CLIMAKE

ASPEN NETWORK OF DEVELOPMENT ENTREPRENEURS
aspen institute

INVESTING IN THE WASTE AND CIRCULARITY SECTOR IN INDIA

An Introductory 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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TABLE OF CONTENTS

Table of Abbreviations 05

Executive Summary 06

Overview of Waste Management and Circularity in India 09

India's Waste Context 09

Overview of India's Waste Ecosystem 16

Waste and Circularity Policy and Regulatory Overview 18

The Investment Potential of the Waste Management Sector 21

The Start-up and Investment Context Today 21

Investor Outlook 29

Non-Dilutive Financing Instruments 32

The Investability Potential of Waste Management Start-ups 34

Overview of the Ten Key Waste Streams 38

Lithium-ion Batteries (LiB) and E-Waste 38

Plastic Waste 43

Agricultural, Food and Biomass Waste 47

Municipal and Industrial Solid Waste 51

Wastewater and Industrial Effluents 55

Textile Waste 59

Construction and Demolition Waste 63

Waste Tyres 65

Lead-Acid Battery Waste 68

End-of-Life Vehicles 71

Research Methodology 74

Annexure 1: Sources for Key Waste Generation and Recycling Insights 76

Annexure 2: The Nature of Waste Enterprises and Investability 78

Annexure 3: Investment Potential Scoring of Waste Streams 82

TABLE OF ABBREVIATIONS

ABBREVIATIONS

ABS:	Acrylonitrile butadiene styrene
ADB:	Asian Development Bank
AMRUT:	Atal Mission for Rejuvenation and Urban Transformation
BioCNG:	Bio compressed natural gas / biomethane
CapEx:	Capital expenditure
CNG:	Compressed natural gas
C&D:	Construction and demolition
CRMB:	Crumb rubber modified bitumen
DFI:	Development Finance Institutions
ELV:	End-of-life vehicles
EPR:	Extended Producer Responsibility
FLDG:	First-loss default guarantee
LAB:	Lead-acid batteries
LiB:	Lithium-ion batteries
MRF:	Material recovery facilities
MSW:	Municipal solid waste
PM:	MITRA PM Mega Integrated Textile Regions and Apparel
PE:	Polyethylene
PET:	Polyethylene terephthalate
PP:	Polypropylene
PVC:	Polyvinyl chloride
PE:	Private equity
PLI:	Production Linked Incentive
SIDBI:	Small Industries Development Bank of India
TPO:	Tyre pyrolysis oil
DFC:	United Stated Development Finance Corporation
VC:	Venture capital
ZLD:	Zero-liquid discharge

EXECUTIVE SUMMARY

India became the world's most populous nation in June 2023, with a population of 1.4 billion people. The country's rapid growth and rising affluence have led to increased consumption demands, especially in urban areas where incomes are rising and a broader range of goods are sought after. Those trends extend to rural areas due to better connectivity and market access. However, the surge in consumption has resulted in a significant increase in waste production, highlighting the need for effective waste management systems to cope with this growing challenge.

Urban India generates about 130,000 to 150,000 metric tonnes (MT) of municipal solid waste daily, with projections indicating a significant increase to 165 million MT by 2030 and 436 million MT by 2050 due to population growth. The composition of waste is shifting towards more non-biodegradable materials, necessitating advanced management strategies. Additionally, India faces challenges from legacy waste, with an estimated 800 million MT stored in 3,159 landfills. To address these issues, the Indian government is focusing on improving waste management through recycling and circularity, incorporating extended producer responsibility policies and embedding circular economy principles in its national strategy. That approach aims to not only mitigate waste impacts but also maximise material reuse from generated waste.

This landscape guide is intended to outline India's current context in recycling and circularity, with a focus on the investment potential, opportunities and business models in the ten most significant waste streams in India:

- Plastic waste
- Lithium-ion batteries (LiB) and Electronic wastes
- Municipal and industrial solid waste
- Agricultural, food and biomass waste
- Wastewater and industrial effluents
- Textile waste
- Construction and demolition waste
- End-of-life vehicles
- Tyre wastes
- Lead-acid battery waste

To provide insights on investment potential, this guide outlines the current operating contexts of these ten waste streams, offering an overview of their policy and regulatory landscapes and stakeholder ecosystems. This guide also contains sector-specific deep dives that identify business models with investment potential in each waste stream by outlining its waste generation drivers, circularity drivers, supply chain and technology readiness, and policy drivers.

Drawing on these insights and analysis, this guide aims to provide a comprehensive outline of the investment potential of each waste stream and the business models found in each. It provides a framework for how investment potential in a waste stream can be determined, which covers five areas that define that potential: market size and growth; investable start-up pipeline; product readiness; policy support; financing needs and gaps. The guide also includes a historical outline of investments and funding in each waste stream and outlines the roles and participation of various types of equity funders, along with the potential and participation of non-dilutive funding options.

While the guide functions as a framework for funders to utilise, one of its key outcomes is determining the potential investment opportunities in the identified streams and business models. These are derived from the consolidation of the previously mentioned analysis. A summary of the investment opportunities identified by this guide is given below.

Investment Potential	Waste Streams	Key Business Opportunities
High Potential	Plastics wastes	Waste sorting technologies and automation
		Chemical recycling of hard-to-recycle plastics into polyolefin outputs
		Higher-quality mechanical recycling
	Lithium-ion batteries (LiB) and electronic wastes	Low-energy, efficient recycling of e-waste
		Recycling technologies for joint high extraction recycling of e-waste and LiB waste
		Recycling of rare earths from LiB waste and e-waste
	Municipal solid waste	Tech-enabled and digitised waste collection solutions
		Automated dry waste sorting technologies
		Biomining
	Agricultural, food and biomass waste	On-farm stubble and waste crop extractors
		Biogas solution providers
		High-efficiency bioCNG and biofuel from agri and biomass wastes

Emerging Potential	Wastewater and industrial effluents	Decentralised wastewater treatment facilities focused on potable water recharge
		Wastewater and effluent treatment filter media and filtration technologies
	Textile waste	High-grade mechanical recyclers
		New-age chemical processing
Long-term Potential	Construction and demolition waste	Higher quality recycled products from construction and demolition wastes
Limited Potential	End-of-life vehicles	N/A
	Tyre wastes	N/A
	Lead-acid battery wastes	N/A

Table 1: Investment potential of the ten sectors and the key business opportunities in each (Source: Climake analysis)

This introductory guide will be followed by a series of sector-specific deep-dive investment guides for the four high-potential sectors identified here: **plastic waste; lithium-ion batteries and e-waste; municipal and industrial solid waste; and agricultural, food and biomass waste.** Those supplementary guides will also feature case studies showing how investors and funders can participate in backing and supporting the wider waste management and circularity sector.

OVERVIEW OF WASTE MANAGEMENT AND CIRCULARITY IN INDIA

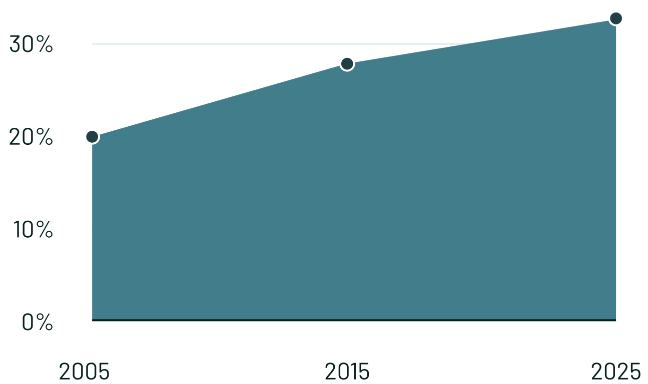
India's Waste Context

In June 2023, India's population reached 1.4 billion, making it the most populous country in the world. Population growth and rising affluence are directly linked to higher consumption. More people are moving into urban areas and their rising incomes are funding a growing appetite for a wide array of goods, ranging from food and clothing to electronics and automobiles. This phenomenon is not limited to urban centres; rural areas are also experiencing a transformation in consumption patterns due to improved connectivity and access to markets.

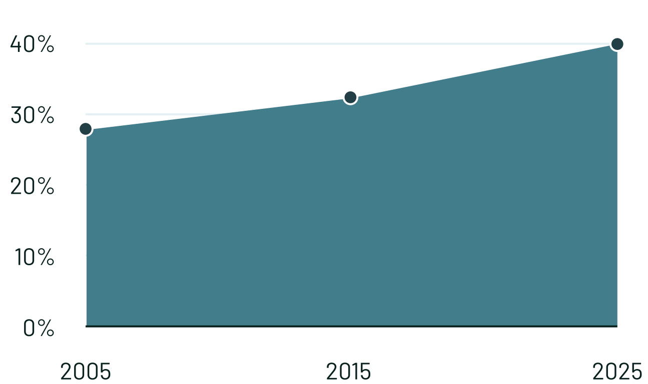
Figure 1 gives a representation of India's growth based on the trends witnessed across key socio-economic indicators in the last twenty years, which show consistent and significant rises.

However, the growth of consumption has led to a significant downside in terms of the generation of waste. As consumption levels soar, so does the amount of waste produced, encompassing everything from household garbage to industrial by-products. This is further exacerbated by ineffective and challenging waste management infrastructure systems and practices; urban areas are often not capable of strengthening and expanding these systems to keep pace with consumption, while rural areas often lack such systems altogether.

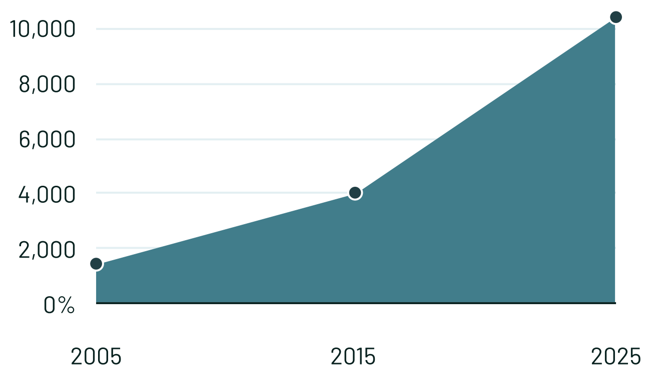
% consumption from Tier 2, 3, and 4 cities*



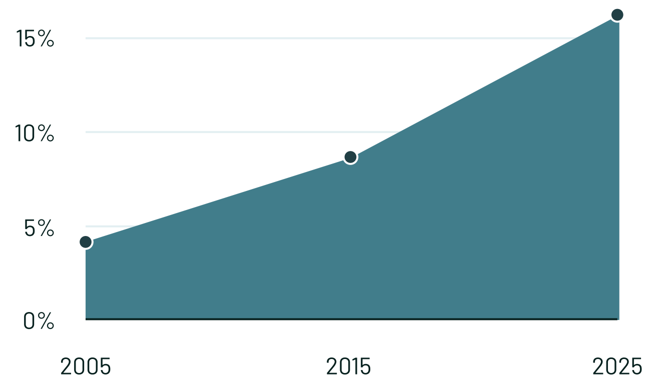
% share of Urban Population in India



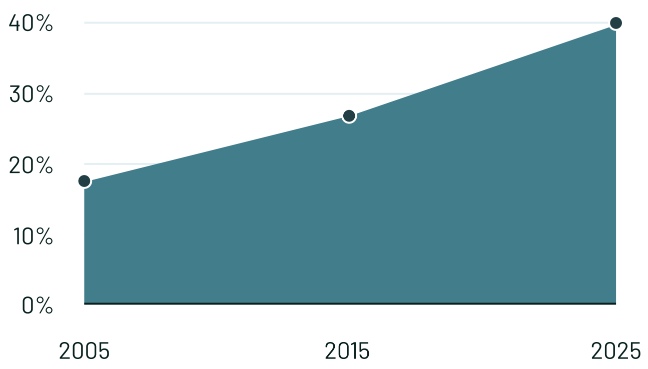
Average household spend (in USD)



Affluent Households as a % of total**



% share of affluent households in total consumer spending



** Cities between 50,000 and 1 million inhabitants*

*** Affluent households are those where household income is more than USD 12,000 per year*

Figure 1: Key socio-economic trends in India that indicate that consumption and growth are increasing in the country. (Source: Boston Consulting Group[1])

1. Singhi A, Jain N., 2017, The New Indian The Rise of Aspirations and More, Boston Consulting Group. Retrieved from: https://media-publications.bcg.com/bcg-sift-1-2-the-new-indian-the-rise-of-aspirations-and-more.pdf

Urban India is currently estimated to generate around 130,000 to 150,000 metric tonnes (MT) of municipal solid waste per day – an annual sum of 55 million MT.[2] India's urban population is expected to grow from 377 million currently to 600 million by 2030 and 814 million by 2050. With this increase, annual municipal solid waste generation is expected to grow to 165 million MT by 2030 and 436 million MT by 2050.

Waste management infrastructure and systems are lagging behind the waste that India needs to handle. The Indian government has recognised the importance and value of improving the country's waste management approaches and is increasingly focused on prioritising recycling and circularity. The country has also embedded the circular economy within its Draft National Resource Strategy and other key policy drivers such as the extended producer responsibility (EPR) regulations for key waste streams – outlined in Page 11 – that now measure targets based on the quantity of high-value materials extracted and recycled and the amount of recycled content that products contain..

Waste management's shift to recycling and circularity is creating private-sector opportunities.

Waste management in India is increasingly about creating an output-oriented sector that focuses on recycling and circularity opportunities rather than just managing the disposal of waste to mitigate pollution effects. That shift has important implications for the participation of private sector enterprises and investors in the waste management space. A recycling and circularity approach ensures waste management does not just stop at mitigating the adverse impact of waste but also focuses on extracting materials that can be reutilised.

This guide identifies ten key streams in India's waste sector and discusses the investment potential and the opportunities for private enterprises in each one. The ten streams are as follows:

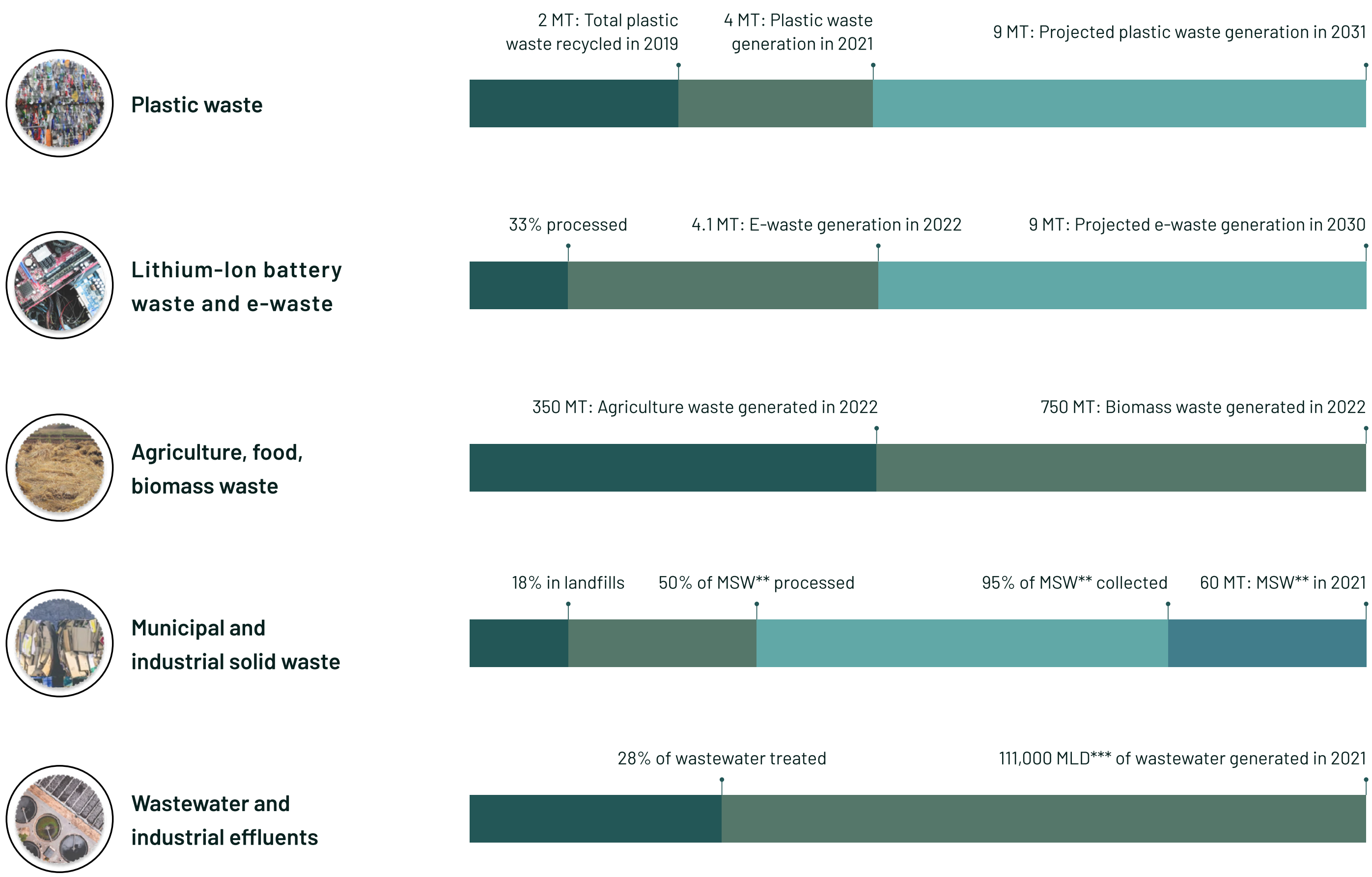
1. Plastic waste
2. Agricultural, food and biomass waste
3. Lithium-ion batteries and e-waste
4. Municipal and industrial solid waste
5. Textile waste
6. Wastewater and industrial effluents
7. Waste tyres
8. Lead-acid battery waste
9. Construction and demolition waste
10. End-of-life vehicles

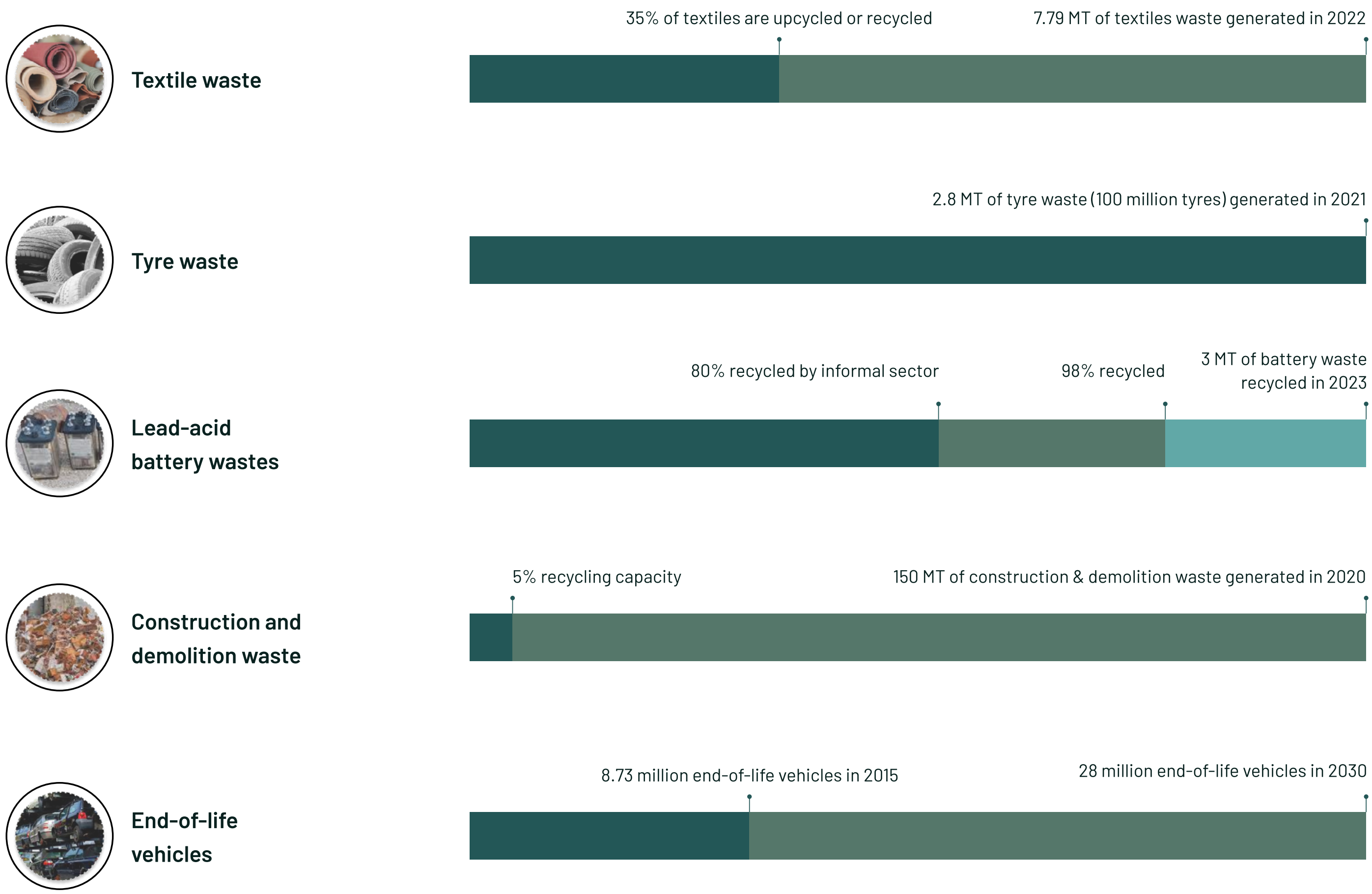
2. TERI, 2023, State of Waste Management Report. Retrieved from: https://www.teriin.org/sites/default/files/2023-10/1695795956State%20of%20Waste%20Management%20Report.pdf

These ten streams comprehensively capture every type of waste generated in India today. Decisions about classifying the different categories for this report have been influenced by the following factors:

- Some waste streams have been classified because there are targeted policies for their management, e.g., end-of-life vehicles and lead-acid battery wastes, which both have extended producer responsibility (EPR) policies and targets for their waste management.
- Other waste streams have been combined due to similarities in the waste products and/or recycling or management approaches, e.g., lithium-ion batteries have been combined with e-waste, and agriculture, food and biomass waste have all been grouped together.
- Other waste streams that lack defined numbers or are too limited in volume or process to be accounted as a single stream have been integrated into other categories, e.g., biomedical waste and (non-electronic) metal waste have been included in the municipal and industrial solid waste category.

Figure 2 outlines the current scenario for each of these waste streams based on the latest available data and insights. It also includes projections for future waste generation, where available.





** MT: million tons*

*** MSW: Municipal Solid Wastes*

**** MLD: Million litres per day*

Figure 2: Key waste generation and recycling insights for the ten waste streams (varied sources — see Annexure 1)

The summary takeaways for each of the ten sectors are outlined below.

PLASTIC WASTE

- Hard plastics and polyethylene terephthalate (PET) are plastic recycling's success stories, with 50% and 90% recycling rates, respectively. Multi-layer and flexible plastic packaging needs more focus and arguably has more detrimental pollution effects through microplastics and choking waterways. The actual rate of plastic recycling is poorly documented but is estimated to range between 30% and 50%.

LITHIUM-ION BATTERIES AND E-WASTE

- Lithium-ion battery (LiB) waste primarily comes from mobile phone batteries; EV and stationary storage will emerge towards the end of the decade.
- E-waste processing has mainly consisted of interim recycling and dismantling. The extraction of high-quality precious materials and rare earths is only emerging but stands to be the big opportunity area in this waste stream.

AGRICULTURAL, FOOD AND BIOMASS WASTE

- Recycling rates are not effectively tracked due to the fragmented nature of generation and gaps between local and formal use. Waste to energy is a primary focus but the use of waste in biomaterials and biofuels is emerging.

MUNICIPAL AND INDUSTRIAL SOLID WASTE

- Issues around the collection of municipal solid waste (MSW) are being solved but recycling such waste or using it for other applications remain gaps. The data showing that 50% of all MSW is processed may be overly optimistic as the definition of how solid waste is processed can differ significantly from safe disposal to recycling.

WASTEWATER AND INDUSTRIAL EFFLUENTS

- Cities contribute 65% of wastewater generation and have most of the available 31,841 million litres per day (MLD) of sewage treatment capacity. The rural wastewater infrastructure is weak. Despite being more regulated, data on industrial effluent generation is not up to date, which can impact efforts to manage industrial discharge effectively.

TEXTILE WASTE

- Textile waste management enterprises are largely dominated by informal operations that produce low-grade or downcycled outputs. However new-age patented tech and high-grade recyclers are emerging.

WASTE TYRES

- Discarded tyre traceability is poor in India. Tyre re-treading is often undertaken by the unorganised sector. Tyre companies, which can access tyres for scrap, contribute less than 1% of tyre recycling.

LEAD-ACID BATTERY WASTE

- Lead-acid battery (LAB) waste management is well-integrated and circular but is largely dependent on the informal sector which often works in hazardous conditions.

CONSTRUCTION AND DEMOLITION (C&D) WASTE

- Construction and demolition (C&D) waste is poorly understood but could account for up to 25% of India's total municipal solid waste. C&D waste could also account for 30% of the total weight of building materials.

END-OF-LIFE VEHICLES (ELV)

- End-of-life vehicles (ELV) are often handled through unorganised operations localised in clusters. An upcoming EPR notification is expected to bring formalisation to this waste stream and, with it, better data traceability.

Overview of India's Waste Ecosystem

India's waste ecosystem has long been driven by the informal and unorganised sectors. It is only with the advent of sector-focused waste management rules, and especially extended producer responsibility (EPR) norms, that more formal players have entered into India's waste management space. However, this is still a place where the informal and formal entities largely work side-by-side. The informal sector operates upstream of the waste value chain, collecting, sorting and aggregating waste; more formal players enter downstream, where waste is turned into value-added outputs through processing and recycling.

Figure 3 gives a schematic overview of India's waste management and circularity ecosystem. Even with societal expectations and norms regarding cleanliness and tackling pollution, the main driver of waste and circularity in India is the regulatory and legislative ecosystem, specifically the enforcement requirements it places on municipalities, brands, producers and companies. Given the nascent stage of formal waste management and circularity participation, the ecosystem of finance and innovation support entities is only just emerging. The opportunities, contexts and gaps in the finance ecosystem, in particular, are featured in this guide.

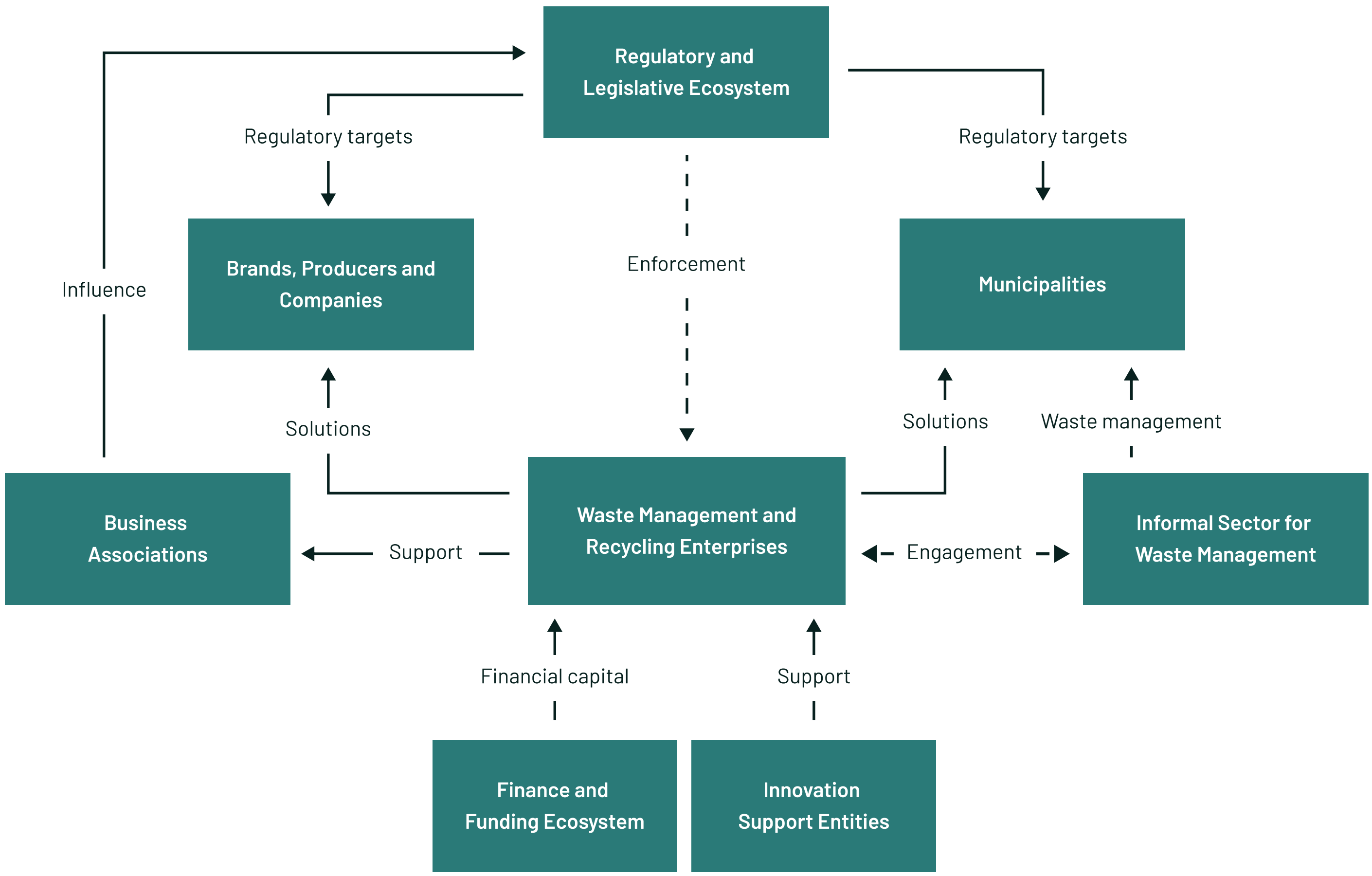


Figure 3: Schematic overview of India's waste management and circularity ecosystem (Source: Climake analysis)

Figure 4 gives an overview of the regulatory structure that is driving the development and evolution of India's waste management and circularity sector. The overall direction is primarily provided by NITI Aayog, a policy-focused government think tank that drives macro-government policy. More immediate direction is provided by the National Green Tribunal, India's environmental court, which enforces directions for compliance on entities and municipalities.

Enforcement is primarily enacted at a national level by the Ministry of Environment, Forest and Climate Change. The Central Pollution Control Board sets targets and frameworks that complement legislation, which cascade down with varying levels of focus and direction from states to municipalities. Responsibility for enforcing the compliance of companies, recyclers and municipalities with regulations is shared between the Central Pollution Control Board and the State Pollution Control Boards based on the nature and scale of the entities.

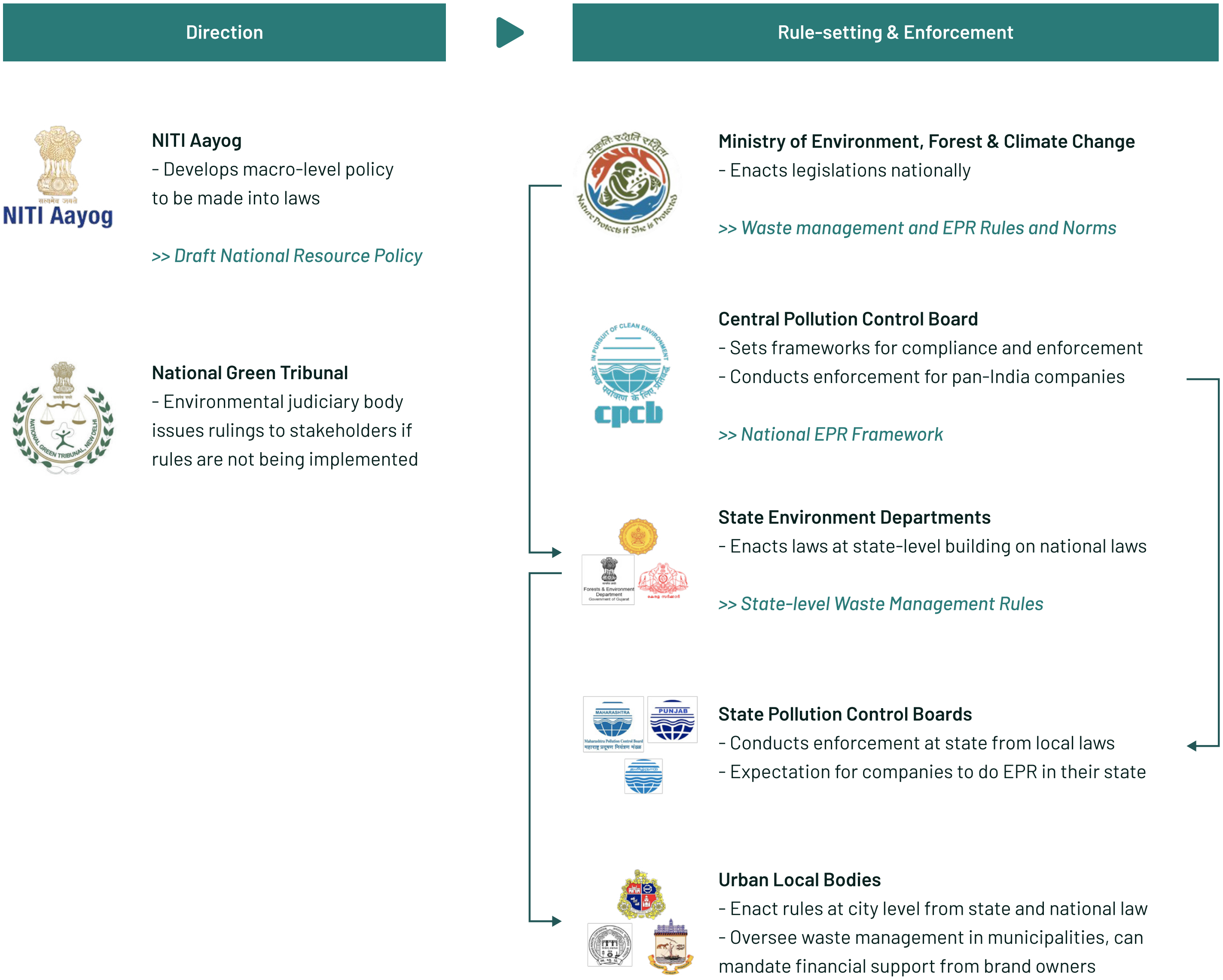


Figure 4: India's regulatory and legislative ecosystem for waste management and circularity (Source: Climake analysis)

Waste and Circularity Policy and Regulatory Overview

Policy and regulations play significant roles in developing and strengthening India's waste and circularity ecosystem. They have traditionally focused on ensuring the proper disposal and management of waste but are increasingly shifting towards circularity and recycling. There are five types of enabling regulations and policies in India, which offer different levels of urgency and incentives to encourage high-quality recycling and circularity across waste streams:

Regulations for proper waste management
These regulations are the minimum and focus more on ensuring the proper disposal and management of waste rather than recycling or circularity.

Policies encouraging circular products and solutions
These are policies that can provide incentives or standards for circular products to be developed and adopted. It is important to note that these may provide financial incentives but are non-mandatory.

Material recovery mandates
These are mandates for recovering materials or components found in waste, mainly through EPR guidelines, which require effective recycling facilities to meet recovery targets.

Recycled content / circular material usage mandates
These are increasingly found in EPR guidelines and mandate recycled content percentages, which incentivise effective recycling that generates high-quality material that can be used in products.

Subsidies for high-quality recycling
Subsidies are being provided at a state level to incentivise the setting up of high-quality recycling facilities and de-risk financial burdens.

Waste Stream	Regulations for proper waste management	Policies encouraging circular products / solutions	Material recovery mandates	Recycled content / circular material use mandates	Subsidies for high-quality recycling / circular outputs
Plastic Wastes	• Plastic Waste Management Rules	• Plastic Waste Management Rules (The Single-Use Plastics Ban)	• EPR Guidelines for Plastic Wastes	• EPR Guidelines for Plastic Wastes	• State-specific rules and guidelines
Lithium-Ion Battery and E-waste	• Battery Waste Management Rules • E-Waste Management Rules		• EPR Guidelines for Batteries • EPR Guidelines for E-Wastes	• EPR Guidelines for Batteries • EPR Guidelines for E-Waste	• State-specific rules and guidelines
Agriculture, Food, Biomass Waste	• Solid Waste Management Rules	• The Electricity Act • Provisions to encourage use of BioCNG • National Policy on Biofuels			• State-specific rules and guidelines
Municipal and Industrial Solid Waste	• Solid Waste Management Rules		• Swacch Bharat Urban Mission		
Wastewater and Industrial Effluents	• The Water Act • CPCB Guidelines for Zero Liquid Discharge				
Textile Waste	• Solid Waste Management Rules				
Tyre Wastes	• Hazardous Waste Rules		• EPR Guidelines for Tyres		
Lead Acid Battery Waste	• Battery Waste Management Rules		• EPR Guidelines for Batteries	• EPR Guidelines for Batteries	
Construction & Demolition Waste	• Construction and Demolition Waste Management Rules				
End-of-Life Vehicles	• Guidelines on Provisions for End-of-Life Vehicles • Draft End-of-Life Vehicles Rules	• Vehicle Scrappage Policy	• Draft end-of-life vehicles Rules		

Figure 5: Enabling policies for circularity and waste management across waste streams (Source: Climake analysis)

Policy and regulation create private-sector opportunities in waste and circularity.

Figure 5 summarises the types of regulations and policies that exist for each of the ten waste streams. The opportunities in each identified waste stream are given below:

1. **Four of the identified waste streams have extended producer responsibility (EPR) norms** placed on them, which include material recycling and recovery targets. These waste streams are plastic waste, lithium-ion batteries and e-waste, lead-acid battery waste and waste tyres. EPR norms for end-of-life vehicles are in line to be introduced imminently. These material recovery mandates require producers and brands that supply these products to ensure a specific quantity of end material is extracted from waste. This creates requirements and opportunities for private enterprises and investors in these waste streams to embed circularity and recycling approaches.

2. **Agricultural and biomass waste recycling is driven by government mandates** that aim to tackle the negative effects of traditional waste management in this field, i.e., crop burning that creates air pollution. States, such as Haryana,[3] have enacted measures to end crop stubble burning by providing financial incentives to encourage the use of such stubble as raw materials in waste-to-energy and other similar applications. India's target for 20% ethanol in biofuel blends[4] is also creating a need to source more agricultural and biomass materials.

3. **Similar government directions are driving municipal solid waste activities.** For example, the Swacch Bharat Mission[5] gives municipalities financial incentives to address solid waste issues; failure to do so leads to enforcement orders and penalties from the National Green Tribunal[6] as part of a carrot and stick approach for municipalities. This approach has led to municipalities engaging private enterprises for a variety of solid waste management activities, including the collection of solid waste, the handling of resource recovery centres and biomining to clean up legacy landfills.

4. **The remaining streams have regulatory rules that focus on waste management and disposal, but ineffective enforcement** has often seen them operated through semi-formal or informal entities; therefore, investable opportunities are minimal. It is likely that EPR-like target-based regulations on producers and brands will be introduced for these streams, such as the upcoming EPR rules on end-of-life vehicles, which could incentivise new innovations, enterprises and investment.

3. Ministry of Environment, Forests and Climate Change, 2023, Haryana to bring down fire counts substantially and will attempt near elimination this year, as per the Haryana State Action Plan for Management of Paddy Stubble Burning submitted to CAQM. Retrieved from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1959679
4. NITI Aayog, Ministry of Petroleum and Natural Gas, 2021, Roadmap For Ethanol Blending in India 2020-25, Retrieved from: https://www.niti.gov.in/sites/default/files/2021-06/EthanolBlendingInIndia_compressed.pdf
5. Swachh Bharat Mission: Driving India's Sanitation Renaissance, Department of Drinking Water and Sanitation, Retrieved from: https://swachhbharatmission.ddws.gov.in/
6. Mishra V., 2023, NGT has imposed a fine of about 80,000 crore so far on states for not disposing of sewage and garbage. Retrieved from: https://www.downtoearth.org.in/waste/ngt-has-imposed-a-fine-of-about-80-000-crore-so-far-on-states-for-not-disposing-of-sewage-and-garbage-90449

THE INVESTMENT POTENTIAL OF THE WASTE MANAGEMENT SECTOR

The Start-up and Investment Context Today

Waste and circularity has emerged as one of India's leading sectors for sustainability investments. US$ 108 million was raised in equity in 2022, three times more than in 2020 and 2021 combined. This has been mainly driven by India's progress in plastic, e-waste and lithium-ion battery recycling. **Figure 6** outlines the equity funding raised in the sector between 2020 and 2023 along with the number of funded entities.

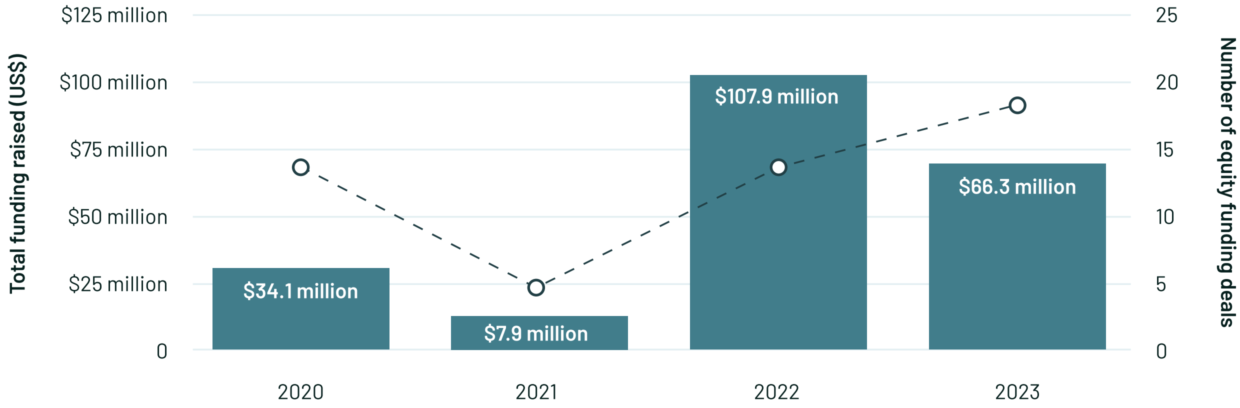


Figure 6: Annual equity funding for waste management and circularity from 2020 to 2023 (Source: Climake analysis)

2022's spike can be attributed to the growing demand for mechanical plastic and e-waste recycling – the two most mature sectors in waste management and circularity. The large capital needs in circularity come from investing in asset-heavy recycling infrastructure and technologies. Even though funding reduced in 2023, the number of entities backed increased, which highlights a move towards more nascent and emerging spaces being backed; more than half of the equity funding in 2023 went to lithium-ion battery recycling.

Additionally, the drop in 2023 can be attributed to equity funding cycles at this stage tending to be longer, with more than 24 months between funding rounds. Debt is also often leveraged to complement the equity raised by recyclers to support the expansion of recycling technologies' capacities. As technologies become more mature and their capabilities improve, the funding cycles of enterprises can be expected to become shorter.

Table 2 provides an outline of the total number of companies providing waste management and/or circularity solutions in each waste stream since records became available. The numbers here relate to verified formal entities working in each stream. The actual number of entities is likely to be significantly higher due to the presence of the informal and unorganised sectors in these activities.

Waste Segments	Identified Companies	Funded Start-ups	Total Amount of Funding Raised (US$)
Plastics wastes	108	36	$139,454,822
Lithium-ion batteries (LiB) and electronic wastes	183	18	$135,843,960
Municipal and industrial solid waste	279	61	$729,082,713*
Agricultural, food and biomass waste	116	37	$305,892,544**
Wastewater and industrial effluents	53	18	$113,120,135
Textile waste	22	3	$2,573,797
Construction and demolition waste	5***	3	$15,485,005
End-of-life vehicles	N/A***	1	$500,000
Tyre wastes	508***	1	$500,000
Lead-acid battery wastes	140***	0	$0

** US$ 600 million of funding in the municipal solid waste stream is attributed to one company – Ramky Enviro – which has raised large-scale private equity investments; this skews the picture of investment in the sector.*

*** US$ 200 million of funding in agricultural waste is attributed to one company – Sukhbir Agro – which converts agricultural waste to energy and has raised large-scale private equity investments; this skews the picture of investment in the sector.*

**** Most enterprises working in construction and demolition waste, end-of-life vehicles, waste tyres, and lead-acid battery waste are informal enterprises. The number of identified companies here are all registered, formal entities. Tyre and lead-acid battery waste enterprises are entities that are registered as recyclers for the two waste streams.*

Table 2: List of the number of identified companies and total funding raised in each waste segment (Source: Climake analysis)

An outline of the nature of enterprises across the value chain of each waste stream is given in **Annexure 2.**

The lithium-ion batteries and e-waste recycling stream has raised the second most funding in the last 4 years of any waste stream. This reflects the potential of that stream and the high funding and financing requirements for its infrastructure. While all the streams involve significant CapEx deployment, the nature of the technologies needed in this particular stream, their nascence, and, importantly, the high value of outputs they can realise are reasons for the increased push to back these solutions.

A lot of the entities identified in this waste stream are e-waste dismantlers or base metal recyclers. Less than 20 of the identified companies had the ability to undertake high-quality recycling of either lithium-ion batteries or e-waste.

Plastic recycling is dominated by hard plastic processing / high-quality recycling services or EPR-driven collection and logistics services. Most flexible and hard-to-recycle plastics are currently sent for incineration as a fuel source for energy plants and cement plants. Only three chemical recycling solutions have been identified, all at pilot stages of development.

The municipal and industrial solid waste stream has the second-highest number of identified entities (after tyre waste) due to the high demand for waste collection, which is a low-entry-barrier activity. Hardware and software sorting technologies, smart bins and other digitised solutions accounted for about 10% of the identified solutions in this stream, and most of them have been recently founded, indicating the growing emergence of digitisation solutions.

Agricultural, food and biomass waste is another stream that contains a large number of entities. It also has the highest funding rate with 37% of the identified companies having raised equity funding. This is being driven by perceptions of the wider environmental and health problems associated with the lack of solutions for dealing with agricultural, food and biomass waste, which is currently being disposed of through environmentally destructive practices such as burning.

Wastewater and industrial effluent solutions are similarly emerging alongside more stringent efforts to ensure that industries and large commercial and residential establishments meet environmental compliance norms. However, the research undertaken to produce this guide identified less than five solutions that were focused on delivering potable water from wastewater recycling, highlighting a potential opportunity area for new solutions.

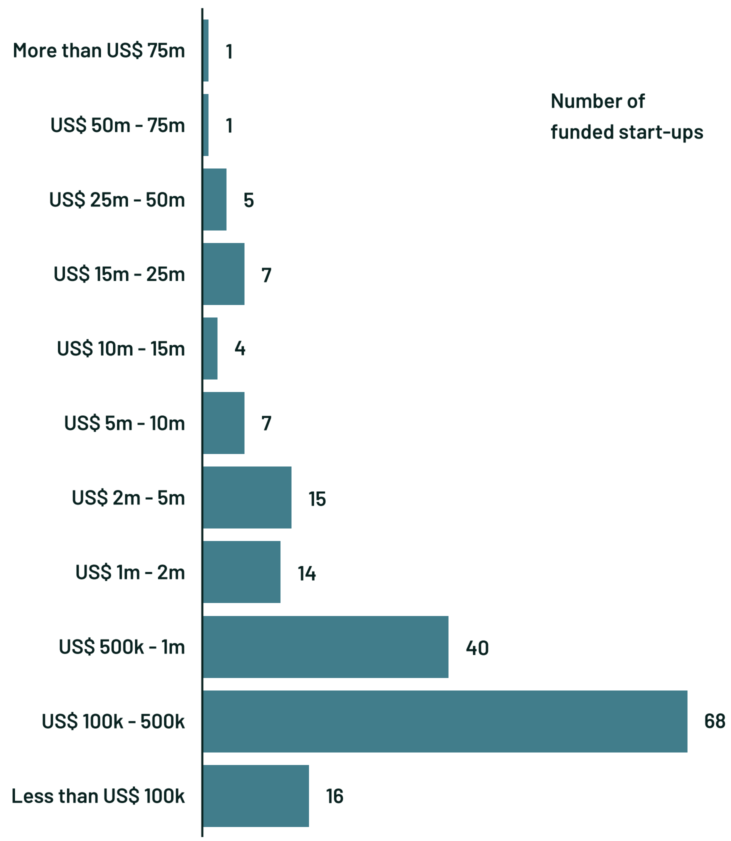


Figure 7: Overall latest stage of investment by number of start-ups funded to date (Source: Climake analysis)

Figure 7 outlines the latest stage of funding for identified waste and circularity start-ups in India. 77% of the latest funding was below US$ 2 million ticket sizes, indicating that the waste and circularity sector is broadly in the early stages of development. However, the opportunities in the area with ticket sizes between US$ 500,000 and US$ 5 million are significant, especially with the emerging crop of enterprises accessing earlier forms of capital. Even though this guide identifies funds operating in this ticket size, there is a gap in funds that are participating or have an interest in this segment.

Figure 8 identifies funding participation across ticket sizes in the four segments with the most active participation: lithium-ion batteries and e-waste, plastic waste, municipal and industrial solid waste, and agricultural, food and biomass waste. The trends are similar to the other segments, with the main difference being the number of entities funded.

- **Lithium-ion batteries and e-waste:** Lithium-ion battery waste investment is exclusively on recycling technologies. While the conversion of waste to black mass (an intermediate product) was being backed, it is forecast that funders will increasingly expect solutions that can create end products such as lithium. E-waste-related enterprises have been present for longer, with collections and initial processing entities being able to access capital before 2022. However, with market expectations and the commoditisation of collection, it is expected that entities offering solutions that contribute to the extraction of precious and valuable materials will have the greatest ability to access funding. The relatively high pollution outcomes of recycling in this stream could lead to the prioritisation of recycling innovations that are more environmentally friendly, but technologies that increase refining outputs will be the most highly valued.

- **Plastic waste:** Plastic waste enterprises have often had the benefit of operating in an established, if informal, sector, which has allowed businesses to grow without significant needs for external capital. This changed, however, when regulatory norms and expectations started prioritising the output of recycling activities over just ensuring that waste was sent for recycling. This has started to drive growth primarily in easier-to-recycle plastics – single monomer and hard plastics – through mechanical recycling approaches; but the future opportunity lies in recycling flexible and complex plastics, which rely on chemical recycling approaches. Currently, the main output of chemical recycling is low-grade fuel oil, which is often used as an industrial fuel, but entities are emerging that have improved chemical recycling processes to create recycled polyolefins that can go back to make new plastics.

- **Municipal and industrial solid waste:** Municipal and industrial solid waste investments have largely been focused on collection and processing solutions, but recent growth has been led by higher-end technologies such as waste sorting solutions. More private sector opportunities have emerged in solving municipal and industrial solid waste issues, which will drive more enterprise opportunities in scaling collection and treatment approaches.

- **Agricultural, food and biomass waste:** Agricultural, food and biomass waste solutions have almost exclusively utilised waste to create useful outputs as biogas, fuels and, more recently, biomaterials. Government policies and incentives around using biomass in energy and fuel applications, in particular, will drive a lot of interest and growth. Logistics and aggregation services will also see opportunities, owing to the fragmented nature of agricultural land, where the collection of such waste needs to be solved to achieve scale.

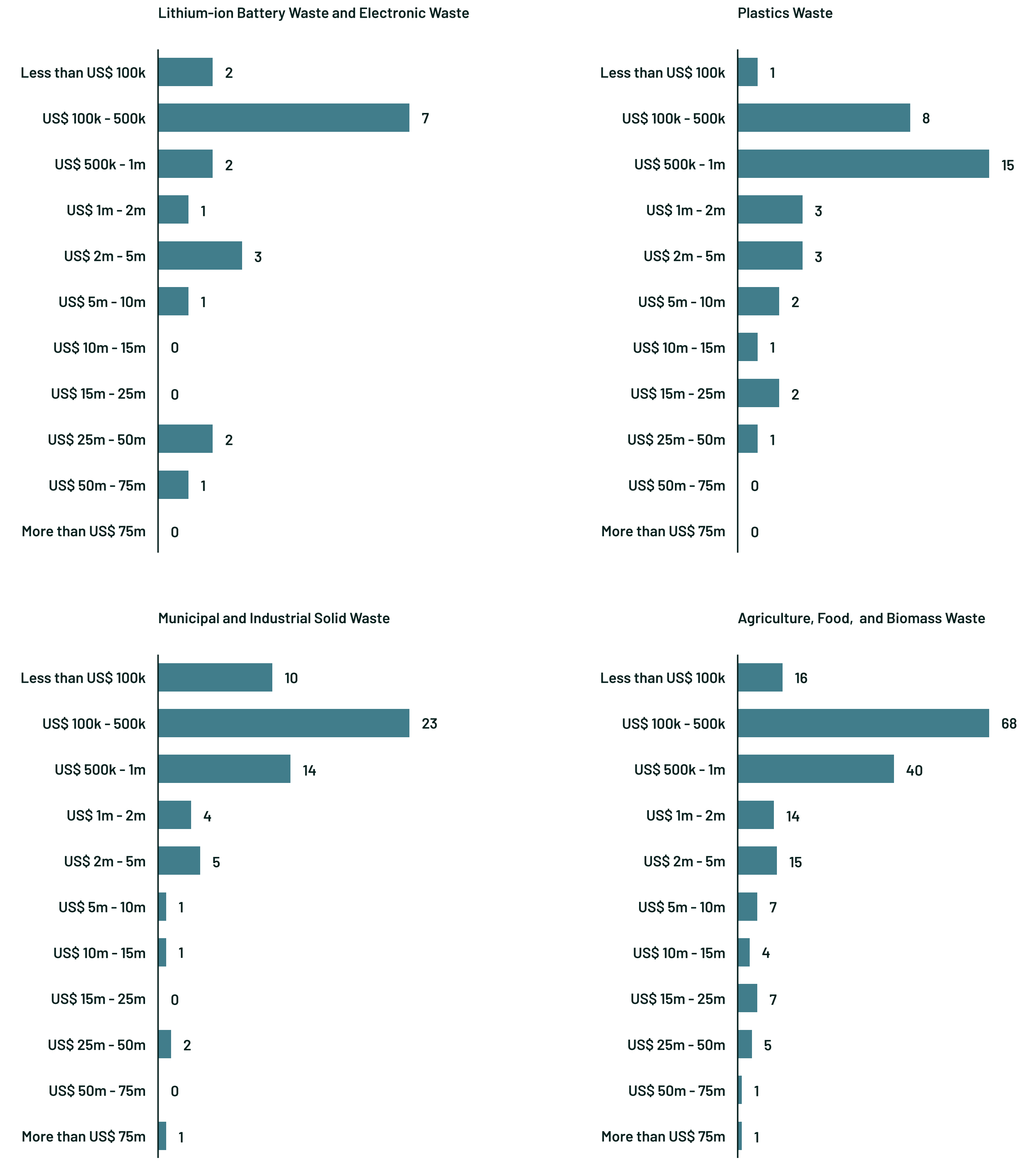


Figure 8: Overall latest stage of investment by number of start-ups in lithium-ion batteries and e-waste; plastic waste, municipal and industrial solid waste, and agricultural, food and biomass waste streams to date (Source: Climake analysis)

Table 3 provides a snapshot of the type of deals that have been seen in these four waste segments in recent years.

PLASTIC WASTE			
Start-up	**Segment**	**Last Raise**	**Investor**
Banyan Nation	High-quality recycling of hard plastics	Equity: US$20 million Debt: US$9 million	Petronas, Asia Impact, DFC
Recykal	Plastics traceability and collection	Equity: US$13 million	360 One Asset Management
Lucro	High-quality recycling of hard plastics	Equity: US$5 million Debt: US$10 million	Circulate Capital, SIDBI
Deluxe Recycling	High-quality recycling of hard plastics	Equity: US$3-5 million	Circulate Capital
Srichakra Polyplast	High-quality recycling of hard plastics	Equity: US$3 million Debt: US$3 million	Circulate Capital, Indian lenders
ReCircle	Plastics collection and interim recycling	Equity: US$560,000	3i Partners Acumen
PolyCycl	High-quality recycling of low-value and flexible plastics	Equity: US$757,000	Angel funds
Terra Bioware	Biomaterials	Equity: US$500,000	We Founder Circle

LITHIUM-ION BATTERIES AND E-WASTE

Start-up	Segment	Last Raise	Investor
BatX	Battery recycling	Equity: US$5 million	Zephyr Peacock, Angel Funds
Metastable	Battery recycling	Equity: US$2 million	SpecialE Invest, Peak XV, Multiple Angels
Lohum	Battery recycling	Equity: US$15 million	Singularity Ventures, Baring Private Equity Partners, other Multiple VCs and Angels
Exigo	E-waste recycling	Project JV: US$25 million	MTC
ElementRe	Battery recycling	Equity: US$2 million	Stellaris Venture Partners
Ziptrax	Battery recycling	Equity: US$120,000	Shell E4
Binbag	E-waste recycling	Equity: US$ 700,000	North Eastern Development Finance Corporation Ltd

AGRICULTURAL, FOOD AND BIOMASS WASTE

Start-up	Segment	Last Raise	Investor
Sukhbir Agro	Biofuels; biomass to electricity	US$1 billion in equity and debt	Norfund, ADB
GPS Renewables	Biofuels	US$50 million in debt and equity	Neev, Indian lenders
PRESPL	Biomass to fuel/steam	Equity: ~ US$10 mn Debt: US$10 million	Shell, Mitsui, DFC

Sistema Bio	Captive biofuel plants for farmers	Debt: US$10 mn	Triodos
Wastelink	Food waste recycling	Equity: US$1.3 million	Indigram Labs, Agreya Capital
Carbonlites	Biogas producer	Equity: US$400,000	Sangam Ventures

MUNICIPAL AND INDUSTRIAL SOLID WASTE			
Start-up	**Segment**	**Last Raise**	**Investor**
Nepra	Municipal waste collection/Material recovery facility (MRF)	Debt: US$5-10 million	Triodos, Aavishkar
BluePlanet	MRF, multi-channel waste recovery	Equity: US$5 million	Mizuho, other VCs
Recykal	Tech/marketplace solutions for waste	Equity: US$7-10 million	Morgan Stanley, Circulate Capital
WeVois	Municipal waste collection	Equity: US$4 million Debt: US$5 million	Upaya Social Ventures, Angel funds, Local Banks
Ishitva	Waste sorting technology	Equity: US$1 million	Inflection Point Ventures
Ecowrap	Waste collection service	Equity: US$500,000	Soonicorn Ventures, Angel funds
TrashCon	Waste collection technology	Equity: US$560,000	Angel funds

Table 3: Summary of key funding deals in the four main waste streams identified (Source: Climake analysis)

Investor Outlook

The equity universe for waste management and circularity is expanding as the sector goes more mainstream. The research for this guide has identified six types of equity funders that are actively participating across the sector. The roles of the different investors are also getting more defined and connected across the funding stages:

- **Incubators,** often linked to academic institutions, are increasingly focusing on climate innovations as a new tech frontier, helping to move lab-scale solutions to market relevance.
- **Angels and family offices** are critical first investors for early-stage innovations, often being able to take a strategic lens to investments. The emergence of more environment-focused family offices, in particular, is a big positive for more first capital to enter the space.
- **Environment-focused funds** are crucial for more high-potential, technologically complex bets, with an ability to better understand technical factors and the potential of innovations.
- **Corporate investors'** participation helps to provide benefits beyond just capital as ventures can get access and scale through corporate investors acting as vendors and partners.
- **Venture capital (VC) funds / private equity (PE) funds** operate from early-stage to late-stage ticket sizes, with private equity funds particularly focused on the growth stage. While the waste and circularity sector is attracting increasing interest, a lot of VC funds, except for seed funds, lack a clear thesis on environmental subjects and often apply a tech-first, asset-light lens in contrast to sectors' needs.
- **Development finance institutions (DFIs)** enter in a catalytic role to bring in more private finance to areas like waste and circularity. They are a crucial funder for concessional and de-risking growth capital, however, given the nascence of the waste and circularity sector, they often see a need to participate at lower ticket sizes than traditional DFI investments.

Figure 9 provides an overview of the investors that have invested in start-ups in this space, **Figure 10** provides an overview of the various areas of an enterprise's lifecycle in which they operate.

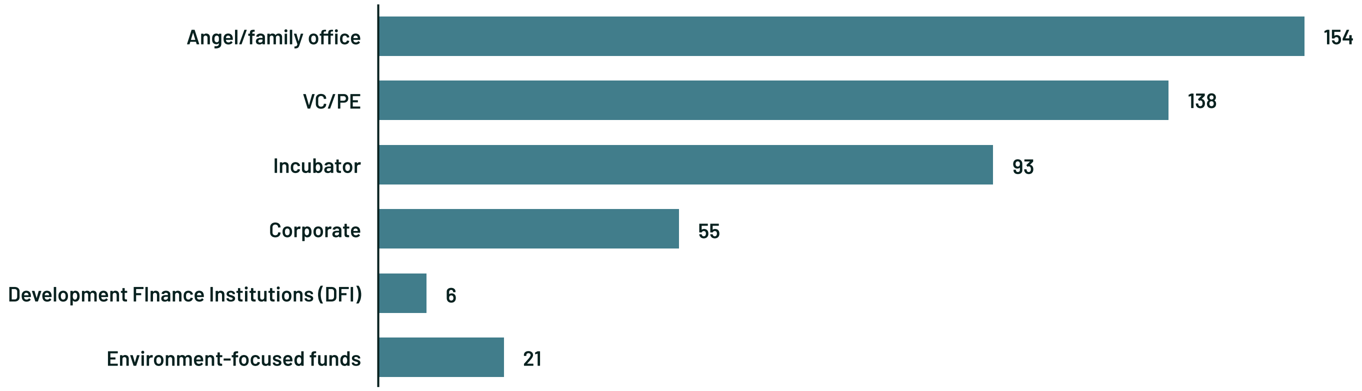


Figure 9: Number of investors who have funded waste management and circularity start-ups by type (Source: Climake analysis)

A key gap in equity funding exists in the Series A/B space – from go-to-market to initial growth. At the product creation and proof-of-concept stages, the participation of incubator and angel funds is thriving as the ticket sizes are small and the funders well-capitalised. Incubators focus on providing initial capital for innovations to move from the idea stage, where ticket sizes are not extensive. At later stages, DFIs and PE funds may not be investing extensively, but the research undertaken for this guide suggests that they have clear mandates and theses to invest in waste management and circularity.

However, they lack an extensive pipeline at this growth stage. That can be attributed to the limited presence of VC funds, especially in the early traction and initial growth stages, to support more start-ups to scale. This gap can be an opportunity area, especially in light of the burgeoning start-ups in the US$ 500,000 to US$ 1 million range, which accounts for over 60% of the currently funded start-ups. **Figure 11** provides a landscape of key debt and equity investors identified in this sector across funding sizes.

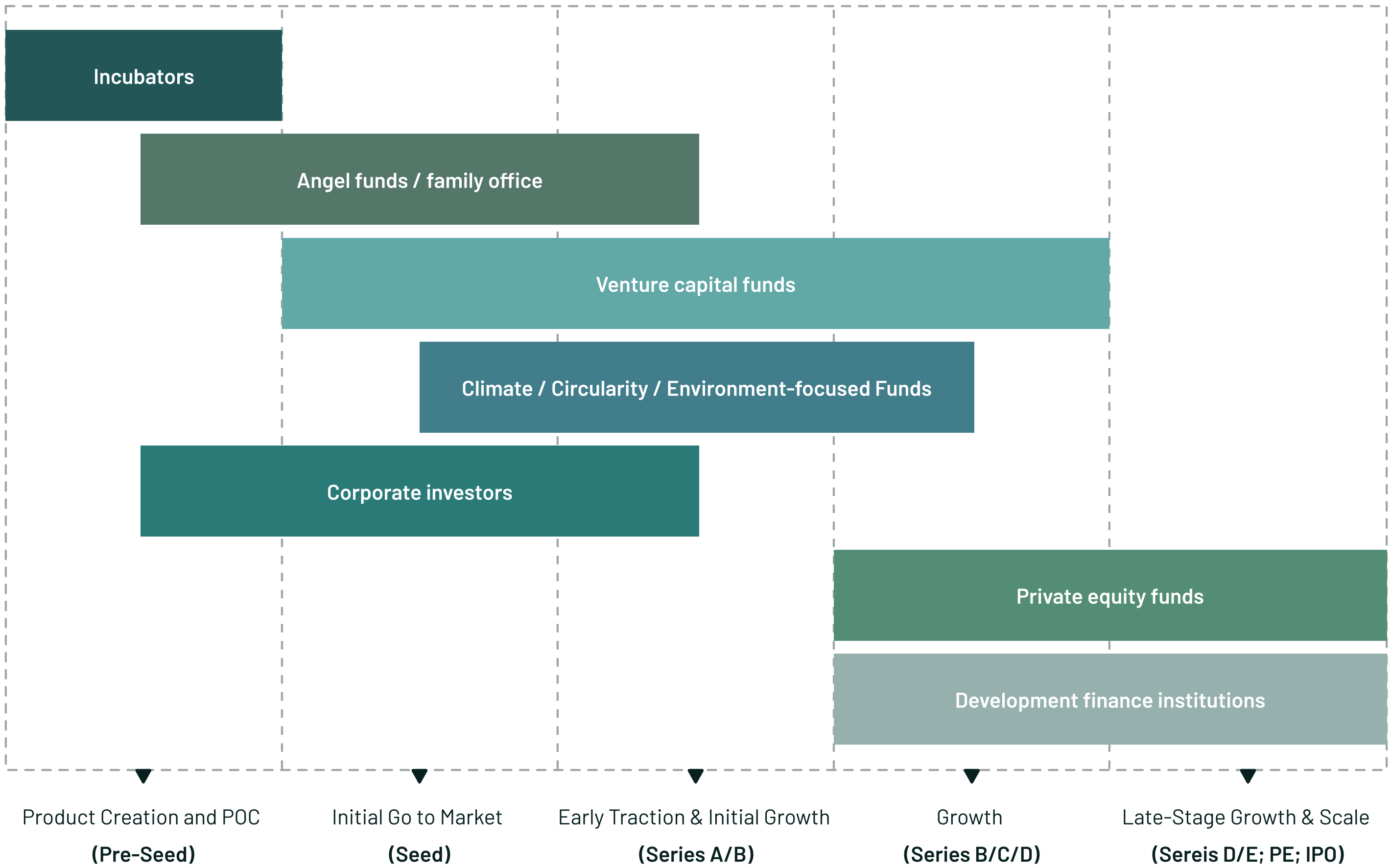


Figure 10: Participation of various funder types across the lifecycle of start-ups (Source: Climake analysis)

Landscape of potential equity investors in India for waste management and circularity

Seed Equity (< US$ 1 million)
- THEIA VENTURES
- Acumen
- MENTERRA
- UPAYA SOCIAL VENTURES
- SPECTRUM IMPACT
- Rainmatter
- momentum capital
- WeFounderCircle

Series A (US$ 1 -7 million)
- omnivore
- CIRCULATE CAPITAL
- SAGANA
- KOIS CARING FINANCE
- ADB Ventures
- chiratae VENTURES
- GREEN FRONTIER CAPITAL
- raintree
- SabrePartners

Series B (US$ 8 - 20 million)
- British International Investment
- Morgan Stanley
- NEEV FUND
- NABVENTURES
- ASIAIMPACT
- nuveen
- gef global environment facility

Series C and Beyond (US$ 20 million+)
- JUST CLIMATE
- MULTIPLES
- TIGERGLOBAL
- TPG RISE CLIMATE
- IFC International Finance Corporation
- niif

Landscape of potential debt lenders in India for waste management and circularity

Early Revenue (< US$ 1 million)
- SPECTRUM IMPACT
- caspian
- BLUE ASHVA CAPITAL
- BlackSoil
- UC INCLUSIVE CREDIT
- ecofy

Early Growth (US$ 1 -7 million)
- responsAbility
- REVX CAPITAL
- NORTHERN ARC
- BlueOrchard
- vivriti CAPITAL
- Startup lending teams of Indian and foreign banks

Growth (US$ 8 - 20 million)
- British International Investment
- OeEB
- IFC International Finance Corporation
- ADB
- DFC U.S. International Development Finance Corporation
- NEEV FUND
- MITSUI & CO.

Scale (US$ 20 million+)
- sidbi
- इरेडा IREDA Indian Renewable Energy Development Agency
- niif
- PFC Power Finance Corporation
- Local Indian Banks

Figure 11: Landscape of key equity and debt funders in waste management and circularity in India (Source: Climake analysis)

Non-Dilutive Financing Instruments

Non-dilutive financing plays a crucial role in supporting equity investment in the waste management and circularity space, often due to the asset-high, working-capital-heavy, and high capital requirements of the sector – especially among the downstream, high-quality recycling operations. From grants to debt and blended finance, non-dilutive financing often complements equity rounds and fundraisers to further capitalise start-ups and enterprises. This section gives a snapshot of the main non-dilutive financing instruments and their current adoption context in the waste and circularity space in India.

Grants

- **Non-renewable and returnable grants:** Grants are usually deployed at early stages to support proof-of-concept testing or the new innovation development of more mature companies. Non-renewable grants are the dominant form, with few examples of returnable grants in the circularity space. Key institutions supporting grants are foundations, such as Shell Foundation, and government entities, such as the Department of Science and Technology,[7] and the start-up and venture fund-supported ACT Grants.

Debt

- **Venture debt:** Venture debt allows established businesses, usually ones that have raised equity, to access debt finance from specialised financial service providers to fund working capital or capital expenses. India has over 50 venture debt funds, but most are attuned towards asset-light entities, which may not be suitable for waste management and circularity ventures.

- **Working capital:** Early-stage entities often have non-banking financing companies (NBFCs) as their only option to access working capital – entities that issue loans at between 16% to 18% interest, compared to the 12% accessible from commercial banks. However, early-stage start-ups and ventures are often not entertained at commercial banks without putting up collateral, which is high risk and often beyond their means.

- **Revenue-based loans:** Revenue-based loans are ones where repayment is based on a percentage of a borrowing company's ongoing revenue rather than a fixed amount. This model has only been utilised so far in software and asset-light companies, where business models allow for better tracking and reliability of revenue flows for lenders. However, in the waste and circularity space, it has a role in an activity like biomining, where contracts have annuities that offer a guaranteed stream of income.

7. Ministry of Science & Technology: Department of Science and Technology, Retrieved from: https://dst.gov.in/

- **Asset financing:** Given the often asset-heavy nature of recycling activities, asset financing involves loans that are raised to purchase assets, with the assets provided as collateral. Asset financing is more accessible to well-capitalised larger players, while early-stage companies often lack suitable track record of performance which carries a higher risk for providing loans.

- **Leasing:** Leasing platforms offer access to machinery, workspaces and other needs on a lease basis, allowing entities without large CapEx investments to access such resources.

- **Concessional loans:** Concessional loans are often offered on more generous terms than market rates. They have so far been provided through development financing institutions, although government-supported financing institutions like SIDBI offer schemes where subsidies are provided as concessions to loans.

Blended Finance

- **First-loss default guarantees (FLDGs):** First-loss default guarantees allow for a third party to cover a portion of losses that may be incurred through loan defaults, reducing risk for investors. FLDGs have usually only been deployed on a case-by-case basis so far in the waste and circularity sector in India, with the nascence of the space and its relative lack of maturity often pointed to as reasons why a more structured and encompassing FLDG product is lacking.

- **Interest subvention:** Interest subvention instruments are ones where a third party pays a portion of the interest on a loan on behalf of the borrower. This is either through part of the loan being converted to a grant or a portion of the interest being provided as a rebate. We have not seen any interest subvention loans in the waste and circularity space in India, although they are often key talking points in conversations around blended finance.

The Investability Potential of Waste Management Start-ups

The different waste streams studied in this report are at varying levels of maturity in terms of their investment potential. The guide defines investability based on each stream's potential to engage in high-quality recycling or high-value material extraction/recovery. Low-value recycling and downcycling have been present across most sectors, mainly due to the unorganised nature of operations and a lack of access to the capital and technology required to produce more high-end outputs. Therefore, India's waste management and recycling efforts should be focused on enabling enterprises operating in each waste stream to deliver high-quality recycling outputs.

Table 4 provides a summary of the investment potential levels of each waste stream across key investment potential criteria. **Annexure 3** details what is covered in each of the criteria areas.

Investment Potential	Waste Stream	Market Size and Growth	Availability of Investible start-ups / pipeline	Product Readiness	Policy Support	Financing Needs and Gaps
High Potential	Plastics wastes	High	High	Medium	High	High
	Lithium-ion batteries (LiB) and electronic wastes	High	High	Medium	Medium	High
	Agricultural, food and biomass waste	High	High	Medium	Medium	High
	Municipal and industrial solid waste	High	High	Medium	Medium	High

Emerging Potential	Wastewater and industrial effluents	Medium	High	Medium	Low	High
	Textile waste	Medium	Medium	Medium	Low	Medium
Long-term Potential	Construction and demolition waste	Low	Low	Low	Low	Medium
Limited Potential	End-of-life vehicles	Medium	Low	Medium	Medium	Low
	Tyre wastes	Medium	Low	High	Medium	Low
	Lead-acid battery wastes	Medium	Low	Medium	Low	Low

Table 4: Investment potential matrix (Source: Climake analysis)

This guide divides the ten waste streams into the following four groups based on their investment potential:

- **High potential:** Sectors that have significant investment potential today.
- **Emerging potential:** Sectors that will have significant investment potential in two to three years.
- **Long-term potential:** Sectors where investment opportunities will grow after five years dependent on policy changes or technology development.
- **Limited potential:** Sectors that are currently saturated and offer limited investment potential.

Table 5 gives a summary of the main potential business opportunities in each of the identified streams (divided by investment potential).

HIGH POTENTIAL WASTE SEGMENTS	
Waste Segments	**Key Business Opportunities**
Plastics Waste	Waste sorting technologies and automation
	Chemical recycling of hard-to-recycle plastics towards polyolefin outputs
	Higher-quality mechanical recycling
Lithium-ion Batteries and E-waste	Low-energy, efficient recycling of e-wastes
	Recycling technologies for joint high extraction recycling of LiB waste and e-waste
	Recycling of rare earths from LiB waste and e-waste
Municipal and Industrial Solid Waste	Tech-enabled and digitised waste collection solutions
	Automated dry waste sorting technologies
	Biomining
Agriculture, Food, and Biomass Waste	On-farm stubble and waste crop extractors
	Biogas solution providers
	High-efficiency bioCNG and biofuel from agricultural and biomass wastes

EMERGING POTENTIAL WASTE SEGMENTS	
Waste Segments	**Key Business Opportunities**
Wastewater and Industrial Effluents	Decentralised wastewater treatment facilities focused on potable water recharge
	Wastewater and effluent treatment filter media and filtration technologies
Textiles Waste	High-grade mechanical recyclers
	New-age chemical processing

LONG-TERM POTENTIAL WASTE SEGMENTS	
Waste Segments	**Key Business Opportunities**
Construction & Demolition Waste	Higher-quality recycled products from construction and demolition wastes

EMERGING POTENTIAL WASTE SEGMENTS	
Waste Segments	**Key Business Opportunities**
End-of-life Vehicles	N/A
Tyres Waste	N/A
Lead-acid Batteries Waste	N/A

Table 5: Investment potential of the ten streams with the main potential business opportunities for each stream (Source: Climake analysis)

OVERVIEW OF THE TEN KEY WASTE STREAMS

Lithium-ion Batteries (LiB) and E-Waste

Overview

India is a significant player in the global e-waste landscape, contributing approximately 4.1 million tonnes of electronic waste (e-waste) in 2022,[8] which accounts for approximately 7% of the world's total e-waste output. In 2021, one-third[9] of India's e-waste was managed through formal and informal channels, with 80% to 90% of e-waste management operations handled by the informal sector. By 2030, India's e-waste output is expected to escalate significantly, reaching approximately 9 million tonnes (based on our estimates) which would represent about 11% of the global e-waste forecast for that year (82 million tonnes).

From 2021 to 2030, India is projected to generate a cumulative total of at least 400,000 tonnes of lithium-ion battery (LIB) waste. This translates to an annual generation rate of approximately 43,000 tonnes of waste.[10] This significant amount of waste highlights the growing demand for LiBs, driven by the rapid adoption of consumer electronics and electric vehicles (EVs). Currently, most LiB waste comes from consumer electronics. However, by 2030, EVs are expected to become the predominant source of this waste.[11]

These figures and trends underscore the pressing need for comprehensive strategies to manage and mitigate the environmental impact of LiB and e-waste.

Waste generation drivers

India's e-waste generation is driven by increasing electrical and electronic equipment (EEE) usage, with the country contributing 3% of global EEE production. Digitalisation and the rising adoption of IT-enabled products, projected to reach 920 million units annually by 2028, are key factors. Mobile phones and computing solutions drive over 70% of this growth. The shortened lifespan of devices and e-commerce trends exacerbate e-waste. Demand for white goods is also rising, with sales expected to hit 480 million units by 2028. Against this growing demand, domestic EEE production has expanded, facilitated by government initiatives such as the "Make in India" scheme. All of these factors make effective waste management a crucial need.

8. Baldé C. P.¬, Kuehr R., Yamamoto T., McDonald R., D'Angelo E., Althaf S., Bel G., Deubzer O., Fernandez-Cubillo E., Forti V., Gray V., Herat S., Honda S., Iattoni G., Khetriwal D. S., di Cortemiglia V. L., Lobuntsova Y., Nnorom I., Pralat N., Wagner M., 2024, Global E-waste Monitor 2024, International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR). Retrieved from: https://ewastemonitor.info/the-global-e-waste-monitor-2024/
9. Government of India Ministry of Environment, Forest And Climate Change, 2023, Status of e-waste in the country. Retrieved from: https://sansad.in/getFile/annex/260/AU2426.pdf?source=pqars
10. Gattu A., Agrawal A., Chatterjee A., Mittal D., Khan M. S., Bagdia R., Singh R., Khan S. M., Singh V, 2022, Advanced Chemistry Cell Battery Reuse and Recycling Market in India, NITI Aayog and Green Growth Equity Fund Technical Cooperation Facility. Retrieved from: https://www.niti.gov.in/sites/default/files/2022-07/ACC-battery-reuse-and-recycling-market-in-India_Niti-Aayog_UK.pdf
11. Confederation of Indian Industry, 2023, Battery Manufacturing & its Ecosystem. Retrieved from: https://www.cii.in/PressreleasesDetail.aspx?enc=6UYt9FK13Sa34a6GeomIIKlavi8RCedYYNjaH0U1+2vp3HCKU+qX9AWibtxRm9DBPuG6MrfG/0vdPv0kz3mbgw==

Battery replacement is required when performance drops below 70–80% of initial capacity, with used batteries often refurbished for secondary applications. Battery retirement is expected to surge to at least 6 gigawatt hours (GWh) annually by 2030[12] due to increased EV adoption, up from less than 0.5 GWh in 2022. Enhanced battery technology aims to extend battery life and reduce costs but will also increase LiB waste. The rise in discarded small electronics from e-commerce further accelerates LiB waste, which is often poorly regulated, highlighting the need for stricter waste management practices.

Circularity drivers

Manufacturing electrical and electronic equipment (EEE) relies on high-value materials like metals and printed circuit boards (PCBs). These utilise scarce and hard-to-access materials, which makes mining e-waste an attractive opportunity to generate reliable sources of these materials. For example, gold extraction from e-waste is highly efficient compared to mining it from ore. Beyond economic benefits, e-waste recycling reduces the need for natural resource extraction, aiding environmental restoration. India's thriving US$ 10 billion[13] second-hand EEE market, driven by e-commerce, supports circular economy practices. This emphasises the industry's shift towards sustainable, closed-loop resource management, which will likely make the transition to circular businesses inevitable.

The market for stationary and mobile batteries in India is set to triple, reaching US$ 6 billion[14] by 2030, driven by growing LiB adoption. Government policies supporting renewable energy and grid stability boost stationary LiB demand. Meanwhile, the electric vehicle (EV) market, with record sales of 1.2 million vehicles in 2023[15] and a projected compound annual growth rate (CAGR) of 22%, is fuelling mobile LiB growth and will continue to do so with at least 10 million vehicles projected by 2030. As a result of these developments, India's LiB imports have surged sevenfold between 2018 and 2023[16], highlighting a reliance on foreign raw materials. To reduce that dependency, the government has auctioned critical mineral reserves and introduced a US$ 2.16 billion Production Linked Incentive (PLI) scheme[17] to develop domestic battery manufacturing.

12. Gattu A., Agrawal A., Chatterjee A., Mittal D., Khan M. S., Bagdia R., Singh R., Khan S. M., Singh V, 2022, Advanced Chemistry Cell Battery Reuse and Recycling Market in India, NITI Aayog and Green Growth Equity Fund Technical Cooperation Facility. Retrieved from: https://www.niti.gov.in/sites/default/files/2022-07/ACC-battery-reuse-and-recycling-market-in-India_Niti-Aayog_UK.pdf
13. Singh S. G., 2020, Centre for Science and Environment, E-Waste Management in India Challenges And Agenda, Retrieved from: https://www.cseindia.org/e-waste-management-in-india-10593
14. Singh R., Ghate A., Ningthoujam J., Gupta A., Sharma S., 2022, NITI Aayog and Rocky Mountain Institute, Need for Advanced Chemistry Cell Energy Storage in India (Part I of III). Retrieved from: https://www.niti.gov.in/sites/default/files/2022-02/Need-for-ACC-Energy-Storage-in-India.pdf
15. Autocar Professional, EV sales in India hit 1.17 million units in FY2023, charge past 100,000 for six months in a row, 2023, Retrieved from: https://www.autocarpro.in/analysis-sales/ev-sales-in-india-hit-117-million-units-in-fy2023-charge-past-100000-for-six-months-in-a-row-114543
16. Sharma A., 2024, India's long road to lithium, The East Asia Forum. Retrieved from: https://eastasiaforum.org/2024/01/27/indias-long-road-to-lithium/
17. Ministry of Heavy Industries, 2022, Three Companies signed Program Agreement under (PLI) Scheme for Advanced Chemistry Cell (ACC) Battery Storage. Retrieved from: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1846078

Value chain and business model

LiB waste from consumer and production sources includes prismatic, cylindrical and pouch cells. High-quality waste is crucial for effective recovery and recycling, focusing on components like casings, electrolytes, separators and, especially, cathodes containing rare metals. Despite lithium's minor composition, it is critical due to cost sensitivity. LiB recycling involves four steps[18] – preparation, pre-treatment, pyrometallurgy and hydrometallurgy – and has a potential material extraction efficiency above 90%. Direct recycling and carbothermal technology are emerging methods. India's LiB recycling capacity, currently at 0.3%, is expected to exceed 50% by 2030. Recyclers focus on high-quality waste and sustainable technologies to meet increasing demand.

E-waste recycling involves collection, sorting, dismantling and processing for material recovery, with some refurbished items entering the second-hand market. Recent efforts have focused on improving dismantling and recycling techniques, but challenges persist, especially with low-quality waste from informal sector aggregators. Increasing formal recycling activities requires equitable integration of informal workers. Indian recyclers rely on exports for final material extraction, limiting domestic value, but with a stronger policy focus on circularity, the end recycling of final valuable materials (such as lithium and cobalt) is increasingly being realised in India. The shift from repair to disposability highlights the need for sustainable e-waste management practices that balance repair and recycling strategies.

The LiB and e-waste value chain is shown in **Figure 12** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection of Waste	Refurbishment and Interim Recycling	Advanced Recycling
Business Models	• Collection centre	• Interim recycler • Refurbisher	• Pyrometallurgical recycling • Hydro-metallurgical recycling
Outputs	• Aggregated and segregated wastes	• Second-life equipment • Base metals	• Recycled precious metals • Recycled rare earths • Recycled critical raw materials

Figure 12: The lithium-ion battery and e-waste value chain with key business models across the value chain and outputs generated (Source: Climake analysis)

18. Singh R., Ghate A., Ningthoujam J., Gupta A., Sharma S., 2022, NITI Aayog and Rocky Mountain Institute, Need for Advanced Chemistry Cell Energy Storage in India (Part I of III). Retrieved from: https://www.niti.gov.in/sites/default/files/2022-02/Need-for-ACC-Energy-Storage-in-India.pdf

1 Collection Centres

Value Chain Area: Collection of Waste

Investment Potential: Low

Collection centres aggregate, collect and dismantle e-waste from waste generators and provide waste to refurbishers and dismantled components to interim metal recyclers and plastic recyclers. They are mainly run by the informal sector and offer little scope for formal players to enter as stand-alone operations. Lithium-ion batteries are currently sourced from mobile phone batteries as the presence of lithium-ion in battery storage is nascent. Recyclers are likely to set up in-house collection centres to improve the supply of waste, especially when larger electric mobility batteries become available as waste.

2 Interim Recyclers

Value Chain Area: Refurbishment and Interim Recycling

Investment Potential: Medium

Interim recyclers focus on recycling base metals of aluminium and copper that can be easily extracted from e-waste. Interim recyclers mainly utilise pyrometallurgical smelters to extract base metals and can also use refining technologies to provide higher-value metal outputs.

3 Refurbishers

Value Chain Area: Refurbishment and Interim Recycling

Investment Potential: Medium

E-waste refurbishers specialise in the repair, refurbishment and resale of used electronic devices, aiming to extend their lifespans and reduce e-waste by providing them as second-life products.

4 Pyrometallurgical Smelters

Value Chain Area: Advanced Recycling

Investment Potential: High

Pyrometallurgical smelters are primarily used to extract precious metals from e-waste as those metals can be separated from melded components at high temperatures. Pyrometallurgy is also used for lithium-ion battery extraction, but the extraction rate is significantly lower than that of hydrometallurgical processes. While pyrometallurgical recycling follows a well-established practice, innovations that offer marginal improvements in efficiency and extraction outputs and deliver recycling through non-energy-intensive and more environmentally friendly processes are significant opportunities.

5 Hydrometallurgical Recyclers

Value Chain Area: Advanced Recycling

Investment Potential: High

Hydrometallurgical recyclers are primarily focused on lithium-ion battery extraction although new innovations are focused on the low-energy extraction of precious metals from e-waste, an activity that has traditionally been undertaken through pyrometallurgy. Hydrometallurgy practices involve using liquids, such as acids or leaching agents, to extract valuable metals like cobalt, lithium and nickel from a black mass compound which can be further refined through electrorefining technologies for higher value output. Similar to pyrometallurgical smelters, opportunities abound in innovations that offer material efficiency and extraction outputs and use more environmentally friendly processes. An untapped application of hydrometallurgical recycling is in the recycling of rare earths, which are scarce materials of increasing importance, making their extraction from LiB and e-waste a potential opportunity.

Plastic Waste

Overview

India grapples with a substantial plastic waste challenge, generating nearly 26,000 tonnes daily,[19] amounting to approximately 4.1 million tonnes annually.[20] Projections indicate that India's plastic waste output will reach 45 million tonnes annually by 2035. Relatedly, India's plastic recycling industry is experiencing remarkable growth; estimated at US$ 2.3 billion in 2023,[21] it is projected to soar to US$ 10.2 billion by 2030. Innovative start-ups and forward-thinking packaging companies are spearheading initiatives across the entire plastic recycling value chain, from collection and segregation to separation and recycling.

Waste generation drivers

Approximately 75% of plastic waste comprises three primary polymers: polypropylene (PP), polyethylene (PE) and polyvinyl chloride (PVC). Packaging accounts for 59% of India's plastic use, followed by building and construction at 13% and agriculture at 9%.[22] India's annual plastic consumption soared to 24.1 million tonnes in 2023[23] estimates indicate a surge to at least 70.5 million tonnes annually by 2035. There is an uptick in the adoption of lightweight hard plastics in sectors such as automotive manufacturing, machinery and equipment production, primarily to reduce the weight of vehicles and machinery. The use of virgin feedstock persists as recycled alternatives face questions related to quality, consistency and scale.

Circularity drivers

Extended producer responsibility (EPR) targets in India, implemented through plastic waste management rules, are driving changes in plastic production, waste management and recycling. Such targets focus on material recovery, reuse and the quantity of recycled content in packaging. These targets, along with the demand for high-quality, contaminant-free recycled plastics, underscore the opportunity for efficient and commercially viable recycling solutions.

Value chain and business models

Plastic waste recycling involves pre-processing – collection, sorting and contamination removal – and recycling, which transforms materials into recycled products. Sorting and segregation are important but low-profit-margin activities. Mechanical recycling[24] accounts for over 90% of plastic waste recycling scenarios, followed by energy recovery and

19. Kikken N., 2023, India generates 26,000 tonnes of plastic waste every day. This is how we reduce that number, Commonwealth Scientific and Industrial Research Organisation. Retrieved from: https://www.csiro.au/en/news/all/articles/2023/december/circular-economy-roadmap-india
20. Central Pollution Control Board, 2021, Annual Report 2020-21 on Implementation of Plastic Waste Management Rules, 2016. Retrieved from: https://cpcb.nic.in/uploads/plasticwaste/Annual_Report_2020-21_PWM.pdf
21. Avendus, 2023, Circular Economy: Recycling waste to wealth. Retrieved from: https://www.avendus.com/india/reports/61
22. Dhodapkar R, Bhattacharjya S, Niazi Z, Porter NB, Retamal M, Sahajwalla V and Schandl H, 2023, National Circular Economy Roadmap for Reducing Plastic Waste in India, Commonwealth Scientific and Industrial Research Organisation. Retrieved from: https://www.csiro.au/-/media/Environment/Circular-Economy-Roadmap-India/23-00249_ENV_REPORT_IACPRoadmap_WEB-230714.pdf
23. ibid
24. Avendus, 2023, Circular Economy: Recycling waste to wealth. Retrieved from: https://www.avendus.com/india/reports/61

chemical recycling, but it is not effective on complex plastics, i.e., flexible, multilayer or contaminated plastics. Energy recovery is preferable to landfill dumping but has downsides related to carbon emissions, pollution risks and high costs. Chemical recycling could overcome the limitations of mechanical recycling, but it is currently limited due to cost and technology maturity factors. The informal sector plays a significant role in plastic waste recycling.[25] However, recycling processes conducted without proper cleaning and segregation often yield low-quality outputs suitable only for low-value applications. Alternatives and direct plastic substitutes are emerging, particularly in medical implants and packaging applications, highlighting evolving approaches to plastic circularity.

The plastic waste value chain is shown in **Figure 13** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection of Waste	Pre-processing	End- recycling	Sustainable alternatives to wastes generated
Business Models	• Collection centre	• Waste sorting technology	• Mechanical recycling • Chemical recycling	• Bio-based plastic alternative producers
Outputs	• Segregated plastic wastes	• Pre-processed wastes	• Plastic granules • Pyrolysis oil • Recycled polyolefins	• Natural plastic alternatives • Bioplastics

Figure 13: The plastic waste value chain with key business activities across the value chain and outputs generated (Source: Climake analysis)

25. Dhodapkar R, Bhattacharjya S, Niazi Z, Porter NB, Retamal M, Sahajwalla V and Schandl H, 2023, National Circular Economy Roadmap for Reducing Plastic Waste in India, Commonwealth Scientific and Industrial Research Organisation. Retrieved from: https://www.csiro.au/-/media/Environment/Circular-Economy-Roadmap-India/23-00249_ENV_REPORT_IACPRoadmap_WEB-230714.pdf

1 Collection Centres

Value Chain Area: Collection of Wastes

Investment Potential: Low

Collection centres work to aggregate and collect plastic waste from waste generators: households, commercial establishments, etc. and provide it to waste aggregators and material recovery facilities. These are mainly run by the informal sector and offer little scope for formal players to enter as stand-alone operations. However, recyclers are setting up collection centres to collect pre-consumer or industrial waste to supply their own recycling facilities.

2 Waste Sorting Technologies and Automation

Value Chain Area: Pre-processing

Investment Potential: High

Waste sorting technologies are solutions that involve automated systems such as conveyor belts, optical sorters and AI-powered robots that identify and segregate recyclable materials from mixed waste. They are installed in material recovery facilities and recycling facilities and are dependent on these businesses for their operation. Improved solutions are needed to better segregate recyclable plastic from other contaminants; current manual practices lead to greater discard of otherwise recyclable wastes. Demand for sorting technologies will increase as higher-quality recycling demands will require greater sorting accuracy for greater waste volumes.

3 Mechanical Recycling Facilities

Value Chain Area: End Recycling

Investment Potential: High

Mechanical recycling facilities for plastic waste employ processes involving sorting, cleaning, shredding and melting to transform plastic waste into pellets or flakes ready for reuse in manufacturing new plastic products. These operations focus on hard plastics and prioritise sorting plastics by type and removing contaminants to ensure the production of high-quality recycled materials. Mechanical recycling technologies that handle hard plastics are getting technologically established, with even 100% recycled PET bottles being produced. However, demand will continually grow for improved outputs for mechanical recycling of other hard plastics. Marginal quality improvements can be the difference between high-value food-grade applications and lower-value options.

4 Chemical Recycling Facilities

Value Chain Area: End Recycling

Investment Potential: High

Chemical recycling facilities employ chemical processes like pyrolysis or depolymerisation to break down plastic waste into molecular components. These components can then be utilised to manufacture new plastics or other chemicals, offering a solution for recycling plastics that are challenging to mechanically recycle such as contaminated plastics, flexibles and mixed composition multilayer packaging. These are commercially non-existent in India currently, other than pyrolysis plants that focus on creating fuels from plastic wastes. Demand for recycled polyolefins, the inputs to new plastic materials, is growing to limit the use of virgin fossil fuels for plastic production and consequently provide a high-value option for hard-to-recycle plastics. Chemical recycling technologies with such outputs will be highly valued solutions.

5 Bio-based Plastic Alternative Producers

Value Chain Area: Sustainable Alternatives

Investment Potential: High

Bio-based plastic alternative solutions focus on developing and producing plastic materials derived from renewable biomass sources, such as plant-based feedstocks. These alternatives aim to reduce reliance on traditional petroleum-based plastic and address environmental concerns by creating biodegradable or compostable plastic. Such solutions have primarily focused on packaging alternatives, which face mass market adoption issues due to unviable pricing and have largely been adopted in smaller volume, higher-value products such as cosmetics and high-end food and beverage products.

Agricultural, Food and Biomass Waste

Overview

India produces approximately 350 million tonnes of agricultural waste annually[26] and the country's annual biomass potential stands at 750 million tonnes.[27] Biomass and agricultural waste can be used in diverse applications42 ranging from fodder for cattle and household cooking to the production of biogas, manure and even renewable fuels such as ethanol and biodiesel. Biomass caters to about 80% of India's rural energy demand.[28] Conversely, more sophisticated biomass technologies are increasingly prominent in applications such as energy generation or fuel production, especially for large-scale operations. In the automotive sector, India has witnessed a notable increase in the sales of compressed natural gas (CNG)-powered vehicles, which constituted 8.6% of total sales in 2022.[29]

Waste generation drivers

Agriculture, food, and biomass wastes come from multiple sources. The main opportunities come from agriculture, pre-consumer food, and biomass sources. Post-consumer food waste is often handled as part of municipal solid waste approaches. This waste stream follows a hierarchy of: pre-consumer food waste, agriculture, municipal waste, forests, industries and aquatic ecosystems. Pre-consumer food waste relates to packaged or processed foods that are disposed by producers and manufacturers which are not sent to retail markets. Agricultural biomass, mainly crop residue and livestock waste, is abundant but often burned due to a lack of alternatives, causing environmental issues. The absence of alternative markets or customers for agricultural by-products often leaves farmers and agribusinesses with no choice but to resort to burning, resulting in the annual incineration of around 90 million tons of paddy straw[30] nationwide; approximately 30%[31] of the smog in North India is attributed to the burning of crop residue. Municipal biomass is increasing with increased urbanisation but is little leveraged as a resource. Forest biomass is limited by accessibility. Industrial biomass is well-documented in some sectors, such as sugar and food production, but underreported in others. Aquatic biomass, especially algae, shows promise for various applications, including wastewater treatment and bioenergy production.

Circularity drivers

Biomass use in India is transitioning from traditional residential heating to more sustainable applications. Biomass is increasingly used for power generation, with government incentives promoting cleaner alternatives like pellets and

26. Indian Council of Agricultural Research (ICAR), Creating Wealth From Agricultural Waste, 2020, Retrieved from: https://icar.org.in/sites/default/files/Circulars/Creating-Wealth-From-Agricultural-Waste.pdf
27. Ministry of New And Renewable Energy, Bio-Energy and Waste To Energy – Recovery Of Energy From Urban, Industrial And Agricultural Wastes/Residues And Role Of Urban Local Bodies in Energy Management, 2023, Retrieved from: https://sansad.in/getFile/lsscommittee/Energy/17_Energy_41.pdf?source=loksabhadocs
28. Chauhan K., Singh V. P., 2023, Prospect of biomass to bioenergy in India: an overview, Materials Today: Proceedings. Retrieved from: https://www.sciencedirect.com/science/article/abs/pii/S2214785323005151
29. Tiwari N., 2022, How Bio CNG rapidly makes inroads into India's automobile market, Times of India. Retrieved from: https://timesofindia.indiatimes.com/blogs/voices/how-bio-cng-rapidly-makes-inroads-into-indias-automobile-market/
30. van de Pas B., 2022, Biomass India: turning waste into valuable products, NL Netherlands. Retrieved from: https://nlplatform.com/articles/biomass-india-turning-waste-valuable-products
31. Maas K., Joshi S., 2021, Final Evaluation of 'Omzet met Impact' Programme, Impact Centre Erasmus. Retrieved from: https://www.government.nl/binaries/government/documenten/reports/2021/10/22/final-evaluation-of-omzet-met-impact-programme/Case%2Bstudy%2Breport%2BBiomass.pdf

briquettes. There is a burgeoning interest in biofuels derived from biomass feedstock, with government initiatives such as India's 20% ethanol[32] and 5% biodiesel[33] targets creating opportunities. Paddy straw shows potential for use in sustainable manufacturing. The power sector mandates 5% biomass co-firing in coal plants,[34] contributing to carbon mitigation goals. Initiatives in bio-jet fuel and bioCNG demonstrate India's commitment to sustainable energy across sectors, marking a shift from traditional biomass use to more innovative, environmentally friendly applications.

Value chain and business models

Biomass utilisation for bioenergy is gaining traction, with pelletisation and briquetting key methods for converting agricultural waste. Pelletisation produces small, cylindrical pellets for residential and industrial use, while briquetting creates larger, denser forms for various applications. Advanced processes like thermochemical and biochemical methods offer additional options for energy production. Biomass can also be used to create agricultural products, consumer goods and other commodities. Despite growing demand and regulations, challenges persist in tracking biomass availability and quality. As formal usage increases, there is a need for greater supply chain transparency. This shift may impact stakeholders relying on low-value biomass applications, particularly in rural India, highlighting the need for balanced development in the sector.

The agricultural, food and biomass waste value chain is shown in **Figure 14** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection and Logistics	On-farm Processing	Centralised Processing
Business Models	• Logistics and traceability	• On-farm waste extractors • Biogas solutions • Biochar production	• BioCNG / Biofuels producers • Biomaterials manufacturers
Outputs	• Collected and segregated wastes	• Localised biogas • Biochar	• BioCNG • Biomaterial • Biofuel

Figure 14: The agricultural, food and biomass waste value chain with key business activities across the value chain and outputs generated (Source: Climake analysis)

32. Report of the Expert Committee, 2021, Roadmap for Ethanol Blending in India 2020-25, NITI Aayog. Retrieved from: https://www.niti.gov.in/sites/default/files/2021-06/EthanolBlendingInIndia_compressed.pdf
33. Ministry of Petroleum & Natural Gas, 2023, Utilisation of Biodiesel. Retrieved from: https://pib.gov.in/PressReleasePage.aspx?PRID=1989224
34. Ministry of Power, 2023, Revised Biomass Policy mandates 5% biomass co-firing in Thermal Power Plants from FY 2024-25. Retrieved from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1945245

1 Logistics and traceability

Value Chain Area: Collection and Logistics

Investment Potential: Medium

Logistics and traceability solutions are critical to aggregate agricultural and biomass waste from diverse sources to be channelised to biofuels, bioCNG producers and biomaterials manufacturers. Traceability-enabled logistics for agricultural and biomass waste are increasingly important components which provide information such as the source, type and nature of collected waste.

2 On-farm Waste Extractors

Value Chain Area: On-farm Processing

Investment Potential: Medium

Extractors focus on removing standing agricultural waste (crop stubble) that is often burnt due to the inconvenience of removing it manually. Extractor machines help to mechanically remove these waste impediments in an efficient manner for further processing and use. Such mechanical solutions can overcome the otherwise labour-intensive work of collecting and extracting waste on farms, which is often not undertaken, leading to a significant loss of waste, usually through burning which creates further complications. The adoption of on-farm stubble and waste crop extractors is low due to financial viability issues. However, government support for such solutions is increasing, making it a viable area for new technologies to be adopted.

3 Biogas Solution Providers

Value Chain Area: On-farm Processing

Investment Potential: High

Biogas solution providers give biodigesters to biomethanation systems to offer farmers both alternative energy sources powered by their agricultural waste and by-products such as fertilisers. This on-farm processing approach helps farmers to reutilise their waste for progressively positive approaches which help to reduce costs and create energy independence. Biogas solutions are technologically validated, but the vast agricultural land and the fragmented nature of farms (more than 50% of which are operated as small-holder lands) present opportunities for new biogas solution providers to evolve and provide value to farmers.

4 Biochar Production

Value Chain Area: On-farm Processing

Investment Potential: High

Biochar is a carbon-rich material produced by burning organic matter through thermochemical methods such as pyrolysis. Biochar serves multiple purposes, including soil improvement by enhancing fertility, water retention and microbial activity; carbon sequestration to help mitigate climate change; water filtration to remove contaminants; and acting as a livestock feed additive to potentially improve animal health and reduce methane emissions. The specific production method can vary based on the feedstock, desired end-product and scale of operation, ranging from simple kilns for small-scale production to advanced pyrolysis reactors for industrial-scale manufacturing. Biochar technology providers are emerging as pyrolysis solutions focus on higher efficiency products, but the constraints are similar to biogas with the fragmented nature of farms, an issue that needs to be solved to achieve scale.

5 BioCNG/Biofuel Producers

Value Chain Area: Centralised Processing

Investment Potential: High

BioCNG and biofuel producers source agricultural and biomass waste to centralised facilities that help to create large-scale supplies of bioCNG and biofuels for industrial, automotive and other large-scale use cases. These fuels are cleaner and potentially cheaper alternatives to conventional fossil fuels. The adoption of these solutions is aided by government policies promoting the use of biofuels and bioCNG, especially from second-generation or waste sources. The centralisation of such facilities makes them highly reliant on building effective logistics and sourcing supply chains for agricultural and biomass waste. Opportunities to provide higher efficiency outputs and improved refining exist in a space that is relatively nascent but poised to become significant as India mandates 20% of fuels to be from ethanol and non-fossil fuel sources. Using agricultural waste is preferable to directly extracting from cultivated crops to avoid food pressures and shortages.

6 Biomaterial Manufacturers

Value Chain Area: Centralised Processing

Investment Potential: Medium

Biomaterial manufacturers look to turn agricultural waste into raw materials for non-energy use cases, e.g., textile fibres. Agricultural and biomass waste is a source of cheap and affordable raw materials and also allows manufacturers to overcome complications related to the diversion of crops away from food security purposes – a key problem in a country where lack of food access is significant.

Municipal and Industrial Solid Waste

Overview

For the purpose of this guide, we define municipal and industrial solid waste to cover the management and handling of municipal and industrial solid wastes from collection and the management of landfills and disposal sites. This section also accounts for certain solid waste types with lower-value recycling potential or volume, e.g., biomedical waste, paper waste and base metals from non-e-waste sources such as aluminium and copper. These types of waste have negligible new investment potential for recycling due either to their nature (e.g., biomedical waste can only be disposed of in treatment facilities) or because large-scale operators are already present in recycling.

India generates around 60 million tonnes[35] of municipal solid waste (MSW) annually, with 90% collected but only 50% processed. MSW is projected to nearly triple to 165 million tonnes by 2031. The country faces significant challenges due to having over 3,000 landfills, which pose serious environmental and health risks.[36] Although landfilling has decreased, sustainable waste management remains critical. Organic waste, which constitutes 50% of MSW, along with other types like construction debris and plastic, complicates management. Effective strategies focusing on waste reduction, recycling and sustainable disposal are essential to address the growing municipal and industrial solid waste problem and its environmental impact.

Waste generation drivers

Increases in municipal solid waste (MSW) and industrial waste in India are being driven by rapid industrialisation, urbanisation and population growth. Heightened consumerism leads to more end-of-life products entering the waste system,[37] worsening waste management challenges. Inadequate waste infrastructure, especially in semi-rural and rural areas, results in uncollected and unaccounted-for waste accumulating in open spaces and informal dumpsites. These disparities highlight the need for targeted interventions to improve waste collection and disposal in underserved regions, addressing the uneven waste management infrastructure across the country.

Circularity drivers

Over half of Indian cities collect less than 25% of their municipal and industrial solid waste, though large cities boost the national average to 83%.[38] India has 456 authorised solid waste management facilities, yet waste segregation remains a challenge, often relying on citizens to sort waste properly. Recyclables like glass, metal and plastic are

35. TERI, 2023, State of Waste Management Report. Retrieved from: https://www.teriin.org/sites/default/files/2023-10/1695795956State%20of%20Waste%20Management%20Report.pdf
36. Singh R., 2021, Towards circular economy: What to do with legacy waste in India, Down to Earth. Retrieved from: https://www.downtoearth.org.in/waste/towards-circular-economy-what-to-do-with-legacy-waste-in-india-75746
37. TERI, 2023, State of Waste Management Report. Retrieved from: https://www.teriin.org/sites/default/files/2023-10/1695795956State%20of%20Waste%20Management%20Report.pdf
38. Gour A. A., Singh S.K., 2022, Solid Waste Management in India: A State-of-the-Art Review, Environmental Engineering Research. Retrieved from: https://www.eeer.org/upload/eer-2022-249.pdf

processed at material recovery facilities (MRFs) to foster a circular economy. Legacy landfills, occupying 10,000 hectares,[39] pose a major issue, with plans to clean up 2,200 sites under the Swachh Bharat Urban Mission[40] using biomining to recover valuable materials and free up land.

Value chain and business models

India's waste management is driven by government directions and policies, such as the Swachh Bharath Mission and Solid Waste Management Rules. Industrial waste management is further mandated through specific policies such as the Hazardous Waste Rules, which outlines waste management regulations for industrial wastes. Environmental monitoring of waste facilities is ongoing in several states. IT-enabled tracking systems offer the potential for improved efficiency. Biomining is emerging as a strategy for legacy waste management, recovering valuable materials and producing fertilisers, compost and refuse-derived fuels from landfills. This approach helps minimise environmental hazards while extracting usable resources. Despite challenges like contamination, these initiatives represent significant steps towards more sustainable and efficient waste management practices in India, addressing both current and accumulated waste issues.

The municipal and industrial solid waste value chain is shown in **Figure 15** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection and Sorting	Pre-processing	Treatment and Disposal
Business Models	• Collection and pickup services	• Waste sorting technologies • Material recovery facilities	• Waste treatment facilities • Biomining
Outputs	• Collected wastes	• Sorted and segregated waste	• Treated biomedical waste • Treated hazardous waste • Cleaned landfill

Figure 15: The municipal and industrial solid waste value chain with key business activities across the value chain and outputs generated (Source: Climake analysis)

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

1 Collection and Pickup Services

Value Chain Area: Collection and Sorting

Investment Potential: High (tech-enabled collection solutions)

Municipalities are increasingly leaning on private enterprises and even digital solutions to improve and optimise MSW collection from generators. This shift towards involving private enterprises in waste collection, handling and sorting through government tenders is intended to increase efficiency in collection, reduce leakage and indiscriminate disposal, and maximise recyclables' potential. Smart bins, which indicate waste levels to waste operators, and other tech-enabled collection and disposal technologies, are also emerging in adoption. Digitisation opportunities are increasing for real-time monitoring of collection and transportation. Other technologies with the potential to improve ground-level mechanisms for collecting, processing and recycling waste include GPS, radio frequency identification (RFID), machine-to-machine communication and Internet of Things solutions.

2 Waste Sorting Technologies

Value Chain Area: Pre-processing

Investment Potential: High

Waste sorting technologies are solutions that involve automated systems such as conveyor belts, optical sorters, and AI-powered robots that identify and segregate recyclable materials from mixed waste. They are installed in material recovery facilities and are dependent on these businesses for their operation. Waste sorting technologies are generally focused on dry waste, which is easier to extract, rather than mixed or wet waste (organic waste). Sorting is a manual or mechanical process. Technologies that improve accuracy and automation in sorting dry waste with lower levels of contamination are highly valued as MSW sorting facilities, mainly MRFs, handle multiple complex types of waste which require higher sorting capabilities.

3 Material Recovery Facilities (MRFs)

Value Chain Area: Pre-processing

Investment Potential: Medium

Material recovery facilities (MRFs) handle large volumes of aggregated waste from commercial waste generators, municipalities and waste management companies to separate recyclables and bale materials to recycling plants. Revenue opportunities come from the sale of sorted recyclables, tipping fees for waste processing and potential government incentives for recycling efforts, but the setup of MRFs is often dependent on government tenders.

4 Waste Treatment Facilities

Value Chain Area: Treatment and Disposal

Investment Potential: Medium

Hard-to-recycle materials or hazardous materials, such as refrigerants and biomedical waste, that cannot be recycled require safe treatment and disposal in authorised waste treatment facilities. These regulated facilities are often run by private enterprises but do not focus on generating valuable circular outputs from their treatment processes.

5 Biomining

Value Chain Area: Treatment and Disposal

Investment Potential: High

Biomining of legacy landfills is an activity that has grown significantly to make more land available, address pollution risks from extant landfills and access recyclable materials. The drive to clean up landfills is creating significant opportunities in this space. Biomining involves the use of moveable sorting and extraction technologies that are deployed in landfills until cleanup is complete and subsequently shifted and moved to other landfills. Biomining is increasing as an opportunity as government mandates direct municipalities to clean up legacy landfills. It offers particular opportunities to technology companies aiming to improve the conversion of extracted waste.

Wastewater and Industrial Effluents

Overview

In 2021, Indian cities generated over 72,000 million litres of wastewater daily, but only 28% was treated, leaving a significant portion to pollute natural water sources.[41] Rural areas produced 39,000 million litres, further stressing water systems. Industrial wastewater treatment is higher at 60%, yet over 6,000 million litres remain untreated.[42] Addressing a 49% treatment capacity gap is crucial, with circular economy approaches like transforming wastewater in bio-factories offering potential solutions for sustainable water management and improved industrial effluent treatment.

Waste generation drivers

Water demand and wastewater management challenges will only intensify in India. Water transfers to urban and industrial areas are rising, putting additional pressure on natural water systems. The lack of sustainable wastewater treatment mechanisms further complicates the situation, highlighting the need to balance water needs across regions and sectors. Industries such as chemicals, textiles, pharmaceuticals and power plants contribute to metal contamination in wastewater, with pollutants including copper, lead, mercury and arsenic. Addressing these challenges requires targeted solutions and improved wastewater management practices. Effective monitoring and regulatory compliance are crucial to ensure environmental protection and sustainable water management.

Circularity drivers

India's wastewater management faces significant challenges due to outdated sewage treatment technologies like activated sludge and anaerobic reactors, which offer only around 65% efficiency. These inefficient methods hinder efforts to improve the wastewater treatment infrastructure. In rural areas, the formal sewage treatment gap exceeds 90%, and even smaller cities face gaps over 80%, thus worsening water pollution. The lack of sustainable wastewater treatment mechanisms highlights the urgent need to address competing water demands across regions and sectors.

Value chain and business models

The industrial wastewater treatment process[43] includes methods like adsorption, photodegradation and membrane separation. Technologies such as membrane bioreactors and nanofiltration are slowly gaining popularity, particularly under the zero-liquid discharge (ZLD) norms that encourage sustainable practices. Industry leaders like the Steel Authority of India and Arvind Limited have implemented advanced wastewater solutions to reduce pollution and

41. Atal Innovation Mission, 2022, Urban Wastewater Scenario in India, Niti Aayog. Retrieved from: https://www.niti.gov.in/sites/default/files/2022-09/Waste-Water-A4_20092022.pdf
42. Dutta D., Arya S., Kumar S., 2021, Industrial wastewater treatment: Current trends, bottlenecks, and best practices, Chemosphere - Volume 285. Retrieved from: https://pubmed.ncbi.nlm.nih.gov/34246094/
43. Obaideen K., Shehata N., Sayed E. T., Abdelkareem M. A., Mahmoud M. S., Olabi A.G., 2022, The role of wastewater treatment in achieving sustainable development goals (SDGs) and sustainability guideline, Energy Nexus: Volume 7. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2772427122000729

water usage. Urban wastewater management involves both on-site and off-site systems, leveraging various technologies,[44] which necessitate targeted investments and adoption. India's Atal Mission for Rejuvenation and Urban Transformation (AMRUT)[45] aims to improve water security and wastewater recycling in 500 cities, with a projected US$ 35 billion investment over five years.

The wastewater and industrial effluents value chain is shown in **Figure 16** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Discharge of wastewater / effluents	Decentralised Treatment	Large-scale Treatment
Business Models		• Decentralized wastewater treatment facilities • Filtration technologies	• Centralised / decentralised wastewater treatment facilities • Effluent treatment plants • Filtration technologies
Outputs		• Treated wastewater / effluents • Sludge (for treated disposal)	• Treated wastewater / effluents • Sludge (for treated disposal)

Figure 16: The wastewater and industrial effluents value chain with key business activities across the value chain and outputs generate (Source: Climake analysis)

44. Atal Innovation Mission, 2022, Urban Wastewater Scenario in India, Niti Aayog. Retrieved from: https://www.niti.gov.in/sites/default/files/2022-09/Waste-Water-A4_20092022.pdf
45. Ministry of Housing & Urban Affairs, 2022, AMRUT 2.0 aims to provide water supply through functional taps to all households in statutory towns and coverage of sewerage/septage management, Press Information Bureau. Retrieved from: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1811880

1 Decentralised Wastewater Treatment Facilities

Value Chain Area: Decentralised Treatment

Investment Potential: High

Decentralised wastewater treatment facilities treat sewage at or near its source, eliminating the need for extensive sewer networks. These facilities can include various technologies, such as septic tanks, aerobic treatment systems, constructed wetlands and advanced treatment units. They generate revenue through user fees, equipment sales or leasing, and grants or subsidies. They also generate revenue by providing recycled treated water for irrigation, industrial use or groundwater recharge. Most decentralised wastewater solutions focus on reducing pollutants in sewage rather than delivering high-quality recycled water outputs for reuse. Wastewater solutions that can create potable water quality outputs are an opportunity area for infrastructure facilities to ensure water security.

2 Industrial Effluent Treatment Facilities

Value Chain Area: Large-scale Treatment

Investment Potential: Medium

An industrial effluent treatment facility is a specialised plant designed to treat the wastewater generated by industrial processes before it is discharged into the environment. Industrial effluent contains various pollutants, including chemicals, heavy metals and organic compounds, which must be removed or treated to meet regulatory standards and protect the environment. Industrial effluent treatment plants process wastewater from manufacturing activities, generating revenue through service fees from industrial clients. They help companies meet regulatory compliance, reduce environmental impact, and often recover valuable byproducts, such as purified water, energy and raw materials, which can be reused or sold.

3 Filtration Technologies

Value Chain Area: Decentralised Treatment and Large-scale Treatment

Investment Potential: High

Wastewater and effluents are cleaned through filter media and filtration technologies. The level of adoption is generally aligned towards the compliance standards that facilities have to follow in wastewater and effluent norms. As water scarcity becomes more common, the demand for high-quality, potable recycled water will increase, making such filtration solutions increasingly valuable.

4 Large-scale Wastewater Facilities

Value Chain Area: Large-scale Treatment

Investment Potential: Medium

Large-scale wastewater facilities treat sewage from extensive urban areas, generating revenue through municipal contracts and user fees. They leverage economies of scale to reduce per-unit treatment costs. Additionally, these facilities often produce valuable byproducts like biogas and recycled water, creating multiple revenue streams.

Textile Waste

Overview

India, a major textile producer, faces the challenge of managing 7.79 million tonnes[46] of textile waste annually. Domestic manufacturers contribute 42%, domestic consumers 51%, and imports 7%. Cotton and blends dominate at 61%, with polyester and synthetics making up 19%. Waste management focuses on recycling (25%), reuse (34%), downcycling (19%), landfill disposal (17%) and incineration (5%).[47] With over 12,000 facilities[48] involved in the textile value chain, India is also a global leader in sustainable handmade textiles, producing 95%[49] of the world's supply with minimal energy and water use, reflecting a strong commitment to eco-friendly practices.

Waste generation drivers

India's textile and apparel market is growing rapidly at a 10% CAGR,[50] but this growth leads to increased textile waste. The textile waste industry, forecast to be worth US$ 375 million by 2028,[51] faces challenges in formalisation and greater adoption due to the lack of a dedicated extended producer responsibility (EPR) framework to mandate recycling targets and incentivise the recycling ecosystem. While state initiatives and NITI Aayog's involvement show progress, the absence of a robust EPR draft for textiles limits sustainable practices. Large-scale manufacturers are hesitant to establish recycling facilities due to limited waste supply and demand, hindering the adoption of circular business models in the sector.

Circularity drivers

India faces challenges in textile waste management due to high demand for cotton in textiles and limited domestic supply, leading to a reliance on imports. As a major textile producer and consumer, India intends to move towards self-sufficiency in textiles, which should incentivise recycling. Government initiatives,[52] such as production-linked incentive schemes and the PM Mega Integrated Textile Regions and Apparel (PM MITRA) Parks scheme, aim to boost manufacturing and innovation in the textile sector. Collaborative efforts between stakeholders to promote upcycling and divert waste from landfills are evolving, but the presence of an EPR scheme could scale this faster and further. The quality of recycled output determines market viability, with high-grade recycling producing premium yarns, and low-grade recycling serving various industries' filler needs, demonstrating the versatility of textile waste in a circular economy.

46. Malpani O., Balecha M., Sureka A., Uchil V. Kansal D., 2023, Unveiling India's Textile Waste Landscape: A Cost Analysis, IDH. Retrieved from: https://www.idhsustainabletrade.com/uploaded/2023/09/IDH_textile-waste-cost-analysis_2023.pdf
47. ibid
48. Open Supply Hub. Retrieved from: https://opensupplyhub.org/?sort_by=contributors_desc
49. Singh S., 2023, Craft in the age of climate crisis, British Council. Retrieved from: https://www.britishcouncil.in/sites/default/files/craft_x_climate_report_-_october_2023_low_res_8mb_file.pdf
50. Malpani O., Balecha M., Sureka A., Uchil V. Kansal D., 2023, Unveiling India's Textile Waste Landscape: A Cost Analysis, IDH. Retrieved from: https://www.idhsustainabletrade.com/uploaded/2023/09/IDH_textile-waste-cost-analysis_2023.pdf
51. Suneja K., 2023, Government cracks the code to track recycled textiles trade, Economic Times. Retrieved from: https://economictimes.indiatimes.com/industry/cons-products/garments-/-textiles/government-cracks-the-code-to-track-recycled-textiles-trade/articleshow/105636375.cms?from=mdr
52. Ministry of Textiles, 2023, Year-End- Review of Ministry of Textiles– 2023, Press Information Bureau. Retrieved from: https://pib.gov.in/PressReleasePage.aspx?PRID=1989149

Value chain and business models

India's textile waste value chain involves collection, sorting and processing by various stakeholders. Less than 50%[53] of available waste is collected, highlighting infrastructure gaps. Higher-quality waste is recycled, while lower-quality is often downcycled or reused. Domestic textile waste is mostly reused or landfilled, while imported waste is largely recycled or re-exported. The private sector drives recycling initiatives, facing challenges like high costs and low demand. Mechanical recycling dominates, with chemical recycling emerging, although this is expected to take another three to four years to become viable. Automation and digital tracking are improving waste management, with platforms like Reverse Resources facilitating digital compliance and waste mapping. Globally, investment in sustainable materials is growing, with hemp and khadi gaining traction in India as eco-friendly alternatives to conventional textiles.

The textile waste value chain is shown in **Figure 17** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection, Aggregation, and Sorting	Textile Recycling	Circular Apparels
Business Models	• Downcyclers • Secondhand clothes	• Mechanical recyclers • New-Age recyclers	• Sustainable / circular apparel brands
Outputs	• Segregated textiles and fabrics • Secondhand textiles	• Recycled / spun fibres	• Circular apparels, textile, and clothing goods

Figure 17: The textile waste value chain with key business activities across the value chain and outputs generated (Source: Climake analysis)

53. Solanki M., 2024, Tripartite MoU to reduce textile waste in India gives hope, but cautious steps needed, Down to Earth. Retrieved from: https://www.downtoearth.org.in/waste/tripartite-mou-to-reduce-textile-waste-in-india-gives-hope-but-cautious-steps-needed-94843

1 Downcyclers

Value Chain Area: Collection, Aggregation and Sorting

Investment Potential: Low

Downcyclers handle textile materials that cannot be recycled back into yarn. They sort and shred wastes that are sold as filler fibres for insulation, bedding, the paper and pulp industry, the automobile industry, etc.

2 Secondhand clothes

Value Chain Area: Collection, Aggregation and Sorting

Investment Potential: Low

Secondhand clothing players focus on making collected clothing that is re-usable available to consumers. Such clothing is either provided to individual consumers through pre-owned businesses or provided to disadvantaged and low-income groups through non-profits and social enterprises.

3 Mechanical Recyclers

Value Chain Area: Textile Recycling

Investment Potential: Medium

Low-grade mechanical recyclers utilise knitted cotton and cotton-rich wastes (more than 50%) in solid colours. Their processes involve the sorting, shredding and open-end spinning of waste. Some low-grade recyclers just shred the waste and sell it to other open-end spinners to create spun cotton blend outputs as low-quality feedstock. While low-grade mechanical recycling is the most mature and widely employed type of textile recycling, high-grade mechanical recycling is an opportunity. Such recycling usually processes higher-quality and single-colour cotton (often white), utilising the sorting, shredding and open-end spinning of waste to create higher-quality cotton blend outputs of varying qualities.

4 New-Age Chemical and Mechanical Recycling

Value Chain Area: Textile Recycling

Investment Potential: High

New-age patented technology recyclers deploy chemical and mechanical processes to recycle textile waste. They can handle cotton and/or polyester waste, depending on the nature of the technologies they operate, and create recycled fibre or pellets for spinning. These fabrics account for about 47% of textile material composition in India and do not have significant recycling opportunities other than downcycling. However, chemical recycling processes are emerging. Even though they are only at a pilot stage in India currently, they offer new opportunities for handling waste streams.

5 Circular Apparel Brands

Value Chain Area: Circular Apparel

Investment Potential: Medium

Sustainable fabrics manufacturers use recycled fabrics to make circular textiles and clothing outputs. These range from boutique brands to larger-scale apparel companies. These brands help drive demand for higher-quality outputs from recyclers. Scale issues in accessing waste tend to be a roadblock, leading to most brands working with pre-consumer (rather than post-consumer) waste.

Construction and Demolition Waste

Overview

Construction and demolition (C&D) waste management in India is challenging due to uncertain estimates and variable generation rates.[54] Official figures suggest annual C&D waste ranges from 150 to 750 million tonnes, potentially making up one-third of global C&D waste. Construction waste alone could contribute up to 25% of municipal solid waste in India. Between 4% and 30% of building materials become on-site waste[55] due to damage, loss and over-ordering. About 90% of on-site waste consists of bulky materials like solid waste, sand, gravel, brick and concrete; the rest includes wood, metal, bitumen and plastic. C&D waste is categorised based on recyclability potential, with brick masonry and concrete having the highest such potential.

Waste generation drivers

The growing demand for primary building materials driven by urbanisation and population growth underscores the urgency of addressing C&D waste. India needs to add about 700–900 million square metres of commercial and residential space every year by 2030; which will generate highly significant quantities of C&D waste.

Circularity drivers

The improper disposal of C&D waste often leads to increased open dumping, which contributes to environmental pollution and health hazards. Despite the significant volume of C&D waste generated, India has limited recycling capacity, possessing less than 5% of the infrastructure required to manage C&D waste effectively.

Value chain and business models

Recycling plants process C&D waste into granular sub-base (GSB), recycled concrete aggregates (RCA), recycled aggregates (RA) and manufactured sand (M-Sand) for construction. Effective waste management depends on reducing waste at the source and using design interventions to cut material use. In India, sustainable materials like bamboo and lime[56] offer environmental benefits, but green building practices are underused, with only 2% of new formal built space certified as of 2020.[57] Improving waste traceability and promoting reuse and recycling are crucial for better management, with significant potential for a circular construction industry in India beyond 2030.

The construction and demolition waste value chain is shown in **Figure 18** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail in the following sections.

54. Somvanshi A., Verma A., 2020, Another brick off the Wall, Centre for Science and Environment. Retrieved from: https://www.cseindia.org/another-brick-off-the-wall-10325
55. Ministry of Housing and Urban Affairs, Government of India, 2024, Government released comprehensive guidelines for effective disposal of C&D waste, Press Information Bureau, Retrieved from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2007086
56. Editorial Team, 2024, Let's Identify Indian Materials for Construction, Building Material Reporter. Retrieved from: https://www.buildingmaterialreporter.com/influencers/articles/lets-identify-indian-materials-for-construction
57. Market Accelerator for Green Construction (MAGC), 2020, India Green Building Market Maturity Snapshot, Edge Buildings. Retrieved from: https://edgebuildings.com/wp-content/uploads/2023/11/IFC0077-2023-India-Green-Building-Market-Maturity-Sheet.pdf

Value Chain	Demolition, Collection, and Segregation	Recycled Construction Materials	Recycled Products
Business Models	• Demolition and collection activities	• C&D Waste processing companies	• C&D recycled products manufacturers
Outputs	• Unsegregated construction waste	• High-quality recycled cement, aggregates, and sands	• Other recycled products from C&D waste

Figure 18: The construction and demolition waste value chain with key business activities across the value chain and outputs generated (Source: Climake analysis)

1 C&D Waste Processing Companies

Value Chain Area: Recycled Construction Materials

Investment Potential: Low

C&D waste processing companies focus on managing and recycling debris generated from construction, renovation and demolition projects. These companies collect C&D waste from various sources, including construction sites and municipal waste facilities. The collected waste is sorted, processed and recycled into usable materials, which are then sold to construction companies and other end-users for new building projects. Additionally, some C&D waste processing companies may offer value-added services, such as waste management consulting, debris removal and on-site recycling services.

2 C&D Recycled Products Manufacturers

Value Chain Area: Recycled Products

Investment Potential: Medium

C&D recycled products manufacturers repurpose materials derived from construction and demolition waste into new, usable products. These manufacturers source recycled materials, such as crushed concrete, reclaimed wood, recycled plastic, and aggregates from C&D waste processing companies or directly from construction sites to make recycled concrete blocks, composite lumber and recycled aggregates. Recycled products that make higher-quality outputs can increase demand for improved recycling access. The incentives for this are limited relative to accessing virgin materials, but they are changing. River sand, which has traditionally been used in construction, is now restricted due to ecological damage, giving rise to the alternative m-Sand, which is sand made from construction and demolition wastes.

Waste Tyres

Overview

India grapples with a substantial challenge in managing end-of-life tyres (ELTs), with over 100 million discarded annually,[58] accounting for about 1% of total municipal solid waste.103 Despite the magnitude of this issue, the country has made strides in establishing a robust tyre recycling sector, with approximately 600 registered recyclers. Tyre and rubber recycling is a US$ 400 million industry, propelled by India's burgeoning automobile sector, it is poised to witness exponential growth on the back of recently introduced EPR norms.

Waste generation drivers

Tyre production in India increased by 21% in 2022[59] and a further 6% in 2023, reaching a total production of 217 million units per year. By weight, 2.5 million tonnes of tyres have been produced in India annually since 2019. The surge in tyre production mirrors the rapid expansion of the automobile industry. However, the tracking and monitoring of discarded tyres remain deficient, with a considerable portion ending up in landfills or dumpsites. Although retreading is prevalent in the informal sector, it does have safety implications for reuse due to a relatively unregulated sector.

Circularity drivers

Less than 1%[60] of recycled tyres are paid for by tyre producers. India handles a substantial volume of tyre scrap, both domestically generated and imported, necessitating stringent measures for sustainable disposal. The recycling of tyre scrap yields valuable materials like reclaimed rubber, crumb rubber and tyre pyrolysis oil (TPO), which drives innovations in various industries, such as road construction and alternative fuel sources, albeit with environmental concerns that necessitate strict regulatory oversight.

Value chain and business models

Materials recovered from tyre scrap include reclaimed rubber, crumb rubber, crumb rubber modified bitumen (CRMB), recovered carbon black (RCB) and tyre pyrolysis oil (TPO). Reclaimed and crumb rubber are used in various products, while CRMB is an additive in road construction, reducing bitumen imports by up to 14%.[61] Tyre pyrolysis produces oil, carbon char and steel wire, with TPO used as furnace fuel. However, improper pyrolysis can cause environmental harm. RCB can partially replace virgin carbon black in new tyres, highlighting the tyre recycling sector's potential for sustainable resource management.

58. Ministry of Housing and Urban Affairs – Government of India, 2021, Circular Economy in Municipal Solid and Liquid Waste. Retrieved from: https://mohua.gov.in/pdf/627b8318adf18Circular-Economy-in-waste-management-FINAL.pdf
59. ATMA India, Production Trend. Retrieved from: https://www.atmaindia.org.in/production-trend/
60. Central Pollution Control Board, Government of India, EPR Portal for Management of Waste Tyre, Retrieved from: https://www.eprtyrescpcb.in/
61. Chaturvedi B., Handa R. R., 2017, Circulating Tyres in the Economy, Chintan Environmental Research and Action Group. Retrieved from: https://www.chintan-india.org/sites/default/files/2019-09/Tyres%20Report_Final.pdf

The waste tyres value chain is shown in **Figure 19** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection and Sorting	Refurbishment	Recycling and Recovery
Business Models	• Tyre yards	• Retreading facilities	• Tyre recyclers • Pyrolysis and Incineration facilities
Outputs	• Collected and segregated waste	• Retreaded / remanufactured tyres	• Tyre waste to energy • Recycled rubber • Recycled steel and fibre

Figure 19: The tyre waste value chain with key business activities across the value chain and outputs generated (Source: Climake analysis)

1 Tyre Yards

Value Chain Area: Collection and Sorting

Investment Potential: Low

Tyre yards collect and recycle used tires. These are currently poorly regulated and function more as scrap facilities for disposing of tyres.

2 Retreading Facilities

Value Chain Area: Refurbishment

Investment Potential: Low

Retreading facilities collect and recondition worn-out tyres, offering a cost-effective solution for commercial fleets and individual motorists. Instead of disposing of old tyres, retreading involves applying a new tread to the tyre casing, restoring its tread depth and extending the lifespan of the tyre significantly.

3 Tyre Recyclers

Value Chain Area: Recycling and Recovery

Investment Potential: Medium

Tyre recyclers rely on resource recovery. These facilities collect and process end-of-life tyres, extracting valuable materials such as rubber, steel and textile fibres. They process tyres into marketable materials like crumb rubber, steel and textile fibres, which are sold to tyre manufacturers and manufacturers of other products like asphalt and playground surfaces. Large tyre producers are present in tyre recycling as a way to secure supplies of critical materials such as crumb rubber and steel.

4 Pyrolysis and Incineration Facilities

Value Chain Area: Recycling and Recovery

Investment Potential: Medium

Pyrolysis also generates tyre pyrolysis oil that is used as an alternative fuel in furnaces and used in hot mixes for road construction. Carbon black is another by-product generated and used as a filler in certain polymer products such as paints and dyes. As a last option, low-value tyres are disposed of in incineration facilities to clear out space. Common facilities include cement kilns, which use waste tyres as a source of fuel.

Lead-Acid Battery Waste

Overview

Lead-acid batteries (LABs) play a crucial role in various applications, ranging from immobile uses like power storage in inverters and grid-scale energy storage to mobile applications in vehicles for ignition and lighting. Holding nearly half of the market share in India's battery market in 2021,[62] LABs are essential yet face challenges due to their limited charging-discharging cycles, leading to quicker end-of-life (EoL). As a result, advanced cell chemistries such as nickel and lithium are gaining prominence in both supply and demand segments, gradually encroaching on LABs' market share.

Waste generation drivers

LABs are today the dominant battery format used in India. 87% of their use is in the automotive sector, which sees around 15 million internal combustion engine vehicles sold annually. They also play significant roles in storage applications for households, large-scale data centres and telecommunications systems, where uptime of power availability is a critical factor. LABs face a threat from more efficient and newer battery chemistries – from lithium-ion batteries in vehicles to flow batteries for energy storage – but they are still expected to be the dominant battery source for the foreseeable future even if their market share reduces.

Circularity drivers

LAB recycling in India typically involves dismantling the battery pack into its constituent components like acids, plastics and membrane separators, followed by the smelting and refining[63] of lead oxide anodes and lead cathodes to obtain pure lead ingots and alloys. Despite the hazardous nature of lead recycling and its associated health risks, approximately 98% of EoL LABs are recycled. However, 80% of this is through informal recyclers who are likely to operate in hazardous and environmentally adverse conditions.

Value chain and business models

70% of battery weight contains lead, and 100% of lead can be recovered. New batteries made by leading original equipment manufacturers (OEMs) contain around 50% recycled lead.[64] Despite the challenges associated with lead recycling, India's LAB value chain remains largely circular and integrated, contributing to the recycling of close to 3 million tonnes of LAB annually. However, the process comes with environmental and health concerns, underscoring the need for sustainable recycling practices to mitigate adverse impacts.

62. Gattu A., Agrawal A., Chatterjee A., Mittal D., Khan M. S., Bagdia R., Singh R., Khan S. M., Singh V, 2022, Advanced Chemistry Cell Battery Reuse and Recycling Market in India, NITI Aayog and Green Growth Equity Fund Technical Cooperation Facility. Retrieved from: https://www.niti.gov.in/sites/default/files/2022-07/ACC-battery-reuse-and-recycling-market-in-India_Niti-Aayog_UK.pdf
63. Varshney K., Varshney P. K., Gautam K., Tanwar M., Chaudhary M., 2020, Current trends and future perspectives in the recycling of spent lead acid batteries in India, Materials Today: Proceedings - Volume 26. Retrieved from: https://www.sciencedirect.com/science/article/abs/pii/S2214785319341793
64. Gattu A., Agrawal A., Chatterjee A., Mittal D., Khan M. S., Bagdia R., Singh R., Khan S. M., Singh V, 2022, Advanced Chemistry Cell Battery Reuse and Recycling Market in India, NITI Aayog and Green Growth Equity Fund Technical Cooperation Facility. Retrieved from: https://www.niti.gov.in/sites/default/files/2022-07/ACC-battery-reuse-and-recycling-market-in-India_Niti-Aayog_UK.pdf

The lead-acid battery value chain is shown in **Figure 20** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection and Sorting	Recycling Facilities
Business Models	• Collection centres	• Lead (base metal) recyclers • Plastic recyclers
Outputs	• Segregated and dismantled components	• Lead recyclers • Plastic recyclers

Figure 20: The lead-acid battery waste value chain with key business activities across the value chain and outputs generated (Source: Climake analysis)

1 Collection Centres

Value Chain Area: Collection and Sorting

Investment Potential: Low

These centres collect used lead-acid batteries from various sources, including automotive shops, recycling facilities and individual consumers. The collected batteries are then transported to recycling facilities where valuable materials like lead, plastic and sulfuric acid are extracted and recycled. Additionally, some collection centres may offer services such as battery testing, maintenance and disposal of non-recyclable components.

2 Lead (Base Metal) Recyclers

Value Chain Area: Recycling Facilities

Investment Potential: Medium

Lead recyclers work on the recovery and processing of lead-containing materials to produce refined lead and other lead-based products. These recyclers source materials such as lead-acid batteries, lead scrap from industries, e-waste and other lead-bearing products. Revenue is generated through the purchase or collection of these materials, often based on market prices and the quality of the lead content. The collected materials are then sorted, cleaned and processed through smelting and refining processes to extract pure lead or lead alloys. Additionally, lead recyclers may offer value-added services, such as battery dismantling, material testing and environmental consulting.

3 Plastic Recyclers

Value Chain Area: Recycling Facilities

Investment Potential: Medium

Plastic recyclers operating within lead-acid waste facilities engage in the recovery and recycling of plastic components from lead-acid batteries. These are usually source-agnostic recyclers of hard plastics, who select components based on the plastic type, which in lead-acid batteries is usually acrylonitrile butadiene styrene (ABS).

End-of-Life Vehicles

Overview

India is expected to have an estimated 28 million obsolete vehicles by 2030,[65] consisting of two-wheelers, three-wheelers, passenger vehicles and commercial vehicles. The need for planned management of end-of-life vehicles (ELVs) is driven by two main factors:122 the significant contribution of old vehicles to air pollution, and the country's import dependence on raw materials, especially metals and alloys.

Waste generation drivers

Commercial vehicles in India have an average age of more than ten years, while private vehicles typically range from ten to 15 years old.[66] A substantial number of vehicles, including 1.7 million medium and heavy commercial vehicles older than 15 years, contribute significantly to air pollution. However, these vehicles hold high recycling potential, offering valuable materials that can be used to produce newer, less polluting vehicles.

Circularity drivers

India's Vehicle Scrappage Policy[67] is expected to reduce auto component costs by 30–40% for manufacturers by increasing the availability of scrapped materials. Vehicle owners participating in the scheme will benefit from scrap value, tax rebates and discounts on new vehicles. Despite currently low rates of end-of-life vehicle (ELV) scrapping and recycling, new regulations and incentives – such as the upcoming EPR guidelines for ELVs – will encourage a circular approach in the automotive sector.

Value chain and business models

ELV recycling begins with dismantling, prioritising the collection of hazardous components like lead or lithium batteries, mechanical oils and refrigerant gases, which are then fed into other waste management streams. Recyclable materials such as engines, tyres and bumpers are then collected, with the process expected to boost aluminium recycling in India. These are then channelled to metal recycling, which is dominated by large, established metal companies.

65. Raghunath V., Kapoor S., 2021, India's vehicle scrappage policy is here, but what next?, EY. Retrieved from: https://www.ey.com/en_in/automotive-transportation/india-s-vehicle-scrappage-policy-is-here-but-what-next
66. Rajakumar J., 2021, Vehicle Scrappage Policy in India: A Massive Supply of Scrap Metals, Scrap News. Retrieved from: https://scrapnews.recycleinme.com/newsdetails-400.aspx
67. Ministry of Road Transport & Highways, Government of India, Voluntary Vehicle Fleet Modernization Program (V-VMP). Retrieved from: https://morth.nic.in/sites/default/files/VVMP-Investor-Handbook.pdf

The end-of-life vehicles waste value chain is shown in **Figure 21** alongside the key business models and outputs generated at each stage of that chain. Each of those business models is then described in more detail below.

Value Chain	Collection and Dismantling	End-Recycling
Business Models	• Scrap Dismantler	• Base metal smelter • Plastic recyclers • Lithium-ion battery recyclers
Outputs	• Segregated vehicle components (metals, plastics, etc.)	• Recycled metals • Recycled plastics • Recycled LiB components

Figure 21: The end-of-life vehicles waste value chain with key business activities across the value chain and outputs generate (Source: Climake analysis)

1 Scrap Dismantlers

Value Chain Area: Collection and Dismantling

Investment Potential: Low

Salvage yards acquire end-of-life vehicles for dismantling into useful components for further recycling and disposal. They segregate vehicle components into different parts such as metals and plastics which are sent for further recycling. More often than not, they function as a source of vehicle parts for repairing existing vehicles.

2 Refurbishers

Value Chain Area: End Recycling

Investment Potential: Medium

Base metal smelters receive end-of-life vehicles from scrap dismantlers, automotive scrapyards and recycling facilities. The smelting process involves melting down the shredded vehicle materials to separate and purify the metals, which are then cast into ingots or sold as scrap metal.

3 Plastic Recyclers

Value Chain Area: End Recycling

Investment Potential: Medium

Plastic recyclers for end-of-life vehicles work on the collection, processing and recycling of plastic components from scrapped automobiles. These are usually source-agnostic recyclers of hard plastics, who select components based on the plastic type; in end-of-life vehicles, this is usually acrylonitrile butadiene styrene (ABS).

4 Lithium-ion Battery Recyclers

Value Chain Area: End Recycling

Investment Potential: High (see LiB recycling section)

With the emergence of electric mobility vehicles, end-of-life vehicles will start to constitute significant lithium-ion battery volumes, which will fast become the dominant stream for LiB recyclers to access and source supply.

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 start-ups, 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: start-up 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 12 interviews were conducted with the following:

- One founder of a lithium-ion battery waste recycling start-up
- One founder of an electronic waste processing start-up
- One founder of a large-scale multi-waste-stream recycler (e-waste, plastic waste and battery waste)
- One expert in electronic waste and lithium-ion battery waste recycling
- One expert in textile waste recycling
- Two founders of a funded agricultural and biomass waste recycler
- One founder of a municipal solid waste startup
- Four funds with defined theses in waste management and 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 in the sector.
- Certain data points, such as some total addressable market (TAM) details for investment potential, have been extrapolated and calculated on a best-effort basis due to the lack of available data points. In such cases, we followed the same validation method described above to produce our best estimate.

ANNEXURE 1: SOURCES FOR KEY WASTE GENERATION AND RECYCLING INSIGHTS

The sources for the insights given in **Figure 2** are outlined below:

Plastic Wastes

1. Dhodapkar R, Bhattacharjya S, Niazi Z, Porter NB, Retamal M, Sahajwalla V and Schandl H, CSIRO, Australia, National Circular Economy Roadmap for Reducing Plastic Waste in India, 2023, Retrieved from: https://www.csiro.au/-/media/Environment/Circular-Economy-Roadmap-India/23-00249_ENV_REPORT_IACPRoadmap_WEB-230714.pdf

E-Waste

2. Baldé CP, Kuehr R, Yamamoto T, McDonald R, D'Angelo E, Althaf S, Bel G, Deubzer O, Fernandez-Cubillo E, Forti V, Gray V, Herat S, Honda S, Iattoni G, Khetriwal DS, di Cortemiglia VL, Lobuntsova Y, Nnorom I, Pralat N and Wagner M, International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR), Global E-waste Monitor, 2024, Retrieved from: https://ewastemonitor.info/the-global-e-waste-monitor-2024/

3. NITI Aayog and Green Growth Equity Fund Technical Cooperation Facility, Advanced Chemistry Cell Battery Reuse and Recycling Market in India, May 2022, Retrieved from: https://www.niti.gov.in/sites/default/files/2022-07/ACC-battery-reuse-and-recycling-market-in-India_Niti-Aayog_UK.pdf

Agricultural, Food and Biomass Waste

4. Indian Council of Agricultural Research (ICAR), Creating Wealth From Agricultural Waste, 2020, Retrieved from: https://icar.org.in/sites/default/files/Circulars/Creating-Wealth-From-Agricultural-Waste.pdf

Municipal and Industrial Solid Waste

5. 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

Wastewater and Industrial Effluents

6 Working with Waste: Key Trends and Developments in Industrial Effluent Management, Indian Infrastructure, 31 December 2021. Retrieved from: https://indianinfrastructure.com/2021/12/31/73992/

Textile Waste

7 IDH and Sattva, Unveiling India's Textile Waste Landscape: A Cost Analysis, 2023, Retrieved from: https://www.idhsustainabletrade.com/uploaded/2023/09/IDH_textile-waste-cost-analysis_2023.pdf

Waste Tyres

8 Kaur R, [Explainer] Why Are Waste Tyres a Growing Environmental Concern? Mongabay, 22 February 2024. Retrieved from: https://india.mongabay.com/2024/02/explainer-why-are-waste-tyres-a-growing-environmental-concern/

Lead-Acid Battery Waste

9 Upadhyay M, South Asia's Toxic Battery Recycling Problem, 2022, Retrieved from: https://dialogue.earth/en/pollution/south-asias-toxic-battery-recycling-problem-2-2-2/

Construction and Demolition Waste

10 Centre for Science and Environment, Another Brick off the Wall, 2020, Retrieved from: https://www.cseindia.org/another-brick-off-the-wall-10325

End-of-life Vehicles

11 Ragunath V, India's Vehicle Scrappage Policy Is Here, EY, 1 July 2021. Retrieved from: https://www.ey.com/en_in/automotive-transportation/india-s-vehicle-scrappage-policy-is-here-but-what-next

ANNEXURE 2: THE NATURE OF WASTE ENTERPRISES AND INVESTABILITY

The nature of waste materials necessitates the presence of a strong and robust value chain. High-quality recyclers cannot function without robust collection and pre-processing activities. As a result, opportunities exist across the value chain of waste streams for private enterprises and investors to participate. In this section, we look at the types of enterprises and opportunities across waste streams that offer varying levels of investment potential.

For the purpose of this summary, we broadly define the value chain into three parts: collection, pre-processing and end recycling. Specific waste streams have more contextualised value chains, which we outline in the sector-specific deep dives. A summary of enterprises across the value chains of each waste stream covered in this guide is given in **Figure 22.**

Waste Stream	Collection of Waste	Pre-processing	End- recycling	Sustainable alternatives to wastes generated
Plastic Wastes	• Collection centre	• Waste sorting technology	• Mechanical recycling • Chemical recycling	• Bio-based plastic alternative producers
Lithium-Ion Battery and E-waste	• Collection centre	• Interim Recycler • Refurbisher	• Pyrometallurgical recycling • Hydro-metallurgical recycling	
Agriculture, Food, Biomass Waste	• Logistics and traceability	• On-farm waste extractor	• Biochar production • BioCNG / Biofuels producer • Biomaterials manufacturer • Biogas solutions	
Municipal and Industrial Solid Waste	• Collection and Pickup	• Waste sorting technologies • Material recovery facilities	• Waste treatment facilities • Biomining	

Wastewater and Industrial Effluents			• Filtration technologies • Centralised / decentralised wastewater treatment • Effluent treatment plants	
Textile Waste	• Downcyclers • Secondhand clothes	• Mechanical recyclers	• New-age recyclers • Circular apparel brands	
Tyre Wastes	• Tyre yards	• Retreading facilities	• Pyrolysis and incineration facilities • Tyre recyclers	
Lead Acid Battery Waste	• Collection centres		• Lead and base metal recyclers • Plastic recyclers	
Construction & Demolition Waste		• C&D waste processing companies	• C&D recycled products producers	
End-of-Life Vehicles	• Salvage yards		• Base metal recyclers • Plastic mechanical recyclers	

Figure 22: Summary of types of enterprises involved at the different stages of each waste stream's value chain (Source: Climake analysis)

The nature and type of enterprises also define the investability potential of enterprises in each waste stream segment. The categorisation of segments given in the Collaborative for Frontier Finance's report "The Missing Middles: Segmenting Enterprises to Better Understand Their Financial Needs",[68] is an effective guide to help investors and funders get a perspective on the investment and financing potential of solutions based on the type of enterprise.
In this guide, we classify enterprises identified across each of the ten value chains, along with the financing potential for each, to give an indicative look at their investment potential.

68. Hornberger K., Chau V., 2018, The missing middles: segmenting enterprises to better understand their financial needs, Collaborative for Frontier Finance. Retrieved from: https://static1.squarespace.com/static/59d679428dd0414c16f59855/t/5c5b4b38e5e5f0051af084a0/1549486917983/Missing_Middles_CFF_Report.pdf

The Collaborative for Frontier Finance's report classifies enterprises and ventures across the value chain into four distinct segments: high-growth ventures, niche ventures, dynamic enterprises and livelihood-sustaining enterprises. Businesses in each of these segments have unique financing needs and experience different gaps between those needs and the available investment options. **Figure 23** gives a summary of the key characteristics that define these enterprises.

		LENS 1: PRODUCT VS. MARKET	LENS 2: GROWTH CURVES	LENS 3: MANAGEMENT BEHAVIORS	FURTHER SEGMENTATION DRIVER	ENTERPRISE SUB-SEGMENTS
HIGH-GROWTH VENTURES	**Physical product based** Small number of high ambition invention-based businesses in high growth potential markets	Large scale potential and intentionally distributive business model	Exponential growth with longer development phase	"Sprinter" – seeks to be recognized for achieving disruption at scale through product/-service innovation	Stage of development	• Startup venture • Promising venture • Poised for growth
	Digital technology based Small number of high growth and disruptiondriv-en businesses in a large and growing market		Exponential growth with fast development phase			
NICHE VENTURES	Small, high ambition niche businesses in modest-sized markets	Moderate scale potential, disruptive business model	High initial growth which tappers off as addressable market has limited upside	"Cross-trainer" – designing new approaches to difficult problems	Business model as relates to financing needs	• Service innovator • Product innovator
DYNAMIC ENTERPRISES	Mostly mature, medium sized and growing in "bread and butter" business activities	Moderate scale potential and traditional but also sometimes innovative business models	Moderate growth with variation year to year but steady upward trajectory	"Marathoner" – building a steady and profitable business for the long term	Business activity as relates to differing levels of financing requirements	• Services enterprise • Trading /merchan-dising enterprise • Financing enterprise • Manufacturing/ processing enterprise
LIVELIHOOD-SUSTAINING ENTERPRISES	Small, often family run in low-growth traditional business	Small scale potential and traditional business	Low but steady growth above local rates of inflation	"Treadmiller" – keeping small business afloat	Collateral availability & financial performance	• Fully credit constrained small enterprise • Partially credit constrained small enterprise

Figure 23: Summary of key characteristics that define different enterprises (Source: Collaborative for Frontier Finance)

For the purpose of this guide, we have classified enterprises found across the value chain of each waste stream into those four segments in **Figure 23.**

Waste Stream	High Growth Ventures	Niche Ventures	Dynamic Enterprises	Livelihood-Sustaining Enterprises
Plastic Wastes	• Chemical recycling • High-quality mechanical recycling	• Bio-based plastic alternatives • Waste sorting technologies		• Collection centre
E-waste and Lithium-Ion Battery Waste	• Pyrometallurgical recycling • Hydro-metallurgical recycling	• Interim recycler	• Refurbisher	• Collection centre
Agriculture, Food, Biomass Waste	• Biochar • BioCNG / biofuels producers	• Biogas solution proividers • Biomaterials manufacturers	• On-farm waste extractors and collectors	
Municipal and Industrial Solid Waste		• Waste treatment facilities • Waste sorting technologies	• Collection & waste pickup solutions • Material recovery facilities (MRFs) • Biomining	
Wastewater and Industrial Effluents	• Decentralised wastewater treatment facilities	• Industrial effluent treatment facilities	• Large-scale wastewater treatment facilities	
Textile Waste		• New-age chemical and mechanical recycling • Circular apparel brands	• Mechanical recyclers	• Downcyclers • Secondhand clothing
Tyre Wastes		• Tyre recyclers	• Incineration Facilities	• Tyre yards • Retreading facilities
Lead Acid Battery Waste		• Lead and base metal recyclers • Plastic mechanical recyclers		• Collection centres
Construction & Demolition Waste		• C&D recycled products producers	• C&D waste processing companies	
End-of-Life Vehicles		• Base metal recyclers • Plastic mechanical recyclers		• Salvage yards

Figure 24: Business models mapped to enterprise segments for each waste stream in India (Source: Climake analysis)

ANNEXURE 3: INVESTMENT POTENTIAL SCORING OF WASTE STREAMS

The investability potential of each area is understood based on specific criteria and questions that help to objectively determine what makes a sector investable. Across the five areas listed below, we have identified 15 criteria that we view as being critical in determining the investment potential of the ten waste streams.

Market Size Potential	This refers to the current value of the market and its projected expansion over time. Growth metrics provide insights into future market potential, helping investors assess long-term viability and the ability to scale operations.
Investable Start-up Pipeline	The investable start-up pipeline comprises start-ups that are not only operational but also meet specific criteria that make them attractive for investment. These criteria include a validated business model, potential for high growth, experienced management and readiness to scale. A robust pipeline indicates a healthy ecosystem with multiple opportunities for investment, reducing the risk of placing capital in the sector.
Product Readiness	In product readiness, we primarily focus on technologies and solutions that can help deliver high-quality recycling or circularity. Low-value recycling and downcycling have often been the standard outputs from recycling sectors, however, the demands of moving towards circular economy practices mean sectors have to enable high-value recycling or circular outputs.
Policy Support	To drive waste management towards higher-quality recycling and circularity, enabling policies are critical to drive demand for solutions. Alternatives to existing solutions are needed to realise impacts and move beyond the status quo, which often needs policy direction to increase adoption and promote growth.
Financing Needs and Gaps	Capital requirements are at different stages for the various sectors. The nature of operations and the solutions needed to achieve high-quality recycling and circularity define the purposes for which capital is needed, e.g., for technology development or scale, and consequently, the type of capital instruments that need to be leveraged over time.

Table 6: Definitions of the five key investment potential areas (Source: Climake analysis)

MARKET SIZE POTENTIAL

1. **Total Addressable Market (TAM)**
The TAM represents the overall revenue opportunity available for a product or service if it achieves 100% market share. A large TAM indicates a significant potential for growth and profitability, making a start-up more attractive to investors.

2. **Growth Rate**
The growth rate of a sector provides insights into how quickly the market is expanding. A high growth rate suggests a dynamic and expanding market, which can lead to faster returns on investment and increased investor interest.

INVESTABLE START-UP PIPELINE

3. **Current Number of Enterprises**
This criterion looks at formal enterprises and start-ups; informal and unorganised operations often abound in these waste management streams, but they are not expected to be investable and consequently are not included in the count. The number of existing enterprises in a waste segment can indicate levels of maturity and market saturation. Fewer start-ups may imply less competition and more opportunity, but too few would indicate a stream that is not mature; a crowded market could mean tougher competition but also validation of market demand. Therefore, a balance is needed.

4. **Investible Pipeline**
This refers to the availability of high-quality start-ups that are ready for investment. A robust investible pipeline suggests that there are numerous viable opportunities for investors, increasing the attractiveness of the sector. We identify this based on the level of existing funding rounds that have gone to enterprises in each stream.

5. **Investor Ecosystem**
Certain investors engage through a focused thesis around waste and circularity, while others may enter into a stream through a different lens, e.g., deep-tech potential (as is the case with lithium-ion battery recycling, for example). The number of investors currently participating in different streams helps identify the near-term and emerging potential streams from an investor’s perspective.

PRODUCT READINESS

6 Technology Commercialisation Level

High-quality recycling technology is at an early stage, but recent years have seen progress in certain streams, such as plastic waste, biomass waste, and lithium-ion batteries. The stage at which new technologies are ready for market application affects investability. Technologies that are already commercialised reduce risks for investors, while ones that are more nascent have less validation and carry higher risks.

7 Technology and Equipment Availability

Technologies that are commercialised may still face adoption issues due to a lack of availability or access to equipment. Certain technologies, such as e-waste smelters, are still often reliant on imports that need to be contextualised to the local feed inputs. This lack of standardisation can make access to technologies more expensive and also carries the risk of inefficient or ineffectual operation.

8 Raw Material Availability

Waste material availability is complex in India due to a reliance on unorganised or informal sectors in the waste collection and segregation value chain. The lack of strong formal infrastructure can lead to supply crunches and price fluctuations. Streams with multiple means to access waste materials help de-risk this.

POLICY SUPPORT

9 Extended Producer Responsibility (EPR) Requirements

EPR mandates are the most stringent policies to incentivise recycling in India today. EPR targets, across waste streams, are expanding to include high-value material extraction and recycled content targets that are incentivising the adoption of higher-quality technologies and equipment for recycling.

10 Subsidies for Recycling

To aid the more scaled adoption of higher-quality recycling, certain waste streams have access to subsidies for the setup of facilities and infrastructure for high-quality recycling. Such subsidies help reduce operational costs and financial risks for waste management start-ups.

11 Other Regulatory Mandates

Other than EPR norms, waste segments often face regulatory mandates to ensure proper waste management and disposal. These often do not directly incentivise high-quality recycling but can help to create a direction that incentivises start-ups in certain waste streams.

12 Import Restriction on Waste Supply

Certain waste streams are reliant on imports to augment the availability of waste raw materials due to the low capacity levels or poor collection infrastructure present in India. Import restrictions placed to prevent the import of low-value junk from other countries can also complicate efforts to bring genuine high-value waste materials into India.

FINANCING GAPS AND NEEDS

13 Funding Needs

The type and amount of capital required by a waste management start-up can also influence its investability. Waste management and recycling is an asset-heavy sector. Funding for scale can indicate validated enterprises but also requires a larger quantity of capital to be effectively deployed. Funding for technology development, inversely, can be high risk but involve smaller ticket sizes.

14 Nature of Businesses

Given the mix of informal, unorganised, and formal enterprises, the nature of recycling businesses in waste streams has a significant influence on their investment potential. Certain streams with low investor participation may actually be saturated due to the presence of unorganised or semi-formal enterprises which can limit the entry of new formal players. Lastly, while policy looms large in influencing waste streams, certain streams may be even more reliant on government activities to function, especially ones related to municipal activities.

15 Socio-economic Benefits

Despite ostensibly being activities undertaken for positive impact purposes, certain circularity and high-quality recycling activities can actually have negative externalities and impacts. The use of certain technologies can be energy intensive or involve processes that are environmentally adverse if not managed properly. This can require the adoption of additional technologies or solutions to ensure recycling activities prevent negative effects. Table 7 provides the impact levels that these 15 criteria are measured against and gives each a score on one of the following four levels:

- **High:** the criterion is highly present and accessible in that waste segment
- **Medium:** the criterion is somewhat present and accessible in that waste segment
- **Low:** the criterion is barely present and accessible in that waste segment
- **None:** the criterion is non-existent in that waste segment

Each score is associated with a measurable metric contextualised to the criteria to ensure an objective selection for the scores. **Table 8** is a summary results table that outlines the investment potential for the ten waste streams based on these criteria.

Investment Potential Areas	Investment Potential Criteria	High	Medium	Low	None
Market Size and Growth	Total Addressable Market	More than US$ 20 billion by 2035	Between US$ 10 and 20 billion by 2035	Less than US$ 10 billion	–
	Growth Rate	Market size growth more than 10% CAGR	Market size growth between 5% to 10% CAGR	Less than 5% CAGR	–
Availability of investible start-ups / pipeline	Number of Enterprises	More than 30 companies identified	Between 16 and 30 companies identified	Less than 15 companies identified	–
	Investible Start-ups/Pipeline	10+ startups scaled or raised more than US$ 1 mn	5 to 10 start-ups scaled or raised more than US$ 1 mn	Less than 5 startups scaled or raised more than US$ 1 mn	–
	Investor Ecosystem	15+ investors in sector in the last 3 years	6 to 14 investors in sector in the last 3 years	Less than 5 investors in sector in the last 3 years	Zero investors in sector in the last 3 years
Product Readiness	Technology Commercialisation Level	Mature / stable technologies available in India	Mature technology globally needs to be adapted for India	Commerical technologies at TRL* 9+	No commerically viable technology
	Technology Availability	Machinery is easily available locally	Equipment needs to be custom built or imported	Imported equipment with long lead times	Equipment supply is a challenge
	Raw Materials Availability	Multiple raw material streams well developed	Raw material value chain is well developed	Raw material available but value chain is not robust	Raw material availability is a constraint

Policy Support	Extended Producer Responsibility Mandate	EPR Mandate in place	–	Upcoming EPR mandate	No EPR mandate
	Subsidy Availability	Subsidies for recycling facilities available	Subsidies for recycling facilities available	Subsidies for recycling facilities available	Subsidies for recycling facilities available
	Other Mandates / Policy Directions	–	Available mandates	Policy direction without mandates	No mandates
	Unaffected Raw Material Supply from Import Restrictions	Import restriction does not affect supply of waste	–	Import restriction affects supply of waste	–
Financing Needs and Gaps	Funding Need	Funding needed for scale	Funding needed for commercialisation	Funding needed for technology development	–
	Nature of Businesses	Opportunity to back private enterprises	Government-reliant / informal heavy businesses	Significant incumbents / established players	–
	Socio-Economic Benefits	Recycling has positive social co-benefits	Limited negative or positive social co-benefits	Recycling has negative social co-benefits	–

** TRL: Technology Readiness Level*

Table 7: Scoring levels of each of the investment potential criteria (Source: Climake analysis)

Investment Potential Areas	Investment Potential Criteria	Lithium-ion Battery Wastes & Electronic Waste	Plastic Waste	Agriculture, Food, Biomass Waste	Municipal & Industrial Solid Waste
Market Size and Growth	Total Addressable Market	> $20 billion	Between $10 Bn and $20 Bn	Between $10 Bn and $20 Bn	> $20 billion
	Growth Rate	>20%	24%	7%	2.5%
Availability of investible startups / pipeline	Number of Enterprises	183	104	116	279
	Investible Startup Pipeline	17	12	10	11
	Investor Ecosystem	80	101	96	162
Product Readiness	Technology Commercialisation Level	Mature technology globally needs to be adapted to India	Mature technology globally needs to be adapted to India	Mature technology globally needs to be adapted to India	Mature technology globally needs to be adapted to India
	Technology Availability	Imported equipment with long lead times	Equipment needs to be custom built or imported	Equipment needs to be custom built or imported	Imported equipment with long lead times
	Raw Materials Availability	Raw materials available, but value chain is evolving	Raw material value chain is well developed	Raw materials available, but value chain is evolving	Raw material value chain is well developed
Policy Support	Extended Producer Responsibility Mandate	EPR mandate in placae	EPR mandate in placae	No EPR mandate in placae	No EPR mandate in placae
	Subsidy Availability	Subsidies available for infrastructure	Subsidies available for infrastructure	Subsidies available for infrastructure	No subsidies available
	Other Mandates / Policy Directions	Available additional mandates	Available additional mandates	No mandates	Available additional mandates
	Unaffected Raw Material Supply from Import	Import restrictions can affect waste supply	Import restriction will not affect waste supply	Import restriction will not affect waste supply	Import restriction will not affect waste supply
Financing Needs and Gaps	Funding Need	Funding needed for commercialization	Funding need for scale	Funding needed for commercialization	Funding need for scale
	Nature of Businesses	High opportunity to back private enterprise	High opportunity to back private enterprise	High opportunity to back private enterprise	Heavily reliant on government-engagement
	Socio-Economic Benefits	Recycling processes can have negative social impacts	Recycling has significant positive social co-benefits	Recycling has significant positive social co-benefits	Recycling has significant positive social co-benefits

Investment Potential Areas	Textiles Waste	Wastewater and Industrial Effluents	Tyres Waste	Lead Acid Batteries Waste	Construction & Demolition Waste	End-of-life Vehicles
Market Size and Growth	< $10 billion	< $10 billion	< $10 billion	< $10 billion	< $10 billion	Between $10 Bn and $20 Bn
	4%	10%	9%	7%	< 5%	10%
Availability of investible startups / pipeline	22	52	508	140	5	N/A
	2	14	3	0	1	0
	4	75	3	0	3	0
Product Readiness	Mature technology globally needs to be adapted to India	Mature technology globally needs to be adapted to India	Mature technology globally needs to be adapted to India	Mature/stable technologies available in India	Commercial Technologies at TRL9+	Mature/stable technologies available in India
	Equipment needs to be custom built or imported	Equipment needs to be custom built or imported	Equipment needs to be custom built or imported	Machinery is easily available today	Equipment supply is a challenge	Equipment needs to be custom built or imported
	Raw materials available, but value chain is evolving	Raw materials available, but value chain is evolving	Raw materials available, but value chain is evolving	Raw material value chain is well developed	Raw material availability is a constraint	Raw materials available, but value chain is evolving
Policy Support	No EPR mandate in placae	No EPR mandate in placae	EPR mandate in placae	EPR mandate in placae	No EPR mandate in placae	Upcoming EPR mandate
	No subsidies available	No subsidies available	No subsidies available	No subsidies available	No subsidies available	No subsidies available
	No mandates	No mandates	Available additional mandates	Available additional mandates	No mandates	Available additional mandates
	Import restriction will not affect waste supply	Import restriction will not affect waste supply	Import restrictions can affect waste supply	Import restriction will not affect waste supply	Import restriction will not affect waste supply	Import restriction will not affect waste supply
Financing Needs and Gaps	Funding need for technology development	Funding needed for commercialization	Funding need for commercializationt	Funding need for scale	Funding need for technology development	Funding needed for commercialization
	High opportunity to back private enterprise	Heavily reliant on government-engagement	Significant incumbent / established players	Significant incumbent / established players	Heavily reliant on government-engagement	Significant incumbent / established players
	Recycling has significant positive social co-benefits	Recycling has significant positive social co-benefits	Recycling has significant positive social co-benefits	Recycling processes can have negative social impacts	Recycling has significant positive social co-benefits;	Limited social co-benefits

Table 8: Data points and answers for the scoring outlined in Table 4: investment potential matrix

Sources for the Investment Potential Matrix.

The data informing these insights have been taken from a variety of sources.

1 Total Addressable Market (TAM)

Total addressable market estimates were determined through a combination of available market size projections, CAGR expectations and insights gathered through interviews relating to the expected growth of waste streams. The source information on the current total addressable market size for the ten streams is given below, along with the latest available year for each source.

Waste Streams	CAGR	Source
Lithium-ion batteries and E-waste	US$11 billion (2030)	Avendus, 2023, Circular Economy: Recycling waste to wealth. Retrieved from: https://www.avendus.com/india/reports/61
Plastics Waste	US$10 billion (2030)	Avendus, 2023, Circular Economy: Recycling waste to wealth. Retrieved from: https://www.avendus.com/india/reports/61
Agriculture, Food, Biomass Waste	US$6 billion (2029)	1Lattice, 2023, Biomass POV. Retrieved from: https://www.1lattice.com/reports-and-publications/industrial-goods-services/biomass-market-in-india
Municipal and Industrial Solid Waste	US$36 billion (2028)	International Trade Administration, 2024, India – Country Commercial Guide: Environmental Technology. Retrieved from: https://www.trade.gov/country-commercial-guides/india-environmental-technology
Textile Waste	US$375 million (2028)	Suneja, K. 2023, Government cracks the code to track recycled textiles trade, The Economic Times. Retrieved from: https://economictimes.indiatimes.com/industry/cons-products/garments-/-textiles/government-cracks-the-code-to-track-recycled-textiles-trade/articleshow/105636375.cms?from=mdr&transcode=66634bfe99d7dd04456880e5

Wastewater and Industrial Effluents	US$3 billion (2030)	International Trade Administration, 2024, India – Country Commercial Guide: Environmental Technology. Retrieved from: https://www.trade.gov/country-commercial-guides/india-environmental-technology
Tyre Waste	US$420 million (2023)	Kaur R., 2024, [Explainer] Why are waste tyres a growing environmental concern, Mongabay. Retrieved from: https://india.mongabay.com/2024/02/explainer-why-are-waste-tyres-a-growing-environmental-concern/
Lead-acid Batteries Waste	~ USD 1 billion (2029) (based on the size of lead-acid battery recycling market)	TechSci Research, 2023, India Lead Acid Battery Market. Retrieved from: https://www.techsciresearch.com/report/india-lead-acid-battery-market/3061.html
Construction and Demolition Waste	N/A (expected to be less than US$10 billion)	N/A
End-of-Life Vehicles	US$6 billion (2028)	Thakkar K., Shyam A. R., 2020, Scrapped vehicle market pegged at RS 43,000 crore, The Economic Times. Retirieved from: https://economictimes.indiatimes.com/industry/auto/auto-news/scrapped-vehicle-market-pegged-at-rs-43000-crore/articleshow/74251241.cms?from=mdr

2 Growth Rate

The growth rate of each sector has been calculated from available public sources and reviewed based on insights from the research.

Waste Streams	CAGR	Source
Lithium-ion batteries and E-waste	> 20%	Avendus, 2023, Circular Economy: Recycling waste to wealth. Retrieved from: https://www.avendus.com/india/reports/61
Plastics Waste	24%	Avendus, 2023, Circular Economy: Recycling waste to wealth. Retrieved from: https://www.avendus.com/india/reports/61

Agriculture, Food, Biomass Waste	7%	1Lattice, 2023, Biomass POV. Retrieved from: https://www.1lattice.com/reports-and-publications/industrial-goods-services/biomass-market-in-india
Municipal and Industrial Solid Waste	2.25%	International Trade Administration, 2024, India – Country Commercial Guide: Environmental Technology. Retrieved from: https://www.trade.gov/country-commercial-guides/india-environmental-technology
Textile Waste	4%	Suneja, K. 2023, Government cracks the code to track recycled textiles trade, The Economic Times. Retrieved from: https://economictimes.indiatimes.com/industry/cons-products/garments-/-textiles/government-cracks-the-code-to-track-recycled-textiles-trade/articleshow/105636375.cms?from=mdr&transcode=66634bfe99d7dd04456880e5
Wastewater and Industrial Effluents	9.70%	International Trade Administration, 2024, India – Country Commercial Guide: Environmental Technology. Retrieved from: https://www.trade.gov/country-commercial-guides/india-environmental-technology
Tyre Waste	7%	https://www.autocarpro.in/news/organised-tyre-retreading-to-grow-at-7-9-cagr-during-fy2023-26-as-recycling-norms-provides-push-120427
Lead-acid Batteries Waste	7%	TechSci Research, 2023, India Lead Acid Battery Market. Retrieved from: https://www.techsciresearch.com/report/india-lead-acid-battery-market/3061.html
Construction and Demolition Waste	Less than 5%	N/A
End-of-Life Vehicles	10%	Thakkar K., Shyam A. R., 2020, Scrapped vehicle market pegged at RS 43,000 crore, The Economic Times. Retireved from: https://economictimes.indiatimes.com/industry/auto/auto-news/scrapped-vehicle-market-pegged-at-rs-43000-crore/articleshow/74251241.cms?from=mdr

3 Current Number of Enterprises

The current number of formal enterprises for each sector has been identified from available venture and enterprise databases, e.g., Tracxn. In the case of tyres and lead-acid battery recyclers, the numbers come from government lists of registered recyclers:

Waste tyre recyclers	Central Pollution Control Board, EPR Portal for Management of Waste Tyre. Retrieved from: https://www.eprtyrescpcb.in/user/recylerview?totalRecived=totalRecived
Lead-acid battery recyclers	Central Pollution Control Board, EPR Portal for Management of Battery Waste. Retrieved from: https://www.eprbatterycpcb.in/viewunitcertificates

4 Investable Pipeline

The investable pipeline data comes from available public information and databases that track venture details and fundraising, e.g., Tracxn, and Climake analysis.

5 Investor Ecosystem

The investable pipeline data comes from available public information and databases that track venture details and fundraising, e.g. Tracxn, and Climake analysis.

6 Technology Commercialisation Level

The sources for technology commercialisation levels were insights from publicly available information and primary research through interviews and engagements by Climake.

7 Technology and Equipment Availability

The sources for technology and equipment availability levels were insights from publicly available information and primary research through interviews and engagements by Climake.

8 Raw Material Availability

The sources for raw material availability levels were insights from publicly available information and primary research through interviews and engagements by Climake

9 Extended Producer Responsibility (EPR) Requirement

The sources for EPR requirements were publicly accessible government platforms that outline EPR requirements and norms:

Plastic Waste EPR	Central Pollution Control Board, EPR Portal for Management of Waste Tyre. Retrieved from: https://eprplastic.cpcb.gov.in/#/plastic/home

E-waste EPR	Central Pollution Control Board, EPR Portal for Management of Electronic Waste. Retrieved from: https://eprewastecpcb.in/
Battery Waste EPR	Central Pollution Control Board, EPR Portal for Management of Battery Waste. Retrieved from: https://www.eprbatterycpcb.in/#
Tyre Waste EPR	Central Pollution Control Board, EPR Portal for Management of Waste Tyre. Retrieved from: https://www.eprtyrescpcb.in/
End-of-life Vehicle EPR	Ministry of Environment, Forests, and Climate Change, 2024, Draft End-of-Life Vehicles (Management) Rules 2024. Retrieved from: https://moef.gov.in/storage/tender/SO367(E)-Draft-End-of-Life-Vehicles-(Management)-Rules-2024.pdf

10 Subsidies for Recycling

Details of subsidies for recycling are usually provided at a state level and come from publicly accessible government sources. Most subsidies are broadly for high-quality recycling of plastic, e-waste and lithium-ion batteries.

States	Subsidies Available	Source of Subsidies
Tamil Nadu	• Capital subsidy of 25% on the value of eligible plant and machinery capped at INR 1.5 crore (around US$180,000) • Additional subsidy of 25% up to a maximum of INR 10 lakhs (around US$12,000) for new and existing enterprises to promote cleaner and environmentally friendly technologies • Additional subsidy of 25% up to a maximum of INR 10 lakh (around US$12,000) for new and existing enterprises to promote cleaner and environmentally friendly technologies	Guidelines for availing capital subsidy, Micro Small and Medium Enterprises Department, Government of Tamil Nadu. Retrieved from: https://msmeonline.tn.gov.in/incentives/html_cye_CS.php

Karnataka	• Financial assistance of 5% of value of fixes assets, with a maximum of INR 10 lakh (around US$120,000) • Subsidy of 25% on land value • Capital subsidy of 20% on eligible plant and machinery value	Recycling of Electronic Waste and Plastic Waste, Yuva Kanaja, Government of Karnataka. Retrieved from: https://yuvakanaja.in/en/industry-commerce-en/recycling-of-electronic-waste-and-plastic-waste/
Kerala	• Capital subsidy up to 45% on value of eligible plant and machinery • Loan interest at 4% capped at INR 10 lakh (around US$12,000) • Reimbursement of state-level consumption tax and electricity dues	Incentive Schemes, Kerala State Industrial Development Corporation Ltd. Retrieved from: https://www.ksidc.org/investinkerala/incentive-schemes/
Uttar Pradesh	• Capital subsidy for MSMEs from the range of 10% to 25% • Interest subsidy of up to 50% on loans capped at INR 2 crore (around US$ 250,000) • Stamp duty reimbursement	Uttar Pradesh Micro, Small & Medium Enterprises Promotion Policy 2022, Invest UP, Government of Uttar Pradesh. Retrieved from: https://invest.up.gov.in/uttar-pradesh-micro-small-medium-enterprises-promotion-policy-2022/
Odisha	• Infrastructural support for setting up MSMEs • Capital subsidy of 25% capped at INR 10 crore (around US$ 1.2 million) • Land incentives of 75% to 100% capped at 25 acres • Stamp duty exemption	MSME Development Policy 2022, Invest Odisha, Government of Odisha. Retrieved from: https://investodisha.gov.in/MSME-Development-Policy-2022/
Gujarat	• Scheme of assistance for Common Environment Infrastructure • Assistance up to 40% of eligible fixed capital investment, capped at INR 50 crore (around US$6.1 million)	Gujarat Industrial Policy 2020, Industries and Mines Department, Government of Gujarat. https://ic.gujarat.gov.in/documents/commondoc/2020/12-GR_02092020.pdf

Telangana	• Capital investment subsidy of INR 1 crore (around US$120,000) for first 5 recyclers and INR 30 lakh (around US$120,000) for first 5 dismantlers • 25% subsidy on lease rentals for first 3 years of operation • Training subsidy of INR 1,000 (around US$12) per month for 3 months for 1,000 people	E-waste Management Policy 2017, Research and Innovation Circle of Hyderabad, Government of Telangana. Retrieved from: https://rich.telangana.gov.in/assets/pdfs/Resources/Telangana-e-Waste-Management-Policy-2017.pdf
Punjab	Provision of infrastructural support for MSME's in focus areas • Core infrastructure – developed industrial plots, water supply, power etc • Support infrastructure – skill development centre, labour housing etc • Support policies (for batteries): manufacturers to facilitate collection • R&D for battery recycling	Draft Punjab Industrial and Business Development Policy 2022, Department of Industries and Commerce, Government of Punjab. Retrieved from: http://investpunjab.gov.in/assets/docs/Industrial_Policy_2022.pdf
Maharashtra	• Government of Maharashtra is planning to set up 4 circular economy eco parks in Aurangabad, Nagpur, Ratnagiri and Pune • Developed land at cheap rates, subsidy on GST, power and water tariffs to be provided • R&D for battery recycling	Key Schemes and Policies, Maharashtra State Data Bank, Government of Maharashtra. Retrieved from: https://mahasdb.maharashtra.gov.in/files/DSP/Sector/MSMEschemes_8thAugust2023.pdf
Madhya Pradesh	• Land at concessional prices, 50% subsidy on development of ancillary infrastructure like roads • Capital subsidy of 50% capped at INR 25 lakh (around US$30,000), in setting up waste management systems • Interest subsidy and tax exemption	Madhya Pradesh MSME Development Policy 2021, Government of Madhya Pradesh. Retrieved from: https://mpmsme.gov.in:8080/mpmsmecms/Uploaded%20Document/Documents/MP%20MSMED%20Policy%202021%20Booklet%20English%20new.pdf

Rajasthan	• Customised package for MSMEs in their identified focus areas • Capital subsidy, term loan interest, and State Goods & Services Tax (SGST) reimbursement.	Rajasthan Investment Promotion Scheme 2022, Government of Rajasthan. Retrieved from: https://istart.rajasthan.gov.in/public/Policies/RIPS-2022.pdf

11 Other Regulatory Mandates

Information about other regulatory mandates comes from insights outlined in the section of this guide on India's Waste and Circularity Policy and the Regulatory Landscape Overview.

12 Import Restriction on Waste Supply

Insights on the impact of import restrictions on waste supply come from primary and secondary research that highlights waste streams that have dependencies on imports: primarily lithium-ion batteries and waste tyres.

13 Funding Needs

Insights and data on funding come from primary and secondary research, including investability information, that highlights the context of most enterprises in each stream, technology maturity and the maturity of the stream.

14 Nature of Businesses

Insights and data on funding come from primary and secondary research that highlights business dependencies that impact existing and new enterprises (and investment opportunities) in these spaces. Three types of business are highlighted: i) ones where private enterprise opportunity is available; ii) ones where enterprise operation is often dependent on government engagement; iii) streams that are already saturated with a significant number of recyclers, limiting opportunities for newer enterprises.

15 Socio-economic Benefits

Insights and data for socio-economic benefits come from primary and secondary research that highlights the external impacts that can be faced by society due to the operation of these recycling facilities: i) ones where recycling addresses negative externalities and has positive social co-benefits; ii) ones where there is no discernible positive or negative co-benefit in operation; iii) ones where recycling technologies can have negative externalities through the operation of recycling facilities, e.g., the significant energy and emission potential in e-waste smelters.

ASPEN NETWORK OF DEVELOPMENT ENTREPRENEURS

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