What We Waste

Household waste generation, and recovery by waste pickers in Pune
Acknowledgements

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Summary of Key Findings

Waste Generation

• Pune’s average per capita household waste generation is 0.238 kilograms per day (0.953 kg per household).
• Wet waste constitutes 76% of household waste.
• Paper (7.9%) and plastic (7.5%) are the most abundant dry waste materials.
• Quantum of waste increases significantly with increase in income. Middle-income and high-income individuals generate twice and thrice respectively, as much as slum dwellers.
• Characterisation remains similar across income groups. The proportion of wet waste ranges between 76-77%. Paper (25-35%) and Plastic (30-32%) are consistently the most abundant types of dry waste across income groups, followed by sanitary waste (11-14%).

Recovery by Waste Pickers

• 35% of the city’s household dry waste is recovered by waste pickers for recycling.
• Paper waste (48 TPD), Plastic waste (37 TPD), Glass (12TPD), together account for 87% of all waste recovered for recycling.
• 37% of plastics are recovered by waste pickers for recycling.
  - Mono-material rigid plastics (PET, HDPE and PP), are the most highly recycled plastics.
  - Within flexible plastics, transparent, monolayered flexible plastics are more highly recycled than their coloured counterparts. Multi-layered plastics have the lowest recovery rates.
  - 68% of compostable plastics end up in the flexible plastic stream instead of the organic waste stream.
  - The current recovery rate for rigid plastics in 2022 (69%) is far higher than the recycling target for 2024-25 (50%) prescribed by the recently notified guidelines for Extended Producers’ Responsibility (EPR).

• 32% of cloth waste is synthetic cloth (including polyester); and less than 6% of cloth waste is reclaimed by waste pickers.
• The most abundantly retrieved waste material by waste pickers in Pune, is paper. Recycling rates of different types of paper wastes vary significantly. Corrugated paper has a recycling rate of 85%. Road Scrap (mixed low value paper waste), accounting for over 70% of all paper waste has a recycling rate of less than 20%.
Introduction

A household waste audit yields the quantum and composition of waste at the point of generation, immediately after it is discarded by the household. Conducting comprehensive waste audits with statistically robust, stratified samples is challenging, as it needs to coalesce with the municipal waste collection. This is evidenced by the paucity of granular data available on waste composition. Waste audits are typically limited to studying a few broad categories of waste — wet, paper, plastic, and some specific categories like domestic hazardous wastes. Such audits often cover small samples, and fail to provide accurate city-level data. Realistic city-level estimates are vital to understand the baseline waste management scenario and indicate the requisite system capacity to handle the waste generated. The scope of this study extended beyond waste generation, and included waste recovered by waste pickers for recycling.

Waste from 70% of Pune’s households is collected by the waste pickers of SWaCH, within the framework of a unique pro-poor public private partnership with the Pune Municipal Corporation (PMC). As per the terms of the agreement, waste pickers retain the right to recover and sell any recyclable materials from the waste they collect. The remaining waste, comprising non-recyclable dry waste and wet waste, is transferred to the PMC’s motorised, secondary waste collection system. This flow of waste is depicted in the image below. As SWaCH waste pickers handle waste at the point of generation, they are uniquely positioned to retrieve recyclables and divert them from the landfill. This, along with their experience in efficient and effective sorting of waste also made them invaluable allies of the research team during the waste audits, without creating a bottleneck in the daily waste collection system.
Objectives

Through this research study, we aimed to determine:

1. The quantum of household waste generated in Pune city, and the variations across income groups.

2. The detailed composition of household waste generated in Pune city, and the variations across income groups.

3. The level of recovery for recycling for each material.
Methodology

To conduct the waste audit, household waste was collected from a stratified sample of waste generators over 7 consecutive days; the waste was hand-sorted into pre-determined categories; and the weight of each category was recorded. The sample was selected with a view to reflect the variations in both the quantum and composition of the waste generation across different socio-economic strata of the population; and the duration was designed to capture the short-term cyclical fluctuations in waste generation. The categories and level of fine sorting were determined by the objective of the analysis. In this instance, since we intended to study both waste generation and recovery for recycling, the categories reflected the primary sorting carried out by waste pickers for recovery of scrap and the handling of materials along the recycling chain. Waste was sorted into 75 unique categories. Prior to the actual waste audit, a household survey was conducted at each site to get the exact household and population count for the study sample. The study was conducted between December 2021 and April 2022, recording over 16,000 kilograms of waste, generated by approximately 10,000 citizens across income groups.

Sample Selection

Waste generation patterns have long been known to directly reflect consumption patterns, and since income levels are the strongest determinant of consumption patterns, they are directly responsible for impacting waste generation patterns too. To cover the range of income groups, a stratified sample of 2,463 households (or 9,862 individuals) across 7 locations was selected (see table).

<table>
<thead>
<tr>
<th>Income Group</th>
<th>No. of Sites</th>
<th>No. of Households</th>
<th>No. of Individuals</th>
<th>Household Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income (slum)</td>
<td>2</td>
<td>944</td>
<td>4253</td>
<td>4.5</td>
</tr>
<tr>
<td>Middle Income</td>
<td>3</td>
<td>1257</td>
<td>4647</td>
<td>3.7</td>
</tr>
<tr>
<td>High Income</td>
<td>2</td>
<td>262</td>
<td>962</td>
<td>3.7</td>
</tr>
<tr>
<td><strong>Total Sample</strong></td>
<td><strong>7</strong></td>
<td><strong>2463</strong></td>
<td><strong>9862</strong></td>
<td><strong>4.0</strong></td>
</tr>
</tbody>
</table>

At each location, waste was studied for a period of 7-8 consecutive days to capture the cyclical fluctuations of waste generation. The audit was not conducted on the days, preceding, following and including festival days during the period, namely Christmas, New Year’s, Sankranti, Holi and Gudi Padva.
This waste audit study was additionally designed to capture waste recovered by the waste pickers for recycling (A), a measure of the recycling rate of specific materials and waste transferred into the municipal waste management system (B). The sum of these is the total waste generated (C), and the ratio of quantum of waste recovered by waste pickers to total waste generation (A/C) yields the recycling rate.

A team of 15 researchers conducted the audit. 5 of them, doctoral students engaged in research on polymers, at the National Chemical Laboratory, guided the accurate identification and categorisation of plastic waste types. At each audit location, between 7 and 10 waste pickers were also engaged in the study.

Before the start of the audit, at each location, data was collected on the sample of households being studied. This was done by a researcher shadowing the waste picker on her waste collection route and following this process:

1. The researcher counted the number of households from which waste was collected
2. The researcher conducted short interviews with each household to capture information on:
   a. Number of individuals, gender disaggregated, per household
   b. Number of individuals living in the household who were not part of the family (domestic help, caretakers, etc)\(^1\)

The 7-8 days of the waste audit began once the household data was finalised. Each audit day typically began at 8 am and ended by 3 pm. The following process was followed on each day:

1. The waste pickers collected household waste along their usual routes.
2. After completing collection, waste was brought to the study site, where the waste picker sorted the waste into:
   a. Waste to be sold to scrap dealers i.e. recyclable waste (A)
   b. Waste to be transferred to the PMC’s secondary waste collection system (B)

3. Category (A) Waste to be sold to scrap shops - was further sorted by the team of researchers and waste pickers into the pre-determined 75 categories of waste. Each category was weighed, and the data recorded. After recording data, the waste was handed over to the waste picker.

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\(^1\) These were factored out of the population count. The waste generated by such individuals was considered a direct result of the lifestyles of the individuals of that household.
4. Category (B) Waste to be transferred to the PMC’s secondary waste collection system was further sorted by the team of researchers and waste pickers into the pre-determined 75 categories of waste. Each category was weighed, and the data recorded. After recording data, the waste was transferred into the PMC secondary collection system.

The household survey and waste data were manually recorded on hard copy sheets and digitized at the end of each audit. Weight data was recorded in kilograms up to the 3rd decimal place on a weighing scale of accuracy up to 20 grams. A kitchen scale was used where the weights were less than 1 kilogram. As far as possible, weights were taken by placing items directly on the scale. Where this was not possible, weight was taken in buckets or sacks and the tare weight of each weighment was recorded, and subtracted during the data collation process.

Waste Categorisation

In this study, waste is broadly categorised into “wet” and “dry” waste. Wet and dry are the commonly used colloquial categories to describe organic waste (including cooked/uncooked food and garden waste) and man-made materials (including paper, metal, plastic, glass, sanitary, etc).

For the audit, household waste was sorted into a total of 75 sub-categories, each classified under one of the following broader waste types— Wet, Paper, Plastic, Metal, Glass, Sanitary, PPE, Shoes, Electronic and Other. The waste categorisation reflected current waste handling within the recycling sector which is not strictly by material type. For example:

- Waste pickers typically bundle 2-3 distinct varieties of rigid plastics in a waste type colloquially termed “fuga”². As this material passes up the recycling value chain, each resin type is further separated. Data was collected by resin type (PP, HDPE, PVC, PS).
- For some waste material, physical characteristics determine its handling within the recycling sector. Transparent and coloured flexible plastics are handled separately as are glass bottles of different shapes and sizes. The categorization was therefore designed to reflect the different streams of waste handling.

Plastic waste was sorted into 30 categories to obtain granular data on its generation and recovery. The growing challenge of handling plastic waste, its increasing relevance within national policy and regulation, and the potential impact on the informal recycling sector, prompted the emphasis on plastic waste generation and handling within the study.

²The term “fuga” comes from the Marathi word for balloon, suggestive of the blow-moulding process by which most of the rigid plastic bottles are manufactured.
### Plastic
1. Cable/Flexible Pipes  
2. Multi-Material Wire  
3. Compostable Flexible Plastic  
4. Other Mixed, Rigid Plastic  
5. Flexible PVC  
6. Flexible HDPE  
7. Rigid Multi-Material  
8. Multi-Layered Plastic (only plastic)  
9. Clear, Flexible LDPE  
10. Clear, Flexible PP  
11. Flexible LDPE Oil Pouch  
12. Non-Woven PP  
13. Tetra Pak  
14. Metal Multilayered Plastic  
15. Coloured, Flexible LDPE  
16. Coloured, Flexible PP  
17. Styrofoam EPS Foam  
18. Nylon  
19. PVC Foam  
20. Woven PP Sacks  
21. PU Foam (Sofa)  
22. PET (1)  
23. HDPE (2)  
24. Rigid PVC (3)  
25. Rigid LDPE (4)  
26. Rigid PP (5)  
27. PS (6)  
28. Styrofoam LDPE Foam  
29. Thermocole  
30. Rubber

### Other
1. Inert Material (rock, sand, dust, ceramic)  
2. Wood  
3. Other Metal  
4. Rigid Multimaterial  
5. Medical Waste  
6. Coal  
7. Unidentified Material  
8. X-ray  
9. Icepack  
10. Acrylic  
11. Dyeing Agent  
12. Melamine  
13. Unsorted Dry Waste

### Paper
1. White Office Paper  
2. Newspaper  
3. Notebook  
4. Road Scrap  
5. Corrugated Paper  
6. Printed Books  
7. Magazine

### Wet
1. Food Scrap  
2. Yard/Garden Waste  
3. Coconut Shells  
4. Other  
5. Biodegradable Material

### Glass
1. Beer  
2. Quarter  
3. Other Glass Bottles  
4. Other Glass incl. Broken

### Metal
1. Aluminium  
2. Steel  
3. Copper  
4. Hindalium  
5. Tin  
6. Other Mix Metal  
7. Iron

### Sanitary
1. Diapers  
2. Sanitary Napkins and Tampons

### Shoes
1. Shoes with Plastic  
2. Leather, Canvas  
3. Rubber Footwear

### PPE
1. Plastic PPE  
2. Non-Plastic PPE

### Cloth
1. Natural  
2. Synthetic

### Electronic
E-Waste
Extrapolation

The audit locations were categorised by income group as low, middle, and high. As there is no singular, reliable source for accurate income data, the size, type and location of property, served as a proxy for income level. The data for each income group was consolidated to provide average waste generation and recovery figures. A weighted average was calculated, to extrapolate to the city-level, based on the proportion of that income group within the city's population (55,00,000).

<table>
<thead>
<tr>
<th>Income Group</th>
<th>Proportion of Pune's Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income (Slum)</td>
<td>28%</td>
</tr>
<tr>
<td>Middle Income</td>
<td>62%</td>
</tr>
<tr>
<td>High Income</td>
<td>10%</td>
</tr>
<tr>
<td>Total Population</td>
<td>100%</td>
</tr>
</tbody>
</table>

Findings from the study were shared with officials from the Solid Waste Management department of the Pune Municipal Corporation for authentication.

Limitations

During the study period (December 2021 – April 2022), Pune was sieged by the omicron variant of the coronavirus. Although this was neither the peak of the coronavirus wave, nor the intense lockdown period, the pandemic did have short, medium and longer- term impacts on waste generation. While the data accurately captures waste generation patterns at the time of the study, it may not accurately reflect waste generation patterns in the long term.

Seasonal variations in waste generation are not reflected in the study.

While festivals affect waste generation and were excluded during the audit to generate data for an ‘average week’, such variations are relevant to calculate annual waste generated in the city.

Although the sample was selected to cover different income groups, differences in consumption patterns based on other factors such as age, ethnicity, religion, etc are not reflected in the study data.

While the per capita and per household waste generation figures from the study are reliable, extrapolation of these figures depends on the accuracy of the population count and the proportion of income groups within the population. Recent and accurate data on both of these were not easily available. To correct for this, the study findings were shared with the PMC, and confirmed by the PMC to be reflective of the city's household waste generation.
The study does not capture waste diverted by citizens before it is collected by waste pickers. This could include the recovery of recyclables by domestic help/housekeeping staff, and the direct sale of recyclables by residents.

The data on waste recovery for recycling captures the characteristics of the waste recovered by waste pickers. This may include non-recyclable, misclassified, or contaminated waste that may be rejected further up the recycling chain. Similarly, recyclable waste may be recovered at a later step within the municipal waste management system (from the motorized, secondary collection vehicles, transfer stations, material recovery facilities and the sanitary landfill). These injections and leakages that occur within the recycling sector are not captured.
Findings

Household Waste Generation (2022)
The average per capita waste generated was 0.238 kilograms per day (or 0.953 kg per household). Based on this, it can be estimated that roughly 1309 MT of household waste is generated in Pune each day. Organic waste is the most abundant type of waste, making up 76% of household waste by weight.
Within dry waste, paper (7.9%) and plastic (7.5%) are the most abundant.
Composition of Each Waste Type

Paper Waste: Disaggregated

- Road Scrap: 49.05%
- Newspaper: 21.85%
- Corrugated Paper: 22.6%
- White Office Paper: 6.91%
- Notebook: 0.08%
- Printed Books: 0.05%
- Magazine: 0.00%

Glass Waste: Disaggregated

- Other Glass Bottles: 8.7 TPD (47%)
- Quarter: 3.8 TPD (21%)
- Beer: 2.6 TPD (14%)
- Mixed Glass: 3.2 TPD (18%)

Detailed information on the relative composition and quantities of each waste type can be found in the annexes.
Metal Waste: Disaggregated

- Aluminium: 2.5 TPD (42%)
- Steel: 1.0 TPD (16%)
- Tin: 1.7 TPD (28%)
- Hindalium: 0.4 TPD (7%)
- Iron: 0.4 TPD (6%)
- Other: 0.0 TPD (1%)

Cloth Waste: Disaggregated

- Synthetic: 6.3 TPD (32%)
- Natural: 13.4 TPD (68%)

PPE: Disaggregated

- Non-Plastic PPE: 0.1 TPD (10%)
- Plastic PPE: 0.9 TPD (90%)

Detailed information on the relative composition and quantities of each waste type can be found in the annexes.
The per capita waste generation increases significantly with increase in income, with middle-income individuals generating twice, and high-income individuals thrice, as much as slum dwellers.

However, the characterization of waste is similar across income groups. The proportion of organic waste remains nearly identical across all income groups, ranging between 76-77% of total waste generated. Paper (25-35%) and Plastic (30-32%) are consistently the most abundant types of dry waste across income groups, followed by sanitary waste (11-14%). Detailed information on recovery of recyclables can be found in the data tables provided in the Annex.

Waste Generation by Income Groups

<table>
<thead>
<tr>
<th>Income Group</th>
<th>Daily Waste Generation Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income (Slum)</td>
<td>0.130 kg/person/day</td>
</tr>
<tr>
<td>Middle Income</td>
<td>0.263 kg/person/day</td>
</tr>
<tr>
<td>High Income</td>
<td>0.386 kg/person/day</td>
</tr>
<tr>
<td>City Average</td>
<td>0.238 kg/person/day</td>
</tr>
</tbody>
</table>

Household Waste Quantum and Composition Across Income Groups
Dry Household Waste:
Quantum and Composition Across Income Groups

Waste generation (kg/person/day)

- Low: 0.029 kg/day
- Middle: 0.064 kg/day
- High: 0.094 kg/day

Detailed information on the relative composition and quantities waste generated across income groups can be found in the annexes.
Composition of Plastic Waste

**Flexible**
- Coloured LDPE: 19% | 15.4 TPD
- Clear LDPE: 10% | 8.1 TPD
- LDPE (Milk Packets): 9% | 7.2 TPD

**Rigid**
- PET: 11% | 8.9 TPD
- PP: 7% | 5.6 TPD
- HDPE: 7% | 5.4 TPD
Multilayered

Clear PP
5% | 4.3 TPD

Coloured PP
4% | 3.4 TPD

Non Woven PP
1% | 0.6 TPD

PVC
1% | 0.5 TPD

Multi-Material
3% | 2.8 TPD

Metal
Multi-Layered Plastic
8% | 6.2 TPD

Multi-Layered Plastic (only plastic)
6% | 5.2 TPD

Woven PP
0% | 0.3 TPD

HDPE
0% | 0.1 TPD

Tetra Pak
1% | 0.8 TPD

Other

PU Foam
1% | 0.8 TPD

Expanded Polystyrene
1% | 0.7 TPD

PS
1% | 1.1 TPD

PVC
0% | 0.3 TPD

Wire
0% | 0.1 TPD

Cable
0% | 0.1 TPD

Rubber
0% | 0.2 TPD

LDPE
0% | 0.1 TPD

PVC Foam
0% | 0.0 TPD

Nylon
0% | 0.1 TPD

Styrofoam
0% | 0.0 TPD
Waste pickers form the base of the recycling pyramid as they are the first link in the recycling supply chain. Waste pickers sort recyclable dry waste into over 20 categories before selling to scrap dealers. Scrap dealers\(^3\) sell the sorted waste to aggregators, who then sell it to wholesalers, who sell to pre-processors after which it finally reaches the apex of the recycling pyramid - the recyclers.

Data on the waste diverted by waste pickers towards recycling, was captured as a proxy for the effective recycling rate. The recovery rate for each material reflects the quantity recovered by waste pickers for recycling, as a proportion of the total quantum generated.

About 35% of the city’s dry household waste is recovered by waste pickers for recycling. In absolute terms, Paper waste (47 TPD) is the most abundant type of waste reclaimed by waste pickers, followed by Plastic waste (36 TPD) and then Glass (12 TPD). These three types of waste account for 87% of all waste recovered for recycling. Electronic waste, Shoes and Metal have high recovery rates, indicating that they are easy to sort and store and/or high in value, though the absolute quantum of these wastes (generated and) recovered is small.

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3Citizens may sell waste directly to scrap dealers. Informal waste pickers and municipal workers may recover waste from secondary collection vehicles, transfer stations and material recovery facilities and sell these to scrap dealers. These are not captured by the study.
Understanding Recycling Rates

Technical recyclability i.e. whether a certain type of material can be recycled or not, is one of most important factors, that determine recovery rates. However, some technically recyclable materials, may not actually be recovered for recycling, for example a recyclable plastic bag heavily contaminated with food waste. Such items would not only be rejected by the scrap dealers, but would be a nuisance to store, given their propensity to attract rodents.

For recyclable materials to be recovered at a scale commensurate to their generation, they need to be economically viable to handle at all stages, for all the players along the scrap value chain. This implies that the value of the recylcate should adequately justify the costs incurred in sorting, storing, transporting and processing the raw material. This would create a ‘natural’ market for the scrap material.

Viability is determined by several micro-local factors. Constraints of space for sorting and storage, as well as the time taken to fine-sort materials, negatively impact recovery rates. Materials that are easier to sort, denser, and have a higher value are universally recovered by waste pickers, unlike lightweight and low-value materials. Similar constraints face scrap dealers, leading to differences in the materials they accept. In the absence of scrap dealers in the vicinity willing to buy certain scrap materials, waste pickers will simply not recover them. Materials with consistently high recovery rates across sites and a high city average, reflect that the waste is relatively well recycled despite these differences in micro-local conditions.

Though both plastic packets are identical (Clear PP bags), the one on the left is likely to end up as litter or at a landfill due to the organic waste contamination which makes it difficult to recycle.
Plastic Waste

Plastic wastes were sorted into 30 distinct categories, based on the way they are handled for recycling/processing. The composition of plastic waste along these categories is shown below. Broadly, 34% of plastics were rigid plastics and 64% were flexible plastics (single- and multi-layered). On average, 37% of plastics are recovered by waste pickers for recycling. However, the relative recycling rates of individual types of plastic vary widely. Mono-material rigid plastics (PET, HDPE and PP), are the most highly recycled plastics. Within flexible plastics, transparent, monolayered flexible plastics are more highly recycled than their coloured counterparts. Multi-layered plastics have the lowest recovery rates. 68% of compostable plastics end up in the flexible plastic stream instead of the organic waste stream. Generation and recovery data for each of the 30 types of plastics are provided in the Annex.

<table>
<thead>
<tr>
<th>Plastic type</th>
<th>Generation (TPD)</th>
<th>Recovery %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid</td>
<td>33.7</td>
<td>69%</td>
</tr>
<tr>
<td>Flexible</td>
<td>48.0</td>
<td>22%</td>
</tr>
<tr>
<td>Multi-layered</td>
<td>14.7</td>
<td>8% (18%)</td>
</tr>
<tr>
<td>Compostable</td>
<td>0.0</td>
<td>68%</td>
</tr>
</tbody>
</table>

Plastic Recycling

For the purposes of this study, the rate of recovery by waste pickers serves as a proxy for the recycling rate. After the leakages and injections that take place as materials pass through the recycling chain, there are two types of ‘recycling’ that materials undergo:

- Closed-loop recycling: Where recycled materials are used for applications similar to the original products — for eg. HDPE plastic granules made from HDPE bottles remoulded into HDPE bottles (bottle to bottle recycling). PP and HDPE plastics are largely handled through closed-loop recycling.
- Open-loop recycling (downcycling): Where recycled materials are used for an application different from the original products, and the products made from recycled materials cannot themselves be recycled. PET, the most highly recycled plastic, is commonly recycled into PET fibres to make

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*This mishandling is due in part to a lack of appropriate infrastructure for handling compostable plastics, and a lack of education to relevant stakeholders within the system — waste pickers, scrap dealers and recyclers. Waste pickers are able to consistently sell compostable plastics to scrap dealers, indicating that the scrap dealers do not reject these materials from the recycling chain. Field visits to flexible plastic recyclers in Malegaon confirmed that compostable plastics are mixed with coloured flexible bags in the recycling process and are not rejected from the recycling chain.

*These categories reflect the commonly understood classification where multi-layered and multi-material plastic sachets are considered multi-layered plastics.

*8% of multi-layered plastics are handled by the recycling market in Pune. An additional 10% of recycling takes place through a targeted multi-layered plastics collection initiative managed by SWaCH Plus. See Annex 1 for details.
Plastic Waste Recovery

Flexible

Coloured LDPE 13%
Clear LDPE 28%
LDPE (Milk Packets) 25%

Rigid

PET 75%
PP 72%
HDPE 83%
Percentages indicate the rate of recovery by waste pickers.
Extended Producer Responsibility

The recently notified guidelines for Extended Producers’ Responsibility (EPR) prescribe recycling targets for different categories of plastic packaging, applicable to producers, importers and brand owners introducing plastic packaging into the ecosystem. The guidelines classify plastic packaging waste into 4 types – rigid, flexible, multi-material plastics and compostable plastics. The informal recycling sector is already recycling a substantial portion of the expected recycling under EPR (see table below). The current recovery rate for rigid plastics in 2022 (69%) is far higher than the recycling target for 2024-25 (50%). However, for these recycling rates to be formally notified under the EPR framework, recyclers would need to be appropriately registered, and this may prove to be a challenge for the largely informal sector.

<table>
<thead>
<tr>
<th>EPR Category</th>
<th>Generation (TPD)</th>
<th>Current Recovery Rate</th>
<th>EPR - Mandated Recycling Rate¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid (Cat. I)</td>
<td>34</td>
<td>71%</td>
<td>50 - 80%</td>
</tr>
<tr>
<td>Flexible (Cat. II)</td>
<td>54</td>
<td>22%</td>
<td>30 - 60%</td>
</tr>
<tr>
<td>Multi-material (Cat. III)</td>
<td>9</td>
<td>8%</td>
<td>30 - 60%</td>
</tr>
<tr>
<td>Compostable (Cat. IV)</td>
<td>0</td>
<td>68%</td>
<td>50 - 80%</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>10%</td>
<td>NA</td>
</tr>
<tr>
<td>TOTAL</td>
<td>99 TPD</td>
<td>37% Recycled</td>
<td></td>
</tr>
</tbody>
</table>

Cloth Waste

The most common application of PET recycling in India is the production of synthetic cloth (polyester). Cloth waste is difficult to sort and has limited options for reuse and recycling. Our audit estimated that roughly 32% of cloth waste is synthetic; and less than 6% of cloth waste is reclaimed by waste pickers.

Paper Waste

In absolute quantum, the most abundantly retrieved waste material by waste pickers in Pune, is paper. However, recycling rates of different types of paper wastes vary significantly. Corrugated paper with a recycling rate of 85%, is the most highly recycled paper waste. It is also recovered in large quantities across the city, estimated at 19 tonnes each day. On the other hand, Road Scrap (mixed low value paper waste), by far the most abundant type of paper waste generated, accounting for over 70% of all paper waste, has a recycling rate of less than 20%.

¹Category IV includes plastic sheets and compostable plastic. However, no plastic sheet waste was recorded during the waste characterization study.
²For a more detailed discussion on EPR, see Annex 3
³Numbers indicate the recycling targets for 2024-25 (lowest) and 2027-28 (highest) for Brand Owners
Paper Waste: Generation and Recovery by Sub-category

Paper cups, food packaging boxes, soap boxes, sweet boxes, white and brown paper bags, clam shell paper packaging, and coloured paper are all part of ‘Road scrap’. Several of these materials have a thin plastic coating to make them suitable for packaging food and personal care products. While some waste pickers are able to reclaim and sell road scrap, the system capacity to absorb this material is limited, evidenced by the low aggregate recovery rate.
Triangulation and Recommendations for Further Study

Per capita waste generation estimates vary widely according to different sources. The CPCB’s Annual Report on the Status of Solid Waste Management estimated the country-level average waste generation per capita to be 119 grams per day for 2021. The Waste Wise Cities report published by CSE, in collaboration with NITI Aayog, estimated urban waste generation per capita to be anywhere between 190-990 grams per day. The Swaachh Bharat Mission 2.0 Guidelines (2021) estimates 550 grams per capita per day for a city of Pune’s size. To better situate the estimate from this study (238 grams per capita per day) it should be noted that estimates from other sources are indicative of total waste generation i.e. municipal solid waste including waste from commercial sources, and not strictly of household waste generation (i.e. waste generated at the household alone).

Extrapolating from the per capita waste generation figures for Pune’s population of 55,00,00 household waste generation accounts for 1309 metric tonnes a day. As Pune’s daily waste collection during the waste audit period, averaged 1747 metric tonnes10, household waste in Pune city accounts for roughly 75% of the city’s solid waste. These finding were shared with and corroborated by the Solid Waste Management Department of the Pune Municipal Corporation. 

The balance (non-household) waste is generated by commercial establishments and institutions including schools, colleges, government and private offices, vegetable markets, hotels etc. An estimation of the total weight of the non-household waste by source will help authenticate the per capita household waste generation data. This would entail an analysis of municipal records of daily waste collection by waste stream and source, and could be undertaken as follows:

• Municipal Records of organic waste sent for processing, can yield the total organic waste generated in the city from all sources (including household waste).
• Similarly, data on dry (recyclable) waste sent to Material Recovery Facilities, can corroborate recovery rates, as well as total dry waste generation in the city.
• Trends in waste generation and composition could be analysed through comparison with previous household waste audit data against the city level waste collection figures.
• Comparison with municipal waste collection figures during the COVID first wave, could yield fairly accurate data on city level household waste generation. (Pune city witnessed an intense lockdown between April and June 2020, when most commercial establishments, save essential services, were shut down).
• In order to factor in weight reduction due to moisture loss, granular data on organic waste weight reduction for a 7-day period need to be maintained and analysed.

Sanitary waste is an abundant stream of waste with no clear method for handling apart from disposal or incineration. Further study on potential modes for safely handling and potentially recycling this waste could be explored.

Waste materials such as cloth and road scrap have very poor recovery rates. As both cloth and paper are promoted as desirables alternatives to plastic waste, it is necessary to investigate the system capacity required to manage these materials. A downstream study of the municipal waste management system can be undertaken to determine whether modes of management exist within the SWM system.

10Data from the Solid Waste Department of the Pune Municipal Corporation: December 2021 to April 2022
System-Level Recommendations

Managing Wet Waste
More than three-quarters of household waste is organic waste with a large moisture content. Unlike dry waste, wet waste can easily be managed at source through technologies such as composting and biomethanation. This can significantly reduce the burden on the city’s solid waste management infrastructure and costs and emissions resulting from the transportation, aggregation and centralised treatment of organic waste.

Equitable Service Provision
As upper- and middle-income groups generate much more waste than slum dwellers, the municipality should enforce and increase subsidies for waste collection, processing and handling charges in slums, to ensure equitable provision of waste management services to all citizens.

Augmenting Recovery of Recyclables
Recovery of recyclable wastes, can be augmented by thorough intensive outreach, aimed at enhancements in source-segregation of wet and dry waste, and promoting the rinsing of dry waste items contaminated by food waste before disposal.
Similarly, lack of spaces available to sort and store recyclables is a major barrier in the recovery of recyclables. This can be addressed with the help of policy mandating the provision of secured spaces for sorting and storing waste both by citizens (within housing societies, for example) and by the Municipal Corporation (in public spaces). Such spaces are currently available to only a fourth of the SWaCH waste pickers.
Flexible and multi-materials plastics, and low value paper waste (road scrap) are both abundantly produced, but poorly recycled. There is a critical need to strengthen the capacities of the recycling sector to absorb more of these materials. Private sector investment towards infrastructure and viability gap funding, can be channelled to create a market value to make recycling of these materials viable at scale. The SWaCH Plus flexible plastics collection system in Pune is a city-scale demonstration of this model. For such material, capacity for collection and processing is required to ensure appropriate handling. Where such systems cannot be created, or are not economically feasible, the production of such materials/items should be systematically reduced. Such waste

Evaluating Alternatives
Cloth, paper and compostable plastics, widely promoted as alternatives to plastic, are not necessarily viable alternatives in the absence of appropriate downstream waste management systems. This study shows that less than 6% of cloth is recovered for recycling, and is typically sent to garages where it is used for wiping grease before it is eventually discarded. Paper used as a substitute for plastics (ending up as road scrap) has recovery rates and handling challenges analogous to flexible and multi-layered plastics. Close to 70% of compostable plastics are currently recovered for recycling (sorted as LDPE plastic), contaminating the plastic recyclate and defeating their purpose as alternatives to plastic. It is critical to evaluate the life cycle handling costs and system capacity required to manage these materials before determining their suitability as an alternative
**Strengthening the Recycling Network**

The existing recycling sector in Pune (and India), though largely informal, is one of the most efficient and robust recycling systems in the world. It would be socially, environmentally and economically prudent to support and strengthen this sector through public and private sector intervention, allowing a transition to formal and compliant operations. This would not only allow regulate the existing work, but also build the capacity of this system to handle larger quantities and more types of materials in the future.
Annex 1: Multi-Layered Plastic Recycling in Pune

Multi-layered and multi-material plastics composed of several different layers and types of plastic, paper and metal, are extremely light in weight and highly voluminous, making them relatively more expensive to handle. Since these plastics are primarily used in food packaging, they are often contaminated, attracting rodents and making them problematic to store. Even when collected for recovery, recycling them remains technologically challenging. The mixture of plastics and non-plastic layers such as metal and paper, make this heterogenous material technologically challenging to recycle.

To address this waste management and environmental challenge, SWaCH Plus, with support from ITC Ltd set up a system for collecting multi-layered plastics in Pune in 2019. The current scale of collection is 3 tonnes per day. The household waste audit separately collected and excluded data from where this system was in place, to avoid over-representing the recovery rate for this material through the extrapolation method. Since city-level data is available from this system, it can be added to the ‘natural’ recovery by waste pickers, to get an accurate estimate of the diversion of this material to recycling in Pune.

So far, 70% of the 2200 MT collected has been diverted towards mechanical recycling. The materials collected by SWaCH Plus is a mix of metallised multi-layered plastics, multi-layered plastics, coloured flexible plastics, and some clear, flexible plastics i.e. a mix of mono-layered flexible and multi-layered plastics. Based on composition data from SWaCH Plus, the quantum of multi-layered plastics is estimated at 50% of the total plastics handled. This means, that of the 3 tonnes per day collected through this system, roughly 1.5 tonnes is metallised multi-layered plastic, putting the effective recycling rate for multi-layered plastics in Pune at 18%.
Annex 2 : Extended Producer Responsibility

Reflections from the Audit

The recently notified guidelines for Extended Producers’ Responsibility (EPR) prescribe recycling targets for different categories of plastic packaging, applicable to producers, importers and brand owners introducing plastic packaging into the ecosystem. The guidelines classify plastic packaging waste into 4 types — rigid, flexible, multi-material plastics and compostable plastics\(^{11}\). Despite the broad categorization, classifying individual items remains challenging. Category II (flexible plastics) includes both single-layered and multi-layered flexible plastics; while Category III includes only multi-material plastics i.e. packaging which includes at least one layer of non-plastic material (like paper or metal). There is some ambiguity as to what distinguishes a multi-layered plastic packet from a multi-material plastic packet\(^{12}\).

It is apparent that the regulations make this categorical distinction to allow for regulations targeting multi-material items which are non-recyclable due to the mixing of multiple materials. However, this may encourage plastic producers, importers and brand owners to mislabel multi-material plastics as multi-layered plastics in order to avoid more stringent regulations that may be applied to Category III plastics in the future.

The informal recycling sector is already recycling a substantial portion of the expected recycling under EPR. The current recovery rate for rigid plastics in 2022 (69%) is far higher than the recycling target for 2024-25 (50%). But, recyclers would have to be formally registered as plastic waste recycling facilities in order to provide EPR certificates to obligated entities. Formal registration comes with environmental, tax, statutory wage and other costs which would render most small and informal recycling enterprises unviable, prompting new players with higher socioeconomic capital to enter these spaces and displace the existing informal recycling supply chain.

On the surface, EPR is expected to create a mechanism for plastic producers, importers and brand owners to bear the costs of the entire life cycle of the goods they sell, including their packaging. However, this may lead to the displacement and loss of livelihoods of marginalised and informal workers in the recycling sector.

\(^{11}\)Category IV includes plastic sheets and compostable plastic. However, no plastic sheet waste was recorded during the waste characterization study.
\(^{12}\)Multi-material plastics are a sub-set of multi-layered plastics.
### Annex 3

#### Table 1: Waste Generation and Recovery of Pune’s Household Waste (tonnes per day)

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Generation (tonnes/day)</th>
<th>%</th>
<th>Recovery for Recycling (tonnes/day)</th>
<th>% Recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet waste</td>
<td>995</td>
<td>75.98%</td>
<td>0.0</td>
<td>0%</td>
</tr>
<tr>
<td>Paper</td>
<td>103</td>
<td>7.87%</td>
<td>47.0</td>
<td>46%</td>
</tr>
<tr>
<td>Plastic</td>
<td>99</td>
<td>7.53%</td>
<td>36.2</td>
<td>37%</td>
</tr>
<tr>
<td>Metal</td>
<td>6</td>
<td>0.45%</td>
<td>3.8</td>
<td>64%</td>
</tr>
<tr>
<td>Glass</td>
<td>18</td>
<td>1.35%</td>
<td>11.6</td>
<td>66%</td>
</tr>
<tr>
<td>Sanitary</td>
<td>38</td>
<td>2.91%</td>
<td>0.4</td>
<td>1%</td>
</tr>
<tr>
<td>Electronic</td>
<td>2</td>
<td>0.12%</td>
<td>1.2</td>
<td>73%</td>
</tr>
<tr>
<td>Shoes</td>
<td>4</td>
<td>0.33%</td>
<td>2.8</td>
<td>66%</td>
</tr>
<tr>
<td>Cloth</td>
<td>19</td>
<td>1.46%</td>
<td>1.1</td>
<td>6%</td>
</tr>
<tr>
<td>PPE</td>
<td>1</td>
<td>0.07%</td>
<td>0.1</td>
<td>8%</td>
</tr>
<tr>
<td>Other</td>
<td>25</td>
<td>1.92%</td>
<td>4.9</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,309</strong></td>
<td><strong>100%</strong></td>
<td><strong>109.0</strong></td>
<td><strong>35%</strong></td>
</tr>
</tbody>
</table>

#### Table 2: Waste Generation by Income Group (grams per capita per day)

<table>
<thead>
<tr>
<th>Categories</th>
<th>Low Income</th>
<th>Middle Income</th>
<th>High Income</th>
<th>Waste as per Pop Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Waste</td>
<td>100.3</td>
<td>199.3</td>
<td>292.2</td>
<td>180.9</td>
</tr>
<tr>
<td>Paper</td>
<td>7.5</td>
<td>21.5</td>
<td>33.0</td>
<td>18.7</td>
</tr>
<tr>
<td>Plastic</td>
<td>8.9</td>
<td>20.7</td>
<td>28.4</td>
<td>18.2</td>
</tr>
<tr>
<td>Metal</td>
<td>0.4</td>
<td>1.2</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Glass</td>
<td>2.2</td>
<td>2.9</td>
<td>8.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Cloth</td>
<td>3.3</td>
<td>3.6</td>
<td>3.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Footwear</td>
<td>0.9</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Sanitary Waste</td>
<td>3.9</td>
<td>7.8</td>
<td>10.2</td>
<td>6.9</td>
</tr>
<tr>
<td>E Waste</td>
<td>0.1</td>
<td>0.4</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Other</td>
<td>1.9</td>
<td>5.5</td>
<td>7.2</td>
<td>4.7</td>
</tr>
<tr>
<td>PPE</td>
<td>0.1</td>
<td>0.2</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong> (grams/person/day)</td>
<td><strong>129.6</strong></td>
<td><strong>263.7</strong></td>
<td><strong>386.5</strong></td>
<td><strong>238.4</strong></td>
</tr>
</tbody>
</table>
### Table 3: Composition of Dry Waste Across Income Groups

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Low Income</th>
<th>Middle Income</th>
<th>High Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>25.5%</td>
<td>33.7%</td>
<td>35.1%</td>
</tr>
<tr>
<td>Plastic</td>
<td>30.5%</td>
<td>31.8%</td>
<td>30.2%</td>
</tr>
<tr>
<td>Sanitary</td>
<td>13.3%</td>
<td>12.2%</td>
<td>10.9%</td>
</tr>
<tr>
<td>Other</td>
<td>6.6%</td>
<td>8.4%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Cloth</td>
<td>11.4%</td>
<td>5.6%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Glass</td>
<td>7.4%</td>
<td>4.5%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Metal</td>
<td>1.5%</td>
<td>1.9%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Shoes</td>
<td>3.2%</td>
<td>1.1%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Electronic</td>
<td>0.4%</td>
<td>0.5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>PPE</td>
<td>0.2%</td>
<td>0.3%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

### Table 4: Paper Waste Generation and Recovery

<table>
<thead>
<tr>
<th>Waste Category</th>
<th>Generation (tonnes/day)</th>
<th>% Within Paper Waste</th>
<th>Recycling (tonnes/day)</th>
<th>% Recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Office Paper</td>
<td>7.1</td>
<td>6.91%</td>
<td>4.4</td>
<td>62.02%</td>
</tr>
<tr>
<td>Newspaper</td>
<td>22.5</td>
<td>21.85%</td>
<td>6.9</td>
<td>30.51%</td>
</tr>
<tr>
<td>Notebook</td>
<td>0.1</td>
<td>0.08%</td>
<td>0.1</td>
<td>100.00%</td>
</tr>
<tr>
<td>Road Scrap</td>
<td>50.6</td>
<td>49.05%</td>
<td>16.2</td>
<td>32.10%</td>
</tr>
<tr>
<td>Corrugated Paper</td>
<td>22.7</td>
<td>22.06%</td>
<td>19.3</td>
<td>84.99%</td>
</tr>
<tr>
<td>Printed Books</td>
<td>0.1</td>
<td>0.05%</td>
<td>0.1</td>
<td>100.00%</td>
</tr>
<tr>
<td>Magazine</td>
<td>0.0</td>
<td>0.00%</td>
<td>0.0</td>
<td>100.00%</td>
</tr>
<tr>
<td>Total</td>
<td>103.1 TPD</td>
<td>47 TPD</td>
<td>46%</td>
<td></td>
</tr>
</tbody>
</table>
## Table 5: Plastic Generation and Recovery by Sub-Category

<table>
<thead>
<tr>
<th>Waste Category</th>
<th>% of Plastic Waste Generation</th>
<th>Generation (tonnes/day)</th>
<th>% of Material Recycled</th>
<th>Recycling (tonnes/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable / Flexible Pipes</td>
<td>0%</td>
<td>0.1</td>
<td>99%</td>
<td>0.1</td>
</tr>
<tr>
<td>PVC</td>
<td>0%</td>
<td>0.3</td>
<td>83%</td>
<td>0.3</td>
</tr>
<tr>
<td>HDPE</td>
<td>7%</td>
<td>5.4</td>
<td>83%</td>
<td>4.5</td>
</tr>
<tr>
<td>PET</td>
<td>11%</td>
<td>8.9</td>
<td>75%</td>
<td>6.7</td>
</tr>
<tr>
<td>PP</td>
<td>7%</td>
<td>5.6</td>
<td>72%</td>
<td>4.0</td>
</tr>
<tr>
<td>PS</td>
<td>1%</td>
<td>1.1</td>
<td>71%</td>
<td>0.8</td>
</tr>
<tr>
<td>Compostable, Flexible Plastic</td>
<td>0%</td>
<td>0.0</td>
<td>68%</td>
<td>0.0</td>
</tr>
<tr>
<td>Multi-Material Wire</td>
<td>0%</td>
<td>0.1</td>
<td>64%</td>
<td>0.1</td>
</tr>
<tr>
<td>Other Mixed Rigid Plastic</td>
<td>4%</td>
<td>3.3</td>
<td>55%</td>
<td>1.8</td>
</tr>
<tr>
<td>Rigid LDPE</td>
<td>0%</td>
<td>0.1</td>
<td>49%</td>
<td>0.0</td>
</tr>
<tr>
<td>Flexible PVC</td>
<td>1%</td>
<td>0.5</td>
<td>44%</td>
<td>0.2</td>
</tr>
<tr>
<td>Flexible HDPE</td>
<td>0%</td>
<td>0.1</td>
<td>42%</td>
<td>0.0</td>
</tr>
<tr>
<td>Multi Layered Plastic (Only Plastic)</td>
<td>6%</td>
<td>5.2</td>
<td>38%</td>
<td>2.0</td>
</tr>
<tr>
<td>Multi-Material Rigid</td>
<td>3%</td>
<td>2.8</td>
<td>36%</td>
<td>1.0</td>
</tr>
<tr>
<td>EPS Foam (Styrofoam)</td>
<td>0%</td>
<td>0.1</td>
<td>35%</td>
<td>0.0</td>
</tr>
<tr>
<td>Clear, Flexible LDPE</td>
<td>10%</td>
<td>8.1</td>
<td>28%</td>
<td>2.3</td>
</tr>
<tr>
<td>Clear, Flexible PP</td>
<td>5%</td>
<td>4.3</td>
<td>26%</td>
<td>1.1</td>
</tr>
<tr>
<td>Milk Packets (LDPE)</td>
<td>9%</td>
<td>7.2</td>
<td>25%</td>
<td>1.8</td>
</tr>
<tr>
<td>Nonwoven PP</td>
<td>1%</td>
<td>0.6</td>
<td>23%</td>
<td>0.1</td>
</tr>
<tr>
<td>Nylon</td>
<td>0%</td>
<td>0.2</td>
<td>23%</td>
<td>0.0</td>
</tr>
<tr>
<td>Other Multi-Material Plastic (Tetra Pak)</td>
<td>1%</td>
<td>0.8</td>
<td>22%</td>
<td>0.2</td>
</tr>
<tr>
<td>Rubber</td>
<td>0%</td>
<td>0.2</td>
<td>21%</td>
<td>0.0</td>
</tr>
<tr>
<td>Coloured, Flexible LDP E</td>
<td>19%</td>
<td>15.4</td>
<td>13%</td>
<td>2.1</td>
</tr>
<tr>
<td>Coloured, Flexible PP</td>
<td>4%</td>
<td>3.4</td>
<td>11%</td>
<td>0.4</td>
</tr>
<tr>
<td>Rafia (PP)</td>
<td>0%</td>
<td>0.3</td>
<td>10%</td>
<td>0.0</td>
</tr>
<tr>
<td>PU Foam</td>
<td>1%</td>
<td>0.8</td>
<td>10%</td>
<td>0.1</td>
</tr>
<tr>
<td>Metal Multi-Layered Plastic</td>
<td>8%</td>
<td>6.2</td>
<td>6%</td>
<td>0.4</td>
</tr>
<tr>
<td>Thermocole</td>
<td>1%</td>
<td>0.7</td>
<td>5%</td>
<td>0.0</td>
</tr>
<tr>
<td>LDPE Foam</td>
<td>0%</td>
<td>0.1</td>
<td>2%</td>
<td>0.0</td>
</tr>
<tr>
<td>PVC Foam</td>
<td>0%</td>
<td>0.0</td>
<td>0%</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100%</strong></td>
<td><strong>81.9</strong></td>
<td><strong>37%</strong></td>
<td><strong>30.1</strong></td>
</tr>
</tbody>
</table>
Kashtakari Panchayat, 5 Pleasant Apartments, Baner, Pune 411007
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