and nature of its rapid urbanisation,
2. The emergence and potential of circular cities, and
3. Emphasising why behavioural changes are necessary in citizens to realise the specific challenges faced by both metropolitan centres and small cities.

Weaving these threads together, the discussion highlights not only the urgency to rethink India's urban pathways but also the opportunities to shape cities that are more livable, inclusive, and environmentally responsible.

1.1 Dual Dimensions of urban transition of India

India's urbanisation journey is not just rapid, but a structural socio-economic transition. It is estimated that about 30 persons per minute migrate to urban areas in search of employment, education and a higher standard of living. While the urban population was 31 per cent in 2011, it is projected to reach more than 43 per cent by 2035, reaching up to 675 million (The Economic Times, 2022). The extent of the transition is evident from the fact that it was only 17 per cent at the time of independence.

Urbanisation has contributed more than two-thirds of India's GDP, according to World Bank and PwC reports (World Bank, 2025). However, with this growth, cities are becoming symbols of inequality, environmental stress and inadequate infrastructure.

. Traffic jams, air pollution, frequent flooding caused by precipitation, and the disorganisation of public services have become features of urban life. Unplanned expansion is a degradation of agricultural land and ecosystems, exacerbating water scarcity and the urban heat island effect (TIME, 2024).

Therefore, urbanisation in India is a multi-faceted socio-economic and environmental challenge and not just a demographic trend. Against this backdrop, the primary goal of urban policies should be to achieve a balance between development, human well-being, and ecosystem stability.

1.2 Circular Cities: A New Paradigm Towards Sustainability

In response to the pressures created by urban expansion, the concept of circular cities is emerging as an alternative and long-term guiding framework. Traditional cities operate on a linear model of 'take-make-dispose', where resources are discarded after use. On the contrary, circular cities are based on closed-loop systems, where resources are recycled, recovered, and regenerated - that is, waste is reduced, and the value of resources is retained for as long as possible (UNECE, 2021).

This is not just a conceptual framework; some cities have already set examples at a global level.
For example:

- **Amsterdam (Netherlands)**: Circularity has been mainstreamed in the construction sector with the introduction of the 'Material Passport' system.
- **Singapore**: The NEWater project is a leading example of a city-wide initiative to recycle and treat wastewater for drinking and industrial purposes; its Waste-to-Energy initiative is also leading the way.
- **Copenhagen (Denmark)**: A target has been set to become carbon-neutral by 2025, which is sought to be achieved through waste management and the use of renewable energy.

Such a concept is also being practically implemented in the Indian context.

- **Indore (Madhya Pradesh)**: Indore has consistently ranked first in cleanliness due to citizen-based waste segregation, door-to-door collection, and biogas plants (MoHUA, 2021).
- **Pune (Maharashtra)**: Formal inclusion of waste collectors by SWaCH Cooperative, as well as decentralised composting initiatives, are examples of spatialised waste valorisation (Chikarmane, 2012).
- **Nagpur (Maharashtra)**: Sewage-to-energy projects have led to the incorporation of circular principles in both water and power sectors.

The above examples clearly depict that circular cities are not only an environmental necessity but also act as a powerful tool for social inclusion and economic sustainability.

For India, adopting circular principles can be transformative. Cities consume an estimated 78 per cent of global energy and generate a significant amount of waste, so a circular approach provides a way to separate growth from environmental degradation.

1.3 The spectrum of challenges in small towns and metropolitan areas

India's urban landscape is diverse with varied but distinct challenges. In metropolitan cities like Delhi, Mumbai, and Bengaluru, population explosion, infrastructure stress, severe air and water pollution, and exhausting traffic jams are a constant reality.

The growth of informal settlements in these cities, characterised by their lack of civic amenities, environmental degradation and overcrowding, has made life difficult for the residents. In such a situation, low-carbon infrastructure, efficient waste management, and the adoption of renewable energy are urgently required as policy measures—but their implementation has been slow due to various political and administrative hurdles (Financial Times).

Smaller to medium-sized cities, on the other hand, have a similar but more volatile capacity for extremes. Financially and institutionally, inadequate capacity, lack of technical training, limitations in tax collection, and low availability of funds in such a city ultimately affect the quality of infrastructure, housing, sanitation, sewage, and waste management (CSR Education WireDrishti IAST, The Times of India).

In particular, untreated sewage, dumped garbage and unplanned settlements—all of which can be found in smaller towns—can be the source of significant amounts of untreated biological pollutants. Such cities can also lead to significant ecological, social, and economic imbalances and stresses, which can have lasting effects on their development. Therefore, the factors that will shape India's urban character are not just the metropolis, but also how effectively small and medium towns are managed.

1.4 Behavioural Adjustment: An Imperative Foundation of Urbanisation

The development of sustainable cities is based on the transformation of the daily behaviour of its citizens, not just policy and technological achievements. Various studies demonstrate that individual actions can result in significant societal change, such as through actions like recycling, water conservation, reducing dependence on private vehicles, and selecting energy-efficient appliances (Springmann et al., 2016; World Bank, 2025). However, simply providing information is not enough to change behaviour; nudges, when implemented according to positive conditioning and social and moral factors, make environmental decisions easier, more attractive, and socially acceptable (Rare, 2020; WWF, 2024).

At the institutional level, the use of persuasive media – such as circulars in schools, campaigns targeted at families and communities, as well as promotional policies – seems to shape sustainable behaviour.

For example, NGC (National Green Corps) eco-clubs in Indian schools and the participation of student movements under the 'MY Bharat' campaigns (such as plastic-free public places, tree plantation, zero-emission day activities) are helping students become active environmental citizens (NGC; Delhi Education Initiative, 2025).

It is necessary to understand that behavioural changes are not simply the manipulation of habits, but a process of changing reality in the mind. Cities are "co-created spaces", and citizens need to share this responsibility, for which the following technological solutions can be effective:

1. **Literacy and Education:** By incorporating circular principles not only in subjects but also through stories, science skills, and practical experiments (e.g., environmental workshops, robotics-based activities, climate-awareness initiatives) can build sensitivity among students for a sustainable world (Horasis, 2023; Earth.org, 2024; Arxiv, 2022).
2. **Structural availability of urban alternatives (Choice Architecture):** Making environmental decisions in cities easier, more attractive, and socially ideal—for example, local initiatives such as shared rainwater harvesting, community composting, and cafe remodelling - motivates members.
3. **Incentive-based policies:** Policies such as property tax rebates for houses that segregate waste, 'Green Campus' certification, and grants for eco-friendly houses can change community behaviour in a positive direction (EAC-PM, 2023).

Ultimately, circular cities are not just shaped by infrastructure and technology – they are a culture that is embraced by ordinary people in their daily lives. The sustainable transition in the city will be incomplete without behavioural change among citizens.

Article 1 - Circular Cities in India: Problems and Opportunities (Mr Sameer Summers)

Why did I choose this article?

I chose Mr Unhale's article because it raises a timely issue of applying the principles of the circular economy to Indian cities. His article connects urban challenges – waste, water, and energy – with practical opportunities for circular solutions.

Rationale

This article aligns with my purpose of examining how circularity can be practically applied within a policy framework. Concrete examples of this, such as compost certification, wastewater treatment, and renewable energy, serve as valuable entry points for sustainable urban policies.

Response Review

Mr Unhale criticises the "linear" growth model and strongly advocates for circular systems. His case studies – Maharashtra's Green Compost Program, the city's waste-to-energy project, and the sewage-to-resource models – illustrate how circularity can generate environmental and economic benefits. The inclusion of renewable energy projects strengthens the link with India's climate commitment.

However, there are still significant barriers: scale-up of pilot projects, limited municipal capacity, weak financing, and lack of citizen participation. This article could have focused more on the institutional integration of informal waste sectors and data-driven technology capabilities, as these elements are essential for accelerating circular city transitions.

Conclusion

Mr Unhale's article highlights the urgency of circularising Indian cities. While the policy framework provides guidance in the right direction, its actual impact depends crucially on local institutional capacity, inclusive urban governance, and the active participation of citizens.

Article 2 – Small Cities and Urbanisation (By Mr Amit Dubey)

Why did I choose this article?
I selected Mr Dubey's article because it highlighted the role of small and medium towns, which are often overlooked in urban debates but are crucial to India's sustainable future.

Rationale
This approach complements the discussion of circular cities with an emphasis on spatial dimensions. Smaller cities face rapid but resource-intensive growth, making them vulnerable and uniquely positioned to adopt circular practices early on.

Response Review
Mr Dubey identifies key obstacles in small towns: limited infrastructure, economic weakness, and fragile governance. However, he also points to opportunities for local circular practices like decentralised waste management, composting, and water reuse. Small towns can innovate faster than large cities burdened by bureaucracy.

I agree with his perspective, but I extend it further: limiting circularity to metropolitan regions risks creating a two-tier urban India. For equality and long-term resilience, it is essential to mainstream circular practices in smaller cities. By considering smaller cities as circular innovation labs, India can create models that can be emulated by larger cities.

Conclusion
Dubey's article shows that India's sustainability cannot solely depend on metropolitan solutions alone. It is crucial to expand the circular approach in smaller cities to avoid repeating the mistakes of megacities and promote balanced, equitable urban development nationwide.

Article 3 - Behavioural change for sustainable cities (Mr Dhiraj Santdasani)

Why did I choose this article?
I chose Mr Santdasani's article because it highlights the human dimension of sustainability — the attitudes and behaviours of citizens that are often overlooked in policy and planning.

Rationale
Circularity is not limited to policies and technology; it depends on how citizens view consumption, waste, and shared responsibility. This article aligns with my interest in incorporating community participation into urban sustainability.

Response Review
Mr Santdasani strongly argues that a circular economy is at risk of becoming a technical exercise without citizen participation. Practices like waste segregation, water conservation, and repair and reuse are crucial at the household level. At the community level, initiatives like neighbourhood composting and cafe repairs promote inclusivity and ownership.

I firmly agree. Circulars should be lived every day, not just legislated. However, systematic efforts are needed to achieve this: government-led awareness campaigns, curriculum reforms to incorporate sustainability into education, and incentives to make sustainable choices attractive and achievable (For example, tax exemptions, utility discounts).

Conclusion
Santdasani's article reminds us that behavioural change is the cornerstone of sustainable cities. Without changing citizens' habits and mindsets, the circular will remain merely a policy statement. Transforming sustainability into practical action requires incorporating awareness, encouragement, and shared responsibility.

My integrated approach:

Circular cities in India have immense potential, but a holistic approach balancing strategic orientation, local realities, and citizen participation is needed to realize this vision. Mr. Unhale's article aptly highlights the principles of the circular economy in an urban context, illustrating practical examples such as waste-to-energy, compost certification, and water reuse projects. His emphasis on the adoption of renewable energy, particularly biogas and solar power, reflects how circularity can be adapted to India's climate goals.

At the same time, scaling up such initiatives beyond pilot projects remains a critical challenge, especially in smaller cities where institutional capacity and financial resources are limited. Without a comprehensive framework and citizen participation, the document risks becoming a tool for elite-driven urban projects rather than a catalyst for transformative change in diverse urban realities.

This is where Mr. Dubey's perspective on small towns becomes significant. While urban policy often focuses on metropolitan regions, India's next wave of urbanization will occur in small and medium towns. Instead of being peripheral, these cities can become laboratories of circular innovation through local waste management, community-driven composting, and decentralized water reuse.

By incorporating circular approaches early on, small cities can avoid repeating the unsustainable growth patterns of megacities and instead set the model for large urban centers to follow. It is also a matter of equity to ensure circularity here, which prevents the emergence of a two-way urban India divided into sustainable metropolises and backward small towns.

However, policies and infrastructure alone cannot drive this transformation. As Mr. Santdasani highlighted, the success of circular cities ultimately depends on human behavior. Circularity is not just technical or administrative; it is cultural. Daily citizen practices of waste segregation, water conservation, responsible energy use, and a preference for recycling are fundamental to determining the circularity of the loop.

Beyond the environmental benefits, citizen-led initiatives such as community composting or repair networks create inclusivity, social bonds, and a sense of ownership in the neighbourhood. However, achieving this change requires systematic investment in awareness campaigns, education, and incentives that facilitate and benefit sustainable choices.

Thus, India's path towards circular cities must include national and state-level policy directions, grassroots engagement, inclusive governance, and realistic local assessments. Small towns should be empowered as centres of innovation, while behavioural changes should be nurtured to bring sustainability to daily urban life. Only by integrating policy, equity, and citizen participation can the vision of a circular city be developed from aspiration to living reality in India's diverse urban landscape.

Comparative Analysis:

A close reading of the three articles reveals both shared concerns and specific perspectives on how India can steer its urban future towards sustainability.

Common threads:

All three authors agree that the traditional linear model of urbanisation, marked by unplanned growth, excessive resource extraction, and increasing waste, is unsustainable. Everyone emphasises the urgency of turning to circularity, where resources are recycled and regenerated instead of being discarded. Sustainability cannot be achieved solely through infrastructure and policy measures; it requires a comprehensive systemic change involving administration, institutions, and communities, which is another integrated concept.

Different Perspectives:

Despite this common foundation, each article approaches the issue from a distinct perspective. Sameer Unhale highlights the policy and foundational dimensions of the circular, giving concrete examples of waste-to-energy projects, water reuse, and the integration of renewable energy.

The article on small cities emphasizes the spatial dimension and argues that small urban centers, often overlooked, should become central laboratories for circular innovations. The third article, focusing on behavioural change, emphasises the human dimension and reminds us of that risk reduction in disaster response must be based on a technical agenda, without neglecting the needs of citizens in their daily lives.

Correlation between circularity, small towns, and behavioural change:

When viewed together, these perspectives are not separate but are deeply interconnected. Circularity provides a broad framework defining the principles of resource efficiency and reproduction. Smaller cities represent important areas where these principles can be tested, adapted, and scaled in ways that are more flexible than large metropolises. Meanwhile, behavioral change is the glue that holds social cohesion together, ensuring that both policies and local experiments are successful on the ground. Without citizen participation, the circularities in small towns or cities will remain incomplete; without viable policies and models, behavioral change alone cannot sustain transformation.

New pathways for a sustainable urban future:

Bringing these three dimensions together opens new avenues for India's urban future. A sustainable model emerges when policies enable circularity, smaller cities act as incubators for innovation, and citizens drive change through conscious behavior. This trinity can create cities that are not only resource-efficient but also socially inclusive and resilient to climate challenges. Such an integrated approach ensures that sustainability is not just limited to urban landscapes but is extends to the entire urban sector, thus ensuring a regenerative, equitable and future-ready form of development for India.

Recommendations:

Based on the three-pronged approach, several actionable recommendations have been derived to shape India's urban future.

A. For policymakers (central, state, and municipal governments)

1. Prioritise circular city strategies in small and medium-sized cities

- State governments should establish dedicated funding sources to support circular initiatives in smaller cities, including decentralised waste management, adoption of renewable energy, and subsidies for water recycling projects.
- The Ministry of Housing and Urban Affairs should mandate city-level circular assessments as part of urban planning, linking them to the parameters of the Smart Cities Mission.

2. Creating an enabling legal and institutional framework

- Local bodies should mandate housing societies, hotels, and restaurants to manage and process wet waste in their own premises through appropriate decentralised systems such as composting or bio-methanation. Municipal collection services should be limited to dry waste from these societies. And to ensure compliance, appropriate penalties should be imposed on non-implementing societies.
- The State Government should frame bye-laws, rules and regulations in this regard.
- States should also start training and capacity building programs for municipal staff, cleaners and local entrepreneurs to take up recycling initiatives.

3. Strengthen measures for social equality

- To integrate informal waste workers into formal systems by providing training, legal recognition, protective equipment, and access to health care.
- Promoting gender sensitive circular economy initiatives by supporting women self - self-help groups in recycling, composting and resource recovery industries.

B. For urban planners and local government

4. Strengthening citizen participation in urban planning

- Urban Local Bodies (ULBs) are to set up Ward Level Steering Committees and Neighbourhood Level Forums to involve citizens in local planning.
- City governments should use participatory tools such as citizen audits and green budgeting to ensure accountability.

5. Promoting education, awareness and behavioural changes

- The Ministry of Education should integrate circular and sustainability into the school curriculum and vocational training programs.
- State Governments should also take up awareness campaigns, particularly on Swachh Bharat Abhiyan themes of reducing, repairing and conserving resources.
- Offer incentives such as discounts on property/utility bills for those households and housing societies that effectively practice waste segregation and recycling.

C. For citizens and civil society

6. Promoting collaborative partnerships

NGOs and civil society organisations should be engaged to provide training, capacity building and support for circular practices at the grassroots level. Private industry should be encouraged to innovate in circular business models such as reverse logistics, extended producer responsibility (EPR), and shared mobility platforms.

Citizens should be empowered to take up community-level initiatives such as composting centres, repair cafes, and rainwater harvesting.

Summary Table: Key Policy Actions

The table below outlines the strategic actions recommended for advancing the City Planning Policy in India. Each action area specifies the responsible key components and measurable outcomes to be achieved within a defined timeframe, ensuring clarity, accountability, and alignment with tools such as GIS mapping and ESG reporting.

Area of action	The main Actor (s)	Measurable results
Circulars in small towns	State Governments, ULBs, Smart Cities Mission, NITI Aayog	At least 100 small and medium towns supported by GIS-based monitoring dashboards will be developed as pilot circular towns by 2030.
Consolidation of waste workers	ULBs, NGOs, Social Enterprises, Ministry of Labour	By 2028, one million informal waste workers will be formally integrated into the workforce with reported training, social security, and benefits through ESG-aligned mechanisms.
The participation of citizens	ULBs, Ward Committees, Civic Bodies, Digital Platforms	By 2027, ward-level sustainability platforms will be established in all tier-I cities, which will be integrated with digital platforms for citizen feedback and grievance redressal.
Education and awareness	Education and awareness ...translating	By 2026, circular economy concepts will be included in school curricula across the country, with annual progress tracked and revealed through ESG-aligned reports.
Behavioural incentives	State Governments, ULBs, NGOs, CSR Organisations	By 2027, at least 200 cities will have adopted behavioural incentive schemes - such as tax breaks, accreditation awards, or green certificates - resulting in measurable increases in citizen and institutional compliance with circular practices.
Decentralized waste management (housing societies, hotels, restaurants)	ULBs, Resident Welfare Associations (RWAs), W.A.), Hospitality Association	By 2028, at least 80 per cent of large housing societies, hotels and restaurants will process wet waste on-site, while ULBs will collect only dry waste; compliance will be tracked through GIS mapping and penalties will be levied for non-compliance.

Conclusion

India's urban future will be determined not by a single policy or technological advance, but by the convergence of three interdependent forces: circularity, small-town development, and behavioural change. Circularity provides a framework for rethinking about how resources are used, reused, and recycled. Small towns, where significant new urban growth is occurring, represent important locations where these circular patterns can be nurtured and measured before unstable patterns take root. And changes in behavior ensure that these models transcend policy documents and are incorporated into the daily lives and attitudes of citizens.

Taken together, these three aspects pave the way for a new approach to sustainable urban development in India – one that is resilient, inclusive, and future-ready. Circularity ensures environmental responsibility, promotes sustainability beyond the confines of megacities by developing smaller towns, and behavioral change supports a complete transition to community participation and ownership.

The challenge ahead is to forge these threads into a coherent national and local agenda where policies are realistic, communities are engaged, and development is guided by long-term ecological balance rather than short-term gains. If India succeeds in combining these forces, its cities, both large and small, can emerge not as symbols of crisis, but as models of sustainability, innovation, and shared prosperity.

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