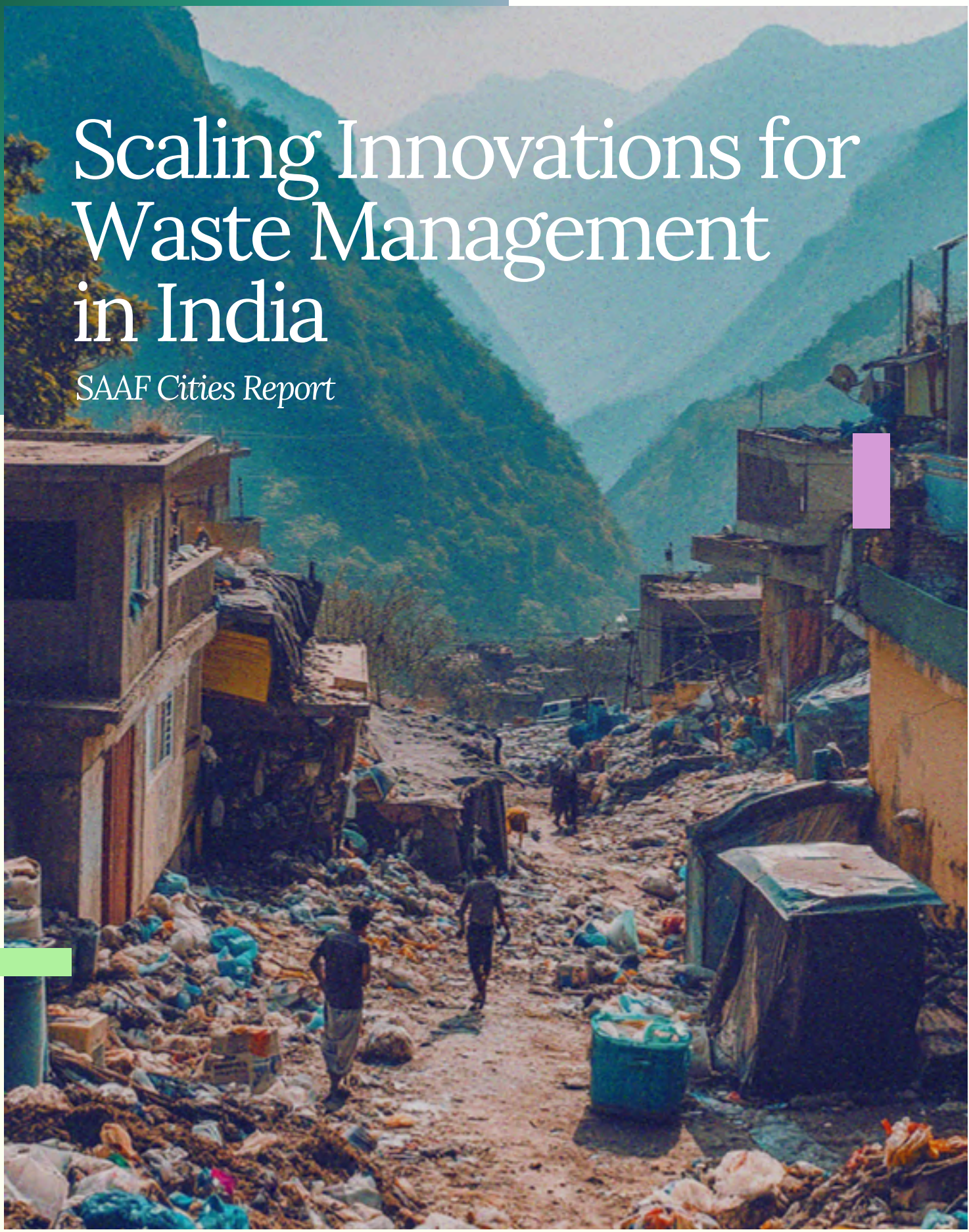
Scaling Innovations for Waste Management in India

SAAF Cities Report



HDFC BANK PARIVARTAN
A step towards sustainable progress

StartUp BuildUp

villgro possible.

Socratus

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TABLE OF CONTENTS

Foreword

Urban India is at a pivotal moment. Our cities are growing faster than ever, and with them, the scale and complexity of waste. From overflowing landfills to informal recycling systems that have long filled the gaps in infrastructure, the need for a shift toward sustainable, scalable, and inclusive waste solutions is urgent.

At Villgro, we have always believed in the power of innovation to solve deeply entrenched challenges. But innovation alone cannot thrive in isolation. It needs ecosystems that are willing to test, validate, and support new ideas, especially in complex sectors like solid waste management, where regulation, infrastructure, markets, and social behaviour all intersect.

The SAAF Cities initiative was born out of this belief. It is our attempt to understand the systemic bottlenecks that keep urban waste innovation from scaling and to explore what a more enabling platform might look like - one that brings together governments, entrepreneurs, funders, and communities.

This ground report captures the insights, barriers, and opportunities that surfaced through extensive engagement with over 30 stakeholders and more than 700 startups. It also offers a blueprint for a platform-based approach to waste innovation, rooted in collaboration, data, and policy alignment.

I hope this work inspires action among changemakers across the ecosystem. Because transforming India's waste challenge is not just about technology or infrastructure. It's about reimagining how we build cities that are circular, inclusive, and resilient for generations to come.

Srinivas Ramanujam

CEO
Villgro Innovations Foundation

Foreword

At HDFC Bank Parivartan, we recognize that environmental challenges like urban waste require solutions that are both innovative and grounded in community realities. We see waste not just as a sanitation issue, but as a powerful opportunity for development, intersecting climate action, circular economy, and inclusive growth.

In collaboration with on-ground partners, HDFC Bank Parivartan designs and implements waste management initiatives across India through a holistic lens. These efforts span infrastructure development, grassroots mobilization, behavior change campaigns, and livelihood integration.

Our Start-Up Grants program supports incubators that empower early-stage enterprises to tackle complex development challenges. SAAF Cities by Villgro exemplifies the potential of these collaborations.

By enabling start-ups to pilot and scale urban waste management solutions, the program opens pathways to circularity, sustainable livelihoods, and dignity for underserved urban communities.

This report reflects the journey and impact of that work. It captures key insights and outcomes from a program that is helping cities reimagine waste management.

As we look to the future, we remain committed to supporting scalable, community-driven solutions that align with India's development priorities.

Nusrat Pathan

Head
Corporate Social Responsibility,
HDFC Bank

Foreword

In 2017, HDFC Bank pioneered CSR grant support for incubators and startups on the back of enabling provisions under the Companies Act (section 135). Now known as HDFC Bank Parivartan StartUp Grants, the program aims to identify startups working in the social impact space and support them through monetary grants to their incubators.

Over the years, we have deployed over Rs 80 crores in grant support under this initiative to support this bustling entrepreneurship ecosystem in India by supporting 120+ incubators and 500+ startups.

Villgro has been one of our early partners, and we have run multiple programs over the years. Having worked at close quarters, we truly believe that they are one of the few incubators in the country that are well-poised to deliver long lasting value for the startups they support and the ecosystem at large.

Hence, SAAF cities was awarded as an initiative for Villgro to lead and create the required community to solve for the waste management challenge our cities face.

This report is a much needed in-depth, on- ground reality check on what is causing friction despite high-level intent, investments and innovations in the space. I firmly believe that point-solutions and a regional lens is insufficient to solve the waste crisis. This report truly is a roadmap for all stakeholders to join in to build a green channel or corridor to validate and scale waste solutions that solve this pressing problem that impacts all of us.

I sincerely hope that we will unleash collective wisdom and action to build a clean and sustainable India, that we all desire and deserve.

Neha Agrawal

Head
Venture Investments,
Structured Finance & CSR
Support for startups

Acknowledgements

We extend our heartfelt gratitude to HDFC Bank for their leadership in driving sustainability initiatives and launching the visionary SAAF Cities initiative—an ambitious effort to scale high-potential waste management solutions and drive systemic change toward a cleaner, more sustainable urban future in India.

We express our sincere gratitude to all those who contributed to the development of this report, "**Scaling Innovations for Waste Management in India**", through their insights, guidance, collaboration, and review. The study has focused on identifying actionable pathways to scale innovations in waste management while fostering stronger engagement with city governments, startups, corporates, and industry stakeholders.

We are especially thankful to Ms. Neha Agarwal and Mr. Niranjan Demanna from HDFC Bank and Mr. Ananth Aravamudan from Villgro for their strategic guidance and unwavering support for this market study. Their leadership has laid the groundwork for a collaborative inquiry into India's waste ecosystem and opened pathways toward inclusive, innovation-led, and market-responsive urban transformation.

We are grateful to Ms. Rini Dutta, Mr. Prashanth Varanasi, Mr. Purushotham Shivkumar, Mr. Sharun Ichigo, Ms. Maithili Rege, Mr. Pratim Raha from Villgro for their steadfast support as part of the core team, and for providing valuable perspectives and driving the SAAF Cities Initiative.

A special note of appreciation to Ms. Preeti Prada Panigrahi, Ms. Amiya Chaudhuri, and Ms. Disha Ranjana from the Socratus Foundation for Collective Wisdom, who spearheaded this initiative—from framing the inquiry and designing the methodology to conducting in-depth semi-structured interviews and synthesizing the insights and narratives that anchor this study.

We also thank Ms. Annie Philip for co-authoring the report and providing valuable insights in the waste management ecosystem of India.

Lastly, we are grateful to all stakeholders across ULBs, Corporates, Start-ups and think-tanks —listed in the report—who participated in surveys, roundtables, and interviews throughout the study. Their candid insights, experiences, and feedback played a crucial role in informing the analysis and findings of this report and shaping the SAAF Cities Platform.

Through a blend of primary research and secondary analysis, we have gathered critical insights to map demand-supply dynamics, identify systemic gaps, and uncover opportunities for convergence, innovation, and scale. We look forward to deepening this collaboration to co-create transformative, waste-wise pathways for sustainable urban futures.

Together, we aim to reimagine cities where circularity and innovation drive systemic impact.

Warm regards,
Devjit Mittra
Executive Director
Socratus Foundation for Collective Wisdom

ABOUT SAAF CITIES

SAAF Cities *is a joint initiative by* ***HDFC Bank*** *and* ***Villgro Innovations Foundation****, designed to bring together* ***innovators****,* ***Urban Local Bodies (ULBs)****, and* ***corporates*** *to accelerate the adoption of climate-smart waste management solutions.*

India generates 1,70,339 tons of waste per day, yet only 54% is processed or treated. The remaining waste burdens landfills, ecosystems, and urban infrastructure, leading to significant environmental and social challenges. While innovative waste management solutions exist, their ability to scale remains constrained due to limited market access, financing barriers, and fragmented ecosystem support.

To address these gaps, SAAF Cities launched -

A dedicated call for applications to identify waste startups with the capacity to scale and collaborate with Corporate and Urban Local Bodies (ULBs).

From **100+ applications received**, an **expert jury evaluated** startups based on their **business model**, **market readiness**, **impact potential**, and **scalability**. As a result, **four high-impact**, **scalable startups** were selected to be part of the program. These startups will work closely with **corporates, ULBs, and ecosystem partners to deploy and scale their solutions through dedicated pilot projects**.

Beyond immediate deployment, **SAAF Cities** is also laying the foundation for long-term transformation through the **Green Channel**, a dedicated platform that will drive **demand mapping, technical validation, market linkages, and financing support**. Over the next three years, this initiative will serve as a **catalyst for waste sector innovation**, streamlining procurement processes and fostering structured collaboration between **startups, corporates, ULBs, financiers, and policymakers.** Anchored jointly by Villgro and the Socratus Foundation, the report aims to showcase commercially viable lighthouse projects that can **reduce risk perception, accelerate large-scale adoption** and build stakeholder confidence.

As the knowledge partner, Socratus Foundation played a pivotal role in synthesizing research, distilling cross-sector insights, and shaping the strategic narrative in enabling a transformative model for India's waste sector through SAAF Cities Platform.

The vision is clear: a future where waste is not just managed but transformed into an opportunity, one that benefits the environment, economy, and livelihoods.

Through SAAF Cities, we are not just scaling solutions but **shaping waste-free communities.**

EXECUTIVE SUMMARY

India's waste management sector is at a critical inflection point. Rapid urbanisation, evolving consumption patterns, and rising waste volumes have outpaced the capacity of existing systems. While regulatory frameworks have matured, implementation remains fragmented. Only 54% of waste is processed; the rest is either informally recovered or dumped in over 3,100+ dumpsites across the country.

The **SAAF Cities initiative** was launched to explore the feasibility of a platform-based approach to scaling innovations in urban waste management. This study drew on primary engagement and secondary research with 32 stakeholders—including Municipal corporations/Urban Local Bodies (ULBs), startups, corporates, and ecosystem enablers, alongside a review of over 700 startups (small and medium enterprises) and 100+ innovation applications.

Jointly anchored by Villgro and the Socratus Foundation, with support from HDFC Bank, the report aims to identify systemic gaps and key priority areas for innovation, focusing on financing, regulatory challenges, and mechanisms to operationalize solutions and models at scale, to advance circularity principles and enhance material recovery in waste management.

Key Findings

Policy-Practice Synergy

- Regulations exist, but ULBs lack the capacity and data to enforce them.
- Smaller towns face high logistics costs and shuttered decentralised infrastructure.
- On-ground implementation gaps persist despite strong policy intent.

Despite comprehensive waste regulations—covering plastics, e-waste, construction and demolition debris, and more—most ULBs face limited processing capacity, lack granular data, and struggle to enforce segregation. Smaller municipalities face unique challenges, including high logistics costs and discontinued decentralised infrastructure.

Stakeholder Expectations

- Upto 80% of waste budgets go to collection & transport, limiting innovation.
- Startups lack access & capital; corporates focus on compliance.
- Public-private partnerships struggle with delayed payments & rigid procurement systems.

Municipalities budgets for waste management leave little room for innovation. Startups often lack access to waste streams and capital, whereas corporates primarily engage through compliance-driven Extended Producer Responsibility (EPR). Delayed payments and the absence of innovation-friendly procurement processes hinder public-private partnerships.

Innovation Landscape

- Only a fraction of the 700+ enterprises have scaled across geographies.
- Most solutions target midstream, missing upstream and the full value chain.
- Informal sector is excluded; impact metrics are rarely tracked.

Most solutions cluster around midstream processing, with limited focus on upstream engagement or end-to-end value chain integration. Informal sector inclusion remains weak, and impact metrics like landfill diversion or emissions avoided have limited tracking.

EXECUTIVE SUMMARY

Pathways Forward

The SAAF Cities platform proposes a five-pronged strategy to enable the acceleration and scale-up of innovations across the waste management value chain in India:

1. *Structured Pilots & Validation:*

Low-risk pilots funded by corporates, with in-kind contributions from ULBs, backed by third-party evaluation of technical and socio-environmental outcomes.

2. *Hybrid Infrastructure Models:*

Combining decentralised and large-scale systems, with regional cluster approaches to reduce costs and improve efficiency.

3. *Transitional Finance:*

Viability gap funding, blended finance, and CSR/EPR-backed models to bridge the prototype-to-scale gap.

4. *Demand & Procurement Reform:*

Enforcing recycled content mandates, introducing green procurement norms, and enabling startup participation in public tenders.

5. *Robust Data Systems:*

From waste characterisation to real-time tracking, embedded within institutionalised solid waste divisions at ULBs.

SAAF Cities Platform

Conclusion

India has the regulatory base and technical know-how to transition toward circular urban waste systems. But siloed efforts and systemic constraints are impeding progress. The SAAF Cities study highlights the need for an integrated innovation platform—anchored in collaboration, evidence, and flexible financing—to align stakeholders, unlock scale, and accelerate the shift from disposal to regeneration in India's urban waste economy.

01

Overview

Rapid urbanization, population growth, and evolving consumption patterns have significantly increased waste generation in India. Although the country has 1,244 landfills, of which 669 are sanitary landfills[1] , a substantial portion of the waste still ends up in open dumpsites.[2]

Waste management not only becomes essential but could also emerge as a commercially viable sector that provides opportunities for growth and impact on people and the planet.

The nature of waste in India is complex due to the diverse nature of consumption patterns, socio-economic conditions, industrial and commercial activity, policy definitions and the geographical patterns. Waste can be classified into:

Municipal solid waste	*Agricultural waste*	*Industrial waste*	*Waste-water*	*Specialised waste*
Household waste, hotels, commercial establishments – wet, dry and domestic hazardous waste	Crop waste from farms, bagasse and others	Chemical waste, and others	Household, commercial and industrial waste water	E-waste,battery, bio-medical waste, hazardous waste and construction and demolition (C&D) waste.

Fig. 1: Categories of waste types

However, to understand the vastness of the challenge we are dealing with, we need to understand the waste ecosystem, stakeholder networks and how the value chain operates.

[1] Sanitary landfills in India are engineered waste disposal sites designed to isolate waste from the environment and prevent contamination of soil and groundwater, however dumpsites are land parcels that dump the unsegregated waste which do not follow the sanitary and hygiene practices as prescribed in the MSW rules.

[2] https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2021-22.pdf

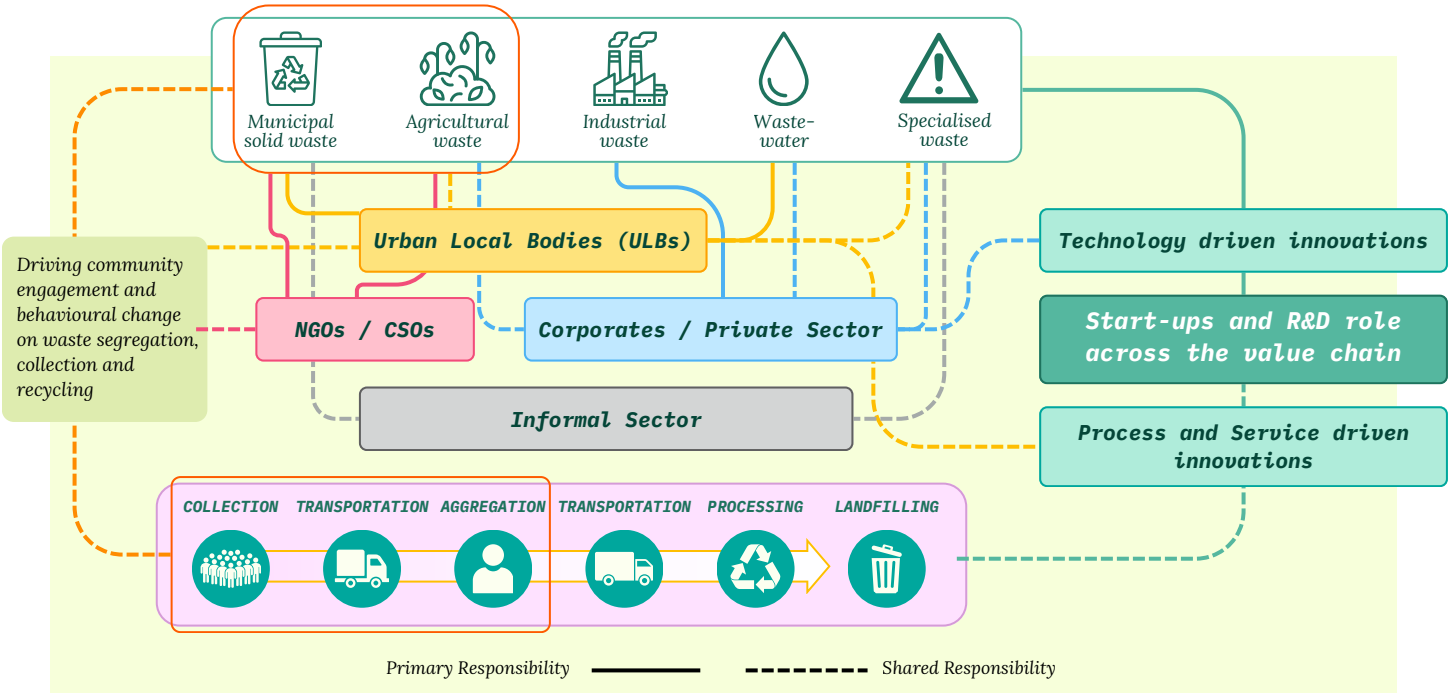


Fig. 2: Stakeholder roles across different waste streams

From the above diagram it becomes evident that the role of start-ups, corporates, ULBs become critical in unlocking the value through efficient management and innovation. The complex nature of the ecosystem also defines the differentiated responsibility of stakeholders for different waste types. Predominantly, the focus from public point of view is on municipal solid waste, agriculture and wastewater management, while the focus for corporates is across post-consumer plastic waste, e-waste (since introduction of EPR in 2016), industrial waste and specific specialised waste streams. This can be attributed to what can be highlighted as **"pre-consumer"** and **"post-consumer" waste streams.**

Pre- consumer waste	Post- consumer waste
Materials discarded during manufacturing or production processes before reaching end-users. *Examples*: Fabric scraps, defective goods, excess raw materials.	Materials discarded after being used by consumers for their intended purpose. *Examples*: Empty plastic bottles, used paper, discarded electronics.

This is critical to understand how the waste streams have to be categorised and a need to identify viable technical and business models across the value chain.

India is poised to become a global economic powerhouse by 2030, and with a waste management market currently valued at ***14.86 (USD Billion)***[3]*, driving* ***sustainability*** *and* ***inclusion*** *in this sector is a top national priority. Shifting narratives in waste, by aligning* ***public***, ***private*** *and* ***informal sector action***, *and* ***reconciling the economic significance of waste as a resource with ecological sustainability*** *in the context of climate change, is therefore imperative.*

[3] https://www.marketresearchfuture.com/reports/india-waste-management-market-21430

02

Snapshot of Waste in India

1,70,339 TPD
total waste generated

1,56,449 TPD
total waste collected

91,511 TPD
waste processed

41,455 TPD
waste landfilled

Overall, 54% of the Municipal Solid Waste (MSW) is either processed or treated

Of the total recycled / treated waste, different categories of waste are treated as follows:

30–60% of paper and cardboard

50–80% of plastic

Nearly 100% of glass bottles

> *"22% of the total waste generated is neither processed nor landfilled"*

Why waste management is critical

Waste represents both an environmental crisis—contributing to pollution and public health hazards—and a missed economic opportunity to recover valuable resources.

01 Environmental hazards – methane emissions, leachate contamination, soil and water pollution

02 Health impacts on people and the habitats

Data Sources:

- https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2021-22.pdf
- https://royalsocietypublishing.org/doi/10.1098/rsos.160764
- https://doi.org/10.1016/j.resconrec.2015.05.012
- https://www.plasticsforchange.org/blog/india-emerges-as-the-worlds-largest-plastic-polluter-what-went-wrong-and-whats-next
- https://edition.cnn.com/2022/12/10/india/india-bhalswa-landfill-pollution-climate-intl-hnk-dst/index.html

03

Key Challenges in the Waste Management Ecosystem

Waste management in most major cities and urban centers is primarily managed by and through Urban Local Bodies (ULBs), which operate as both service providers and regulatory authorities. This dual role impedes effective functioning in both areas, given the limited resources in city municipalities and local bodies.

Therefore, cities are plagued with

- Insufficient infrastructure for effective waste management.
- Shortage of recycling facilities - lack of decentralized recycling and processing facilities
- Inadequate and limited funding for effective waste collection and transportation without contamination.
- Customized technology for waste management and recycling to suit Indian conditions
- Availability of waste related data from source generation to recycling remains a bottleneck
- Techno-commercial feasibility of innovations and access to capital for setting up large scale recycling and processing units
- Additionally, low citizen participation and lack of awareness impede source segregation and recycling efficiency.

Private players have increasingly entered downstream operations to fulfill waste management service requirements and regulatory mandates (such as EPR for plastics), highlighting the government's limited capacity to act as both regulator and service provider.

Meanwhile, the informal sector, comprising waste pickers, scrap dealers, and other informal workers, plays a crucial role in managing India's waste yet remains marginalized. These workers are frequently excluded from formal policies such as Extended Producer Responsibility (EPR) and business models. Waste pickers face vulnerabilities such as persecution and caste-based stigmatization from citizens, municipalities, contractors, and other stakeholders within the waste management ecosystem. Their marginalization obscures critical data necessary for transparent waste management.

It hinders direct engagement between industries, brands, and waste workers, often forcing them to rely on intermediaries or local contractors/aggregators, sometimes called the 'waste mafia'.

The lack of reliable data is one of the most pressing challenges faced by India's waste management sector today. Even between different government sources, large discrepancies in data persist - for instance, a report by the Ministry of Housing & Urban Affairs [4](MoHUA) revealed that urban India generates around 62 million tonnes per annum (MTPA) of municipal solid waste (MSW) and treats 33.40 MTPA. However, the Swachh Bharat Mission claims that India currently generates 57.89 MTPA of MSW and treats 44.94 MTPA. Given the vast variations in waste composition, moisture content etc. across India's geography and seasons, the need for comprehensive waste characterization data is all the more urgent.

[4] https://www.downtoearth.org.in/waste/policy-updates-alone-wont-solve-indias-waste-problem#:~:text=This%20discrepancy%20highlights%20one%20of,with%20seasons%20and%20lifestyle%20changes. https://sbmurban.org/storage/app/media/pdf/Waste%20to%20Wealth.pdf

Municipalities also struggle to track and record data on tonnage and types of waste collected from households and transportation and processing data, with most of this work outsourced to local contractors and informal sector workers.

Collecting and analysing high-quality data in the sector can not only lead to increased transparency and accountability, but can also drive innovations that optimize and streamline collection and processing, formalise and recognise the invisible efforts of informal workers and track and mitigate environmental and health impacts of waste.

Amidst these challenges, market actors such as startups, industries and corporates play a pivotal role in accelerating India's transition toward sustainable waste management. More fundamentally, industries are key to driving upstream innovations, such as minimizing input materials and reducing waste generation at the source. With producer companies and brands contributing over 10 million metric tons of plastic packaging to the country's waste streams (2018-19)[5], and initiatives like the India Plastic Pact emphasizing industry responsibility, the collaboration between state and market actors has never been more crucial.

Innovation in India's waste management sector can address the overwhelming scale of waste generation that far exceeds current infrastructure capacity. With an evolving policy landscape including EPR regulations and government initiatives such as Swachh Bharat Mission, startups now hold the potential to develop solutions ranging from affordable technologies adapted to Indian conditions, data-driven optimization systems, decentralized processing models, and platforms that formalize waste collection and resource recovery, ultimately creating more circular and sustainable waste management systems.

Together, there is an opportunity to build a sustainable and equitable ecosystem for waste management that addresses both environmental and social dimensions, with innovation playing a central role.

[5] https://www.cseindia.org/the-plastic-life-cycle-11509

04

About the Study

Through the SAAF Cities initiative, HDFC Bank and Villgro have come together to accelerate innovation in India's waste management ecosystem. While many solutions have demonstrated success at a small scale, they face significant barriers to scale. Urban Local Bodies (ULBs) and corporates are critical to enabling wider adoption. This study sets out to understand the ecosystem more deeply and explore how a unified platform — the **SAAF Cities Platform** — can bridge existing gaps and unlock opportunities across the value chain.

The report offers a systems-level view of the circular economy startup landscape, incorporating perspectives from municipalities, government bodies, corporates, and civil society.

The study draws insights from the SAAF Cities call for applications, winners announced at the Start-up Mahakumbh 2025, and extensive work done by Villgro and inputs gathered from Socratus Foundation's convenings and scoping study on waste entrepreneurship conducted in 2024.

By analyzing the interplay between startups, ULBs, nonprofits, and industry, the study identifies how strategic partnerships can foster innovation, mobilize capital, and build an enabling environment. Ultimately, the SAAF Cities Platform aims to catalyze market-based, demand-driven solutions through public-private collaboration — accelerating India's transition to a sustainable circular economy.[6]

[6] https://idronline.org/article/environment/can-startups-solve-indias-waste-problem/

4.1 Approach and methodology

The study followed a systems approach to understand the market landscape of different waste streams, engage with key stakeholder groups in the ULB, corporate and start-up ecosystem and analyse key opportunities that can help define the **SAAF Cities Platform**.

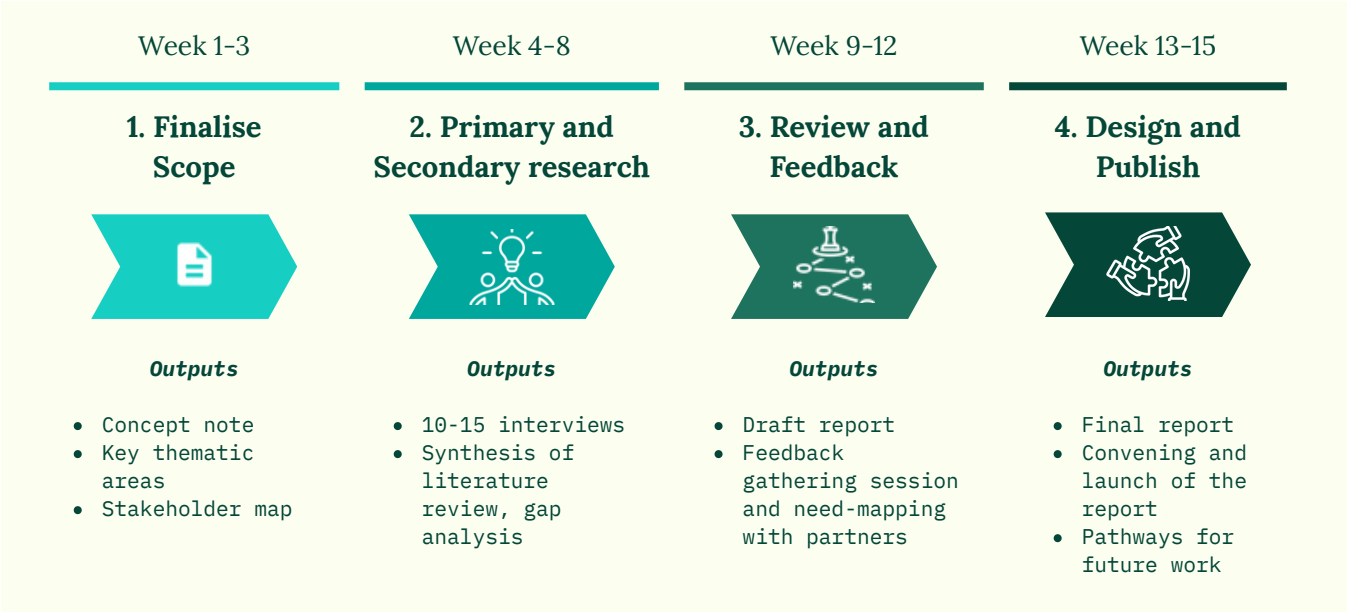


Fig. 3: Approach for the study

As part of the methodology, we conducted semi-structured interviews with a focus on understanding

- Start-up challenges to scaling and market access
- Corporate and ULB perspectives to assess their needs
- Infrastructure needs for waste management in India
- Regulatory hurdles in enabling public-private partnerships
- Investor perspectives
- Case studies and learnings across the ecosystem.

We engaged with diverse stakeholders across the value chain

6	8	4	4	3	7
Start-ups	ULB representatives	Municipal officers	Experts	Incubators	Corporates
Early and late-stage start-ups to assess needs and gaps	Senior leaders to share light on ULB operations and role of innovations	Waste management officers' perspective on MSW operations	Academic and sector experts sharing ecosystem pathways	Start-up investors highlighting the market needs to scale	Industry experts providing insights on waste as a ESG and sustainability targets

4.2 Outputs from the study

This study lays the foundation for the **SAAF Cities Platform** — a framework designed to foster collaboration between Urban Local Bodies (ULBs), startups, and corporates. The platform aims to unlock capital, drive innovation adoption at scale, and reduce landfill waste through demand creation and systemic engagement.

What we uncovered:

A comprehensive landscape

of circular economy startups across key sectors: plastics, textiles, C&D waste, e-waste, and wet waste.

Core challenges startups face

in scaling, adopting circular models, and navigating market and regulatory complexities.

The enabling (or limiting) role

of ULBs, investors, and corporates in supporting startup growth.

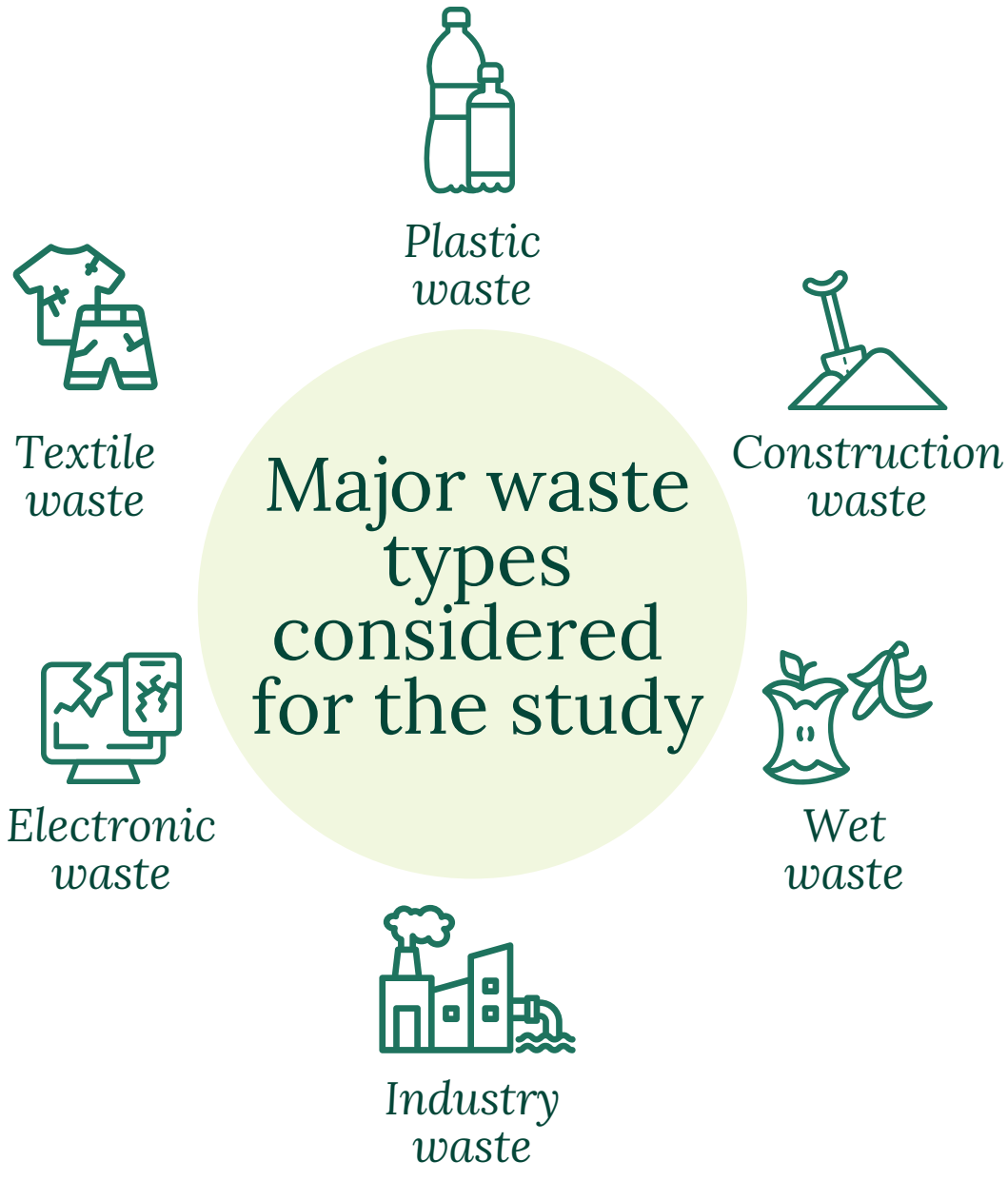
Clear, actionable recommendations

to overcome barriers and accelerate the circular economy transition.

4.3 Focus sectors of the study

Given the waste ecosystem for solving the complex challenges of waste management sector, within the many categories of waste that are generated in India, this report focuses on plastics, textiles, C&D waste, e-waste and wet waste, as specific sectoral areas. These waste categories are selected on the basis of criteria including the quantum of waste generated as a proportion of total waste generated in India, scale of environmental and health impacts, prioritisation by ULBs and/or corporates, ease of access and operation for startups, prevalence of conducive policies, technologies and best practices, and potential scope for innovation.

While the primary focus is on reducing landfill waste, the study also considers industrial waste as a key opportunity. Addressing this not only supports broader sustainability goals but also helps corporates tackle operational challenges. The report does not deep dive into specific industrial waste streams, as each requires a tailored, demand-driven approach.



05

Policy and Regulatory Landscape

Waste began to pose a greater environmental and health risk, the sector came to be governed by the MOEFCC with mandate to draft policies and laws, with execution and implementation mandates from the Central Pollution Control Board (CPCB) supported by state agencies, municipalities (urban areas) and gram panchayats (rural areas). Despite this system in place, there is hardly any change seen in the operational structure, even when the waste problem has grown to the colossal scale that we see today.

A key policy driving waste management is the Municipal Solid Waste (Management and Handling) Rules, 2000, followed by Solid Waste Management Rules, 2016 (SWMR) and over the period of time in the last decade we have seen an evolving pivot in sector specific policies on the principle of "**Polluter Pays**" and "**Extended Producers Responsibility**". With the 2024 rules coming in effect from October 2025, there is expected to be a strengthened and sharpened focus on **end-end** waste management **across waste streams.**

Waste type	Policy/ Regulation	Governing agency	Description
Municipal solid waste	Solid Waste Management Rules, 2016 (SWMR)	MoEFCC, CPCB, SPCB, ULBs, Gram Panchayats	The Solid Waste Management Rules, 2016 (SWMR) apply to municipal waste, mandating source segregation, collection, and treatment of biodegradable and non-biodegradable waste, with local bodies responsible for implementation.
Plastic waste	Plastic Waste Management Rules, 2016 (PWMR)	MoEFCC, CPCB, SPCB, ULBs, Gram Panchayats	The Plastic Waste Management Rules, 2016 (PWMR) introduced Extended Producer Responsibility (EPR) for plastic producers, importers, and brand owners alongside a ban on Single-Use Plastics (SUP), below 120 microns.
	Extended Producer Responsibility (EPR) regulations under PWMR	MoEFCC, CPCB, SPCB	Extended Producers Responsibility (EPR) regime is under implementation in Plastic Waste Management Rules, 2016 (amended in 2022), according to which it is the responsibility of Producers, Importers and Brand-owners to ensure processing of their plastic packaging waste through recycling, re-use or end of life disposal (such as co-processing/Waste-to-energy/Plastic-To-oil/road making/industrial-composting). EPR policy has divided plastics into four broad categories: Rigid plastics- Category I, Flexible plastics (made up of more than one layer of plastic and may contain different types of plastic material)- Category II, Multi-layered plastics (at least one layer of plastic along with a layer of non-plastic material)- Category III, Compostable plastics- Category IV.

Waste type	Policy/ Regulation	Governing agency	Description
Construction and Demolition waste	Construction & Demolition Waste Management Rules, 2016 (C&D WMR)	MoEFCC, CPCB, SPCB, municipal authorities	The Construction and Demolition Waste Management Rules, 2016 (C&D WMR) emphasize the segregation, proper disposal, recycling, and reuse of construction materials.
Electronic waste	E-Waste Management Rules, 2016 (EWMR)	MoEFCC, CPCB, SPCB, ULBs	The E-Waste Management Rules, 2016 (EWMR) mandates EPR for manufacturers and producers, outlining their responsibilities in collecting, disposing, and recycling electronic waste.
Bio-medical waste	Bio-medical Waste Management Rules, 2016 (BMWR)	MoEFCC, Ministry of Health and Family Welfare, CPCB, SPCBs	The Bio-medical Waste Management Rules, 2016 (BMWR) govern the segregation, collection, transportation, and disposal of medical waste, placing the responsibility on healthcare facilities to ensure safe handling and treatment.
Hazardous and chemical waste	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 (HWMR)	MoEFCC, CPCB, SPCBs, State Governments/ Union Territory Administration, Directorate General of Foreign Trade (for transboundary movement), Customs authorities (for monitoring imports/export)	For hazardous waste, the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 (HWMR) regulate the handling, transport, and disposal, incorporating EPR for waste tyres and governing the import/export of hazardous waste.
Battery waste	Battery Waste Management Rules, 2022 (BWMR)	MoEFCC, CPCB, SPCBs, ULBs	The Battery Waste Management Rules, 2022 (BWMR) further reinforces EPR, requiring battery producers to ensure the collection, recycling, and environmentally sound disposal of used batteries.

Table 1: Key policies and regulations for waste sector in India



Various policies are evolving with learnings from the global ecosystem and to achieve the sustainability goals set by India for 2070, sectors like textile waste, agriculture waste and others are also expected to have regulations that will help reduce their destination in landfills, burning or oceans.

While the waste management policies at the Centre are implemented and executed, several states across India are also taking timely action and setting region specific targets for different waste types through state-wide bans, waste collection and recycling. Some of these state level policies / examples of action on waste management are,

- Gujarat and Tamil Nadu are leading **textile** manufacturing states and also house the country's largest textile recycling hubs. Additionally, medium and small scale recycling facilities are prominent in Amroha and parts of Rajasthan, Madhya Pradesh, Punjab and Gujarat which have medium to small-scale recycling facilities (Fashion for Good).[7]

- Maharashtra, Assam and Sikkim have pioneered efforts against **plastics**, implementing single-use plastic bans even before the Central government ban, and seeing significant progress in achieving their targets. Assam, for instance, has completely banned packaged plastic bottles under 1 litre in the state. While the Andaman & Nicobar Islands does not allow sale of packaged water bottles below 2 litres.

- Delhi is considered a pioneer in **C&D waste** management, with the Municipal Corporation of Delhi currently having four C&D waste plants in Burari, Rani Khera, Bakkarwala and Shastri Park — all with an aggregate 5,000TPD capacity, and the country's largest C&D waste plant in Burari. In addition, there are 3 additional proposed plants with a combined capacity of 1550 MT per day. In Gujarat, Ahmedabad is another city with a relatively successful C&D waste processing facility operating through a Public Private Partnership (PPP). Amdavad Enviro Projects Private Ltd (AEP), a joint venture between the city municipal corporation and a private firm, manages and processes C&D waste in the city (DevAlt).[8]

- India now has a total of 295 **e-waste** recycling units[9] spread across various states. Uttar Pradesh leads the charge with 82 units, followed by Karnataka with 45, Maharashtra with 43, and Haryana with 32.

These examples and actions from national and regional governments highlight the impact we can create in end-end waste management. However, this requires further acceleration by enabling demand creation for recycled / repurposed products, adoption of new and innovative technologies and collaboration of the public-private sector.

[7] https://reports.fashionforgood.com/report/sorting-for-circularity-india-wealth-in-waste/chapterdetail?reportid=813&chapter=3
[8] https://www.devalt.org/images/L3_ProjectPdfs/AhmedabadreportonC_Dwastemanagement.pdf
[9] https://www.business-standard.com/india-news/total-recycling-units-in-india-reach-295-highest-in-up-followed-by-k-taka-124120800471_1.html

06

Innovation Landscape in India

*As of April 2023, **1,411** waste management startups have been recognised by DPIIT across 230 districts in 28 States and UTs, with over 54% based in Tier-II and Tier-III cities. Maharashtra, Delhi, Uttar Pradesh, Karnataka, and Gujarat lead in startup count.*[10]

These ventures are driving circular economy innovation essential for sustainable urban development — yet face persistent barriers to scale, resource recovery, and sustainable manufacturing. Their challenges reflect deeper systemic gaps in enabling effective public-private partnerships across the sector.

Area	Key challenge/s
Regulatory barriers	Delays in approvals, payments, and cost overruns hinder commercial-scale waste projects.
Market integration issues	Private sector participation requires long-term contracts, waste supply agreements, and favorable land terms.
Financial constraints	Investors and small businesses face high risks in securing financial returns.

Table 2: Key challenges in the waste management innovation ecosystem

Source: A 2024 study by Amit Kapoor and Natalia Chakma [11]

Public-private partnerships can bridge gaps in infrastructure and operations. A key solution is for government entities to frontload the approval process, reducing project risks and uncertainties. As Kapoor and Chakma highlight, this streamlines timelines, minimizes delays, and allows bidders to develop realistic proposals with effective resource allocation.

To assess the needs of startups and innovators, we conducted a detailed analysis using public DPIIT data and primary insights from the SAAF Cities applications across the value chain. The key takeaways have been highlighted in subsequent sub-sections.

700+

Start-up database analysed from DPIIT etc.

100+

Start-ups from SAAF Cities Applications

16

Primary interviews from Socratus Foundation

The analysis has been done on various parameters such as:

Waste types

Technology as an innovation

Revenue models

Engagement and partnership models

Geographic presence

Scale and impact, among other basic parameters

[10] https://www.startupindia.gov.in/content/sih/en/bloglist/blogs/washsector.html

[11] https://eacpm.gov.in/wp-content/uploads/2024/05/Solid_Waste_management_Updated.pdf

6.1 Start-ups based on waste type

Urban waste streams like MSW, plastic, and e-waste dominate innovation, driven by municipal systems and visibility. However, only **5%** of enterprises focus on growing sectors like C&D, textiles, sanitary, and hazardous waste, highlighting significant underinvestment in these complex areas.

While startups are spread across the country, their operations often extend beyond their registered state. Notably, most startups originate from Gujarat, Karnataka, and Maharashtra, where favorable ecosystems with ULBs support business development.

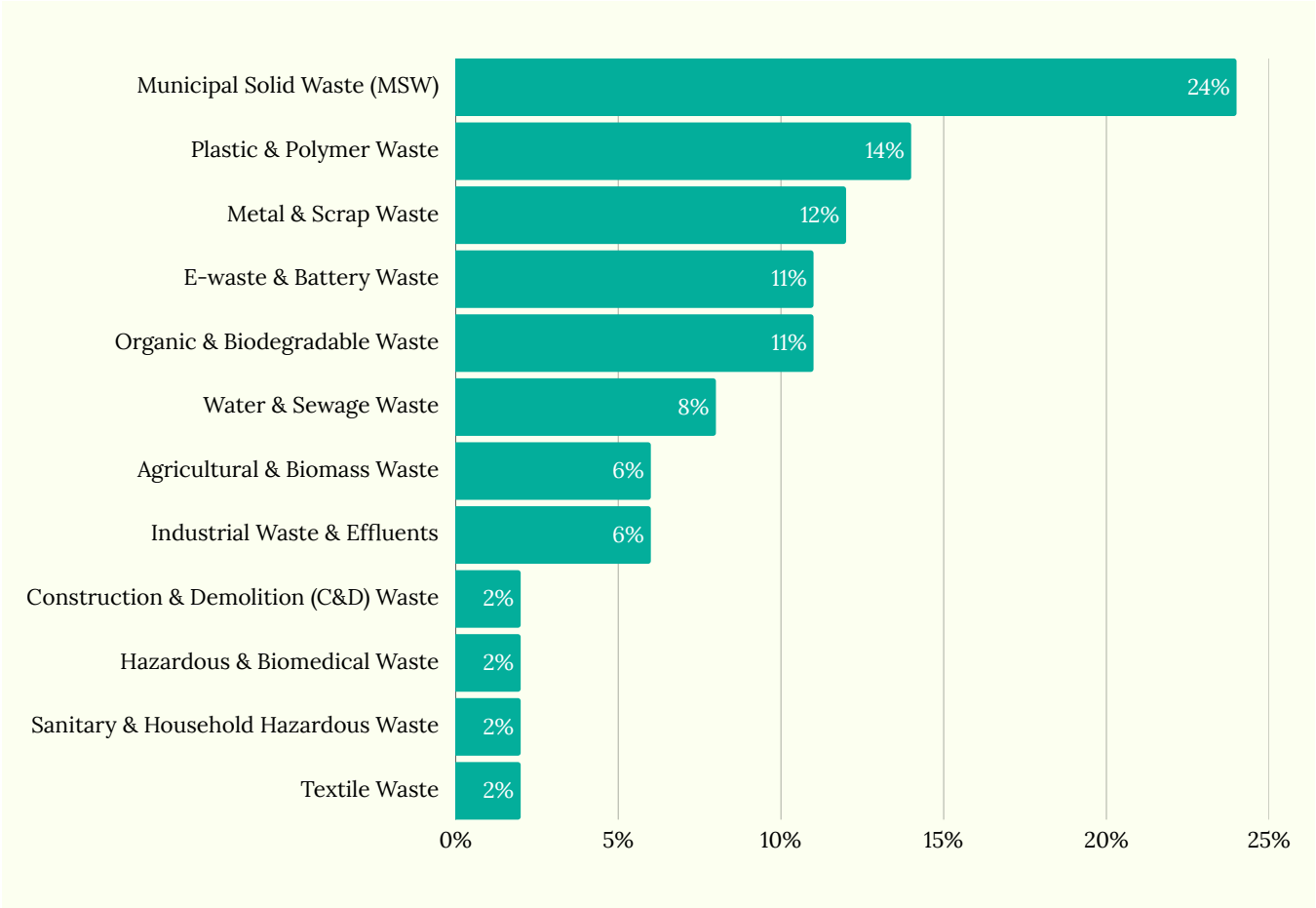
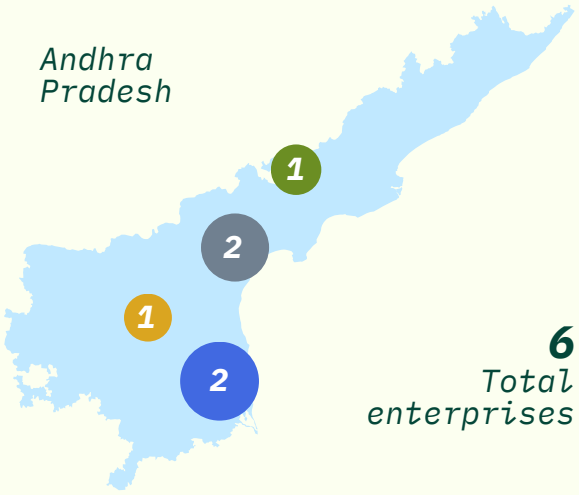


Fig. 4: Share of start-ups in the innovation for different types of waste streams.

Start-ups registered under waste management sector in India as per geographies

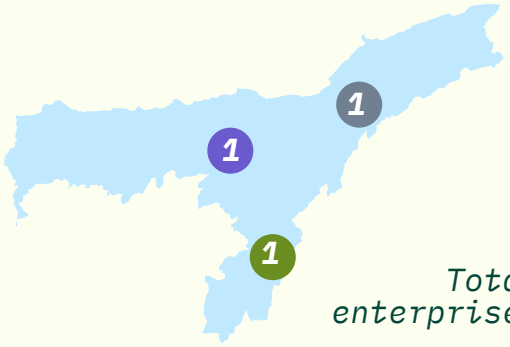
- Municipal Solid Waste (MSW)
- Plastic & Polymer Waste
- Metal & Scrap Waste
- E-waste & Battery Waste
- Organic & Biodegradable Waste
- Water & Sewage Waste
- Agricultural & Biomass Waste
- Industrial Waste & Effluents
- Construction & Demolition (C&D) Waste
- Hazardous & Biomedical Waste
- Sanitary & Household Hazardous Waste
- Textile Waste

Andhra Pradesh



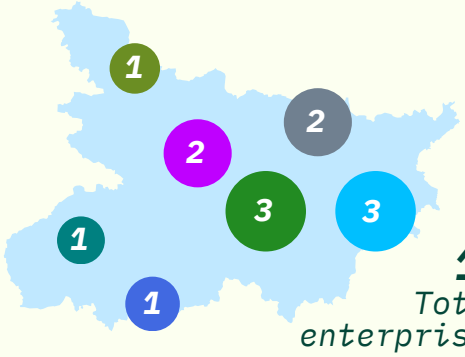
6 Total enterprises

Assam



3 Total enterprises

Bihar

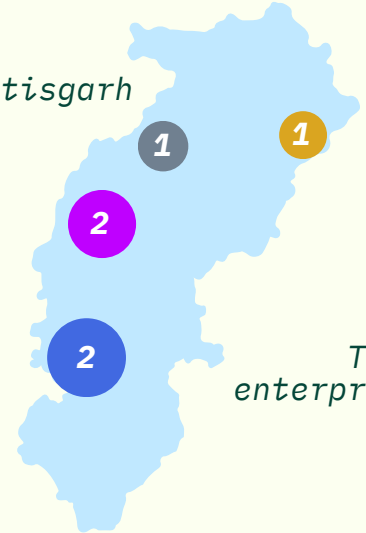


13 Total enterprises

Chandigarh

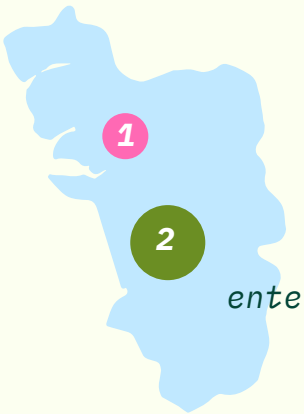
2 Total enterprises

Chhattisgarh



6 Total enterprises

Goa

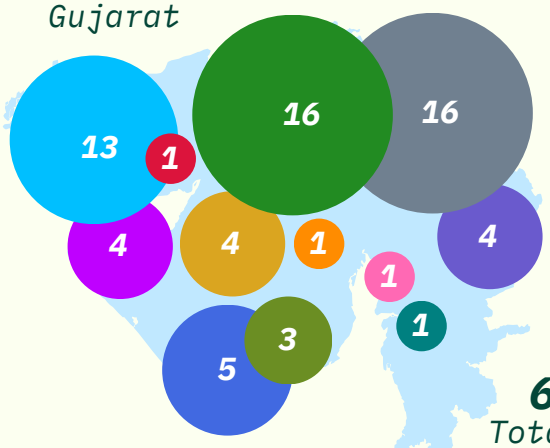


3 Total enterprises

Start-ups registered under waste management sector in India as per geographies (contd.)

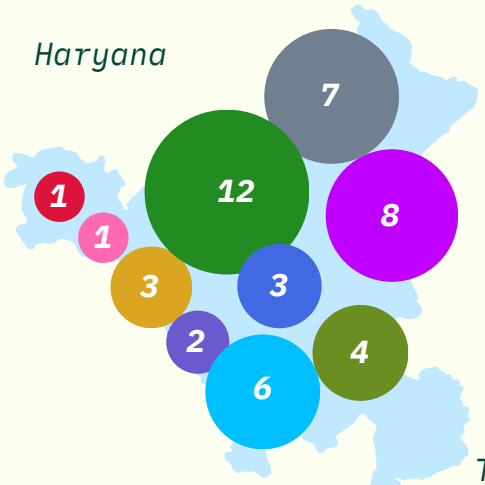
- Municipal Solid Waste (MSW)
- Plastic & Polymer Waste
- Metal & Scrap Waste
- E-waste & Battery Waste
- Organic & Biodegradable Waste
- Water & Sewage Waste
- Agricultural & Biomass Waste
- Industrial Waste & Effluents
- Construction & Demolition (C&D) Waste
- Hazardous & Biomedical Waste
- Sanitary & Household Hazardous Waste
- Textile Waste

Gujarat



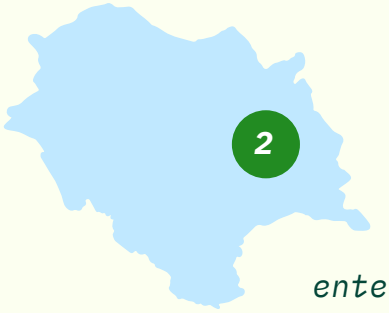
69 Total enterprises

Haryana



47 Total enterprises

Himachal Pradesh

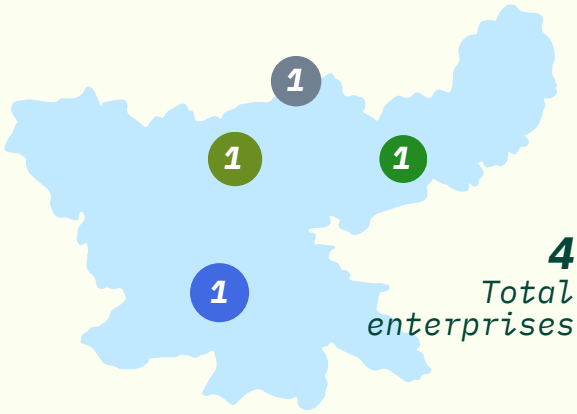


2 Total enterprises

Jammu & Kashmir

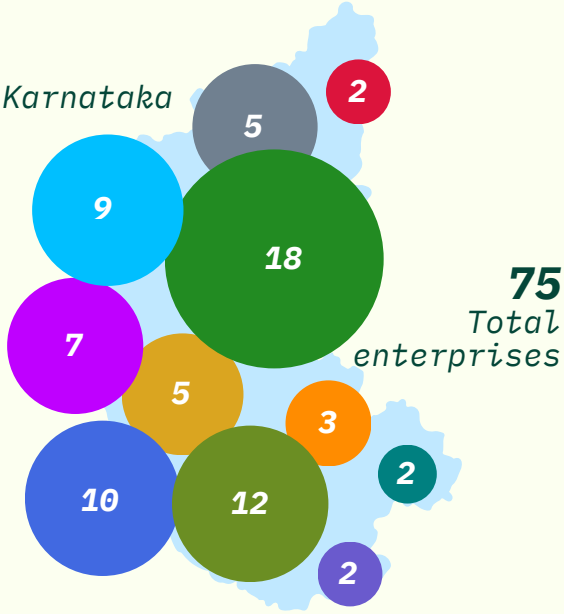
3 Total enterprises

Jharkhand



4 Total enterprises

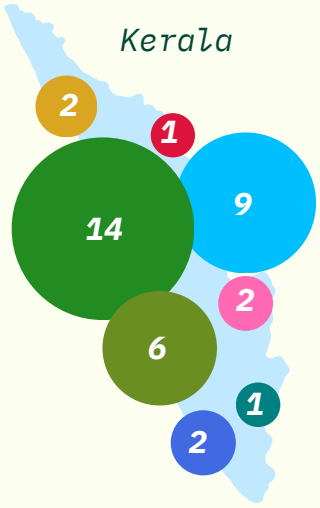
Karnataka



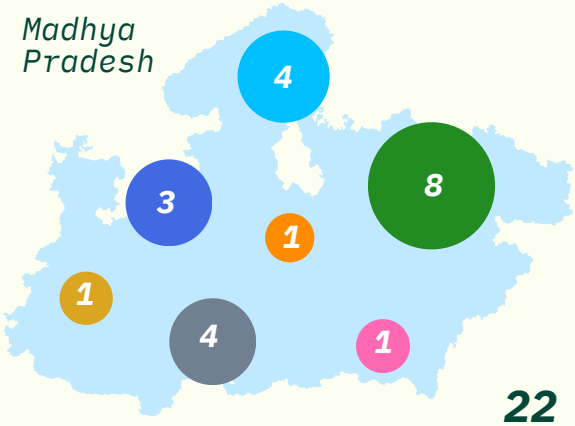
75 Total enterprises

Start-ups registered under waste management sector in India as per geographies (contd.)

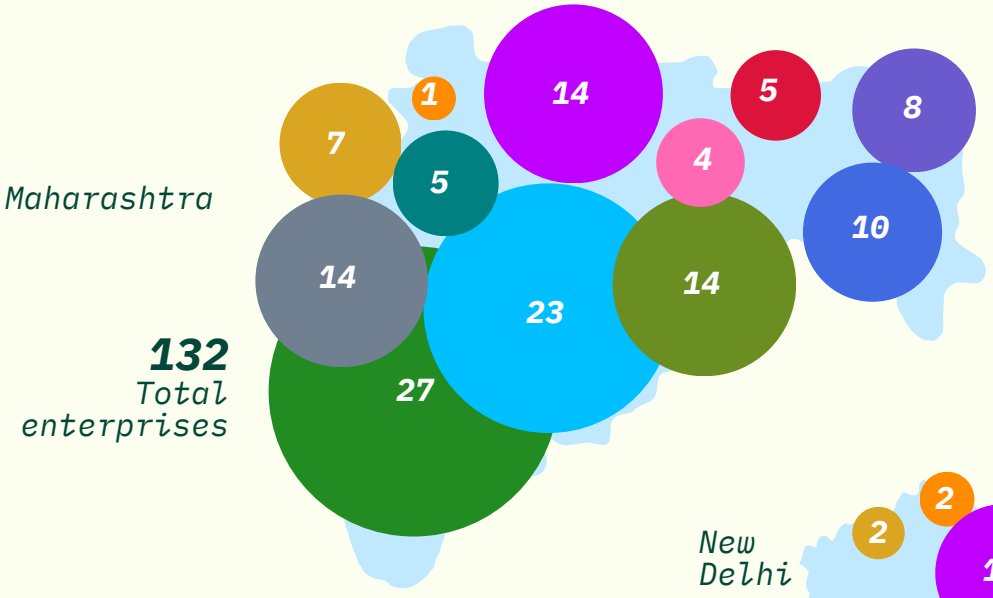
- Municipal Solid Waste (MSW)
- Plastic & Polymer Waste
- Metal & Scrap Waste
- E-waste & Battery Waste
- Organic & Biodegradable Waste
- Water & Sewage Waste
- Agricultural & Biomass Waste
- Industrial Waste & Effluents
- Construction & Demolition (C&D) Waste
- Hazardous & Biomedical Waste
- Sanitary & Household Hazardous Waste
- Textile Waste



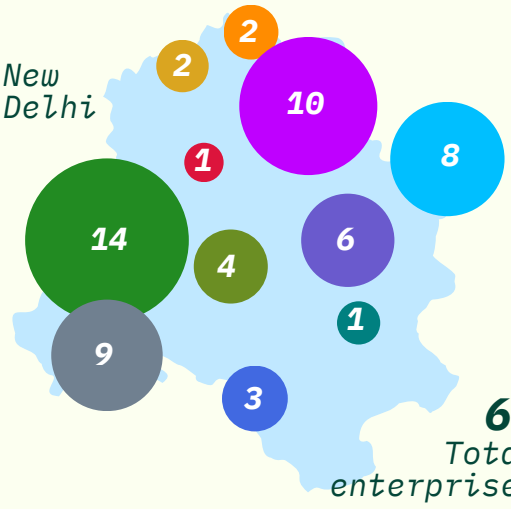
37
Total enterprises



22
Total enterprises



132
Total enterprises

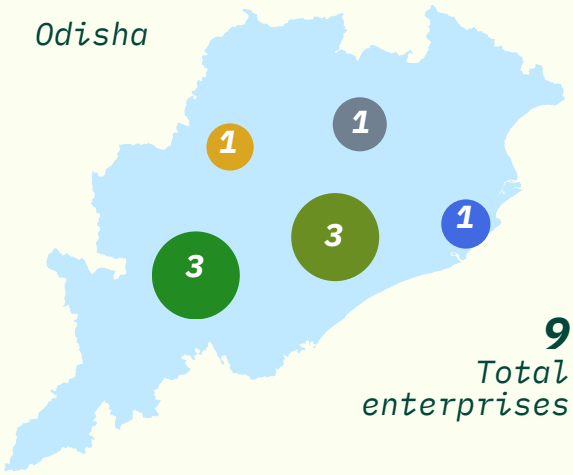


60
Total enterprises

Start-ups registered under waste management sector in India as per geographies (contd.)

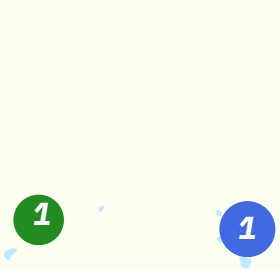
- Municipal Solid Waste (MSW)
- Plastic & Polymer Waste
- Metal & Scrap Waste
- E-waste & Battery Waste
- Organic & Biodegradable Waste
- Water & Sewage Waste
- Agricultural & Biomass Waste
- Industrial Waste & Effluents
- Construction & Demolition (C&D) Waste
- Hazardous & Biomedical Waste
- Sanitary & Household Hazardous Waste
- Textile Waste

Odisha



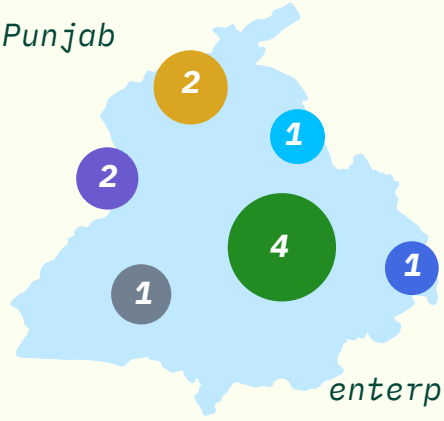
9 Total enterprises

Puducherry



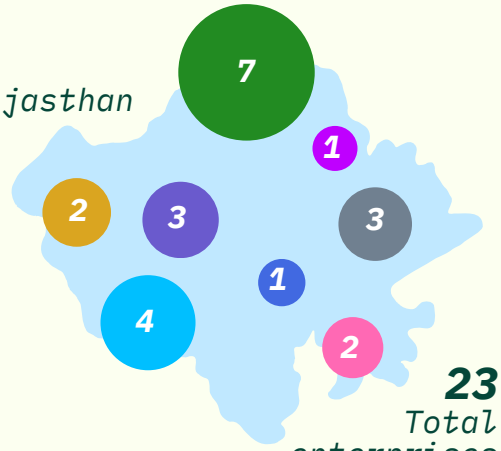
2 Total enterprises

Punjab



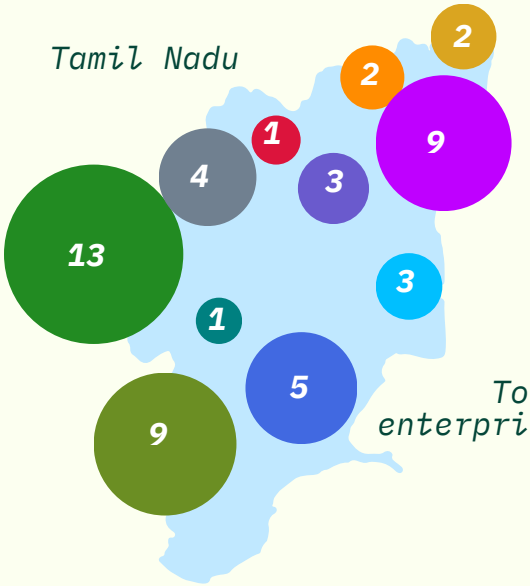
11 Total enterprises

Rajasthan



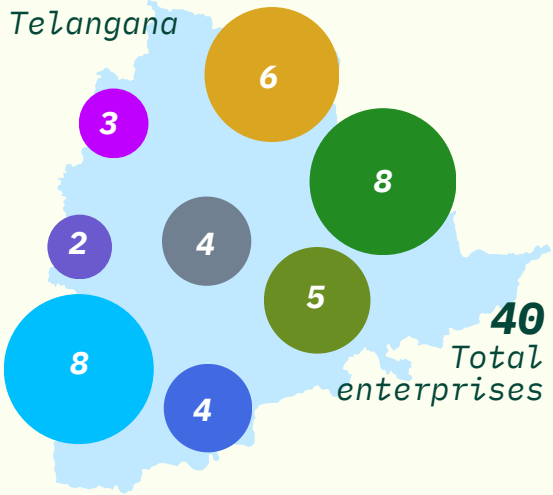
23 Total enterprises

Tamil Nadu



52 Total enterprises

Telangana

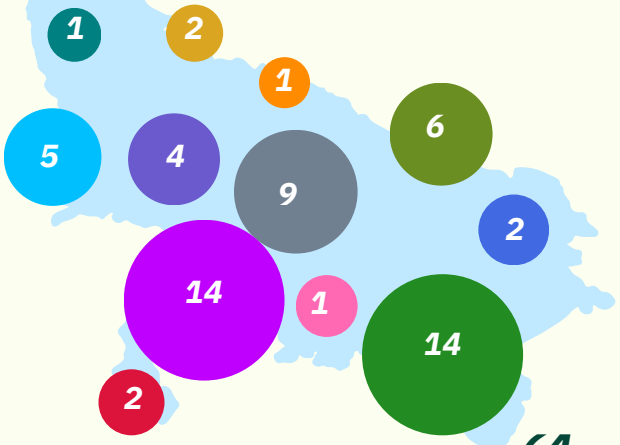


40 Total enterprises

Start-ups registered under waste management sector in India as per geographies (contd.)

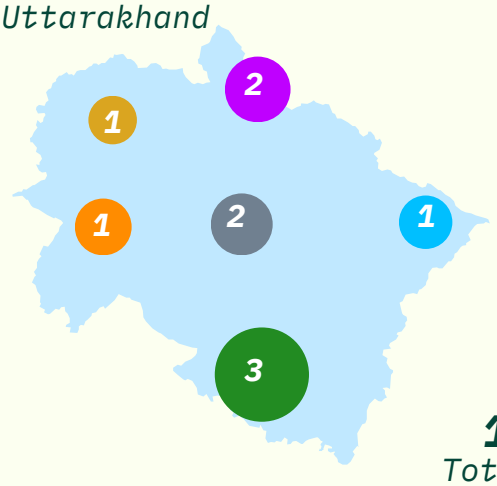
- Municipal Solid Waste (MSW)
- Plastic & Polymer Waste
- Metal & Scrap Waste
- E-waste & Battery Waste
- Organic & Biodegradable Waste
- Water & Sewage Waste
- Agricultural & Biomass Waste
- Industrial Waste & Effluents
- Construction & Demolition (C&D) Waste
- Hazardous & Biomedical Waste
- Sanitary & Household Hazardous Waste
- Textile Waste

Uttar Pradesh



61
Total enterprises

Uttarakhand



10
Total enterprises

West Bengal

8
Total enterprises

A grand total of **700** start-ups

6.2 Startups based on models

Given the unique dynamics of each waste type, startups are adopting different intervention models, which can be broadly categorized into three types.

Intervention models	Description
Innovation Type	Start-up providing either product, service or hybrid innovations 1. Service: End-to-end waste handling services, logistics, maintenance, operations, collection/disposal contracts. 2. Products: Physical technologies, machines, devices, treatment units, upcycled products. 3. Hybrid: Technology bundled with operations, on-site systems with remote monitoring, product and service integration.
Revenue Type	Start-ups with one of the following: 1. Product Sales Model- Enterprises generate revenue through the direct sale of physical products such as composters, machines, or recycled goods. 2. Service Contract Model- Enterprises provide recurring services — often to municipalities, industries, or healthcare such as for collection, treatment, or compliance. 3. Hybrid (Product + Service) Model- These enterprises blend product sales with recurring service revenue. This is often used when technical systems require installation, maintenance, data services, or leasing. 4. Output-Sales Model- Enterprises process waste and monetize the outputs — such as compost, fuel, recycled materials, or upcycled goods. 5. Marketplace/Platform Model- Digital or physical platforms connect waste generators with recyclers or upcyclers. Found mostly in Metal, E-waste, Textile, and urban scrap trade.
Deployment Type	Start-ups with deployment in central or decentralised or hybrid models.

Table 3: Startup categories based on types of models

While no direct correlation can be established between these model types, over **51%** of startups focus on providing services like collection, segregation, and sorting. Additionally, **46%** of them collaborate with ULBs, corporates, and bulk waste generators to offer similar services.

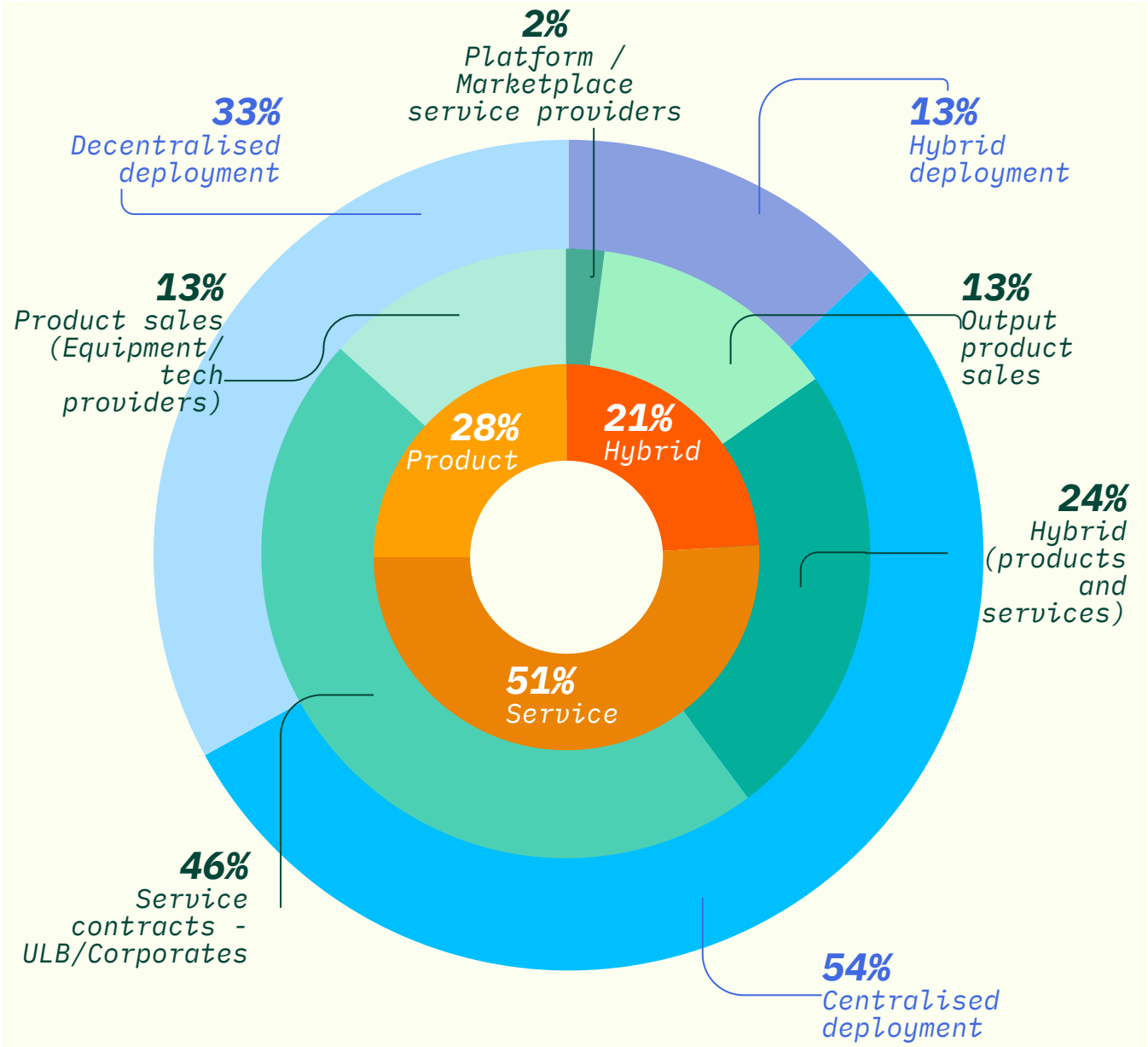


Fig. 5: Share of start-ups in the innovation with different models for delivery and deployment

Key takeaways: Only **28%** of startups focus on product development and technology innovations, with just **13%** involved in their sales and marketing. The majority (54%) operate with centralized models.

This highlights the need for startups to not only provide services but also prioritize technology and innovation to disrupt waste processing and recycling.

6.3 Startups by stage

Innovation in the waste sector varies based on value chain integration—whether startups focus on specific stages or span multiple ones. Using the dataset's "Journey Stages" field, we categorize solutions into stage-specific (one stage) or integrated (multiple stages), covering Collection, Sorting/Segregation, Processing (Recycling/Treatment), and End-use/Market Deployment.

The dataset shows a balanced split:

53%
of startups operate across multiple stages (e.g., collection + processing, or processing + end-use)

47%
focus on a single stage, primarily processing

> *Our analysis highlights that transportation, while critical, functions as an enabling layer rather than a standalone focus, with no startups dedicated solely to it.*

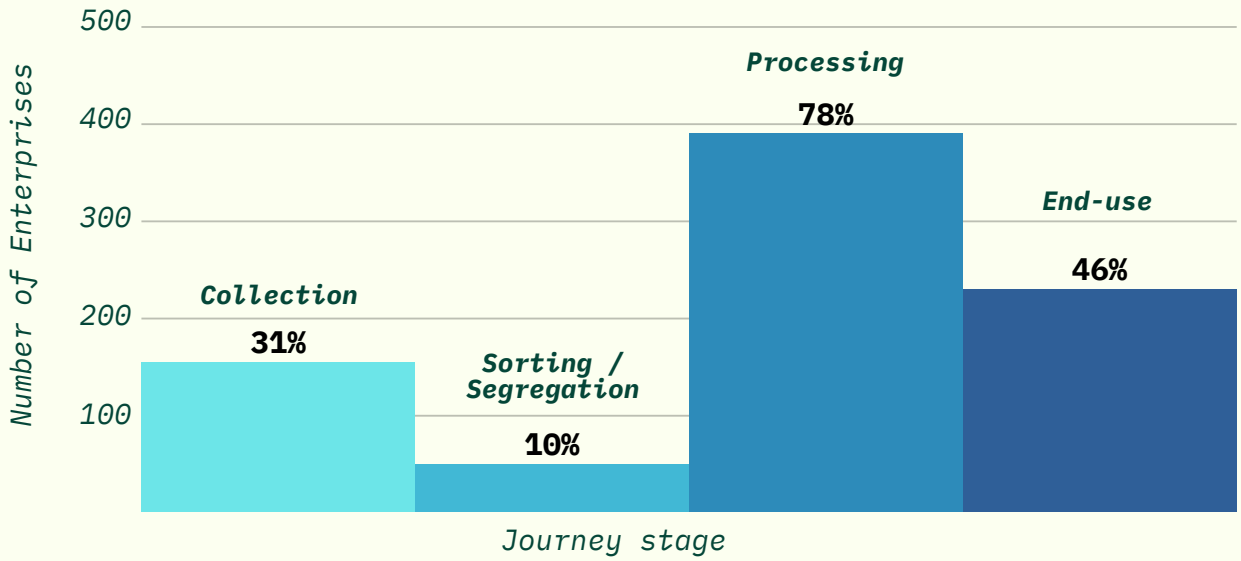


Fig. 6: Share of start-ups operating in the waste management value chain

By tagging startups by value chain stage and waste stream, we created a cluster map to identify areas where innovations are concentrated.

Further analysis across waste streams shows that MSW, C&D, organic waste, agri-waste, and e-waste account for over **50%** of startups operating across multiple stages of the waste value chain. In contrast, plastics, water, metal, industrial, and hazardous waste focus more on single-stage processes, due to the nature of the waste, engagement models, and revenue types.

There is a strong correlation between integration level and innovation type:

Integrated solutions, typically service-based or hybrid models, make up 79% of multi-stage solutions and often require centralized hubs or service networks (e.g., e-waste handlers managing both collection and dismantling).

Stage-specific innovations are more likely to be pure product innovations (30% in single-stage vs. ~21% in multi-stage), often involving decentralized deployment, like composting units or sorting machines.

Thus, the degree of integration not only reflects the waste type but also the business model complexity and deployment style.

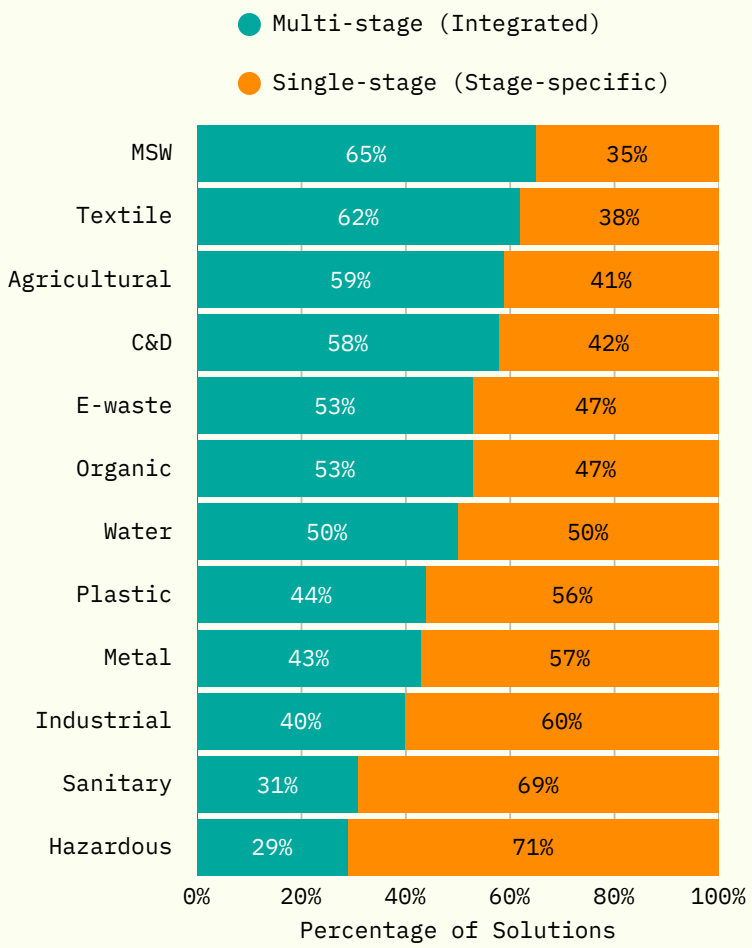


Fig. 7: Share of start-ups with focus of innovations in different stages and processes of the value chain

> *From the dataset, we further analyzed the hotspots where innovations are concentrated across different waste types and stages.*

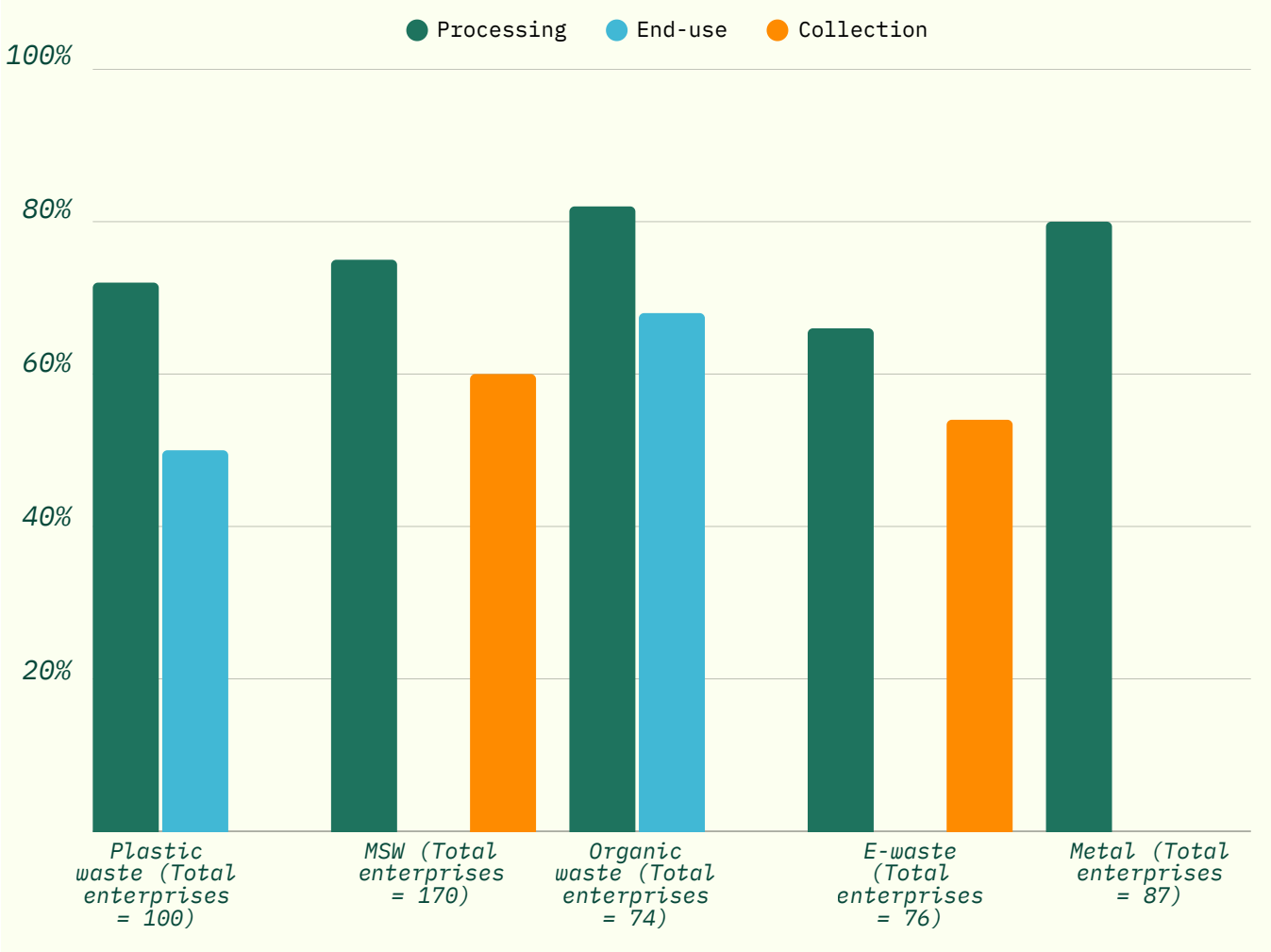


Fig. 8: Start-up hotspots across different waste streams

Key takeaways from the hotspots reveal a strong focus on **processing plastic, MSW, organic, e-waste, and metal waste**. However, gaps remain in **sorting** and **collection** across all waste streams and stages. There is a growing need for startups to address these gaps and play a crucial role in scaling waste processing solutions.

6.4 Startups based on partnerships

Service-based models handling high-volume, complex waste streams often require regulatory compliance and partnerships with Urban Local Bodies (ULBs) for operations like door-to-door collection or centralized MRFs, biogas, or incineration units. Around **48%** of startups engage with ULBs through service contracts, while **38%** partner with the private sector, focusing on output sales or platform-based models. Only **14%** work at the institutional or community level—highlighting a critical gap in community engagement needed to drive behavior change and improve segregation at source.

6.5 Technical mapping of the waste management start-ups in India

The mapping, across 12 key waste categories, highlights how startups align their business models, deployment strategies, and technologies to the specific operational and regulatory realities of each stream.

Decentralized, on-site solutions are prevalent in agricultural, organic, plastic, and C&D waste—leveraging technologies like biogas units, composters, and rubble crushers to reduce transport costs and enable local processing. These models typically run on product sales or small-scale service fees, supported by partnerships with farmer groups, rural bodies, or ULBs.

In contrast, **centralized models dominate e-waste, biomedical, industrial, and hazardous waste streams, driven by safety, compliance, and scale.** These involve large facilities, long-term contracts, and close coordination with producers and regulators, often under Extended Producer Responsibility (EPR) frameworks.
Emerging digital platforms are bridging gaps across streams—enabling scrap trading, EPR traceability, and smart-bin monitoring—while unlocking new revenue through data services and compliance support.

Emerging digital platforms are bridging gaps across streams—**enabling scrap trading, EPR traceability, and smart-bin monitoring**—while unlocking new revenue through **data services** and **compliance support**.

Waste type	Technology & Solutions	Deployment	Business Models
Agricultural & Biomass Waste (No. of enterprises = 44)	Innovations focus on thermochemical (e.g., pyrolysis), biological (anaerobic digestion, composting), and mechanical processing. Solutions include portable biomass converters, stubble collection and processing, decentralized biogas and bioCNG units, biochar production, and on-site composters for rural or peri-urban communities.	Primarily decentralized and physical. Technologies are designed for on-site use in farms or villages, minimizing transport. Emphasis on low-cost, rugged equipment suitable for smallholders. Some units are portable to enable flexible deployment.	Revenue from sale of end-products (biochar, bioCNG, compost), equipment sales/leasing, and processing service fees. Partnerships involve farmer cooperatives, agricultural input dealers, energy utilities, and rural development schemes. Solutions often enable value recovery for farmers while offering environmental co-benefits (reduction in air pollution, improved soil health).

Waste type	Technology & Solutions	Deployment	Business Models
Municipal Solid Waste (MSW) (No. of enterprises = 170)	Solutions span waste segregation systems, smart bins with sensors, decentralized waste processing units, composting hubs, AI/ML-driven sorting lines, digital waste collection tracking, and integrated material recovery facilities. Tech includes IoT sensors, AI-based automation, low-tech composters, and app-based citizen engagement platforms.	Deployments range from centralized MRFs and compost plants to hyperlocal decentralized waste stations. Digital solutions include mobile apps and dashboards used by municipalities and waste workers. Community-level interventions are common, often supported by civic participation or social enterprises.	Revenue via collection fees, service contracts with municipalities, monetization of recyclables, and sale of compost. Partnerships with local governments, housing societies, NGOs, and informal sector aggregators. Some platforms also monetize data and offer SaaS tools to cities for waste operations monitoring.
Plastic & Polymer Waste (No. of enterprises = 100)	Technologies include mechanical recycling, chemical recycling (e.g., pyrolysis to fuel), plastic-to-tile or panel conversion, and polymer repurposing. Solutions range from drop-off collection services and plastic banks to product creation (e.g., roads, tiles, packaging).	Physical deployment of collection units, recycling infrastructure, and distributed manufacturing. Also includes B2B partnerships for sourcing plastic waste and converting it into market-ready products or fuel.	Revenue from selling upcycled plastic products (tiles, packaging), sale of fuel, corporate ESG partnerships, and credits for plastic recovery. Partnering with FMCG brands, municipal authorities, schools, and retail chains for supply aggregation and awareness campaigns.
E-waste & Battery Waste (No. of enterprises = 76)	Solutions include modular dismantling lines, safe battery recycling systems, second-life battery repurposing, traceability platforms, and awareness/collection services. Technologies used: electrochemical recovery, robotics, AI-based disassembly guidance, digital tracking.	Centralized facilities for treatment and material recovery, supported by collection points in urban centers. Some startups use tech platforms to enable reverse logistics or consumer-driven pickups via apps.	Revenue through material recovery (precious metals), service contracts for safe disposal, refurbished electronics resale. Partnerships with electronics manufacturers, e-retailers, and extended producer responsibility (EPR) programs.
Organic & Biodegradable Waste (No. of enterprises = 74)	Solutions include community composters, anaerobic digesters, black soldier fly composting, enzyme-based digestion, and smart organic bins. Technologies: biological processing, fermentation, controlled aeration, and IoT for condition monitoring.	Largely decentralized at apartment, institution, or ward level. Innovations focus on odor control, compact footprint, and ease of use. Some centralized bio-CNG units also exist for institutional clients or municipalities.	Revenue from compost and biogas sales, AMC contracts for equipment, and service models for composting operations. Partners include schools, hotels, municipalities, resident welfare associations, and community-based organizations.

Waste type	Technology & Solutions	Deployment	Business Models
Metal & Scrap Waste (No. of enterprises = 87)	Tech includes smart scrap sorting, magnetic separation, shredding, and metallurgical recovery. Solutions involve scrap marketplace platforms, B2B scrap collection services, and end-to-end logistics coordination.	Primarily centralized or semi-centralized with collection networks feeding into processing hubs. Some digital platforms support booking, tracking, and resale of scrap.	Revenue from scrap resale, processing fees, and bulk trading. Partners include manufacturing units, workshops, scrap dealers, and industrial parks.
Water & Sewage Waste (No. of enterprises = 57)	Technologies: on-site greywater systems, containerized STPs, bioreactors, membrane filtration, and IoT-based monitoring. Solutions include plug-and-play treatment units for institutions, digital water quality tracking, and nutrient recovery from sludge.	Modular systems for decentralized deployment in apartments, campuses, and industrial sites. IoT tools enable remote monitoring and maintenance.	Revenue via sale and maintenance of treatment systems, pay-per-use treatment models, and AMC contracts. Partners include builders, industries, municipal boards, and facility managers.
Industrial Waste & Effluents (No. of enterprises = 40)	Solutions include chemical treatment plants, zero-liquid-discharge (ZLD) systems, toxic substance neutralization, and sludge valorization. Technologies involve membrane systems, reverse osmosis, catalytic oxidation, and high-pressure filtration.	Typically centralized or on-site at large-scale industrial units. Solutions are high-capex and customized for each industry type.	Revenue from EPC contracts, licensing proprietary systems, and sludge-derived byproduct sales. Partners include industries, pollution control boards, and environmental auditors.
Hazardous & Biomedical Waste (No. of enterprises = 14)	Innovations include autoclaving, plasma incineration, chemical disinfection, secure transportation tracking, and traceability platforms. Tech also includes blockchain for chain-of-custody and IoT tagging for compliance.	Centralized facilities with strict protocols. Supported by logistics chains with containerized transport and digital manifests.	Revenue from compliance-based service contracts, government empanelments, and hospital tie-ups. Partners include healthcare institutions, labs, waste logistics firms, and regulatory authorities.

Waste type	Technology & Solutions	Deployment	Business Models
Construction & Demolition (C&D) Waste (No. of enterprises = 12)	Tech includes crushing units, mobile C&D waste processors, and reprocessing for bricks, blocks, and aggregates. Solutions often offer on-site services or tie-ups with urban local bodies for C&D recycling.	Mobile or centralized based on city scale. Emphasis on reducing transport cost by processing at source where feasible.	Revenue from recycled construction material sales, service contracts for debris clearing, and city-level PPPs. Partners include real estate developers, contractors, and municipal corporations.
Textile Waste (No. of enterprises = 13)	Solutions include mechanical tearing, fiber regeneration, upcycling scrap into home/fashion products, and traceable recycling pipelines. Tech also involves material recovery from blends using chemical processes.	Processing hubs or fashion-brand-aligned collection systems. Some tech-enabled traceability chains exist to verify recycling.	Revenue from upcycled product sales, B2B sales of recovered fibers, or brand-backed circularity programs. Partners include fashion brands, export houses, and sustainability platforms.
Sanitary & Household Hazardous Waste (No. of enterprises = 13)	Includes incineration tech, compostable sanitary alternatives, safe collection boxes, and sterilization units. Emerging tech for eco-friendly diaper and pad disposal is present. Solutions are often community or hospital-focused.	Deployed at ward/community level, hospitals, or in smart bins. Requires behavioral engagement and privacy sensitivity.	Revenue from waste collection service subscriptions, sales of compostable alternatives, and grants/public health contracts. Partners include health NGOs, FMCG brands, and urban local bodies.

Table 4: Technical Mapping of Waste Innovations by Waste Type

6.6 Bridging innovation vs deployment

Waste-tech solutions, often hardware-driven or process-intensive, face significant hurdles in moving from lab to market. The Technology Readiness Level (TRL) framework—now formally adopted by the Central Pollution Control Board (CPCB)—is a key tool to assess the maturity of these innovations. Ranging from TRL 1 (basic concept) to TRL 9 (commercial deployment), it helps determine if a solution is ready for field use or still needs further development.

Common challenges across the TRL levels:

TRL Stage	Level	Focus	Typical Challenges
Early-stage	TRL 1–3	Research, proof of concept, lab-scale testing	High technical risk; unclear path to market; R&D funding is limited
Mid-stage	TRL 4–6	Lab validation to pilot prototype	Known as the "Valley of Death"; limited funding; tough regulatory approvals; difficulty finding pilot hosts
Late-stage	TRL 7–9	Pilot implementation to commercial rollout	Scale-up funding; market entry barriers; procurement hurdles; regulatory compliance

Table 5: Key challenges for various TRL level startups

The most critical—and difficult—part of an innovation journey is TRL 4–6. This is where technologies are taken out of the lab and tested in the field. Many promising startups in waste management get stuck here due to a combination of regulatory, financial, and institutional barriers.

Barrier	Description	Example
Procurement Misfit	ULBs and departments lack mechanisms to onboard new or unproven startups	**Jalodbust** could not qualify for city tenders despite successful pilots due to rigid eligibility criteria
Lack of Pilots	Cities are risk-averse; no dedicated infrastructure or permissions to test solutions	**Digital Paani** struggled to integrate analytics tools in STPs despite functional prototypes
No Technical Validation	Many solutions lack standardized testing protocols, delaying recognition and acceptance	**Takachar** had to self-generate evidence through third-party validation of its biochar system
Funding Gaps	No structured capital for pilot-stage innovations—too risky for investors, too late for grants	**Loopworm** could not access capex funding needed to transition from TRL 5 to 7

Table 6: Example startups facing key challenges for scale-up

6.7 Conclusion and Recommendations

Addressing key challenges in waste management requires innovation across all stages of the value chain and waste streams. For startups to scale, it's critical to demonstrate not just technical feasibility but also commercial viability.

Ecosystem insights point to five interconnected steps needed to help innovations move from TRL 4 to full-scale deployment.

Stage	What it enables
Procurement Access	Creates a pathway for cities and institutions to engage early-stage technologies, even for limited or pilot use.
Piloting Opportunities	Provides operational proof and helps startups test, refine, and demonstrate their solutions in real conditions.
Technical Validation	Builds credibility through standardized performance benchmarks, enabling regulatory recognition and wider acceptance.
Deployment Support	Enables integration into institutional systems, backend infrastructure, and public workflows for sustained use.
Blended Finance	Unlocks capital for scale-up by de-risking the investment environment through grants, concessional funds, or guarantees.

Table 7: Proposed solutions for a thriving innovation ecosystem in waste management sector for scale-up

> *India's waste management ecosystem stands at a critical juncture—fragmented infrastructure, low compliance with waste segregation, and limited traceability continue to hinder meaningful progress. At Bintix, we believe that scalable, technology-driven solutions are key to bridging these systemic gaps. Our platform has shown how digital tools can revolutionize the way waste is tracked, monitored, and processed—enhancing operational efficiency, driving accountability, and improving the quality of life for waste workers. Realizing this impact at scale, however, requires timely funding and strategic collaboration.*
>
> **-Jayanarayan Kulathingal, Co-Founder, Bintix**

07

Deep dive on Waste Streams

This section examines specific waste types to identify innovation needs, the role of ULBs and corporates, and the potential impact of reducing landfill dependency.

Each section explores the value chain, stakeholder ecosystem, policies and regulations, current practices, key challenges, and innovation pathways to address them.

7.1 Construction and Demolition Waste in India

C&D waste, as defined by the Construction and Demolition Waste Management Rules, includes building materials, debris, and rubble generated from the construction, renovation, repair, or demolition of civil structures.

According to a study by the Technology Information, Forecasting and Assessment Council (TIFAC), construction activities generate approximately 35 kg of waste per square meter, while demolition activities produce around 350 kg per square meter.

7.1.1 Overview of the construction and demolition waste in India

Driven by a growing population and rising disposable incomes, India has witnessed rapid urbanisation and infrastructure development over the past three decades—a trend that continues to accelerate. By 2050, India's construction sector is expected to add over 35 billion square feet of floor space, positioning the country as the third-largest construction market globally.

This surge in new construction, along with the renovation and demolition of existing infrastructure, has made construction and demolition (C&D) waste a significant challenge for urban local bodies (ULBs) and developers to manage effectively.

The C&D waste gets generated from

- ***Construction***
- ***Renovation***
- ***Excavation***
- ***Demolition***

The waste can be contributed from various activities including but not limited to residential and commercial buildings; public infrastructure like bridges, roads, highways, utility lines; mining and other similar activities.

150 – 600 tonnes per year [12]	*C&D waste generated annually, as per Building material and technology promotion council (2017) and Centre for Science and Environment (CSE) (2013), while unofficially the volume could be 3-5x higher than this*
Non-uniform composition across regions	*Geographical practices for construction, raw materials used and rate of development influences the constituents of the C&D waste*
5-25% of the MSW [13]	*C&D waste generates in cities is around 5-25% of the overall MSW collected / disposed*
6,500 tonnes recycled per day [14]	*Official recycling capacity is a meagre 6,500 tonnes per day — just about 1% of the total C&D waste generated*

Fig. 9: Overview of construction and demolition waste in India

[12] https://www.downtoearth.org.in/waste/india-recycles-only-1-of-its-construction-and-demolition-waste-cse-73027
[13] https://sbmurban.org/storage/app/media/pdf/circular-economy-in-municipal-solid-liquid-waste.pdf
[14] https://timesofindia.indiatimes.com/business/india-business/india-recycles-only-1-of-construction-and-demolition-waste-study-finds/articleshow/77747060.cms

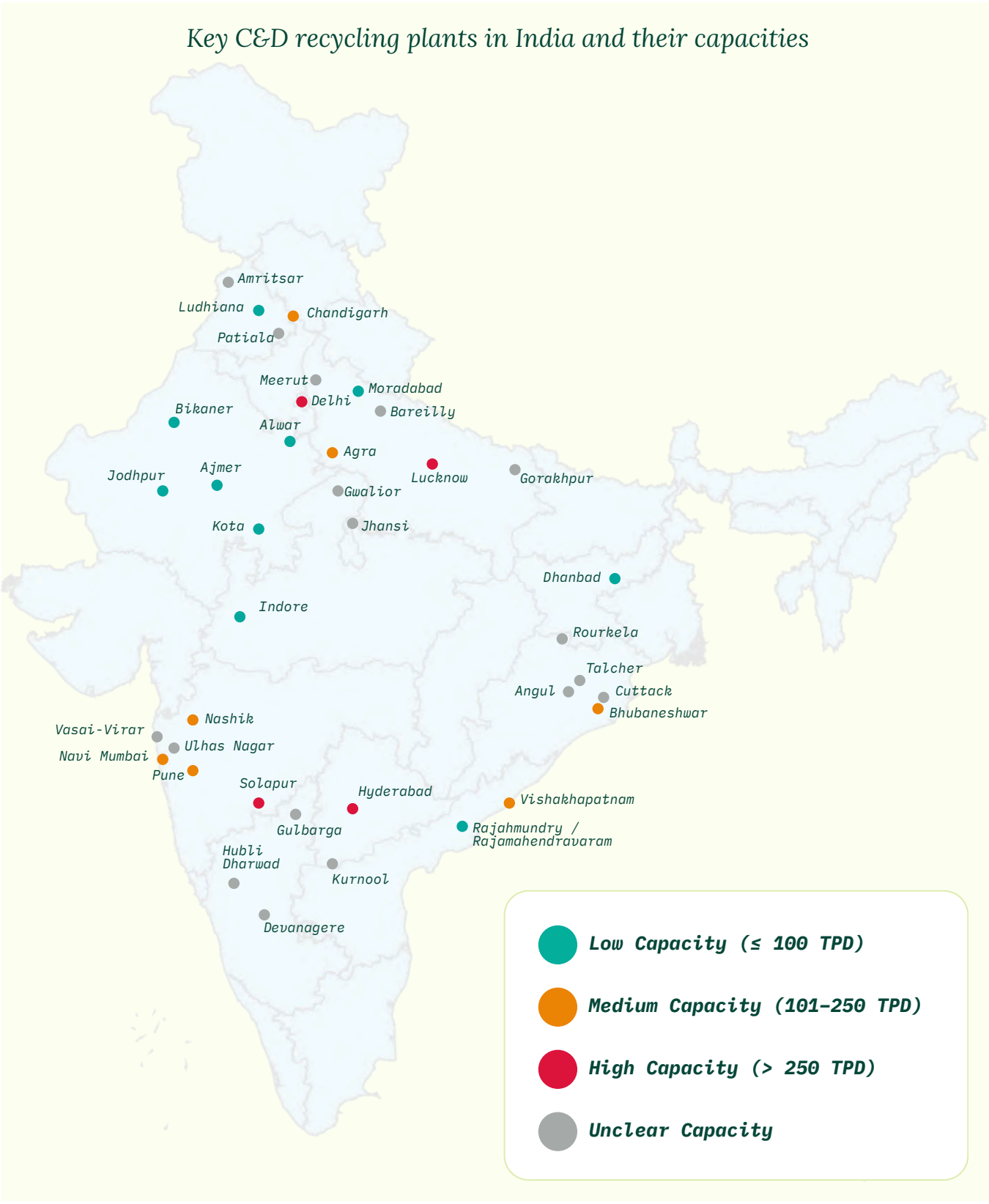


Fig. 10: Geographical distribution of C&D plants in India

India has over ***34 operational C&D recycling plants****, and the country's recycling capacity is below the total C&D waste generated. More than 35 additional facilities are planned in the coming years. However, there is a notable gap in the market's understanding of the financial mechanisms, challenges, processes, and economic viability of establishing and running these facilities.*[15, 16]

15 https://www.hindustantimes.com/cities/delhi-news/kejriwal-inaugurates-india-s-largest-c-d-waste-plant-in-delhi-s-burari-101696787904867.html

16 https://www.devalt.org/images/L3_ProjectPdfs/AhmedabadreportonC_Dwastemanagement.pdf

7.1.2 How does the C&D management work?

As per the C&D Waste Management Rules, 2016, "Waste Generator" include individuals, institutions, and establishments—like residential/ commercial complexes, railways, airports, and defence—that produce waste during construction or demolition.

Two key categories are defined:

01 Service Providers:

Public authorities generating waste from infrastructure projects.

02 Bulk Generators:

Those producing over 20 MT/day or 300 MT/month per project.

These entities are responsible for managing their waste, while Urban Local Bodies (ULBs) oversee and regulate the overall C&D waste management process, including collection, transportation, and disposal.

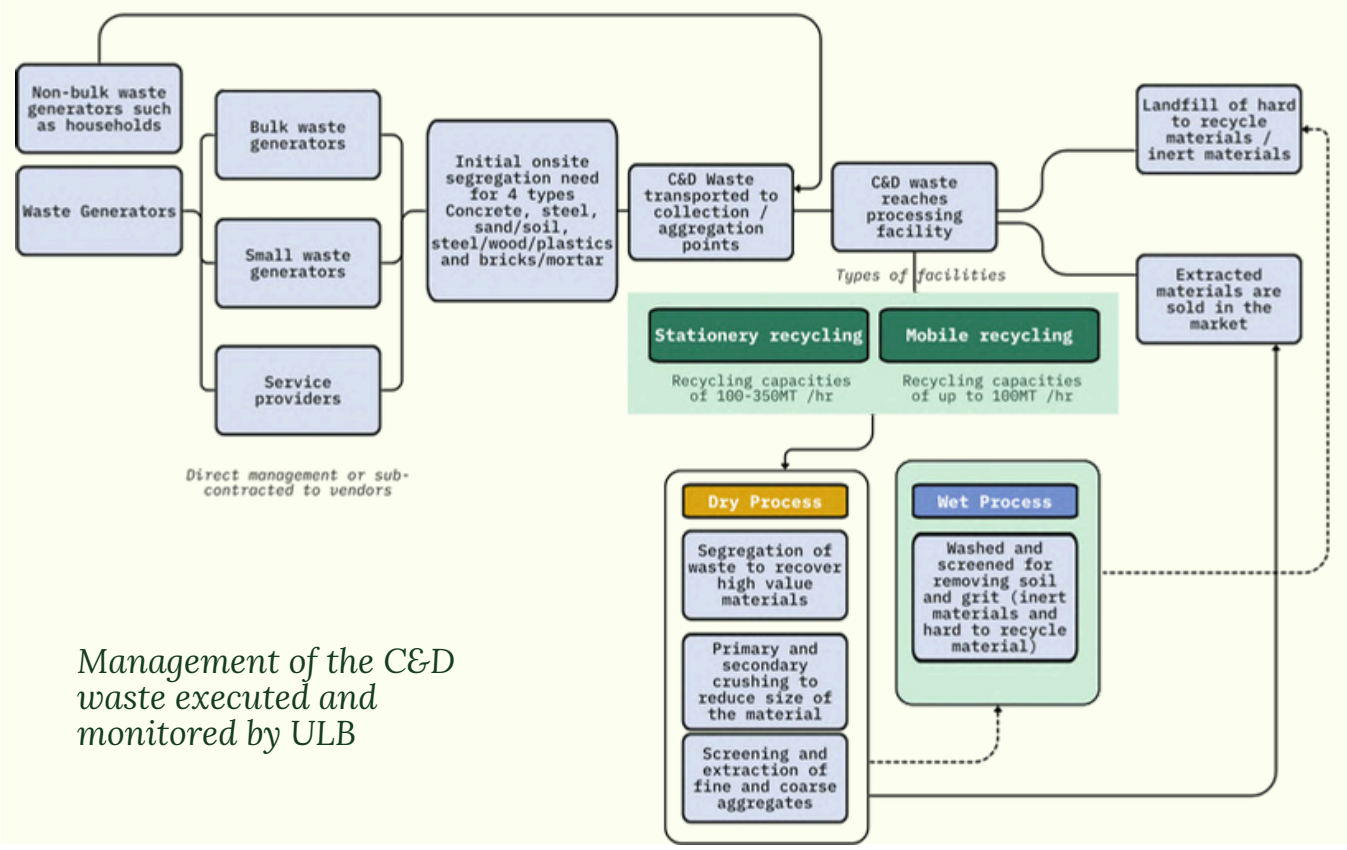


Fig. 11: Value chain and flow of C&D waste recycling in India

Stationary processing facilities for recycling	Mobile processing facilities for recycling
• Stationary facilities are larger in capacity and act as centralised recycling units in a city. • Usually have a capacity of 100 to 350 MT/hour. • Require a higher investment but are considered a more sophisticated technology than mobile plants. • Stationary plants usually include sorting equipment and are suitable for areas of high density. They produce high-quality products if the input is cleanly segregated.	• Mobile plants, on the other hand, have capacities of up to 100 MT/hour. • Suitable for temporary demolition works. • Considered a more basic technology and produce lower-grade recycled aggregates because they lack the cleaning technology. • Potential to produce high-quality aggregate if they deal with homogenous C&D waste. • Mobile plants were considered economically feasible when 5000-6000 MT of waste is being processed on-site.

Note:

1. The selection of the appropriate process for recycling of C&D waste should consider factors such as the type of soil and other geological conditions, quality of segregation, use of end products etc. For example, using the wet process with black soil would create sludge rather than washing away the residue.

2. Informal sector plays a key role in extracting high value products across the value chain

7.1.3 Various uses of the recycled C&D materials

Recycled materials from C&D waste can be effectively used for non-structural applications such as kerbstones, paver blocks, and road construction. Coarse and fine aggregates can partially replace natural sand.

Since raw materials account for 40–60% of construction costs, using recycled inputs not only lowers expenses but also reduces environmental and health risks.

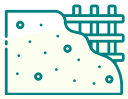
Key processing steps include cleaning, crushing, screening, sorting, pulverisation, and recycling. Common end-uses by material type are outlined below.

Cement

End use:
New cement blocks

Dirt

End use:
Landscaping/ Landfill cover

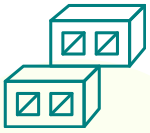


Reinforced concrete

End use:
Crushed, sorted aggregate. For recycling

Clay bricks and roof tiles

End use:
Reused for masonry Aggregate
Mixed with lime to produce mortar



Calcium silicate bricks

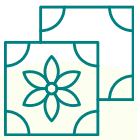
End use:
Reused for masonry Aggregate
Recycled into new Calcium Silicate bricks

Natural stone masonry

End use:
Reused for masonry Aggregate

Natural stone slabs

End use:
Flooring, cladding, aggregate



Ceramic Tiles

End use:
Flooring, cladding, aggregate

Asphalt Paving

End use:
Road construction excluding wearing course

Mixed demolition waste

End use:
Fill material

Steel

End use:
Reused steel components
New steel components

Aluminium

End use:
Aluminium recycled streams

Timber beams, doors

End use:
Reused as shuttering and other products
Feedback for engineered woods

Plastics

End use:
Plastic recycling stream

Gypsum plasterboard

End use:
Reuse as boards
Soil conditioners
New gypsum products

Glass

End use:
Glass recycling streams

7.1.4 Commercial operations of C&D facilities

Larger construction and demolition (C&D) waste recycling plants benefit significantly from economies of scale. While a 1,500 TPD facility requires only 2.5 to 3 times the capital investment of a smaller 200 TPD plant, the per-tonne capital cost drops substantially as fixed expenses—such as land, equipment, and infrastructure—are distributed over a larger volume of processed waste.

According to a study by the Centre for Science and Environment (CSE), setting up a 500 TPD plant costs around ₹12 crore, whereas a 1,600 TPD plant costs approximately ₹22 crore. A typical 1,000 TPD plant also requires about 6 acres of land.

Operational costs range from ₹350 to ₹600 per tonne, and these are highly dependent on the quality of incoming waste and transportation logistics. Clean, well-segregated waste leads to higher quality recycled products and better returns.[17]

For example, recycling 100 tonnes of well-segregated C&D waste can yield sales revenues of around ₹40,000–₹43,000, while waste with a high soil and silt content brings that figure down to about ₹36,000. The quality and composition of the waste have a direct impact on the viability of recycled products, which still face tough competition from conventional construction materials.

Another major barrier is the lack of trust in the quality of recycled materials among construction professionals. This skepticism, combined with variability in feedstock and inconsistent segregation practices, limits market uptake. To overcome this, widespread material testing and public disclosure of results are essential.

Ultimately, the value of C&D recycled products must be established based on their performance in end-use applications, rather than their source or method of production. A robust ecosystem that validates and certifies these products for specific use cases is key to making C&D waste management commercially viable and scalable.

17 Villgro Analysis based on information sourced from CPCB, CSE and Niti Aayog

7.1.5 Regulatory landscape for C&D waste

The Government of India issued the Construction and Demolition Waste Management Rules, 2016 ("C&D Rules") in March 2016 to deal with the issue of rising C&D Waste generation in India, challenge of construction and demolition waste recycling and sustainable use of natural resources.

Recently in July 2024, Ministry of Environment, Forest and Climate Change (MoEFCC) issued draft Construction and Demolition Waste Management Rules, 2024, which came into effect from April 2025.

The policy ecosystem for C&D waste is governed beyond the C&D waste rules enabling in either setting standards or driving market adoption. This includes policies such as

C&D Waste Management Rules	National Building Code	Organisation Specific Rules
• Mandated EPR framework in 2025 for C&D waste, requiring developers to recycle and purchase EPR certificates • Strict monitoring and evaluation, reporting framework for reporting and waste utilisation	• Demand creation and % use mandate of recycled aggregates **BIS Standards** • Standards for recycled aggregates and recycled concrete	• Central Public Works Department (CPWD) and National Building Construction Company (NBCC) have mandated use of recycled portions of C&D wastes • Indian Roads Congress guidance on using C&D for Road Sector • Indian Roads Congress guidelines on use of C&D in construction of roads

Table 8: Key policies in the C&D waste sector

As part of the 2016 rules, three geographical categories have been identified to identify the sites for collection and processing facilities, and commissioning of these facilities by October 2017 and October 2017 – 2019 respectively.

S.no	Action/compliance	Cities with population of 10 lakhs and above	Cities with population of 5 lakhs -10 lakhs	Cities with population of less than 5 lakhs
1	Identification of sites for collection and processing facility	Within October 2017	Within October 2017	Within October 2017
2	Commissioning and implementation of the facility	Within October 2017	Within April 2018	Within April 2019

Waste generators	Required to submit a waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodelling work.
ULB / City local authorities	Co-ordinate (in consultation with Department of Urban Development of the State or the Union territory) with the concerned organisations for giving necessary approvals and clearances to the operatorsShare appropriate incentives to waste generators for salvaging, processing and recycling preferably in situ and make provision for giving incentives for use of material made out of C&D Waste in the construction activity including in non-structural concrete, paving blocks, lower layers of road pavements, colony and rural roads.Arrange appropriate equipment for regular collection and transportation
State department	Responsible for providing suitable sites for setting up of the storage, processing and recycling facilities for construction and demolition and handing over the sites to the concerned local authority for development, operation and maintenance.Mandatorily required to procure materials made from C&D Waste up to a certain percentage (10-20%) in municipal and government contracts subject to strict quality control.

Table 9: Key provisions under the rules include responsibilities and key activities for C&D waste management.

The 2025 rules introduces Extended Producer Responsibility (EPR) for C&D waste management, requiring developers and waste generators to comply in reporting and managing their entire C&D waste. Some other key updates include:

Producers with built-up area of 20,000 square meters and above projects become eligible for the stricter EPR framework	Waste Management Plans (WMPs) to be submitted and approved before project clearances	Only the debris part of the waste such as cement concrete, bricks, cement plaster, stone, rubble, tiles etc. shall be considered for EPR and not resalable/ reusable streams of waste like iron, wood, plastic, metal and glass.	EPR target fulfilment via certified recyclers and use of digital platform for registration, issuance of EPR certificates and monitoring (by CPCB) including Manifest-based waste tracking from site to processor, before-after photo records & VTM-enabled vehicles	Mandatory use of recycled materials in new works for the government projects - The target for minimum utilisation for 2026-27 is 5% and increases to 25% from the year 2030-31 onwards. For road construction, the minimum target from the year 2030-31 onwards is 15%.

The Bureau of Indian Standards (BIS) has amended specification for coarse and fine aggregate for concrete (Third Revision) (IS: 383-2016) to include "manufactured aggregates produced from other than natural sources" for use in the production of concrete for normal structural purposes including mass concrete works. These manufactured aggregates are of two types namely:

- Recycled Aggregate (RA): It is made from C&D waste which may comprise concrete, brick, tiles, stone, etc.
- Recycled Concrete Aggregate (RCA): It is derived from concrete after requisite processing.

In addition, National Building Code (NBC- CED 46) of India 2005: Part 11 of NBC 2005 on 'Approach to Sustainability' (Chapter 11), states that:

(a) Recycled Coarse Aggregate may be used in concrete for bulk fills, bank protection, base/fill of drainage structures, pavements, sidewalks, kerbs and gutters etc.

(b) Up to 30% of natural crushed coarse aggregate can be replaced by the recycled concrete aggregate.

(c) This percentage can be increased up to 50% for pavements and other areas which are under pure compression specific to the standards and practices pertaining to construction of roads.

The Central Public Works Department (CPWD) and National Building Construction Company (NBCC) have mandated use of recycled portions of C&D wastes in their construction activities or if the same is available within 100 km from the construction site. In addition, CPWD, and NBCC promote (a) maximum of 20% replacement of aggregates in RCC with RCA, (b) for load bearing structures, up to a maximum of 20% of course and fine RCA can be mixed with RCC and (C) 100% replacement of aggregates with RCA in light or non-load bearing lean concrete.

The Indian Roads Congress (IRC) has issued 'IRC-121:2017 Guidelines for Use of C&D Waste in Road Sector' outlining what kind of materials from recycled C&D waste and in what proportion, may be safely used for specific road construction/repair applications.

7.1.6 Financing ecosystem for C&D waste

01 Swachh Bharat Mission – Urban 2.0

In addition to the C&D Rules, one of the focus areas under the Swachh Bharat Mission – Urban 2.0 - Operational Guidelines, October 2021 issued by MoHUA ("SBM 2.0") is management of Construction and Demolition Waste.

SBM 2.0 envisages a cost of INR 600 crores for C&D waste management catering to a population of 17.14 crores with central government share @INR 378 crores, state/ULB and private sector have a share of INR 111 crores each.

154 ULBs constitute of non-attainment cities and remaining cities with population greater than 500,000, can avail funding for procuring mechanised sweeping equipment and setting up processing facilities for effective management of C&D waste.

Potential to execute PPP models and extend support as viability gap funding, where applicable, for municipalities.

02 National Clean Air Programme

MoEFCC launched the National Clean Air Programme (NCAP) in 2019 with the aim of improving air quality at the city, regional and national levels. NCAP targets 131 non-attainment cities to reduce particulate pollution by 20–30% from 2017 levels by 2024, with a subsequent goal of achieving a 40% reduction by 2026.

C&D waste management is critical to reduce air pollution in cities and approximately INR 9,650 crores has been allocated to these cities from FY 2019–20 to FY 2023–24 (until 15 December) under NCAP.

200 TPD C&D recycling plant was set up at Pimpri-Chinchwad with the help of funding received through this scheme.

03 15th Finance Commission

Besides the specific funding earmarked for NCAP, the funding from 15th Finance Commission serves as a performance-based supplemental grant to address the critical funding gaps in clean air plans.19 This allocation totals INR 29,250 crore for ULBs and operates on a performance-linked basis. The city of Pune has utilised these funds to make C&D collection points in the city.

04 Public Private Partnership Models

The PPP model has emerged as the dominant one with most C&D recycling plants being set up in the country through this route. Under the PPP model, land is provided by the municipality, while the plant is set up and operated by a private party for a fixed number of years (generally, 15–25 years). After the set duration, the land is transferred back to the municipality. The risk lies with the plant operator to recover the cost of setting up of the plant and generating profit within the lease period. It is also called the Design-Build- Operate-Transfer model.

C&D recycling plants in larger cities such as Delhi, Pune, Gurugram, Noida, Greater Noida, Hyderabad, Thane, Ghaziabad, Kolkata and Hyderabad have used this model to set up and operate their plants.

05 Private sector

Private investments into the waste management sector have been increasing over the last few years. Some of the largest investments include the acquisition of the entire stake of integrated waste management company, IL&FS Environmental Infrastructure & Services Ltd (IEISL) by EverEnviro Resource Management Pvt Ltd, a wholly owned subsidiary of Green Growth Equity Fund (GGEF), India's leading climate fund, managed by EverSource Capital.

IEISL used to operate the C&D recycling plants in Delhi including the one at Burari. KKR, one of the largest US private equity firms purchased a 60% stake in Re Sustainability (formerly Ramky Enviro Engineers) which operates the C&D waste recycling facilities in Hyderabad.

7.1.7 Stakeholder ecosystem for C&D Waste management

While governments at central, state and local level play a key role in the policy and overall management of C&D waste, the private sector also contributes to these efforts. Some of the stakeholders working across the value chain (with single or multiple touch points) are as follows.

Name of the entity	Details of activity
Collection of C&D Waste [1]	
Antony Waste Handling Cell Ltd	Collects and transports C&D waste in cities where they are operational and provide other waste management services.
Pragati AL Natural Resources Pvt Ltd	Concessionaire appointment by the Gurugram municipality for C&D waste collection, transportation, management of collection centers, waste assessment, database maintenance, and operating an IoT-based customer interface solution.
Saahas Zero Waste	Collect C&D waste from bulk waste generators who are carrying out renovation work. These are need-based collection and quantities not exceeding 50MT.
Start-ups [2]	
Angirus Ind Pvt Ltd	To replace clay-based bricks with sustainable, it manufactures bricks and paver blocks, made from recycled plastic and industrial waste.
Recyclex	Recyclex has developed an innovative composite material that uses plastic and industrial waste to manufacture blocks and bricks.
Earth Blocks India Pvt. Ltd.	Manufactures Compressed Stabilized Earth Blocks (CSEB), Compressed Earth Blocks (CEB), and Compressed Soil Mud Blocks (CSMB) using soil from construction site excavations, mixed with 6-9% Portland cement and water. This prevents the soil from being discarded in landfills, roadsides, or water bodies.
Rhino Machines Private Limited	Manufactures Silica Plastic Blocks - a sustainable building brick that is made from recycling foundry dust/sand waste (80%) and mixed plastic waste (20%).
Zerund Manufacturing Pvt. Ltd.	Manufactures bricks using multi-layered plastic along with fly ash, sand, water, cement, lime, gypsum and an organic chemical.

Greenjams	Manufactures building material made of crop residues and industrial by-products.
Strawcture Eco	Manufactures panels made of more than 90% straw (leftover from wheat, harvesting of rice, sugarcane etc) and a proprietary binding adhesive which is compressed at a high temperature & pressure.
Recycling of C&D Waste	
EverEnviro Resource Management Pvt Ltd [3]	Operates India's largest C&D waste processing plant in Delhi with a capacity of 2,000 metric tonnes per day, using CFlo technology for efficient recycling and producing high-quality output for the circular economy.
Re Sustainability andRecycling Pvt. Ltd	Set up and operates C&D waste recycling plants in Kolkata, Noida, Hyderabad, Vishakhapatnam with operational capacity between 150 TPD to 1600 TPD
Rise Eleven concreteproduct private limited	Set up and operates C&D waste recycling plants in Agra, Noida, Delhi with operation capacity between 20 TPD to 1000 TPD
Rock Crystals	Rock Crystals is a C&D recycling facility which is empanelled by the Bengaluru municipality to process the C&D waste generated in the city. It has a capacity of 1000 MT per day and uses the dry processing method.
Sobha Concrete Products Limited	Sobha Developers is a leading construction company in Karnataka, and it has set up its own C&D recycling plant which manages C&D waste generated by its construction activities and C&D waste from other sources.

Table 10: Key stakeholders across the C&D waste value chain

Useful resources on C&D waste:

- Rubble Recast, Navigating the Road to Efficient C&D Waste Recycling, CSE (2024) at https://www.cseindia.org/rubble-recast-navigating-the-road-to-efficient-c-d-waste-recycling-12386
- Construction and Demolition waste: Closing the waste loop for sustainability, CSE (2023) AT https://www.cseindia.org/construction-and-demolition-waste-11992
- Waste Wise Cities, Best Practices in municipal solid waste management, CSE and Niti Ayog, (2021) at https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf

[1] Many informal players exist in the C&D waste collection value chain. In addition, in many cities with the C&D waste processing facilities, the entities operating the plants also carry out transportation of C&D waste.
[2] The startups are not making products of C&D waste, but their products reduce the use of conventional building materials, which in turn reduces the quantum of C&D Waste.
[3] IL&FS has sold its stake in Environment business - IL&FS Environmental Infrastructure & Services Limited ("IEISL") and its subsidiaries - to EverEnviro Resource Management Private Limited, a 100% owned subsidiary of the Green Growth Equity Fund ("GGEF"), India's leading climate fund, managed by EverSource Capital.

7.1.8 Key challenges

The effective management of Construction and Demolition (C&D) waste faces several environmental, health, and operational hurdles, including:

Lack of Designated Collection Points

Absence of proper collection points leads to unauthorized dumping, creating safety hazards, environmental issues, and damaging green spaces, water bodies, and public areas.

Air Pollution

Toxic dust particles from construction debris significantly degrade air quality, contributing to particulate matter (PM 2.5 and PM 10) levels exceeding National Ambient Air Quality Standards, as seen in Delhi.

Illegal Dumping and Encroachment

C&D waste is often dumped illegally, causing environmental degradation. In Bengaluru, for example, C&D waste is used to encroach on lake-bed land for construction purposes.

Lack of Segregation

Improper sorting and mixing of C&D waste with other waste streams reduces the quality of recycled input, impacting the value of the final products.

Financial Constraints

Limited financial support for C&D waste management in Tier II and III cities, coupled with inconsistent waste inflows, hampers the scalability of recycling operations.

Informal Sector Involvement

A significant portion of waste collection is handled by the informal sector, with valuable materials being salvaged, while the remainder is dumped improperly.

Enforcement Gaps

There is insufficient enforcement of C&D Waste Management Rules, particularly the mandate for municipalities and government contracts to source a percentage (10-20%) of recycled products, which often lack strict quality control.

Expensive and Land-Intensive Recycling

The costly wet processing and the large land area required for sorting and segregating waste hinder the production of high-quality end products from C&D waste.

Limited Technological Development

The lack of mobile crushing and processing mechanisms, coupled with insufficient testing of recycled C&D products, further slows progress in waste management.

7.1.9 Scope for innovation

Startups like Saltech, which transforms single-use plastics, construction and demolition (C&D) waste, industrial minerals, and fly ash into alternative composite building materials, are pioneering solutions in the C&D waste sector.

However, the journey towards circularity in C&D waste is not just about downstream management but also upstream innovation—such as creating more climate-friendly building materials.

GreenJams, based in Visakhapatnam, exemplifies this by producing Agrocrete, a sustainable building material made from agricultural residues like paddy straw, cotton stalks, and bagasse, thus leading the way in circular construction materials.

In the C&D waste collection space, startups like Malba Project are offering specialized services through a network of authorized haulers. Their Malba Map dashboard tracks C&D dumping spots and processing infrastructure across Delhi, bringing greater transparency and efficiency to waste management.

The potential for innovation in this sector is vast, from mobile C&D waste processing units and recycled construction materials to logistics platforms and high-value material recovery.

Given the existing challenges and gaps, startups have a crucial role to play in scaling solutions for urban local bodies (ULBs) and corporations, reducing C&D waste in landfills, and advancing circularity in construction.

01

Recycling Tech for Specific Components

Explore recycling technologies such as Plaster Of Paris, ceramics, and glass by improving sorting, segregation, and cost-effective processing methods.

02

Efficient Waste Storage and Transportation

Offered as semester-long programs where students assist faculty in ongoing research projects. Participants gain hands-on experience and present their findings in university-hosted research symposia.

03

Mobile Recycling Enhancements

To improve output quality and operational efficiency.

04

Air Pollution Reduction in Waste Collection

Design C&D waste collection vehicles that reduce air pollution during loading and unloading activities.

05

Dust Mitigation and Control

To improve air quality during the recycling process.

06

Improving Recycled Aggregate Quality

To increase their potential for replacing natural aggregates.

07

Digitization for racing

Implement digitization for waste traceability and data transparency throughout the C&D waste value chain.

08

Advanced Material Testing

To ensure only high-quality recycled products enter the market, enhancing their ability to replace natural materials.

09

Circular Solutions in Construction

Encourage architectural, design, and construction companies to develop and commercialize circular solutions using materials from C&D waste for interior design and structural purposes (e.g., Supreme Court's new block built using C&D waste components).

10

Repurposing Salvaged Materials

Repurpose salvaged materials like wood for construction (e.g., a U.S. startup reclaims wood waste and repurposes it into durable lumber products).

11

Marketplace for C&D Waste Products

Create a marketplace for construction businesses, developers, homebuilders, and merchants to buy, sell, or donate unused construction materials or products made from C&D waste.

7.2 Wet Waste in India

"Biodegradable waste" under SWM Rules 2016 means any organic material that can be degraded by micro-organisms into simpler stable compounds. .The definition overlaps with similar terminology such as agri-residue, floral waste, horticulture waste, slaughterhouse waste and coconut waste – but the governance and management of most of these wastes come under the operational purview of an ULB.

7.2.1 Overview of the wet waste in India

Wet waste is a growing challenge in India, with per capita generation increasing from 0.25 kg per day in 2010[18] to around 0.5 to 0.6 kg per day (CSE, 2018). This now constitutes nearly half of the total municipal solid waste generated in the country. The lack of proper segregation results in contamination of dry waste streams, which in turn lowers recycling rates due to moisture content. Addressing wet waste segregation and processing can solve half of India's waste management issues and indirectly improve the segregation of dry waste, enhancing overall recycling capacities.

[19]

95,000 to 100,000 TPD
of wet waste generated every day in India

45,000 TPD
of processing capacity needed for wet waste in India as per SBM 2.0

30-35%
of the wet waste goes untreated

INR 2500 Cr
per year of additional benefits by processing wet waste

In addition to the defined waste streams as per the definition of wet waste, there are also some special waste streams which come within the ambit of biodegradable waste and these include:

- **Slaughterhouse waste** comprise the inedible tissues/parts of the animals slaughtered for production of meat, as well as blood, fat, bones, and other materials found associated during the processing of slaughtered animal.
- **Coconut waste** includes husk and coconut shells which are typically discarded after consumption of the fruit.
- **Floral waste** is dried or decayed flowers which are generated in religious institutions, weddings, other events and ceremonies etc.
- **Horticulture waste** includes grass and wood clippings, weeds, woody 'brown' carbon-rich material such as pruning, branches, twigs, wood chipping, straw or dead leaves and tree trimmings.
- **Agricultural waste** are the wastes from the growing and processing of raw agricultural products such as fruits, crops, vegetables such paddy husk, sugarcane etc. Within agricultural waste, there is processing of specific waste streams such as banana stem, sugarcane bagasse, jute waste, corn waste etc. and conversion of these waste streams into useful products.

In addition to the above, there is biodegradable waste that is generated at the pre-consumption segment encompassing food brands and manufacturers, wholesalers and distributors and retailers. Typically, this waste is generated on account of excess or defective produce and expired food.

[18] https://cdn.cseindia.org/docs/5thnational-knowledge-conclave/Status-of-Solid-waste-management-implementation-challenges.pdf

[19] https://timesofindia.indiatimes.com/india/recyclable-city-waste-may-help-generate-30k-crore-a-year-govt-report/articleshow/91608114.cms

7.2.2 Key challenges

Environmental	Health	Operational	Financial
Greenhouse gas emissions like methane that contribute to global warming and dumpsite fires. Contamination of water bodies during the rainy season when runoff is discharged into open waters. In addition, soil and ground water is also contaminated due to leachate from mixed waste through the soil.	Spread of diseases such as dengue, typhoid, malaria etc due to breeding of mosquitos and microorganisms in stagnant water pools found on the dumpsites. In addition, there are other potential health hazards caused by vermin, flies, and scavenging animals, which can affect workers and nearby residents.	Poor segregation from households leads to dumping of mixed waste Inadequate testing facilities for compost produced at large integrated waste management facilities Operational viability of large scale composting plants due to inadequate feedstock or marketability of city compost Mismanagement in handling of different wet waste streams resulting in loss of opportunity to produce specialised products such as pet food, textile dyes, cooking essence, fragrances etc. Absence of traceable frameworks (similar to EPR credits) for incentivizing wet waste management. Lack of adequate technologies for biomethanation in colder climates, purification techniques, offtake and/or market for biogas among others	Limited sources of revenues for wet waste processing facilities Lack of financial viability in operating large composting facilities.

Table 11: Key challenges for wet waste management in India

7.2.3 How does the value chain work for wet waste management?

The flow of municipal solid waste from generation to disposal including all the intermediate steps/activities such as primary and secondary collection, sorting, processing (such as composting & bio methanation) and disposal in landfills.

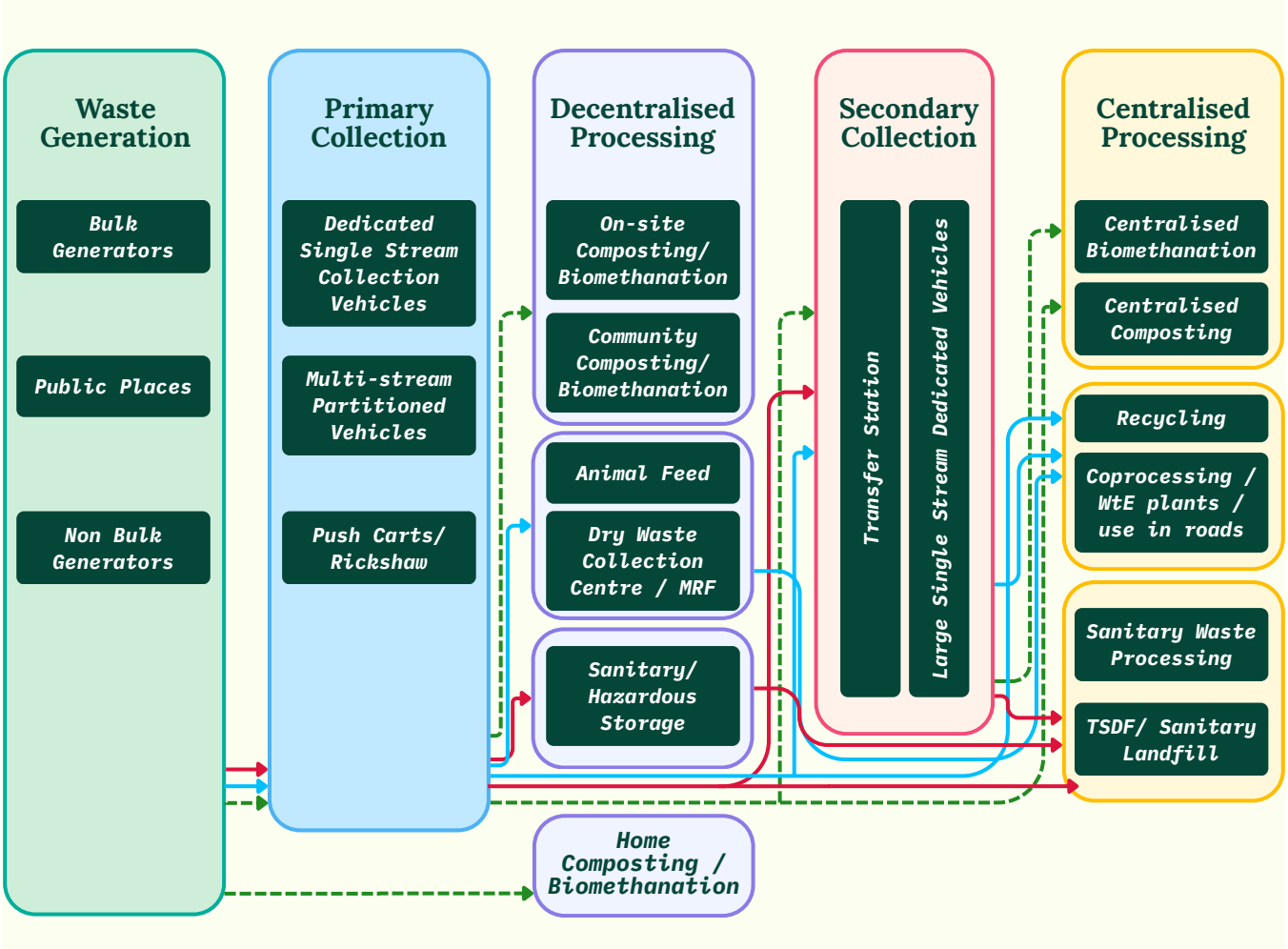


Fig. 12: Value chain and flow of wet waste recycling in India

Processing of wet waste can be conducted largely in two methods which derive value added and low-carbon natural products.

	Composting	Bio Methanation
Process	Converts biodegradable waste into nutrient-rich compost via biochemical decomposition.	Anaerobic digestion of wet waste to produce biogas (methane) and fertilizer sludge
Methods	Vermicomposting, windrow, aerobic/anaerobic, in-vessel (ideal for >2 TPD waste)	Small (< 2TPD), Medium (2-50 TPD) and Large scale (>50TPD) capacity plants

	Composting	Bio Methanation
Impact and benefits	Low-tech, scalable, improves soil quality (water retention, nutrients), reduces GHG emissions.	Handles high-moisture waste, compact, odour-free, reducing GHG emissions Commercial value is higher with biogas and manure
Challenges	Requires space (except in-vessel) and time for processing (≥30 days)	High upfront costs, 75% energy loss in electricity conversion, sludge transport logistics
End-use products	Organic manure for plants and gardens	Biogas for cooking, electricity, or compressed (CBG) as CNG alternative Organic manure as an alternative to fertilisers

Table 12: Key solutions for wet waste recycling

Composting suits decentralized, low-budget setups, while bio methanation offers energy recovery but needs investment and infrastructure. The chart below provides an assessment of the key elements in the value chain of processing wet waste to biogas.

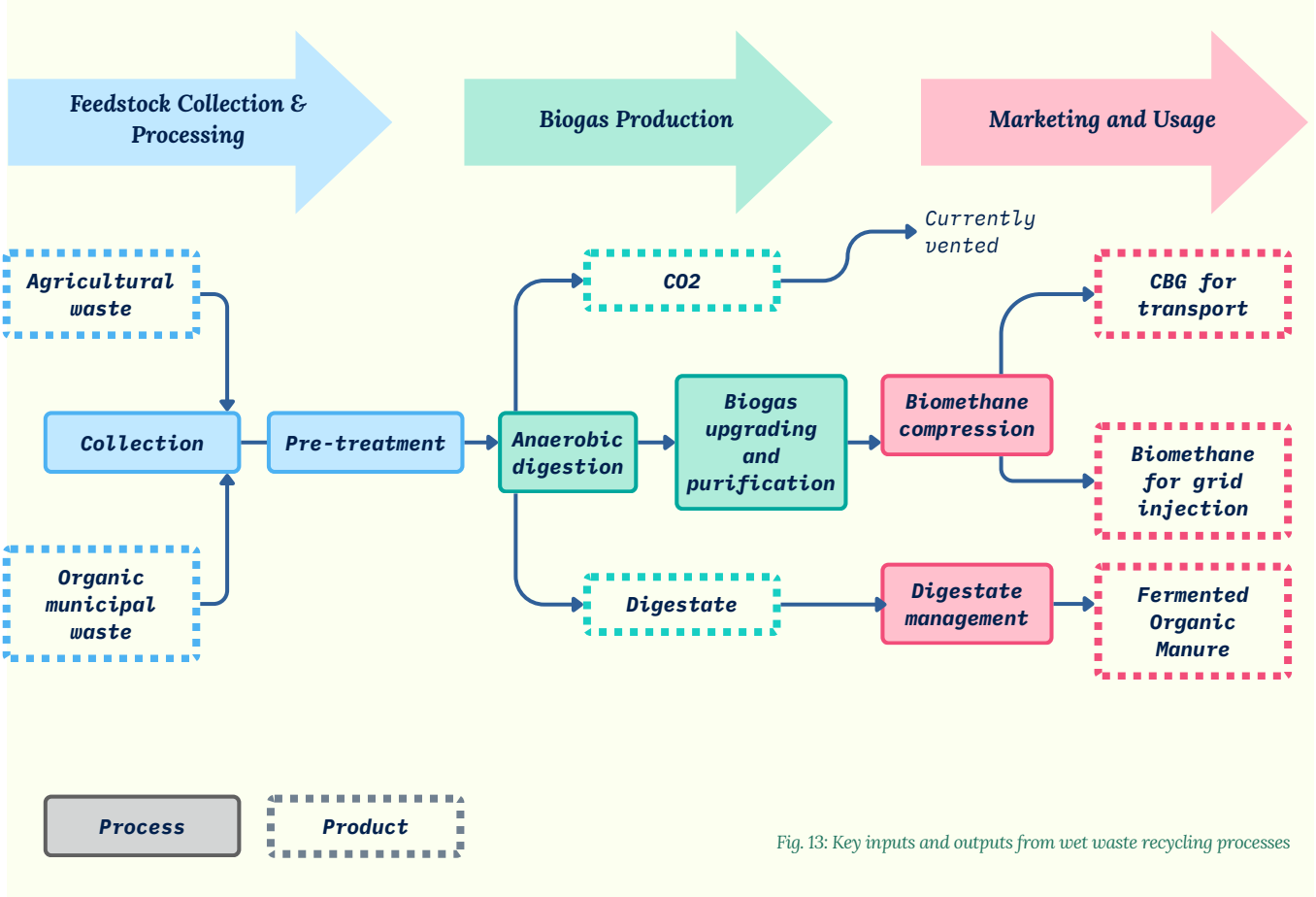


Fig. 13: Key inputs and outputs from wet waste recycling processes

7.2.4 Regulatory framework for wet waste

India's regulatory framework for wet waste management is strengthened by the introduction of the Solid Waste Management (SWM) Rules 2016. These rules mandate Bulk Waste Generators (BWGs) —entities generating over 100 kg of waste per day or occupying over 5,000 sq.m of area—to process wet waste on-site through composting or bio-methanation where feasible. The SWM rules focus on decentralized processing methods like vermicomposting and anaerobic digestion to reduce transportation costs and environmental impact, while also promoting compost use and establishing quality standards through agricultural ministry guidelines.

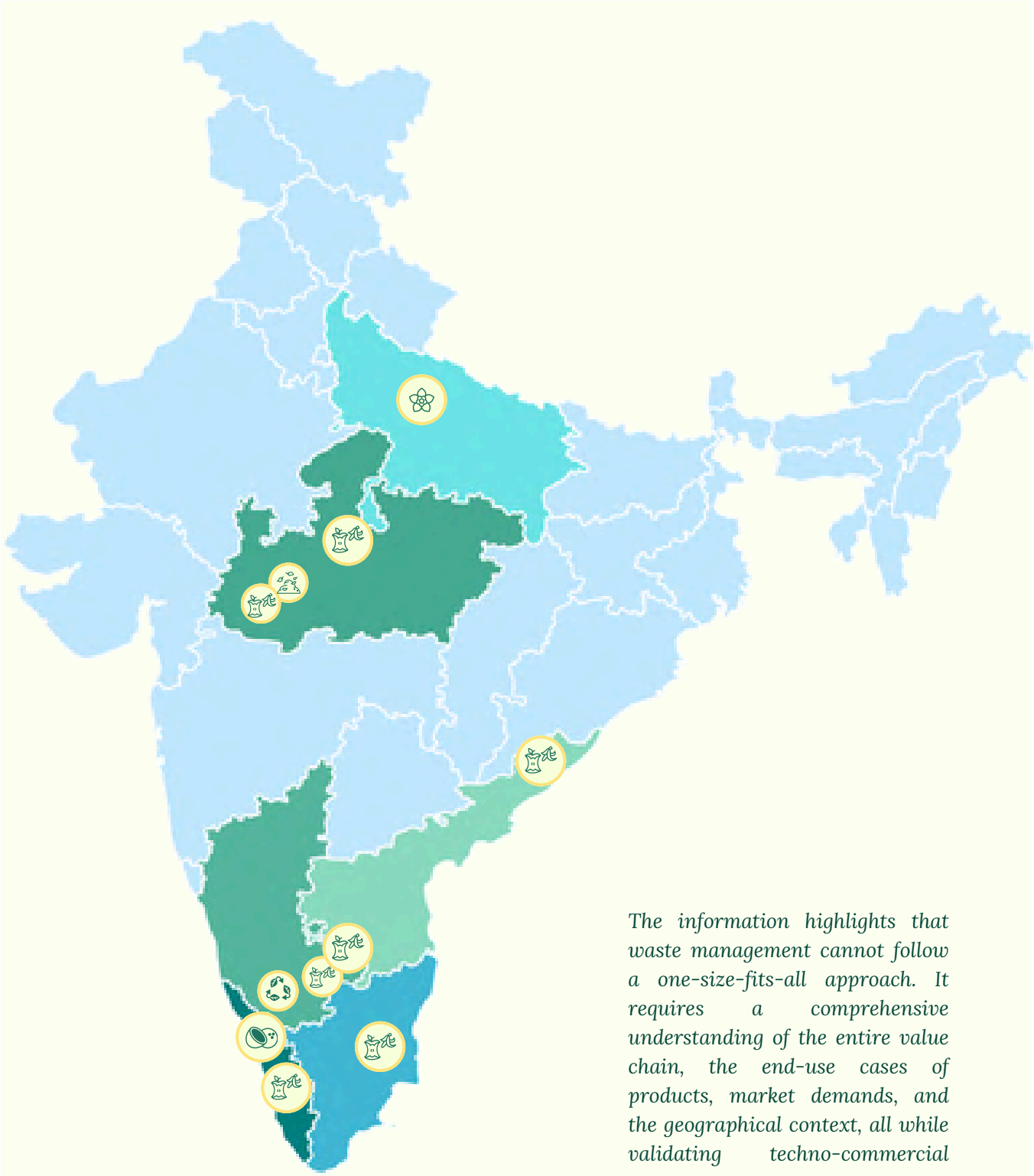
The draft SWM Rules 2024 expand the BWG definition to include entities with a built-up area of ≥20,000 sq.m, high water consumption, or non-industrial waste generation. These entities are required to register on a centralized portal, report waste management activities annually, and face penalties for non-compliance. BWGs lacking on-site processing capacity must obtain an Extended Bulk Waste Generator Responsibility (EBWGR) Certificate and outsource waste processing to authorized third parties. The rules also enforce environmental compensation (fines) and set stricter compliance deadlines (6–18 months for urban areas), while mandating local bodies to manage agricultural and horticultural waste and standardize compost quality through third-party testing.

The SATAT scheme further promotes Compressed Biogas (CBG) production from organic waste, partnering with oil companies to market CBG as a green fuel alternative, while allowing entrepreneurs to monetize by-products like bio-manure.

Despite these efforts, challenges remain, including weak enforcement of BWG mandates, limited market demand for compost and CBG, funding gaps for small-scale infrastructure, and logistical issues in sludge management. Addressing these challenges requires stricter penalties, subsidies for compost adoption, and standardized quality protocols to fully unlock the potential of wet waste.

7.2.5 Best practices in wet waste management

The following section showcases the key learnings from case studies from India – action from ULBs, corporates and start-ups - in order to assess the best practices and processes in wet waste management.



The information highlights that waste management cannot follow a one-size-fits-all approach. It requires a comprehensive understanding of the entire value chain, the end-use cases of products, market demands, and the geographical context, all while validating techno-commercial parameters.

Fig. 14: Example project case studies in wet waste management

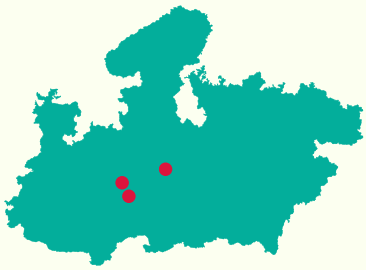
Project	Impact	Capacity

Kanpur, Uttar Pradesh

Centralized Kanpur Floral Waste (Phool)	Reduces Ganga pollution; **400 incense sticks/hour,** compost	3-4 TPD floral waste → 15% reject

Indore, Madhya Pradesh

Decentralized Bio methanation Plant	Reduced transport costs (₹3L/day saved), Bio-CNG for buses, compost sales	20 TPD → 800 kg Bio-CNG, 6 TPD compost



Devguradia, Madhya Pradesh

Centralized Biogas Facility	Asia's largest biogas plant; powers 50% city buses, SATAT/GOBARdhan aligned	550 TPD → 17,000 kg Bio-CNG, 100 TPD compost

Bhopal, Madhya Pradesh

Hybrid Bhopal Waste Management	Processes 50 TPD locally; reduces transport emissions	410 TPD composting + 105 TPD biogas

Bobbili, Andhra Pradesh

Decentralized Bobbili System	Zero wet waste to landfill; biogas for cooking, compost for farmers	7.5 TPD wet waste

Harohalli, Karnataka

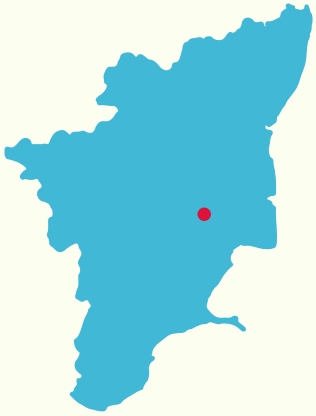
Project	Impact	Capacity
Decentralized CBG Plant	Diverts waste from landfills; Bio-CNG for restaurants, compost for farmers	30 TPD capacity (15 TPD operational)

Bengaluru, Karnataka

Project	Impact	Capacity
Decentralized Bengaluru BWG Compliance	Ensures 100% segregation; reduces municipal burden	Mandatory for 100+ kg/day generators

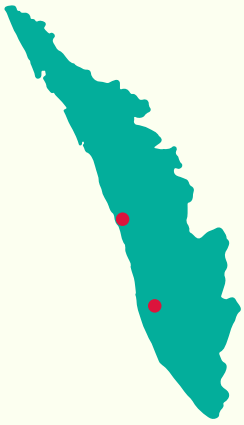
Mysuru, Karnataka

Project	Impact	Capacity
Hybrid Mysuru Zonal Composting	Sells compost (₹1,200/MT; ₹200-400/MT if buyer transports)	25 TPD (decentralized) + 200 TPD (central)



Tiruchi, Tamil Nadu

Project	Impact	Capacity
Decentralized Tiruchi MCCs	Empowers 677 women SHGs; compost sold at ₹1/kg	60 TPD total (1-2 TPD/MCC)



Kunnamkulam, Kerala

Project	Impact	Capacity
Decentralized Kunnamkulam Coconut Waste	Converts husks to coir fiber/coco peat; supports SHGs	14-15 days sun-drying + defibering

Alappuzha, Kerala

Project	Impact	Capacity
Decentralized Alappuzha Tanks	Prevents water pollution; community-driven waste management	2 MT/tank (165 tanks)

7.2.6 Key stakeholders across the value chain

Name of the entity	Details of activity
Pre-consumer food waste	
Waste-link	New Delhi-based start-up converting commercial food waste (such as food by-products, surplus materials, and produce rejects) into animal feed.
Loop worm	Bengaluru-based agri-biotech startup "Loopworm" is engaged in the farming of Black Soldier Fly (BSF) Larvae that converts food waste to produce premium animal feed and pet food.
Ento Protein	They utilise Black Soldier Fly (BSF) larvae to convert pre-consumer organic waste into high-quality protein and oil products for aquaculture, poultry, and pet feed industries.
Collection and decentralised waste management especially service providers to BWGs	
Saahas Zero Waste	Bengaluru based company which provides services to BWGs and sets up and operates onsite wet waste management units for such BWGs including composting and bio methanation. They provide services to BWGs located in Bengaluru, Chennai, Delhi NCR, Goa, Hyderabad etc.
Hasiru Dala Innovations Private Limited	Bengaluru based company which provides services to BWGs which collects wet waste from the BWGs for processing at their decentralised biogas plants set up in collaboration with Carbonlites in Harohalli, Karnataka.
Swaaha Resource Management Private Limited	Swaaha provides indigenously designed and developed wet waste management technology solutions and services to BWGs in Indore, Ujjain, Bhopal, Pune, Goa and Coimbatore.
Eco-Wise Waste Management	Located in Noida, Uttar Pradesh, they provide waste management services to BWGs
Earth Recycler	Chennai based SWM service provider empanelled with the municipality which provides wet waste management services to BWGs through different composting techniques and bio methanation.

Northamps ENV Solutions	Kerala based waste management company that provides waste management services to local bodies and companies.
ULB level wet waste management	
IL&FS Environment	Sets up and operates ULB-level waste processing facilities which processes wet waste through windrow composting. It operates wet waste processing facilities in Delhi, Punjab, Kerala, Karnataka, Tamil Nadu.
Antony Waste Handling Cell Ltd	Provides wet waste collection, transportation and processing services at the ULB level and the wet waste processing is carried out using windrow composting technique. They are operational in Greater Noida, Mumbai, Nagpur, Mangalore, North Delhi, Varanasi etc. It is also one of the few publicly listed waste management companies.
Ramky Enviro Engineers	Provides wet waste collection, transportation and processing services at the ULB level and is operational in Hyderabad, Delhi, Kolkata, Guwahati, Chennai, Mumbai, Aurangabad, Ajmer, Cuttack etc. The wet waste is typically processed using windrow composting technique.
MSGP Infra Tech	Operates a large windrow composting facility in the outskirts of Bengaluru
Wet waste processing through bio methanation	
Carbonlites	Carbonlites, a brand of Carbon Masters India Pvt. Ltd., offers modular and other biogas solutions by converting wet waste into bio-compressed natural gas (bio-CNG) and organic fertilizers. They service BWGs such as hotels and have also set up units for ULBs in Karnataka, Telangana and Tamil Nadu
Carbon Loops	Specialize in decentralized waste-to-energy solutions, transforming organic waste into clean energy and compost. Their approach not only reduces landfill dependency but also promotes circular economy practices in urban areas.
GPS Renewables Pvt Ltd	GPS designs modular biogas units for decentralised waste management systems in corporate campuses/BWGs (i.e. with a capacity of 200 kgs to 2 MT per day) as well as large scale biofuel projects at a city level with a capacity to process 400 to 600 MT per day. The city level projects are based in Madhya Pradesh.
Ahuja Engineering Services	It specialises in providing environmentally sustainable and financially viable turnkey solutions in the biofuels and solid waste management sectors. They are present across the country in Delhi, UP, Gujarat, Telangana, Andhra Pradesh, Karnataka etc.

LR Energy	Provide compressed biogas solutions for biodegradable waste and their existing projects are based in Haryana.
EverEnviro Resource Management Pvt Ltd	It was established in 2019 by Eversource Capital and specialises in waste-to-energy initiatives. EverEnviro manages wet waste fractions in municipal and agricultural waste. It operates the 550 TPD biogas plants in Indore.
TruAlt Bioenergy	One of India's largest biofuels producers, primarily in the production of Ethanol. It has now diversified into CBG and has entered into a joint venture with GAIL India to establish 10 CBG plants
Agrogaz (Primove Engineering)	They primarily provide biogas solutions for agricultural residue but do claim process organic waste fraction of MSW as well.
Urja Bio System Private Limited	Pune based company that designs and installs prefabricated-biogas digesters, floating/fixed Domes, biogas storage balloons and engines. Their projects are predominantly based in Maharashtra.
Start-ups in wet management Swachhata Startup Challenge organised by Ministry of Housing and Urban Affairs	
Mangala Resource Management Institute	Ramakrishna Mission has launched a startup dedicated to handling wet waste
Pelican Kenterra	Kerala-based start-up developed a patented technology to convert biodegradable waste into a soil-less planting medium, using low electrical conductivity. This planting medium is sold to municipalities for road median gardening
WeVOIS Labs	IoT-based door-to-door waste collection services which include operations, fleet monitoring of waste collection vehicles and other SWM operations
Nellikka Complete Solutions Pvt Ltd	Kerala based waste management company that provides waste management services along with software technology for digital mapping and automated messaging.
KNP Arises Green Energy	Marketplace for the disposal of used cooking oil. It then converts the used oil into biodiesel
Trashback India	Web and mobile applications providing on demand waste collection and recycling services for different waste types
Jivoule Biofuels	Transforms biodegradable waste including agricultural waste,etc. into biomethane or CBG or renewable natural gas (RNG).
E&P Community Farms	Uses different processing technologies for management of wet waste and their existing projects are in Delhi, Vishakhapatnam, Hyderabad etc.

Processing of special wet waste streams	
Phool	Collect temple flower waste in Kanpur and other temples across India and creates useful products such as incense and vermicompost.
Nirmalaya	Converts floral waste from temples in Delhi to incense sticks, cones etc.
Reichwerde Industries	This company specialises in converting coconut shells into high-quality charcoal products, including coconut shell charcoal and hexagonal charcoal briquettes. Additionally, they manufacture coir pith blocks from coconut husk waste.

Table 13: Key stakeholders in the wet waste management value chain

7.2.7 Scope for Innovation

Some of the examples of potential opportunities that can be explored with the intervention of innovations (technology and models) for wet waste management are as follows.

Advanced composting solutions

Start-ups can focus on developing scalable alternatives like black soldier fly composting method to mitigate odour/space issues associated with centralised windrow composting. These solutions can also be scaled further with improvement in technologies and operation costs.

Specialized waste stream processing

can be accelerated with dedicated collection and recycling systems for floral, coconut, and banana stem waste to produce dyes, fragrances, or textiles. Decentralised models can be adopted depending on the scale.

Biomethanation

can be accelerated further with development in biomethanation technologies for cold climates, upgraded purification for wider industrial use, and grid injection for CBG distribution. This should be supported by building awareness and creating measures for adoption of organic manure such as testing, branding, farmer training among others.

Efficient and reliable testing infrastructure

could be developed by startups and businesses enabling faster compliance and better marketability of compost from centralised and decentralised facilities.

Digital credit systems

can enable track and trade of wet waste credits for BWGs, aligned with SWM Rules 2024.

Food waste reduction

can be achieved with affordable refrigeration for large-scale donations and tech to convert expired food into animal feed (poultry, fisheries).

Useful resources on wet waste:

- Swachh Bharat Mission, Municipal Solid Waste Management Manual, Part II: the Manual, CPHEEO, Ministry of Urban Development at https://mohua.gov.in/upload/uploadfiles/files/Part2.pdf
- https://www.cseindia.org/decentralized-management-of-segregated-organic-waste-10877
- https://sbmurban.org/storage/app/media/pdf/Waste%20to%20Wealth.pdf

7.3 Textile Waste in India

Textile waste refers to any discarded or unwanted textile material or product that is no longer in use or suitable for its original purpose. It is a component of municipal solid waste and, as such, falls under the same legal framework, governing authorities, and waste management systems as other municipal solid waste fractions.

It is important to distinguish this from waste generated during the textile production or manufacturing process, which primarily consists of wastewater and pre-consumer textile waste.

7.3.1 Overview

The Textile and Apparel industry is a significant contributor to India's economy, accounting for 2% of the total GDP, 7% of industrial output in value terms, and approximately 12-15% of total exports, while employing[10] over 45 million people. India is also one of the largest producers of cotton, jute, and silk, contributing more than 25% of global cotton production.[20]

While cotton and cotton-rich blends (with at least 50% cotton composition) dominate the fabric and garment sector, 24% of total apparel production consists of other blended fibers like polyester.

Global

92 Million tons

of textile waste is produced every year globally and is expected to increase to 134 million tons by 2030.

18.6 Million tons

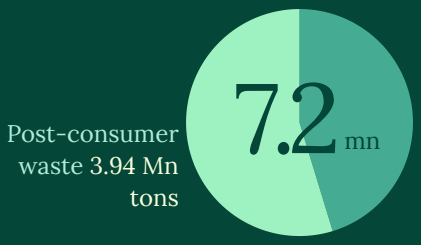
of textile waste ends up in landfills annually and is expected to increase to 150 million by 2050.

India

7.2 Million tons

of textile waste generated annually in India, accounting for 8% of the global textile waste.

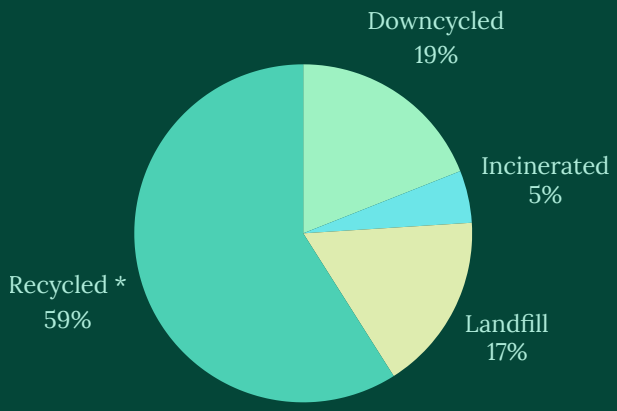
In 2021-2022:



On an average, a garment is used for 2-3 years in urban India and 4-6 years in rural India

Recycling rates in India

* only a fraction of this makes it back into the global supply chain due to quality and visibility challenges.



[20] https://reweave.enviu.org/wp-content/uploads/2024/12/Issue-Synthesis-Deck_Webinar_Enviu.pdf

7.3.2 Hubs for textile recycling in India

India has become a global textile recycling hub, with a significant portion of both domestically generated and imported textile waste converging at Panipat and Tirupur, the major recycling hubs in the northern and southern regions of the country. In addition, medium- and small-scale recycling facilities are prevalent in cities like Amroha, as well as in parts of Rajasthan, Madhya Pradesh, Punjab, and Gujarat. These areas host a network of smaller recycling operations, contributing to the country's extensive recycling ecosystem (Fashion for Good).

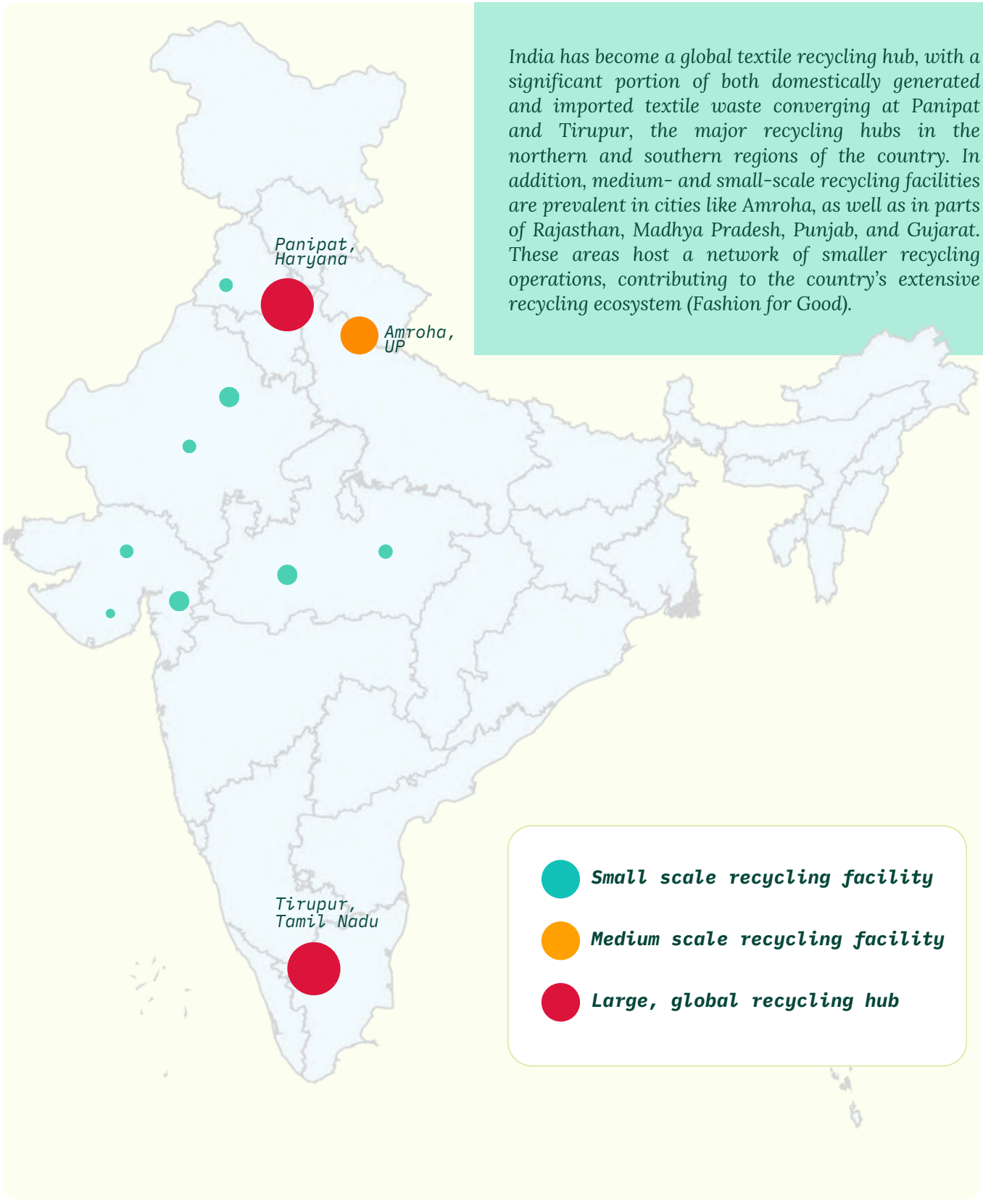


Fig. 15: Major textile recycling hubs in India

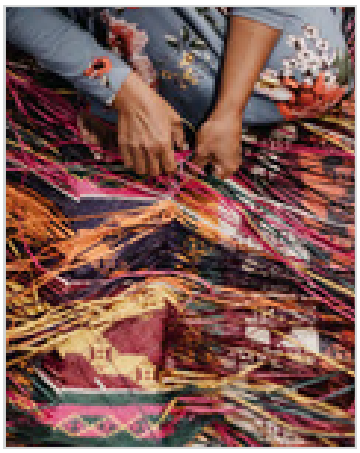
7.3.3 Types of Textile wastes

The textile industry generates significant waste during both the production and consumption of textiles and apparel. This waste can be categorized into three main streams: ***pre-consumer****,* ***domestic post-consumer****, and* ***imported waste****.*

01

Pre-consumer waste

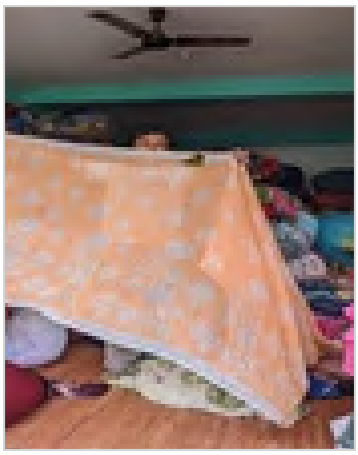
is produced during and after manufacturing at fabric mills, spinning units, and Cut-Make-Trim (CMT) operations. This includes fibre and yarn waste, cutting waste (which accounts for 6-25% of fabric waste), fabric deadstock, and unsold garments, among other by-products.



02

Domestic post-consumer waste

includes garments and textiles discarded by domestic consumers (households and commercial establishments like hotels and restaurants), as well as fabric cuttings from tailors and other similar sources.



03

Imported waste

includes second-hand clothing and mutilated rags imported to India.

7.3.4 Value chain of the textile waste in India

Textile waste management ecosystem in India has established a stronghold in mechanical recycling, the usage of manual sorting methods and presence of allied industries. The figures below set out the textile waste value chain in India for the different types of waste streams:

01
Pre-consumer waste

In India, pre-consumer waste is categorized into two value chains: fibre and yarn waste from spinning and mills, and fabric waste from production. This waste is largely managed by an unorganised, small-scale industry of brokers and middlemen. High economic incentives and a well-established network ensure minimal leakage, particularly for fabric deadstock and overproduced apparel. Sorting processes, such as colour separation and contamination removal, are often required before these materials are sent for recycling.

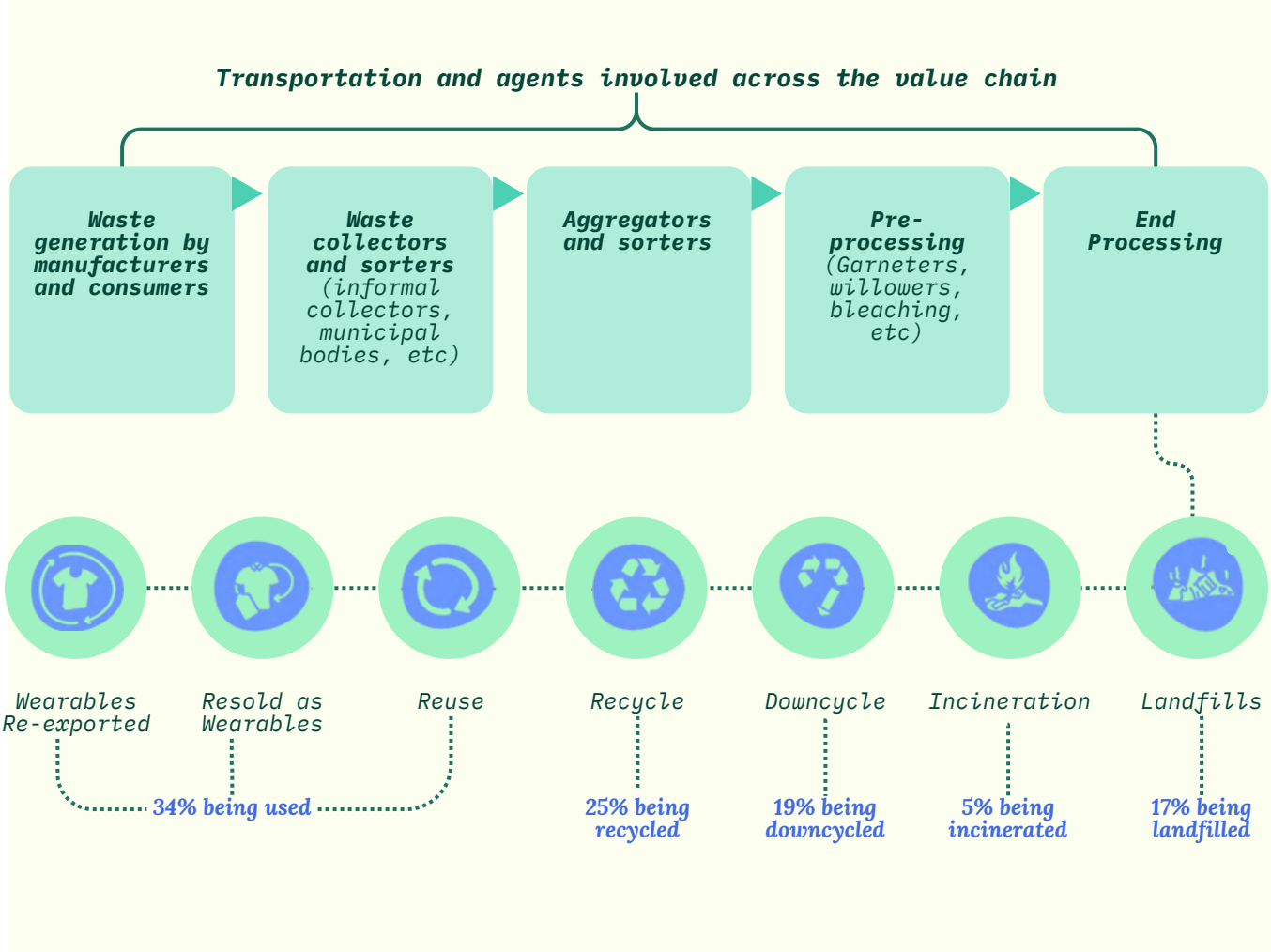


Fig. 16: Pre-Consumer textile waste recycling value chain in India

02
Domestic post-consumer waste

This waste is collected through various channels, including community organizations like Goonj, corporate take-back programs, informal waste collectors, and donations. Industries like hospitality, which generate significant textile waste (e.g., linens and curtains), typically rely on separate collection systems, primarily managed by the informal sector. Post-consumer textiles are sorted into wearable and non-wearable categories, with their final destination determined by condition and usability.

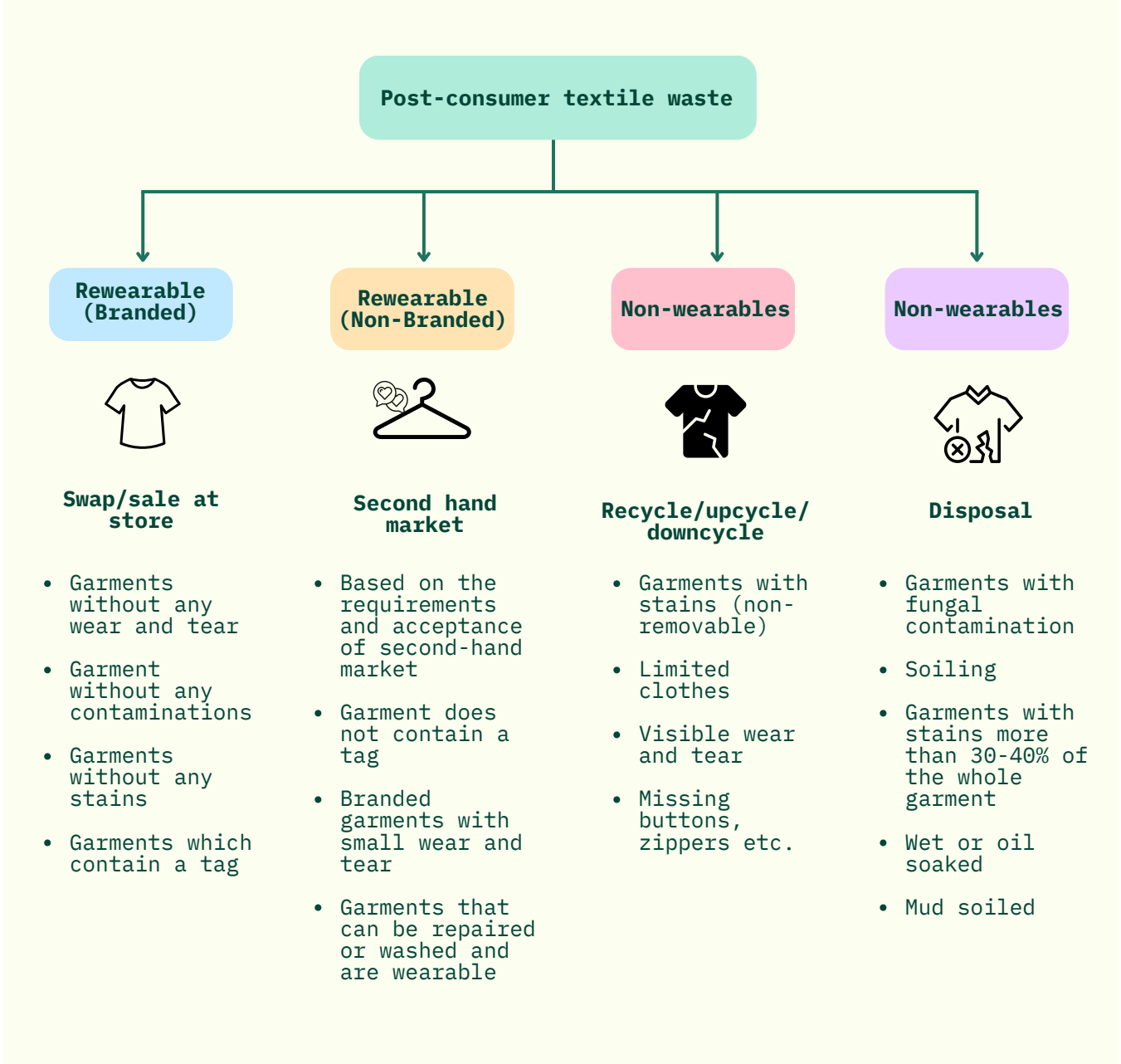


Fig. 17: Post-Consumer textile waste recycling value chain in India

03
Imported textile waste

Imported second-hand clothing is only allowed through specific ports, such as Mundra Port. Upon arrival, the first level of sorting occurs at the importer level, categorizing items like pants, shirts, dresses, and kids' wear. While regulations mandate that at least 50% of imports be re-exported, a significant portion of the waste leaks into the domestic market for repair and resale. Re-wearable clothing is either exported or sold locally, while non-wearable items (e.g., contaminated clothing, cutting waste, or mutilated rags) are further sorted for recycling, wipes, and allied industries.

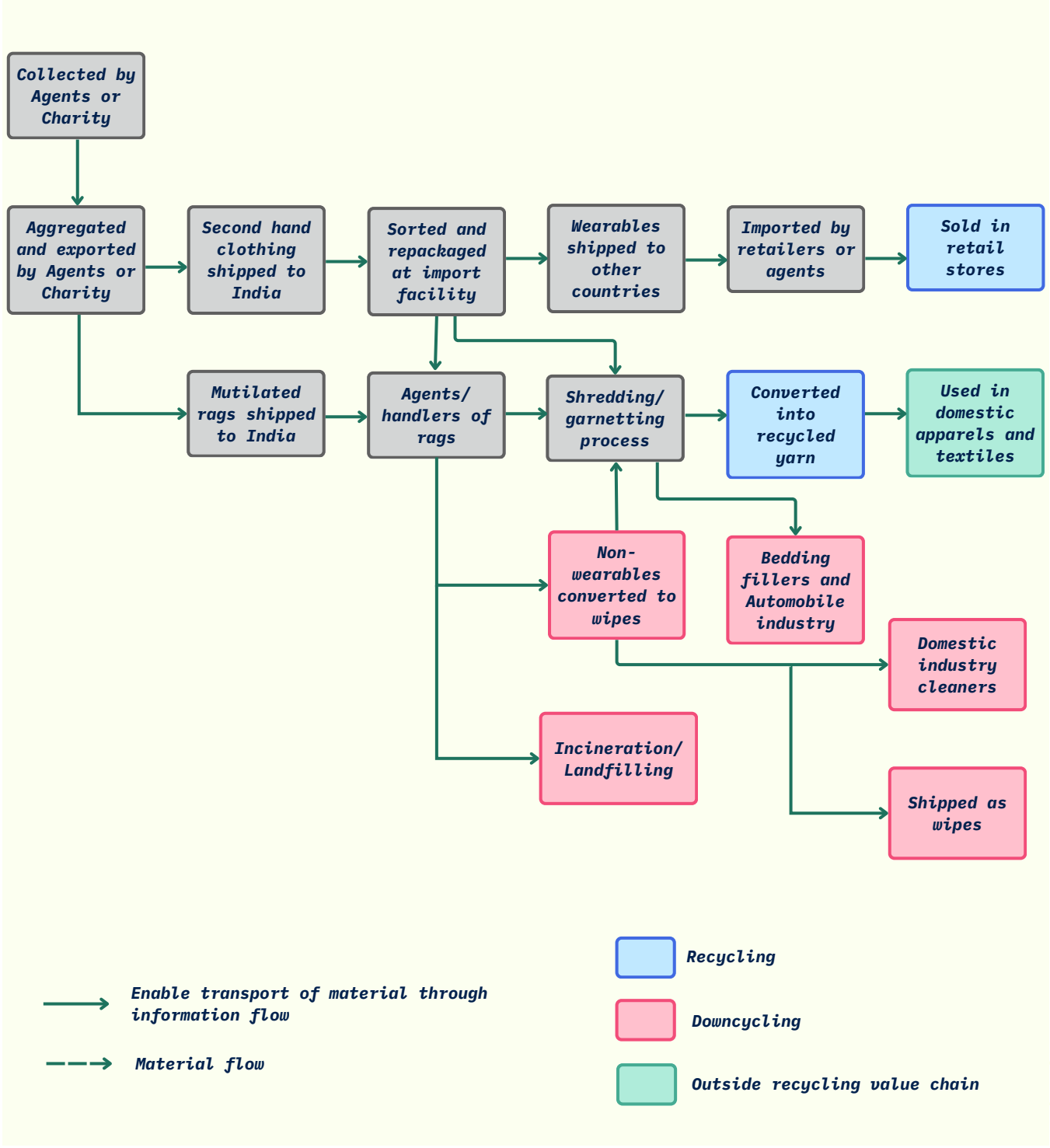


Fig. 18: Imported textile waste recycling value chain in India

7.3.5 Processing of textile waste

Various methods are using for processing of pre-consumer, post-consumer and imported textile waste to enable re-use, recycling and disposal of textile waste.

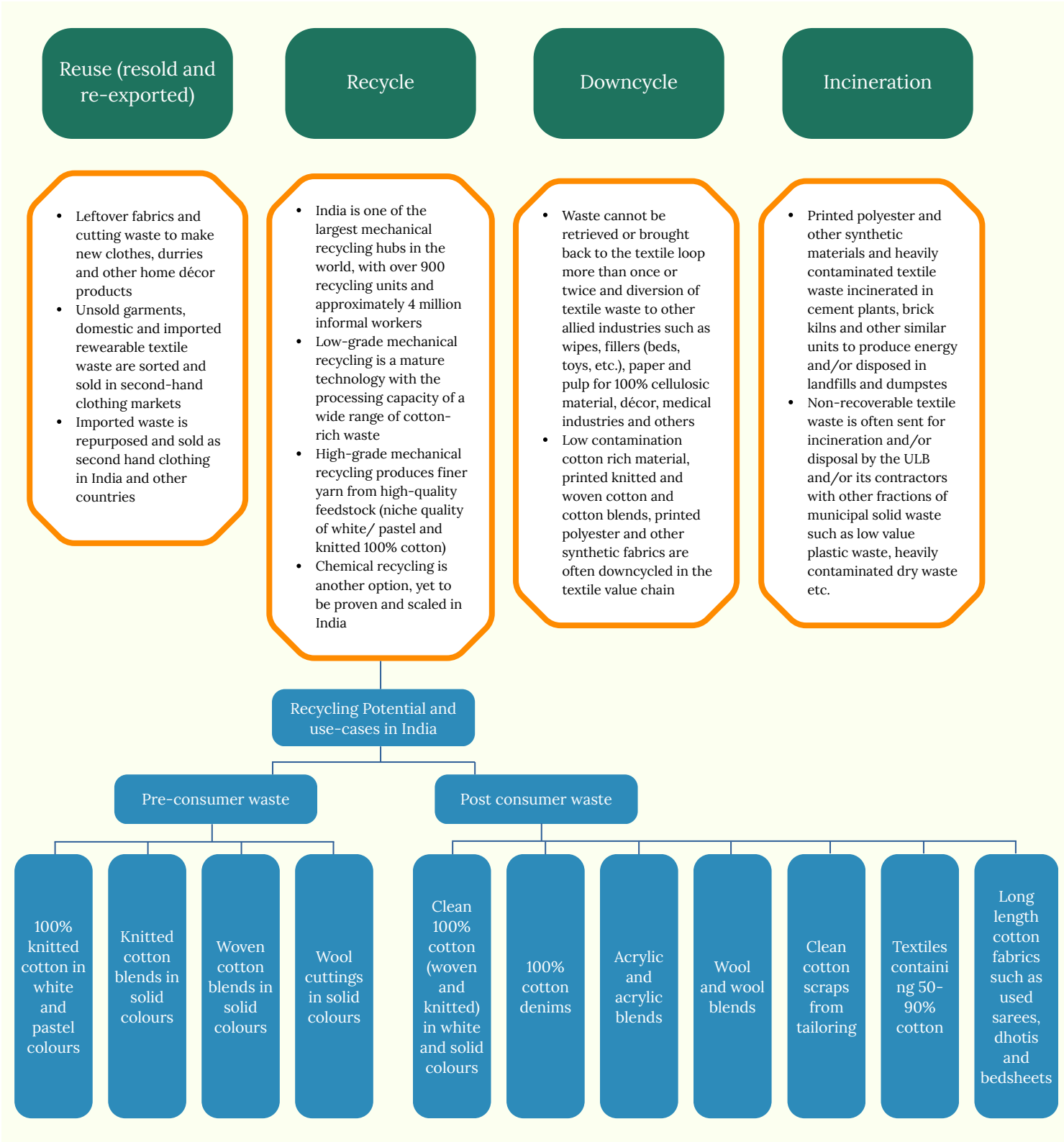


Fig. 19: Processing of textile waste

7.3.6 Key stakeholders across the value chain for textile waste

Name of the entity	Type of textile waste	Details of activity
Manufacturing		
Sizenfit, TryNDbuy, Creyate and Eshakti	Post consumer waste	These applications offer customers the opportunity to customise their clothing in a ready-to-wear, e-commerce environment. Leveraging technologies of sizing, augmented reality, and virtual trials, these retail platforms have templated customisations while reducing over-stocking
Reuse		
Relove	Pre and Post consumer waste	Digital platform for sale of preloved clothing by individuals and sale of unsold inventory by brands
Bombay Closet Cleanse, Swap Fashions, Swappcycle	Post consumer waste	Digital platforms such as websites and mobile applications for swapping clothes and/or thrifting.
Collection and sorting of domestic textile waste		
MuddleArt	Pre-consumer textile waste	Acts as a link between manufacturers and recyclers/other organisations by collecting all kinds of pre-consumer textile waste from brands and manufacturers and then sorting it based on the specifications of the end users/recyclers.
Nepra Resource Management Private Limited	Pre- and post-consumer textile waste	Existing large player in dry waste management. It has started collect textile waste in a segregated manner from different stakeholders, both pre-and post-consumer waste generators and sorting them as per recycler requirements.

Hasiru Dala Innovations Private Limited	Domestic post-consumer waste	Social impact organisation that focuses on securing justice for waste pickers through different and they have initiated a pilot to test a microentrepreneurs led approach for local collection and sorting of domestic post-consumer textile waste. It also operates a textile recovery facility in Bengaluru.
Saahas Zero Waste	Domestic post-consumer waste	Operates textile recovery facilities in Gurgaon and Bengaluru focussing on sorting of post-consumer textile waste as per recycler requirements.
Green Worms	Domestic post-consumer waste	Operates textile recovery facility in Kerala focussing on sorting of post-consumer textile waste as per recycler requirements.
Recircle, CARPE|Ecosattva, Material Library of India & Chintan	Domestic pre- and post-consumer waste	These entities have recently been involved in collection and aggregation of pre- and post-consumer textile waste in Maharashtra, Aurangabad and Delhi NCR region.
Sorting and handling of imported textile waste		
Bank & Vogue	Imported textile waste	While based in Canada, it operates in Kandla Special Economic Zone (SEZ) where BVH works to maximise the value of used clothing and textiles across multiple key areas at scale. This includes circular design, textile-to-textile recycling, component remanufacturing and re-commerce depending on their client requirements.
Flax Apparels Pvt Ltd	Imported textile waste	Flax Apparels imports and re-exports used clothing in India. They also make fibres for recycled yarn making, wipes and sell recyclable materials in the domestic markets. They are also based out of Kandla SEZ.
Canam Clothing, US Clothing, and Texpoly Impex	Imported textile waste	These entities also import, and re-export used clothing in India. Canam and US Clothing are entities based outside of India but have operations in India.

Upcycling		
Doodlage	Pre and Post consumer waste	Upcycles pre- and post-consumer textile waste to make new garments, accessories and packaging.
I was a Sari	Post consumer waste	Sources pre-worn saris from informal physical resale markets like Chor Bazaar in Mumbai and employs underprivileged craftswomen to rework them into luxury garments and accessories.
Bunko Junko	Pre and Post consumer waste	Upcycles pre- and post-consumer textile waste to make new garments, accessories, home décor and gift items.
Jaggery	Post consumer waste	Upcycles pre- and post-consumer textile waste to make different types of bags
Dwij	Post consumer waste	Upcycles post-consumer denim waste to make new bags, accessories and other products
Refash	Post consumer waste	Online platform for upcycled brands where they can sell upcycled clothing and accessories.
Recycling		
Birla Cellulose	Pre consumer textile waste	Birla Cellulose has developed a chemical recycling technology for production of viscose fibre 'Liva Reviva' using pre-consumer cotton waste. It comprises up to 30% pre-consumer waste and the remaining wood pulp from sustainable forests. Products from Liva Reviva have been sold to more than 20 brands like H&M, adidas, Levi Strauss & Co, Walmart, Ikea and Inditex. They are piloting their technology with other materials and are considering a potential long-term collaboration with Sweden-based Renewcell for man-made cellulosic fibre production. However, Birla Cellulose is limited to using only white and pastel coloured pure cotton pre-consumer material for recycling.

Jindal Wollen, Geetanjali woollens and Texwool	Imported waste	These entities are some of the few mechanical recyclers in the country, recycling imported acrylic second hand clothing. They import second hand clothing which contains around 85% of acrylic clothing. After the sorting and trim removal stage, the acrylic waste goes for shredding, carding and is then spun into yarn. The recycled acrylic yarn is produced by blending acrylic wastes with same colour polyester fibres to achieve the finer quality and strength in many different shades.
Usha and Vardhaman	Pre- and post-consumer waste	They recycle pre- and post-consumer textile waste that have over 95% of cotton
Kaygee and Kakkar	Pre- and post-consumer waste	Kakkar recycles cotton and cotton blends while Kaygee recycles polyester, polyester blends, cotton blends and wool blends.
Kishco, Venkateshwara, Rafi, Sulochana	Pre-consumer waste	Recycles pre-consumer waste containing 90-100% cotton.
Kayson Exports	Pre-consumer waste	Recycles pre-consumer waste containing cotton which is more than 50%
Usha Yarns	Pre-consumer waste	Services both the domestic and international market with their 100% recycled content yarns made from pre-consumer cotton waste and polyester made from recycled PET bottles.
Digital technologies		
Reverse Resources	Pre-consumer waste	Reverse Resources has developed a Software-as-a-Service platform that connects the full supply chain of textile waste from source to recycling, and all stakeholders involved in these supply chains and integrating textile waste back into the same production. For example, it makes leftover information from garment factories visible online, which enables virtual traceability of fabrics towards the best recycling solution from factory onwards.

Circular business models		
Flyrobe		It is a clothing rental platform, with a focus on occasion wear. It offers pick-up and drop-off logistics and also has brick-and-mortar stores in 16 cities around the country

Table 14: Key stakeholders in the textile waste management value chain

7.3.7 Scope for innovation

As per studies carried out by Fashion for Good, the following innovation areas represent different stages of maturity and have different capital intensity, disruptiveness and return profiles in the global textile industry.

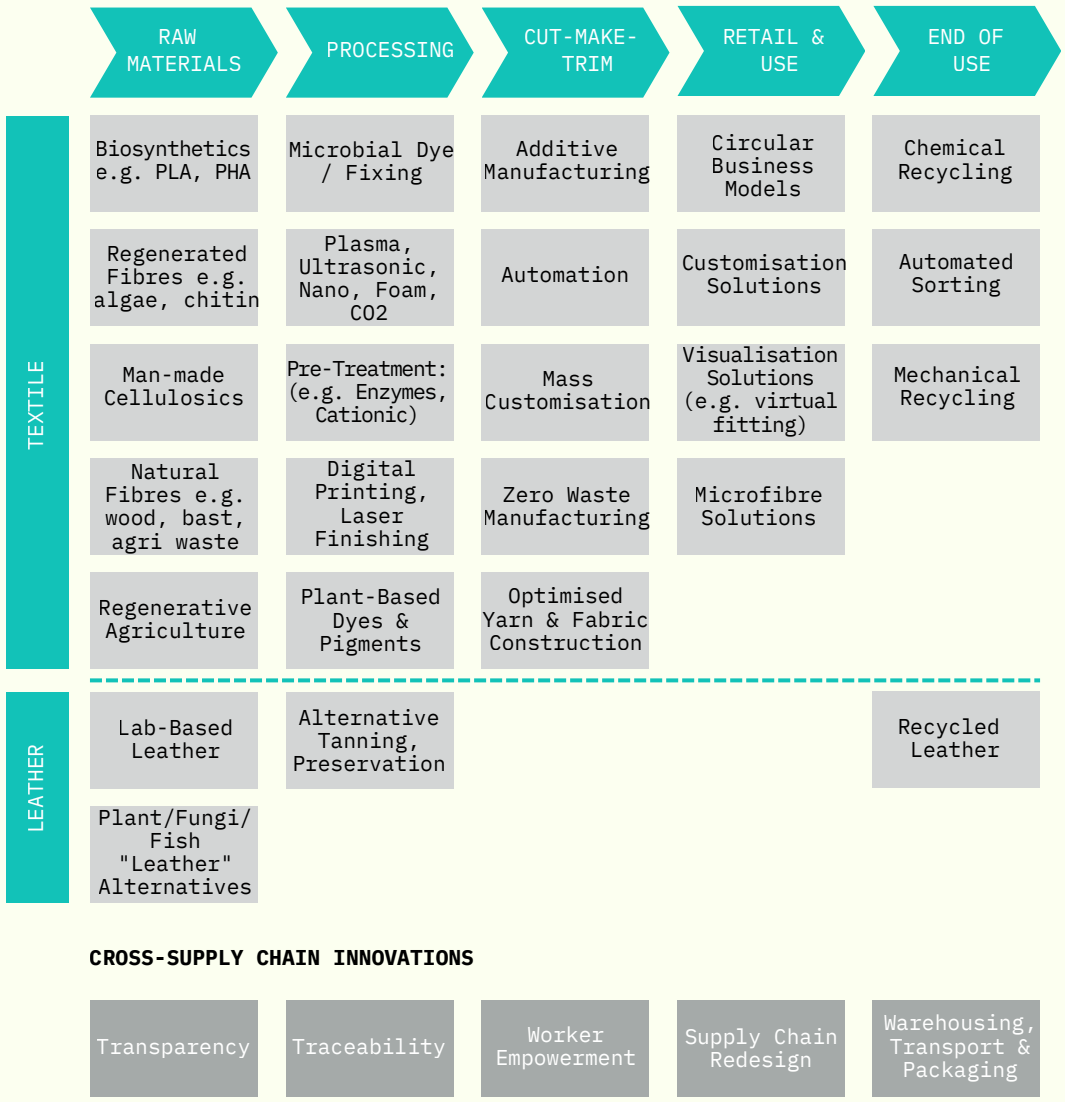


Fig. 20: Potential innovations across the value chain to recycle textile waste

Across the value chain, there is a role for innovations – technologies and enablers – to help improve segregation and reducing the burden of textile waste in the landfills.

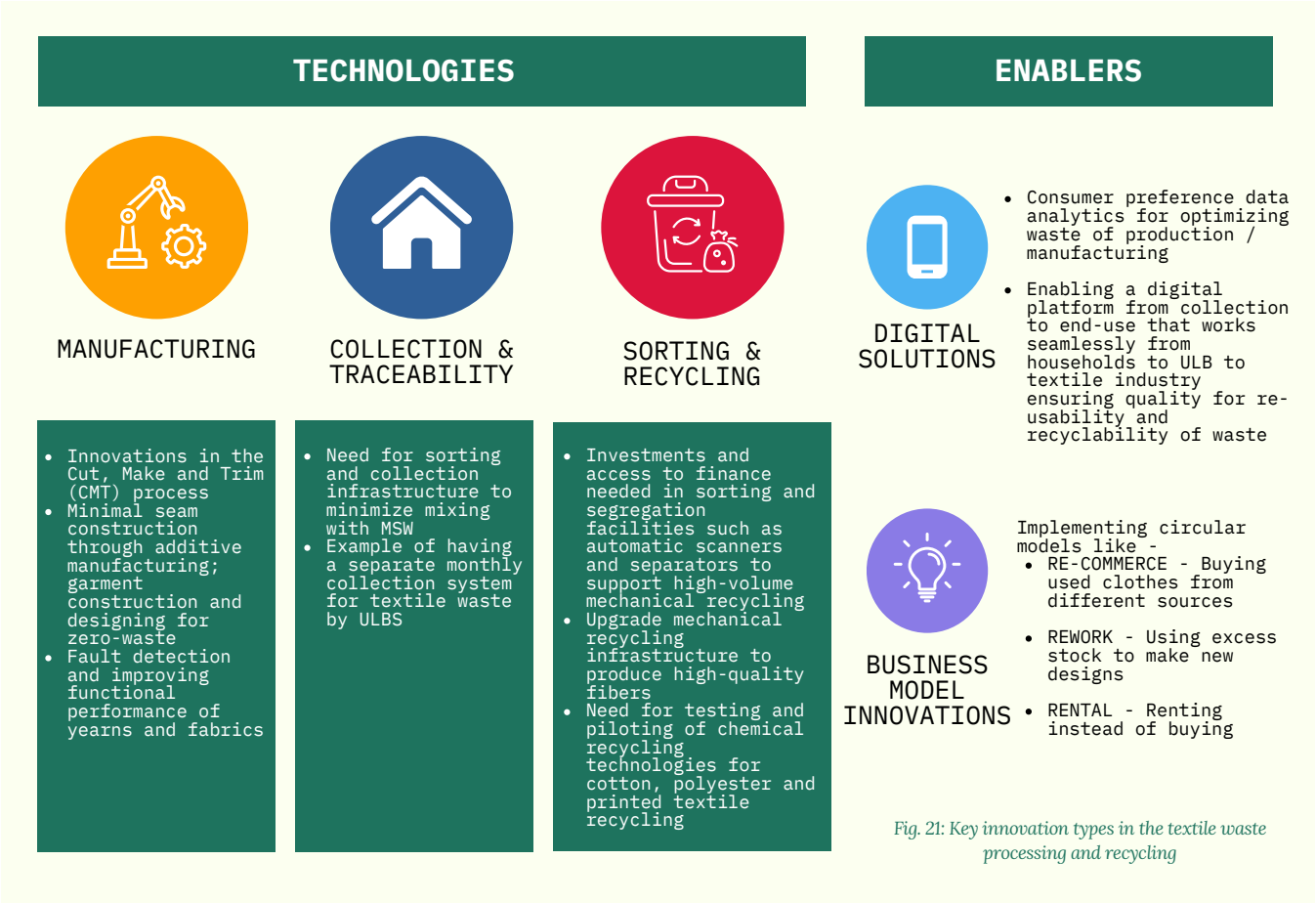


Fig. 21: Key innovation types in the textile waste processing and recycling

In India, a few startups are focusing on textile waste, with organizations like Good Fashion Fund targeting long-term USD debt investments in textile and apparel manufacturers, particularly in **post-consumer recycling.**

Government support for textile waste management is also growing, with initiatives like the **Union Government's Project SU.RE** – the Indian apparel industry's largest commitment to sustainable fashion. This includes a 5-point agenda to promote **sustainable sourcing, traceability of materials, and consumer awareness.**

Innovation opportunities in textile waste include fiber recycling technologies, upcycled fashion products, industrial textile waste processing (pre-consumer), and fashion waste collection platforms (post-consumer).

Currently, the preferred feedstocks for recycling are **cotton-rich pre-consumer waste** and **imported used garments**, as cotton is easier to recycle. Cotton-polyester blends are also being recycled, with advancements in separation technologies led by organizations like CIRC.

Despite these efforts, **polyester recycling remains underdeveloped**, **expensive**, and **limited**, but there is significant **potential for innovation** in this area due to the growing quantity of synthetic textile waste, especially polyester, in India. Thrift stores like Thrift Save Rave and India Wasted are gaining popularity in cities like Chennai, Bangalore, and Jaipur. Institutes such as NIFT, IIT-Delhi, and NID are spearheading R&D in sustainable textile solutions, including an Innovation Centre for Natural Fiber.

7.4 Plastic waste in India

As per the Plastic Waste Management Rules, "plastic waste" refers to any plastic discarded after use or once its intended purpose is over. Plastic waste can be categorized into types based on recyclability. PET is the most widely recycled plastic globally, while HDPE is one of the easiest polymers to recycle. In contrast, plastics like PVC (used in pipes), LDPE (cheap plastic for grocery bags), and PP (used in packaging) are difficult and costly to recycle.

In India, while a value chain exists for collecting and recycling higher-value plastics, a significant portion of plastic waste remains unprocessed. This is primarily due to a lack of economic incentives and technical expertise for recycling more challenging plastics. [21, 22]

[21] https://cpcb.nic.in/displaypdf.php?id=cGxhc3RpY3dhc3RlL1BXTV9HYXpldHRlLnBkZg==
[22] https://www.plasticsforchange.org/blog/which-plastic-can-be-recycled

7.4.1 Overview

India has emerged as the world's largest plastic polluter, releasing 9.3 million tonnes (Mt) annually, which constitutes about one-fifth of global plastic emissions as of 2024. [23]

> *"Despite leading in plastic waste generation, India ranks only 12th globally in plastic waste management and is expected to rise to 5th place by 2025, according to The Plastic Lifecycle report by CSE.* [24]

This underscores the urgent need for **efficient systems for plastic waste collection and processing**.

Packaging is the primary contributor to plastic waste, accounting for **59%** of India's total plastic consumption. In 2019-20, India recycled just 12% and incinerated 20% of the 3.5 million tonnes of plastic waste generated. [25]

The remaining **68%** likely ended up in dumpsites and landfills, with no clear information on its disposal. Additionally, between 2005 and 2020, plastic production increased by 60-300% to meet growing consumption demands.

[23] https://www.downtoearth.org.in/waste/india-tops-plastic-pollution-rankings-emitting-a-fifth-of-global-plastic-waste
[24] https://www.cseindia.org/the-plastic-life-cycle-11509
[25] https://www.ceew.in/sites/default/files/plastic-waste-recycling.pdf

7.4.2 Types of waste

Plastic waste in India varies in form and use, each posing significant environmental and health challenges due to their differing degradability. In 2018-19, 59% of plastic consumption in India was used for packaging, amounting to approximately 10.9 MMT of plastic. A majority of this packaging is single-use. [26]

Priority plastic waste categories to address include:

01 Multi-layered Plastics (MLPs)

India generated nearly 3.8 MMT of multi-layered plastic packaging waste in 2018-19. Most of this waste, collected under extended producer responsibility and sustainability initiatives, is incinerated in cement kilns or processed in waste-to-energy or pyrolysis plants, rather than being recycled. [26]

02 Single-use Plastics

These items, such as plastic bags, straws, and food packaging, are designed for one-time use and disposal. They contribute significantly to marine pollution and are difficult to recycle.

03 Difficult-to-recycle Plastics

Some plastics, like flexible packaging (LDPE) and specific plastic films, are hard to recycle due to their composition or contamination. Challenges to recyclability include low weight, high volume, and low market value. However, recyclability can be enhanced by avoiding composite packaging (which merges multiple types of plastics/materials), using plastics from the same polymer family for packaging, and minimizing print on packaging. These steps can make recycling more feasible and economically viable at scale. [26]

[26] https://www.cseindia.org/the-plastic-life-cycle-11509

Reusability is possible in case of rigid plastics (PET, HDPE) and also a legal mandate under the Indian EPR regulations. The packaging has to be designed to be refillable and should be collected back by brands through a reverse logistic mechanism, re-filled and put back on the market.

Plastic Type	Any potential low carbon / sustainable alternatives	Use-cases	Impacts and challenges
Polyethylene Terephthalate	Bio-PET from sugarcane or biomass	Beverage bottles, food containers.	High ocean pollution; low recycling rates.
Polyurethane	Bio-PUR from plant oils	Foam insulation, mattresses, adhesives.	Toxic when burned; hard to recycle.
Polyamide/Nylon	bio-nylon from castor oil	Clothing, fishing nets, carpets.	Non-biodegradable; marine debris.
Polycarbonate	N/A	Eyeglass lenses, electronics.	BPA toxicity; limited recycling.
Acrylonitrile Butadiene Styrene	Experimental bio-ABS from plant-based acrylonitrile	Lego bricks, electronics, car parts.	Mixed-material products hinder recycling.
Polyvinyl Alcohol	partially bio-based PVA in development	Detergent pods, dissolvable films.	Microplastic residues despite solubility.
Polymethyl Methacrylate	N/A	Signage, car taillights.	Non-recyclable; microplastic fragmentation.
Bioplastics	Produced from Corn, sugarcane and algae	Food packaging, 3D printing.	Requires industrial composting; recycling contamination.
Composite Plastics	Sustainable composites like bioplastic and natural fibers	Food pouches, electronics.	Unrecyclable due to mixed materials.
Oxo-degradable Plastics	N/A	Shopping bags, packaging.	Fragments into microplastics; no true biodegradation.
Microplastics	N/A	Cosmetics, tire wear, clothing fibers.	Pervasive pollution; harms ecosystems and health.

Table 15: Different plastic types and their impact on planet

7.4.3 Processing of plastic waste

The plastic waste processing value chain transforms discarded plastic into usable materials through a multi-step process involving collection, sorting, recycling, and eventual reuse. The aim is to promote a circular economy for plastics. Key stakeholders in this chain include waste pickers, wholesalers, assorters, recyclers, and traders.

01 Waste Generation and Collection

Plastic waste originates from households, businesses, and industries. Collection occurs through both informal systems (e.g., waste pickers) and formal mechanisms (e.g., municipal or private waste management companies), playing a crucial role in aggregating plastic waste.

02 Sorting and Processing

Collected waste is sorted—manually or mechanically—based on plastic type and contamination levels. This stage often includes washing and shredding to prepare the material for recycling.

03 Recycling

There are two main recycling methods:

- Mechanical Recycling: Melting and remoulding plastic into new products.
- Chemical Recycling: Breaking plastic down into its chemical components to create new polymers or chemicals.

While plastic is recyclable, its quality deteriorates with each cycle (typically recyclable only 2–3 times), due to thermal stress. Recycled products often contain harmful additives and dyes. Most recycling today results in downcycling—producing lower-grade plastic—whereas closed-loop recycling, which retains the original material properties, accounts for less than 1% of global plastic recycling. Therefore, recycling[27] is not a long-term or completely safe solution for disposal.

[27] https://sbmurban.org/storage/app/media/pdf/SBM%20Plastic%20Waste%20Book.pdf

04 Recyclate Market

Recycled plastic (recyclate) is sold to industries to manufacture a range of products, from low-value items like bags to higher-value items like furniture or construction materials.

05 Recovery

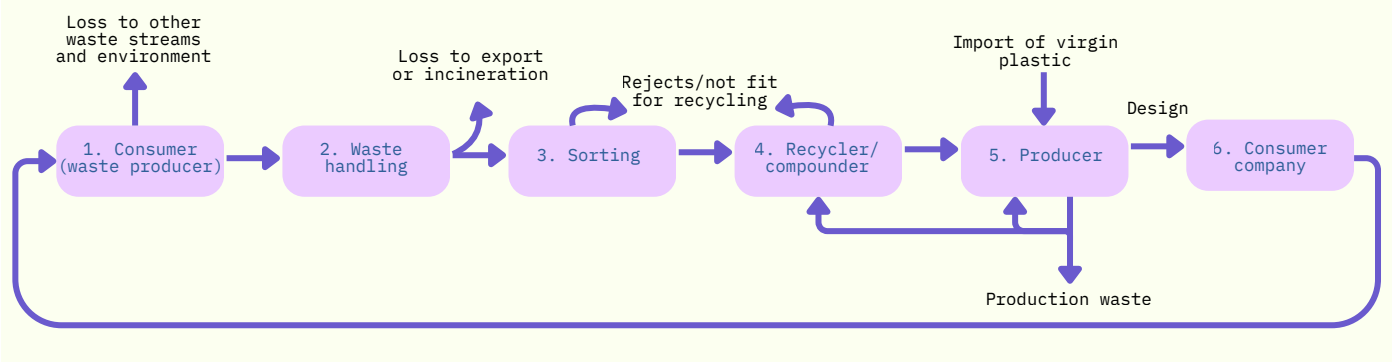
Plastic waste can also be used for energy recovery by converting it into fuel or energy. Technologies like co-processing in cement kilns or power plants utilize plastic waste as Alternative Fuel and Raw Material (AFR).

06 End-of-Life Management and Incineration

At the end of its lifecycle, recycled plastic can be reprocessed again or incinerated. Incineration reduces waste volume but is controversial: although it can generate energy, it poses serious health and environmental risks.

Waste-to-Energy (WTE) plants, promoted as a landfill solution, emit harmful pollutants such as dioxins, furans, hydrogen chloride, and heavy metals. For instance, the WTE plant in Okhla, Delhi, has been linked to air and soil contamination with cadmium and other toxins, affecting nearby homes and schools. These emissions are associated with cancer, respiratory illnesses, birth defects, and reduced fertility. [28]

The plastic waste recycling value chain, with each stage indicated by a number (1-6). The black arrows indicate material flows between the value chain stages, and for each stage material exchanges to/from the environment, either by operational losses or inputs - [29]



[28] https://www.nytimes.com/2024/11/09/world/asia/india-air-quality-trash.html

[29] https://www.researchgate.net/figure/The-plastic-waste-recycling-value-chain-with-each-stage-indicated-by-a-number-1-6-The_fig6_340940460

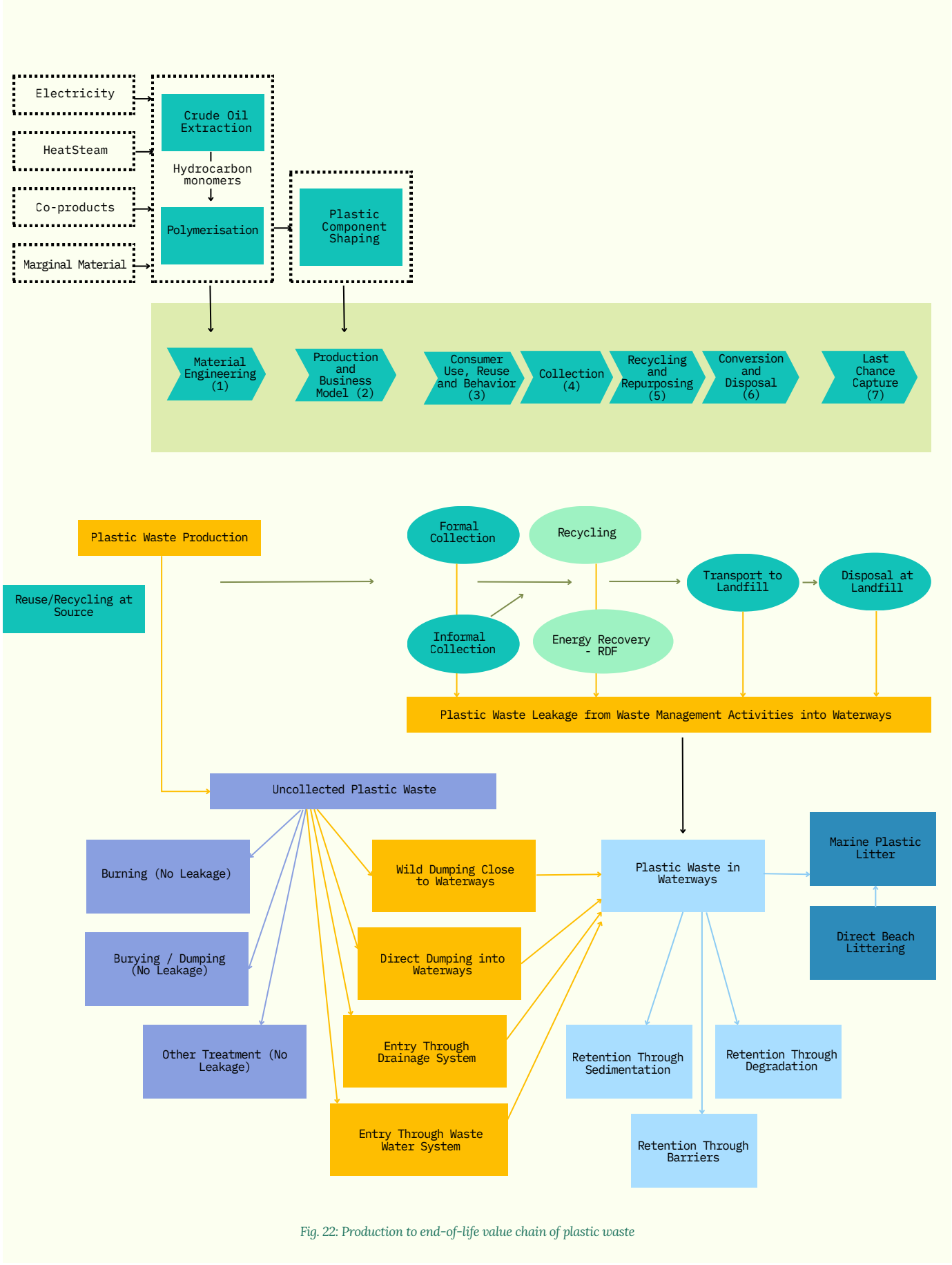


Fig. 22: Production to end-of-life value chain of plastic waste

7.4.4 Regulations in the plastic waste sector

Hierarchy of regulatory institutions linked to plastic value chain in India [30]

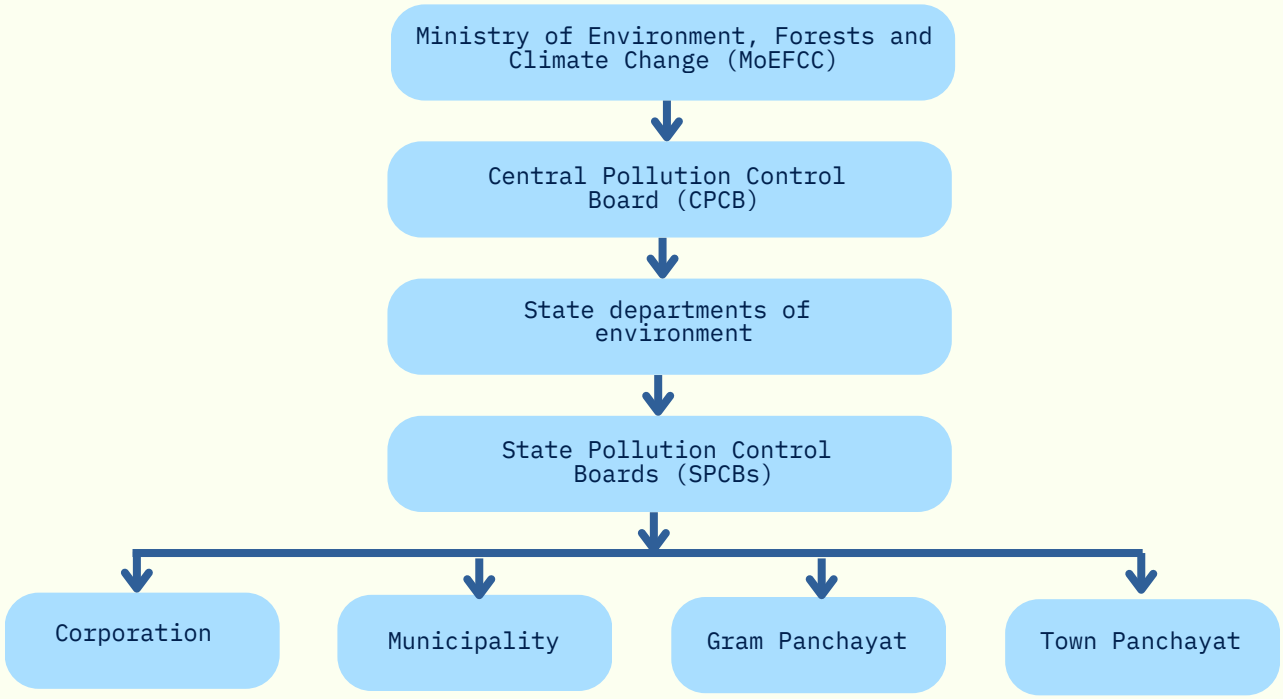


Fig. 23: Hierarchy of regulatory institutions linked to plastic value chain in India

The Plastic Waste Management Rules, 2016, mandate the generators of plastic waste to take steps to minimize generation of plastic waste, not to litter plastic waste, ensure segregated storage of waste at source and hand over segregated waste in accordance with rules. [31]

The rules mandate the responsibilities of local bodies, gram panchayats, waste generators, retailers and street vendors to manage plastic waste. The PWM Rules, 2016 cast Extended Producer Responsibility (EPR) on Producer, Importer, and Brand Owner (PIBOs) and are applicable to both pre consumer and post-consumer plastic packaging waste.

Plastic packaging categories covered under EPR: [31]

Category I

Rigid plastic packaging

Category II

Flexible plastic packaging of single layer or multilayer (more than one layer with different types of plastic), plastic sheets or like and covers made of plastic sheet, carry bags, plastic sachet or pouches

Category III

Multi-layered plastic packaging (at least one layer of plastic and at least one layer of material other than plastic)

Category IV

Plastic sheet or like used for packaging as well as carry bags made of compostable plastics

[30] https://www.sei.org/publications/plastic-waste-value-chain-india/
[31] https://environment.delhi.gov.in/sites/default/files/inline-files/pwm_epr_1.pdf

7.4.5 Stakeholder ecosystem in the plastic waste sector

Driven by EPR, Producer Importer Brand Owners (PIBOs) in India are prioritising collection, recycling and use of recycled materials in their manufacturing (with different targets for rigid, flexible, multi-layered and compostable plastics). EPR has given rise to a new market opportunity for startups - provision of EPR services.

Enterprises like Swachha Eco Solutions and Saahas Zero Waste offer services, from assisting PIBOs across different industries register with CPCB under PWM Rules, to building a collection network that includes consumers and the informal sector. They also collaborate with recyclers and end-of-life destinations and use MIS to capture data and prepare reports for PIBOs.

Name of the entity	Type of plastic waste	Details of activity
Collection and aggregation		
Saahas Zero Waste (also works in EPR services and recycling)	Rigid plastics, PET, MLP	SZW provides comprehensive services including collection, compliance tracking and facilitates plastic waste recycling to help businesses meet EPR targets and reduce environmental impact
Hasiru Dala Innovations(also works in EPR services and recycling)	PET, LDPE	HDI has a logistics system to collect, transport and source plastic waste. They aggregate PET and LDPE plastic waste and supply it to recyclers and brands. This aggregated plastic waste can be used by recyclers/brands in the manufacturing of recycled packaging or products.
Sorting and Processing		
Dalmia Polypro	Post consumer plastic wastes	Dalmia Polypro produces high quality recyclates from local post consumer plastic waste for reuse, helping to solve India's plastic waste problem and to advance the circular economy
GEM Enviro Management	Rigid, flexible, MLP	EPR (Extended Producer Responsibility) Fulfillment, ESG (Environment, Social and Governance) Consulting & BRSR (Business Responsibility and Sustainability Reporting) Reporting and Project Advisory & Management for Plastic Credits.

Recycling		
Banyan Nation	PE and PP	Banyan Nation is one of India's first vertically integrated plastics recycling companies, pioneering a circular economy in polyolefins (PE and PP) in the country. Banyan Nation produces rPE (Recycled High Density Polyethylene), rPP (Recycled Polypropylene) and also provides EPR and Plastic Credits services
Lucro Plastecycle	Flexible and rigid post-consumer plastic waste	Specialises in difficult-to-recycle plastics, produces recycled granules, flexible packaging and more
Shakti Plastic Industries	HDPE, PP	Services include Extended Producers Responsibility (EPR) as per Plastic Waste Management Rules 2016, post-consumer plastic waste management across India, recycled plastic granules, CSR/IEC activities related to environmental sustainability, industrial waste management solutions, and the manufacture of eco-friendly and sustainable consumer and industrial products made from plastic waste.
Dalmia Polypro	Polyethylene Terephthalate (PET) and Polyolefins.	Dalmia Polypro is a leading plastic recycler in India, producing high quality recyclates from local post consumer plastic waste for reuse, including PET bottles and various Polyolefins like Polypropylene (PP) and High-Density Polyethylene (HDPE).
Upcycling		
reCharkha	Non-biodegradable and difficult-to-recycle Plastic bags and Wrappers	B2C company selling products (bags, home decor, etc) made from plastic wastes
EcoKaari	Post consumer plastic wastes	EcoKaari upcycles waste plastic into handcrafted fabrics using Charkha (spindle) and Handloom.
EPR services		
Swachha Eco Solutions	HDPE, LDPE, PET, PS, PP, and EPS	Integrated waste management organisation, authorised KSPCB recycler, offering collection, transportation, processing and recycling services

EcoWrap	Post consumer waste	End-to-end services for compliance with government regulations
Product Design and Alternative Materials		
Ecoware	Material alternatives	Biodegradable food packaging manufacturer, plant based packaging as an alternative to single-use plastics
Earthware	Material alternatives	Biodegradable cutlery and packaging made from plant fibres
Bambrew	Material alternatives	Sustainable packaging material supplier and manufacturer, harnessing plant fibers and pulp to create eco-friendly & biodegradable solutions.
TGP Bioplastics	Material alternatives	TGP Bioplastic initially specialized in biodegradable plastic granules. Now, they've expanded their range to include eco-friendly plastic films, bags, and specialized filaments for 3D printing.
Digital technologies		
Kabadiwalla Connect	Post consumer plastic wastes	Kabadiwalla Connect works with city residents and commercial establishments to provide them with solutions for waste segregation. They also help them sell the recyclable waste materials (like paper, metal scrap, glass, plastic, etc.) to the local kabadiwallas, who in turn sell it to be upcycled, or recycled for a profit.
TraceXTechnologies	Post consumer and pre consumer plastics	Blockchain traceability solutions to enhance efficiency and accountability in waste management
Recykal	Post consumer and pre consumer plastics	Tech-driven services to recyclers and brands, to bulk buy recyclables. Recykal8 is a B2B marketplace for post-consumer recycled materials. Services to brands includes traceable plastic recovery, EPR for plastics and more

Waste to Energy		
Ramky Enviro Engineers	Municipal solid waste	One of the largest providers of comprehensive waste management services in Asia, Ramky Enviro Engineers Ltd (REEL) has also launched south India's first waste-to-energy plant.
Jindal Group	PP, PE	Jindal is involved in waste-to-energy projects in India, particularly through their subsidiary Timarpur Okhla Waste Management Company Limited (TOWMCL) and Jindal Urban Infrastructure Limited (JUIL). They have a large-scale waste-to-energy facility at Okhla in Delhi, and are also involved in projects in Visakhapatnam and Guntur. These projects aim to generate electricity from municipal solid waste.

Table 16: Key stakeholders in the plastic waste management value chain

Key stakeholders under EPR obligations for plastics -

1. Producers (P) of plastic packaging;
2. Importers (I) of all imported plastic packaging and / or plastic packaging of imported products;
3. Brand Owners (BO) including online platforms/marketplaces and supermarkets/retail chains other than those, which are micro and small enterprises as per the criteria of Ministry of Micro, Small and Medium Enterprises, Government of India
4. Plastic Waste Processors (PWPs), except cement kilns & road construction

7.4.6 Key challenges

EPR's geography-agnostic nature and emphasis on 'plastic neutrality' gives polluters a loophole, allowing them to collect waste only in regions where it is easy to do so (neglecting remote regions) and to focus more on collection rather than recycling and reduction in production.

The lack of alignment between policies means producers often find loopholes (or simply pay fees instead of actually recycling), and the intended environmental benefits of EPR are not fully realized. Stronger enforcement mechanisms and audit of producer take-back systems are needed to close these loopholes. Some of the key challenges we see in the plastic waste ecosystem are as follows:

01 Low source segregation leads to contaminated plastics reaching waste management facilities, and most plastic waste is sent as refuse-derived fuel (RDF) for co-processing.

02 Lack of recycling technologies for low value and flexible plastic wastes.

03 Informality of the plastic waste value chain which impacts occupational health and wellbeing of waste workers, and makes the true cost of plastic waste management and traceability a big question.

04 Weak collection systems in many remote and rural geographies in addition to lack of decentralised, localised recycling infrastructure.

05 Design constraints: The plastic packaging and products used nowadays are not designed for recyclability because of mixing of multiple polymers and other chemicals used along with varying colours and prints.

06 EPR: EPR's geography-agnostic nature and emphasis on 'plastic neutrality' gives polluters a loophole, allowing them to collect waste only in regions where it is easy to do so (neglecting remote regions) and to focus more on collection rather than recycling and reduction in production. The lack of alignment between policies means producers often find loopholes (or simply pay fees instead of actually recycling), and the intended environmental benefits of EPR are not fully realized. Stronger enforcement mechanisms and audit of producer take-back systems are needed to close these loopholes.

07 Many regions face challenges due to insufficient recycling infrastructure. Inadequate facilities hinder proper collection, sorting, and processing of plastic waste, leading to increased reliance on landfills or incineration. Investing in robust recycling systems, alongside public education on proper waste disposal, is crucial for enhancing recycling rates and reducing the environmental burden of plastic waste. [32]

The global trade of plastic waste poses challenges for effective waste management. Developing countries often receive plastic waste from more affluent nations, leading to environmental and social consequences. Addressing this issue requires international cooperation, transparent waste management practices, and sustainable solutions to curb the negative impacts of plastic waste trade on both importing and exporting countries.

[32] https://tracextech.com/understanding-plastic-value-chain/

7.4.7 Scope for Innovation

India's evolving regulatory landscape and the urgency of addressing plastic pollution have opened up multiple avenues for innovation across the plastic waste value chain.[33]

Extended Producer Responsibility (EPR)

Under the Plastic Waste Management (PWM) Rules, Producer-Importer-Brand Owners (PIBOs) are mandated to meet specific collection, recycling, and reuse targets across different plastic categories (rigid, flexible, multi-layered, compostable).
This has spurred the growth of EPR service providers like Swachha Eco Solutions and Saahas Zero Waste, which:

- Assist PIBOs with registration under CPCB norms
- Build inclusive collection networks involving consumers and informal workers
- Partner with recyclers and end-of-life processors
- Use digital tools to track, verify, and report plastic waste compliance

Bio-based Alternatives

The Ministry of Environment, Forest and Climate Change (MoEFCC) is encouraging the development of compostable and biodegradable plastics as alternatives to single-use and conventional plastics. This has led to a rapid expansion of the bioplastics sector in India.
However, claims of being "bio-based," "compostable," or "biodegradable" must be backed by verified standards. Innovations are needed in:

- Establishing standardized testing for biodegradability
- Developing collection systems and industrial composting infrastructure
- Creating robust value chains for end-of-life processing of bio-based materials

Advanced Recycling Technologies

- Chemical and dissolution recycling offer scalable solutions to convert complex and contaminated plastic waste into valuable raw materials or energy.

- Mechanical recycling and sorting technologies are crucial for enhancing processing efficiency and increasing material recovery rates.

[33] https://iuk-business-connect.org.uk/perspectives/indias-plastic-recycling-market-and-innovation-landscape/

Packaging Redesign

- Shifting from multi-layered plastic (MLP) to mono-material films can drastically improve recyclability by reducing material complexity.
- Advanced film sorting technologies are essential for accurately segregating plastic films by type and quality, enabling high-value recycling.

Reuse and Refill Models

Promoting reuse and refill systems presents a sustainable alternative to single-use packaging. Innovations in business models, logistics, and consumer engagement can significantly reduce plastic waste and environmental impact.

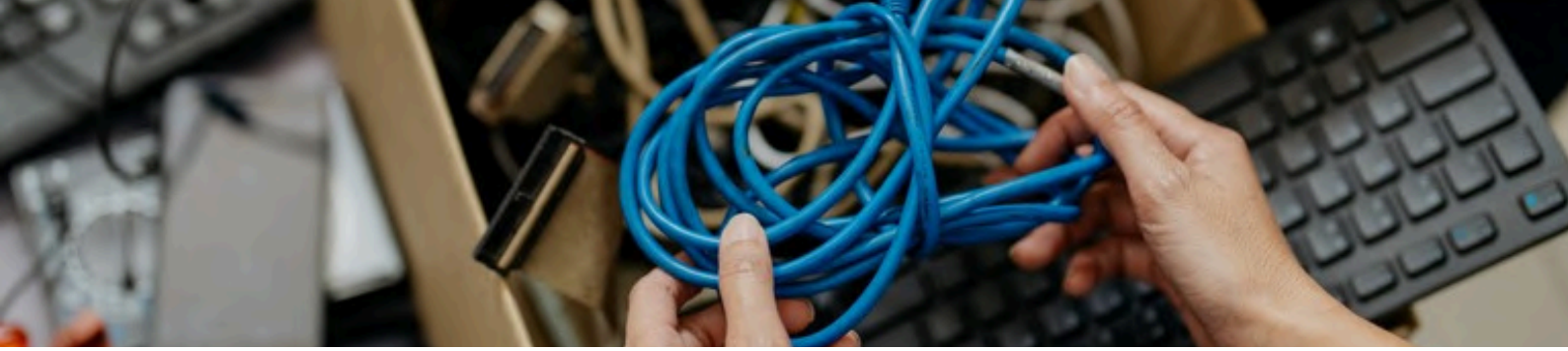
7.5 Electronic waste and battery waste in India

In India, e-waste, as defined under the E-waste (Management) Rules of 2016—issued by the Central Pollution Control Board (CPCB)—is electrical and electronic equipment (EEE), whole or in part, discarded as waste by consumers (individual or bulk) as well as rejects from manufacturing, refurbishment and repair processes. [34]

Battery waste: The classification of batteries as e-waste depends on their context of use and disposal. Standalone batteries, such as those used in household items, may not be classified as e-waste. However, when batteries are embedded in electronic devices, they fall under the e-waste category. This distinction is crucial for regulatory purposes and recycling practices. [35]

[34] https://www.cseindia.org/content/downloadreports-10593

[35] https://www.legalraasta.com/blog/batteries-identified-under-epr-battery-waste/#:~:text=Standalone%20batteries%20are%20such%20as%20those,regulatory%20purposes%20and%20recycling%20practices.



7.5.1 Overview of e-waste and battery waste in India

India witnessed a surge in electronic waste (e-waste) generation over the past five years, rising from 1.01 million metric tonnes (MT) in 2019-20 to 1.751 million MT in 2023-24.

Top cities producing e-waste

1 Mumbai
2 Delhi
3 Bangalore
4 Chennai
5 Kolkata
6 Ahmadabad
7 Hyderabad
8 Pune
9 Surat
10 Nagpur

73% increase in India since 2019

57% of e-waste (1 MMT) remains to be processed

By 2025, India will be producing 7mMT of e-waste annually, which will increase to over 134 million tons by 2030.160 mMT by 2050. [36]

Telecom/phones made up most of the remaining e-waste at 12%, followed by electrical equipment at 8%, medical equipment at 7%. [37]

82% of India's e-waste comes from personal devices such as smartphones, tablets, laptops and PCs. [37]

The latest Battery Waste Management Rules set a target of 90 per cent recovery of the battery material — 70 per cent by 2024-25, then 80 per cent by 2026, and 90 per cent after 2026-27 onwards. [38]

The total demand for Lithium-ion batteries (LiB) in India is expected to cross 230 GWh by 2030. The rising LiB demand is coupled with a need for a robust recycling ecosystem driven by: [39]

- Geopolitical supply chain risk associated with critical minerals like lithium, cobalt and nickel in batteries (India's heavy import dependence, with China having the biggest share in processing and sourcing of critical minerals)
- Managing environmental hazards, such as untreated LiB in landfills leaking metals into soil and water
- Improved price discovery for LiB batteries, with recycling improving resale value and reducing cost of input materials

36 https://www.cseindia.org/content/downloadreports/10593
37 https://www.globenewswire.com/news-release/2024/03/25/2851808/0/en/India-e-Waste-Management-Market-to-Offer-Opportunity-Worth-USD-5-198-52-Million-by-2032-Metals-are-A-Hidden-Treasure-Trove-Says-Astute-Analytica.html
38 https://www.downtoearth.org.in/renewable-energy/ramping-up-e-waste-bsttery-recycling-can-spur-a-better-impact-from-battery-recycling
39 https://evreporter.com/current-lib-recycling-landscape-in-india-leading-players-and-commitments/

7.5.2 Types of e-waste

As per the E-Waste (Management) Rules, 2016, two categories of electrical and electronic equipment are classified as e-waste, namely -

1. IT and Telecommunication Equipment such as smartphones, personal computers, printers including cartridges and
2. Consumer Electricals and Electronics such as TVs, Washing Machines, Refrigerators, Air Conditioners including fluorescent and other mercury containing lamps

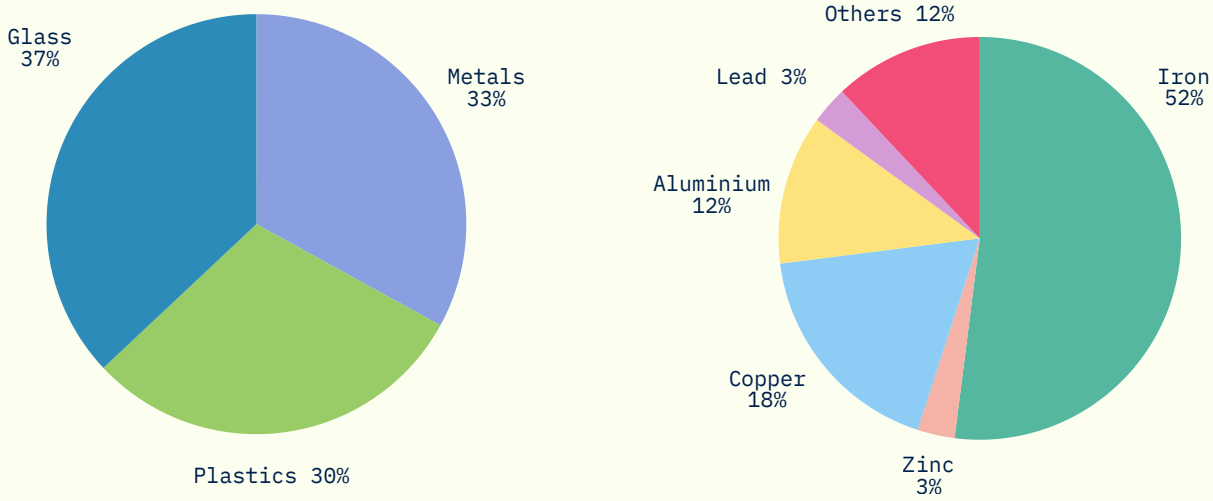


Fig. 24: Key components in electronic waste [40]

Pollutant / E-Waste materials	Occurrence / Source of the waste
Liquid crystal	Displays
Lithium	Mobile telephones, Photographic equipments, video equipments, batteries
Mercury	Components of Copper machines and steam irons, batteries in clocks and pocket calculators, switches, LCDs
Nickel	Alloys, batteries, relays, semiconductors, pigments
PCBs (poly chlorinated biphenyls)	Transformers, capacitors, softening agents for paints, glue, plastic

[40] Electricals and Electronics manufacturing in India, ASSOCHAM, NEC technologies, 2018

Selenium	Photoelectric cells, pigments, photo copiers, fax machines
Silver	Capacitors, Switches (contacts) batteries, resistors
Zinc	Steel, brass, alloys, disposable and rechargable batteries, luminous substance
Arsenic	Semiconductors, diodes, microwaves, LEDs (light emitting diodes), solar cells
Barium	Electron tubes, filler of plastic and rubber, lubricant additives
Brominated flame proofing agent	Casings, circuit boards (plastic), cables and PVC cables
Cadmium	Batteries, pigments, solders, alloys, circuit boards, computer batteries, monitor, cathode ray tubes (CRTs)
Chrome	Dyes/ Pigments, Switches, Solar
Cobalt	Insulator
Copper	Conductor Cables, copper ribbons, coils, circuitry, Pigments
Lead	Lead rechargeable batteries, solar, transistors, lithium batteries, PVC (polyvinyl chloride), stabilizers, lasers, LEDs, thermo electrical elements, circuit boards

Table 17: List of key components in electronic waste [41]

[41] https://www.epa.gov/sites/default/files/2014-05/documents/india.pdf

7.5.3 E-waste value chain

E-waste in India is primarily generated through two channels -[42]

01

Households account for 70% of the annual total e-waste—led by air conditioners (115,000 tonnes), refrigerators (675,000 tonnes), washing machines (630,000 tonnes), televisions (36,000 tonnes), laptops (10,000 tonnes), and smartphones (35,000 tonnes). Large appliances account for 1.2 MMT, while temperature exchange equipment accounts for 1.3 MMT of e-waste.

02

The remaining **30%** comes from **businesses**, which use refrigerators, water coolers, centralised air conditioners, hot and cold dispensers, industrial printers and copiers, commercial washing machines, lab equipment, professional medical devices, coffee machines, shredders, hand dryers, power tools, servers, desktops, monitors, smartphones, and laptops.

E-waste in India is primarily collected through two channels -

01

Informal collection and processing: Across these cities, there is a large network of informal aggregators and collectors, using rudimentary techniques to dismantle e-waste and extract precious metals etc. 60-70% of e-waste flows through informal channels, making them key collection points.

02

Formal collection and processing: India's current formal system has 595 authorised dismantlers and recyclers with a capacity of 1.8 MMT as of FY24. Formal e-waste recycling is set to grow by 17%, but will cover only 40% of e-waste in a decade.

E-waste marketplaces in India connect e-waste generators with certified recyclers, and a trader/aggregator system is in place. However, only a few players in India have advanced recycling capabilities, like full in-house recycling, high processing capabilities, and efficient infrastructure for rare earth and metal extraction without external help.

[42] https://www.fortuneindia.com/business-news/india-becomes-third-largest-e-waste-generator-as-tech-boom-fuels-surge/121182

7.5.4 Stakeholder ecosystem

Private sector - Attero, with revenue of Rs 446 crore and a capacity to process 1,44,000 tonnes, is the only player with verified and comprehensive capabilities for Printed Circuit Board (PCB) recycling and precious metal refining. Exigo, Namo, and international players like Cerebra and TES-AMM are the major e-waste recyclers in India. [43]

Roles and responsibilities of ULBs / Urban Local Bodies (Municipal Committees or Councils or Corporations): [44]

1. If e-waste is found mixed with municipal solid waste, to ensure its proper segregation, collection and channelization to authorized dismantlers or recyclers
2. To ensure that e-waste pertaining to orphaned products is collected and channelized to authorized dismantlers or recyclers

In addition, some of the key stakeholders involved in e-waste management and battery recycling are as follows:

Stakeholder ecosystem - Major market players in e-waste: [45]

Name of the entity	Details of activity
Formal e-waste recyclers and processors	
A2Z Group	Leading provider of collection and processing services
Ecogreen Energy Pvt. Ltd.	Ecogreen scope of work includes door to door collection of municipal solid waste from households & commercial centers, transportation and processing of waste into compost and RDF. The RDF is used to generate electricity
Green IT Recycling Center Pvt Ltd.	Green IT Recycling Center Pvt. Ltd. is an asset recovery solution provider, managing excess or end-of-life IT assets.

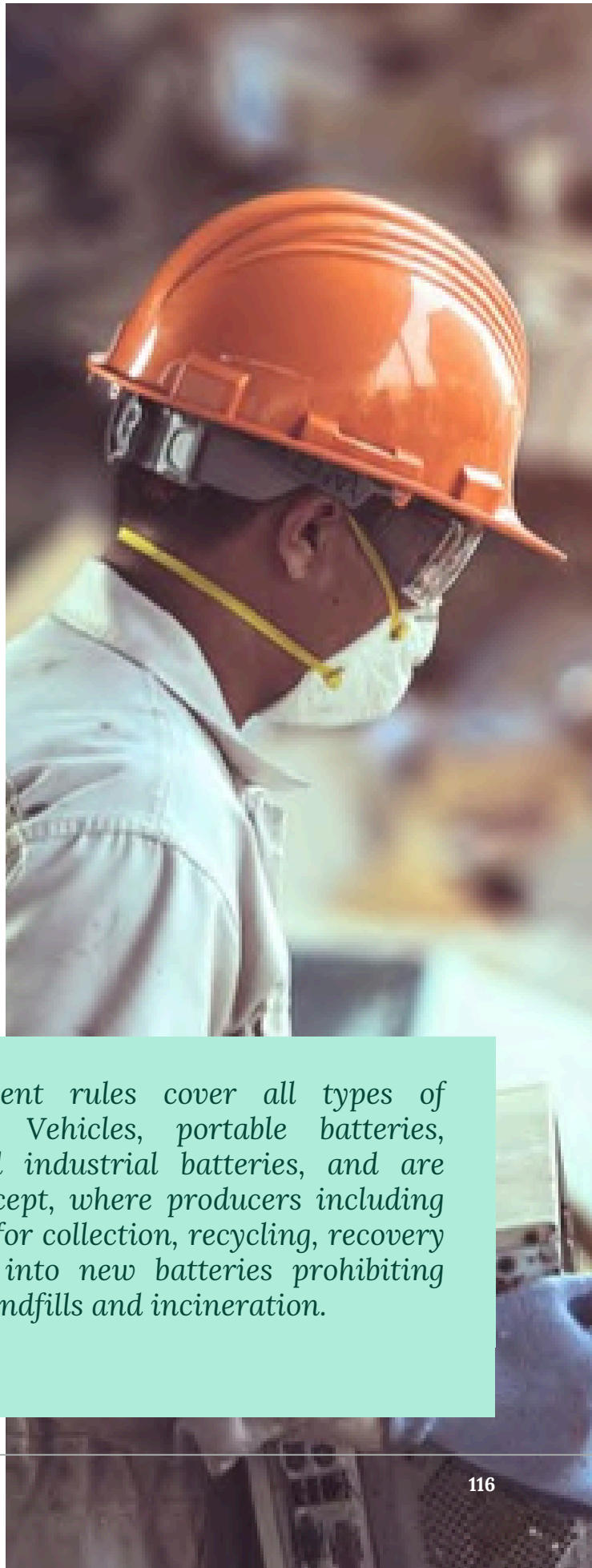
[43] https://www.fortuneindia.com/business-news/india-becomes-third-largest-e-waste-generator-as-tech-boom-fuels-surge/121182
[44] https://www.cseindia.org/content/downloadreports/10593
[45] https://www.globenewswire.com/news-release/2024/03/25/2851808/0/en/India-e-Waste-Management-Market-to-Offer-Opportunity-Worth-USD-5-198-52-Million-by-2032-Metals-are-A-Hidden-Treasure-Trove-Says-Astute-Analytica.html

EcoRecycling Limited	EcoReco offers IT asset disposal, reverse logistics and also has a state-of-the-art WEEE Recycling facility that offers end-to-end processing of E-waste.
Attero	Attero Recycling Pvt Ltd - Integrated recycler with advanced metal recovery
TES HQ	TES-AMM (TES HQ) is a major global e-waste processor
Cerebra	IT asset management services including 'device as a service', recycling and refurbishing offerings
Producer Responsibility Organisations (PROs)	
Karo Sambhav	Karo Sambhav works with governments, businesses and consumers and is a major PRO covering multiple states in India
Reverse Logistics Group (RLG)	Global PRO with India operations
CorpSeed	Services to help establish e-waste recycling plants in India
Saahas Zero Waste	Waste management services with an e-waste division

Table 18: Key stakeholders in the electronic and battery waste management value chain

7.5.5 Regulatory landscape of E-waste & Battery waste

1. The E-waste (Management) Rules, 2016 have entrusted the responsibility of collection and channelization of e-waste on producers of EEE as per the principle of Extended Producer Responsibility (EPR).[46]
2. End-of-life EEE has to be collected from consumers by the producers. Consumers are divided into two categories, individual and bulk. The Rules define bulk consumers as entities that employ 20 or more people or whose annual turnover is greater than Rs 1 crore. Bulk or institutional consumers include offices, departments, ministries, public sector undertakings (PSUs) and multinational companies (MNCs).
3. Producers are also required to have legal agreements with authorized dismantlers and recyclers either individually, collectively, or through a Producer Responsibility Organization (PRO), which have to be disclosed through their EPR plans.
4. An EPR plan has to be submitted to CPCB while applying for Extended Producer Responsibility Authorization (EPRA) through the Form 1 appended with the Rules. The plan includes details of collection points, transportation partners, dismantling and recycling partners, website toll free numbers, details of awareness campaigns to be conducted and contact details of producers. CPCB approves the EPR plan before granting EPRA to a producer.
5. Producers authorized by CPCB have to meet their collection targets as per Schedules III and III-A of the Rules
6. The targets for recovery from LiB in electric vehicles are set to increase phase-wise from 70% in FY'25 to 90% in FY'27.



Battery waste management rules cover all types of batteries, from Electric Vehicles, portable batteries, automative batteries and industrial batteries, and are governed by the EPR concept, where producers including importers are responsible for collection, recycling, recovery and re-use of materials into new batteries prohibiting disposal of batteries into landfills and incineration.

[46] https://pib.gov.in/PressReleasePage.aspx?PRID=1854433

Stakeholders and their legal regulatory obligations:[47]

Producers	Dismantlers, recyclers, manufacturers andrefurbishers	Dealers
Obtaining EPRA, which includes submission of the EPR plan to CPCB along with other information required in the Form 1 appended with the2016 Rules.	Obtaining authorization [through Form 1 (a) for manufacturers andrefurbishers and Form 4 for recyclers and dismantlers] from the concerned SPCB.	Collecting e-waste by providing the consumers a box, bin or ademarcated area to deposit e-waste in and to send it to a collection centre, dismantler or recycler as designated by the producer (if they arepart of the reverse logistics of the producer).
Fulfilling their collection targets as per Schedule III or III-A of the 2016 Rules.	Maintaining records of e-waste generated, handled and disposed of in Form 2 and making it available for scrutiny if requested by theconcerned SPCB.	
Maintaining records of e-waste handling in Form 2 and making such records available for scrutiny by CPCB or the concerned SPCB.	Filing annual returns in Form 3 to the concerned SPCB on or before 30 June every year.	
Filing annual returns in Form 3 to the concerned SPCB on or before 30 June every year.		

Table 19: E-Waste regulatory obligations for various stakeholder groups in the value chain

[47] https://www.cseindia.org/content/downloadreports/10593

7.5.6 Key challenges

Key challenges across the electronic waste value chain including battery waste are as follows:

Informality of the sector:

Informality of the sector: E-waste collection, transportation, processing, and recycling is dominated by the informal sector. The sector is unregulated and often, all the materials and value that could be potentially recovered is not recovered. In addition, there are serious issues regarding leakages of toxins into the environment and workers' safety and health. Seelampur in Delhi is the largest e-waste dismantling centre of India. Adults as well as children spend 8–10 hours daily extracting reusable components and precious metals like copper, gold and various functional parts from the devices. E-waste recyclers use processes such as open incineration and acid-leaching.[48]

Lack of citizen awareness and source segregation:

Lack of citizen awareness and source segregation leading to mixing up of e-waste with municipal waste streams - when these are openly burned, hazardous substances are released into the air.

Inadequate infrastructure:

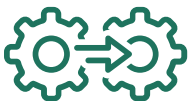
Inadequate infrastructure: India has very few recognised and government-approved recycling centres to dismantle and repurpose electronic waste. Despite the government granting funds of 25% to 50% of the expenses in setting up infrastructure to repurpose electronic waste, recycling centres and organised supply chains are very few in number.[49]

48 https://www.teriin.org/article/e-waste-management-india-challenges-and-opportunities

49 https://www.karosambhav.com/blogs/the-prominent-challenges-of-e-waste-management-in-india

7.5.7 Scope for Innovation

The e-waste market indicates scope for innovations in improved product-tracking, as well as take-back schemes that could help create a recycling chain. E-waste experts point to developments in the cloud and the internet of things (IoT) that could help "dematerialize" the electronics industry. Leasing 'technology as a service' could also create greater incentives for manufacturers to repurpose and reuse.[50]



Integrating the informal sector

Startups like Karo Sambhav in Delhi are working with the informal network to bring together stakeholders across collection channels to dismantling and recycling companies to organizations that utilize secondary materials for new product creation.

Extended product lifespan and alternate business models like 'product as a service'

Companies such as Cerebra are offering device-as-a-service (DaaS), allowing clients to extend the lifespan of their IT assets and reduce waste sent to landfills. Philips is pioneering this globally, introducing 'lighting as a service' or LaaS to allow customers to purchase subscriptions to 'lighting services' rather than use and throw bulbs.

Transparency through blockchain technology, AI and smart bins for waste tracking

Blockchain technology and data analytics offer significant potential for improving waste management by enhancing transparency, traceability, and efficiency. By leveraging blockchain's decentralized and immutable ledger, waste management processes can be tracked securely and transparently from generation to disposal. Bintix, Recykal and a few other organisations are at the forefront of these efforts in India.

[50] https://theprint.in/india/an-indian-startup-is-tackling-the-worlds-e-waste-problem/622173/

08

Research Findings

As part of the objectives of this study, for establishing the SAAF Cities Platform – an integrated innovation platform, along with secondary research and analysing the start-up landscape for various waste streams, we have conducted primary engagements with stakeholders across the value chain to gain perspectives on the key challenges and opportunities for scaling innovations in India.

Stakeholders engaged

Our research included engaging with 32 stakeholders across the start-up, investor, ULB and corporate ecosystems.

Fig. 25: Key stakeholders engaged for the study

Key findings from these engagements are given below highlighting the need and opportunities for innovations to scale.

8.1 ULB perspectives

From municipalities across the country, including Jaipur, Rajkot, Sikkim, Pune and Jatni in Odisha, we spoke with representatives involved in supervising waste management across varying levels of seniority from executive engineers to municipal commissioners. Their perceptions of waste ranged from viewing it as a social problem of ***poor citizen awareness*** *and* ***cleanliness****, to viewing it as an* ***inconvenience*** *and an* ***eyesore for the municipality*** *to get rid of. When asked about their interactions with for-profits, many spoke of* ***collaborations with private sector*** *entities to outsource the hiring and managing of human resources (road sweepers, sanitation workers, tipper vehicle drivers etc.).*

> *Very few municipalities perceive waste as an economic resource, as it is expensive to manage the end-end ecosystem without the support of corporates and communities.*

Although the prevailing sentiment was the hope that in the near future, the ULB's role in waste management would reduce and private sector involvement would increase, there was also an undercurrent of concerns regarding the 'sustainability' and financial feasibility of startups getting involved. As a ULB officer noted, "we get a lot of startups and consultants coming in without an understanding of on-ground implementation of SWM", expressing concerns regarding the **lack of long-term engagement with startups** ("they vanish"). In Jaipur, we heard of private players providing SWM services to residential apartments and commercial buildings in and around the city - they serviced these apartments by simply transporting and dumping the waste elsewhere. Municipality officers highlighted the need for more **holistic, end-to-end solutions from the private sector**, and for **startups to customize their solutions to the infrastructure, collection and processing systems unique to each city**.

8.1.1 Challenges

The following are the challenges and gaps in existing waste management processes, as highlighted by the municipalities we spoke with:

1. Technical and Market Challenges

Data Gaps: Despite GPS tracking and volume measurement at transfer stations, municipalities lack granular data on waste types and sources (e.g., waste characterization reports).

Low-Value Plastics: Recycling multi-layered plastics (MLPs) remains a challenge. Impurities like stones in mixed waste hinder waste-to-energy (WTE) plant efficiency.

Segregation Needs: Municipalities show interest in WTE but emphasize the urgent need for mechanised systems to separate non-combustibles like mud and debris.

2. Infrastructure Limitations

Underutilised Facilities: Existing processing units operate below capacity and cannot handle the full waste load. For instance, Rajkot's two cement plants process under 10% of its total waste.

Remote Area Barriers: In hilly or remote areas, land scarcity, scattered households, and high labour costs due to out-migration hinder effective waste collection.

3. Financial Constraints

Funding Shortages: The bulk of municipal budgets go to door-to-door collection and transport. Minimal user charges are hard to collect and enforce.

Lack of Expertise: Smaller cities struggle without adequate manpower or funds to hire consultants for vendor onboarding or tender drafting.

High Transport Costs: Waste is often transported 30–40 km, or even 300 km in Sikkim's case, to distant recycling facilities—raising costs and increasing pilferage of high-value recyclables.

Decentralisation Dilemma: While ULBs favor colony-wise decentralised models to cut transport costs, smaller municipalities find O&M expenses unsustainable, as seen in Jatni.

No Perceived Value in Waste: Most municipalities do not see waste as an economic resource. Lack of forward linkages for recycled products and minimal compensation from WTE players discourages 'waste-to-wealth' approaches.

4. Social and Administrative Barriers

Low Source Segregation: The most critical gap identified is poor household-level segregation. Despite awareness drives, 100% segregation remains elusive.

Limited IEC: Campaigns lack continuity and follow-up. Officials advocate regular, door-level engagement (e.g., every 15 days) to build lasting habits.

Behaviour Change Needed: Officials recognize that waste management is as much a social issue as a technical one. Without sustained community engagement, even well-funded solutions fall short.

Startup Collaboration Issues: Municipalities prefer working with local startups due to restrictive local policies and ease of support. Non-local startups face policy hurdles in states like Sikkim.

"The gap lies in source segregation, many D2D campaigns have been devised and carried out to generate awareness on source segregation, even in schools, however, 100% segregation is still a challenge", an official from Jaipur noted.

8.1.2 Scope for Innovation

Technical

Municipalities are keen to explore technologies for collecting and processing specialised waste types—E-waste (batteries, CFLs), slaughterhouse waste, biomedical and sanitary waste, composite paper, textiles, and thinner plastics like MLPs. Pune highlighted the need for solutions to manage **sanitary waste from bulk generators** like hostels and maternity hospitals. There's also interest in upstream innovations to reduce single-use plastic consumption.

Tier 1 cities are exploring niche categories such as **temple flower waste,** while smaller ULBs are open to pilot innovations through cluster-based models (within 25–30 km radii) to ensure feasibility.

There is growing interest in using **processed waste**—such as plastic—for roads and paver blocks. Mechanised segregation in processing plants and improving efficiency of existing infrastructure is another priority. Drought-prone regions like Rajasthan seek innovations in **decentralised STPs** (sewage treatment plants), inspired by Bangalore's apartment-level greywater reuse models.

Infrastructural

Decentralised infrastructure was cited as a pressing need across ULBs. Experts recommend **colony- or apartment-wise decentralisation in large cities, and cluster-based models for smaller towns,** possibly integrating rural-urban zones (as seen in Panjim, Goa).

This would **increase local processing capacity** while enabling access to rural development funds (e.g., NABARD). Space constraints were a repeated concern. Officials proposed vertical construction for transfer and processing stations: "We can find space for parks and schools—why not for waste?"

Financial

Smaller ULBs face **high transport costs for specialised waste**, making localised solutions essential. There's untapped potential in EPR (Extended Producer Responsibility) and "polluter pays" revenue models. ULBs are exploring new business models involving **SHGs**—for instance, Jatni's SHG-led C&D waste unit and Sikkim's SHG-run IEC and collection efforts under NULM and Swachh Bharat.

Innovative financing models are emerging. ITC's CSR-backed partnership with Shakti Plastics and SWaCH Pune demonstrates how manufacturers can fund recycling of low-value plastics. Rajkot is piloting 'premium' MSW services—such as twice-a-day pickups—to raise user fee revenue, while Sikkim plans to sell compost produced by SHGs.

Social and Administrative

Targeted IEC campaigns are needed across the board—for citizens, waste pickers, enterprises, and municipal staff. There's also urgent need for **social innovations** that improve inclusion, wellbeing, and livelihoods of informal waste workers.

Mechanising D2D collection could reduce worker fatigue and create dignified green jobs across the waste value chain.

As potential opportunities for startups and innovators, ULBs offer support in the form of land on lease to enterprises. In our interviews, officials also offered to support pilots of startups by merging them with existing projects or projects that are reaching the end of their shelf life. ULBs giving pilots to startups with limited prior experience can go a long way in terms of helping startups test the waters while also allowing municipalities to assess the feasibility of new entrants.

8.1.3 Potential opportunities

Opportunities for startups to work on municipal waste management are relatively better in smaller cities, for instance, in Jatni, startups can either approach the DMA or directly approach the ULB for collaborations. Moreover, cities faring poorly in Swachh Survekshan rankings or cities with higher NGT fines, would also be more amenable to working with newer private players.

And while there is no way for startups to bypass the tendering process against a certain value of project capacity and size, in some cases, funds received from multilateral funders are used as ‘golden money’ to work with private and social enterprises without going through the usual bidding process.

6

8.2 Start-up perspectives

The findings of the study illuminate the challenges faced by enterprises, opportunities for their growth and collaboration with ULBs and CSOs, and, on a more personal level, the motivations that underlie their efforts to start and operate ventures amidst a high-risk and potentially low-reward environment. We have taken 3 approaches to engage with start-ups -

A. *Findings compiled from existing research study and primary engagements by Socratus Foundation*

B. *Review of applications from SAAF Cities initiative launched in January 2025*

From January to June of 2024, Socratus Foundation carried out a landscape assessment of startups working in waste management (published here), across cities like Chennai, Bengaluru, Delhi, Bhubaneswar, Kochi, Hyderabad and more. Speaking with start-up founders, nonprofits, and accelerators based in these cities, the participant pool included four small-scale, early-stage start-ups; two larger, late-stage enterprises with pan-India operations; five nonprofits or CSOs; and four incubators.

8.2.1 Challenges

Technical

Startups face major uncertainties due to the lack of **comprehensive waste characterization studies** and **reliable data on sources and types of waste**. Existing technologies, largely designed for Western waste streams, are often incompatible with India's unique waste profile—higher organic content, informal sector dynamics, and diverse geographies (e.g., coastal, hilly areas). There is a clear gap in **context-specific**, **affordable technologies** tailored to Indian conditions.

Infrastructural

Waste segregation policies are **poorly enforced**, leading to default "pick and dump" models that prioritize **volume** over recovery. Tipper-based collection systems leave little room for resource recovery. Startups struggle to access **high-value waste streams**, which are often controlled by ULBs or contractors. **Lack of source segregation** leads to contaminated waste that smaller enterprises lack the tech or capital to process effectively.

Financial

R&D funding is critical to develop solutions suited for India's complex waste mix, but it remains scarce. Early-stage startups struggle to raise capital, especially with **unproven models. Delayed municipal payments** create severe cash flow issues—one startup reported waiting over two years for a payment. The **informal** nature of operations further deters investors. The recycled materials market is **underdeveloped**, with **limited demand** and **fragmented supply chains**. Startups are often seen as niche players catering to climate-conscious elites. Without **stronger policies** mandating recycled content use, profitability remains low.

Incubators also tend to support similar types of startups, often based in a few regions and parts of the value chain, limiting innovation diversity.

Social and Administrative

Adoption of innovations often hinges on individual municipal champions rather than **systemic support**. Startups face significant hurdles in **public procurement**—long payment cycles, inadequate record-keeping, and contracts skewed in favor of large incumbents. Despite being designed for accessibility, the **GeM portal remains difficult** for small enterprises to navigate.

The concessionaire model creates monopolies that stifle competition. Startups, especially in metros, often avoid ULB engagement due to **complex tenders and lack of connections.** Some even reported threats, vehicle vandalism, and forced shutdowns by local waste contractors or "waste mafias."

Environmental

Many current interventions offer short-term fixes that worsen long-term outcomes. **Landfill remediation without preventive strategies** is ineffective. Waste-to-energy plants designed for **mixed waste discourage segregation**. There is an overemphasis on IT-led solutions, while real on-ground recycling and processing innovations remain **underfunded**.

Waste management solutions often lack **a life-cycle lens**. For example, products combining C&D and plastic waste don't account for end-of-life processing, potentially creating new waste problems.

8.2.2 Scope for innovation

The insights captured have helped us in identifying the potential scope and role for innovations by start-ups in the waste management.

Technical

Innovative product prototypes present significant opportunities. Startups spoke of **pyrolysis incinerators that convert waste into fuel** for diesel generators that could provide **energy solutions for residential complexes** while addressing waste challenges simultaneously.

Similarly, **R&D focused on specialized waste streams** offers untapped potential. These include salon hair waste, restaurant organic waste, glass waste, electronic waste, and construction debris. **Innovations can target both collection methodologies and processing technologies.** Although many of these specialized waste streams are currently processed through informal channels—**enterprises can create value by standardizing, streamlining, and scaling these processes** while preserving local livelihoods and knowledge systems.

> ***As Saltech scales its impact, establishing strategic partnerships with Municipal Corporations (ULBs) and Corporates becomes increasingly critical. Collaboration with ULBs enables effective access to essential waste streams and local infrastructure, while alliances with Corporates, Industries & Brands facilitate broader technology adoption and market reach. Together, these partnerships can help overcome the challenges associated with mass-scale adoption of our solutions and unlock substantial opportunities for a sustainable and circular future.***
>
> — Aditya Shukla, Founder & CEO, Saltech Design Labs

Infrastructural

Regional innovation and incubation hubs could serve as critical connectors between ULBs and enterprises.

Startups and CSOs concur that these hubs would facilitate collaboration to address **region-specific waste management challenges faced by municipalities**, creating tailored solutions for local contexts rather than implementing one-size-fits-all approaches.

Financial

As a leading urban development expert and startup mentor pointed out to us, innovative funding approaches for startups can include the development of **“specialized risk capital instruments for waste management ventures”**. Blended finance solutions that combine developmental and commercial capital can provide the agility and reasonable returns needed to attract investment while acknowledging the social and environmental benefits these businesses create.

Social and Administrative

New partnership models present opportunities for waste management entrepreneurs. These include **collaborations with smaller municipalities** that may lack waste management infrastructure, and partnerships with builders to integrate solutions such as composting and/or biogas during the construction phase itself, rather than as an afterthought.

Integration of **informal waste workers and aggregators** represents an opportunity to strengthen local waste economies rather than disrupting them. This inclusive approach can leverage existing expertise while improving working conditions and economic outcomes for these workers.

Citizen engagement initiatives can increase demand for and awareness of solid waste management services. **Educational programs** that illuminate the entire waste value chain—showing citizens what happens to waste after it leaves their homes—can drive behavioural changes and support for sustainable waste management practices.

Most importantly, **"waste to value" business models** can achieve profitability when demand is not solely dependent on consumer behaviour but is instead supported by **institutional regulations and government policies.** Examples include effective EPR mandates for manufacturers to buyback / use processed or recycled materials in their production processes.

Environmental

Critical evaluation of waste management solutions based on c**arbon footprint** and **long-term sustainability** can help identify and avoid what one entrepreneur referred to as **"false solutions in play at the moment."** For example, assessment of emissions and pollutants from waste-to-energy plants and incineration facilities to ensure that environmental impact is not exacerbated, especially in the case of incinerating mixed wastes.

8.2.3 Potential opportunities

Findings from the study highlights key areas of opportunity for startups in this sector -

Accessible tenders:

Regulations that reserve separate tenders for start-ups to handle smaller orders can help them achieve scale and gain an entry point into working with municipalities. The Government e-Marketplace (GeM) portal for public procurements has taken the lead in this. Alert to the difficulties that start-ups face in winning government tenders, GeM launched 'Startup Runway', which exempts small businesses from having to declare prior turnover and experience—conditions that larger businesses have to meet. [51]

Enabling policies:

India's policy ecosystem for waste management startups has evolved significantly, with multiple initiatives spanning national and state levels. At the national scale, the Extended Producer Responsibility (EPR) guidelines under the Plastic Waste Management Rules 2016 (amended in 2022) have created market opportunities for startups such as Swachha Eco Solutions by mandating producer responsibility for plastic waste collection and recycling. EPR policies hold producers, importers, and brand owners (PIBOs) accountable to using eco-friendly materials, collaborating with recyclers, and taking care of end-of-life product disposal. This has opened up a market for waste management start-ups to step in and fulfil these service requirements. Additionally, EPR policies that require recycled materials to be used in product manufacturing can help create a market for repurposed materials, often produced by small businesses and start-ups.[51]

Government initiatives:

National initiatives like the Atal Innovation Mission and the National Clean Air Programme have integrated waste management into their funding priorities, creating multiple avenues for startups to access government support and market opportunities in the circular economy space. The Ministry of Housing and Urban Affairs (MoHUA) has actively promoted innovation through its Swachhata Startup Challenge, offering financial support and mentorship to startups like Bintix Mudita and Radhesh. The Startup India program complements these efforts by providing tax benefits, fast-tracked patent applications, and funding support through the Startup India Seed Fund Scheme (SISFS).

[51] https://idronline.org/article/environment/can-startups-solve-indias-waste-problem/

State governments have further enriched this landscape through startup policies – for instance, Karnataka's Startup Policy 2015-2020, and now 2022-2027, offers innovation grants and proof-of-concept funding for waste management solutions. Within Maharashtra State Innovative Startup Policy 2018, the fintech-focused sandbox regulations have enabled waste management startups to leverage technology for tracking and trading recyclable materials. The state has leveraged its metropolitan scale and robust industrial base to drive smart waste management technologies- with a surge in startup activity. Odisha's startup policy 2016 actively promotes sustainable waste management through its offerings such as; targeted incubators and financial incentives that support segregation & collection, recycling and material recovery initiatives.

The framework not only encourages entry of startups into the waste economy, but also houses over 2000 startups, while facilitating collaboration with ULBs wherever deemed fit. The state of Tamil Nadu has been integrating technology-driven waste management solutions through the Tamil Nadu Startup and Innovation Policy 2023. The state encourages public–private partnerships and has established dedicated incubation centers for waste management startups. The Swachh Bharat Mission-Urban 2.0 has also created opportunities through its focus on sustainable solid waste management, with several Urban Local Bodies (ULBs) actively seeking startup partnerships for waste processing solutions.

8.3 Corporate perspectives

Corporates and industry have shared their perspectives on key challenge areas and opportunities to solve for the waste management sector, highlighting the alignment towards **ESG compliances** and **net-zero targets.** While ULBs have start-ups focus is on the overall ecosystem and different waste streams, the focus for corporates is specifically on **waste streams generated majorly from their manufacturing process, logistics and post-consumer wastes of their product lines.** Ex: FMCG company focus will be on plastic waste, a Tyre company will focus only on tyre waste.

The pre-consumer waste is currently all captive, and the policy mandates the corporates to manage their own waste and reduce disposing off the waste in landfills. However, to achieve the ESG goals and targets, corporates have to **sort the post-consumer waste** which is where the synergy with ULBs (for products linked to MSW / specialised waste streams managed by ULBs) come into picture – focusing on **collection of segregated waste, recycling and processing of the waste and reduce disposing the waste into landfills.**

"Corporates require innovative solutions that can be commercially viable at scale, and reduce the burden on compliance needs"

8.3.1 Key Challenges

01

For pre-consumer waste, focus and need for innovations to recycle / process specific waste streams and each industry has its own problem of solving the waste crisis – wastewater, chemical waste, foundry waste, abrasive powders, sludge, textile, and many others.

02

High costs of removing contaminants (e.g., heavy metals, pharmaceuticals) and meeting discharge standards. Industrial wastewater often contains toxic byproducts (e.g., from textiles, chemicals) requiring tailored treatment.

03

Transporting low-value, high-volume waste (e.g., construction debris) to recycling hubs is economically unviable.

04

Recycled materials (e.g., recycled plastics, reclaimed solvents) compete with cheaper virgin resources. Industries resist adopting "downcycled" products. Requirement to solve challenges for off-take of byproducts or recycled products (if not useful in the same industrial process).

05

Compliance with regulatory requirements and standards for managing waste.

06

Technology Adoption: SMEs lack access to advanced waste treatment solutions (e.g., AI-driven sorting, chemical recycling).

07

Policy-Industry Misalignment: Regulations prioritize waste disposal over prevention, stifling innovation in circular design given the techno-commercial feasibility of such circular innovations.

08

Funding Gaps: High upfront costs for waste-to-resource infrastructure (e.g., anaerobic digesters, material recovery facilities).

09

Skills Shortages: Shortage of experts in industrial ecology, waste lifecycle analysis, and circular supply chain design.

10

Dependency on third-party disposal increases costs and regulatory risks (e.g., landfill taxes, leakage incidents).

8.3.2 Scope for innovation and opportunities

To help in pre-consumer and post-consumer waste management for each corporate, start-ups can play a pivotal role. This includes,

- Create co-development models between start-ups and corporates that will customise the innovation to the technical specifications and needs for each waste stream
- Need for innovative and commercially viable solutions to reduce the operational costs
- Specific needs to manage waste on-site and reducing the waste ending up in landfills, reducing dependency on local disposal services, offering greater control over waste management and potential cost savings
- Creation of a market (captive or competitive demand) for recycled / repurposed products
- Industry-specific accelerators (e.g., for textile waste or foundry byproducts) to fast-track solutions like AI-driven waste sorting or blockchain traceability.
- Startups developing modular pyrolysis/ recycling units to convert plastic/agricultural waste into fuel on-site, reducing transport/logistics costs.
- Effective implementation of mandates and demand side activation rules supporting start-ups in market linkages - Mandate recycled content quotas (e.g., EU's Single-Use Plastics Directive) to create captive markets.

Strategically, key recommendations from corporates are open for fostering partnerships with startups and ULBs, which can turn waste liabilities into revenue streams while also achieving net-zero and ESG targets.

8.4 Conclusion

The needs and opportunities identified from the primary engagements underscores data transparency, decentralization, cross-sector collaboration, and policy-driven demand as critical levers to solving the waste management challenges in India and transition from a linear waste disposal models to circular economy models. These have to be aligned to the priorities of the stakeholders – a) Cost reduction for ULBs b) Alignment on circularity and ESG goals for corporates and c) creating and scale niche technology and innovative models for start-ups.

Key strategies for scaling waste innovation in India

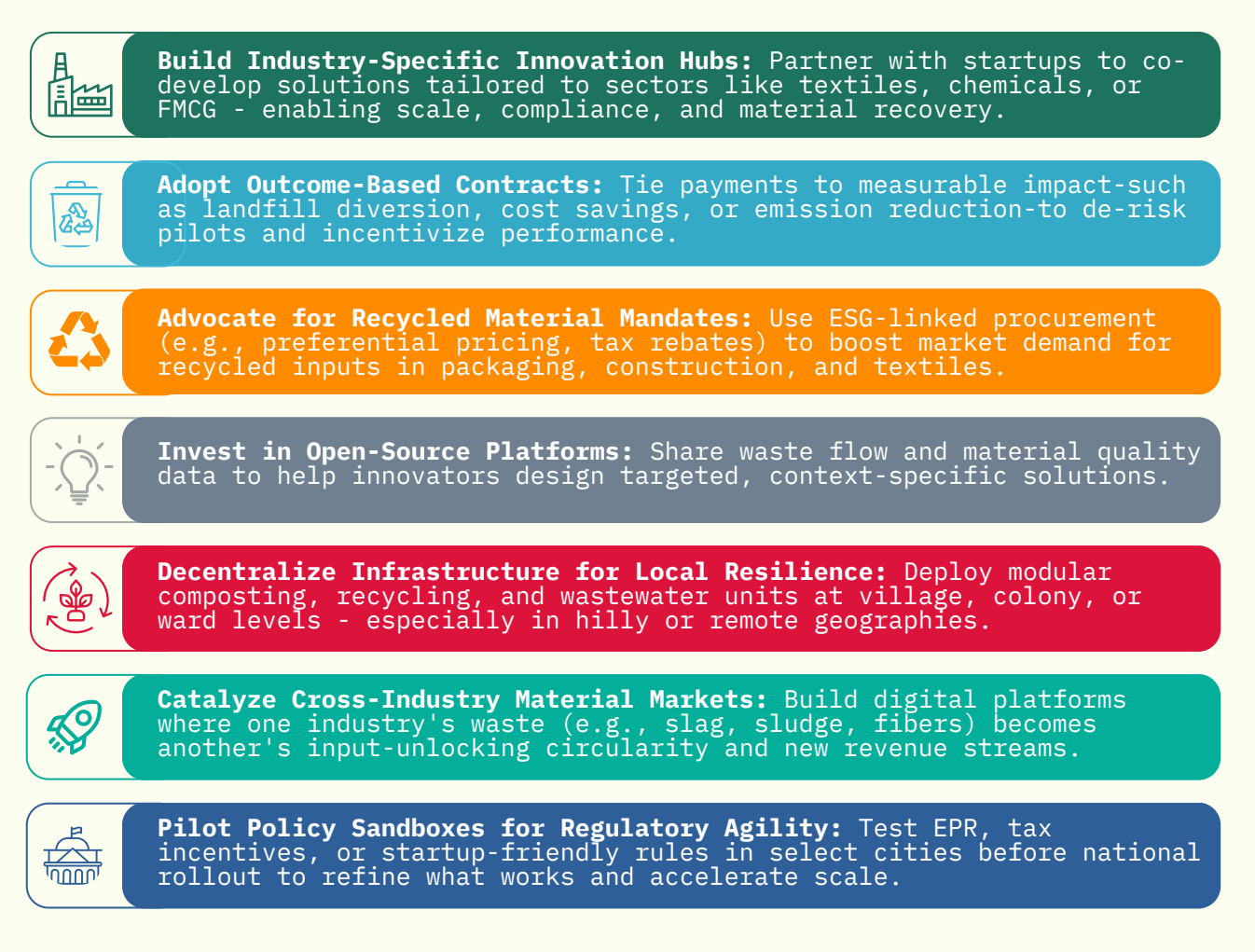


Fig. 26: Proposed strategies for scaling innovations in the waste management sector

1. Sector-Specific Focus to Build Customized Innovations at Scale

Tailoring solutions to **industry-specific waste streams** is critical for scalable impact. For instance, textile waste demands fiber-to-fiber recycling technologies, while chemical sectors require detoxification methods for hazardous solvents. Customized innovations address unique **contamination profiles, regulatory demands, and market needs, ensuring solutions** are both technically viable and commercially sustainable. Startups and corporates must co-develop technologies that align with **sector-specific challenges**, such as repurposing foundry slag into construction materials or converting low-value plastics into fuel. This approach prevents one-size-fits-all failures and accelerates adoption across high-impact sectors like FMCG, automotive, and construction.

2. Geographic Strategy for recycling facilities

Implementation of **decentralised models** and **cluster-based hubs** to improve efficiency and operational capacity of recycling / processing plants. Decentralized, modular recycling facilities reduce dependency on distant processing hubs, particularly in remote or hilly regions where transportation costs are prohibitive. Urban areas can adopt **colony-level composting units** or **apartment-based wastewater treatment systems**, while rural clusters (e.g., 2–3 towns within a 30 km radius) benefit from **shared infrastructure** to achieve **economies of scale**. For high-volume waste streams like plastics or C&D debris, **centralized large-scale recycling plants** remain essential. This hybrid model balances localized efficiency with regional capacity, minimizing landfill reliance and optimizing resource recovery.

3. Business and delivery models

Leasing modular waste processing units—such as containerized pyrolysis plants or IoT-enabled sorting systems—to industries and ULBs reduces upfront costs and accelerates adoption. Startups can offer these technologies via **subscription or pay-per-use models**, ensuring affordability for SMEs and municipalities. For example, a corporate could lease on-site wastewater treatment units to meet compliance standards, while ULBs might adopt mobile MRFs (Material Recovery Facilities) for seasonal waste surges. This model shifts **capital expenditure to operational costs,** aligning with budget constraints and risk-averse stakeholders.

4. Public-Private Partnerships for Infrastructure

PPPs are vital for building **sorting facilities, transfer stations, and material recovery infrastructure.** Municipalities can partner with startups to modernize **legacy systems**—such as integrating AI-driven route optimization for waste collection or mechanized segregation lines at processing plants. Joint ventures with corporates under **CSR/EPR mandates** can fund infrastructure upgrades, like biogas plants for organic waste or SHG-operated C&D recycling units. These collaborations **distribute risks, leverage private-sector efficiency, and ensure long-term operational support.**

5. Industrial Symbiosis for Cross-Sector Resource Exchange

Cross-industry reuse of byproducts transforms waste into **inputs for adjacent sectors**. Foundries can supply slag to cement manufacturers, while textile recyclers provide raw materials to automotive or packaging industries. Digital platforms, akin to Sweden's SYSAV, can match waste generators with potential buyers, creating circular supply chains. For example, chemical manufacturers might partner with agriculture to repurpose nutrient-rich sludge as fertilizers. Such symbiosis reduces **virgin resource dependency, cuts emissions, and unlocks revenue from "waste" streams.**

6. Financing mechanisms

Diverse funding mechanisms are essential. Municipalities can issue **green bonds** for waste infrastructure or introduce tiered user fees (e.g., premium services for frequent waste pickup). Corporates might fund startups via **viability gap funding (VGF) tied to EPR compliance**, while outcome-based contracts link payments to measurable results like landfill diversion rates. **Revenue-sharing models**—such as profits from compost sales or recycled material markets—incentivize performance. Blended finance (grants + venture capital) can support high-risk pilots, such as PFAS removal technologies.

Insurance coverage for waste processing infrastructure mitigates risks like equipment failure, contamination incidents, or payment delays from ULBs. Products could include **performance guarantees** for recycling outputs or **disaster recovery funds** for SMEs. For instance, a startup operating a pyrolysis plant might insure against revenue loss due to feedstock shortages. Such safeguards attract private investment and stabilize operations in a volatile sector.

High-risk innovations—like enzymatic breakdown of hazardous chemicals or AI-powered microplastic capture—require **dedicated funding** mechanisms. Government-backed grants, corporate venture arms, and impact investors can pool capital into **specialized funds**. For example, a "Circular Tech Fund" might prioritize startups addressing niche streams like salon hair or flower waste. Additionally, concessional loans or milestone-based grants can bridge the "valley of death" between pilot validation and commercial scaling.

7. Policy Sandboxes

Government-industry partnerships can test novel frameworks in controlled environments. For example, piloting **Extended Producer Responsibility (EPR) schemes** for microplastics or lithium-ion batteries in select cities allows regulators to refine rules before national rollout. Sandboxes could also trial **tax incentives** for industries using recycled materials or fast-track approvals for decentralized units. These experiments reduce compliance uncertainties and foster innovation-friendly regulation.

8. Data Transparency, Reporting and Auditing for Informed Decision-Making

Robust data transparency frameworks are essential to address gaps in **waste characterization, track progress, and build accountability.** Standardized reporting systems—such as real-time dashboards for waste volumes, types, and disposal routes—enable ULBs to optimize collection routes and identify high-impact streams (e.g., MLPs in municipal waste).

Startups and corporates require access to granular data on **waste composition** (e.g., moisture levels, contamination rates) to design context-specific solutions. **Publicly accessible platforms**, like blockchain-enabled traceability systems, can verify recycled material flows and prevent fraud in EPR compliance. For example, Jaipur could deploy IoT sensors in transfer stations to generate waste characterization reports, while corporates might adopt digital Material Passports to track recycled content in products.

In line with this, **standardized and universal metrics**—such as landfill diversion rates, carbon footprint per ton processed, or circularity percentages—enable consistent ESG reporting across industries. Aligning these with global frameworks (e.g., GRI, TCFD) ensures comparability for MNCs operating in India. For example, a universal "net-zero waste" definition could distinguish between mere diversion (e.g., incineration) and true circularity (e.g., closed-loop recycling).

Harmonizing these datasets with **national ESG reporting standards** (e.g., Swachh Bharat Mission metrics) ensures alignment with global frameworks and empowers stakeholders to make evidence-based investments. Transparent data sharing between ULBs, industries, and startups also mitigates risks like **"greenwashing"** and builds public trust in circular economy claims.

Further to this, **independent audits** of corporate, ULB, and startup initiatives validate claims around waste recovery, emissions reductions, and social impact. Auditors could certify recycled content in products, verify landfill diversion data, or assess working conditions for informal waste workers. For instance, a third party might audit a ULB's decentralized composting program to ensure compliance with Swachh Bharat metrics. Transparent reporting builds credibility attracts ESG-focused investors and ensures compliance with evolving regulations.

9. Governance and management of waste

ULBs are stressed with various initiatives and activities of a region that will require **resources** and **manpower.** Waste as a sector can be fragmented out with a targeted focus with its own department focus and targets. This will enable **resource allocation and improving the efficiency** in the overall operations of waste management, recycling and landfill management. This can also support start-ups and corporates in engaging and extending the support for solving the waste management crisis across regions and sectors.

10. Strengthening Ecosystem Collaboration

Fostering collaboration between **research institutions, startups, and ULBs** is critical. Universities can host **innovation labs** for waste-tech R&D, while industry associations facilitate **knowledge sharing** on best practices. Regional task forces—comprising policymakers, corporates, and NGOs—can address **localized challenges**, such as optimizing collection in coastal areas or managing festival-generated waste. This ecosystem approach ensures sustained momentum toward India's circular economy goals.

09

SAAF Cities Platform

With the launch of SAAF Cities initiative by Villgro and HDFC, the goal is to achieve two folded objectives:

A. Help waste management innovations to commercially scale

B. Reduce waste disposal in landfills

Given the research findings and the scale of the challenges (what can be seen as opportunities), the pathway for the initiative is to propose and establish a framework that will **bring together stakeholders – Urban Local Bodies, Start-ups and Corporates – together, with an intent to collaborate and solve complex challenges of the ecosystem.**

While there are solutions and offerings available in the market to help start-ups, corporates and ULBs, in establishing pilots and proof of concepts, provide access to initial capital, there is still a gap in **achieving scale for the waste management projects in India**, as we understand these from the stakeholder perspectives from the study.

To address these gaps and drive innovations to scale,

our focus of establishing a SAAF Cities Platform is to drive a be-spoke, integrated and consolidated approach to scale these innovations in the market.

9.1 Key offerings of the SAAF Cities platform

SAAF Cities platform is an integrated innovation-first platform that enables technologies and models to scale for solving the challenges of the waste management ecosystem.

This platform will enable the levers needed for the innovations to scale as identified in the previous sections of the report. The platform will be a physical and digital platform that will enable global access yet driving local solutions given the needs and opportunities for the stakeholder ecosystem. The offerings are curated given the challenges of various sectors and stakeholders in the value chain.

These offerings include:

01 Enabling access to capital

Support start-ups and innovators with financing mechanisms to help set-up large scale projects, pooling resources from philanthropy, banks and corporate financing. A “technology demonstration and scale-up fund” will help bring grant, equity and debt capital that will help enable in accessing the capital for viability gap funding, pilot testing and proof points and setting up large scale plants.

02 Establishing market demand

Developing the supply and demand for innovative technologies with ULB, corporates and final product users of products generated / recycled from waste, creating impactful partnerships for scaling-up. A collaborative network of demand and supply side players will be established to leverage cross sectoral synergies and off-take of recycled / repurposed products.

03 Creation of a marketplace

Showcase potential and commercially scalable innovations in one marketplace with all technical, commercial and technical aspects, with support to implement pilots and commercial projects after match-making problem and the solution. The marketplace will act as a one-stop shop for scalable innovations, knowledge on technology and commercial know-how and adoption requirements / practices, which will strengthen the uptake of this innovations by corporate and government.

04 Incubation of innovations

Customised problem-solving solutions for ULBs and corporates and supporting innovations to scale through be-spoke approach to incubation and make the innovations deployment worthy. A systems approach will be taken to identify the needs of the stakeholders and map innovations, establish the use-cases and help in scaling up. The engagement models will include workshops and knowledge sharing sessions, including pitch sessions for various innovations and use-cases.

05 Empowering skilled workers

Create an ecosystem to provide training and skill-building for waste workers to support ULBs and corporates in end-end waste management and upskilling them on innovative technologies and digital solutions to enable job security and new job creation. This will extend the support to ULBs and the start-up ecosystem in engaging with the right talent and availability of workforce trained to manage and operate new innovations and solutions.

9.2 Pathway for SAAF Cities platform

The pathway to operationalize and implement the platform will be in a phased yet be-spoke approach to help solve the needs and opportunities identified. The platform will be initially operated for a 5-year timeline, with an intent to give the boost and establish sufficient proof points for setting up large scale, commercially viable recycling/ repurposing plants for different waste streams identified.

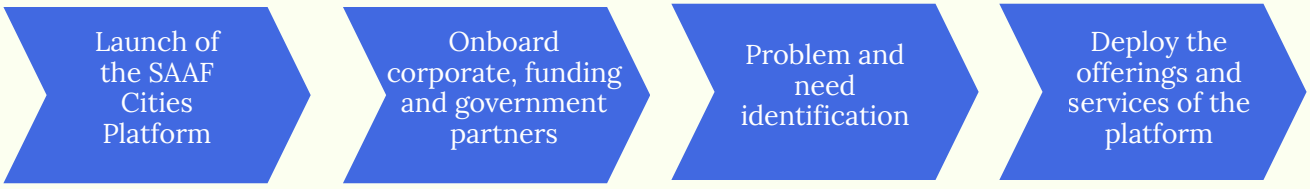


Fig. 27: Proposed pathway for SAAF Cities Platform

Key activities to be conducted by the SAAF Cities platform includes (but not limited to) are as follows:

1. *Mapping the needs and opportunities from ULB, corporate and start-up ecosystem*
2. *Create a pathway for short-term and long-term opportunities*
3. *Identify and onboard partners from public and private sector, including the financing community*
4. *Match-making innovations with the needs*
5. *Design and delivery of the projects by start-ups*
6. *Facilitating market creation, financing and knowledge dissemination in the process*
7. *Impact analysis and assessment of waste diverted from landfills*

Key activities to implement through the SAAF Cities Platform in year 1 and beyond include,

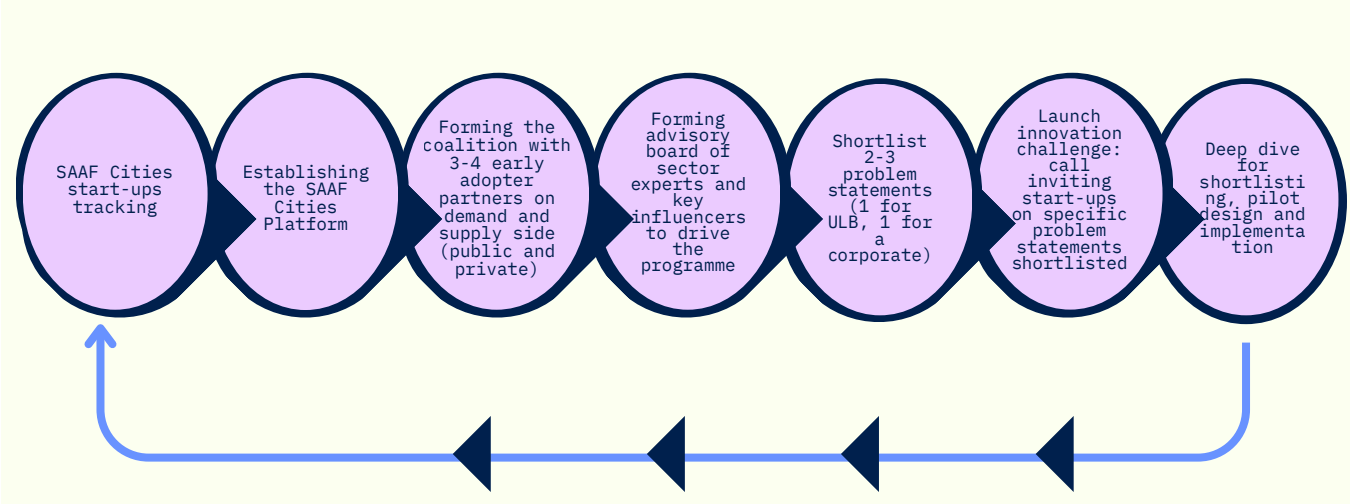


Fig. 28: Key activities proposed under the SAAF Cities Platform

Start-ups in year 1 cohort of the SAAF Cities Platform include:

Bintix

Enables end-to-end waste traceability.

Deployment: Digitization and technology enablement of Brihanmumbai Municipal Corporation's waste management system at Malad.

Saltech Design Labs

Converts plastic waste into high-performance composite building materials.

Deployment: Setting up a waste to wealth plant at Gandhinagar Municipal Corporation.
Unit 1 – Low Density Material & Recovery Separation (30TPD)
Unit 2 – Manufacturing precast polymer composite construction products (10TPD)

Carbon Loops

Converts organic waste into clean biofuels.

Deployment: To provide Solid Waste Management to 11 Urban Local Bodies in Tamil Nadu by installing biogas plants.

Carbon Masters

Convert wet waste into CBG and organic fertilizers.

Deployment: Upgrading the 8 TPD Biogas Plants to demonstrate the Revenue Sharing Model with Municipal Council Siddipet (Karnataka)

9.3 Partner network for SAAF cities platform

The platform will bring together stakeholders across the value chain and sectors to help bring economies of scale, techno-commercial viability and ROI (social and commercial) impact, with key roles and responsibilities of various partners - implementation agencies, think-tanks, corporates, ULBs, startups, and financing agencies - forming a consortium of partners to operate and create long-term impact for the waste management sector in India.

Secretariat of the SAAF Cities platform will be hosted by Villgro. Villgro will lead the activities of the SAAF Cities platform to,

- Enable the ecosystem for ULB, corporate and start-up across focus areas like access to capital, marketplace creation, demand generation.
- End-end support for start-up growth - incubation to scale-up pathways.
- Creation of funding mechanisms and instruments to help scale waste to value projects
- Leverage co-funding to help de-risk secretariat and project activities and achieve scale and national reach of the programme
- Bringing together like-minded organisations and facilitate partnerships for strategic and bespoke solutions (innovations and implementation models) to solve customised challenges in the waste sector and drive market creation.
- Curate an advisory board of the platform to help in prioritisation and decision-making of the platform activities represented from the partner network, sector experts and government.

Socratus Foundation will lead the activities of the SAAF Cities platform as knowledge partner to conduct key activities like,

- Build the ecosystem through knowledge dissemination and organizing stakeholder convenings
- Adopt systems tools such as Wicked Sprint and Citizens' Jury, for stakeholder convenings to collectively comprehend the many dimensions of 'wicked problems' in the waste sector.
- Scale SAAF Cities by enabling partnerships across government, market and civil society with extensive network across the ecosystem.

With shared vision, Villgro will partner with like-minded organisations including think-tanks, corporates, ULBs, start-ups and financing agencies to enable end-end management and implementation of activities under the SAAF Cities Platform.

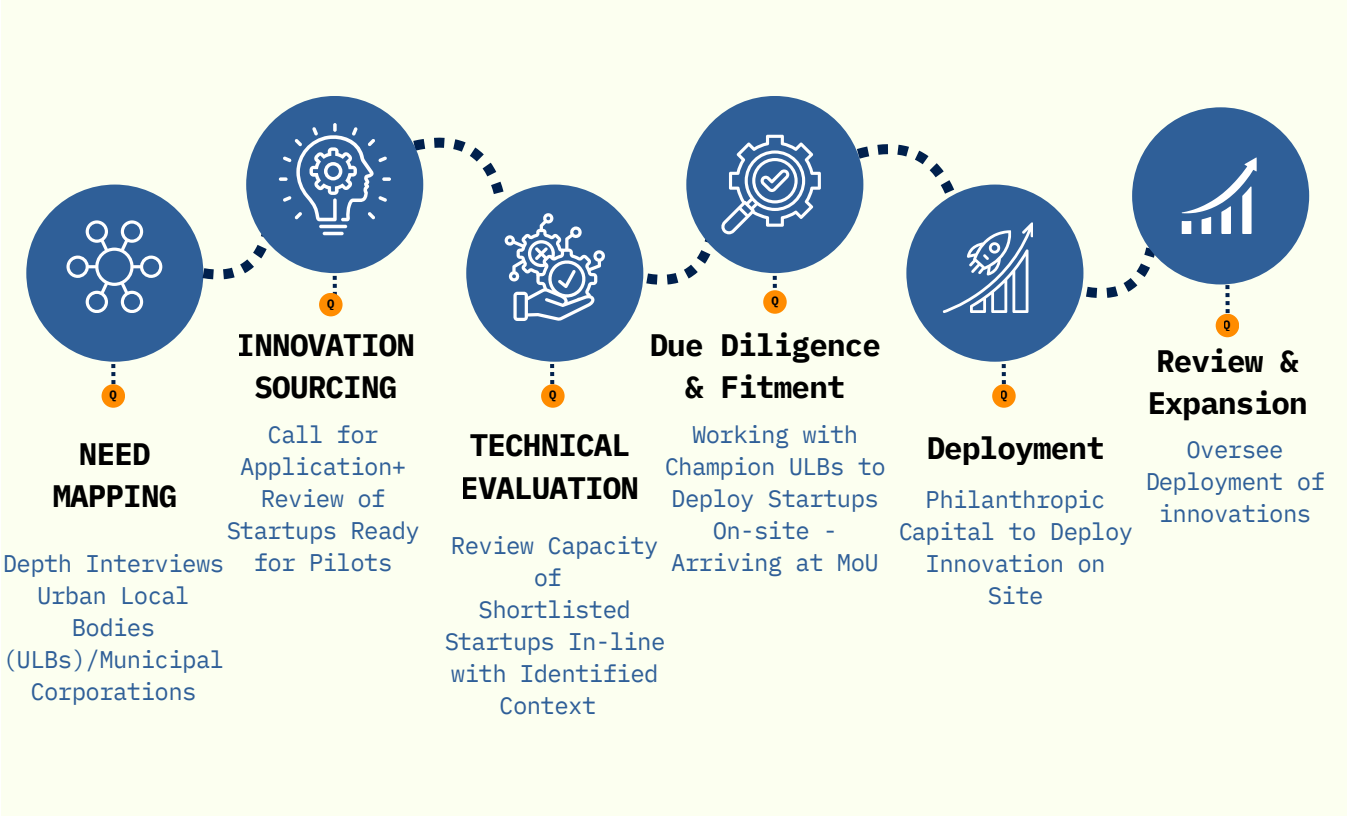


Fig. 29: Example of the partner ecosystem under SAAF Cities Platform

9.4 Potential Opportunities for SAAF Cities Platform

From the research study conducted, there are few example opportunities that are identified to implement and execute with support from relevant partners and interest received from primary engagements.

MOHUA / MOEFCC

- Regional innovation hubs to uncover solutions suitable for diverse geographic contexts
- Institute and enforce policies (EPR and beyond) to ensure effective collection and buyback of recycled products and materials
- Mobilise funding and policy support for inclusive business models (eg SHGs, cooperatives), that empower waste workers

State / ULB

- Revising existing government procurement systems (including GeM portal) to ease entry for small businesses
- Decentralised processing (apartment and colony-wise in larger cities, and clustering 2–3 smaller towns)
- IEC partnerships with CSOs and startups to improve source segregation rates

Industry and corporates

- Manufacturers bearing viability gap funding under their CSR/EPR mandates
- Building market linkages and supply chains for recycled/reprocessed products to be reused in manufacturing

Funding agencies

- Regional innovation hubs to uncover solutions suitable for diverse geographic contexts
- Institute and enforce policies (EPR and beyond) to ensure effective collection and buyback of recycled products and materials
- Mobilise funding and policy support for inclusive business models (eg SHGs, cooperatives), that empower waste workers

A detailed overview of the challenges highlighted and opportunities for innovations across the value chain for the priority waste types considered under the study are as follows:

Waste Type	Stage	Generation	Collection & Transport	Segregation	Processing	Market & End-Use
C&D	**Challenges**	Lack of tracking, unstructured demolition, weak EPR enforcement.	High transport costs, noise issues, informal sector dominance.	Manual & inefficient; low demand for recycled aggregates.	Weak market for recycled products; no reuse incentives.	No demand for C&D-based products; pricing issues.
	Opportunities for innovations	On-site mobile crushers; product-sale models.	Bulk pickup via apps; ULB-integrated providers.	Manual sorting; mobile MRF pilots.	Debris processed into certified tiles, bricks, and pavers.	Recycled materials used in local construction and public procurement.

Waste Type	Stage	Generation	Collection & Transport	Segregation	Processing	Market & End-Use
Plastic Waste	**Challenges**	Post-consumer waste mixed; contamination risks.	Pilferage; informal sector dominates.	Labor-intensive sorting; no market-driven segregation.	Only high-value plastics recycled; low-value to landfills.	Weak EPR enforcement; limited recycled plastic market.
	Opportunities for innovations	Plastic banks; traceability tools; community-led models.	Aggregated collection via school/NGO/retail partnerships.	AI-based sorters in formal MRFs.	Recycling to tiles, fuels, granules; EPR credit models.	Reuse in roads, packaging, and B2B resale markets.

Waste Type	Stage	Generation	Collection & Transport	Segregation	Processing	Market & End-Use
Textile Waste	**Challenges**	Post-consumer waste mixed; no efficient disposal.	No dedicated channels; mixed in MSW streams.	Labor-intensive; no formal biomedical sorting.	No established recycling market; high labor costs.	Low demand for recycled textiles; no economic benefits.
	Opportunities for innovations	Pre-consumer recovery hubs; brand take-back systems.	Brand-affiliated aggregators; resale-based models.	Manual fabric sorting; fiber-based innovations.	Mechanical upcycling for garments and accessories.	Circular fashion platforms; brand buy-back programs.

Waste Type	Stage	Generation	Collection & Transport	Segregation	Processing	Market & End-Use
Biomedical Waste	**Challenges**	No formalized collection; hazardous materials mixed.	Handled privately; no specific mechanisms.	High contamination risks; no formal system.	Over-reliance on incineration; emissions/cost inefficiencies.	No economic model for safe disposal.
	Opportunities for innovations	Color-coded bins at hospitals.	Licensed vendors; contracts bundled with treatment.	Segregation via color-coded bags.	Compact incinerators; microwave disinfection.	Digital compliance tools for monitoring.

Waste Type	Stage	Generation	Collection & Transport	Segregation	Processing	Market & End-Use
Organic Waste	**Challenges**	Irregular collection; seasonal fluctuations.	High transport costs; decentralized plants unsustainable.	Poor segregation; composting challenges.	High operational costs; viability issues.	Weak forward linkages for compost/biogas.
	Opportunities for innovations	Smart bins with sensors; hybrid sales/service models.	Ward-level collection linked to composting hubs.	Auto-segregating bins with RFID tracking.	Biogas digesters; black soldier fly composting.	Compost for farmers; biogas in community kitchens.

Waste Type	Stage	Generation	Collection & Transport	Segregation	Processing	Market & End-Use
E-Waste	**Challenges**	Labor-intensive collection; informal dominance.	High compliance costs; informal pickers dominate.	Complex sorting due to hazardous components; no standard protocol.	High-tech recycling rare; hazardous handling concerns.	Low formal recycling industry presence.
	Opportunities for innovations	QR-tagged drop-off bins; OEM partnerships.	App-based logistics platforms; authorized providers.	Pre-sorting via QR/barcode tagging.	Dismantling and refurbishment centers.	Recovered materials sold to OEMs and industrial buyers.

Table 20: Potential challenges and opportunities for the priority waste streams identified from the study

Potential sectors, waste streams and applications have been identified from the primary engagements with ULBs, corporates and start-ups.

Waste streams	Waste type	Opportunity	Potential partners
C&D waste	Gypsum recycling	Potential to pilot efficient gypsum recycling solutions with a leading conglomerate	Corporates
C&D waste	C&D waste	Upstream 'design for dismantling' - to enable better segregation of materials at source i.e. in the demolition stages	Construction and design companies, corporates
C&D waste	C&D waste	Manufacturing higher-value products from C&D waste (different colour finishes, different paver block types etc)	Construction and public infrastructure companies Potential interest with Ahmedabad ULB

Waste streams	Waste type	Opportunity	Potential partners
Sanitary waste	Domestic hazardous wastes	Potential to separately collect and process sanitary waste from bulk generators such as maternity hospitals, women's hostels, PGs etc	Hospitals, PGs, schools and colleges Potential interest from Pune ULB
Slaughter house waste, butchery wastes	Wet waste	Currently these wastes are incinerated, ULBs expressed interest in processing this waste stream better	ULBs Potential interest from Pune ULB
IEC for source segregation	Municipal solid wastes	Targeted IEC campaigns for better source segregation (one of the major challenges faced in sustainable waste management remains poorly segregated waste and low citizen awareness)	ULBs, waste pickers, schools, residential complexes
MLPs and low value plastics	Plastics	Use in road construction, public works, paver blocks	ULBs, corporates

Table 21: Potential opportunities identified from the market study for SAAF Cities Platform

10

Call for Action

Innovations play a pivotal role in solving the challenge of waste being sent to dumpsites and landfills in India. This has been proven with the perspectives reflected from ULBs, corporates and start-up ecosystem. However there needs to be an integrated and strategic approach to help these innovations scale.

SAAF Cities will act as that bridge in the ecosystem with integrated offerings of capital, market creation, incubation and knowledge dissemination, that will help ULBs in reducing the stress on the resources and costs, corporates to achieve their ESG and net-zero targets, and start-ups increase their scale of operations and impact.

We invite stakeholders across the value chain to collaborate and help in creating a circular economy and driving India's sustainability goals.

11

Case Studies

Saltech Design Labs

Advancing sustainable construction with recycled materials

Saltech Design Labs identified the critical gap of construction & demolition waste, combined with mixed, hard to recycle (and often low-value) plastics and developed a patented process to upcycle single-use plastics and C&D waste into high-value composite building materials, offering a sustainable alternative to conventional construction resources.

Focus sector(s)

- Plastic waste
- Construction & Demolition (C&D) Waste

Impact

- 65,500 kilograms of plastic waste recycled
- More than 163,700 kilograms of non-recyclable waste diverted from landfills and incinerators.
- Production of over 52,100 square feet of composite products, effectively reducing environmental pollution
- Awards and certifications, including the Affordable Sustainable Housing Accelerator (ASHA – India) under the Global Housing Technology Challenge-India, organized by the Ministry of Housing & Urban Affairs (MoHUA), Government of India.
- Funds raised till date - 1 cr.

Key challenges and learnings

Saltech's journey for market entry and sustainability included:

Market Adoption:

Introducing novel materials into a market dominated by traditional construction practices required extensive education and demonstration of the benefits of Saltech's products to potential clients and stakeholders

Scaling Operations:

Expanding processing capacity to handle larger volumes of waste necessitated significant investment in infrastructure and technology, as well as the development of efficient supply chains for waste materials.

Regulatory Navigation:

Aligning operations with environmental regulations and obtaining necessary certifications involved navigating complex bureaucratic processes, underscoring the need for additional resources for compliance management

Key highlights

Saltech works with ULB, academia and ecosystem players to create an impact in the value chain of C&D waste.

Strategic Partnerships

Halol Municipality

Transformed 6000 kilograms of seized single-use plastic into 3,295 square feet of garden tiles, providing a cost-effective and sturdy alternative to traditional cement blocks while addressing plastic pollution

Monkspaces

Facilitated the attainment of the GreenPro Certification from the Confederation of Indian Industry (CII), underscoring Saltech's commitment to eco-friendly building materials.

Technology and Process innovation

Employed advanced close-loop technology helps create a high-value composite building material from C&D and plastic waste

Patented process outperforms traditional concrete material in durability and sustainability, offering a carbon-negative alternative for pre-cast applications like pavers, bricks and tiles

Engagement with academic institutions to promote research and development in sustainable materials, fostering innovation and knowledge dissemination

> *"Our collaboration with Saltech Design Labs exemplifies how businesses can take tangible steps toward sustainable operations. Achieving GreenPro certification demonstrates Saltech's commitment to environmental stewardship and sustainable development."*
>
> Monk Spaces, Sustainability Consulting Firm

> *"Saltech's innovative approach to upcycling post-consumer plastic waste into composite building materials offers a sustainable alternative to traditional construction resources, aligning with global sustainability goals."*
>
> TRANSFORM, Global Impact Accelerator

Carbon Masters

Transforming Organic Waste into Renewable Energy

Carbon Masters was born out of a desire to reduce India's carbon footprint by tackling one of the most overlooked urban issues—organic waste. Starting in Bengaluru, the company envisioned a circular economy solution to manage food and agricultural waste, reduce landfill burden, and create clean energy for urban and rural consumption. The company addressed the twin challenges of urban organic waste and dependence on fossil fuels through a decentralised, tech-enabled waste-to-energy model.

Focus sector(s)

- Wet Waste
- Organic Waste
- Restaurant Waste

Impact

Livelihoods: Directly impacted more than 200 farmers, distributing over 170 tons of high-quality organic manure, helping reduce input costs and encouraging a shift to sustainable agriculture.

GHG Mitigation: Reduced over 9,000 tonnes of CO_2e emissions annually by diverting organic waste from landfills.

Clean Energy Access: Offered a decentralized renewable energy source for urban kitchens and logistics.

Key challenges and learnings

Carbon Master's journey included:

Waste Segregation at Source:
Remains a bottleneck for consistent input quality; requires behaviour change and municipal engagement.

Adoption of Bio-CNG:

Market education is crucial; customers are accustomed to LPG and unaware of the cost/environmental benefits of bio-CNG.

Infrastructure Bottlenecks:
Setting up decentralized plants faces regulatory and land acquisition challenges.

Key highlights

Carbon Masters is working with ULB, academia and ecosystem players, creating an impact in the value chain of wet waste.

Strategic Partnerships

Municipalities

Collaborated with local municipalities to ensure a reliable stream of segregated organic waste, essential for its anaerobic digestion processes

Mahindra & Mahindra

Joined hands with Mahindra & Mahindra to expand brand offerings and streamline its supply chain. This partnership enabled co-development of scalable waste-to-energy solutions.

Technology and Process innovation

The company developed an end-to-end anaerobic digestion process that transforms organic waste into bio-CNG.

This bio-CNG is further purified and bottled under the "Carbonlites" brand, providing a sustainable and cleaner fuel alternative to LPG and diesel.

The digestate generated from the biogas process is not discarded— it is processed into bio-enriched organic manure, creating a secondary, high-impact product that contributes to regenerative farming

Commercial viability and scale-up

Multi-pronged revenue model that ensures both financial viability and community value creation. Its primary income comes from the sale of Carbonlites bio-CNG to commercial kitchens and logistics operators. The sale of organic manure to farmers adds a secondary stream, while operating fees from decentralized biogas plants provide additional financial support

Carbon Masters' expansion to Indore and upcoming interest in Andhra Pradesh and Tamil Nadu suggests scalability. The company is also deeply engaged with rural communities, working through micro-retailers and Farmer Producer Organizations (FPOs) to distribute its organic manure.

> *"The Malur bio-CNG project is Mahindra's first commercial waste-to-energy project, which not only generates green energy but also creates rural employment and supports the farmer community with the organic fertiliser. This very well synergises and supplements Mahindra's vision of farm tech prosperity."*
>
> Hemant Sikka, President–Chief Purchase Officer, Powerol & Spares Business, Mahindra & Mahindra Ltd.

> *"Our collaboration with Carbon Masters is helping us solve the waste disposal problem in the city. This is going to immensely benefit all stakeholders."*
>
> Srinivas Reddy, Executive Engineer, Bruhat Bengaluru Mahanagara Palike (BBMP)

Karo Sambhav

Enabling Circular Economy Through E-Waste and Plastic Waste Management

Karo Sambhav identified the gap in managing e-waste and plastics in India, and developed an integrated solution that bridges producers, consumers, recyclers, and the informal sector through data and design-led approaches. The enterprise was founded with a mission to solve India's growing problem of non-biodegradable waste through a systems-change approach. By building scalable, transparent, and tech-enabled circular economy solutions, the company is transforming how electronic and plastic waste is collected, processed, and reintegrated into the economy.

Focus sector(s)

- Electronic Waste
- Plastic Waste

Impact

- Over 30,000 metric tonnes of e-waste and plastic waste managed responsibly.
- Collaborated with 25+ leading brands, offering end-to-end EPR compliance.
- Enabled traceability and transparency in waste value chains using digital platforms.
- Livelihoods? Jobs created?? Fostered formal inclusion of the informal sector, promoting safety and dignity.

Key challenges and learnings

Karo Sambhav's journey included:

Bringing **informal actors** into formal systems required sustained trust-building and incentives.

EPR policy awareness among producers varied widely—constant engagement was key.

Tech adoption was initially low among grassroots actors; required training and simplification.

Logistics and last-mile collection in remote or semi-urban areas still pose operational hurdles.

Key highlights

Karo Sambhav is working with ULB, academia and ecosystem players, creating an impact in the value chain of e-waste and plastic waste.

Strategic Partnerships

Municipalities, schools

Collaboration with municipalities and SPCBs to formalize informal waste networks. Partnerships with 400+ schools and collection centers, to scale awareness and impact.

Electronics & FMCG

Working with more than 25 major electronics and FMCG brands to implement their EPR obligations, including names like Apple, HP, Dell, Xiaomi Lenovo, and HUL.

Technology and Process innovation

Developed an EPR tech platform that enables real-time tracking of waste from source to verified recycler. The platform ensures full auditability and compliance for producers, using QR codes, GPS, and blockchain for traceability

Process design also ensures safe dismantling and material recovery.

The platform brings the informal sector into the formal loop, equipping aggregators and collectors with tools for digital tracking and fair remuneration.

Commercial viability and scale-up

Revenue is generated through EPR compliance services provided to brands, supported by material recovery and recycling incentives.

Also provides training and capacity building to informal workers, improving safety and income stability.

Karo Sambhav's work covers over 60 cities, with deep engagement in community behavior change programs. Its educational modules in schools foster long-term awareness, while its collector network creates dignified green jobs.

> *"As one of the largest distributors of I.T products in India, we felt vulnerable to the multiple layers of EPR compliance. Karo Sambhav has improved our ease of business, by providing us with an end-to-end EPR solution."*
>
> Devang Pandya, SaveX Technologies

> *"Xiaomi's engagement with Karo Sambhav helps it to strengthen electronic waste channelisation. Xiaomi commends Karo Sambhav's exhaustive school programmes targeting a behavioural change among young children, thought leaders of tomorrow. Karo's extensive execution checklist brings in clarity and transparency in the collection and recycling supply chain."*
>
> Muralikrishnan B., Chief Operating Officer, Xiaomi India

MUDDLEART
textile waste management

MuddleArt

Reimagining Fashion Waste Through Circularity

Focus sector(s)

Textile Waste

Fashion Waste

MuddleArt addresses textile wastes by building a formal, transparent, and decentralized network to recover and repurpose textiles at scale. In a world where fast fashion fuels overproduction and millions of tonnes of fabric are discarded before even reaching the market, MuddleArt emerged with a bold mission: to systemically tackle textile waste and redirect it back into productive use. The company has pioneered a first-of-its-kind platform that links garment manufacturers, collectors, and recyclers to create a transparent and efficient textile waste ecosystem.

Impact

Diverted over 1,500 tonnes of pre-consumer textile waste from landfills and incineration.

Involved 250+ B2B Recycling, up-cycling and ecosystem partners

Created an organized marketplace for waste textiles with high traceability and price transparency.

Support 250+ downstream partners, and empower women and informal workers by integrating them into formal supply chains.

Serve 200+ paying customers while diverting 7,000+ metric tons of waste annually with a 800+ Tonnes Monthly Pre-Consumer Textile Waste processing capacity.

Key challenges and learnings

MuddleArt's journey included:

Textile waste is highly **fragmented**; establishing consistent quality standards took time and training.

Waste generators were initially **skeptical** about traceability and compliance—required patient onboarding.

Scaling operations required **customising logistics** for different fabric types and geographies

Convincing the fashion industry to view waste as a resource rather than liability remains an ongoing effort.

Key highlights

MuddleArt is working with ULB, academia and ecosystem players, creating an impact in the value chain of textile waste.

Strategic Partnerships

Textile manufacturers

MuddleArt has built partnerships with over 300+ garment manufacturers and export houses across major textile hubs like Delhi-NCR, Tirupur, and Ludhiana.

Brands and recyclers

Collaboration with recyclers, upcyclers, and social enterprises that repurpose fabric into new garments, home décor etc. Engagement with global brands and designers interested in sustainable sourcing.

Technology and Process innovation

MuddleArt has designed a traceable inventory and grading system that classifies fabric waste by type, quality, color, and size. This makes pre-consumer waste usable across different industry applications

Digital dashboard tracks quantity, movement, and buyer preferences, creating supply chain visibility rarely seen in waste streams.

Decentralised sorting centers to make waste segregation efficient and scalable.

Commercial viability and scale-up

Revenue is generated through the sale of graded waste to recyclers, upcyclers, and brands. The model creates micro-entrepreneurial opportunities for women and informal workers involved in sorting and logistics.

The enterprise reinvests a portion of earnings into training programs and awareness campaigns to shift mindsets in the textile industry.

From a pilot in Gurugram, MuddleArt now operates across multiple cities and handles over 1,500 tonnes of textile waste annually. Its model has been particularly effective in engaging women's collectives and green entrepreneurs in peri-urban areas who convert the waste into marketable products.

> *"MuddleArt has been a great quality waste supplier, supplying the best of clean, contamination-free waste."*
>
> Harshit Kakkar, Head of Marketing and Public Relations, Kakkar Spinning Mills

> *"MuddleArt's holistic approach is inspiring! They are creating circular solutions in the textile industry by connecting the ecosystem, enabling responsible disposal and management of pre-consumer textile waste."*
>
> Cynthia Reynolds, Founder & Systems Architect, Circular Regions

Green Worms

Addressing the decent work deficit in waste management

Green Worms' 'waste-preneurs' model tackles issues plaguing the waste management sector, including high degree of informality, low wages or even a complete lack of wage-employment, uncompensated long-working hours, and primarily male-centric and urban-centric opportunities. The organisation goes beyond simply focusing on the lack of dignity in waste management work, and solves for the higher degree of economic risk, broken infrastructure, lack of basic social protection or employment benefits, and absence of targeted skills-training confronting the waste-management workers. In doing so it has not only created dignified, fair-income jobs for existing waste management workers but also created novel employment opportunities for local women from low-income communities, who were earlier unemployed.

Focus sector(s)

Municipal solid waste

Impact

Started with managing 300 kgs of waste a day and today Green Worms handles ~180 tons of waste per day.

Created 650 direct dignified jobs and also nurtured 2,800 Waste-preneurs. The majority of these jobholders are women from rural areas, and 72% of direct employees have seen an increase in their income (Zerodha).

A workforce of female waste workers who used to manage just 100 days of wages a year under their current work conditions, are now guaranteed 200-250 days of work.

Initiated the largest waste processing plant in Kasargod district, Kerala that can process 800 metric tons of waste collected from 41 local bodies

Key challenges and learnings

Green Worm's journey included:

The **need for a sense of shared purpose** towards waste management initiatives. Without adequate community engagement and acceptance, without significant investment funds that prioritize impact, and without receptive local authorities, such models often fail to take off. Combining all these ingredients on a common platform results in a tacit agreement of the parties towards this shared purpose, which in turn nudges further public awareness, draws-in policy and implementation support.

Replicating such a model in other parts of India, will require in-depth understanding of the gaps in waste hierarchy in that geography, the dynamics and motivations of existing self-help groups, and the specific nuances of financial and supervisory autonomy placed with those local bodies.

Key highlights

Green Worms is working with ULB, academia and ecosystem players, creating an impact in the value chain of municipal waste.

Strategic Partnerships

Kudumbashree, SHGs

In Kerala, Green Worms has partnered with Kudumbashree and in-turn with local self-government institutions to provide appropriate training and support to local women and empower them as 'Waste-preneurs' with a minimum guaranteed income.

Technology and Process innovation

Green Worms creates unique offerings for various local bodies using their needs-assessment tool.

Upon agreement they enter into a partnership with the administration to manage the solid waste in the locality.

Established a Social Impact Team and on-the-ground data collection procedures that include detailed surveys to understand the needs and profiles of the waste workers they work with.

Commercial viability and scale-up

Green Worms has diversified revenue streams which include Waste Collection & Disposal Services, EPR Compliance Fulfillment and Sale of Processing & Recycled materials.

Women waste-preneurs receive minimum guaranteed income. Green Worms also provides training on Standard Operating Procedures and IT systems to these women

Initiated the largest waste processing plant in Kasargod, Kerala that can process 800 metric tons of waste collected from 41 local bodies. Also started operations in Lakshadweep and Andamans. They have become a certified Ocean-bound plastics collector, which only 9 other companies have in India.

The Alappuzha success story- In Alappuzha, Kerala, the local administration has been locally and globally lauded for its effective solid waste management systems. For over a decade now the municipality has been following a largely decentralised waste management system whereby most waste generated in a locality is segregated and treated at the same area via pipe/aerobic composting units. For remaining waste collection needs, the local bodies partner with Green Worms who provide the necessary infrastructure and training to the women waste workers, the Haritha Karma Sena (of the Kerala community network - Kudumbashree) to ensure a near-complete and efficient solid waste management journey.

End-end C&D waste management - a case study of Delhi City

Delhi has adopted an ecosystem approach in management of C&D waste which has allowed for large-scale collection and processing of C&D waste and marketability of the C&D recycled products.

Key highlights of Delhi for C&D waste management:

Regulatory Framework

The 2018 waste management bye-laws outline provisions for the collection, segregation, storage, and processing of C&D waste.

Collection

- Over 250 collection points across Delhi, with each municipality operating its own system.
- Bulk waste generators, including government agencies like DMRC, CPWD, and NBCC, must pay a service fee and directly deposit waste at collection points or recycling plants.
- Non-bulk waste generators can request on-demand collection services.

Transportation

- The Municipal Corporation of Delhi and New Delhi Municipal Council operate dedicated vehicle fleets (tractor loaders and trolleys) equipped with GPS for waste transport, either operated in-house or by third parties.
- Four decentralised facilities (with additional proposed plants) reduce transportation time and costs, improving management efficiency.

Recycling and Processing

- A PPP model was implemented during the 2009 Commonwealth Games, leading to the creation of India's largest 2000 TPD processing facility in Delhi, operated by IL&FS Environmental Infrastructure and Services Limited.
- Facilities use both wet and dry processing techniques to produce commercially viable products like aggregates, bricks, and paving blocks.

≅ 3800 MT
of waste generated daily

4 recycling facilities with combined recycling capacity of **5000 MT**

3 new plants with **1550 MT** of combined capacity proposed

Marketability of Recycled Products

- The Department of Urban Development mandated in 2016 that all public construction works use recycled C&D products.
- At least 2% of C&D recycled products must be used in building works, and 10% for road works.
- ULBs require a 5% usage of C&D recycled products in non-structural applications, including for private individuals.
- C&D waste products are included in the CPWD Schedule of Rates 2023, encouraging wider adoption.

Use-Case Example

DMRC stores and transports C&D waste in closed containers, recovering and recycling over 95% into products like aggregates, sand, silt/soil recovery, RMC, kerb stones, pavement blocks, and concrete bricks.

SHG led C&D waste management - a case study of Jatni Municipality

The Jatni Municipality in Odisha has adopted a forward-looking approach to this issue and set up a small-scale C&D Waste plant operated by a local self-help group.

Focus sector(s)

Construction & Demolition (C&D) Waste

Key challenges and learnings

- Regulatory Compliance and Enforcement
- Institutional & Capacity Deficits to focus specifically on C&D waste
- Land Availability & Urban Planning to set up accessible C&D plants
- Technical Inadequacy in recycling and reuse of C&D materials
- Market Limitations and economic feasibility of C&D plants

≅ 20 Tonnes of C&D waste processed

12 women operating the C&D plant

≅ 1500 blocks produced per month

Strategic Partnerships

SHG Group

The land and infrastructure for the processing plant were provided by the municipality to a local self-help group in Jatni

Technology and Process innovation

The SHG members were trained to produce building materials using the processed waste, such as concrete blocks, decorative jaalis and balusters, flowerpots, and crushed aggregates.

Training and technical support to ULB engineers, municipal officials, and workers on segregation, processing, and regulation enforcement

Impact

Policy Innovations and Support:

- Regional C&D waste hubs to serve urban clusters of small towns more effectively by aggregating waste and achieving economies of scale.
- Subsidies or incentives for setting up recycling facilities in smaller cities to encourage PPP models.
- Government procurement policies that incentivise the use of recycled aggregates in public works through mandates and subsidies.

Innovative Implementation Models:

- Smaller, decentralised mobile crushers and modular waste processing units for smaller urban centers and large individual projects,
- SHGs and informal workers trained and formalised for waste collection services, while micro and small enterprises are provided with techno-financial support for processing and market development.

Tools and Capacities: Digital monitoring & data systems such as GIS mapping of waste hotspots, use of drones or digital tools to track dumping, and dashboards for public accountability

Abbreviations

- **AFR:** Alternative Fuel and Raw Material
- **AI:** Artificial Intelligence
- **AMC:** Annual Maintenance Contract
- **ASHA:** Affordable Sustainable Housing Accelerator
- **B2B:** Business-to-Business
- **BBMP:** Bruhat Bengaluru Mahanagara Palike
- **BIS:** Bureau of Indian Standards
- **BMWR:** Bio-medical Waste Management Rules (2016)
- **BRSR:** Business Responsibility and Sustainability Reporting
- **BSF:** Black Soldier Fly (used for composting organic waste)
- **BWG:** Bulk Waste Generator
- **BWMR:** Battery Waste Management Rules
- **CBG:** Compressed Biogas
- **CBPC:** Central Pollution Control Board
- **C&D:** Construction and Demolition
- **C&D WMR:** Construction & Demolition Waste Management Rules
- **C&D / C&D Waste:** Construction and Demolition Waste
- **CMT:** Cut-Make-Trim
- **CNG:** Compressed Natural Gas
- **CO2e:** Carbon Dioxide Equivalent
- **CPWD:** Central Public Works Department
- **CPCB:** Central Pollution Control Board
- **CSR:** Corporate Social Responsibility
- CSE: Centre for Science and Environment
- **DaaS:** Device-as-a-Service
- **DMRC:** Delhi Metro Rail Corporation
- **DPIIT:** Department for Promotion of Industry and Internal Trade
- **EEE:** Electrical and Electronic Equipment
- **EPRA:** Extended Producer Responsibility Authorization
- **EPC:** Engineering, Procurement, and Construction
- **EPR:** Extended Producer Responsibility
- **ESG:** Environmental, Social, and Governance
- **EWMR:** E-Waste Management Rules
- **FICCI:** Federation of Indian Chambers of Commerce and Industry
- **FMCG:** Fast-Moving Consumer Goods
- **FPO:** Farmer Producer Organization
- **GeM:** Government e-Marketplace
- **GGEF:** Green Growth Equity Fund
- **GHG:** Greenhouse Gas
- **GIS:** Geographic Information System
- **HDPE:** High-Density Polyethylene
- **HWMR:** Hazardous and Other Wastes (Management and Transboundary Movement) Rules
- **IEC:** Information, Education, and Communication
- **IECSL:** Indo Enviro Integrated Solutions Ltd
- **IEISL:** IL&FS Environmental Infrastructure & Services Ltd
- **IMC:** Indore Municipal Corporation
- **IoT:** Internet of Things
- **IRC:** Indian Roads Congress
- **ISCDL:** Indore Smart City Development Limited

- **LDPE:** Low-Density Polyethylene
- **LiB:** Lithium-ion Battery
- **LPG:** Liquefied Petroleum Gas
- **ML:** Machine Learning
- **MLP:** Multi-Layered Plastics
- **MNC:** Multinational Corporation
- **MMT:** Million Metric Tonnes
- **MoEFCC:** Ministry of Environment, Forest and Climate Change
- **MoHUA:** Ministry of Housing and Urban Affairs
- **MRF:** Material Recovery Facility
- **MSW:** Municipal Solid Waste
- **MT:** Metric Tonnes
- **MTPA:** Million Tonnes Per Annum
- **NABARD:** National Bank for Agriculture and Rural Development
- **NBCC:** National Building Construction Company
- **NBC:** National Building Code
- **NCAP:** National Clean Air Programme
- **NGT:** National Green Tribunal
- **NULM:** National Urban Livelihoods Mission
- **O&M:** Operations and Maintenance
- **OEM:** Original Equipment Manufacturer
- **PCB:** Printed Circuit Board
- **PET:** Polyethylene Terephthalate
- **PIBO:** Producer, Importer, and Brand Owner
- **PP:** Polypropylene
- **PPP:** Public-Private Partnership
- **PRO:** Producer Responsibility Organization
- **PSU:** Public Sector Undertaking
- **PVC:** Polyvinyl Chloride
- **PWMR:** Plastic Waste Management Rules (2016)
- **RA:** Recycled Aggregate
- **RCA:** Recycled Concrete Aggregate
- **RDF:** Refuse-Derived Fuel
- **RMC:** Ready-Mix Concrete
- **SATAT:** Sustainable Alternative Towards Affordable Transportation
- **SBM:** Swachh Bharat Mission
- **SBM 2.0:** Swachh Bharat Mission – Urban 2.0
- **SaaS:** Software as a Service
- **SHG:** Self-Help Group
- **SISFS:** Startup India Seed Fund Scheme
- **SME:** Small and Medium Enterprises
- **SPCB:** State Pollution Control Board
- **STP:** Sewage Treatment Plant
- **SUP:** Single-Use Plastics
- **SWMR:** Solid Waste Management Rules (2016)
- **SWMR / SWM Rules:** Solid Waste Management Rules (2016)
- **TCO:** Total Cost of Ownership
- **TIFAC:** Technology Information, Forecasting and Assessment Council
- **TPD:** Tonnes Per Day
- **TRL:** Technology Readiness Level
- **ULB:** Urban Local Body
- **UTs:** Union Territories
- **VGF:** Viability Gap Funding
- **WEEE:** Waste Electrical and Electronic Equipment
- **WtE:** Waste-to-Energy
- **WtE / WTE:** Waste-to-Energy
- **ZLD:** Zero Liquid Discharge

Definitions

1. Aggregator: Middleman who collects and supplies waste to recyclers.

2. Anaerobic Digestion: Biological process breaking down organic waste without oxygen to generate biogas.

3. Battery Waste: Discarded batteries, including lithium-ion types; governed by Battery Waste Rules (2022).

4. Biodegradable Waste: Organic waste that decomposes naturally (e.g., food, floral, horticultural waste).

5. Bio-Methanation: Anaerobic digestion of wet waste to produce methane-rich biogas and slurry.

6. Biochar: Carbon-rich material derived from biomass, used for soil improvement and carbon sequestration.

7. Bulk Consumers (E-Waste): Offices or institutions with ≥20 employees or annual turnover >₹1 crore.

8. Bulk Generators (C&D): Entities producing more than 20 MT/day or 300 MT/month of construction and demolition debris.

9. CBG (Compressed Biogas): Purified biogas compressed for use as a clean fuel.

10. C&D Waste (Construction & Demolition): Waste generated from construction, renovation, or demolition (e.g., concrete, steel).

11. Centralized Processing: Large-scale waste management facilities handling bulk municipal waste (e.g., incineration plants).

12. Chemical Recycling: Conversion of waste materials (e.g., textiles or plastics) into raw materials via chemical processes.

13. Circular Economy: Economic model focused on reuse, repair, and recycling to reduce waste.

14. Co-Processing: Use of waste (e.g., plastics) as alternative fuel in industrial operations like cement kilns.

15. Composting: Aerobic decomposition of organic waste to produce compost.

16. Decentralized Processing / Waste Management: Localized waste treatment at or near the point of generation (e.g., community composting, local biogas units).

17. Domestic Post-Consumer Textile Waste: Used textiles discarded by households or businesses.

18. Downcycling: Turning waste into products of lower quality or value (e.g., converting textiles into wipes).

19. Dry Waste: Non-biodegradable recyclable materials like paper, plastic, and metal.

20. Dump Site: Unregulated areas for waste disposal without environmental safeguards.

21. E-Waste: Discarded electrical/electronic devices regulated under E-Waste Management Rules.

22. EEE (Electrical and Electronic Equipment): Devices operating using electric current or electromagnetic fields.

23. EBWGR (Extended Bulk Waste Generator Responsibility): Certification required for BWGs lacking on-site processing (as per draft SWM Rules 2024).

24. Green Procurement: Policy promoting recycled content in procurement across public or private sectors.

25. GreenPro Certification: Eco-label issued by CII for products meeting sustainability standards.

26. Hybrid Infrastructure: Systems combining decentralized and centralized waste processing for cost and efficiency optimization.

27. Imported Waste: Second-hand or mutilated textiles imported to India (e.g., via Mundra Port).

28. In-vessel Composting: Enclosed composting process suitable for >2 TPD waste, more efficient than windrow.

29. Informal Sector: Unregulated or marginalized workers (e.g., waste pickers) playing a critical role in waste systems.

30. IRC-121:2017: Indian guidelines for using recycled C&D waste in road construction.

31. IS: 383-2016: BIS specification permitting use of recycled aggregates in concrete.

32. Landfill: Engineered site designed to isolate and dispose of waste safely (compliant with environmental regulations).

33. Leachate: Toxic liquid generated from decomposition of waste in landfills.

34. Material Recovery: Extraction of recyclables (like plastics and metals) from mixed waste.

35. Material Recovery Facility (MRF): Centralized facilities that sort recyclables from mixed waste streams.

36. Mechanical Recycling: Physical processing of waste (e.g., shredding plastic or textiles) for reuse.

37. Multi-Layered Plastics (MLPs): Plastic packaging with two or more layers (e.g., chip packets) that are hard to recycle.

38. PIBO (Producer, Importer, Brand Owner): Entities responsible for managing plastic packaging waste under EPR.

39. Post-Consumer Waste: Waste discarded after use by the consumer (e.g., plastic bottles, worn clothing).

40. Pre-Consumer Textile Waste: Manufacturing byproducts (e.g., fabric cuttings, unsold garments).

41. Pre-consumer Waste: Waste generated during manufacturing before reaching consumers.

42. Pyrolysis: Thermal breakdown of materials in absence of oxygen to generate fuel.

43. RDF (Refuse-Derived Fuel): Fuel generated from non-recyclable waste, used in energy recovery.

44. Resource Efficiency: Optimizing resource use to reduce material consumption and environmental impact.

45. Rubble: Bulky construction waste like bricks, concrete, and stones, reused in filling or road sub-base.

46. SATAT Scheme: Government initiative promoting Compressed Biogas (CBG) from organic waste.

47. Sanitary Landfill: Engineered disposal sites that isolate waste from the environment in line with sanitary standards.

48. Single-Use Plastics (SUP): Disposable plastics banned or regulated under Plastic Waste Management Rules.

49. Solid Waste Management Rules (SWMR): 2016 national guidelines for municipal solid waste management.

50. Techno-Commercial Feasibility: Evaluation of both technical and financial viability of solutions.

51. Textile Waste: Discarded textile materials unsuitable for their original use (e.g., torn clothes).

52. Technology Readiness Level (TRL): A 1–9 scale assessing the maturity of technologies, from ideation (TRL 1) to full deployment (TRL 9).

53. Vermicomposting: Composting using earthworms to break down organic waste into nutrient-rich compost.

54. Viability Gap Funding: Public funding to bridge financial shortfalls for early-stage innovations.

55. Waste Electrical and Electronic Equipment (WEEE): E-waste products requiring special recycling and handling.

56. Waste Generators (C&D Rules): Individuals or institutions generating waste from construction/demolition.

57. Waste-preneurs: Waste sector workers operating as entrepreneurs in formal waste systems.

58. Waste-to-Energy (WtE): Conversion of waste into usable energy such as electricity or heat.

59. Wet Waste: Biodegradable waste like food scraps, flowers, and garden waste (constituting ~50% of MSW).

60. Windrow Composting: Large-scale aerobic composting requiring at least 30 days.

61. Zero Liquid Discharge (ZLD): Water treatment method ensuring no wastewater discharge; complete reuse.

List of Figures

List of Tables

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