CLIMAKE

ASPEN NETWORK OF DEVELOPMENT ENTREPRENEURS

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INVESTING IN THE WASTE AND CIRCULARITY SECTOR IN INDIA

Municipal Solid Waste Management Guide

ABOUT ANDE

The Aspen Network of Development Entrepreneurs (ANDE) is a global network of organizations that propel entrepreneurship in developing economies. ANDE members provide critical financial, educational, and business support services to small and growing businesses (SGBs) based on the conviction that SGBs create jobs, stimulate long-term economic growth, and produce environmental and social benefits.

As the leading global voice of the SGB sector, ANDE believes that SGBs are a powerful, yet underleveraged, tool in addressing social and environmental challenges. Since 2009, ANDE has grown into a trusted network of over 250 collaborative members that operate in nearly every developing economy. ANDE grows the body of knowledge, mobilizes resources, undertakes ecosystem support projects, and connects the institutions that support the small business entrepreneurs who build inclusive prosperity in the developing world. ANDE is part of the Aspen Institute, a global non-profit organization committed to realizing a free, just, and equitable society.

ABOUT CLIMAKE

Climake was founded in 2020 as a platform to make climate finance more accessible. Climake focuses on improving access to equity and non-dilutive capital, for startups, and to support investors to improve funding flows to the climate action, especially into emerging sectors. Climake's work focuses on 4 core areas: investment advisory for high-potential climate startups, development and adoption of innovative financing structures to mainstream climate innovations, research and knowledge sharing on climate finance trends, and advocacy with investors to focus on climate action.

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IKEA Foundation

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ABBREVIATIONS

AMRUT:	Atal Mission for Rejuvenation and Urban Transformation
CPCB:	Central Pollution Control Board
DFI:	Development finance institution
EPR:	Extended producer responsibility
FY:	Financial year
GPS:	Global positioning system
IoT:	Internet of Things
MRF:	Material recovery facility
MSW:	Municipal solid waste
NBFC:	Non-banking finance company
PE:	Private equity
PPP:	Public-private partnerships
RDF:	Refuse-derived fuel
RFID:	Radio frequency identification
RTMS:	Real-time monitoring system
SGB:	Small and growing business
SHGs:	Self-help groups
SME:	Small and medium enterprises
TReDS:	Trade receivables electronic discounting system
ULBs:	Urban local bodies
UTs:	Union territories
W2E:	Waste-to-energy

CHAPTER 1: THE OPPORTUNITY IN MUNICIPAL SOLID WASTE MANAGEMENT

This guide focuses on the management and handling of municipal solid waste (MSW) from its initial collection to how it is processed and dealt with at landfills and dumpsites. It also covers some solid wastes with lower-value recycling potential or volumes, e.g., biomedical waste, paper waste, and base metals from non-electronic waste sources, such as aluminium and copper.

Managing the close to 60 million tonnes of MSW that India generates annually is a daunting challenge.[1] 90% of that waste is apparently collected but lower levels of processing – around 50% – show a significant amount is either not processed or remains unaccounted for, highlighting inefficiencies in waste management systems. Projections indicate a staggering increase in MSW generation, nearly tripling to 165 million tonnes by 2031.[2]

The proliferation of landfills compounds environmental and health concerns, with 1,924 identified scientific landfills[3] and an additional 3,184 unscientific dump sites across the country. These sites pose significant health, safety, and environmental risks.[4] Although there has been a decline in the percentage of MSW being landfilled – from 54% in 2016 to 18% in 2021[5] – the lingering presence of landfills underscores the urgency of transitioning towards more sustainable waste management practices.

THE OPPORTUNITY

There are significant opportunities to improve waste processing and resource recovery in India's MSW sector through decentralisation, automation, and logistical improvements. These cascade into specific opportunity areas across the value chain, which are summarised below (and detailed further later in this guide):

- New businesses in the segment can help expand coverage and boost processing efficiency by deploying localised collection and automated sorting. Operating at the neighbourhood level helps lower downstream costs, improve safety, and enhance operational efficiency.

- Using the Internet of Things (IoT), GPS, and radio frequency identification (RFID) systems, small and growing businesses (SGBs) can optimise waste collection, enhance tracking and ensure regulatory compliance. These tools allow urban local bodies (ULBs) to monitor and refine collection cycles more effectively.

1. The Energy and Resources Institute, 2023, The Incubation Network, State of Waste Management Report. Retrieved from: https://www.teriin.org/project/state-waste-management-report
2. Ministry of Housing and Urban Affairs, Government of India, Circular Economy in Municipal Solid and Liquid Waste, 2021. Retrevied from: https://mohua.gov.in/pdf/627b8318adf18Circular-Economy-in-waste-management-FINAL.pdf
3. Dutta S., 2017, Disposing Waste Scientifically: How Scientific Landfills Can Change The Waste Disposal Scenario In India. Retrieved from: https://swachhindia.ndtv.com/disposing-waste-scientifically-how-scientific-landfills-can-change-the-waste-disposal-scenario-in-india-8159/
4. Singh R., 2021, Towards circular economy: What to do with legacy waste in India. Retrieved from: https://www.downtoearth.org.in/waste/towards-circular-economy-what-to-do-with-legacy-waste-in-india-75746
5. CPCB, 2020, Annual Report on Solid Waste Management 2020-21. Retrieved from: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2020-21.pdf

- Biomining businesses can reclaim waste from legacy landfills and convert it into high-quality recyclables for material recovery facilities (MRFs), advancing a circular economy.

While each of these innovations offers a scalable approach for SGBs to contribute to India's waste management ecosystem, regulatory gaps and policy enforcement inconsistencies remain substantial hurdles. Therefore, collaboration between SGBs and regulatory bodies will be essential to navigate those challenges, establish clear frameworks that support sustainable growth, and unlock the full potential of these opportunities.

THE OPPORTUNITY DRIVERS

Despite the lack of extended producer responsibility (EPR) mandates and subsidy policies, MSW management has a high potential for investment in India. There are three main reasons for the growth of the MSW management industry in India, which is presenting significant growth opportunities for companies in the sector and investment opportunities for investors:

Figure 1: The three main drivers for municipal solid waste management (Climake analysis)

1. Cities and towns in India are being required to manage municipal waste through societal and compliance norms.
2. Urbanisation and population growth are fuelling the need for improved waste management.
3. There is increasing demand for material recovery from biomining landfills and disposal sites.

1 Cities and towns in India are being required to manage municipal waste through societal and compliance norms

Although many Indian cities, states, and towns collect less than one-fourth of the MSW that they generate, cities like Mumbai, Delhi and Hyderabad collect more than 90% of their solid waste and process it using conventional methods. The state of Maharashtra has built up the capacity to collect 99.3 % of its generated solid waste. Other states, like Tamil Nadu and Kerala, also have started proactively boosting their capacities.

Institutions such as the National Green Tribunal are directing municipalities to develop and implement solid waste management plans. States and municipalities that do not implement effective plans are issued penalties and directions to ensure compliance with legal norms such as the Solid Waste Management Rules and the Swacch Bharat Mission.

Municipalities and states are outsourcing time-bound contracts to companies in the MSW sector, to improve the management of new waste generated and safely process legacy waste in landfills or disposal sites. One of the primary reasons for that drive is that cleaner neighbourhoods are becoming more socio-politically important across India. Therefore, the management of MSW is increasingly recognised as a valuable state asset, with over 400 authorised solid waste management facilities nationwide aiming to enhance waste processing and disposal rates.

2 Urbanisation and population growth are fuelling the need for improved waste management

India's urban population increased by 2.32% from 2020 to 2021, highlighting the growing trend of urban migration and expansion.[8] This demographic shift, coupled with improving buying power, increases the volume of end-of-life products with limited recycling and reuse options. As a result, a substantial portion of these products enter the MSW ecosystem, deepening the need for improved waste management nationwide.

Table 1: Gap in solid waste management from 2018–19 to 2020–21 (Source: CPCB[9])

Year	Gap in solid waste management (%)
2018–19	30.35%
2019–20	25.82%
2020–21	31.70%

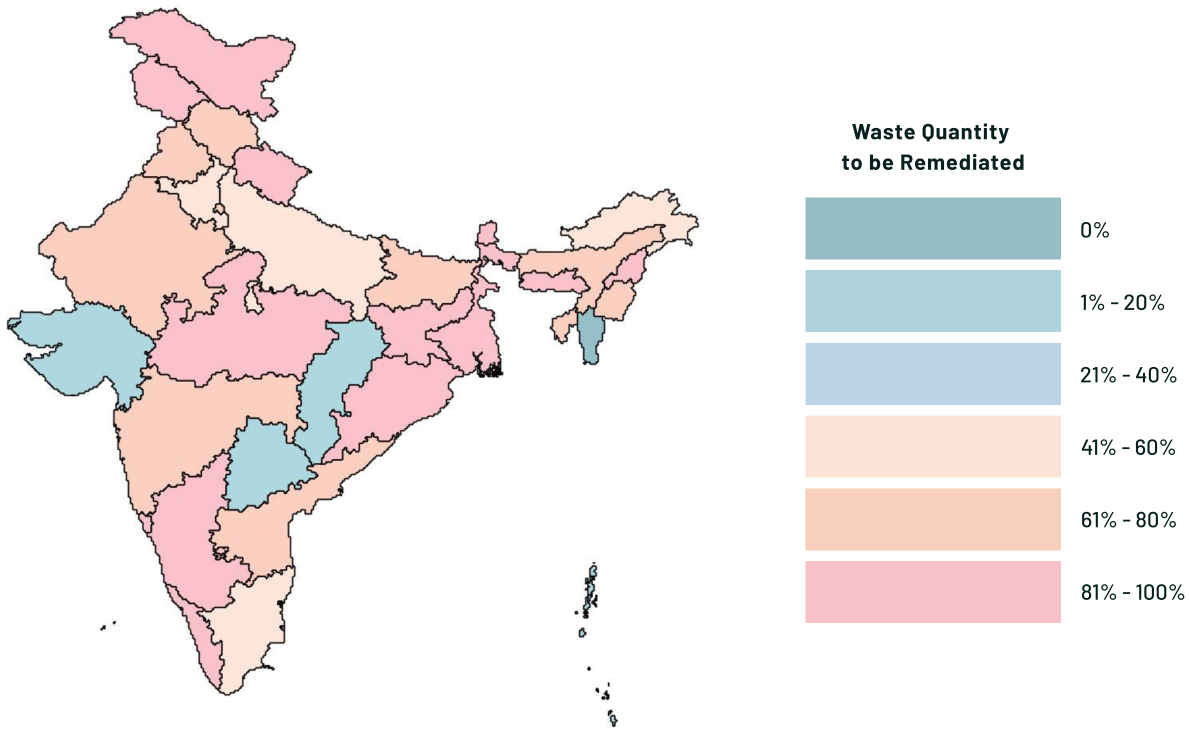
6. Gour A.A., Singh S.K., 2022, Solid Waste Management in India: A State-of-the-Art Review. Retrieved from: https://www.eeer.org/upload/eer-2022-249.pdf
7. Kumar S., 2023, NGT Imposes States Rs 79,098 Cr for Not Complying with Solid Waste Management Rules, Outlook Business. Retrieved from: https://www.outlookbusiness.com/news/ngt-imposes-states-rs-79-098-cr-for-not-complying-with-solid-waste-management-rules-news-416662
8. The Energy and Resources Institute, State of Waste Management Report, 2023. Retrieved from: https://www.teriin.org/sites/default/files/2023-10/1695795956State%20of%20Waste%20Management%20Report.pdf
9. Central Pollution Control Board, 2021, Annual Report 2020-21 on Implementation of Solid Waste Management Rules, 2016. Retrieved from: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2020-21.pdf#page=8

The problems associated with the growth in MSW generation are being exacerbated by gaps in the waste management value chain, beginning with collection inefficiencies. Table 1 illustrates a consistent shortfall, with approximately 30% of all MSW in India remaining uncollected due to inadequate collection, particularly among smaller waste generators. Bulk waste generators, such as commercial establishments and large residential complexes, are subject to stricter regulations and penalties, compelling them to partner with accredited, private dry waste collection agencies. This requirement helps mitigate collection gaps as these entities face compliance risks.

In contrast, small waste generators – primarily individual households – lack such regulatory pressures, which contributes significantly to the collection gap. In response, municipalities are increasingly contracting with professional private agencies to implement door-to-door collection and ensure waste is transported securely to disposal sites. These efforts involve the use of mini-dumpers, 12- to 16-ton covered garbage bins, and community street dustbins to minimise leakage. However, while these initiatives improve collection rates, the lack of effective waste recovery and segregation facilities post-collection continues to result in leakages and improper disposal, undermining the broader goal of efficient MSW management.

3 There is increasing demand for material recovery from biomining landfills and disposal sites

Figure 2: Swachh Bharat Mission's legacy waste management mapping (Source: Swachh Bharat Mission[10])



10. Swacch Bharat Mission, Mission Progress. Retrieved from: https://sbmurban.org/swachh-bharat-mission-progess

Another major issue that India must address as it seeks to improve the handling of its MSW is cleaning up legacy landfills. India loses over 1,250 hectares of useful land every year to the disposal of MSW. The country's 3,159 legacy landfills currently account for 10,000 hectares of usable urban land.[11] India has outlined a plan to clean up 2,200 legacy landfills that are no longer in use and extract value from their waste through the Swacch Bharat Mission (Urban).[12] The plan is that this will be achieved through biomining, the process of excavating, treating, segregating, and gainfully utilising legacy wastes.

Despite the challenge of contamination, biomining holds promise for recovering high-value materials and minimising the environmental hazards associated with legacy waste sites. The high-volume outputs from biomining are fertilisers and compost (from organic waste that has settled in landfills) and dry waste that can be used as refuse-derived fuels in cement plants, incinerators, and waste-to-energy plants. The high-value outputs from biomining are primarily precious metals and resources that can re-enter key manufacturing supply chains as inputs. The recovery of high-volume outputs (which are, generally, of low to moderate value) and high-value outputs (which are, generally, low volume) is done using MRFs, which are often owned and operated by private companies.

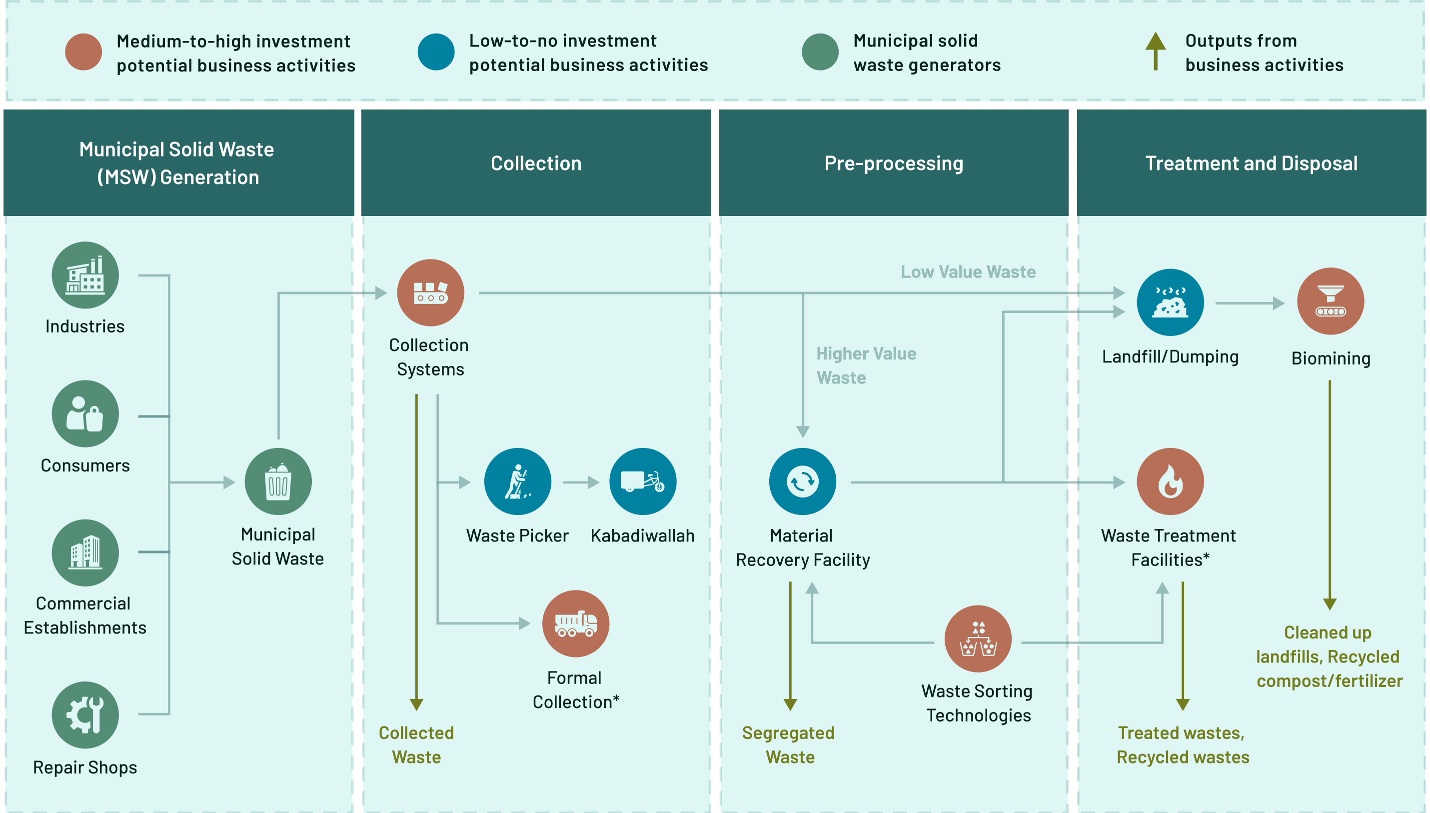
11. Singh R., 2022, Reuse of reclaimed land after biomining of legacy waste: What needs to change. Retrieved from: https://www.downtoearth.org.in/waste/reuse-of-reclaimed-land-after-biomining-of-legacy-waste-what-needs-to-change-82208
12. Swacch Bharat Mission, Mission Progress, Retrieved from: https://sbmurban.org/swachh-bharat-mission-progess

CHAPTER 2: THE CASE FOR INNOVATION IN MUNICIPAL SOLID WASTE MANAGEMENT

The Municipal Solid Waste Management Value Chain

The disparities in waste management systems across different geographic regions in India highlight the need and opportunity for targeted improvement of waste collection and disposal practices in currently underserved communities. Waste management companies, including both SGBs and high-growth startups, are offering solutions and services across the value chain. Some of these companies focus on operating large volumes in a single location or at a specific step of the municipal solid waste (MSW) management process, while others offer integrated or turnkey solutions across the waste value chain. The MSW management value chain is shown below alongside the key business models and outputs generated at each stage of that chain.

Figure 3: Municipal solid waste management value chain (Climake analysis)



**Waste treatment facilities include recycling and treatment facilities in other waste streams (e.g., plastics) that can be high potential.*

The main business models that form part of the MSW management value chain are described below:

Collection and Pickup Services

Municipalities across India have started engaging private enterprises and adopting digital solutions to improve MSW collection. This shift is to enhance collection efficiency, reduce leakage, minimise indiscriminate disposal, and maximise recovery of recyclable waste. Through government tenders, private entities participate across the waste management value chain – from collection and handling – to sorting and processing.

Municipalities implementing smart bins signal waste levels to operators, enabling optimised collection routes and schedules. Such technology-enabled collection systems are emerging as municipalities are starting to prioritise efficiency and reliability. The adoption of real-time digital monitoring is expanding, allowing municipalities to track collection and transportation more effectively. Technologies like GPS, RFID, the IoT, and machine-to-machine communication are improving collection logistics and streamlining recycling and processing.

Significant portions of India, particularly smaller cities and towns, remain underserved by MSW collection and transport services. 30% of all MSW in India remain uncollected due to inadequate collection.[13] To address these infrastructure gaps, private and public-private entities are stepping in, making use of diverse solutions to meet local needs and improve service coverage.

Waste Sorting Technologies

Waste sorting technologies primarily focus on dry waste, which is simpler to extract than mixed or organic (wet) waste. Sorting is typically performed through manual or mechanical methods, with a strong emphasis on accuracy and automation. Technologies that enhance precision in sorting dry, low-contamination waste are in high demand, particularly at MSW-sorting facilities like MRFs (see business model below), which manage diverse and complex waste streams that require advanced sorting capabilities.

To boost efficiency and minimise manual intervention, sorting facilities are now adopting advanced technologies such as optical sorters and AI-powered robots.[14] These tools enable higher throughput and improve accuracy, catering to market demand and resource supply conditions.

13. Central Pollution Control Board, 2021, Annual Report 2020-21 on Implementation of Solid Waste Management Rules, 2016. Retrieved from: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2020-21.pdf#page=8
14. N. Thaker, Ishitva Robotic Systems: Mad engineers revolutionising the dump yard, Forbes India, 2023. Retrieved from: https://www.forbesindia.com/article/startups/ishitva-robotic-systems-mad-engineers-revolutionising-the-dump-yard/83377/1

In India, dry waste is prioritised for recovery and recycling because of its greater economic value within the waste-to-value chain. Organic waste, commonly derived from abundant sources like agricultural biomass, is often directed towards applications such as energy generation or animal feed. This dual approach – focusing on dry waste for recycling and organic waste for energy or disposal – allows efficient resource allocation.

Material Recovery Facilities (MRFs)

MRFs process large volumes of dry solid waste collected from commercial waste generators, municipalities, and waste management firms – sorting recyclables and baling materials for recycling plants. MRFs generate revenue through the sale of sorted recyclables, tipping fees for waste processing, and local government budget allocation for recycling initiatives as part of the Swachh Bharat Mission. Their establishment and operation often rely on government tenders.

MRFs are the primary source of post-consumer recyclable dry waste in India. Given a stable demand for recycled materials from end-users and a consistent supply of sorted dry waste, the MRF model has strong viability. Insights from successful MRFs indicate that large-capacity facilities, which aggregate and process waste from multiple sources, are better positioned to achieve profitability in this margin-based business model.

Waste Treatment Facilities

Hazardous materials, like refrigerants and biomedical waste, require specialised handling because they are non-recyclable. They demand careful treatment in certified facilities, like treatment, storage, and disposal facilities (TSDFs) or incinerators. In India, approximately 50 such facilities operate under standards enforced by the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs).[15] While these facilities are predominantly managed by private enterprises, some are jointly operated by companies within specific industrial clusters.

For hard-to-recycle, inert materials, disposal in secured landfills is the standard practice. These landfills must comply with CPCB guidelines to prevent leachate contamination and other environmental hazards. However, inadequate enforcement usually results in landfills operating below regulatory standards,[16] while unauthorised disposal remains prevalent.

15. CPCB, Availability of Common Integrated Treatment, Storage & Disposal Facilities (TSDFs) with Common Incinerators & Secured Landfills. Retrevied from: https://cpcb.nic.in/uploads/Projects/Hadzardous-Waste/Common_TSDF.pdf
16. Climate Centre for Cities, NIUA in association with UNEP under the Counter Measures (II) project, Scientific Landfill Availability and Operations, 2022. Retrevied from: https://niua.in/c-cube/sites/all/themes/zap/pdf/scientific-landfill.pdf

Recent policy measures, like those relating to extended producer responsibility (EPR),[17] aim to reduce reliance on the disposal by incentivising circular waste processing. In parallel, biomining, focused on reclaiming materials from legacy landfills, has gained traction as a regulatory priority[18] –channelling waste away from conventional disposal sites and towards circular value chains.

Biomining Companies

The biomining of legacy landfills has rapidly expanded to address three critical needs: freeing up land, mitigating pollution risks, and recovering valuable recyclable materials. This growing demand for landfill reclamation presents significant opportunities for innovation in the waste management sector. Biomining operations rely on portable sorting and extraction technologies, which are deployed to clean up landfill sites and then moved to other locations as needed. The rise of government mandates through the Swachh Bharat Mission 2.0[19] directing municipalities to clean up legacy landfills is driving biomining, with strong potential for technological advancements to improve waste extraction and conversion efficiencies.

In India, biomining contracts are typically funded by municipalities through allocations based on central and state budgets. These are influenced by the waste management priorities of the region's political leadership. Recovered materials from biomining are sold directly to large MRFs or recyclers at profitable margins, without the government taking commissions. However, the complexity of operating on certain landfill sites and the rigid, low-priced structure of many government tenders pose operational challenges for biomining companies.

17. CPCB, Centralized Extended Producers Responsibility Portal for Plastic Packaging. Retrieved from: https://eprplastic.cpcb.gov.in/#/plastic/home
18. CPCB, Direction under Section 5 of the Environment (Protection) Act, 1986 for enforcement of Provisions of Solid Waste Management (SWM) Rules, 2016 regarding bio mining of legacy waste, 2021. Retrieved from: https://cpcb.nic.in/openpdffile.php?id=UHVibGljYXRpb25GaWxlLzM5NjNfMTYxMTkyMTMyMF9tZWRpYXBob3RvNDMyNy5wZGY=
19. Swachh Bharath Mission, Legacy Waste Management Dashboard. Retrieved from: https://sbmurban.org/swachh-bharat-mission-progess

The Current State of Municipal Solid Waste Management in India

Of the 62 million tonnes of municipal waste generated annually in India, 7.9 million tonnes (12%) are hazardous waste, 4-6million tonnes (6-9%) are plastic waste, 1.5 million tonnes (2%) is e-waste (this only constitutes e-waste generation through municipal collection channels, e-waste generation in 2022 overall was 4.1 million tonnes) and 0.17 million tonnes (0.2%) are biomedical waste; the rest consists of different forms of organic waste.[20] Today, 75–80% of the country's MSW gets collected, 22–28% of which is processed and treated. The remaining MSW is deposited at dumpsites.

Municipalities and companies are using different ways to improve MSW management across the value chain. For example, the Andhra Pradesh state government launched a real-time monitoring system (RTMS) by integrating the Internet of Things and information communication technology tools. The system was launched in 89 urban local bodies (ULBs) that are responsible for MSW management. The RTMS supports micro-level planning with pinpoint details of gate-to-gate collection, collection routes, source segregation, the weight of the waste before it is loaded into trucks, and transfer points.[21] Such tech-enabled waste collection improves transparency for stakeholders and enables waste management to become more efficient.

However, there is currently substantial variation in the technologies adopted for MSW management across different regions in India. For example, composting as a technology for solid waste processing has been adopted by all 28 states and eight union territories (UTs), but waste-to-energy (W2E) plants have only been set up in ten states/UTs, and biomethanation is only available in 22 states/UTs.[22]

Currently, waste collection and transport are the biggest opportunity gaps in smaller cities, while processing and material recovery have high potential in larger cities. For municipalities, tax financing and grants from central/state governments are currently the most common ways to fund attempts to fill such opportunity gaps.[23] They further finance startups and enterprises, mostly on a project-to-project basis, to achieve desired improvements in MSW management. This is supported by programmes like the Swachh Bharat Mission and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), encouraging better waste management and mandating public-private partnerships (PPPs) for MSW management.

20. Central Pollution Control Board, 2021, Annual Report 2020-21 on Implementation of Solid Waste Management Rules, 2016. Retrieved from: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2020-21.pdf#page=8
21. The Energy and Resources Institute, 2023, The Incubation Network, State of Waste Management Report. Retrieved from: https://www.teriin.org/project/state-waste-management-report
22. International Trade Administration, India Solid Waste Management, 2023. Retrieved from: https://www.trade.gov/market-intelligence/india-solid-waste-management
23. Institute for Competitiveness, 2024, Challenges of Solid Waste Management in Urban India. Retrieved from: https://eacpm.gov.in/wp-content/uploads/2024/05/Solid_Waste_management_Updated.pdf#page=11

Investable Business Models for SGBs

The following three emerging areas in the MSW ecosystem could offer the potential for innovative SGBs to attract significant investment in the next decade.

1 DECENTRALISED COLLECTION ALONG WITH AUTOMATED SORTING

Context and opportunity

Decentralising the collection of MSW addresses the gap in cities and towns where most of the waste currently goes uncollected. Better waste collection at the neighbourhood level in such areas significantly improves opportunities for processing and recovery. Collection itself is not a new business; large corporations like RE Sustainability and Antony Waste already operate in Tier 1 cities. However, there is now an opportunity to expand waste collection to smaller towns. New businesses expanding to hitherto uncovered markets in India can collect dry and wet waste separately, reducing waste management costs in the next steps of the value chain.

After the waste is collected and transported, sorting can be done either manually or mechanically. Technologies that automate the process of sorting dry waste with lower levels of contamination and improved accuracy are highly valued as MSW sorting facilities, mainly material recovery facilities (MRFs), handle multiple complex types of waste that require higher sorting capabilities. This is especially important when segregating waste at its source is challenging. Automating this step for large volumes of complex/mixed waste is most relevant for larger cities with diverse types of waste. It reduces the cost of processing and recovering the waste, while also improving safety for waste workers.

EXAMPLES OF STARTUPS IN THIS BUSINESS MODEL

Early/Growth Stage	Green Worms; NEPRA / Let's Recycle; Saahas Zero Waste
Mature Stage	re Sustainability; Antony Waste

GREEN WORMS - CASE STUDY

ORGANISATION SUMMARY

Year of foundation: **2018**
Number of employees: **38**
Plastic waste collected: **67,000 tonnes**
Number of villages and towns operated in: **140**

Green Worms positions itself as a circular economy transition company, with a comprehensive focus on waste collection, sorting, processing and recycling. The company's process fosters traceability and transparency while creating safe, dignified employment opportunities for waste workers from socio-economically disadvantaged backgrounds. Through partnerships with local governments, Green Worms provides last-mile waste management services for towns, villages and islands across India. For brands and manufacturers, it enables EPR compliance and supplies raw materials from recovered waste to support circular economy goals.

To strengthen its operational control and expand its asset base, Green Worms has embarked on infrastructure development, constructing a 20,000 sq ft material recovery facility to streamline its waste processing capabilities. This facility provides Green Worms with greater control over the waste value chain and valuable physical assets, appealing to potential investors. The company is also exploring recycling facilities for materials with limited recycling options, such as textiles.

Founded in 2014, Green Worms was inspired by founder Jabir Karat's first-hand experiences with waste pickers during a fellowship programme, where he observed the harsh conditions and economic challenges these workers faced. This exposure drove him to create a company that would not only address waste management but also enhance the lives of waste collectors by providing dignified employment and fair wages. Initially exploring various approaches to tackle waste, the team recognised a need for systemic change to provide stable, respectable jobs in an industry typically marked by informal, low-paid labour.

Today, Green Worms' scaled model leverages insights gained over years of operation, with a particular focus on empowering local women through self-help groups (SHGs). By involving SHGs in waste collection and management, Green Worms ensures reliable income for its workers while expanding its operations and offerings to transform waste into valuable resources, thereby supporting a circular economy in areas lacking adequate waste infrastructure.

SCALE

- **Existing revenue (FY23–24): US$ 5 million**
- **Break-even: 2018**
- **30% of revenue from work with local governments**
- **7% net profit**

IMPACT

1 NO POVERTY — 320 jobs created

8 DECENT WORK AND ECONOMIC GROWTH — 2,067 women "wastepreneurs" supported

11 SUSTAINABLE CITIES AND COMMUNITIES — Waste of 139 villages managed

12 RESPONSIBLE CONSUMPTION AND PRODUCTION — 67,000 tonnes of plastics recovered to date

14 LIFE BELOW WATER — Avoided 67,000 tonnes of plastic waste leakage to marine and coastal environments

AWARDS AND RECOGNITION

- Winner of Business Innovation, TiE Kerala, 2020
- 3R Award for Excellence in Innovative Solutions Startup, International Conference on Waste to Worth, 2022
- Social Impact Leader in Recycling, 2023
- DBS Foundation Business for Impact Grant

FUNDING RAISED

Type of Funding	Year	Purpose	Funders / Investors
Grant	2020	Product development	DBS
Equity	2021	Growth and working capital	Upaya, Zerodha
Debt	2024	Infrastructure development	Beiersdorf, asset lessors, NBFCs

INVESTMENT OPPORTUNITY

Total funding raised to date	**Equity: US$ 100,000** **Concessional debt: US$ 1 million**

Green Worms aims to expand its infrastructure to manage increased waste volumes from a growing number of municipalities and settlements, including extending its reach into neighbouring states. The company is also seeking to deepen its engagement across the waste management value chain, focusing on recovering and processing lower-value waste streams, such as textile waste and multi-layer plastics, to create marketable end-products. Through this strategic expansion, Green Worms intends to capture greater value from the waste it collects, securing more stable revenue streams and enhancing its contributions to a circular economy.

SUCCESS FACTORS

Green Worms has developed a decentralised, last-mile waste management model to address underserved markets where waste collection rates are often below 50%. By concentrating on specific states such as Kerala and Tamil Nadu, Green Worms tailors its approach to local dynamics and community needs, resulting in waste management solutions that are more effective and better aligned with regional requirements.

The company's model integrates environmental sustainability with social impact, placing a strong emphasis on community engagement and job creation. This dual focus not only addresses immediate waste management needs but also builds local capacity and resilience, elements that are increasingly critical for long-term success in the sector. Through that approach, Green Worms positions itself as a socially responsible leader, effectively bridging the gap between environmental goals and local economic empowerment in waste management.

2 TECH-ENABLED AND DIGITISED WASTE COLLECTION SOLUTIONS

Context and opportunity

The growing involvement of private enterprises in MWC is increasing digitisation opportunities for real-time monitoring of collection and transportation. Technologies like GPS, RFID, machine-to-machine communication, and IoT solutions improve and smoothen ground-level mechanisms for collection and efficient processing and recycling of waste.

Environmental monitoring of solid waste management facilities is underway in several states, reflecting efforts to uphold regulatory compliance and mitigate adverse environmental impacts. Leveraging IT-enabled tracking systems offers significant opportunities for enhancing waste management efficiency and transparency, from the collection to the disposal stage.

Businesses operating in this space are also enabling urban local bodies to better track waste management and recovery, provide tools to administrators to monitor gaps in waste collection cycles, plan resource and manpower deployment and build budgets and plans for improved operations.

EXAMPLES OF SCALED-UP BUSINESSES IN THIS SEGMENT

Early Stage	WeVOIS, ISHITVA®
Growth Stage	blueplanet.

WEVOIS LABS - CASE STUDY

ORGANISATION SUMMARY

Year of foundation: **2018**
Number of employees: **38**
Households served: **500,000 every day**
MSW collected every day: **1,200 tonnes**
Current presence: **18 cities**
Projected presence: **50 cities (by 2026)**

WeVOIS operates in eighteen cities across India, delivering automated, IoT-enabled, door-to-door waste collection services that drive transparency and efficiency for urban local bodies (ULBs). At the core of WeVOIS's offering is a comprehensive technology platform that equips ULBs with tools for systematic waste collection and transportation. The company's model includes smart home cards placed outside each household to track collection schedules, an optimised route manager for streamlined transportation and staff deployment, a mobile app that provides households with collection alerts and an integrated solution for collecting user fees on behalf of ULBs.

WeVOIS's founding vision stemmed from the Swachh Bharat Abhiyan, India's nationwide sanitation campaign, which highlighted the inefficiencies of traditional waste management approaches. Observing that only 60–70% of household waste was typically collected – leaving large amounts of waste unaddressed and contributing to open dumping – WeVOIS's founders identified an opportunity for a technology-driven solution to improve collection coverage and efficiency. Early on, the company encountered hurdles in securing partnerships with municipal corporations, facing multiple rejections as it adapted to the challenges of local governance. By piloting its approach with ULBs in Rajasthan, WeVOIS was able to validate its model, achieving a significant improvement in operational efficiency from 45% to 90%. This success has supported WeVOIS's expansion to other ULBs and solidified its role as a reliable partner in enhancing waste management systems.

SCALE

- **Existing revenue (FY23–24):** **US$ 4 million**
- **Break-even:** **2018**

IMPACT

1,200 sanitation workers supported

400,000 tonnes of fresh MSW collected and processed so far

AWARDS AND RECOGNITION

- Doing Good for Bharat Award, 2024
- Best Practice Award, Government of Rajasthan

FUNDING RAISED

Type of Funding	Year	Purpose	Funders / Investors
Equity	2022	Product development / growth	Innovana, Upaya, angels
Debt	2022	Working capital	Revenue-based finance
Debt	2023	Asset finance	Banks, NBFCs

INVESTMENT OPPORTUNITY

Total funding raised to date	Equity: US$ 5 million debt and equity mix

WeVOIS has ambitious plans to expand its footprint to over 50 cities within the next 18 months. To achieve that scale, the company will need to secure equity capital to enhance its technology platform and build out its team, bolstering its operational capacity. Additionally, WeVOIS will require funding to support asset development, primarily in establishing new collection centres, as well as working capital to sustain its day-to-day operations.

As part of its growth strategy, WeVOIS is also pursuing forward integration into waste segregation and material recovery facilities (MRFs), necessitating project financing to support these capital-intensive initiatives. This expansion into MRFs would allow WeVOIS to capture additional value within the waste management chain.

SUCCESS FACTORS

WeVOIS has distinguished itself as a leader in India's waste collection space through a strategic blend of technology and a robust operational framework, driving notable efficiency gains in waste collection. The company harnesses advanced technologies such as the Internet of Things and artificial intelligence to optimise collection processes. With its proprietary navigation app, WeVOIS enables sanitation workers to follow highly efficient, optimised routes, significantly reducing travel time and resource expenditure. Real-time tracking of waste collection vehicles further ensures smooth coordination between municipal authorities and residents, resulting in reliable and timely waste disposal.

WeVOIS has built a growing base of ULB clients who value its tech-first, data-driven approach to waste management. Its platform provides ULBs with an efficient, easy-to-adopt solution, enabling improved waste collection performance and operational transparency. The company's integrated model has delivered impressive results, raising collection efficiency from 40 to 95% in serviced areas. Additionally, WeVOIS has prioritised social impact, improving wages and working conditions for sanitation workers and equipping them with better training. This combination of technology, operational effectiveness and social responsibility has positioned WeVOIS as a high-performing partner for ULBs aiming to modernise their waste management systems.

3 BIOMINING TECHNOLOGIES FOCUSED ON HIGHER QUALITY CONVERSION OUTPUTS FOR EPR

Context and opportunity

Biomining is an opportunity area due to government mandates directing municipalities to clean up legacy landfills. Biomining technologies based on improved conversion of extracted wastes can help to create greater output opportunities and adoption.

A significant portion of MSW is made up of recyclable materials, including glass, metal, plastic, clothes and paper. Post-collection biomining segregates these materials and makes them free from contamination so they can be recycled through specialised material recovery facilities. This process enables the sorting and recovery of high-value materials from waste streams, fostering a circular economy approach to resource utilisation.

EXAMPLES OF STARTUPS IN THIS BUSINESS MODEL

Early Stage	HINDUSTAN	BHUMI GREEN ENERGY
Growth Stage	i3X ideation3x Mission: <2 degrees	ZIGMA Alchemists of the MSW

HINDUSTAN SWM - CASE STUDY

ORGANISATION SUMMARY

Year of foundation: **2022**
Number of employees: **30**
Legacy waste processed: **100,000 tonnes**
Landfill sites cleared: **Seven**

Hindustan SWM operates primarily in plastic waste management through extended producer responsibility (EPR) projects and in MSW management, with a specific emphasis on biomining legacy waste. Concentrated in Tamil Nadu, Hindustan SWM partners with urban local bodies (ULBs) to execute large-scale biomining projects, focusing on clearing accumulated landfill waste while adhering to government regulations and public funding frameworks. The company has developed considerable expertise in handling the complexities of MSW and is targeting expansion to larger projects across additional Indian regions.

Hindustan SWM currently possesses the capacity to process up to 150 tonnes of legacy landfill waste per day. Its facility conducts mechanical sorting and converts non-recyclable materials into refuse-derived fuel (RDF) – suitable for energy generation in cement kilns – and inert compost. The RDF production further enables Hindustan SWM to secure plastic recovery sources, aligning with its EPR obligations.

The company's trajectory builds on the management team's experience in plastic waste recycling and material recovery facilities from prior ventures. Recognising an opportunity to address broader municipal waste management needs, Hindustan SWM's leadership saw potential in expanding their service offerings with municipal clients. Leveraging its plastic recycling expertise, biomining has become the first strategic step in Hindustan SWM's approach to positioning itself as a comprehensive MSW management provider to municipalities. A future focus could be the processing of fresh solid waste.

SCALE

- **Existing revenue (FY23–24):** **US$ 300,000**
- **Break-even:** **2024**

IMPACT

Seven legacy landfills cleared up

20,000 tonnes of plastics recovered from landfills

FUNDING RAISED

Type of Funding	Year	Purpose	Funders / Investors
Equity	2023	Growth capital	Founders
Debt	2023	Asset finance	Asset leasing company

INVESTMENT OPPORTUNITY

Total funding raised to date	**Founder equity: US$ 100,000** **Asset leasing: US$ 60,000**

India has an estimated 2,000 to 3,000 landfill sites yet to be biomined, each averaging 40,000–50,000 tonnes of waste, with plans for biomining projected over the next 10 to 15 years. Hindustan SWM aims to capture a significant portion of this opportunity by focusing on large-scale biomining projects in major cities, which would provide a reliable pathway to enhance profit margins. In this evolving sector, new entrants are likely to encounter challenges similar to those faced by incumbents. However, firms that can adapt and refine operational efficiencies will gain a competitive advantage.

Hindustan SWM is pursuing a "land and expand" approach to develop its capabilities, infrastructure and assets across the MSW value chain. This strategy is designed to strengthen its position by extending control over each stage of the waste management process, reinforcing the company's competitive stance as a comprehensive provider in the biomining and MSW management sectors.

SUCCESS FACTORS

Hindustan SWM has significantly expanded its project portfolio, now handling six to eight times the volume of projects compared to its early operations. The company has developed the capability and operational scale required to undertake biomining initiatives at India's largest landfill sites – projects valued in the multi-million-dollar range. This enhanced capacity positions Hindustan SWM as a leader in large-scale landfill cleanup efforts, which are critical to urban waste management across the country. The Hindustan SWM founders and team have extensive on-ground and hands-on experience in different areas of plastic waste and municipal solid waste, which supports their intended land and expand model to grow into other MSW activities.

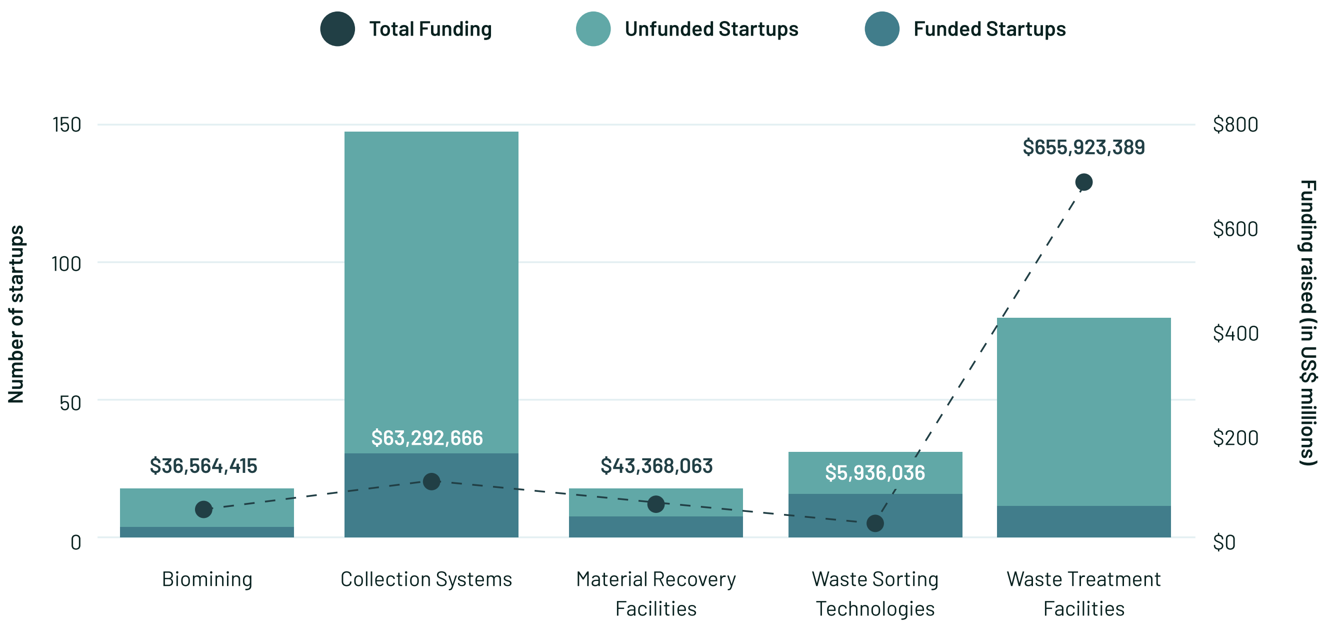
Beyond legacy landfill biomining, the competencies and infrastructure that Hindustan SWM have built provide a strong foundation for addressing ongoing waste processing requirements. The expertise gained from managing complex biomining operations can be applied to other waste streams, opening additional avenues for growth and enabling the company to extend its service offerings in municipal solid waste management.

CHAPTER 3: INVESTMENT LANDSCAPE

Equity Investment Trends in Municipal Solid Waste Management

Identified Companies	Funded Startups	Total Equity Funding Raised (US$)
278	63	805.1 million

Figure 4: Startups across the five main business models in the municipal solid waste management and circularity value chain (Climake analysis)



The **278 startups** identified in Figure 4 are formal entities that operate across the municipal solid waste value chain; they include collection systems entities, material recovery facilities, deployers of waste sorting technologies, treatment facilities and companies cleaning up landfills through biomining. As the municipal solid waste segment handles multiple types of wastes which are covered in other guides, e.g., plastics and food waste, this guide mainly focuses on the value chain for handling and processing municipal solid waste towards further recycling. Waste treatment facilities here mainly relate to specialised treatment facilities, such as those used for biomedical wastes and hazardous wastes, which often focus on safe disposal over creating recycled outputs or producing low-quality scrap outputs, such as lead and other base metals.

A key factor of the nature of enterprises in this segment is their potential to operate in multiple business models. For example, it is common to see a biomining entity also engaged in waste treatment, or a material recovery facility player also engaged in collection. For the purpose of categorisation, we have classified these companies based on their main business activity.

Collection systems account for the largest number of enterprises – 53% of all companies in the segment. A key reason for this is the need for localised players at a municipality level, which leads to enterprises focusing on one, or at most two to three, cities where they have a direct presence. Certain large-scale players, such as RE Sustainability, have a multi-city, multi-business presence, but few other businesses perform a similar role due to the significant amount of capital and resources required. RE Sustainability accounts for US$ 600 million of the equity raised in the overall segment, i.e., 75% of the overall funding. Waste treatment facilities account for 28% of the overall enterprises, largely because multiple treatment types are categorised in that group, ranging from biomedical waste to base metal scrap.

Material recovery is a key activity of enterprises, which is often undertaken in partnerships with municipalities to mitigate the low margins this business model tends to deliver. Waste sorting technologies, such as smart bins or imaging software that help segregate and sort mixed waste, are emerging. They are at the point where technology risks have been addressed but cost considerations are still hindering their adoption. Despite that, such technologies are seeing traction in cases where improved recycling rates can be achieved, especially in municipalities that have a robust infrastructure for handling and recycling waste.

Lastly, biomining may account for a small number of enterprises, but MSW companies in other segments are entering this space as an ancillary business model; therefore, the true number of biomining-involved companies will be higher than the figure given in this guide. Biomining offers significant growth opportunities due to policy targets and the funding flows intended to help realise those targets. It stands as one of the fastest-growing segments in the MSW sector as India looks to clean up 2,400 legacy landfills to recover land and create value from waste, mainly in the form of fertiliser and refuse-derived fuel.

Figure 5: Stage of investments of startups across the five business models in the municipal solid waste management and circularity value chain by funding raised (Source: Climate Analysis)

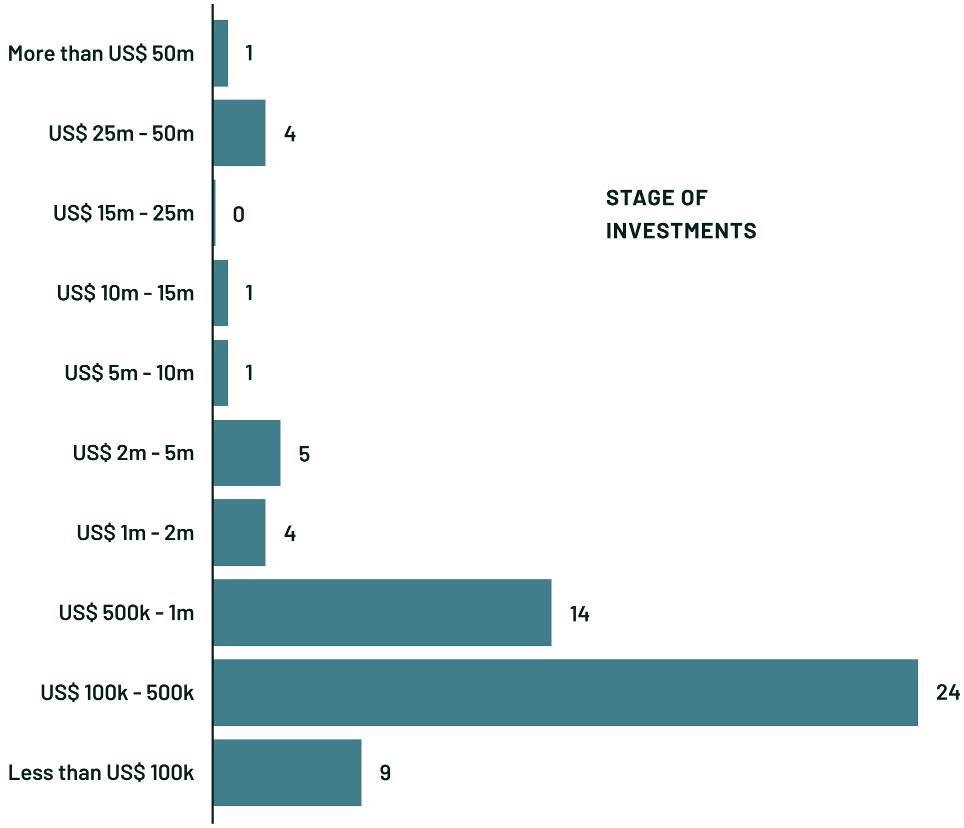
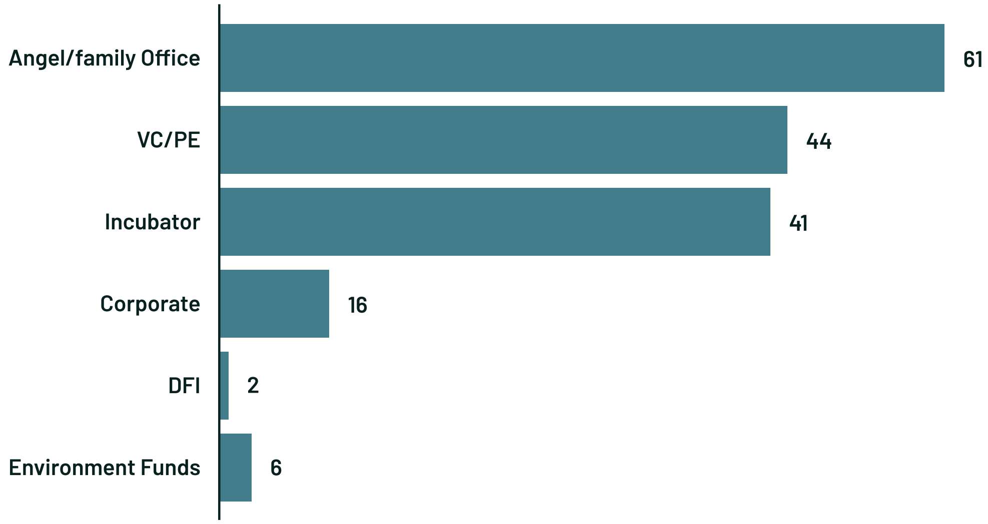


Figure 5 outlines the latest stage of funding for municipal solid waste enterprises in India. 75% of the funding received by companies totalled less than US$ 1 million ticket sizes - a stage that covers companies' early traction and growth. These are predominantly enterprises working mainly in collection systems and waste sorting technologies. This is reflective of the emergence of new opportunities in MSW that have arisen mainly as a result of policy and compliance incentives, which have encouraged private sector participation in solving municipal solid waste issues. Waste treatment facilities account for a larger proportion of the total funding raised over US$ 2 million, as these enterprises are often well established and offer specialised safe handling and disposal of waste or create recycled outputs from waste – activities that generate higher-value outputs. Companies like RE Sustainability and Blue Planet, which have raised US$ 600 million and US$ 40 million respectively, show that large-scale opportunities do currently exist for this segment.

Investor and Funding Landscape

Figure 6: Number of investors who have funded MSW management and circularity startups by type (Source: Climate Analysis)

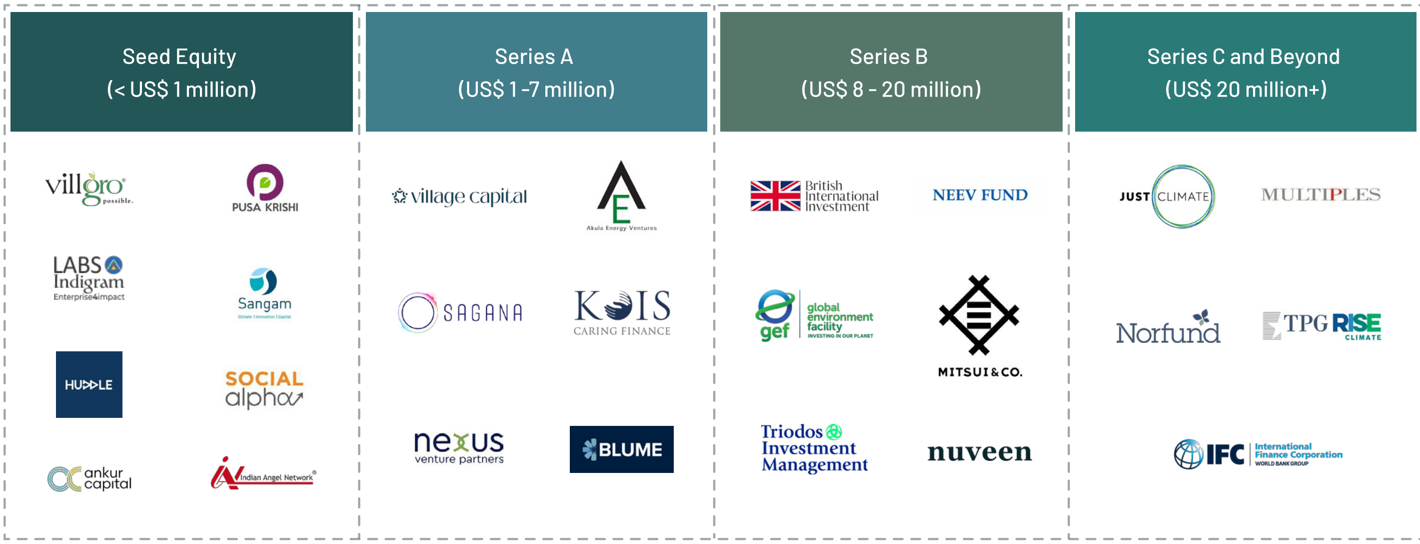


MSW management is unique among the waste and circularity segments in that it has a long tradition of well-funded, scaled-up businesses. The traditional model – waste collection and processing by the likes of RE Sustainability and Antony Waste with ULBs as the primary customers – has been funded by private equity and traditional debt sources, typically banks. Several legacy MSW companies are also listed and have accessed public capital.

The new-age MSW startups have attracted a different spectrum of investors:

- Angel funds and family offices have come in as the first investors for early-stage startups, funding technology development, initial go-to-market and the piloting of new business models like direct collections from homes without relying on ULBs.
- Venture capital (VC) and private equity (PE) funds operate in a wide space from funding initial go-to-market, seed-stage investments up to growth-stage investments, based on the nature of focus of such funds. However, these funds often lack a clear thesis on asset-heavy investments, which is needed in climate action and circularity. VC funds, in particular, operate in the current biggest funding gap in MSW circularity: providing Series A/B ticket sizes for enterprises that are setting up forward integration from collection into extracting value from segregated municipal waste.
- Environment-focused funds, which come in with a clear thesis aligned to the needs of MSW enterprises, are potentially better equipped to fund and back these high-potential, often asset-heavy bets.
- Development finance institutions (DFIs) fund growth, but the scale of capital they can deploy means that their MSW investments have been focused on legacy business models.

Figure 7: Active equity investors in municipal solid waste management (Source: Climate Analysis)



MSW Management Businesses Also Have Significant Debt Potential

MSW management businesses in India, particularly those in the growth stage, have demonstrated an ability to fund part of their capital needs with debt. These companies are raising three kinds of debt:

Project Finance

Both fresh waste and legacy waste projects require the setting up of capital-intensive, asset-heavy plants. Collected fresh waste requires the setting up and expansion of MRFs for segregation and downstream processing. Legacy waste and landfills require biomining equipment. For companies that have raised equity and built a profitable business model, debt financing is widely available from banks in India.

Banks, however, require companies to provide three years of profitable track record and offer collateral security beyond the project's assets. For companies who do not meet such criteria, available options include specialised lenders like Tata Cleantech Capital, as well as asset financing and leasing companies. Recent examples of such funding include the green bond issued by NEPRA, with Triodos Bank as the investor.[24]

Working Capital

As with project finance, profitable companies that can offer collateral security and personal guarantees from their founders are able to raise credit lines from local banks to meet their working capital needs. There are several other options for those who do not qualify for bank loans:

- Non-banking finance companies (NBFCs) offering unsecured business loans to meet the working capital requirements of young startups
- Invoice discounting offered by banks, NBFCs and multiple trade receivables electronic discounting system (TReDS) platforms
- Financing linked to orders that provides working capital to purchase raw materials and pay vendors with repayments linked to the revenue received from such orders
- Revenue-based financing for companies that have fixed monthly revenue or standard offtake contracts.

24. Triodos Groenfonds finances NEPRA Resource Management, Triodos Investment Management, 2023. Retrieved from: https://www.triodos-im.com/articles/2023/investment-tgf---nepra-resource-management

Venture debt

While more popular with technology startups, venture debt is increasingly gaining traction in the environment and circularity sectors as well. Venture debt providers are able to complement the equity raised with a small debt component, thus increasing the runway for early-stage startups and providing an option for lower dilution in the early rounds of fundraising.

The universe of active debt investors in India's MSW management segment is shown below.

Figure 8: Active debt lenders in municipal solid waste management (Source: Climate Analysis)

CHAPTER 4: CONCLUSION

India generates around 60 million tonnes of municipal solid waste (MSW) annually, and that figure is expected to grow to 165 million tonnes by 2031. While 90% of the current waste is apparently collected, less than 50% of India's waste is actually processed, and processed outputs are also expected to be of low quality due to inefficiencies in waste management and treatment systems. Additionally, India has around 2,400 legacy landfills that require cleaning, and over 3,100 unscientific dump sites that need to be addressed. For all those reasons, the need and opportunities to tackle MSW are significant in India.

There are three prevailing trends that incentivise the adoption of solutions and support enterprises to tackle MSW issues in India:

- Cities and towns in India are being required to manage municipal waste through societal and compliance norms.
- Urbanisation and population growth are fuelling the need for improved waste management.
- There is increasing demand for material recovery from biomining landfills and disposal sites.

This study has identified 278 formal enterprises operating across five main business models in municipal solid waste management and circularity: collection systems (53% of all MSW circularity enterprises), waste treatment facilities (28%), waste sorting technologies (10%), material recovery facilities (4%) and biomining (4%). Each segment offers differing levels of investment opportunity and potential based on the nature of the business and operating context. Only 15% of waste treatment facilities and 18% of collection system enterprises received equity funding, in contrast to 55% of the firms offering waste sorting technologies. The emphasis in the MSW sector is on delivering efficiency to increase the rate of recycling and waste management or focusing on enterprises that can build scaled businesses. Often MSW enterprises are involved in more than one of the five business models identified. This is often a consequence of the need to engage with urban local bodies (ULBs) across these business activities, where the development of trust and continued engagement opens up new opportunities; ULBs are more likely to work with an already engaged enterprise.

75% of the equity investments have been early-stage, sub-US$-1-million investments, which explains why incubators and angel funds have a significant presence in the investor landscape backing MSW enterprises. However, the MSW segment is unique in the waste and circularity sector because of the presence of long-established, well-funded, traditional, scaled-up businesses. This is because the waste collection and processing field has been a well-established business area for longer than other waste and circularity segments. As a result, large-scale private equity players and traditional debt sources from banks have been involved in funding MSW enterprises.

Debt plays a significant role in complementing equity financing. Managing both fresh and legacy waste requires the setting up of capital-intensive, asset-heavy facilities. The longevity of private enterprises in the sector has led to profitable businesses being a consistent presence, which opens up a lot more opportunities for securing project finance and working capital relative to the opportunities that exist for emerging, early-stage startups in a segment like e-waste and lithium-ion battery waste recycling. There has not been a viable blended finance offering for the MSW space as the focus has been on financing growth and not addressing technology risks, which are limited in this space.

RESEARCH METHODOLOGY

The insights and conclusions of this guide were informed by data gathered from primary and secondary sources. The insights also leveraged the extensive work that Climake has already undertaken in the waste management and circularity sector.

DATA COLLECTION

1 Secondary Public Source Analysis

The first phase involved a thorough review of publicly available secondary sources: academic literature, industry publications and reports, government reports and statistics, news articles and press releases, and open-access databases and repositories.

2 Access to Proprietary Databases

We also accessed proprietary databases containing specialised and detailed information relating to startups, funding and investors. The main database leveraged for this was Tracxn. Access to these databases allowed us to obtain up-to-date market data and gather detailed company and investor-specific information.

3 Primary Research

To gather sector-specific feedback, we engaged in primary research with key stakeholders: startup founders, investors and experts in waste management and circularity. This primary research was undertaken as part of targeted and ongoing engagements with stakeholders. A total of five interviews were conducted with the following:

- Three founders of funded entities in the following core business models:
  - Collection systems and initial processing
  - Digitised waste collection solutions
  - Biomining
- Two funds with a defined thesis in MSW circularity.

DATA ANALYSIS AND SYNTHESIS

The data collected from all sources were systematically analysed and synthesised. This process involved:

- Conducting content analysis to identify insights, conclusions, trends and forecasts
- Using data visualisation approaches to represent quantitative findings
- Validating assumptions and identifying discrepancies by cross-referencing information from different sources.

LIMITATIONS

While efforts were made to ensure comprehensive and accurate data collection, some limitations should be noted:

- Accurate data on key metrics such as waste quantities and recycling rates are poorly documented in India and vary significantly across waste streams. Our research aimed to validate all data points identified by identifying multiple sources, if available, validating with primary interviewees and leveraging our extant knowledge of the sector.

ASPEN NETWORK OF DEVELOPMENT ENTREPRENEURS

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