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Solid and Plastic Waste Assessment in Udaipur, India

FINDINGS FROM THE **CLOSING THE DATA GAP CHALLENGE**

The Circulate Initiative | FINISH Society | WASTE | ALLIANCE TO END PLASTIC WASTE

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Findings from the Closing the Data Gap Challenge

Produced by

WASTE and FINISH Society

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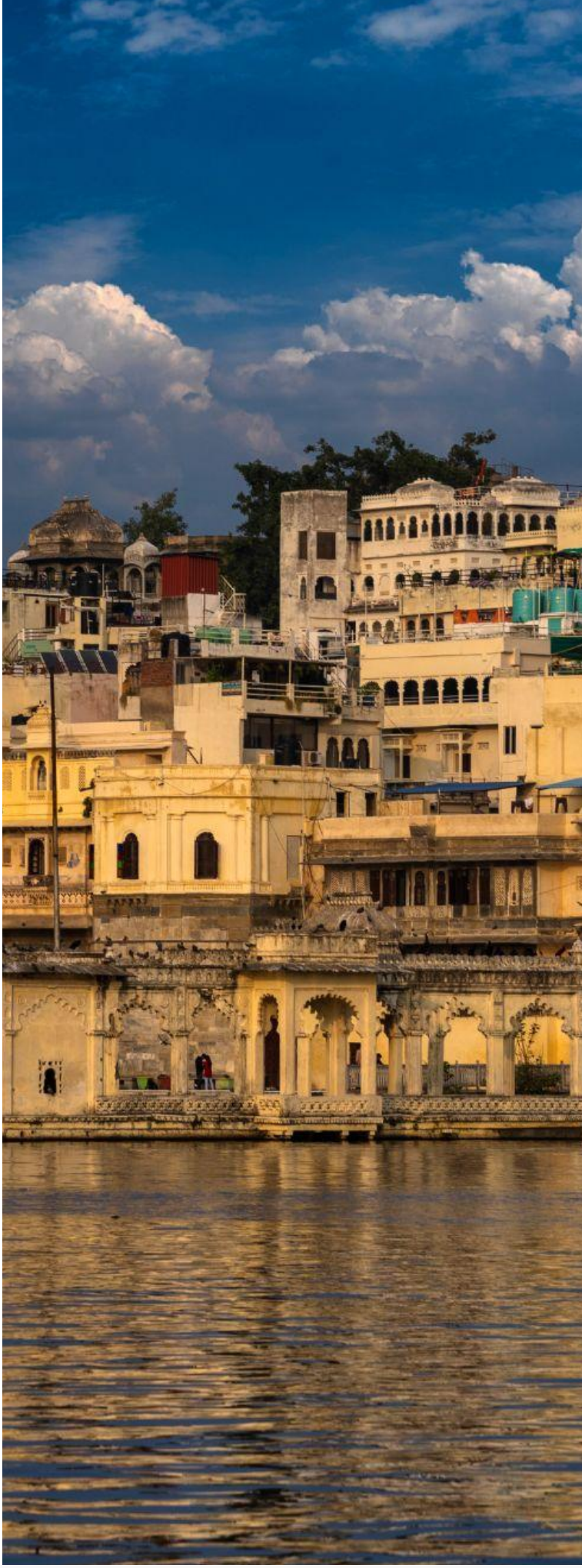


1. Introduction

Plastic waste pollution is recognised as one of the major problems that must be solved to protect our oceans and living environment. This pollution largely originates from rapidly urbanising areas throughout the developing world. As the scale of the plastic pollution continues to grow, the need for reliable, consistent data has increased.

The Alliance to End Plastic Waste and The Circulate Initiative identified the absence of credible, harmonised data on municipal solid waste and the recycled plastics value chain as a challenge that must be overcome to support better decision-making.

The Closing the Data Gap Challenge represents an initiative through which the Alliance to End Plastic Waste and The Circulate Initiative share mutual interest to support decision-makers and other stakeholders with better quality data to prevent plastic pollution and advance a more inclusive, circular economy.

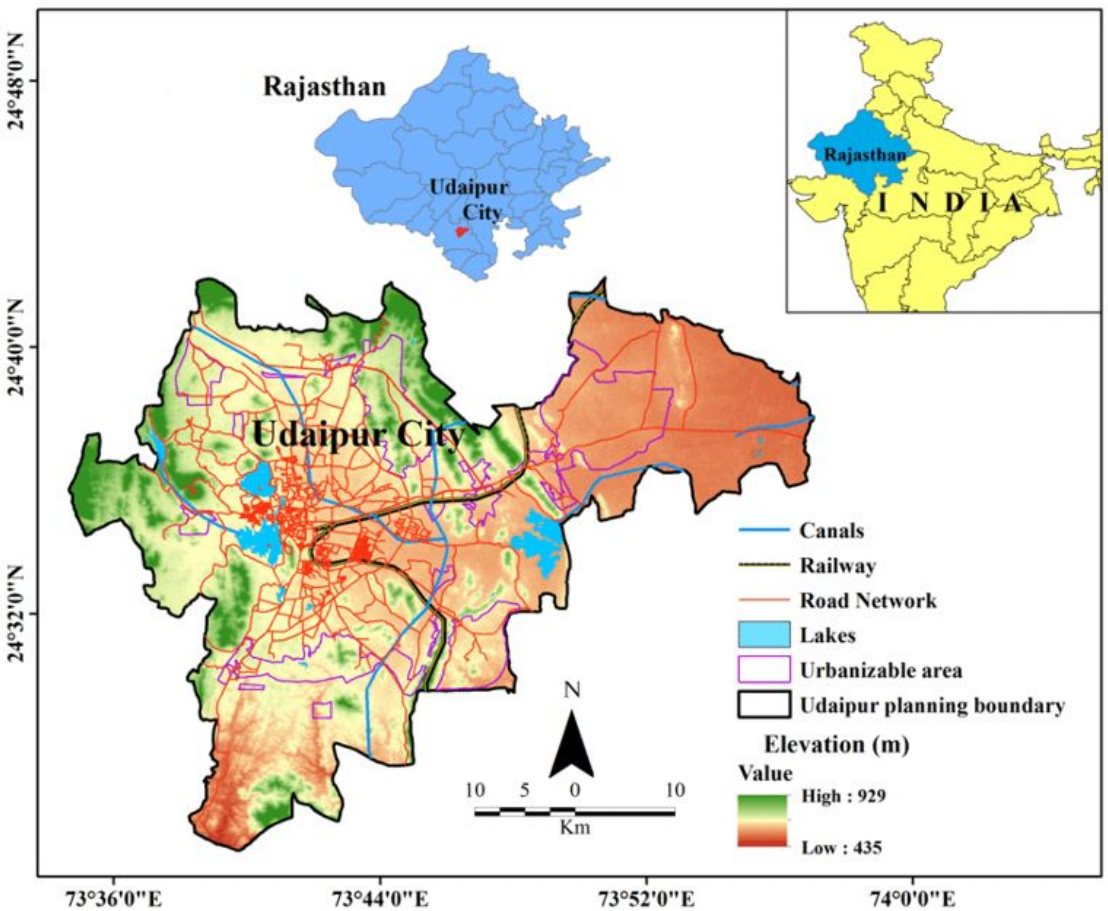
In response to the Request for Proposals (RFP) of the Closing the Data Gap Challenge, the Alliance to End Plastic Waste and The Circulate Initiative contracted WASTE Netherlands and FINISH Society/TOP Trust to execute a detailed assessment. This project assessed the city of Udaipur in India on the requested data points between January and July 2022.

2. City Profile

Udaipur is situated in the state of Rajasthan, also known as the "City of Lakes". Udaipur is surrounded by the Aravalli hills and it has five lakes – Pichola, Fateh Sagar, Rang Sagar, Swaroop Sagar and the smaller Doodh Talai. Udaipur has one river running through the city, the Ayad River, but it does not contain much water during the dry season. The rainy season starts in the month of July and ends in September. According to the Census of India conducted in 2011, the population of Udaipur was 451,100 in 2011.[1] The estimated population of the city in 2021 was 580,000. In the absence of city-specific data on the household distribution by income segments, households in Udaipur city were categorised into low-income (30%), middle-income (60%) and high-income (10%) households following the national income distribution brackets.

The economy of Udaipur is diversified, with significant contributions from tourism, trade and commerce. Udaipur is a touristic city and numerous Indian and international tourists visit each year. In 2019, just before the COVID-19 pandemic, 1,185,246 tourists visited the city.[2] Udaipur is rich in minerals and has been instrumental in the formation of Rajasthan State Mines and Minerals Limited. Most businesses associated with metals, automobiles, stone grinding and auto repair are primarily situated near the city's railway station. Udaipur serves as a market centre for the smaller towns of the region. There are an estimated 1,324 hotels and 7,000 commercial establishments in the city.[3]

FIGURE 1: Map of Udaipur City



[1] Census India - *Udaipur City Population (2011)*
[2] Rajasthan Tourism Department – *Progress Report 2020-21 (2021)*
[3] ICLEI South Asia - C*limate Resilient City Action Plan – Udaipur (2019)*

TABLE 1: Udaipur City Profile

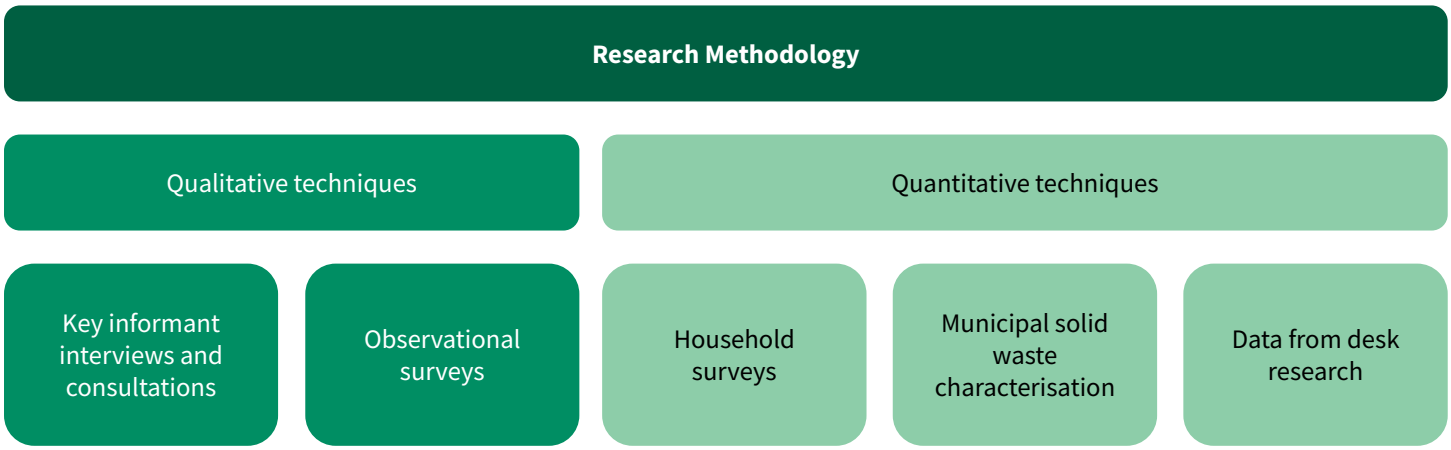
Area	64 sq. km
Administrative wards	55
Climate	Tropical
Government body for solid waste management	Udaipur Municipal Corporation (UMC)
Total population (2021 est.)	580,000
Low-income	30%
Middle-income	60%
High-income	10%
Tourist population (2019)	1,185,246
Hotels	1,324
Other commercial establishments	7,000

Sources: *Census of India (2011), Rajasthan Tourism Department Progress Report (2021), ICLEI South Asia - Climate Resilient City Action Plan – Udaipur (2019)*

3. Research Methodology

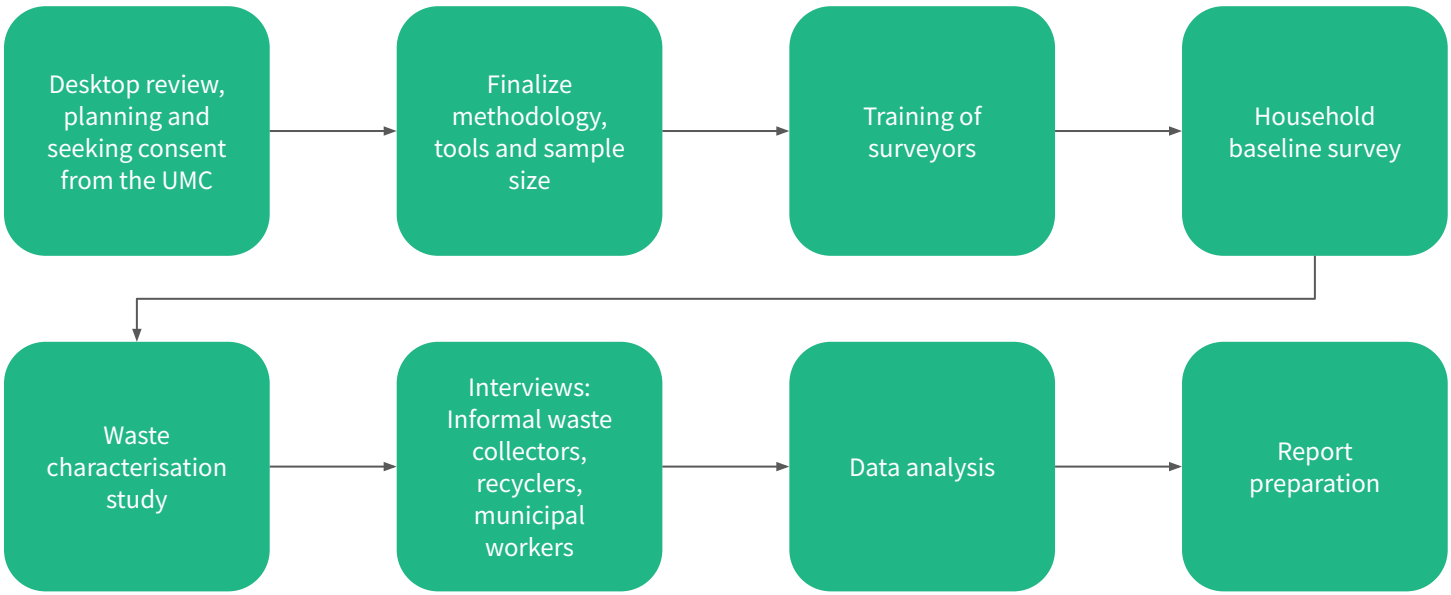
A mixed methodology approach was adopted for the study, with quantitative and qualitative techniques utilised to collect primary and secondary data. The primary data for municipal solid waste generation, management and leakage was captured with the help of household surveys and waste characterisation surveys by utilising the Waste Wise Cities Tool (WaCT) developed by UN-Habitat.[4] Along with household surveys, key informant interviews, consultations and observational surveys were conducted with informal waste workers, aggregators, city authorities and local recyclers. Secondary sources considered included demographic data, existing reports and data from the UMC. The design of the study is presented in Figure 2.

FIGURE 2: Design of the Study



The project commenced in January 2022 and field data collection took place from 10 March to 30 April. The steps undertaken in the study are shown in Figure 3.

FIGURE 3: Activities Executed in the Study



[4] United Nations Human Settlements Programme (UN-Habitat) - *Waste Wise Cities Tool (2021)*

3.1. Municipal solid waste and plastic waste generation and composition analysis

Municipal solid waste generated in any city consists not only of household waste but also commercial waste (e.g. from markets, restaurants, shops, hotels, etc.), institutional waste (e.g. from schools, administrative buildings, offices, etc.), as well as waste from public spaces (e.g. parks and streets). The latter waste types are referred to in this report as "household-similar" waste. Section 3.1.1 below explains how household solid waste generation was assessed and Section 3.1.2 provides the approach to assessing household-similar waste.

3.1.1. Household waste generation and composition

To obtain a clear understanding of the quantity and composition of municipal solid waste generated in the city at the household level, a waste characterisation study was executed following the WaCT guidelines. The tool was utilised to meet the objectives of the study on the different types of plastics and to estimate the data for key indicators. Preparations started at an earlier stage of the project, and a consent letter was obtained from the UMC. Tools and other necessities were also purchased (hanging weighing scales, baskets, bags, stickers, personal protection equipment, etc.). A dedicated team of 10 researchers was selected for the purpose of the study.

Waste generation differs among families of different income levels due to different consumption behaviours. To cover different parts of the city, nine clusters, three each from low-, middle- and high-income groups, were identified. The estimated share of low-, middle- and high-income group families was taken as 30%, 60% and 10% respectively based on national household income distribution and after confirmation with the local team. Furthermore, a baseline survey was conducted with 160 households from the mapped locations covering different income classes. The type of dwelling, locality and ownership of vehicles such as motorcycles and cars were used as the proxies for categorising households into the three income segments. Following the baseline survey, 108 households were selected for the waste characterisation study: 32 low-income households, 65 middle-income households and 11 high-income households.

The team visited the selected households to explain the purpose of the study. The households were also presented with the letter from the municipality with its approval to conduct this study and carry out the waste characterisation assessment. In addition, consent was sought for their voluntary participation.

The team reminded the households not to sell or take out recyclables or give food waste to animals so that the total waste generation in the household was captured as accurately as possible.

A training workshop was organised on 22 March 2022 to train the survey team on WaCT implementation in the city. During the workshop, the WASTE and FINISH Society team briefed the participants on the purpose of the survey, the division of tasks and responsibilities, and the procedure for the daily distribution and daily collection of garbage bags. In a role play, two participants were invited to practise the detailed explanation of the survey to the residents of the selected households.

This was followed by a practical exercise on identifying and categorising the different types of plastic. An owner of a *kabadiwalla* (aggregator) was present to explain how to recognise the different types of plastic and their related local names. In the final segment of the training workshop, stickers with the unique code were used to identify each household selected for the waste characterisation study. These stickers were used to code the bags that were distributed to the selected households.

Each day the selected households received three bags for segregating household waste into wet, dry and hazardous household waste. The bags were distributed to:

- 32 low-income households
- 65 middle-income households
- 11 high-income households

The bags were handed over to the selected households and the survey team explained the purpose of the survey, the duration and the daily collection and daily distribution of bags. They gave the residents a leaflet about the separation of waste into the three categories

3.1.1. Household waste generation and composition (continued)

and included a telephone number that they could call in case of questions or complaints (see Annex 1).

The collection of the bags with segregated waste took place over a period of eight days from 24 March to 31 March 2022. Two collection vehicles that set out every day at 7:00 am were used to collect the filled bags from the selected households. The bags were transported to the sorting centre at Titardi, Udaipur, where the sorting took place. The bags were unloaded and placed at the designated sites for low-, middle- and high-income households. The weight of all bags was recorded; this was followed by emptying the dry waste bags onto one heap. The wet waste bag was checked for plastic waste and discarded together with the hazardous waste bag. Following that, dry waste was sorted and weighed according to the different categories. Plastic waste was further sorted according to the types of polymers and application.

3.1.2. Household-similar waste generation and composition

For household-similar waste generation, existing data from the municipality and from the agency responsible for collecting commercial waste in Udaipur city was referred to. Data from previous reports was also considered for household-similar waste quantities generated. For example, the ICLEI report provided inputs for the generation and composition figures from hotels and restaurants, other commercial places, institutional waste and vegetable markets.

Waste characterisation training – sorting exercise

Marking stickers to code waste bags

Stickers used to code waste bags

3.2. Solid and plastic waste collection, transport and treatment

To obtain insight into the quantities of plastic waste collected, transported and treated in Udaipur, site visits were conducted and site managers were consulted to understand the details of the transfer station, the material recovery facilities, waste treatment plant and waste disposal site. Information gathered included quantities of solid and plastic waste collected, transported and treated, for example in the biogas installation, or quantities of plastic waste transported to the cement kiln.

As the collection, transportation, sorting and recycling of plastic waste is carried out by both formal and informal economic units, data was collected on both sets of actors (see Section 3.3).

3.3. Informal waste workers: their livelihoods and working conditions

Informal waste workers in India play a significant role in the collection and recycling of solid waste, especially inorganic waste including plastics, paper, metal and glass. A mapping of the informal waste worker community was conducted to determine the total number of waste workers and families in Udaipur.

A semi-structured questionnaire was developed for conducting interviews with the waste workers to obtain information about the quantities of plastic waste handled and about their socio-economic conditions. In total, 12 informal waste worker interview sessions were conducted with a total of 64 waste workers interviewed.

3.4. Plastic consumption

The per capita consumption of plastics is estimated to be 11 kg per year in India. It is anticipated that it will continue to grow to between 16 and 20 kg per person per year by 2025.[5] As part of this study, consumption specifically for the city of Udaipur was not carried out as it was beyond the scope of the project.

[5] Centre for Science and Environment - *The Plastics Factsheet 1 (2019)*

Waste bags handed over to households

Weighing waste bags collected from households

Interviews with informal waste workers

3.5. Mismanaged waste and plastic leakage

To calculate the mismanaged waste and plastic leakage quantity in Udaipur, guidance from the International Union for Conservation of Nature's (IUCN) "The marine plastics footprint" report,[6] and "National Guidance for Plastic Pollution Hotspotting and Shaping Action",[7] were referred to. In the absence of data specific to Udaipur, the release rate of 10% was applied to calculate the volume of macroplastic leaked into the environment.

[6] IUCN - *The marine plastic footprint (2020)*
[7] IUCN - *National Guidance for Plastic Pollution Hotspotting and Shaping Action (2020)*

4. Results and Key Findings

4.1. Municipal solid waste and plastic waste generation and composition

Municipal solid waste is defined as the total amount of waste generated by households and household-similar entities (commerce and trade, small businesses, offices, hotels, etc.). It excludes waste from construction and demolition, and industrial waste. Section 4.1.1 below discusses the findings from the household waste characterisation study, Section 4.1.2 discusses the findings of the household-similar waste estimation and Section 4.1.3 details the estimation of total municipal solid waste generation and composition in Udaipur.

4.1.1. Household waste generation and composition

Table 2 below highlights the daily per capita waste generation in Udaipur. On average, waste generation from the three categories of selected households (low-, middle- and high-income) was 0.261 kg per person per day. The per capita waste generation for middle-income households was higher than high-income households. This contradicts the common view that household waste generation tends to increase by income level. In the absence of precise data on household income for Udaipur, proxies such as type of dwelling, locality, and ownership of vehicles such as motorcycles and cars were used to classify the households. As such, the higher per capita data for middle-income households could be due to middle income households being captured as high-income.

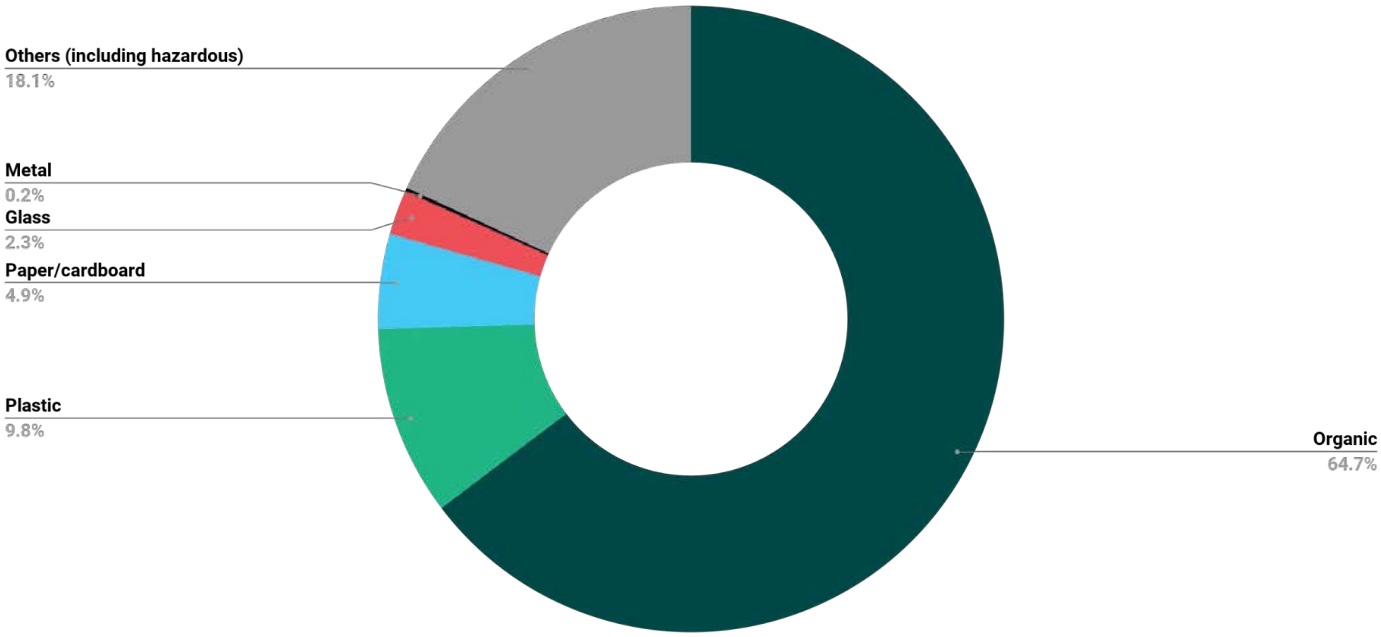
TABLE 2: Per Capita Generation of Household Waste Per Day

Household type	Per capita waste generation per day (kg)
Low income	0.217
Middle income	0.285
High income	0.244

Source: *Municipal Solid Waste Characterisation Study, Udaipur (2022)*

Alongside the generation of household waste, the composition of the waste from the 108 households sampled for the study was also analysed. The results revealed that organic waste contributed to 65% of the weight of the household waste, followed by others (18%) and plastic waste (10%).

FIGURE 4: Composition of Household Waste



Source: *Municipal Solid Waste Characterisation Study, Udaipur (2022)*

Plastic waste was further sorted into the different types of polymers for different income groups to obtain a weighted average of each polymer out of total plastic waste. The results can be found in Table 3 and pictures of the different types of polymers can be found in Annex 3. The share of multi-layer packaging was observed to be comparatively high.

TABLE 3: Household Plastic Waste Generated by Polymer Type

Polymer type	Share in low-income households	Share in middle-income households	Share in high-income households	Share of solid waste	Share of plastic waste
PET	0.6%	3.1%	1.5%	1.7%	17.6%
HDPE	0.4%	0.1%	5.0%	1.8%	18.4%
LDPE	1.7%	1.8%	3.8%	2.4%	24.7%
PS	0.0%	0.3%	0.6%	0.3%	3.0%
PVC	0.0%	0.0%	0.3%	0.1%	1.1%
PP	1.6%	0.1%	0.3%	0.7%	6.9%
MLP	0.8%	1.8%	2.1%	1.6%	16.3%
Other plastic	0.2%	1.3%	1.4%	1.2%	12.0%

Source: *Municipal Solid Waste Characterisation Study, Udaipur (2022)*

4.1.2. Household-similar waste generation and composition

Based on data from Trashonomy (a private contractor collecting commercial waste in the city) and other publications, the quantity and percentage of plastic waste in total waste generated by household-similar entities (hotels, restaurants, commercial places, offices and markets) were estimated as shown in Tables 4 and 5 below.

TABLE 4: Quantity of Solid Waste and Plastic Waste Generated by Household-Similar Entities

Data type	Quantity (tons per day)
Solid waste generated by hotels and restaurants	40.5
Solid waste generated by other commercial places	13.4
Solid waste generated by institutions	2.7
Solid waste generated by vegetable markets	2.8
Total commercial and institutional waste generation (household-similar)	59.4

Source: *ICLEI South Asia (2019), WASTE/FINISH Society estimates (2022)*

TABLE 5: Share of Plastic Waste in Solid Waste Generated by Household-Similar Entities

Household-similar entity	Share of plastic in solid waste
Hotels and restaurants, Other commercial places, Institutions, Vegetable markets	35.3%

Source: *ICLEI South Asia (2017), WASTE/FINISH Society estimates (2022)*

4.1.3. Total amount of municipal solid waste generation in Udaipur

The survey of municipal solid waste generation used primary and secondary data to assess waste from different streams, including households, commercial and institutional places, and street sweeping. Based on the results of the survey, the estimated total municipal waste generation in the city of Udaipur is 230 tons per day with a per capita waste generation of 0.396 kg a day based on a population of 580,000. The breakdown of municipal solid waste from different streams is presented in Table 6.

Waste collected from street sweeping

TABLE 6: Total Municipal Solid Waste Generated in Udaipur

Sources of Waste	Quantity (tons per day)
Household waste	149.6
Household-similar waste	59.4
Sweeping waste	21.0
Total municipal solid waste	**230.0**

Sources: *Municipal Solid Waste Characterisation Study, Udaipur (2022), ICLEI South Asia (2019), Trashonomy, Udaipur Municipal Council, WASTE/FINISH Society estimates (2022)*

4.2. Solid and plastic waste collection, transport and treatment

Solid waste management is a compulsory activity of the UMC under the supervision of the municipal commissioner.

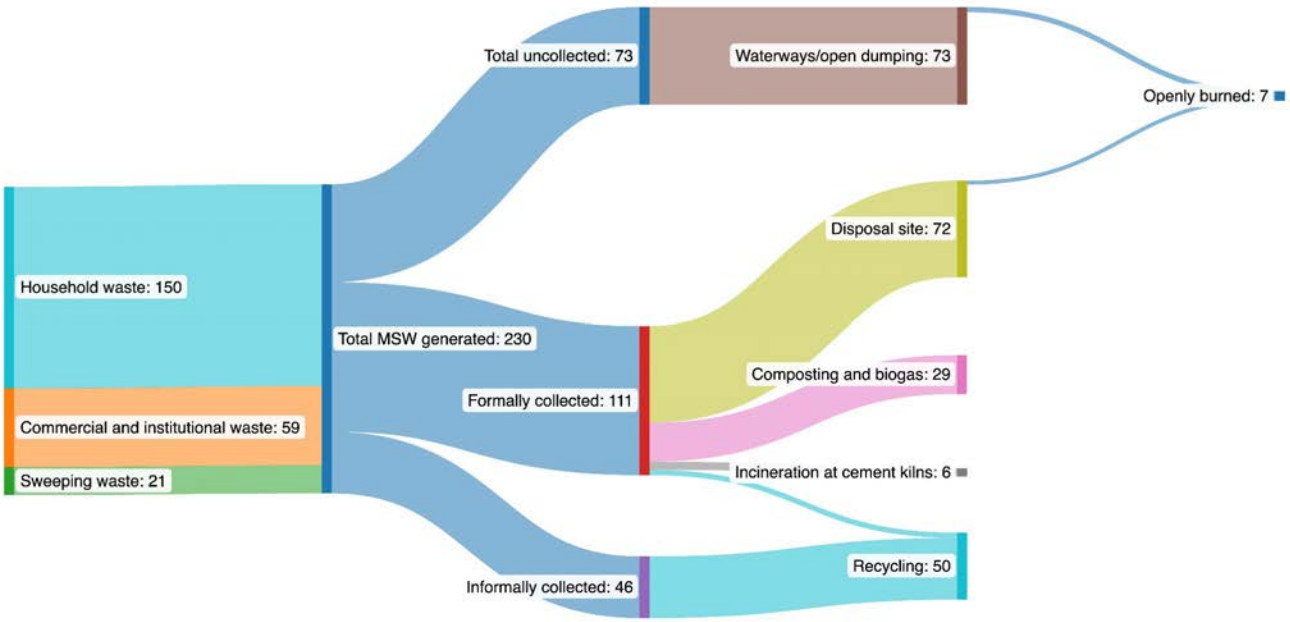
Since 2018, the UMC has invested INR 2.79 billion (USD 35.1 million) in the purchase of 100 collection trucks, two material recovery facilities (MRFs) including a composting site (capacity 50 tons/day), a transfer station with compacting installations and a biogas reactor. Collection of household waste from different wards is outsourced to four agencies, with FINISH Society one of the selected service providers. Waste collection data is obtained from the transfer station where every incoming truck is weighed. For commercial waste, a separate agency, Trashonomy, has been appointed to cover selected areas of the city.

There are also other private operators engaged by commercial establishments to collect and dispose of their waste. The total waste collected in Udaipur city by both formal and informal collection systems is estimated to be 157 tons per day, with 73 tons (32%) of the 230 tons of solid waste generated per day uncollected.

The municipal solid waste flow for the city is depicted in Figure 5.

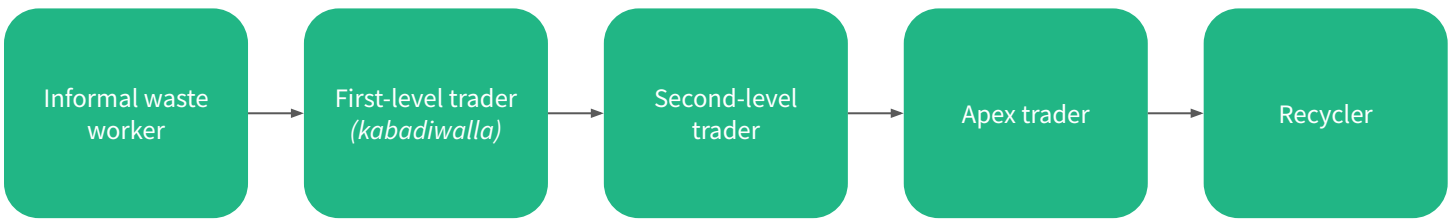
Commercial waste collection

FIGURE 5: Municipal Solid Waste (MSW) Flow Diagram for Udaipur City (tons/day)



Sources: *Municipal Solid Waste Characterisation Study, Udaipur (2022), ICLEI South Asia (2019), Trashonomy, Udaipur Municipal Council, WASTE/FINISH Society estimates (2022)*

FIGURE 6: Main Actors in the Plastic Waste Value Chain



In Udaipur, a vibrant informal plastic waste value chain exists, with the five main actors in this system identified above. Informal waste workers are the primary collectors of recyclable plastic waste and are essential actors in the value chain. They collect plastic waste not only from the waste disposal site but also from houses, commercial establishments and from the streets. As they are neither registered nor recognised by formal authorities, they form part of the informal waste collection system. Informal collection of plastic waste is estimated based on the average amount of plastic waste collected by an informal waste worker. Informal waste workers sell the collected recyclables to the next actor in the chain, the *kabadiwalla* (aggregator).

First-level traders/*kabadiwallas* receive materials from both formal and informal recyclable collection systems (including waste workers), then store and prepare these materials for onward trading to apex traders. *Kabadiwallas* sort the waste materials and pay the informal waste workers based on the type and weight of material provided. Small (second-level) traders and apex traders buy and sort plastic waste with basic sorting, baling, washing and shredding done by some of these traders.

The final actor in the chain is the recycler, who produces granules or pellets using plastic waste or produces recycled products. An example of a plastic waste recycler in Udaipur is a company producing irrigation tubes from LDPE plastic waste. The company purchases the LDPE granules on the local market to produce the tubes.

Plastic waste used in recycling

Recycler of LDPE waste into irrigation tubes

4.3. Plastic waste generation and recycling

The share of plastic waste in household, non-household and sweeping waste was estimated, and the share of plastic waste in total municipal solid waste was calculated based on the weighted average from the different streams (see Table 7 below).

TABLE 7: Share of Plastic Waste in Municipal Solid Waste

Sources of waste	Percentage of plastic waste	Municipal solid waste (tons per day)	Plastic waste (tons per day)
Household waste	9.8%	149.6	14.7
Non-household waste	35.3%	59.4	21.0
Sweeping waste	5.0%	21.0	1.1
Total	**16.0%**	**230.0**	**36.7**

Sources: *Municipal Solid Waste Characterisation Study, Udaipur (2022), ICLEI South Asia (2019), Trashonomy, Udaipur Municipal Council, WASTE/FINISH Society estimates (2022)*

TABLE 8: Plastic Waste Collected and Recycled

Data	Quantity (tons per day)	Percentage of plastic waste
Informally collected	14.8	40.3%
Formally collected	17.7	48.2%
Informally recycled	15.0	40.9%
Formally recycled	1.4	3.8%
Total plastic waste recycled	16.4	44.7%
‣ Recycled rigid plastic	11.5	
‣ Recycled flexible plastic	4.9	

Source: *Municipal Solid Waste Characterisation Study, Udaipur (2022), WASTE/FINISH Society estimates (2022)*

4.4. Plastic consumption

Plastic consumption for Udaipur was estimated based on secondary data sources. As per a report by The Energy and Resources Institute, India, the total consumption of plastic polymers was estimated at 15 million tons per annum in 2018-19,[8] or a per capita plastic consumption of 11 kg per annum. It is also estimated that approximately 70% of total plastic consumed is discarded as waste.[9] Table 9 below presents the estimated share of plastics consumed, broken down by the common polymers.

In the absence of specific sources for Udaipur, plastic waste generation data was assumed to be equivalent to plastic consumption (see Figure 7).

TABLE 9: Plastic Consumption by Polymer Type

Polymer	Consumption share (%)
PP	37.6%
PET	14.5%
HDPE	13.9%
LLDPE and LDPE	12.8%
PVC	9.7%
PS	1.9%
Others	9.6%

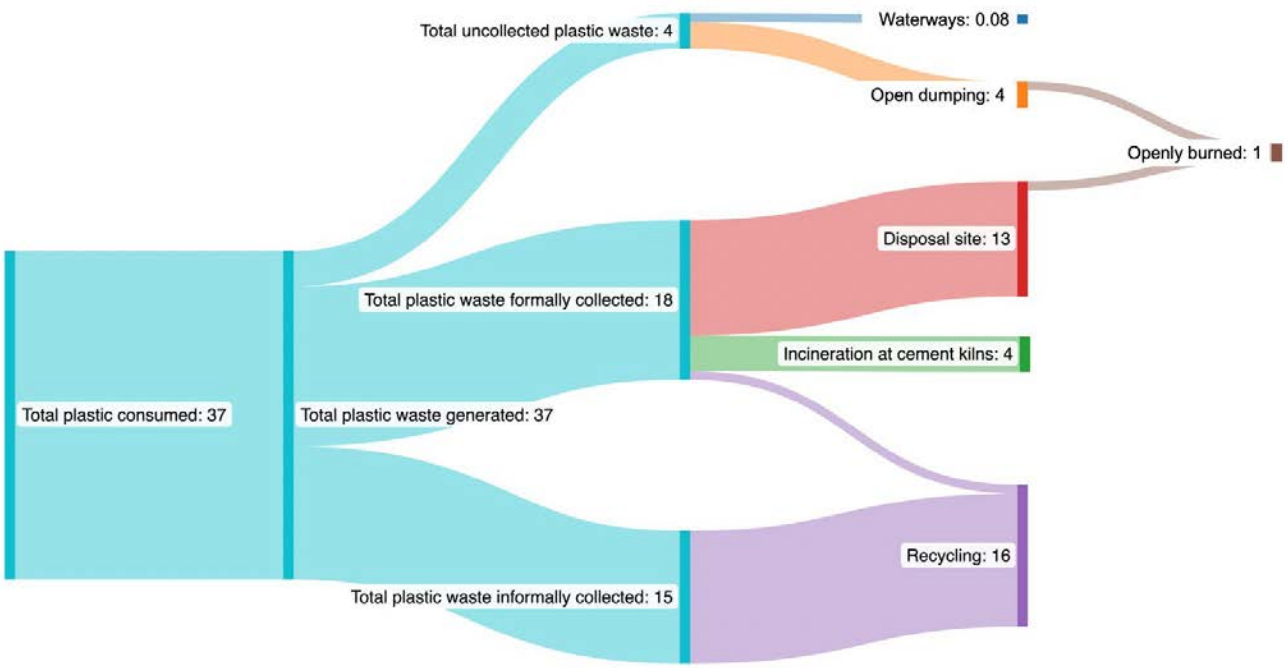
Source: *Circular Economy for Plastics in India: A Roadmap, TERI (2021)*

[8] The Energy and Resources Institute - *Circular Economy for Plastics in India: A Roadmap (2011)*
[9] United Nations Environment Programme and Institute for Global Environmental Strategies - *Strategies to Reduce Marine Plastic Pollution from Land-based Sources in Low and Middle-Income Countries (2019)*

4.5. Mismanaged waste and plastic leakage

Mismanaged waste refers to any waste either directly discarded in water, uncollected or poorly managed. Following this definition, the total quantity of mismanaged plastic waste in Udaipur was estimated as 16.0 tons per day. With a release rate of 10%, the total leakage of plastic waste to the environment in Udaipur was estimated as 1.6 tons per day.

FIGURE 7: Plastic Waste Flow, Udaipur (tons/day)



Sources: *Municipal Solid Waste Characterisation Study, Udaipur (2022), ICLEI South Asia (2019), Trashonomy, Udaipur Municipal Council, WASTE/FINISH Society estimates (2022)*

4.6. Informal waste workers: their livelihoods and working conditions

Twelve interview sessions were held with informal waste workers, both men and women, in different parts of the city. The selected informal waste workers satisfied one or more of the following screening criteria:

- Do not work within dedicated premises and collect waste from roadsides, dump yards, trash bins, etc.
- Do not receive a regular fee or salary from any private or public employer.
- Are not covered by any insurance or medical benefits provided by an employer.

A total of 64 informal waste workers were interviewed, consisting of 18 males (28%) and 46 females (72%). The following are the main findings of the interviews conducted with the informal waste workers in Udaipur:

- All respondents were illiterate and did not have any formal education. They lived in informal settlements or notified slums where other families also engaged in similar work. None of the waste workers were part of any formal association or recognised by the urban local body.
- The family sizes of these informal waste workers were quite large, averaging fourteen members per family compared to the average family size of five members in Udaipur city taken from census 2011 data and confirmed by our household baseline survey. The average number of children per family below fifteen years was found to be seven. Reasons attributed to the large family size were early marriages and the perception that a large family would lead to more earning members, hence more income.
- Fifty percent of the respondents interviewed conveyed that their children do not attend school; 68% of the respondents shared that children help in the waste collection work.
- Forty-two percent of the respondents shared that male members of the family were engaged in other occupations aside from waste collection, such as unskilled labour, driving, etc. Female household members, on the other hand, focus on waste collection (with children helping) and take care of the household chores.

Faces behind the informal waste sector

4.6. Informal waste workers: their livelihoods and working conditions (continued)

- Most respondents (75%) shared that they have been working as waste workers since childhood. They were inducted into this line of work by the elders of the family and shared that they have not learnt any other livelihood skills. While a few of them mentioned that they would like to work with the municipality or in a more formal set-up as cleaners or waste collectors, many women shared that they would not prefer a job with fixed hours.
- Most female respondents work an average of four to five hours daily, starting from early in the morning, working till noon, and later take care of their families. However, women with infants and small children leave the children at home without any proper care. This is one of the primary reasons for the low school enrolment rate and school dropouts amongst children from these families.
- With door-to-door waste collection services in Udaipur increasing in the past few years, the volume of waste available to the informal workers has been significantly reduced. Forty-two percent of the waste workers shared that they travel more than 10 km per day to collect waste. Others reported travelling a minimum of four kilometres every day for waste collection.
- After the collection of waste by all family members, the waste is compiled, segregated and then stored. Most of them sell to local kabadiwallas and have a long-standing working relationship with them. These are the first level of sorters or traders in the recycling chain, who further segregate the waste and sell it to a bigger aggregator. The frequency of the sale depends on the volume, but most respondents shared that they sell sorted waste weekly. All respondents shared that they always receive their payments in cash.
- The average income per day per person was found to be in the range of INR 200-300 from selling dry waste. The average volume of dry waste collected per day by all family members was reported as 25 kg. Of the total waste, the volume of plastic collected was approximately 5 kg per day.
- Common waste categories into which recyclables were sorted included PET, HDPE, flexible plastics (HDPE, LDPE, etc., but excluding MLP), paper, glass and metal. PET, metal and LDPE were among the most profitable waste categories in terms of value per kilogram.
- All waste workers possess an Aadhaar card, a unique identification number issued by the government that provides access to social security benefit programmes. Eighty-three percent of respondents own a bank account.
- The surveyors observed that none of the informal waste workers were wearing gloves while picking and segregating waste. None of the respondents have life insurance or any health insurance coverage.
- Some of the common challenges faced by them are harassment by local officials, the challenge of collecting a high volume of waste, injuries while collecting waste and lack of adequate storage space.

5. Conclusion

Through the execution of a waste characterisation study in Udaipur city, this report provides key baseline statistics on the state of plastic waste generation and management in the city. With growing focus on the impact of plastic pollution on human health and the environment, it is imperative for reliable data on this issue to be readily available for better decision-making. This study can set a precedent for obtaining key data on plastic pollution within a city, and similar efforts should be replicated across more cities to address existing data gaps.

To reduce the overall amount of mismanaged plastic waste, we need to examine the scale of the problem and devise methods to implement better waste management systems. Successful efforts to combat plastic pollution will rely on a combination of the availability of consistent data and increased action to combat plastic pollution by key stakeholders, including national governments, the public sector, and the private sector.

In assessing the next steps that should be taken to improve on Udaipur's waste management system, a holistic approach should be employed, where waste management strategies are developed in tandem with the improvement of the lives of informal waste workers. Informal waste workers have a significant role in the municipal solid waste management system of Udaipur, and their contributions towards plastic waste collection and recycling should be recognised. Alongside the integration of the informal waste worker community, strategies such as improving source segregation by households and commercial entities, and utilising digital tools for data monitoring, should also be considered to improve plastic waste collection and recycling.

6. References

Census of India 2011. (2011). *Udaipur City Population 2011 – 2022* [Online]. Available at: https://www.census2011.co.in/census/city/92-udaipur.html (Accessed: 4 August 2022).

Centre for Science and Environment. (2019). *The Plastics Factsheet 1. The Problem of Plastics* [Online]. Available at: https://cdn.cseindia.org/attachments/0.57139300_1570431848_Factsheet1.pdf (Accessed: 4 August 2022).

ICLEI South Asia. (2019). *Climate Resilient City Action Plan – Udaipur* [Online]. Available at: https://southasia.iclei.org/publication/climate-resilient-city-action-plan-udaipur/ (Accessed: 4 August 2022).

International Union for Conservation of Nature. (2020). *The marine plastic footprint* [Online]. Available at: https://portals.iucn.org/library/efiles/documents/2020-001-En.pdf (Accessed: 4 August 2022).

International Union for Conservation of Nature. (2020). *National Guidance for Plastic Pollution Hotspotting and Shaping Action* [Online]. Available at: https://plastichotspotting.lifecycleinitiative.org/modules/ (Accessed: 4 August 2022).

Quantis. (2020). *Plastic Leak Project Methodological Guidelines* [Online]. Available at: https://quantis.com/report/the-plastic-leak-project-guidelines/ (Accessed: 4 August 2022).

Rajasthan Tourism Department. (2021). *Progress Report 2020-21* [Online]. Available at: https://www.tourism.rajasthan.gov.in/content/dam/rajasthan-tourism/english/pdf/annual-progress-report/Annual-Progress-report-2020-21.pdf (Accessed: 4 August 2022).

The Energy and Resources Institute. (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: 4 August 2022).

United Nations Environment Programme and Institute for Global Environmental Strategies. (2019). *Strategies to Reduce Marine Plastic Pollution from Land-based Sources in Low and Middle-Income Countries* [Online]. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/31555/Marine_Plastic_Pollution.pdf?sequence=1&isAllowed=y (Accessed: 4 August 2022).

United Nations Human Settlements Programme (UN-Habitat). (2021). *Waste Wise Cities Tool* [Online]. Available at: https://unhabitat.org/wwc-tool (Accessed: 4 August 2022).

7. Annexes

Annex 1: Distributed Leaflet

Annex 2: Composition of Household Waste

	% of solid waste	% of dry waste
Organic/ bio	64.7%	-
Plastics	9.8%	27.8%
‣ Hard plastic	4.7%	13.3%
‣ Flexible plastic	5.1%	14.4%
Glass	2.3%	6.5%
Metal	0.2%	0.6%
Paper and cardboard	4.9%	13.9%
Others*	18.1%	51.3%

Source: *Municipal Solid Waste Characterisation Study, Udaipur (2022)*
* Others include textile, shoes, e-waste, inert material and hazardous waste

Annex 3: Different Types of Plastic — Sorted

PET

HDPE

LDPE

PS

PVC

PP

MLP

Other plastics

Annex 4: Glossary of Key Terms

Term	Description
Apex traders	Apex traders receive materials from intermediate traders or directly from formal and informal recyclable collection systems (including waste workers). They store and prepare these materials for onward trading to end-of-chain recycling or recovery facilities.
Commercial waste	Waste that comes from shops, retail outlets and other generators that are neither residential nor industrial. Sometimes includes institutional or public-sector waste.
Controlled waste disposal site	An engineered method of disposing of solid waste on land, in which there is minimal fencing and gate control. Some form of reporting is typical. A weighbridge might be used to determine the weight of waste and a tipping fee is usually charged.
Flexible plastic packaging	Flexible plastic packaging is made from plastic films and includes soft or malleable packaging. This packaging may contain a single layer or multiple layers of plastic. It uses fewer materials than rigid plastic and could be made up of one polymer (typically polyethylene) or a combination of multiple materials. Flexible plastic packaging is used in a range of food, beverage and non-food packaging applications, such as grocery bags, films, pouches, etc.
Household and household-similar waste	Household waste refers to waste material generated in the residential environment. Household-similar waste refers to waste with similar characteristics that may be generated during other economic activities and can thus be treated and disposed of together with household waste.
Improper disposal	Waste is considered to be improperly disposed of when the waste fraction is disposed of in a manner where leakage to the environment is expected to occur, such as at a dumpsite or an unsanitary landfill. A dumpsite is a particular area where large quantities of waste are deliberately disposed of in an uncontrolled manner. A landfill is considered unsanitary when waste management quality standards are not met, thus entailing a potential for leakage.
Incineration	Incineration is a waste treatment technology dedicated to the thermal treatment of waste, with or without recovery of the combustion heat generated. Energy recovery from waste means the conversion of (non-recyclable) waste into usable heat, electricity or fuel through a variety of processes, including incineration plants.
Kabadiwalla	Kabadiwallas are first-level traders who receive recyclable materials from both formal and informal recyclable collection systems (including waste workers). They store and prepare these materials for onward trading to apex traders.
Landfill	Landfills are disposal sites for waste. They are a waste treatment approach that involves a final placement of waste in or on land in a controlled or uncontrolled way.
Leakage	According to the 'National Guidance for Plastic Pollution Hotspotting and Shaping Action', leakage refers to plastic that is released to the environment, specifically to rivers and oceans. The leakage rate is the ratio between leakage and total plastic waste generated, and its value is given in percentage.

Annex 4: Glossary of Key Terms (continued)

Term	Description
Mismanaged waste	This is defined as the sum of uncollected and improperly disposed of waste (that which is not formally managed), such as waste disposal in dumps or open, unsanitary landfills, which could leak to the surrounding environment, and littered waste.
Multi-layered plastic (MLP)	MLP is any material used for packaging and having at least one layer of plastic as the main ingredient in combination with one or more layers of materials such as paper, paper board, polymeric materials, metallised layers, or aluminium foil, either in the form of laminate or having a coextruded structure. Sachets, packaging for snacks and other food packaging with plastic as the main raw material are included. Carton packaging for liquids (e.g.: Tetra Pak) is excluded.
Materials recovery facility (MRF)	An MRF is a plant that receives, separates and prepares recyclables to be sold to an end buyer.
Municipal solid waste (MSW)	Municipal solid waste refers to the total amount of household and household-similar waste. It excludes industrial waste and construction waste.
Rigid plastic packaging	Rigid plastic packaging refers to plastic packaging material that is stronger than flexible plastic packaging and which can retain its shape when squeezed or slight pressure is applied. Rigid plastic packaging is most often made from PET, PP and HDPE and common items include milk cans, yoghurt tubs, jars, beauty and personal care, laundry care, and pharmaceutical packaging. They are heavier in weight in comparison to flexible plastic packaging.
Solid waste	Solid waste is waste with a low liquid content. It includes municipal garbage, industrial and commercial waste, sewage sludge, waste resulting from agricultural and animal husbandry operations and other connected activities, demolition waste and mining residues.
Waste Wise Cities Tool (WaCT)	A tool that guides users through seven steps to collect data on municipal solid waste generated, collected and managed in controlled facilities.