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Mapping Local Plastic Recycling Supply Chains: Insights from Selected Cities in India

The Circulate Initiative

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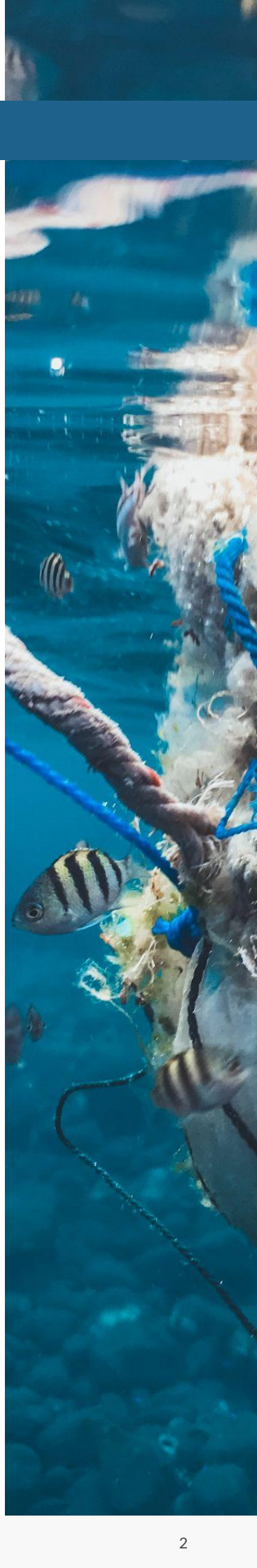

Glossary

Aggregation / consolidation point	Location at which waste materials are consolidated (bulked) into larger amounts for onward transport. Activities vary by site and may allow for consolidation only or include some pre-processing e.g., sorting or picking of valuable material. In India, these are sometimes referred to as Material Recovery Facilities (MRF).
Bangarwallah / Godaamwalla / Kabadiwala / Kantawallah	Various terms used in India (varies by region) for small, local aggregators who often also undertake collection.
Collected for recycling (CFR)	Plastics that are collected for recycling. This does not necessarily mean they are recycled in practice (e.g., they may be rejected during sorting or lost as residues during recycling). The CFR rate is calculated using the amount of plastic collected for recycling vs. the overall amount of plastic waste generated.
Central Pollution Control Board (CPCB) Portal	The online portal run by the Central Pollution Control Board where producers, importers, and brand owners register for the extended producer responsibility (EPR) scheme.
Deposit return system (DRS)	A system through which a deposit for a plastic container (e.g., a bottle) is paid for upfront by the consumer. This deposit is then redeemed when the container is returned for recycling. This could be by the original consumer or another actor (e.g., the informal workforce). It may involve a monetary deposit or token system and is typically implemented to encourage container return and set a minimum guaranteed price for the collection/return of containers.
Extended Producer Responsibility (EPR)	A policy approach whereby producers are made responsible (either financially or physically) for the end-of-life management of the products and/or packaging they sell.
Formal recyclers	Typically large recycling sites with large-scale equipment that hold suitable business and waste permits and licenses for their operations.
Formal sector	Collective term for municipal (or licensed) collectors and fully permitted/licensed aggregators and recyclers.
Informal recycler	Typically small recycling facilities that operate without full licenses and permits.
Informal sector	Collective term for informal waste workers and typically smaller-scale aggregators and recyclers that operate without full licenses and permits.
Infrastructure (e.g., plastic infrastructure, waste infrastructure)	Equipment and facilities used to aggregate, sort, and/or treat waste materials.
Junk shops	Typically small spaces, often in the houses of the owners. Materials may be brought to the site by the waste-pickers or their family members, with owners sometimes also undertaking collection themselves. Usually run informally without licenses or permits.
Kabadi	Term used in India for pre-sorted dry waste sold by households.
Kurawala/Kude-uthane wala / Safai Saathis	Various terms used in India for waste pickers.
Landfill	Landfill mainly describes permitted landfill disposal facilities and sanitary waste dumps permitted by the authorities. Some data sets might also include illegal dumping and unsanitary landfills.

Municipal solid waste (MSW)	Within this report, we use the term 'municipal solid waste' to describe waste generated by smaller sized properties such as households, small businesses, and schools. It generally excludes wastes from larger businesses, industrial sites, and from construction.
Pay-as-you-throw	A policy through which properties are charged based on the amount of waste they present for collection. In some cases, charging for separately presented recyclables is lower than residual waste.
Plastic leakage	Refers to plastic waste that is not kept within managed (formal or informal) systems and 'leaks' into the environment.
Plastic recycling supply chains	A formal or informal system through which discarded plastics can be recycled. Typically includes collection, aggregation, pre-processing, reprocessing, and manufacture into new goods.
Plastic waste	Plastic packaging or products that have been discarded by the user.
Pre-processing	Preparing material for recycling (e.g., can include sorting, label removal, washing, and shredding).
Raddiwallas	Term used in India for informal collectors who purchase materials from households.
Recyclables	Waste materials collected for recycling.
Recyclate	Material that is recycled e.g., rPET and rHDPE.
Recycling/reprocessing	The process of transforming waste into a new output product so the material can be used again.
Refuse-derived fuel (RDF)	Fuel created from certain types of waste, such as municipal solid waste and other combustible refuse.
Safai Karamcharis	Term used in India for people employed to manually carry out sanitation work.
Safai Mitras	Term used in India for waste collectors.
Swachhta Kendra	Term used in India for a facility where waste is collected and separated before it is sent for recycling.
Urban Local Bodies (ULBs)	Term used in India for municipal bodies or city authorities.
Waste collection/recycling cooperative	While cooperative arrangements can vary, the broad meaning is an umbrella organization with a legal structure that unites individual waste workers and coordinates the work undertaken. Cooperatives are usually controlled by workers and provide them with shared benefits and profits. In some areas, the term 'self-help groups' is used.
Waste-to-Energy (WtE)	This mainly includes formal, permitted Waste-to-Energy plants with heat and electricity recovery, where known. Data sets might also include some basic incineration plants without energy recovery, depending on data sets available.
Waste Transfer Station	Municipal aggregation points that are usually used to transfer waste. They are spread throughout cities to help allow for efficient collection and have no equipment or very basic equipment. They are not designed for waste extraction but are often used by informal waste workers for final extraction before landfill.
Wasteshed	A geographical region having a common solid waste disposal system or designated by the governing institutions as an appropriate area within which to develop a common recycling program. Wastesheds broadly reflect the boundaries of the selected cities; however, collection and aggregation activities often cross boundaries. If appropriate recycling infrastructure is located just outside city boundaries, these have been included in the infrastructure assessment to provide a better understanding of the material flows from the wasteshed.

General abbreviations

CFR	Collected for recycling
CPCB	Central Pollution Control Board
EPR	Extended producer responsibility
IWC	Independent waste collectors
KT/yr	Kilo tonnes (or thousand tonnes) per year. Metric tonnes are used.
MRF	Material recovery facility
MSW	Municipal solid waste
MT/yr	Mega tonnes (or million tonnes) per year. Metric tonnes are used.
RDF	Refuse-derived fuel
SWM	Solid waste management
T/d	Tonnes per day. Metric tonnes are used.
WtE	Waste-to-Energy

Polymer abbreviations

HDPE	High-density polyethylene
LDPE	Low-density polyethylene
LLDPE	Linear low-density polyethylene
PET	Polyethylene terephthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
r (e.g., rPET, rPP)	Recycled plastic of that polymer

Introduction

BACKGROUND

Though many urban areas of India, Indonesia, Thailand, and Vietnam have municipally managed waste collection coverage, there remains a high reliance on the informal sector for the collection, aggregation, and recycling of plastic and other valuable materials. The informal sector plays a critical role in the management of material, with workers benefiting directly economically, though this often comes with risks to their health and welfare. Leaving recycling activities to the informal sector results in supply chain insecurity for recyclers and is often a barrier to investment in local plastic supply chain infrastructure. In addition, there tends to be a focus on collecting the most valuable polymers only, leaving large amounts of plastic waste uncollected or leaked into the environment.

The opportunity to improve the management of plastic waste and recover the inherent value is vast in India, Indonesia, Thailand, and Vietnam. There is scope to increase the amount and consistency of recycled plastic supply, preserve the material value within these countries, and reduce dependency on polymer and plastic waste imports. This should concurrently result in an improvement of the welfare of informal workers and the health of communities and the regional environment.

For local plastic supply chains to be effective, several conditions must be in place. These include demand from buyers for recyclates, which needs to be matched by supply of good quality plastic waste; the right regulatory and policy framework and respective implementation measures; and transparent pricing at each stage to incentivize the investment of time and resources. Handling practices at each stage of the plastic recycling supply chain need to be efficient and conducted in a socially- and environmentally-friendly manner. In addition, supply chains must have the ability to scale, to increase the quantity and range of plastic collected for recycling to meet the growing demand for high-quality recycled plastic from local sources rather than imports.

Solutions cannot be achieved by one organization or individual in isolation. Change will require dedication, collaboration, and cohesively planned investment from multiple influencers of local plastic recycling supply chains.

RESEARCH OBJECTIVES

Plastic recycling supply chains are often local and unique as they rely on many informal transactions driven by local conditions, traditions and cultures, as well as local and regional infrastructure and markets. While there are a range of existing studies on national waste flows, few explore the plastic supply chains in more localized contexts. Recognizing this need, The Circulate Initiative, in partnership with Anthesis Group, conducted a detailed assessment of wastesheds in four countries, India, Indonesia, Thailand, and Vietnam.

This document presents the outcomes of this study, which was undertaken in 2022 to map local plastic recycling supply chains and their corresponding infrastructure in selected wastesheds in India, Indonesia, Thailand, and Vietnam.

The objectives were to:

- Understand the supply chains for secondary plastics at a local level, including the key actors, infrastructure, and influencing regulations.
- Understand the economics for secondary plastic at each stage of the local plastic supply chains and the key factors influencing prices.
- Identify where interventions to improve supply chains could be made.

SCOPE AND METHODOLOGY

The study focused on municipal waste (generated primarily by households and small businesses) as this is where many of the local environmental issues are occurring and where there appears to be the most potential to scale up plastic waste collection and recycling.

The wasteshed areas were selected to include:

- The capital city of each country (capital).
- Mega or large cities with existing and functional plastic recycling supply chains e.g., having a number of existing plastics recycling plants (established).
- Cities or regions with considerable plastic waste generation and emerging plastic recycling supply chains e.g., they might have waste collection, but limited sorting and recycling capacity (emerging).

It should be noted that wastesheds broadly reflect the boundaries of the selected cities; however, there is some fluidity. Aggregation and recycling activities sometimes cross boundaries and, where appropriate, relevant infrastructure and key players outside the city boundaries were included in the assessment to provide a better understanding of the wasteshed material flows.

The polymers selected for this study include PET, LDPE, HDPE, and PP. Combined, these are expected to make up around 85% of plastic packaging and food-service plastic. Rigid plastics using PET, HDPE, and PP dominate the post-consumer recycling industry today, whereas flexible packaging using LDPE and some PP or combinations thereof are expected to require further interventions to enter recycling cycles.

[1] Though both have established basic supply chains, Chon Buri and Rayong were selected in addition to Bangkok in Thailand as it was thought entrepreneurial actions by local supply chain actors made them interesting areas of study.

[2] Da Nang is the name of a region as well as a city. This study only focused on exploring local plastic recycling supply chains in Da Nang city, not the wider region.

Table 1: Cities that were selected for plastic waste supply chain mapping.

	INDIA	INDONESIA	THAILAND	VIETNAM
Capital	Delhi	Greater Jakarta	Bangkok	Hanoi
Established	Mumbai	Surabaya	Chon Buri Rayong[1]	Ho Chi Minh City
Emerging	Chennai	Makassar	-	Da Nang[2]

Information regarding plastic supply chains in each wasteshed was gathered through a review of publicly available literature, as well as interviews conducted with local supply chain actors (59 collectors, 45 aggregators, and 21 recyclers across the four countries). Anthesis Group, the lead research partner for the study, was supported by in-country partners in each country to carry out the local interviews. The in-country partners were Evergreen Labs for Vietnam, PRO India for India, Rebel (with Waste4Change) for Indonesia, and the Stockholm Environment Institute (SEI) for Thailand.

Additional interviews were conducted with organizations privy to local arrangements (such as local plastics associations, municipal waste management organizations, waste operators, and producer responsibility organizations) to gain additional insight and to help corroborate the findings.

The status of plastic recycling in these countries and the nature of informal supply chains means that it is not possible to accurately trace tonnages through the supply chain, to list all active actors, or to undertake a detailed pricing and economic assessment for all wastesheds.

This report provides another step towards understanding wastesheds and relies on primary and secondary information that has been reviewed, analyzed, and extrapolated for this project to provide an informed view for debate and discussion. The data provided should be understood as being the best estimates at this point in time, to be improved on and ratified once waste data monitoring and tracking systems, as part of Extended Producer Responsibility (EPR) and other policy measures, have been implemented. This report focuses on creating a better understanding of the wastesheds and suggests potential interventions to grow plastics recycling and reduce environmental impact.

The National Picture

COUNTRY OVERVIEW[3]

Population

1.3 BILLION

Total Municipal Solid Waste (MSW) generation

62 MT/YR

Plastic waste generation (in MSW)

9.4 MT/YR

Plastic waste recycled (in MSW)

5.6 MT/YR

India is the second highest populated country in the world, consuming around 15.12 MT/yr of plastic in 2018/19. Although the formal sector achieves a high collection rate of around 60% for plastic waste, it is estimated that over 30% is mismanaged i.e. littered, informally burned, or dumped.[4] A recent study on packaging in India forecasts that almost USD 133 billion worth of plastic material value will be lost between 2020 and 2030 due to unsustainable waste management practices.[5]

NATIONAL REGULATION

The Indian Government has implemented legislation since the early 2000s to increase the recycling of plastic waste and prevent plastic pollution, including rules around municipal waste management, a goods and services tax act, which targets PET plastic, and prohibiting the import of PET flakes.

Many regulations affect all actors in the supply chain and might also support the formalization via registration, waste flow monitoring, and other measures. This will result in significant changes for collectors and aggregators as more plastic waste will likely be available to be recovered. In general, an increasingly regulated sector may benefit informal waste workers as they get more recognition and enjoy the rights of formal workers through fair or living wages, for example.

However, increased regulation may increase the price of plastic waste further up the supply chain, due to formalization of the informal sector. Broader regulations on electricity and labor will indirectly affect actors in the supply chain as higher energy and labor costs will be placed on plastic materials.

India has announced an international commitment to ban all single-use plastics by 2022. In August 2021, the government amended the Plastic Waste Management Rules, prohibiting the manufacture, sale, and use of several single-use plastic commodities from July 1, 2022; it also prohibited the use of plastic carrier bags with thickness less than 75 microns with effect from September 30, 2021 and 120 microns with effect from December 31, 2022.[6]

Extended Producer Responsibility (EPR) was introduced in India via the Plastic Waste Rules in 2011. The rules note that all companies using plastic packaging must register as 'producers' and submit an EPR plan. In 2020, the government released the draft Uniform EPR Framework to implement EPR along with third-party monitoring mechanisms by roping in the private sector (brands, manufacturers, producers, recyclers) and integrating the informal sector. It includes a fee-based model, producer responsibility organizations (PROs) based model, and a plastic credit model.

The new draft framework also includes provisions to impose stringent penalties on producers if they fail to meet their targeted collection.[7] In 2022, the guidelines for EPR implementation were released, covering global practices, the rationale for an EPR mandate, and suggesting alternative EPR models that may be adopted to be compliant. As of October 2022, the latest figures show that only 1,800 producers have registered on the CPCB Portal, with 1.9 MT/yr of plastic set as a requirement under the scheme.[8]

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[3] Population figure: World Bank – *Data Bank, data for 2021*. MSW generation: TERI – *MSW Management: The pitiable situation of Municipal Solid Waste Management (2022)*. Plastic waste generation: CSE – *The Plastic Factsheet 1 (2019)*. Plastic waste recycled: Calculated by Anthesis Group.

[4] TERI – *Circular Economy for Plastics in India: A Roadmap (2021)*.

[5] FICCI – *Strategies for Sustainable Plastic Packaging in India (2020)*.

[6] The Times of India – *IPMA expresses concern over increase in GST on packaging material (2021)*.

[7] TERI – *Circular Economy for Plastics in India: A Roadmap (2021)*.

[8] Ministry of Environment, Forest and Climate Change, Government of India – *Centralized Extended Producers Responsibility Portal for Plastic Packaging (2022)*.

Figure 1: Summary of key national legislation in India.

Plastics and recycled plastics manufacture, sale, and usage rules

2003

Description: These rules provide specifications for virgin and recycled plastic manufacturing and mandate registration and authorization for manufacturers, production, sale and trade of plastic packaging.

Expected impact: Attempts to formalize the sector may lead to increased red tape on authorized operators, while informal ones benefit from their "looser" position.

SWM (Management and Handling) Rules

2016

Description: Any MSW generated in a city or a town, shall be managed and handled in accordance with the compliance criteria. Additionally, waste processing and disposal facilities to be set up by the municipal authority must meet certain specifications.

Expected impact: If the supply chain is formalized, this may increase the amount of plastic waste recovered for recycling, hence its demand, too.

Goods and Services Tax Act

2017

Description: The Goods and Services Tax rate on scrap PET plastic and plastic beads is set at 12%, while other plastics and bottles attract 18% tax, regardless that MSW is in an exempt category for GST.

Expected impact: The GST is significant for recyclers due to purchase of scrap materials.

Plastic Waste Management (Amendment) Rules

2018

Description: Focuses on regulating the single-use plastics and EPR regime that would help fund waste collection, sorting and recycling. It also states that recycling of plastic waste shall conform to the Indian Standard: IS 14534:1998.

Expected impact: It is assumed to increase demand for plastic scraps and plastic waste, and increase flow of plastic waste that is collected from households, streets, dumpsites and sent through sorting and further recycling.

Prohibition of import of PET flakes

2019

Description: The import of PET bottle waste/scrap/PET flakes made from used PET bottles was prohibited in 2019.

Expected impact: This will mainly affect collectors, sorters and aggregators as there is less competition for plastic waste.

Guidelines for EPR Implementation

2022

Description: Introduces rationale for an EPR mandate and provides the EPR obligators, executors and monitors with suggestive alternative EPR models that may be adopted to be compliant. EPR targets in force, minimum recycling target yet to be implemented.

Status of policy

- Announced
- Being rolled out
- Fully implemented

Stakeholders impacted by policy

- Brands, plastic manufacturers
- Plastic recyclers
- Collection, sorting and aggregation
- Recyclate / R-polymer buyers

Overview of Selected Wastesheds

The three wastesheds selected for plastic waste mapping in India are:

- **Delhi:** One of the oldest cities in the world, Delhi is a megacity containing New Delhi, the capital of India. It has well-defined waste service areas managed by private contractors.
- **Mumbai:** Known as the financial capital of India, Mumbai is one of the most populated cities in India. It has a good infrastructure of material recovery facilities in all wards and source segregation of materials mainly led by housing associations.
- **Chennai:** Located on a flat coastal plain, Chennai has a strong tourism industry and is the capital of the southern state of Tamil Nadu.

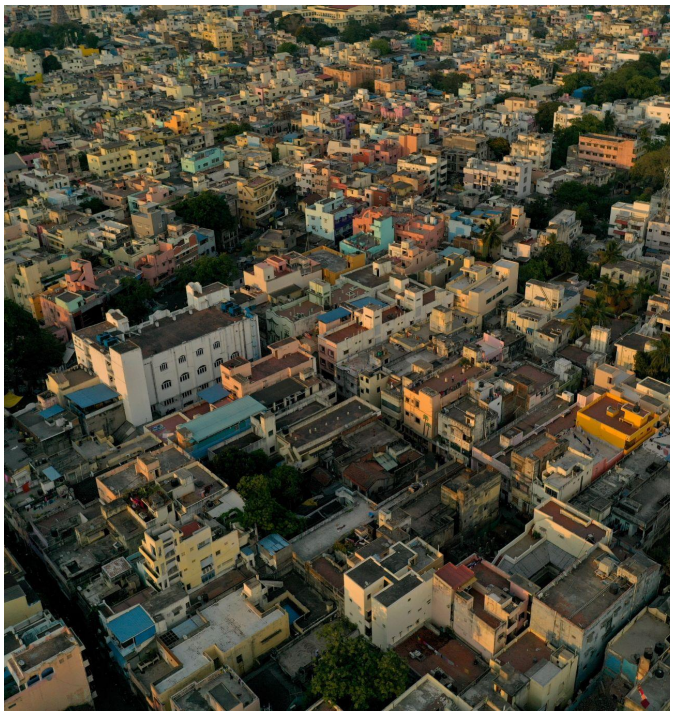
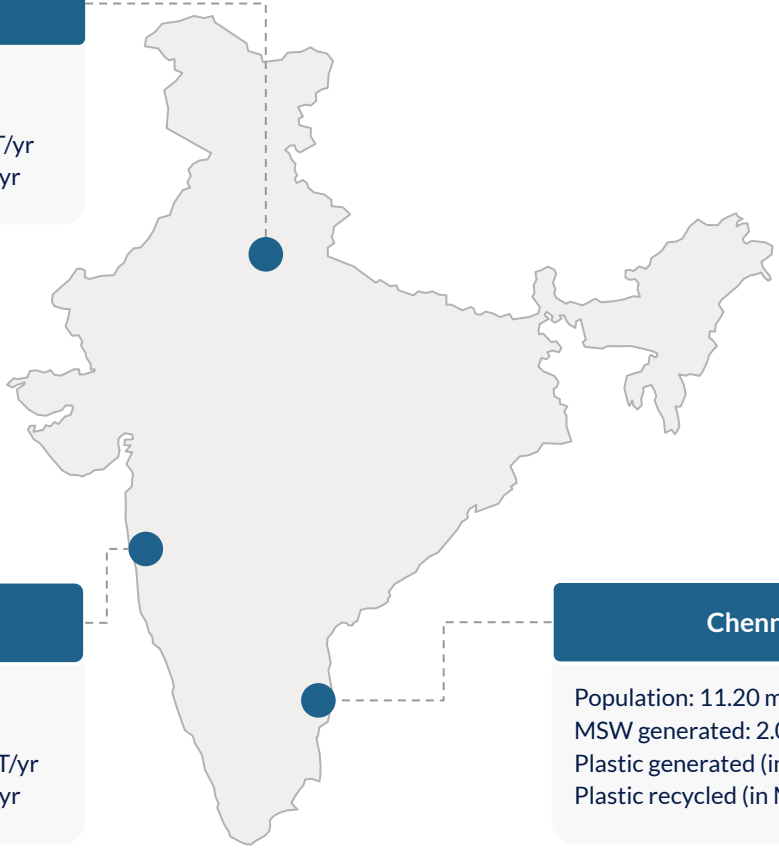


Figure 2: Key statistics for the areas selected for plastic waste mapping.

Delhi (City)

Population: 31.20 million
MSW generated: 4.01 MT/yr
Plastic generated (in MSW): 0.56MT/yr
Plastic recycled (in MSW): 0.34 MT/yr



Mumbai

Population: 20.70 million
MSW generated: 2.43 MT/yr
Plastic generated (in MSW): 0.12 MT/yr
Plastic recycled (in MSW): 0.02 MT/yr

Chennai (City)

Population: 11.20 million
MSW generated: 2.08 MT/yr
Plastic generated (in MSW): 0.14 MT/yr
Plastic recycled (in MSW): 0.03 MT/yr

CURRENT SUPPLY CHAINS

This section describes how local plastic waste recycling supply chains typically operate within the selected wastesheds, before providing a detailed outline of plastic waste flows, key actors, and infrastructure.

Collection: Stakeholders and processes

The municipal corporations of Delhi, Chennai and Mumbai either collect waste using in-house collection services (including paid waste pickers or so-called *Safai Karamcharis* or government sanitation workers) or through contracts with private waste management companies. This is mainly mixed waste 'door-to-door' collection, where organic and non-organic waste is being collected in bags or bins. Under the Solid Waste Management (SWM) Rules 2016, the local bodies charge fixed monthly amounts for mixed (and in many cities, segregated) waste collection from waste generators, such as households or small shops. However, plastic waste collection largely depends on the informal sector.

There are three main types of waste collectors in India:

- Waste pickers (or *Kurawalas*), who are 'responsible' for doorstep collection of mixed municipal waste within a certain territory using a tricycle or similar to transport the waste, and are paid a monthly fee by each household. They are often employed by the municipal administrations and transport waste to material recovery facilities (MRFs) and transfer sites, but also extract recyclables to be sold on.
- Waste pickers (*Kude-uthane walas*), who collect and recover recyclable materials from mixed waste at transport terminals, streets, and markets, or from landfills, municipal waste transfer sites, or MRFs. These waste collectors pick and separate recyclables, like plastics, and are often on foot and free roaming.
- Itinerant buyers (*Raddiwallas*), who purchase materials from households. Pre-sorted dry waste sold by households is described as *'Kabadi'*. It is generally cleaned and sorted to a certain degree at household level e.g., plastic bottles and jars from packaging, paper, cardboards, metal, and glass. Pre-sorted and segregated recyclables are mainly available from middle- and high-income households. Many collectors use shoulder bags, rickshaws or carts to help move recyclable material and will spend time preparing the material for sale, e.g., sorting it to ensure the greatest value is achieved.

Many collectors use shoulder bags, rickshaws or carts to help move recyclable material and will spend time preparing the material for sale, for example, sorting it to ensure the greatest value is achieved. Materials are sold on to the nearest aggregator or *Kabadiwala*, who charges the 'market price' of the area according to the local demand and supply.

Aggregation: Stakeholders and processes

Materials are sold on to the nearest aggregator, who charges the 'market price' of the area according to the local demand and supply. These local aggregators (for which local terms vary by region and include *Kabadiwala, Bangarwallah, Kantawallah and Godaamwalla*) buy different types of waste paper, glass, metal, and plastic, and typically operate out of small shops where they collect, store and minimally process waste materials.

Preparation steps during aggregation are usually limited to further sorting and bulking. The sorted plastic waste is then sold to larger aggregators/junk yard owners, intermediate dealers, or other agents. At this stage, larger aggregators will sometimes shred material, as well as undertake further sorting and bulking. This trading is done in a rather hierarchical and non-transparent value chain in a market space that is semi-formal and informal, with no clear price estimates for different plastic waste products.[9]

[9] TERI – *Circular Economy for Plastics in India: A Roadmap (2021).*

Most supply chains in India have the following key actors collecting and aggregating plastic waste for recyclers:[10]

- Waste collectors: 30-120 kg per day collected of dry mixed waste, generally including plastics (such as PET, PE, and PP), paper, and metal. The lower range represents waste pickers, often women on foot, while the higher range reflects collectors on tricycles or scooters with baskets.
- Scrap dealers: 800 kg-1 T/d of mixed dry waste, including plastics, paper, metal, and e-waste.
- Multiple levels of aggregators specializing in one or two materials: 1-10 T/d, including PET bottles, recycled paper, and LDPE milk pouches.

In addition, there are traders or agents, who source plastic waste on behalf of recyclers. These can be large aggregators or individuals organizing and administering plastic waste supply.

Recycling: Stakeholders and processes

India is estimated to have over 7,500 registered and unregistered recyclers, who collectively recycle approximately 60% of the plastic waste generated (or about 5.6 MT/yr).[11] An estimated 70% of the recycling infrastructure is formal, 20% informal recycling, and 10% informal focusing on reuse or repurpose activities.[12] However, the definitions are fluid as smaller recyclers might be exempt from permits and therefore do not form part of the formal system, but nevertheless are compliant with environmental regulations. In other cases, the business might be a registered company, but not permitted under environmental regulations.

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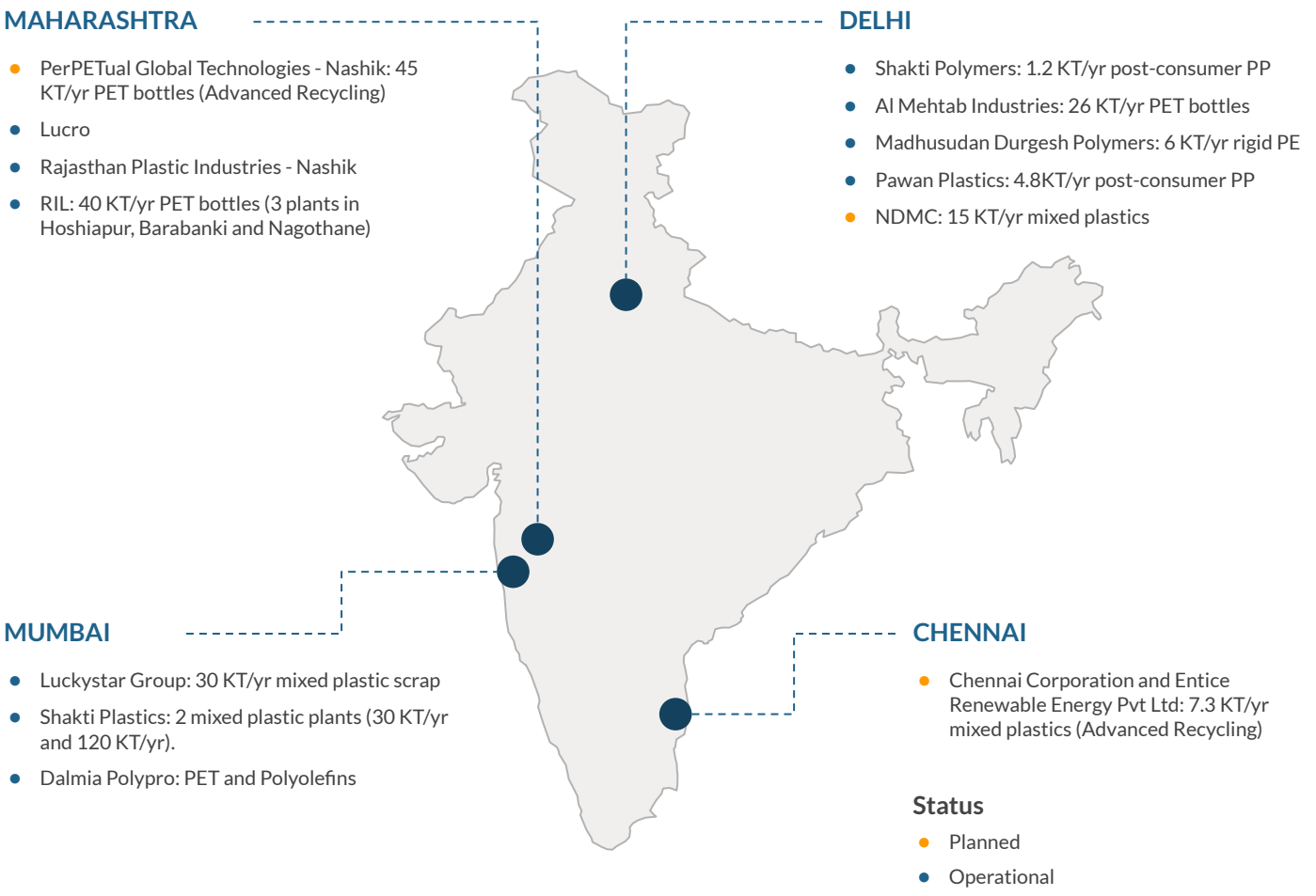
[10] Anthesis' stakeholder interviews, analyzed October 2022.

[11] Recykal – A *digital marketplace for quality material – Case study (2022).*

[12] Shanker, R., et al. – *Plastic waste recycling: existing Indian scenario and future opportunities (2022).*

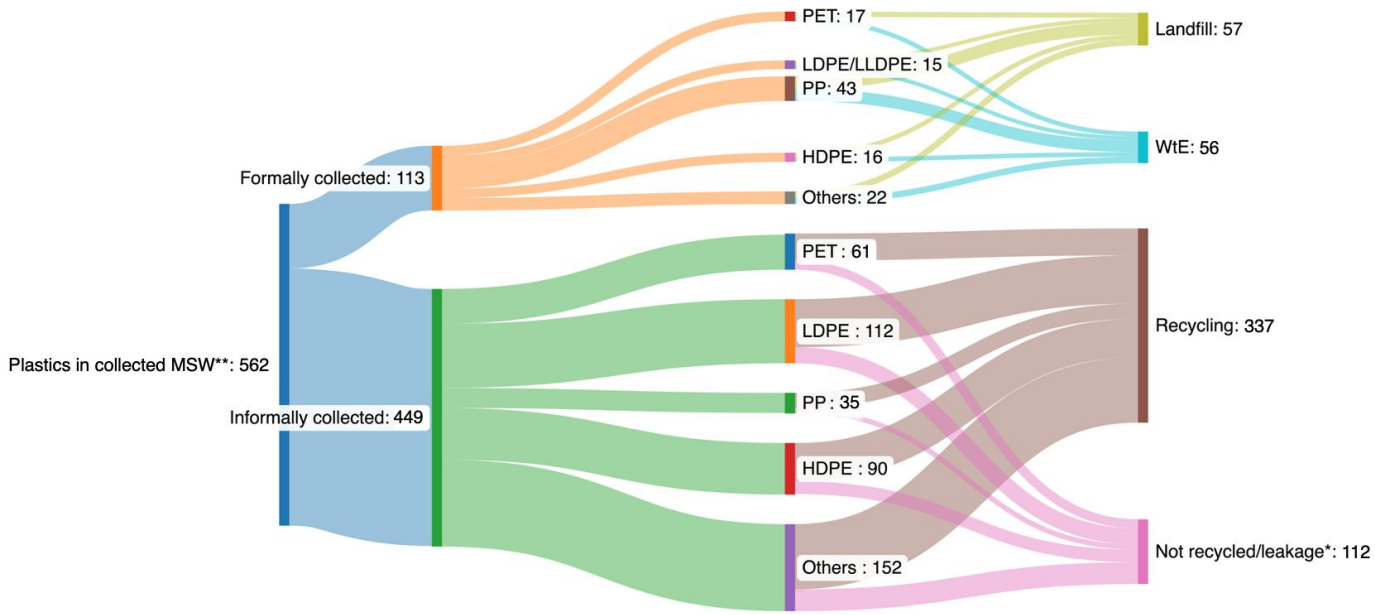
Figure 3: Overview of formal plastic recycling facilities and their recycling capacity, where available, in the vicinity of Delhi, Maharashtra (Mumbai), and Chennai (locations are approximates).



Insights on local plastic recycling supply chains in Delhi

Recycling rates of collected plastic waste in Delhi are estimated to reach 60% or 337 KT/yr. Almost all the plastics recycled in Delhi are collected by informal waste pickers, either directly collecting the waste at households, or working with non-governmental organizations (NGOs) and informal waste collection organizations. Delhi has a very high number of waste pickers (estimated 200,000-500,000), and when comparing the proportion of waste pickers to Delhi's population, it is much higher compared to that in Mumbai and Chennai.[13][14] In addition, PROs are operating 'reverse logistics' (take-back) systems for plastic bottles, for example in South and North Delhi, and some recyclers, like RLI, are also operating collection centers and collaborate with waste pickers active at stations, hotels, etc.

Figure 4: Flow of plastic within municipal solid waste in Delhi (thousand tonnes per year). Figures are rounded to the nearest whole number and may not sum because of rounding. * 'Not recycled/leakage' refers to plastic waste collected, but not recycled due to contamination or the collectors being unable to sell low-value plastics to aggregators. ** The share of plastics collected in Delhi is calculated based on a 100% MSW collection rate.



The Delhi Cantonment Board (DCB) plastic monitoring dashboard reports 0.4-0.5 MT of plastic waste being processed (2022);[15] however, details about whether this includes WtE and all types of plastics are unavailable. While the South Delhi board reported approximately 1,000 T of plastic waste being sold for recycling in 2020, this only relates to the plastic waste collected as part of the formal sector. No further data has been collected or published to clarify the actual recycling of household plastic waste in Delhi.[16]

In 2021, the Delhi Department of Environment asked all municipal bodies to prepare an action plan to achieve 100% segregation, recycling, and reprocessing of plastic waste. The progress is supposed to be monitored on the respective Urban Local Bodies' (ULB's) plastic waste dashboards, but only the DCB had published figures at the time of writing.

Delhi had five municipal zones or Urban Local Bodies (ULBs) responsible for municipal waste management: The Delhi Cantonment Board (DCB), East Delhi Municipal Corporation (EDMC), South Delhi Municipal Corporation (SDMC), North Delhi Municipal Corporation (NDMC) and New Delhi Municipal Council. Each municipal zone manages MSW collection or contracts private players. Currently, EDMC and SDMC have contracted IL&FS Environmental Infrastructure and Services (IEISL) to manage and operate MSW collection and transportation.

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[13] International Alliance of Waste Pickers - *City Report: Interview with a local waste picker (2014).*

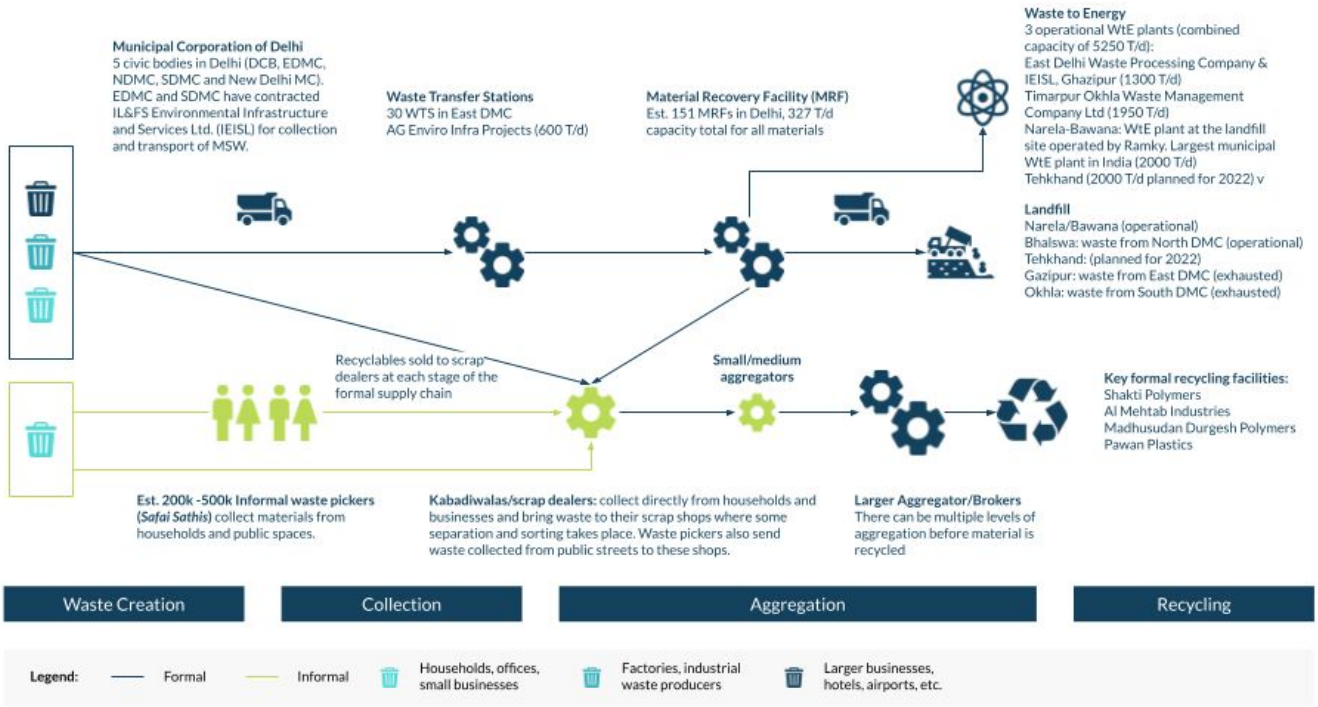
[14] Hasiru Dala - *What is the mainstream waste system (2018).*

[15] *Delhi Cantonment Board – Plastic Waste Monitoring Dashboard (2022).*

[16] Anthesis has used the 60% plastic recycling rate quoted in the literature and assumed that the majority of plastic is collected via the informal sector, as informal waste collections are responsible for 80% of recycled and reused waste collected in Delhi, according to a report from FICCI and Accenture – *Strategies for sustainable plastic packaging in India (2020).*

In May 2022, EDMC, SDMC and NDMC were merged into the Municipal Corporation of Delhi (MCD), reducing the ULBs to three key ULBs, namely the DCB, MCD and the New Delhi Municipal Council; however, the data provided for this study mainly relates to the original five zones as outlined below.[17]

Figure 5: The plastic waste supply chain in Delhi.



Delhi has several local regulations, including the Plastic Bag Act. This involves provisions to reduce the use of plastic bags and prevent the disposal of plastic bags in drains, roads, and public places to tackle plastic pollution in Delhi.

In addition, a protocol for developing facilities for waste management has been introduced, requiring facilities to adhere to a set of specific criteria. This includes environmental compliance, quality of both input and output, and health and safety standards and operating protocols for waste operators.

ULBs have declared Delhi to be in a waste crisis, with existing landfills reaching capacity while quantities of MSW generated continue to increase. In response, municipalities have facilitated and encouraged the privatization of the waste supply chain. Since 2005, contracts have been granted to private companies to manage and operate the collection and transportation of MSW.[18]

Formal waste collection in Delhi starts with door-to-door collection by local municipal collectors (sanitation workers), who bring mixed waste to formal transfer stations, of which there are 30 in East Delhi alone. The East Delhi Municipal Corporation rolled out door-to-door collection by municipal collectors across all wards in 2021.[19] In South Delhi, door-to-door collection is carried out by independent (contracted) rickshaw collectors, while in North Delhi, Ramky, a waste management operator, collects waste directly from households. From the transfer stations, mixed waste is either transported to an MRF or sent directly to landfills or other disposal facilities.

Only a limited number of individual MRFs separate recyclables from non-recyclables; in these cases, sorted plastic waste is either sent to scrap dealers, where it enters the informal waste management system, or goes directly to recycling.

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[17] Municipal Corporation of Delhi (2022).

[18] Global Alliance of Waste Pickers – *City Report: Interview with a local Waste Picker (2022).*

[19] Times of India – *EDMC begins door-to-door waste pickup in all 64 wards (2021).*

There are 151 MRFs operating in Delhi; however, there is no expectation that materials sent to MRFs go to recycling. South Delhi reported 2% of plastics being sold to recycling from their waste treatment centers and MRFs in 2020, indicating the low level of sorting taking place. Key new MRFs focusing on sorting for recycling in Delhi include:

- Chintan NGO: MRF at the New Delhi Railway Station as a partnership between Chintan, Safai Sena and the New Delhi Railway Station, processing 13 T/month of wet and dry waste.[20]
- The MCD in partnership with the United Nations Development Program (UNDP) is expected to set up 24 municipal waste MRFs over the next 6 months, to be completed in 2023.[21]
- SDMC and UNDP opened an MRF in 2022 that is capable of processing 240-300 T/d, and hired 200 waste pickers as an effort to integrate the informal sector through providing social protection schemes, and financial, health and social inclusion.[22]
- The NDMC MRF under the Zakhira Flyover opened in 2021 and is capable of processing 8 T/d of waste.[23]

The majority of collected waste is sent to two operational landfills, Bhalswa (taking waste from North Delhi) and Narela-Bawana. Two additional landfills have reached their capacity and are no longer operational in Ghazipur and Okhla.

In addition, Delhi has three operational WtE plants with a combined capacity of 5,250 T/d. These are the East Delhi Waste Processing Company and IESL in Ghazipur, Timarpur Okhla Waste Management Company and Narela-Bawana operated by Ramky, which is the largest WtE plant in India. The latter WtE processes nearly 350 T/d of RDF 'mined' from the Bhalswa landfill site. One additional planned WtE plant is expected to be operational by the end of 2022 in Tehkhand, adding an additional 2,000 T/d of capacity.[25]

The informal sector drives plastic waste recycling in Delhi through the efforts of waste pickers – there are an estimated 200,000-500,000 waste collectors and itinerant waste buyers. Informal waste pickers collect recyclable waste at different stages of the formal waste supply chain, from households, offices, shops, streets, transfer stations, and landfills either by foot, tricycle or bicycle. Non-recyclable materials are either leaked into the environment, illegally dumped or sent to waste transfer stations, while recyclable material is sold to local scrap dealers (*Kabadiwalas*) where waste is sorted into 5-15 streams.

Before the plastic waste reaches recycling facilities, further sorting takes place along different stages of aggregators before reaching more specialized facilities that sell waste to agents. Larger aggregators (agents) coordinate and manage the sale of recyclable plastic waste to recycling facilities.

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[20] Chintan – *Innovation in Waste: Material Recovery and Livelihoods at the New Delhi Railway Station (2017).*

[21] News Nine – *LG VK Saxena directed MCD to set up 24 MRF across Delhi within 6 months (2022).*

[22] City Spidey – *Dwarka gets a 'Material Recovery Facility' to manage its waste (2022).*

[23] Times of India – *Waste facility to recycle 8 tonnes/day (2021).*

[24] Construction World – *North Delhi municipal corp to develop plastic waste processing plant (2021).*

[25] Delhi Pollution Control Committee – Annual Report for the Year 2020-2021.

In October 2021, the Delhi Pollution Control Committee (DPCC) issued closure notices to over 550 plastic manufacturing units and 1,278 recyclers operating without a valid registration under the PWM Rules 2016. All plastic recyclers were invited to apply for registration and renewal, but no details of how many reapplied and registered, or how many businesses closed down in due course, are available.

As of 2022, there are an estimated 315 recycling facilities in and around Delhi, mainly processing rigid plastic waste, but also some flexible LDPE.[26] Many recyclers are small-scale with 10 or more employees, providing a very fragmented market, matching the informal collection and aggregation supply chain. Key large-scale recyclers have been mapped, but smaller recyclers include:

- Ganesha Ecosphere Ltd, on the outskirts of Delhi.
- 21 Century Polymers in Bawana, Delhi.
- SS Plastics (and Jai Shree Balaji Plastic) in Narela, Delhi.

Delhi's main recyclers are located in Narela or Bawana, or just outside the city in surrounding areas, which provides a good infrastructure for plastic waste recycling. In addition, in 2021, NDMC announced plans to build a 15 KT/yr plastics recycling plant in Tikri Kalan, but no further details are available.

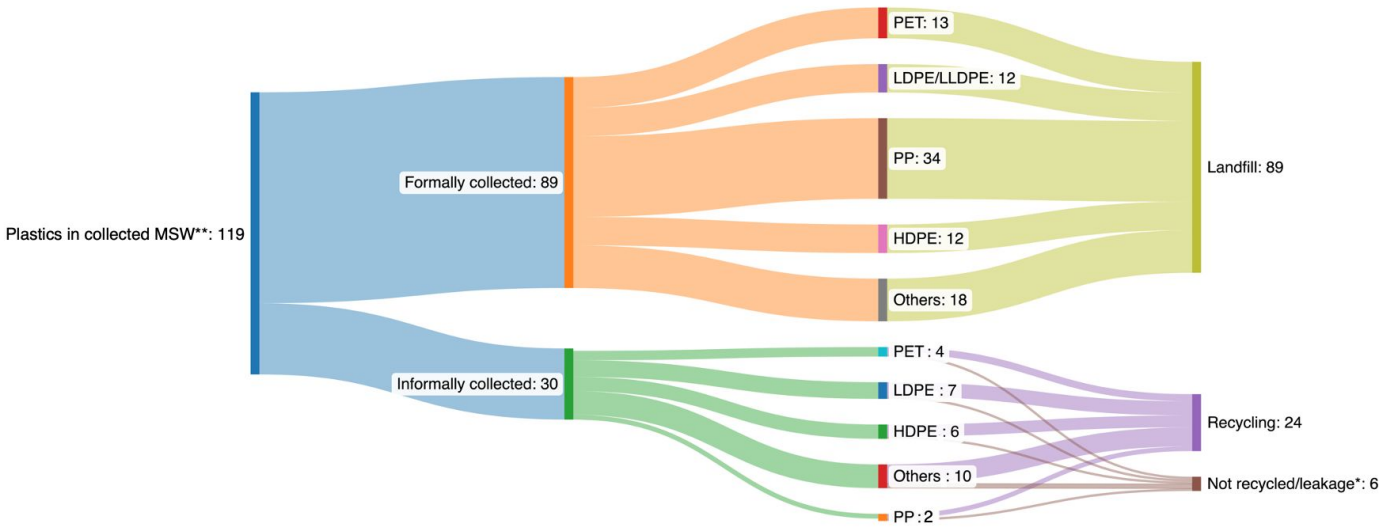
Delhi has a good level of door-to-door collection, a large informal collection and aggregation sector, as well as considerable plastic recycling infrastructure within the city and surrounding areas. The efforts made to improve sorting and segregation of plastic waste at MRFs should further improve the rates and overall plastic waste recycling in the city.

[26] Delhi Pollution Control Committee, Annual Report for the Year 2020-2021

Insights on local plastic recycling supply chains in Mumbai

Mumbai is estimated to have a 20% recycling rate of collected plastic waste (equivalent to 24 KT/yr), which is considerably below the recycling rate in Delhi. This is reflective of the lower rate of MSW collection in Mumbai i.e. 81% in comparison to 100% stated for Delhi by the respective City Pollution Control Boards, as well as the lower number of waste pickers (estimated 20,000) in Mumbai. Anecdotally, the level of source segregation is supposed to be higher than in Delhi; however, this is currently not being reflected in the recycling rates likely due to the lack of compliance with the source segregation requirements on bulk waste generators. Almost all the plastic waste recycled in Mumbai can be attributed to the collection efforts of informal waste pickers.

Figure 6: Flow of plastic within municipal solid waste in Mumbai (thousand tonnes per year). Figures are rounded to the nearest whole number and may not sum because of rounding.. * 'Not recycled/leakage' refers to plastic waste collected, but not recycled due to contamination or the collectors being unable to sell low-value plastics to aggregators. ** The share of plastics collected in Mumbai is calculated based on an 81% MSW collection rate.



The Brihanmumbai Municipal Corporation (Greater Mumbai Municipal Corporation – BMC) has introduced several policies to improve waste management and address plastic waste. From 2017, it has required bulk waste generators (housing societies or commercial establishments that generate more than 100 kg of waste a day or have an area above 20,000 m^2) to segregate and compost their wet waste. There are thought to be over 3,100 bulk waste generators in Mumbai, with only around half of these complying with the rules. To increase transparency about the steps being taken, BMC has planned the development of a dashboard to provide real-time information about the waste performance of waste generators. It will include daily updates on the amount of waste generated in each ward area and steps taken by housing societies to manage waste.[27]

A regional ban on single-use plastics was introduced in 2018 by the Maharashtra Government, covering items such as disposable dishes, cups, plates, cutlery, non-woven polypropylene bags, pouches used to store liquid, and plastic food packaging.

Although enforcement of the ban was relaxed during the height of the Covid-19 pandemic, the law was extended in 2022 to include items such as ear buds with plastic sticks, plastic candy sticks, and wrapping film on items such as candy boxes and cigarette packets.[28] Moreover, under the ban, dairies are required to develop a deposit return scheme to provide a mechanism for the buying back and recycling of pouches that are used for milk, with a buy-back price of no less than INR 0.50 per pouch.[29]

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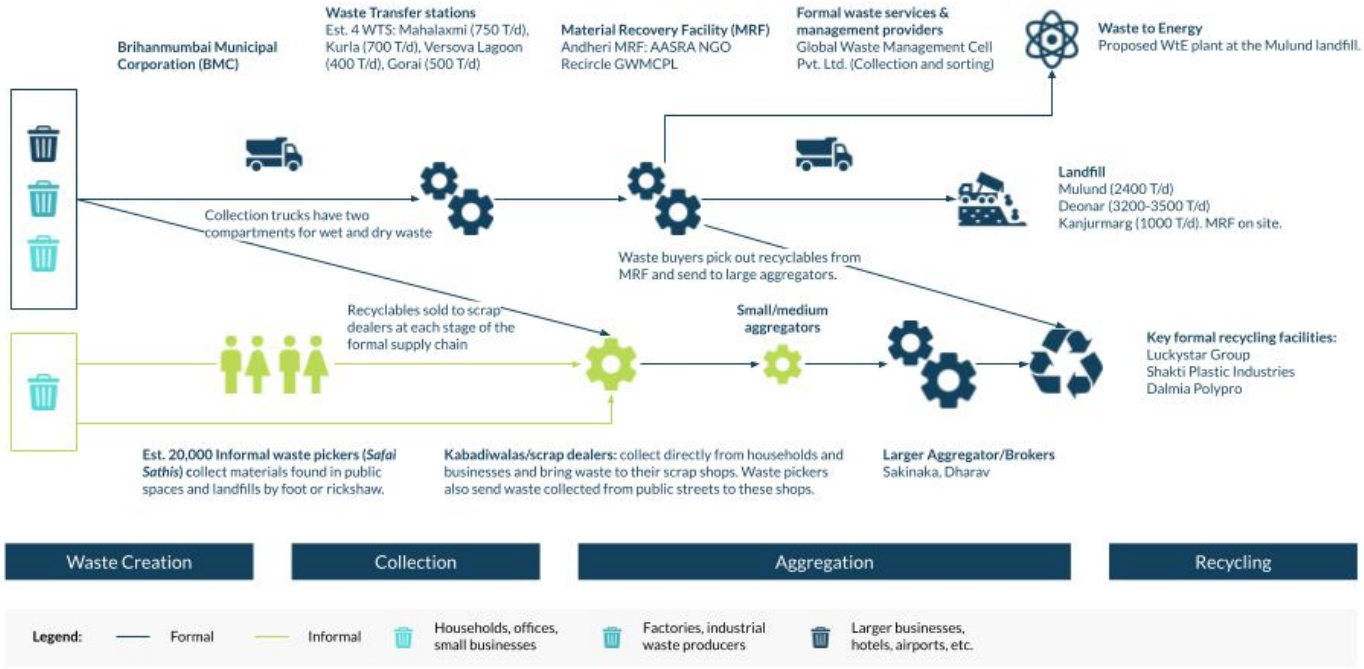
[27] Construction World – *BMC plans real-time dashboard to improve waste management system (2021).*

[28] Maharashtra Pollution Control Board – *Notice for Prohibiting Production, Commerce, Stocking, Distribution, Sale and Use of Single Use Plastic Items (2022).*

[29] Indian Express – *Plastic ban: Most dairies in Maharashtra yet to start buying back and recycling of milk pouches (2019).*

Figure 7: The plastic waste supply chain in Mumbai.



The BMC undertakes collection in vehicles with two compartments to allow wet and dry waste to be separated. The dry materials are sent (usually via a transfer station) to an MRF for sorting, one of which is located at the Kanjurmarg landfill site. The MRF used varies depending on the locality that material was collected from. They have different processes and levels of automation, with some MRFs relying mainly on manual sorting, while others utilize equipment (which can include processing/pre-processing equipment such as extruders, balers, and shredders). The difference in capabilities means some achieve a higher level of segregation of recyclables than others. Typically, however, high-value recyclables, including HDPE, PP, LDPE, and PET are extracted and sent to larger private aggregators in the Sakinaka and Dharavi areas for further segregation and consolidation. The plastic is then sold to recyclers in these areas, and recyclers from Mulund, Bhiwandi, and Palghar localities, where most plastic waste is reprocessed.

Formal collection and segregation is challenging in many areas in Mumbai and there are a number of areas within the city that are not accessible to the vehicles used by BMC. In these areas, communal bins are used, and informal collectors, supported by NGOs, often collect material door-to-door and transport it to the bins. This material is not currently segregated for recycling. In the Dharavi area, which also has a recycling hub, BMC is seeking to improve this arrangement by appointing contractors to provide professional waste management services, which includes door-to-door collection and segregation of recyclable waste.[30] The initial tender in 2018/19 only identified one bidder and it is understood that BMC is planning to request further tenders to procure further waste collection and sorting service providers.

Informal collectors play a critical role in collecting plastic waste from households and picking plastics from public locations and landfill sites. Plastic waste is sold on to *Kantawallahs*, small local aggregators who often also undertake collections, before onward sale to larger aggregators and ultimately recyclers.

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[30] Indian Express – *For garbage-free Dharavi, BMC to appoint PVT agencies to collect and recycle waste (2022).*

Among several formal recyclers reprocessing plastic waste from Mumbai, Dalmia Polypro is one example of a recycler that focuses on PET bottles, and manages two MRFs to help secure a steady supply of recycled materials. Dalmia previously noted plans to expand the number of MRFs it manages to 12 facilities, where plastic waste will be sorted.

Mumbai also has a large informal recycling sector, with an estimated 1,500 units processing plastics, located mainly in the Dharavi, Lalbagh, Sakinaka, Wadala and Andheri areas. Dharavi is the most active of these areas with many micro-entrepreneurs recycling plastic waste, and is believed to recycle a substantial portion of the city's plastic waste.[31] Mumbai does not have many registered recyclers and many of these are small. The plastic waste is also transported to Gujarat, a state with one of India's recycling hubs and is located about 120 km from Mumbai.

Currently any plastic waste that is not recovered is landfilled at one of two landfill sites. The largest (and oldest) of these is the Deonar site, located in an eastern suburb of the city, Shivaji Nagar. Options for WtE treatment have been explored and there are plans for a 600 MT/d facility to be situated at the Deonar landfill.[32] Another potential site could be the Mulund landfill site, which is now closed and could be used for landfill mining.

Mumbai's recycling rate is considerably lower than that in Delhi, which is likely due to the lower collection rates and the lower coverage of the city by waste pickers and sorting at MRFs, or a lack of demand from local recyclers as plastic waste is being transported to Gujarat for recycling. The collection and aggregation part of the supply chain seems to be less efficient than in Delhi, and MRF sorting needs to be improved to increase the amount of plastic waste made available for recycling.

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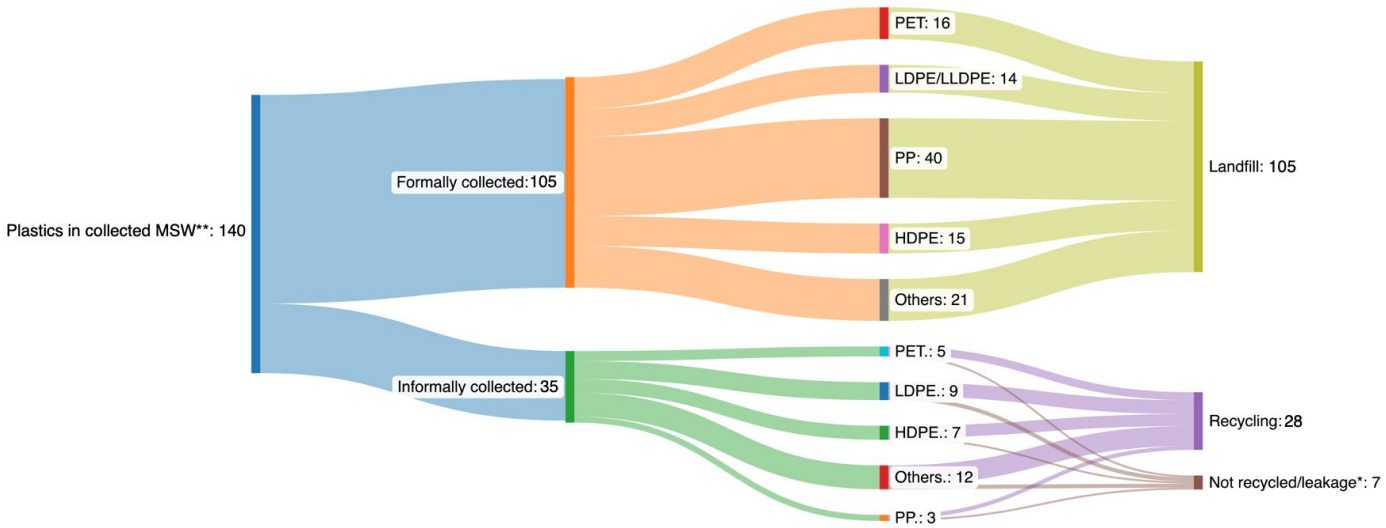
[31] KNN – *There are hardly any plastic processing units in Dharavi: Study (2016).*

[32] Mid-day, Mumbai – *After bio-waste plant, Deonar waste-to-energy plant also spells trouble (2022).*

Insights on local plastic recycling supply chains in Chennai

Recycling rates of collected plastic waste in Chennai are estimated to reach 20% (equivalent to 28 KT/yr), which is comparable to Mumbai as Chennai has a similar plastic content in the MSW, as well as comparable coverage of waste pickers in relation to the population. An estimated 20-25% of the MSW is collected by waste pickers in Chennai, which will be mostly recycled.[33]

Figure 8: Flow of plastic within municipal solid waste in Chennai (thousand tonnes per year). Figures are rounded to the nearest whole number and may not sum because of rounding. * 'Not recycled/leakage' refers to plastic waste collected, but not recycled due to contamination or the collectors being unable to sell low-value plastics to aggregators. ** The share of plastics collected in Chennai is calculated based on 96% MSW collection rate.



The Greater Chennai Corporation oversees MSW management in Chennai and outsources collection and transportation to private companies. Waste management in seven out of the 15 administrative zones is outsourced under an 8-year contract to Urbaser-Sumeet and the remaining zones are managed by Ramky under a 7-year contract.[34] [35]

In 2016, the city corporation made it mandatory for households to segregate waste into dry, wet, and hazardous waste in color-coded bins provided by the municipality in line with SWM Rules implemented by the Tamil Nadu Pollution Control Board. To support the rollout of mandatory waste separation, contracts with Urbaser-Sumeet and Ramky involve handing out penalties to households that fail to separate waste, with a target of 100% waste segregation at source. Details on the penalties have yet to be determined and the rollout and implementation time frame is not known.[36]

In addition, the Greater Chennai Corporation launched a 'Zero Waste Initiative' involving segregating and treating solid waste and including a ban on single-use plastic (SUP) rolled out by the Government of Tamil Nadu. There are a recorded 28 SUP product types included in the ban; these include films, plastic bags, food packaging, and others.[37] This is estimated to have reduced plastic use in Chennai by 5-10% since inception in 2019.[38]

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[33] Interviews with local value chain participants, October 2022.

[34] The Hindu Business Line – *Ramky Enviro in 7-year waste management contract in Chennai (2021).*

[35] Urbaser – *Urbaser Extends its International Presence with New Contracts in Asia and Latin America (2020).*

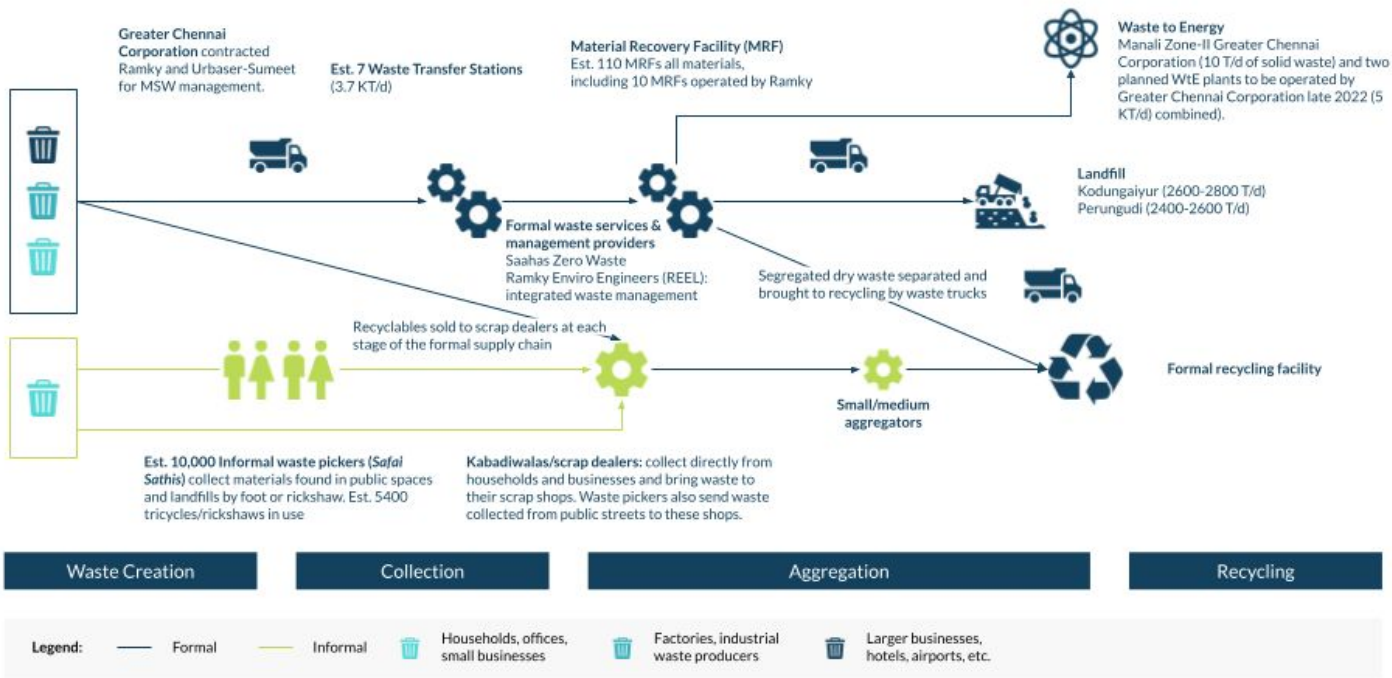
[36] Times of India – *Chennai's waste management to go hi-tech (2020).*

[37] Government of Tamil Nadu – *Details of Banned Items by Government of Tamil Nadu and MoEF & CC (2022).*

[38] Times Now News – *Zero Waste Initiative: Chennai civic body's exemplary move to reduce plastic waste (2019).*

In Chennai, an estimated 95% of households are covered by door-to-door collection.[39] Formal MSW collection in Chennai is managed by Ramky and Urbaser-Sumeet. The organization has 850 collection trucks in the city collecting mixed waste, which is sent to seven transfer stations with a total capacity of 3.7 KT/d.[40]

Figure 9: The plastic waste supply chain in Chennai.



There are an estimated 110 MRFs in Chennai managed by the Greater Chennai Corporation, 10 of which are operated by Ramky.[41] From MRFs, waste is sent to Chennai's two landfills: Kodungaiyur (2.6-2.8 KT/d of waste received) and Perungudi (2.4-2.6 KT/d of waste received). Waste is also sent to a WtE plant operated by the Greater Chennai Corporation in Manali Zone-II with a capacity of 10 T/d. Two additional WtE plants owned by the Greater Chennai Corporation are planned with a combined capacity of 5 KT/d.[42] The Chennai Corporation and Entice Renewable Energy plan to build a pyrolysis plant capable of processing 7.3 KT/yr of mixed plastic waste.[43]

Informal waste collection drives recycling in Chennai, with an estimated 10,000 waste collectors, 5,400 of which are expected to transport waste using tricycles or bicycles. Recyclable plastic waste is sold to scrap dealers, who separate plastic into different streams to be sold to aggregators.

Unlike Delhi and Mumbai, Chennai does not seem to have any large aggregators, thus smaller recyclers often buy plastic waste directly from scrap dealers or informal sector organizations.[44] For example, Kabadiwalla Connect is a key social enterprise in Chennai that supports waste collectors and aggregators. The organization has traced aggregators and pickers using a geo-spatial mapping approach and estimates that Chennai has 2,500 aggregators, who are buying and selling 130 KT/yr of recycled waste.

The recycling industry in Chennai focuses mainly on rigid plastics as there are few flexible plastic recyclers; however, some flexible plastic waste collected in the city is transported to the state of Gujarat for recycling. Plastic waste also travels all the way from Chennai to Gujarat – an estimated >1,200 km from the East coast to the West coast.

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[39] Greater Chennai Corporation – *Solid Waste Management (2022).*

[40] Greater Chennai Corporation – *Solid Waste Management (2022).*

[41] Tamil Nadu Pollution Control Board – *Letter No. T1/TNPCB/PWM/F.31251/2011 (2021).*

[42] Central Pollution Control Board Delhi - *Annual Report 2019-20.*

[43] New Indian Express – *Pyrolysis plant to make oil and carbon from 20 tonnes of plastic a day (2022).*

[44] Interviews with local value chain participants, October 2022.

Analysis of pricing and pricing transparency along the value chain[45]

The amounts and types of plastic waste collected for recycling are dependent on the value of the polymer at different stages of the value chain and the level of pricing transparency.

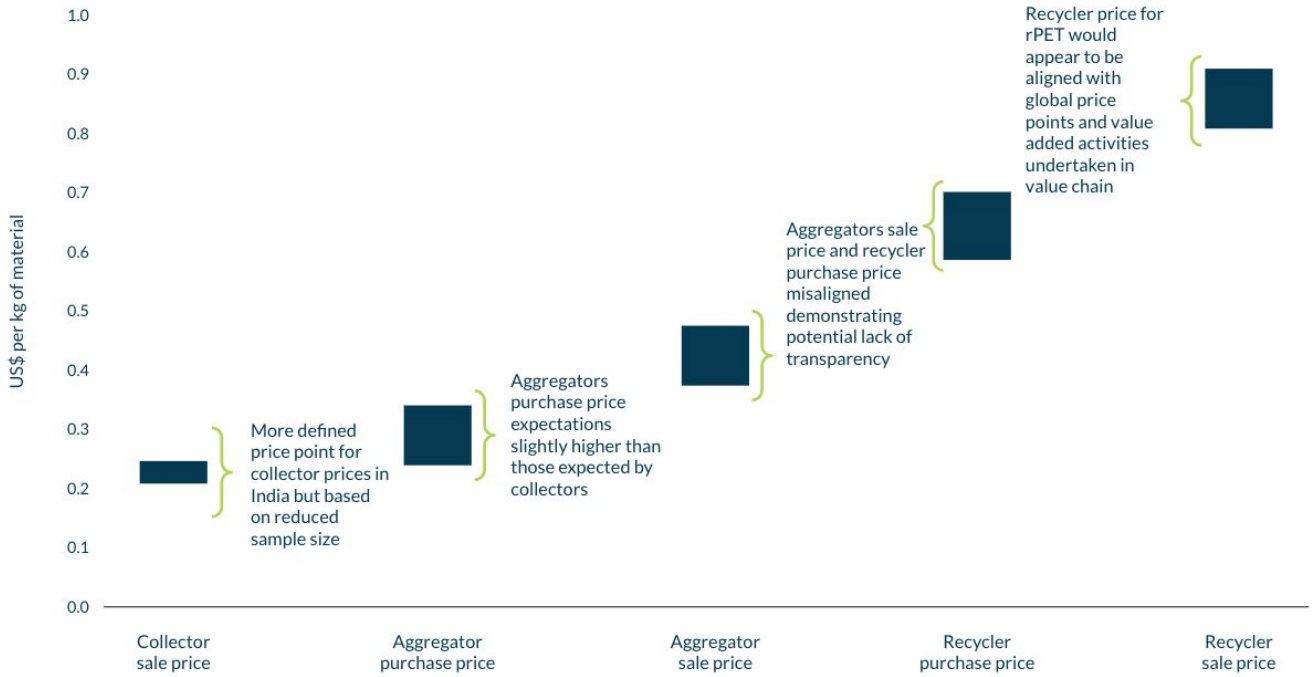
Pricing transparency refers to the degree to which pricing information is available to all buyers and sellers in a market. High levels of pricing transparency ensure healthy competition, efficient markets, and better pricing of products and is often considered an indicator of an efficiently operating supply chain, which enables growth.

The sample data collected through interviews in India limits the ability or level of comfort in sharing pricing data for all polymers. Full supply chain data has only been presented for PET in this report. This may demonstrate a lack of transparency, or a more competitive market where pricing is more commercially sensitive, as well as more localized and fragmented in the individual wastesheds. The data collected for PET highlights a more conventional market structure with price points consistent with a value chain where each actor may determine prices based on their value-added activities. This idea is demonstrated by the conventional waterfall shape presented in Figure 10, which shows a distinct step up in pricing, reflecting costs and added value at each stage of the supply chain.

In the data, however, there are still some inconsistencies among the value chain stakeholders regarding the anticipated sale and purchase price. The difference between the aggregator sale price and recycler purchase price is the most prominent example, where recyclers quote a higher price paid for PET feedstock than aggregators claim they sell it for. In addition, in some wastesheds there are traders or agents acting as final aggregators or links to recyclers, by buying plastics from aggregators to sell to recyclers without adding actual value to the material in the supply chain, but taking a margin for their services.

[45] The findings presented in this section of the report are an extract from a pricing and policy interventions analysis on the recycled plastics value chain that was undertaken by The Circulate Initiative in parallel to this study. The results are published separately from this report.

Figure 10: India PET pricing information from research and stakeholder interviews.



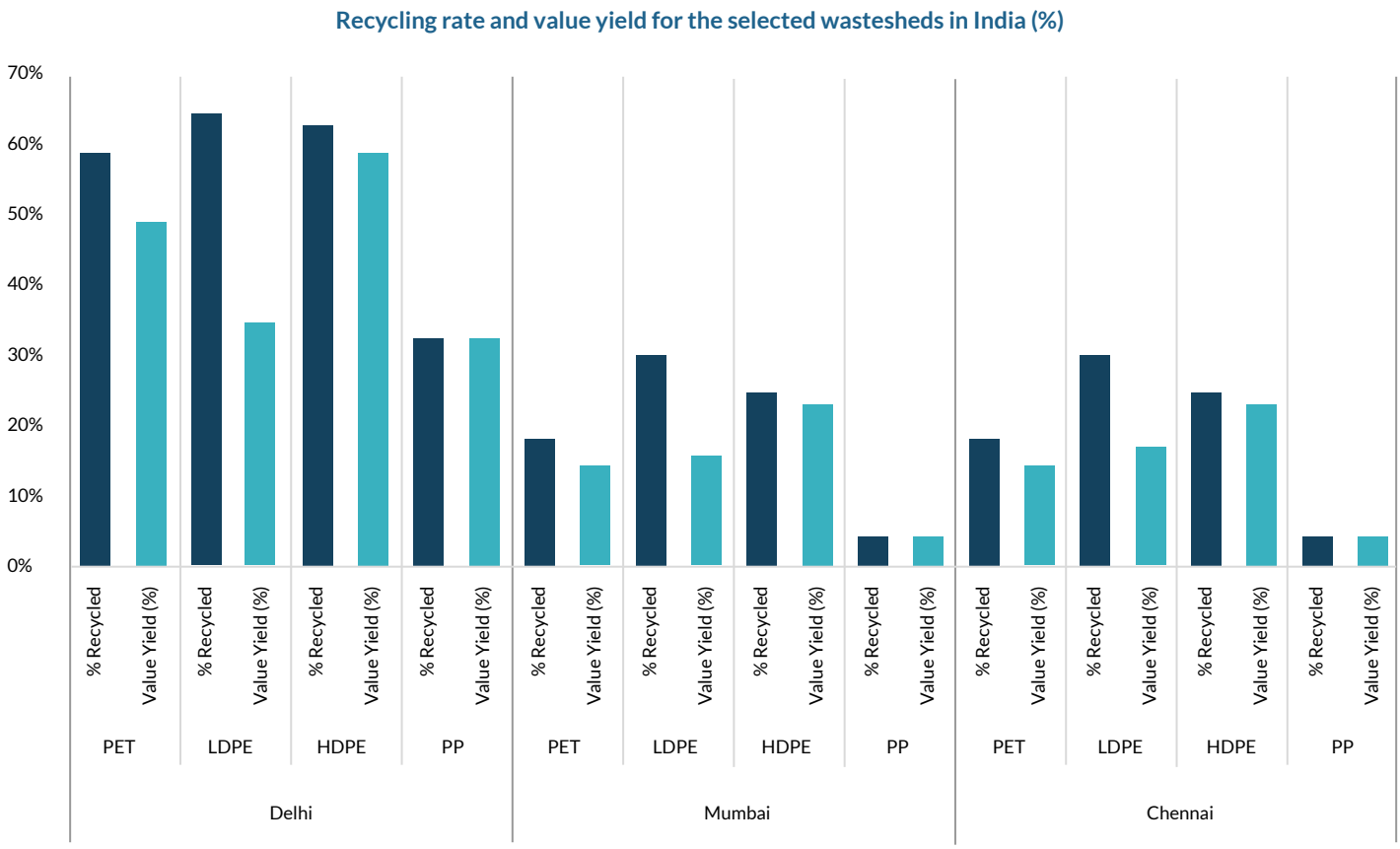
The plastic waste supply chains in the three wastesheds in India indicate an imbalance in market power, which mostly benefits recyclers in the supply chain and negatively impacts collectors and aggregators. Analysis of supply chain actor profit margins (as a proxy for market power) drawn from the survey data estimates that 70-80% of the total trade benefits in the value chain are attributable to the recyclers, while the remainder is split between aggregators and collectors. It is also evident that a large proportion of market power is retained by recyclers, and this is comparable to other geographies reviewed. Consequently, any price increases associated with the final output products will not easily flow back to the earlier stages of the value chain, such as the collectors. However, a more direct link between recyclers and collectors, reducing the number of aggregators active in the supply chain, may influence the high upper range of price points presented by collectors in India as they have greater knowledge of the value of the end-product. This affects the amounts, formats, and polymers collected in the supply chain.

In principle, virgin and recycled PET, HDPE, PP, and LDPE are commodities that are traded in well understood markets, where values are influenced by virgin polymer prices and recyclate quality that should filter back into supply chains.

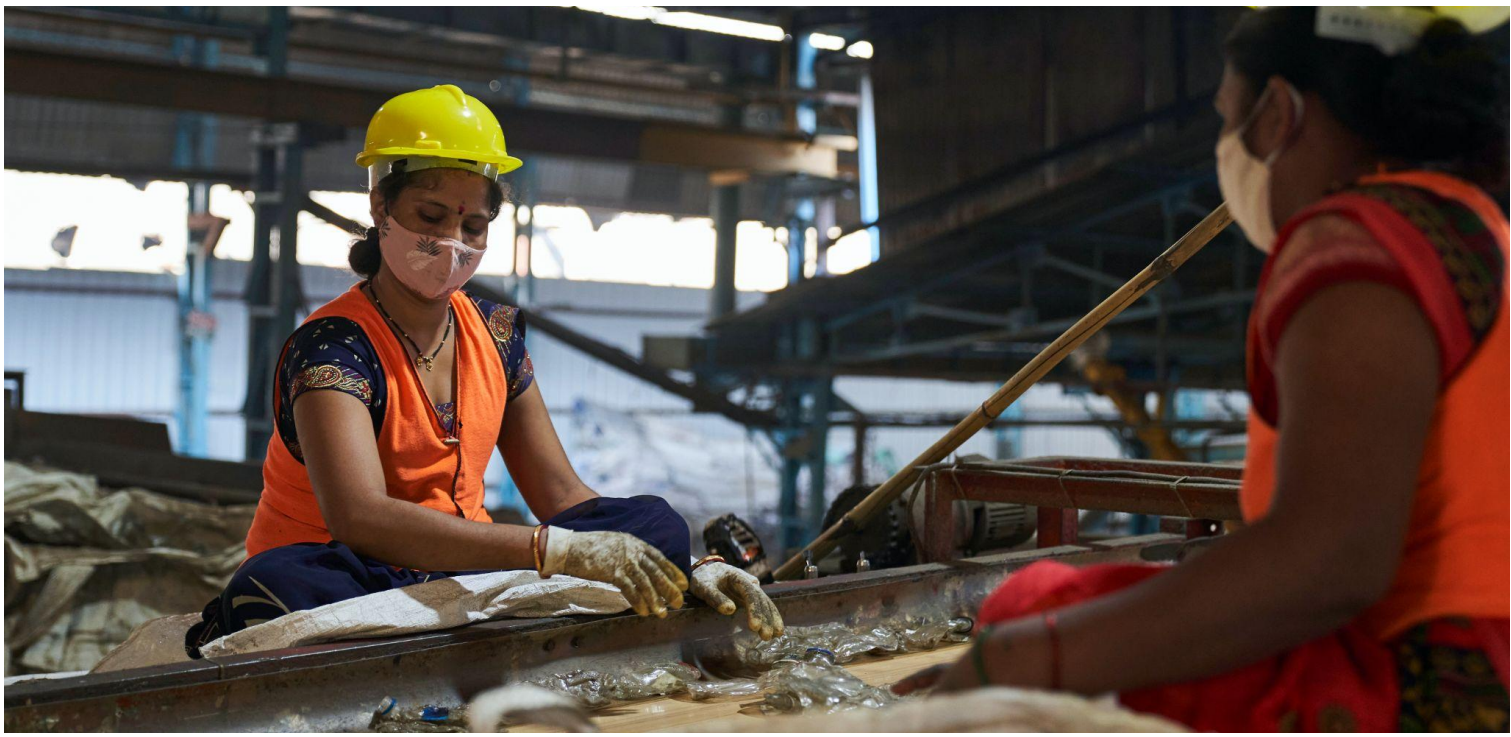
The comparison between estimated recycling rates and value yields (value of recycled plastics using recycled pricing vs. value of plastics collected using virgin prices) has been produced for recycled PET, LDPE, HDPE, and PP for Mumbai, Delhi, and Chennai.

While the recycling performance remains high for PET, it is less capable of retaining the value of the material than rHDPE and rPP, which might be due to general market prices or quality of the recyclate. This is demonstrated by how aligned the volume of material recycled and the value yield for each polymer are. In the case of PP, the complete alignment between volume of material recycled and value yield demonstrates that for each tonne of PP recycled, the market value at the end of the recycling process is comparable to that of the virgin polymer and there is full value retention.

Figure 11: Plastic recycling rates vs. value yields in India.



Sources: Recycled pricing for individual polymers were obtained from research and interviews conducted. Virgin prices are virgin polymer price points from local producers (pre-Covid-19) from Circulate Capital - Safeguarding the Plastic Recycling Value Chain: Insights from Covid-19 impact in South and Southeast Asia (2020).



SUPPLY CHAIN ASSESSMENT

This section provides an overview and comparison of key aspects of the local plastic waste recycling supply chains in each wasteshed and the current barriers to recycling. An evaluation of each wasteshed in terms of different criteria identified to assess a well-functioning supply chain is presented in Table 2.

These indicators include the collected for recycling (CFR) rate, types of processes and infrastructure available, pricing transparency and regulatory framework. A high (green), moderate (amber), and poor (red) rating is assigned to each indicator depending on the status of the wasteshed, with a fuller description of the indicators provided in Appendix 1.

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Table 2: Evaluation of supply chains in Delhi, Mumbai and Chennai using a red, amber, green rating approach.

Region	CFR Rate	Market Structure - Collection	Market Structure - Aggregation & Sorting	Market Structure - Recycling
	Main polymers being recycled are PET, LDPE and HDPE, but also some PP mainly via the informal sector. However, majority of plastics is disposed in landfills or leaked into the environment.	State and city administration provide collection services, but mainly rely on the informal sector to collect recyclables.	Multitude of transfer, bulking and potential sorting stations (MRF) at ward and city level. However, there is no data or evidence that these extract recyclables before landfill disposal or being sent to WtE facilities.	Formalized recycling infrastructure with medium to large scale recyclers for a wide range of plastics, but majority of recyclers process rigid plastics e.g. PET, HDPE, PP.
Delhi	60%	The five municipal zones provide key waste services and contract with private sector providers. Est 500,000 informal waste collectors.	Est. 30 transfer stations and ~150 MRFs. These facilities mainly remove organic/ wet waste for composting, with limited sorting of recyclables and plastics.	Nationally, an est. 70% of plastics is collected and expected to be recycled in formal plants, 20% in informal and 10% reused / repurposed.
Mumbai	20%	Brihanmumbai Municipal Corporation (BMC) is the key waste service agency. Est. 20,000 informal waste collectors.	Est. 4 large scale transfer stations and an unknown number of MRFs. These facilities mainly remove organic/ wet waste for composting, with limited sorting of recyclables and plastics.	Nationally, an est. 70% of plastics is collected and expected to be recycled in formal plants, 20% in informal and 10% reused / repurposed.
Chennai	20%	Greater Chennai Municipal Corporation has a service contract with private waste providers Urbaser-Sumeet and Ramky. Est. 10,000 informal waste collectors.	Est. 7 transfer stations and ~110 MRFs (incl. 10 MRFs operated by Ramky). These facilities mainly remove organic/ wet waste for composting, with limited sorting of recyclables and plastics.	Nationally an est. 70% of plastics is collected and expected to be recycled in formal plants, 20% in informal and 10% reused / repurposed.

Legend: High Moderate Poor

Region	Pricing Transparency	Knowledge Gaps & Data Availability	Value Yield & Quality of Outputs	Regulatory Framework
	Poor pricing transparency with high number of informal collectors and aggregators as well as informal and formal recyclers.	Limited data availability. Main data sets were derived from a literature search of recent studies and supported by interviews.	There is considerable value loss for both rigid and flexible plastic waste. Plastic value loss has been defined as the value of plastic collected based on virgin pricing against the value of plastics recycled based on recyclates prices for individual polymers.	Various regulations have been in place since the early 2000s, including taxes, EPR implementation and rules for MSW management.
Delhi	Market power or share of the profit margins/trade benefits held by recyclers/large aggregators ranges between 70 -80%.	0-5 city studies on plastic waste generation, collection and treatment. Limited information on plastics recycling, informal sectors contribution and recycled polymer breakdown.	Est. value yields: 49% PET, 59% HDPE, 36% LDPE, 33% PP	Several regional regulations, including the Plastic Bag Act.
Mumbai	Market power or share of the profit margins/trade benefits held by recyclers/large aggregators ranges between 70 -80%.	0-5 city studies on plastic waste generation, collection and treatment. Limited information on plastics recycling, informal sectors contribution and recycled polymer breakdown.	Est. value yields: 15% PET, 24% HDPE, 17% LDPE, 5% PP	Limited regional regulations.
Chennai	Market power or share of the profit margins/trade benefits held by recyclers/large aggregators ranges between 70 -80%.	0-5 city studies on plastic waste generation, collection and treatment. Limited information on plastics recycling, informal sectors contribution and recycled polymer breakdown.	Est. value yields: 15% PET, 24% HDPE, 17% LDPE, 5% PP	Limited regional regulations.

Legend: High Moderate Poor

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Table 2: Evaluation of supply chains in Delhi, Mumbai and Chennai using a red, amber, green rating approach.

Region	CFR Rate	Market Structure - Collection	Market Structure - Aggregation & Sorting	Market Structure - Recycling
	Main polymers being recycled are PET, LDPE and HDPE, but also some PP mainly via the informal sector. However, majority of plastics is disposed in landfills or leaked into the environment.	State and city administration provide collection services, but mainly rely on the informal sector to collect recyclables.	Multitude of transfer, bulking and potential sorting stations (MRF) at ward and city level. However, there is no data or evidence that these extract recyclables before landfill disposal or being sent to WtE facilities.	Formalized recycling infrastructure with medium to large scale recyclers for a wide range of plastics, but majority of recyclers process rigid plastics e.g. PET, HDPE, PP.
Delhi	60%	The five municipal zones provide key waste services and contract with private sector providers. Est 500,000 informal waste collectors.	Est. 30 transfer stations and ~150 MRFs. These facilities mainly remove organic/ wet waste for composting, with limited sorting of recyclables and plastics.	Nationally, an est. 70% of plastics is collected and expected to be recycled in formal plants, 20% in informal and 10% reused / repurposed.
Mumbai	20%	Brihanmumbai Municipal Corporation (BMC) is the key waste service agency. Est. 20,000 informal waste collectors.	Est. 4 large scale transfer stations and an unknown number of MRFs. These facilities mainly remove organic/ wet waste for composting, with limited sorting of recyclables and plastics.	Nationally, an est. 70% of plastics is collected and expected to be recycled in formal plants, 20% in informal and 10% reused / repurposed.
Chennai	20%	Greater Chennai Municipal Corporation has a service contract with private waste providers Urbaser-Sumeet and Ramky. Est. 10,000 informal waste collectors.	Est. 7 transfer stations and ~110 MRFs (incl. 10 MRFs operated by Ramky). These facilities mainly remove organic/ wet waste for composting, with limited sorting of recyclables and plastics.	Nationally an est. 70% of plastics is collected and expected to be recycled in formal plants, 20% in informal and 10% reused / repurposed.

Legend: High Moderate Poor

Region	Pricing Transparency	Knowledge Gaps & Data Availability	Value Yield & Quality of Outputs	Regulatory Framework
	Poor pricing transparency with high number of informal collectors and aggregators as well as informal and formal recyclers.	Limited data availability. Main data sets were derived from a literature search of recent studies and supported by interviews.	There is considerable value loss for both rigid and flexible plastic waste. Plastic value loss has been defined as the value of plastic collected based on virgin pricing against the value of plastics recycled based on recyclates prices for individual polymers.	Various regulations have been in place since the early 2000s, including taxes, EPR implementation and rules for MSW management.
Delhi	Market power or share of the profit margins/trade benefits held by recyclers/large aggregators ranges between 70 -80%.	0-5 city studies on plastic waste generation, collection and treatment. Limited information on plastics recycling, informal sectors contribution and recycled polymer breakdown.	Est. value yields: 49% PET, 59% HDPE, 36% LDPE, 33% PP	Several regional regulations, including the Plastic Bag Act.
Mumbai	Market power or share of the profit margins/trade benefits held by recyclers/large aggregators ranges between 70 -80%.	0-5 city studies on plastic waste generation, collection and treatment. Limited information on plastics recycling, informal sectors contribution and recycled polymer breakdown.	Est. value yields: 15% PET, 24% HDPE, 17% LDPE, 5% PP	Limited regional regulations.
Chennai	Market power or share of the profit margins/trade benefits held by recyclers/large aggregators ranges between 70 -80%.	0-5 city studies on plastic waste generation, collection and treatment. Limited information on plastics recycling, informal sectors contribution and recycled polymer breakdown.	Est. value yields: 15% PET, 24% HDPE, 17% LDPE, 5% PP	Limited regional regulations.

Legend: High Moderate Poor

THE NEED FOR INTERVENTION

Recognizing the gaps that are limiting the effectiveness of existing local plastic waste recycling supply chains across the wastesheds, this section outlines the need for intervention in terms of collection and aggregation, plastic recycling and reprocessing, and municipal solid waste treatment.

Collection and Aggregation

There is high reliance on the informal waste workers to collect and sort plastic waste in all three wastesheds, but while Delhi has high plastic recycling rates, the wastesheds in Mumbai and Chennai are not performing as well. Key challenges in the wastesheds are:

- Delhi has limited source segregation of waste and mixed or low-value plastics are often left in the MSW and transferred to landfills. In addition, the diverse waste collection methods across the five municipal zones lead to different performances in source segregation and collection across the city, depending on the system and the collectors.
- Mumbai relies on informal collectors for door-to-door collection, and sorting for transfer and recycling as some areas are not accessible to the vehicles used by the BMC. Despite policies for bulk waste generators to segregate wet waste, there has been a lack of enforcement and compliance. Additionally, MRFs in Mumbai have different processes and levels of automation, resulting in varied capabilities.
- In Chennai, the research suggests that an estimated 90% of waste is still collected without source segregation, which means mixed or low-value plastics are often left in the MSW and transferred to landfills. The waste contractors are to impose source segregation at household level, but the implementation seems to be delayed.

The formal and informal collection systems both have a role to play across all three wastesheds, with waste workers employed by the municipality or ULBs and private contractors picking up mixed waste (wet and dry fractions) for transport to MRFs and transfer stations, while informal waste collectors focus on valuable waste streams (e.g., plastic, paper, and metal) for recycling.

In addition, the multiple levels of aggregation in the Indian wastesheds lead to very fragmented supply chains, with plastic waste going to scrap dealers, aggregators, and agents/brokers before reaching sufficient volumes of individual polymer streams to be sold to recyclers. This is driven, firstly, by a lack of space as bulking and storage are limited in the cities. Secondly, the different aggregation levels are bridging payment/credit chains between the waste collectors' need to be paid directly on delivery and recyclers' requirement to source minimum volumes weekly or monthly at good prices along the value chain.

Plastic Recycling and Reprocessing

Across the wastesheds, the reliance on informal collection and trading limits the scale-up of recycling infrastructure. Recyclers are challenged with ensuring security of feedstock supply in terms of quantity, quality and pricing as most facilities would engage a number of aggregators who in turn receive plastic waste feedstock from various sources with potentially differing qualities and pricing.

In Delhi, the locations for recycling are small and the lack of space makes it difficult for recyclers to expand their operations. Additionally, with no expectation for materials at MRFs to be sent for recycling, only a small percentage of plastics get sold for recycling through multiple levels of aggregation, contributing to the lack of feedstock supply security for recyclers.

The recycling industry in Mumbai is still broadly informal and run by small players, and a lot of plastic waste is being transported from Mumbai to Gujarat, which is one of the key recycling hubs in India, indicating a lack of demand from local recyclers in Mumbai.

Anecdotally, recyclers in Chennai face a lack of access to high quality waste from households in the absence of implementation of source segregation measures. Plastic waste is also transported over large distances from Chennai in the East coast to Gujarat in the West coast, similarly indicating a lack of demand from local recyclers.

Municipal Solid Waste Treatment

All three wastesheds currently rely on landfills for the majority of MSW disposal, with two to three operational landfills in each area. However, as seen in Delhi with the recent closing of two landfills after reaching maximum capacity, and similar issues in Chennai and Mumbai with landfills nearing full capacity, there is a clear incentive for alternative waste management solutions to divert waste from landfills.

Due to planned or unplanned landfill closures and the recognition of the environmental impact of landfilling, there has been significant investment in WtE plants across all of the wastesheds. While WtE plants divert waste from landfills, they also reduce the opportunity for waste picking from landfills. Instead, they could provide opportunities to install centralized recyclables sorting equipment, or MRFs at the WtEs to improve recycling rates. However, the reduction of plastic waste in the mixed MSW going to WtE might change waste composition and the energy content, which could impact the WtE plant performance.

Recommendations for interventions

This section summarizes interventions that could be considered to improve local plastic waste recycling supply chains in terms of: improving collection rates, increasing sorting and segregation of plastics for recycling, and enabling growth in plastics recycling for a circular economy. The interventions are aimed at governments and industry to improve supporting regulatory and social conditions to create a stable policy framework. They cover financial interventions to improve value creation from plastic waste, as well as technical and digital improvements to increase supply chain efficiency.

The interventions presented in this section are generally similar as most wastesheds in a country encounter common challenges in terms of infrastructure gaps, fragmented supply chains, limited enforcement of regulations, and imbalance of market power between value chain stakeholders. Where appropriate, examples of models or interventions that could be applied in specific wastesheds are highlighted. The implementation pathways for these interventions were not part of the study and are not outlined in detail. Key interventions for consideration are summarized in Table 3 and described in more detail in the following sections.

Table 3: List of potential interventions to improve plastics recycling and increase value creation along the supply chain.
Legend: Primary interventions/*(Secondary interventions)*.

	Intervention categories →		
Desired supply chain impacts ↓	1. Improve supporting regulatory and social conditions to create a stable policy framework	2. Financial interventions to improve value creation from plastic waste	3. Technical and digital improvements to increase supply chain efficiency
Improve collection rates of plastics	Implement (harmonized) source segregated collection and EPR systems	Support payment of informal sector (fair and prompt payment)	*(Digitize recyclable collection and material tracing, linked to material quality and level of segregation)*
	(Improve welfare standards of informal workers e.g., annual health check-ups, PPE, insurance etc.)	Market incentive payments for hard to recycle, low-value waste formats and polymers	
		(Subsidize formalization of informal pickers e.g., cooperatives, tax payments, permits, share EPR fees)	
Improve sorting of polymers and quality for recycling	Introduce sorting and segregation quality standards for key waste streams (as part of an EPR system)	Tax relief for sorting and segregation equipment and facilities	Upgrade existing sorting facilities with automated equipment
		Support payment of informal sector –financial incentives for high-quality recyclables	*(Digital certification and tracing of sorted plastics waste and polymers)*
	(Mandate design for recycling standards to improve plastic and polymer separation as part of EPR)	*(Plastic collection and sorting credits/incentives through EPR system)*	*(Fund paid for private industry to provide grants for small-scale equipment: balers, sorting bays/containers, transport)*
		(Subsidize formalization of informal or small-scale aggregators e.g., cooperatives, tax payments, permits)	
Increase demand from plastic recyclers	Mandate recycled content targets in key applications (incl. rigid and flexible packaging)	Invest in medium- to large-scale plastics recycling of mixed and hard to recycle plastics	R&D funding for innovative plastics recycling technologies
	Landfill disposal limits or bans, limitation of recyclables to WtE plants (pre-processing requirements for residual/wet waste)	Taxation of virgin content or tax relief for recycled content	
		(Quality standards for recycled plastics incentivizing circular recycling e.g., plastic credits for hard to recycle plastics, high recycling yields, closed loop recycling)	

IMPROVE COLLECTION RATES OF PLASTICS

The limited availability of source segregation at household level in the three wastesheds is partially compensated for via the informal waste collectors and respective aggregators and traders. From a recycling perspective, this approach is relatively successful and results in high collection and medium to high recycling rates for plastic waste, depending on the coverage and efficiency of the informal waste collectors. However, as small amounts of plastic waste is being traded multiple times before it reaches recyclers, there is an opportunity to shift these informal supply chains towards a more efficient one.

The success of the micro-entrepreneurial system of informal collectors and aggregators has considerable consequences in terms of welfare standards of informal workers, such as limited access to annual health check-ups, PPE, and insurance. One of the key interventions would be to improve their welfare standards and provide support to raise welfare levels, literacy rates, and social security for the informal sector. This would improve the working environment for these workers, as well as help to address environmental pollution from informal aggregation and recycling. This needs to be coupled with a fair payment system that creates sufficient income to raise welfare, working, and living standards. Market incentive payments for PE film and other polymer streams via plastic credit systems or via digital platforms and market systems are some initiatives that can support the upliftment of informal workers.

There are numerous programs and joint activities between public and private sectors which are being carried out to address the environmental and welfare issues of these informal systems. An example is the UNDP Plastic Waste Management Program, which is currently operational in 35 cities, partnering with corporates and ULBs for sustainable waste management practices. The project has reached out to 5,000 Safai Saathis to institutionalize workers from the informal sector.

These efforts are further supported by Hindustan Unilever through the set-up of four Swachhta Kendras in Mumbai, or accessible recycling centers for waste collectors. In other parts of India, Recykal Foundation connects these centers digitally to Recykal's network, enabling direct payment of waste collectors (or *Safai Mitras*) to increase access to fair and transparent payment and incentivize collection of good-quality recyclables.

Since 2011, there have been challenges around the implementation of EPR. Overall, India has a variety of registered PROs[46] ranging from administrative and consulting companies organizing EPR compliance to companies setting up take-back schemes (reverse logistics) and operating recycling plants. In order to experience the benefits of EPR, several interventions are necessary:

- Address awareness gaps amongst various stakeholders, and in particular waste collectors on source segregation, recyclability, and the value of the different plastic waste types.
- Create adequate collection, sorting, and recycling infrastructure and capacity at local level.
- Monitor enforcement and design of business models that integrate the informal sector into the formal plastic waste management initiatives.
- Expand the focus of EPR across the entire value chain to include upstream design and material use considerations.
- Promote innovations that are product delivery-related, for example, along the use-phase.[47]

A number of digital solutions are already being used to improve the management of plastic waste, particularly incentivizing take-back. Future work could be undertaken to further develop this and to help improve pricing transparency, to show prices that can be expected from aggregators and provide virtual marketplaces for material to help increase availability and reduce use of imports.

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[46] Central Pollution Control Board – *Producer Responsibility Organisation (PRO) registered with CPCB (2022).*

[47] TERI – *Circular Economy for Plastics in India: A Roadmap (2021).*

IMPROVE SORTING OF POLYMERS AND QUALITY FOR RECYCLING

Basic sorting of plastic waste is carried out at the collector level to generate the best price for the waste when sold to the aggregator. Aggregators perform further sorting into the finer categories as part of their quality process before selling plastic waste to recyclers. Some waste makes its way to an MRF where sorting is primarily a manual process, but some are equipped with conveyor belts for more efficient manual picking, and some have pre-processing equipment such as shredders and balers.

The difference in capabilities means some MRFs achieve a higher level of segregation of recyclables than others. In order to improve sorting of recyclables and potential for recycling, sorting and segregation quality standards could be put in place as part of the EPR system, or more broadly. This could include a mandate on how sorting and segregation is carried out at MRFs across wastesheds, which will improve the quality of sorting and the condition of the waste before it is sent to recyclers.

Further support for the MRFs in terms of tax relief for sorting equipment, and additional funding and grants for more sophisticated and automated sorting equipment would increase the efficiency and throughput of the MRFs and increase consistency of quality plastic waste streams. If complemented by the standard operating procedures for sorting and clearly defined processes to meet quality requirements, this would provide more secure and better working conditions for waste workers, as well as upskilling and educational opportunities e.g., numeracy and literacy skills required to operate machinery and equipment.

Supporting the informal collectors at the beginning of the value chain is key to improving the quality of waste collected for recycling. Financial incentives can be offered to collectors, scrap dealers or smaller aggregators to increase collection of high-quality recyclable materials, and hard-to-recycle plastics.

INCREASE DEMAND FROM PLASTIC RECYCLERS

A collection system that purely relies on informal collection and trading also limits the scale-up of the recycling infrastructure as most facilities will use a number of agents/aggregators who need to source plastic waste feedstock from a wide range of sources with potentially differing qualities and pricing. This impacts the security of supply and potentially the economic viability of existing recycling plants, but in particular the expansion of recycling infrastructure and the ability to secure funding for new and potentially larger recycling plants with economies of scale. In addition, new facilities are struggling to receive investment without being able to evidence a secure feedstock supply in terms of quantity, quality, and pricing.

EPR is creating change, such as through mandating recycled content targets in key applications. To date, only an estimated 10% of plastic processors needed to meet the 2 MT EPR compliance requirements for brands who have registered with the CPCB; however, this is growing.[48] The growing demand for recycled plastics stimulated through EPR drives the set-up of new supply chains via PROs or encourages key recyclers and brands to put their alternative supply chains in place as per the following examples:

- There are an estimated 20 or more PROs registered in India. However, a notice issued by the CPCB in May 2019 states that the registration of PROs is no longer required and therefore producers and other stakeholders can plan their EPR compliance as they see fit.[49] PROs provide aggregation and traceability. For example, the PRO GEM Enviro Management Pvt Ltd collects and processes waste on behalf of companies such as Coca-Cola, Bisleri, PepsiCo, and Google, and is expected to recycle 500 T/month of plastic waste through its partnership with Ganesha Ecosphere. The company is using a 'reverse vending' approach (a machine costs up to 5 lakhs and can take 500 PET bottles per day, dispensing rewards to users), and there are more than 50 collection centers in 15 states in India.[50]

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[48] Ministry of Environment, Forest and Climate Change, Government of India - *Centralized Extended Producers Responsibility Portal for Plastic Packaging (2022).*

[49] CPCB - *Notice for Withdrawal of PROs by CPCB (2019).*

[50] The Better India – *Start-up Helps Recycle 100K Tons of Plastic Waste Into Bags & Shirts (2019).*

- Reliance Industries Ltd recycled 2.2 billion plastic bottles and has 150 collection centers across the country. Reliance's PET bottle collection initiative directly and indirectly provides employment to around 300,000 informal waste collectors. The majority of recycling being carried out is at Reliance's Barabanki, Hoshiarpur and Nagothane plants, but the company is also planning to build a new recycling plant in Andhra Pradesh to double its recycling capacity from approximately 22,000 T/d currently to nearly 50,000 T/d of PET recycling in future.[51]

In addition, many interviewees mentioned that there should be an adjustment of the 18% GST tax rate. The current tax applies to both virgin and recycled plastics, and therefore does not encourage the use of recycled plastics or provide an advantage when trading recycled plastics throughout the value chain.

[51] Algosonline – *Reliance Industries to set up PET recycling plant of 5 billion bottles (2021).*

Conclusion

The reviewed wastesheds in India have well-established informal plastic waste recycling systems, which enable considerable amounts of plastic recycling to be carried out via a network of entrepreneurial relationships and micro-businesses, especially in Delhi.

However, these informal systems also have environmental and welfare issues, which need to be addressed in due course via collaboration between the public and private sectors. There are numerous programs and joint activities currently underway, such as the UNDP Plastic Waste Management Program and supporting efforts by Hindustan Unilever and Recykal Foundation.

The supporting regulatory framework (e.g, Swachh Bharat SWM Rules, EPR) is one of the key drivers for improving the wastesheds' sorting infrastructure and potentially channeling a supply of plastic waste from the 'formal' sector via MRFs and transfer stations. This could provide considerable scale-up for the plastics supply chain across the wastesheds. In addition, further infrastructure seems to be required in Mumbai and Chennai as plastic waste is currently transported to Gujarat for recycling.

References

Algosonline. (2021). *Reliance Industries to set up PET recycling plant of 5 billion bottles* [Online]. Available at: https://www.algosonline.com/news/reliance-industries-to-set-up-pet-recycling-plant-of-5-billion-bottles (Accessed: October 2022).

Business Standard. (2022). *Plastic waste management* [Online]. Available at: https://www.business-standard.com/topic/plastic-waste-management (Accessed: October 2022).

Central Pollution Control Board. (2019). *Notice for Withdrawal of Producer Responsibility Organizations (PROS) by CPCB* [Online]. Available at: https://cpcb.nic.in/uploads/plasticwaste/Notice_PRO_Withdrawal.pdf (Accessed: October 2022).

Central Pollution Control Board. (2022). *Producer Responsibility Organisation (PRO) registered with CPCB* [Online]. Available at: https://cpcb.nic.in/list-of-registered-pro/ (Accessed: October 2022).

Chintan. (2017). *Innovation in Waste: Material Recovery and Livelihoods at the New Delhi Railway Station* [Online]. Available at: http://iced.cag.gov.in/wp-content/uploads/2016-17/NTP%2003/CM.pdf (Accessed: October 2022).

Circulate Capital. (2020). *Safeguarding the Plastic Recycling Value Chain: Insights from Covid-19 impact in South and Southeast Asia* [Online]. Available at: https://www.circulatecapital.com/_files/ugd/77554d_6464ccce8ff443b1af07ef85f37caef5.pdf (Accessed: October 2022).

City Spidey. (2022). *Dwarka gets a 'Material Recovery Facility' to manage its waste* [Online]. Available at: https://www.cityspidey.com/news/16553/dwarka-gets-a-material-recovery-facility-to-manage-its-waste (Accessed: October 2022).

Construction World. (2021). *BMC plans real-time dashboard to improve waste management system* [Online]. Available at: https://www.constructionworld.in/urban-infrastructure/wastewater-and-sewage-treatment/bmc-plans-real-time-dashboard-to-improve-waste-management-system/29854 (Accessed: October 2022).

Construction World. (2021). *North Delhi municipal corp to develop plastic waste processing plant* [Online]. Available at: https://www.constructionworld.in/urban-infrastructure/wastewater-and-sewage-treatment/-north-delhi-municipal-corp-to-develop-plastic-waste-processing-plant/29396 (Accessed: October 2022).

CSE. (2019). *The Plastics Factsheet 1: The Problem of Plastics* [Online]. Available at: https://cdn.cseindia.org/attachments/0.57139300_1570431848_Factsheet1.pdf (Accessed: October 2022)

Delhi Cantonment Board. (2022). *Plastic Waste Monitoring Dashboard* [Online]. Available at: https://delhi.cantt.gov.in/sanitation-dashboard/ (Accessed: October 2022).

Delhi Pollution Control Committee. (2021). *Annual Report for the Year 2020-2021* [Online]. Available at: https://www.dpcc.delhigovt.nic.in//uploads/pdf/PMWAnnualReport2020-21pdf-0ee6d3448355f608c9d5d4d2a81292d2.pdf (Accessed: October 2022).

FICCI. (2020). *Strategies for Sustainable Plastic Packaging in India* [Online]. Available at: https://ficci.in/spdocument/23348/FICCI-Accenture-Circular-Economy-Report1.pdf (Accessed: October 2022).

Global Alliance of Waste Pickers. (2022). *City Report: Interview with a local Waste Picker* [Online]. Available at: https://globalrec.org/city/new-delhi/ (Accessed: October 2022).

Government of Tamil Nadu. (2022). *Details of banned items by Government of Tamil Nadu and MoEF & CC* [Online]. Available at: https://tnpcb.gov.in/PPFTN/ (Accessed: October 2022).

Greater Chennai Corporation. (2022). *Solid Waste Management* [Online]. Available at: https://chennaicorporation.gov.in/gcc/department/solid-waste-management/ (Accessed: October 2022).

Hasiru Dala. (2018). *What is the mainstream waste system* [Online]. Available at: https://hasirudala.in/about/waste-ecosystem/ (Accessed: October 2022)

Indian Express. (2019). *Plastic ban: Most dairies in Maharashtra yet to start buying back and recycling of milk pouches* [Online]. Available at: https://indianexpress.com/article/cities/mumbai/plastic-ban-most-dairies-maharashtra-yet-to-start-buying-back-and-recycling-of-milk-pouches-6043258/ (Accessed: October 2022).

Indian Express. (2022). *For garbage-free Dharavi, BMC to appoint PVT agencies to collect and recycle waste* [Online]. Available at: https://indianexpress.com/article/cities/mumbai/for-garbage-free-dharavi-bmc-to-appoint-pvt-agencies-to-collect-and-recycle-waste-8229845/ (Accessed: October 2022).

International Alliance of Waste Pickers. (2014). *City Report: Interview with a local Waste Picker* [Online]. Available at: https://globalrec.org/city/new-delhi/ (Accessed: October 2022).

KNN. (2016). *There are hardly any plastic processing units in Dharavi: Study* [Online]. Available at: http://knnindia.co.in/news/newsdetails/knowledge-resource/there-are-hardly-any-plastic-processing-units-in-dharavi-study (Accessed: October 2022).

Maharashtra Pollution Control Board. (2022). *Notice for Prohibiting Production, Commerce, Stocking, Distribution, Sale and Use of Single Use Plastic Items* [Online]. Available at: https://mpcb.gov.in/sites/default/files/plastic_notice_28032022.pdf (Accessed: October 2022).

Mid-day, Mumbai. (2022). *After bio-waste plant, Deonar waste-to-energy plant also spells trouble* [Online]. Available at: https://www.mid-day.com/mumbai/mumbai-news/article/mumbai-after-bio-waste-plant-deonar-waste-to-energy-plant-also-spells-trouble-23248304#:~:text=Deonar%20receives%20around%20600%20metric,of%20electricity%20and%20incinerate%20waste. (Accessed: October 2022).

Ministry of Environment, Forest and Climate, Change Government of India. (2022). *Centralized Extended Producers Responsibility Portal for Plastic Packaging* [Online]. Available at: https://eprplastic.cpcb.gov.in/#/plastic/home/main_dashboard (Accessed: October 2022).

Municipal Corporation of Delhi. (2022). [Online]. Available at: https://mcdonline.nic.in/portal/;jsessionid=07D7129E89E3C5A48CDC7BC424C80F7A.sp (Accessed: October 2022).

New Indian Express. (2022). *Pyrolysis plant to make oil and carbon from 20 tonnes of plastic a day* [Online]. Available at: https://www.newindianexpress.com/cities/chennai/2022/jun/11/pyrolysis-plant-to-make-oil-and-carbon-from-20-tonnes-of-plastic-a-day-2464185.html (Accessed: October 2022).

News Nine. (2022). *LG VK Saxena directed MCD to set up 24 material recovery facilities across Delhi within 6 months* [Online]. Available at: https://www.news9live.com/state/delhi-ncr/lg-vk-saxena-directed-mcd-to-set-up-24-material-recovery-facilities-across-delhi-within-6-months-183108 (Accessed: October 2022).

Recykal. (2022). *Case study: a digital marketplace for quality material* [Online]. Available at: https://recykal.com/recykal-library/ (Accessed: October 2022)

Shanker, R. et al. (2022). *Plastic waste recycling: existing Indian scenario and future opportunities* [Online]. Available at: https://link.springer.com/article/10.1007/s13762-022-04079-x (Accessed: October 2022).

TERI. (2022). *MSW Management: The pitiable situation of Municipal Solid Waste Management* [Online]. Available at: https://www.teriin.org/article/msw-management-pitiable-situation-municipal-solid-waste-management#:~:text=Currently%2C%20as%20per%20government%20estimates,28%25%20is%20processed%20and%20treated (Accessed: October 2022)

TERI. (2021). *Circular Economy for Plastics in India: A Roadmap* [Online]. Available at: https://www.teriin.org/sites/default/files/2021-12/Circular-Economy-Plastics-India-Roadmap.pdf (Accessed: October 2022).

The Better India. (2019). *Start-up Helps Recycle 100K Tons of Plastic Waste Into Bags & Shirts* [Online]. Available at: https://www.thebetterindia.com/180488/delhi-plastic-waste-shirt-bags-management-india/ (Accessed: October 2022).

The Hindu Business Line. (2021). *Ramky Enviro in 7-year waste management contract in Chennai* [Online]. Available at: https://www.thehindubusinessline.com/news/national/ramky-enviro-in-7-year-waste-management-contract-in-chennai/article33916236.ece (Accessed: October 2022).

Times Now News. (2019). *Zero Waste Initiative: Chennai civic body's exemplary move to reduce plastic waste* [Online]. Available at: https://www.timesnownews.com/mirror-now/civic-issues/article/zero-waste-initiative-chennai-civic-bodys-exemplary-move-to-reduce-plastic-waste/498743 (Accessed: October 2022).

Times of India. (2020). *Chennai's waste management to go hi-tech* [Online]. Available at: https://timesofindia.indiatimes.com/city/chennai/chennais-waste-management-to-go-hi-tech/articleshow/78376635.cms (Accessed: October 2022).

Times of India. (2021). *IPMA expresses concern over increase in GST on packaging material* [Online]. Available at: http://timesofindia.indiatimes.com/articleshow/86375551.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst (Accessed: October 2022).

Times of India. (2021). *Waste facility to recycle 8 tonnes/day* [Online]. Available at: https://timesofindia.indiatimes.com/city/delhi/waste-facility-to-recycle-8-tonnes/day/articleshow/81179597.cms (Accessed: October 2022).

Urbaser. (2020). *Urbaser Extends its International Presence with New Contracts in Asia and Latin America* [Online]. Available at: https://www.urbaser.com/en/2020/11/urbaser-extends-its-international-presence-with-new-contracts-in-asia-and-latin-america/ (Accessed: October 2022).

Appendices

Appendix 1: Supply chain assessment indicator descriptions and rating scales

Criteria to assess a well-functioning supply chain	Benchmark for good standard
CFR rate for plastic waste: Plastics collected for recycling (CFR) out of plastics collected in MSW.	>30% 15-30% < 15%
Market structure - Collection: Proportion of plastic collected for recycling via the formal sector.	Majority of plastics collected for recycling via the formal sector with a good level of formalized infrastructure for source segregated collection. % of plastics collected for recycling by the formal sector: >50% 25-50% < 25%
Market structure - Aggregation & sorting: Proportion of plastic aggregated/sorted for recycling via the formal sector.	Majority of plastics collected for recycling is being aggregated and sorted by the formal sector with a good level of formalized infrastructure for bulking and sorting of plastics for recycling. >50% 25-50% < 25%
Market structure - Plastic recycling: Proportion of formal vs. informal recyclers and 'fair' competition.	Majority of plastics collected is being recycled in permitted, formal sector facilities. >50% 25-50% < 25%
Pricing transparency: Pricing transparency as an economic concept refers to the degree to which pricing information is available to all buyers and sellers in a market. A high level of pricing transparency ensures healthy competition, efficient markets, and better pricing of products, and is often considered an indicator of an efficiently operating supply chain, which enables growth.	High transparency: with a good level of pricing information and similar number of buyers and sellers. Moderate or poor transparency: with a medium level of pricing information and disproportionate number of buyers and sellers. Ranking based on market power or share of the profit margins/trade benefits held by recyclers/large aggregators: < 50% 50-75% 75%
Knowledge gaps and data availability: Availability of and confidence in data on waste flows, ecosystems and transactions. This relies on the amount, recency and quality of data available from trusted sources, such as local and national government reports, EPR system data and trusted industry bodies.	High: Multiple recent data and information sources available from reputable sources – >10 city studies with detailed, verified waste flow data. Moderate: Some data is available but it is less recent or is from less reputable sources – 5-10 city studies with some verified waste flow data. Poor: No/extremely limited data and information sources available; data is not recent or there are considerable discrepancies between different sources – 0-5 city studies with contradictory or unverified data sets.
Value yield and quality of outputs: Estimated value of plastics recycled based on local recyclate pricing/estimated value of plastics collected based on virgin polymer prices.	>50% 25-50% < 25%
Regulatory framework: Waste management policies, permitting systems, funding and fiscal incentives that are driving the collection, segregation, and recycling of plastics. Level of implementation of EPR systems, plastics taxation, and other specifically targeted measures.	High: Suitable national (or local) legislation in place, which has been implemented and is functioning well in practice. Moderate: Some suitable national (or local) legislation is in place, though it has not been fully implemented in practice. Poor: Suitable national legislation (and local legislation) is not yet established/is in very early stages of development.

Legend: High Moderate Poor

Appendix 2: List of potential interventions

Full list of potential interventions to improve plastics collection rates and increase value creation along the plastic waste supply chain.

	Intervention categories →		
Desired supply chain impacts ↓	1. Improve supporting regulatory and social conditions to create a stable policy framework	2. Financial interventions to improve value creation from plastic waste	3. Technical and digital improvements to increase supply chain efficiency
Improve collection rates of plastics	Implement (harmonized) source segregated collection and EPR systems.	Increased waste collection fees/levies charged to households.	Digitize recyclable collection and material tracing; for example, explore 'pay-as-you-throw (PAYT) systems' linked to material quality and level of segregation.
	Improve welfare standards of informal workers (annual health check-ups, PPE, insurance etc.).	Improve funding for formal waste collection infrastructure.	Smart bins, underground containers etc. to reduce collection costs and maximize space and access (linked to registered informal collectors).
	Registrations or permits for informal waste pickers with the incentive to receive tools/equipment, access to loans, PPE etc. to build capacity.	Support payment of the informal sector (fair and prompt payment).	
	Central registry of official collection points for specific plastics/waste formats.	Market incentive payments for hard to recycle, low-value waste formats and polymers.	
	Awareness-raising campaigns and behavior change e.g., to sort household waste, and stop discharging bottles etc. into seas and oceans.	Fund/incentivize take-back schemes via retailers, hospitality and transport sectors.	
		Subsidize formalization of informal pickers (cooperatives, tax payments, permits, share EPR fees).	
Improve sorting of polymers and quality for recycling	Clear administrative pathways for operating permits for sorting and aggregation.	Invest in formal segregation and sorting infrastructure (public sector, FMCGs etc.) and integrate the informal sector (employ waste pickers).	National or regional virtual marketplaces to improve pricing transparency and increase access for buyers.
	Mandate design for recycling standards to improve plastic and polymer separation (part of EPR).	Support payment of the informal sector – financial incentives for good quality recyclables.	R&D funding for innovative plastics/polymer sorting technologies (NIR, AI etc.).
	Introduce sorting and segregation quality standards for key waste streams (as part of an EPR system).	Plastic collection and sorting credits/incentives (as part of an EPR system).	Upgrade existing sorting facilities with automated equipment.

Appendix 2: List of potential interventions (continued)

Desired supply chain impacts ↓	Intervention categories → 1. Improve supporting regulatory and social conditions to create a stable policy framework	2. Financial interventions to improve value creation from plastic waste	3. Technical and digital improvements to increase supply chain efficiency
Improve sorting of polymers and quality for recycling	Import restrictions (bans, import fees) for mixed and low-value plastic waste.	Improve funding for environmental regulators and protection agencies.	Digital certification and tracing of sorted plastics waste and polymers.
	Comprehensive monitoring and enforcement of environmental regulations/permits.	Tax relief for sorting and segregation equipment and facilities.	Fund paid for private industry to provide grants for small-scale equipment: balers, sorting bays/containers, transport.
	Central registry and master planning of segregation and sorting of plastics and polymers for recycling.	Subsidize formalization of informal or small-scale aggregators (cooperatives, tax payments, permits).	
		Funding of automated/large-scale plastic segregation from mixed MSW prior to WtE/landfill (secondary sorting systems).	
Increase demand from plastic recyclers	Mandate recycled content targets in key applications (incl. rigid and flexible packaging).	Invest in medium- to large-scale plastics recycling of mixed and hard to recycle plastics.	National or regional virtual marketplaces to improve supply chain security.
	Clear administrative pathways for operating and building permits for recycling facilities.	Subsidize formalization of informal/small-scale recyclers (cooperatives, tax payments, permits).	R&D funding for innovative plastics recycling technologies.
	Green/sustainable public procurement policies and funding support for regional plastic recycling projects.	Improve funding for environmental regulators and protection agencies to ensure a level playing field.	
	Export restrictions (bans, fees) for collected and segregated plastic waste.	Tax relief for plastics recycling equipment and facilities.	
	Landfill disposal limits or bans, and limitation on recyclables to WtE (pre-processing requirements for residual/wet waste).	Quality standards for recycled plastics incentivizing circular recycling (plastic credits for hard to recycle plastics, high recycling yields, closed loop recycling).	
		Taxation of virgin content or tax relief for recyclate content.	
		Landfill or incineration taxes.	

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