aviral
Reducing Plastic Waste in the Ganga

Rishikesh

Baseline Assessment Report

September to October 2020

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Implemented by: giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

In Cooperation with: SIA SUSTAINABILITY INNOVATIONS AND ADVISORIES PVT. LTD.

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Executive Summary

India's plastic consumption is increasingly outpacing the ability of urban waste management infrastructures to ensure a sustainable processing of plastic waste. With approx. 9.4 million tons/year of plastic waste generated in India, rising urban populations and an increasing per-capita waste generation, sustainable solutions to prevent plastic waste leakage are imperative. In particular cities in the Indian state Uttarakhand, which experience large influxes of tourists every year, require immediate action to address the impacts of improper plastic waste management.

Within project *Aviral* - Reducing Plastic Waste in the Ganga, plastic waste entering the cities environments is reduced by strengthening an integrative and improved plastic waste management system in the two Ganga cities Rishikesh and Haridwar. The efforts also contribute to achieving the objectives of the flagship programs of the National Mission for Clean Ganga *(Namami Gange)* and the Clean India Mission *(Swachh Bharat Mission)*. In order to sustainably enhance existing capacities, improve selected elements of the plastic waste value chain, promote innovations and implement awareness activities, *Aviral* has addressed the existing plastic waste flow data in both cities by carrying out a detailed assessment study of plastic waste material flows and existing plastic waste management practices and trends in Haridwar and Rishikesh.

This city report focusses on the results obtained in Rishikesh.

The objective of this assignment is to achieve a better understanding and identify gaps and barriers for sustainable plastic waste management and potential areas of intervention. In addition to this, the assessment study results feed into the development of a city specific Plastic Waste Management Action Plan for Rishikesh. Generally, the availability of accurate data on waste quantities and qualities in Indian cities is commonly low. In cities such as Rishikesh, where collected, transported and disposed waste amounts are barely recorded, the estimation of waste is challenging. The data on waste generation by different government agencies, waste contractors, municipalities and literature sources vary widely.

This assessment was conducted from September to October 2020 during the ongoing COVID-19 pandemic in India. In order to prevent infection risks for the personnel of this assessment and due to existing restrictions, this study had to be conducted with certain limitations and adjustments of the methodology. Due to the COVID-19 pandemic, deviations from the previous disposal behavior were observed globally, with a tendency to an increased share of inter alia sanitization and hygiene products, packaging waste as well as delivery and to-go food and beverage containers.

In Rishikesh, municipal solid waste (MSW) contains 69% organic and 12% plastic waste. Within the plastic waste, 49% are comprised of LDPE, while waste materials of higher value like PET and HDPE have a share of 8% and 11% respectively. For the urban waste generation, a total daily mass flow of 31.4 tons/day is estimated. Approx. 9% of all generated plastic waste remain

unmanaged and leak into the environment, caused to 73% by uncollected waste and to 22% by leakages during waste collection and transportation. Plastic waste leakage hotspots exist primarily in the city center with a high density of commercial establishments and tourism influx. Besides three smaller composting facilities, the city disposes their entire daily waste generation without further treatment on an open dumpsite within the city center. Informal traders of recyclables in Rishikesh trade majorly plastic materials, followed by paper and metal. Rishikesh does not have an own recycling infrastructure. Recyclables collected by the informal sector are aggregated and transported to other cities. Only 8% of households and 18% of the commercial establishments use two different bins to segregate their waste into wet and dry waste. However, even these segregated waste amounts are mixed during collection and disposed together on the city's dumpsite. More than 90% of all citizens would be willing to segregate their waste, if an adequate separate collection infrastructure is provided. A general satisfaction with the daily waste collection system was perceived among the citizens. Waste leakage was majorly found during waste transfer and outside of commercial establishments.

Awareness on waste management was found to be low. At an average, only one in four persons was aware of the waste hierarchy and sustainable waste management practices. However, almost all citizens perceived littered waste in the environment as a major challenge and are willing to act.

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Abbreviations

CFC	Central Finance Commission
CPCB	Central Pollution Control Board
EWS	Economically Weaker Section
GIS	Geographic Information System
HDPE	High-density polyethylene
HH	Household
INR	Indian Rupee
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
LDPE	Low-density polyethylene
MLP	Multi-Layered Plastic
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
PET	Polyethylene terephthalate
PP	Polypropylene
PPE	Personal Protection Equipment
PSU	Primary sampling units
PVC	Polyvinyl chloride
RCC	Reinforced cement concrete
RNN	Rishikesh Nagar Nigam
SBM	*Swachh Bharat Mission* (Clean India Mission)
SFC	State Finance Commission
SSU	Secondary sampling units
SWM	Solid Waste Management

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1. Introduction

1.1. The Global Plastic Waste Concern

The continually increasing generation of plastic waste and its management pose one of the biggest challenges for countries across the globe. It is being estimated that 220 million tons of plastic waste were generated in 2016. Out of these, 129 million tons were either recycled (31 million tons), landfilled (69 million tons) or incinerated (28 million tons). The remaining 91 million tons were mismanaged and hence either openly burned (49 million tons), terrestrially leaked (31 million tons) or leaked into the ocean (11 million tons). The amount of mismanaged plastic waste is estimated to increase to 239 million tons by 2040 (Pew Charitable Trusts and SYSTEMIQ, 2020). These predictions create the pressing need for considerable action to address the growing plastic pollution and the herewith connected environmental challenge.

1.2. India's Plastic Waste Challenge

This plastic waste concern is especially true for emerging and fast-growing economies like India that are facing dynamic transformations which are characterized by a growing population, rising (average) incomes, increasing urbanization levels and a growing middle class. While cities continue to grow, they often lack adequate waste management systems. The plastic waste generation data for India ranges from 3.3 million tons/year to 9.4 million tons annually (Ministry of Housing and Urban Affairs, Government of India, 2019). This data from the Central Pollution Control Board (CPCB) and the Ministry of Housing and Urban Affairs respectively, underlines the fact that the existing plastic waste flow data in India is inconsistent. This data gap increases the challenges attached to addressing and tackling India's plastic waste concerns.

The growing generation of plastic waste and the management thereof are an increasing challenge particularly for urban local bodies, since the lack of financial means and capacities lead to a severely constrained infrastructure and limited solutions. According to the Ministry of Housing and Urban Affairs, about 60% of the 26,000 tons of plastic waste, which are generated per day, are currently being recycled, which leaves over 9,400 tons of plastic waste per day either landfilled or leaked into the environment.

1.3. Uttarakhand

Amongst the Indian states, Uttarakhand faces great challenges for sustainable plastic waste management: More than 80% of its geographic area are mountainous terrain and more than 60% are covered by forest, which calls for innovative and adaptable plastic waste management solutions along the value chain (Nainital Tourism, n.d.). The large number of tourists travelling to Uttarakhand annually, either on pilgrimage or to visit its diverse natural resources, increases the state's plastic waste challenge. According to the Uttarakhand Environment Protection

and Pollution Control Board, it is estimated that a total of 31,100 tons of plastic waste were generated in 2019 (Central Pollution Control Board, 2019). Low segregation rates and reduced recycling capability of plastic materials within the municipal solid waste collection impede the establishment of sustainable plastic material circles. Therefore, action needs to be taken to address the impacts of improper plastic waste management in the state.

1.4. *Aviral* - Reducing Plastic Waste in the Ganga

In July 2020, GIZ entered a strategic partnership with the Alliance to End Plastic Waste. Launched in January 2019, the Alliance is a CEO-led, cross-sector, not-for profit organization with a mission to develop, accelerate and deploy solutions, catalyze public and private investment and engage communities to help end plastic waste in the environment. Envisaging a series of projects globally, this partnership aims to contribute to the achievement of the Sustainable Development Goals, notably focusing on SDG 6, SDG 8, SDG 11, SDG 12, SDG 13 and SDG 17.

The first joint project to combat the negative impacts of the increasing amounts of plastic waste is being implemented in India since the end of 2019 (The Week , 2020). The objective of this project, *Aviral* - Reducing Plastic Waste in the Ganga, is to reduce the plastic waste entering the cities environments of Haridwar and Rishikesh by strengthening an integrative and improved plastic waste management system. The efforts also contribute to achieving the objectives of the flagship programs of the National Mission for Clean Ganga *(Namami Gange)* and the Clean India Mission *(Swachh Bharat Mission)*.

In Rishikesh, *Aviral* works hand in hand with the municipal corporation, while it is embedded in the broader plastic waste management ecosystem, collaborating with inter alia the private sector, informal waste workers, schools and local NGOs.

In order to sustainably enhance existing capacities, improve selected elements of the plastic waste value chain, promote innovations and implement awareness activities, *Aviral* has addressed the existing plastic waste flow data in Rishikesh by carrying out a detailed assessment study of plastic waste material flows and existing plastic waste management practices and trends in Rishikesh. The objective of this assignment is to achieve a better understanding and identify gaps and barriers for sustainable plastic waste management and potential areas of intervention. In addition to this, the assessment study results feed into the development of city specific Plastic Waste Management Action Plans for Rishikesh.

2. Definitions

Ashram	*Ashram* is a Hindi term, describing a spiritual and/or religious place. In the area of investigation, Ashram's are also used for yoga.
Blackspot	Blackspots, also called litter spots, are open and illegal dumping locations for waste, mostly found in open spaces, on roadsides and on riverbanks. Depending on its size and concentration of plastic waste, blackspots can become plastic waste hotspots.
Commercial establishment	According to the Shops and Establishment Act in India, a commercial establishment is a premise where any trade, business, profession or any work related with it, is undertaken.
Dharamshala	*Dharamshala* is a Hindi term, which is used in the area of investigation for public resthouses or shelters, in particular for religious travelers at pilgrimage sites like Rishikesh.
Dry waste	Dry waste according to the Indian SWM Rules 2016 means waste other than bio-degradable waste and inert street sweeping and includes recyclable and non-recyclable waste, combustible waste, sanitary napkins and diapers.
Ghat	*Ghat* is a Hindi term, which is used in the area of investigation and refers to a stairway or a downward path leading to a river.
Informal waste collector	An informal waste collector is defined as a person or a group of persons informally engaged in the collection and recovery of reusable and recyclable solid waste from households, streets, bins, Material Recovery Facilities (MRF) and processing and waste disposal facilities to earn their livelihood by selling - directly or through intermediates - the collected and recovered solid waste to recyclers.
Kabadi Walas	*Kabadi Walas* are scrap vendors, who trade recyclables and valuable waste items purchased from waste collectors and sell the aggregated valuables to recyclers. *Kabadi Walas* can be individuals, associations or waste traders, involved in the sorting, sale and purchase of recyclable materials.
Plastic waste hotspot	Plastic waste hotspots are uncontained locations with high plastic waste concentrations, generated by direct disposal or indirect accumulation. Plastic waste hotspots directly or indirectly contribute to plastic waste leakage into the environment.
Tipper / Auto Tipper	In Rishikesh, small four-wheeled tipping trucks, called tipper, are used for waste collection. Tippers with a closed garbage box are used for door-to-door collection and transportation of municipal and other types of waste from the collection to the disposal point. The vehicles have a loading capacity of approx. 2 m^3.
Wet waste	Wet waste is defined as biodegradable waste according to the Indian Solid Waste Management (SWM) Rules 2016. Further, biodegradable waste is defined as any organic material that can be degraded by micro-organisms into simpler stable compound.

3. Area of Investigation

Rishikesh, one of India's most prominent pilgrimage sites, is situated on the bank of the river Ganga within the region Tehri-Garhwal of the northern Indian State of Uttarakhand. The city is commonly known as the Yoga Capital of the World and is a major tourist destination in northern India. The name Rishikesh is loosely applied to four distinct sections encompassing the town of the same name as well as the hamlets and settlements on both sides of the river Ganga. These include:

- the city Rishikesh, which is the commercial hub;
- the sprawling suburban Muni Ki Reti;
- the temple town Lakshman Jhula;
- and the assorted ashrams around Swarg Ashram on the East Bank of the river.

The city is governed by three districts: Dehradun, Pauri Garhwal and Tehri Garhwal. This study was restricted to the areas falling within the Rishikesh Municipal Corporation (Rishikesh *Nagar Nigam*). Rishikesh *Nagar Nigam* (RNN) is comprised of 40 wards (Figure 1) with a total population of 106,320 in 2018 according to data of the RNN. The municipality is spread over an area of 26 km^2.

The municipality is divided into primarily residential and primarily commercial wards (Figure 2). The city center is characterized by a high number of shops and commercial establishments, surrounded by primarily residential areas. A commercial area is also located in the vicinity of the railway station and along the banks of the river Ganga. The settling structure is rather equally distributed across the urban area. The population density per ward shows only minor fluctuations, with slightly higher agglomerations in the city center. The average daily influx of commuters and tourists was estimated to be 12,344 persons in 2016 (GIZ 2020). The average daily population influx amounts to 12% of the overall population of Rishikesh. v

Table 1: Demographic profile of Rishikesh.

Resident population in 2018 (RNN, 2018)	106,320
Number of households (approx.)* (RNN, 2020)	21,300
Number of commercial establishments (approx.) (RNN, 2020)	3,000
Additional daily influx (2016) (GIZ 2020)	12,344
Average daily tourist influx in 2019* (Uttarakhand Tourism Department, 2020)	4,810
Average daily influx of other persons (e.g. commuters, workers) (calculated from daily influx and tourist influx)	7,534
Number of wards	40

* Calculated from data provided by the Uttarakhand Tourism Department. The average daily tourist influx is estimated based on the total tourist bed nights.

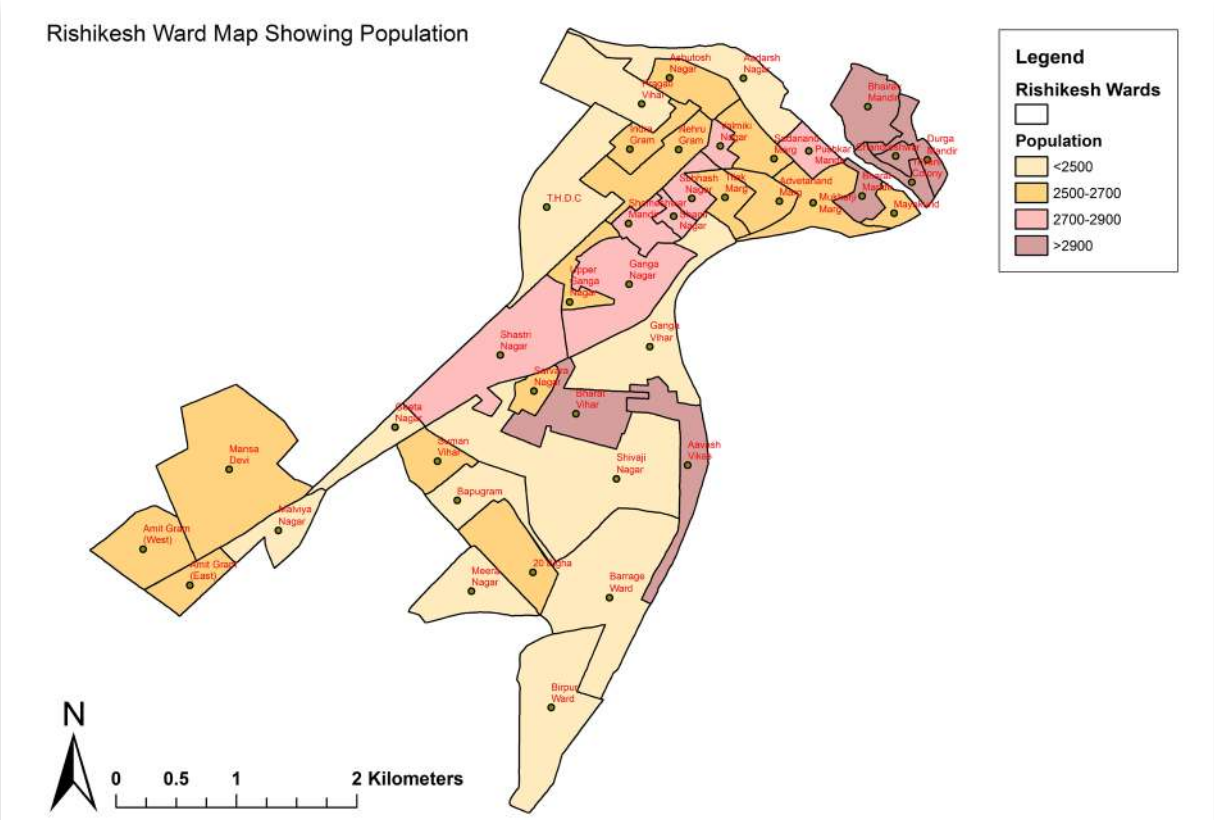

Figure 1: Rishikesh ward map showing population.

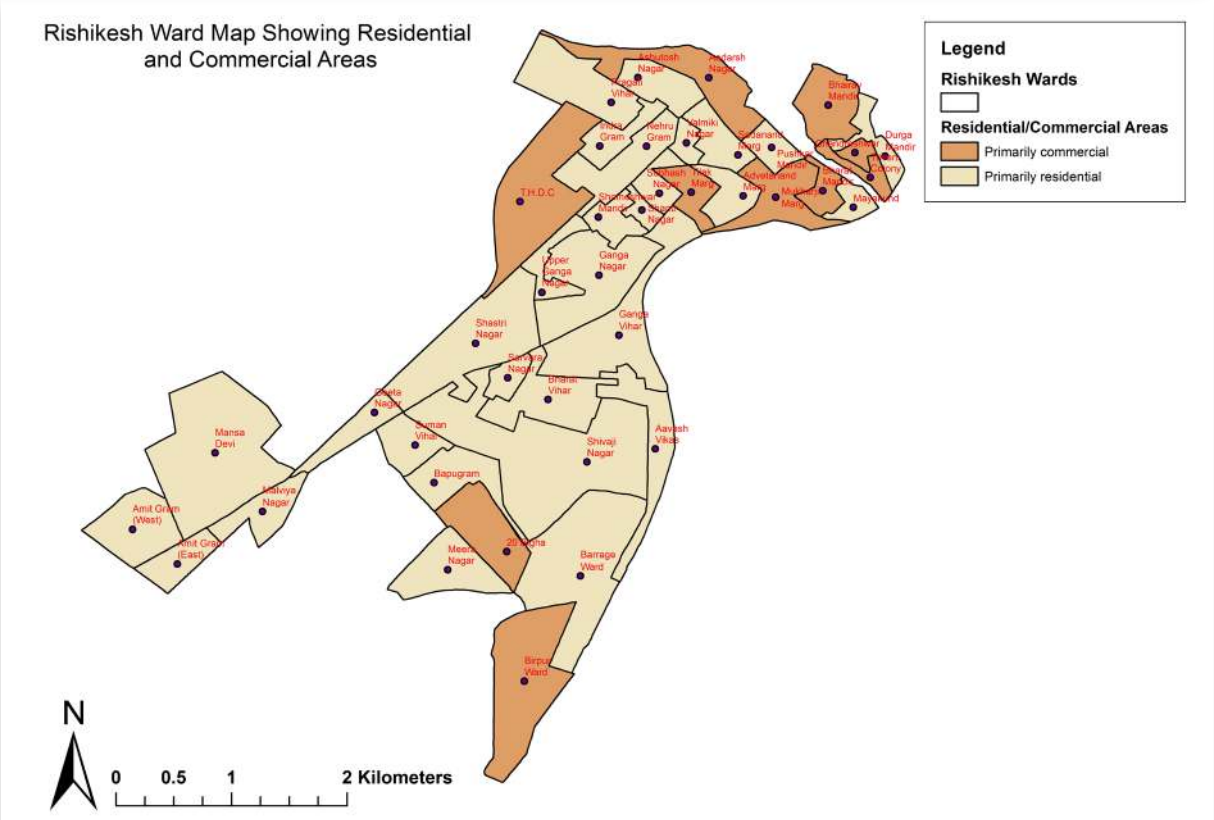

Figure 2: Rishikesh ward map showing residential and commercial areas.

The majority of tourists are from within the country; foreign tourists only contribute 1%. The tourist number, however, also includes multiple night stays. In order to estimate the additional daily population number, the total number of bed nights is utilized (Table 2).

Table 2: Month-wise tourist influx in Rishikesh (Uttarakhand Tourism Department, 2020).

	Monthly number of tourists	Monthly number of bed nights			Daily bed nights
		Nationals	Internationals	Total	
January	36,940	82,314	762	83,076	2,680
February	29,196	72,316	856	73,172	2,613
March	31,880	68,996	2,137	71,133	2,295
April	57,314	126,270	1,771	128,041	4,268
May	128,163	216,370	4,005	220,375	7,109
June	116,863	224,340	1,430	225,770	7,526
July	86,627	182,318	922	183,240	5,911
August	76,909	162,316	1,122	163,438	5,272
September	112,702	219,318	988	220,306	7,344
October	68,939	142,318	1,550	143,868	4,641
November	66,317	144,218	1,719	145,937	4,865
December	42,666	96,318	1,058	97,376	3,141
Total	**854,516**	**1,737,412**	**18,320**	**1,755,732**	
Annual average					**4,810**

The estimated number of tourist beds in hotels and ashrams amounts to approx. 20,000 (RNN, 2020). During the year, the average daily tourist influx of 4,810 ± 39% varies strongly in festive seasons and is generally higher on weekends due to short time tourist visits from the nearby cities of Delhi-NCR. On average, tourists spend two nights in Rishikesh. According to the RNN, weekend stays contribute to 60 to 75% of the total weekly tourist population. As a result, the daily tourist population on weekends can amount to up to 30% of the total urban population of Rishikesh and has a significant impact on Rishikesh's urban infrastructure, especially its waste management system.

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4. Methodology

4.1. Overview

The objective of this baseline assessment is to identify the current status of the solid waste management system in Rishikesh to strengthen the city's plastic waste management. Besides an accurate data basis on solid waste quantities and qualities, an investigation of institutional and social roles and responsibilities as well as the interaction of stakeholders within the city and the current awareness level of citizens are an imperative for supporting the city's in their management of plastic waste. This assessment describes the status-quo of the project city's waste management systems. The presented waste quantification and characterization was conducted within a seven-day time period in each city. Seasonal effects on public disposal behavior and waste composition are not mapped in this assessment, however, they have been evaluated through secondary literature and will be addressed and added during the further course of the *Aviral* project implementation.

Generally, the availability of accurate data on waste quantities and qualities in Indian cities is commonly low. The data waste generation by different government agencies, waste contractors, municipalities and literature sources vary widely. This is also the case in Rishikesh, where strongly varying data on waste quantities and qualities are available. Following a standardized methodology reduces the uncertainty of values, however, cannot eliminate it. Especially the Indian waste sectors is based to a significant extend on informal activities, which poses a notable challenge for an appropriate and scientifically accurate methodology design.

This assessment was conducted from September to October 2020 during the ongoing COVID-19 pandemic in India. In order to prevent infection risks for the personnel of this assessment and due to existing restrictions, this study had to be conducted with certain limitations and adjustments of the methodology. Due to the COVID-19 pandemic, deviations from the previous disposal behavior were observed globally, with a tendency to an increased share of inter alia sanitization and hygiene products, packaging waste as well as delivery and to-go food and beverage containers.

As a baseline study, this assessment does not reflect seasonal variations of waste quantities and qualities. Seasonal waste data from previous assessment in the area of investigation are not available for data validation. The extent of seasonal variations on waste quantities and qualities have to be further investigated in the course of project *Aviral*. The assumed deviations of the disposal behavior and the pandemic-related limitations of this assessment are investigated through an evaluation of existing data and secondary literature from previous years. The assessments conducted in Rishikesh contain three key components:

1. Waste inventory analysis

- Composition;
- Plastic typology;
- Quantification.

2. Analysis of current status of waste management in the city

- Population and source enumeration;
- Existing waste management infrastructure;
- Assessment of plastic leakage;
- Assessment of the informal waste sector and the plastic waste value chain.

3. Stakeholder perception, awareness, knowledge and capacity assessment

- Survey of households and commercial entities;
- Assessment of capacity building needs of various stakeholders including ULBs, the informal sector and private entities.

The methodologies of the conducted assessments are presented in the following.

For population and source enumeration, additional background information are required, which are elaborated in detail in the Annex, see Table 17, Table 18 and Table 19.

4.2. Waste Quantification and Characterization

Number of samples

The Guidelines for Solid Waste Management Assessment (baseline survey) developed by the United Nations Economic and Social Commission for Asia and the Pacific were adopted to collect and measure the waste from sampling units and assess the waste composition with regards to different waste generator types (UNESCAP, 2010). For waste quantification and characterization, the desired level of data accuracy must be balanced with the available resources and time. An analysis of all waste generators within one city, the parent population, commonly exceeds the feasibility of assessment studies, in particular in large cities. In order to ensure an adequate level of data reliability, the current status of the total urban area is assessed through the number of random samples, collected at different locations throughout the assessment area and representing the parent population through approximation. The required minimum number of samples is calculated to ensure the desired precision level.

The UNESCAP's Guidelines for Solid Waste Management Assessment do not provide a statistical equation for sampling in secondary cities and small towns (<1 million population) in Asia and the Pacific. The guidelines have recommended the following sampling approach:

- Define several residential areas, which represent different socio-economic population groups (low, middle- and upper-income groups);
- Select 60 to 100 households (HHs) for each of the residential areas;
- Identify a predominant business area, where a large number of shops and offices are located and select 50 shops and offices for the business area;

- Alternatively, business areas can be further divided into more specific categories such as hotels and restaurants, offices, shops and stores, and workshops. Select approximately 10 to 20 samples for each category;
- Collect the waste generated in the above areas once a day at a fixed time for eight successive days to allow variation over the week (the sample of the first day shall be discarded to avoid biased results due to waste accumulated from two or more days).

According to the methodology, the total number of samples in Rishikesh needs to be 180-300 household samples and 50 commercial and institutional samples. The total sample size is required to be 230-350.

Another recent methodology for determining waste quantities and compositions is the Waste Wise Cities Tool developed by UN-Habitat (UN Habitat, 2021). To ensure data comparability of this assessment in Rishikesh with international data of the Waste Wise Cities Tool, the statistical parameters are evaluated. According to the Waste Wise Cities Tool, in order to achieve a confidence level of 95% and a 5% error, at least 370 to 384 households need to be sampled over a period of seven days for a city with 10,000 to 10 million inhabitants. In order to verify this approach, the statistically required minimum number of samples was determined. The sample size was estimated based on a 95% confidence level and a 5% error. This reflects a reasonable balance between resources and statistical integrity.

$$\text{Sample size} = \frac{\frac{z^2 \cdot p\,(1\text{-}p)}{e^2}}{1 + \frac{z^2 \cdot p\,(1\text{-}p)}{e^2 N}}$$

Where:

- N population size
- e Margin of error (percentage in decimal form)
- z z-score based on the confidence level (for 95% confidence level, z-score is 1.96)

In practice, households and commercial establishments are not used to the sample requirements during the sampling period (i.e. seven days for this assessment). To meet the theoretical requirement, the actual sample size is recommended to be 25% higher than the theoretical calculation. This will ensure that on all sampling days, the sample collected is on the higher side and not on the lower side of the theoretical requirement.

With a total number of households (approx.) of 21,300 and a total number of commercial establishments (approx.) 3,000, the number of waste generators amounts to 24,264. Following the equation above, the required minimum number of samples amounts to 379. In the assessment of Rishikesh, 394 households and 89 commercial establishments participated in the perception survey and 309 households and 79 commercial establishments were included in the waste characterization.

The sample number considered for Rishikesh is higher than recommended by the UNESCAP guidelines and in line with the recent Waste Wise City Tool by UN-Habitat. Hence, the presented assessment ensures a high level of data precision and data comparability with international waste system data.

Sampling methodology

This assessment was conducted from September to October 2020 during the ongoing COVID-19 pandemic in India. Commonly, samples are collected without contacting the waste generators in advance to avoid biased disposal behavior. Without any interventions, however, this would result in waste generators also disposing medical waste potentially contaminated with COVID-19, posing a significant risk to the subsequent sorting personnel. In order to avoid any potential health impact, the waste generators were approached prior to the assessment and asked to collect their medical waste in a separate bag. Firstly, the selected waste generators were surveyed regarding their waste management awareness and perception. Secondly, the same generators were requested to store their waste for measurement.

In Rishikesh, it was initially estimated that approx. 90% of the generated waste is collected through door-to-door collection and only approx. 10% through 16 community bins based on an initial survey and discussions with RNN. The impact of community bins on the total waste composition was therefor considered to be minimal. As a result, only waste from households and commercial establishments were sampled.

A stratified two-stage sampling design was adopted to capture the diversity in economic status and economic activities in the city. The city area was divided according to two stratification criteria:

› Economic status of wards as primary sampling units (PSU);

› Waste generator type as secondary sampling units (SSU).

As a first step for PSU, the wards were divided into five groups based on the property tax rates and the proportion of taxes collected from different economic sectors:

› High-income residential wards;

› Mixed income residential wards;

› Economically Weaker Section (EWS) of residential wards;

› Commercial wards;

› Mixed residential and commercial wards.

The tax rate is based on the width of the road and type of construction. In Rishikesh, for a common concrete house located on a 24 m width road, the tax rate for high-income amounts to 2 Indian Rupee (INR) per square foot. For mixed land use, it is 1.5 INR per square foot and for low-income it is 1.25 INR per square foot. Similar rates have been specified for 12 to 24 m wide roads and roads with less than 12 m width. The tax data was complemented with the support of

the Municipality. RNN listed areas as high-income, low-income and mixed land use as per their own categorization.

The SSU were primarily households and commercial entities. In normal times, hotels, schools, colleges and offices would have also been included as part of the SSU. However, during the study period, education institutions were mostly closed and tourism barely existent in the city. These waste generators could therefore not be analyzed. To determine the share of these waste generator types in the total urban waste generation, the extrapolated waste generation values were validated with the data available from the waste collection. Within the selected PSU, the SSU (i.e. households and commercial establishments) were selected through a stratified random sampling method, using a skip interval and random start method. The selected wards in Rishikesh are presented in Figure 3. The distribution of the SSU within the selected PSU are presented in Table 3. The SSU values represent the intended sampling amount. The actual values are slightly lower due to the waste generators' actual participation in this assessment.

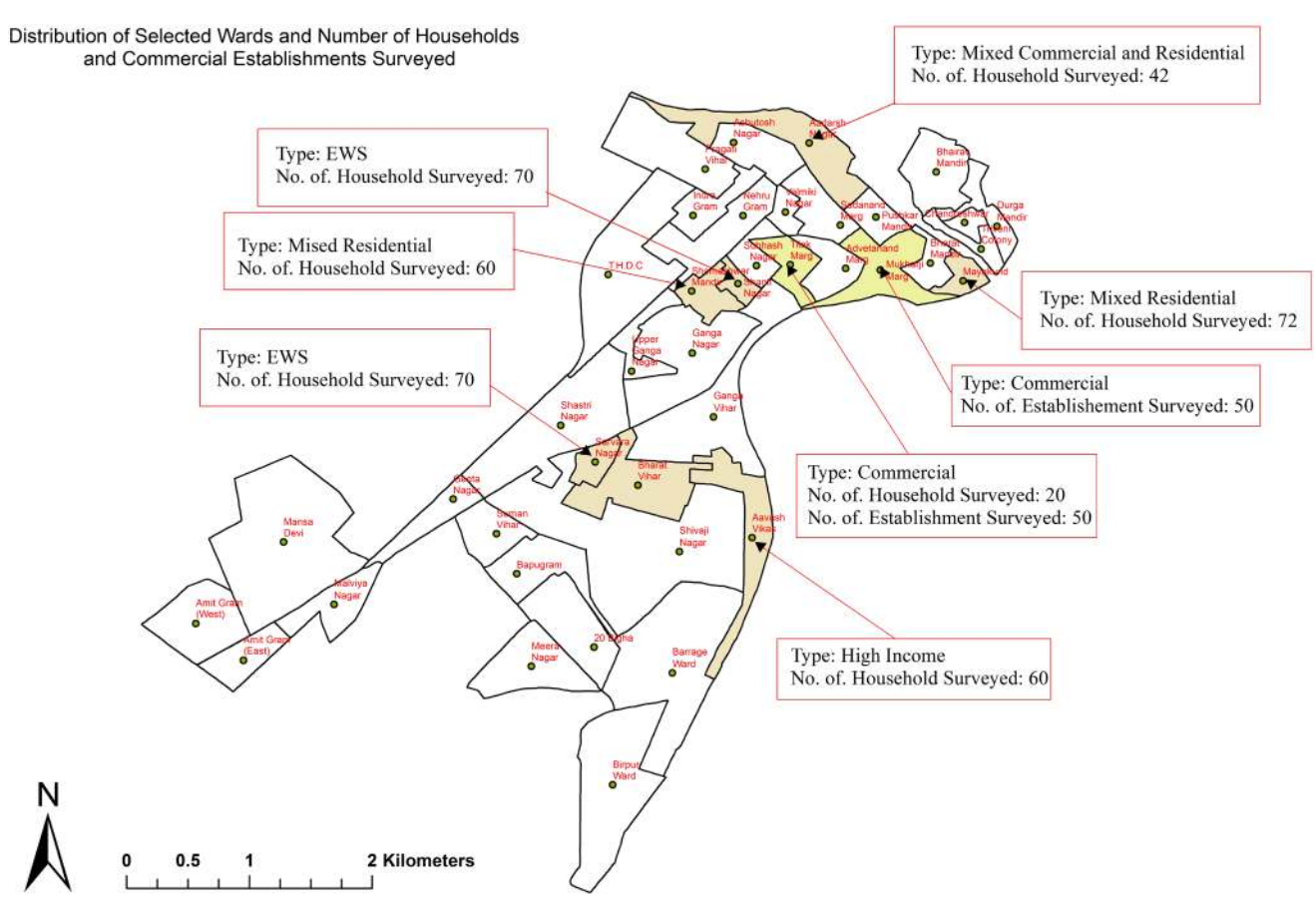

Figure 3: Distribution of selected wards and number of Households and commercial entities surveyed in Rishikesh.

Table 3: Sampling in Rishikesh.

Name of selected ward	Type of selected ward	Number of SSU
Someshwar Nagar	Mixed Residential	60
Shanti Nagar	EWS Residential	70
Mayakund	Mixed Residential	70
Sarvahara Nagar	EWS Residential	70
Adarsh Gram	Mix Commercial & Residential	50
Mukherjee Marg (Ghat Road)	Commercial	50
Awash Vikas & Bharat Vihar	High-Income Residential	60
Tilak road	Commercial	70

In Rishikesh, 2,398 individual samples and 1.6 tons of waste were collected, sorted and weighed to develop the inventory over an analysis period of seven days.

Sorting methodology

Due to the COVID-19 restrictions, the sampling of certain sectors such as hospitality, offices and institutions was not possible. Waste generation from these sectors was estimated based on secondary sources. The waste inventory was conducted in two parts.

1. Estimation of waste based on physical sampling from households, commercial establishments and community bins; and,
2. Estimation of waste from hotels, institutions, religious places, road sweeping and *Ghat* cleaning based on the secondary data.

The overall process flow scheme of the quantification and characterization process is presented in Figure 4.

Figure 4: Project team during the exercise of waste characterization for the baseline assessment.

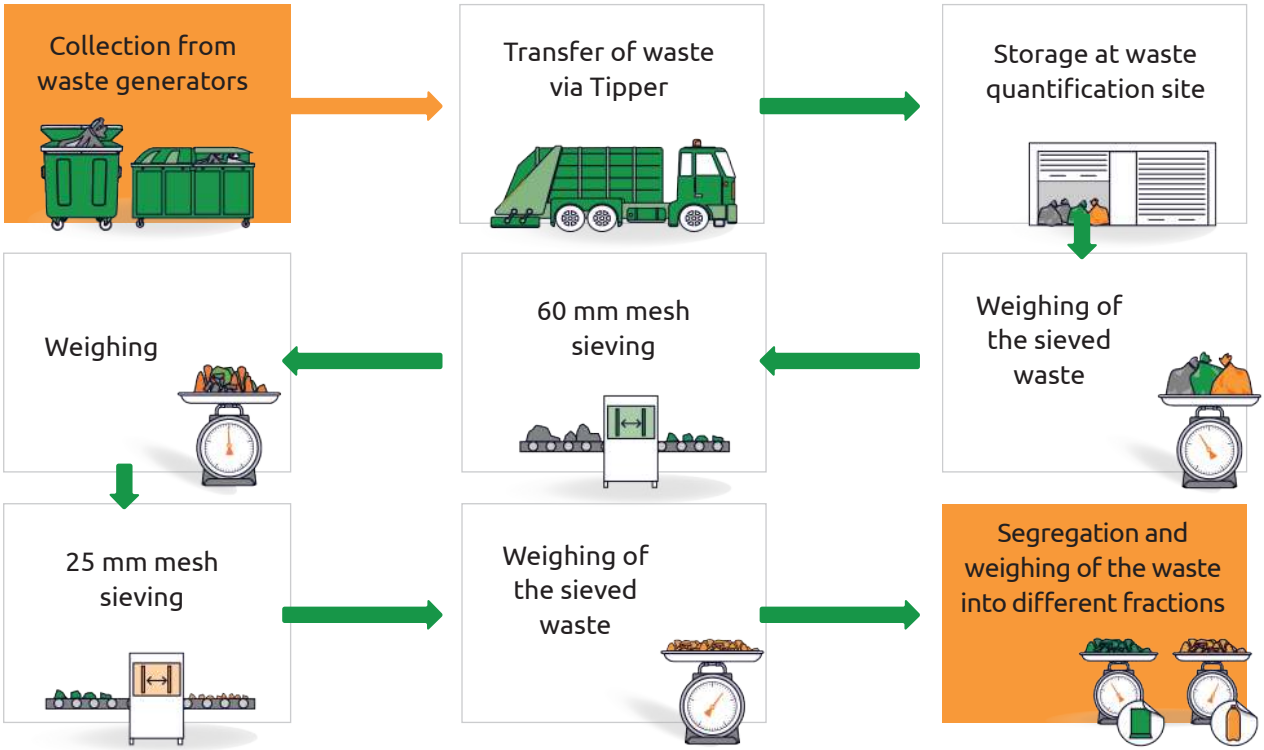

Figure 5: Flowchart for waste quantification.

Step 1: Collection of waste

In each selected ward, a volunteer was made responsible for coordinating the sample collection alongside the municipal waste collector. The survey staff was trained for the perception study and for coordinating the waste collection. A three-day hands-on training was provided in Rishikesh. The main responsibility of the volunteer was to ensure that the samples were collected and recorded correctly. To identify the selected households and commercial establishment, a sticker with the ward number and the household/establishment number was fixed at the gate of the waste generators. For each ward, a checklist was handed out to the volunteers, which included the sample code and date to record the waste collection from the sampling units.

The waste generators were provided with plastic bags to store their generated waste. 15-liter black bags were distributed to collect daily mixed waste. Additionally, a single 35-40-liter red garbage bag was provided for domestic hazardous waste to reduce the infection risks for the survey and sorting personnel. To raise awareness about domestic hazardous waste, a pictorial pamphlet in English and Hindi was handed out and explained to the participating waste generators. The households were asked to store their daily waste in the provided bags over a period of eight days, while the commercial establishments were asked to store their two-day waste. The waste collected on the first day was discarded to avoid biased results from previous days. The waste samples were collected in the morning according to the sampling checklist illustrated in Table 4.

Table 4: Sampling checklist for marking waste collection.

Sample code	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
AVHH01								
AVHH02								
AVHH03								
…								

As mentioned above, the existing waste collection systems are reflected in this assessment.

Step 2: Transfer of the collected waste

The waste samples from each ward and community bin were collected separately in jumbo bags with a volume range of 500-1,000 liter and carefully marked with the name of the ward and the total number of households that had given away their waste on the respective day. For commercial establishments, a separate jumbo bag was provided. The collected waste was transferred to the sorting station with the help of an auto tipper. Jumbo bags from different wards and categories were stored separately and brought to the waste quantification site.

Step 3: Weighing the waste from different wards

The weighing and sorting of the samples was carried out, in accordance with the municipality, at a temporary sorting station for this assessment located at an open space which is commonly used by the informal sector for waste segregation. The waste from each jumbo bag was analyzed separately. The waste from the jumbo bags was emptied in a bucket and the garbage bags were discarded. The empty weight was noted and subsequently subtracted from the total waste. A digital iron platform weight scale with a capacity of 250 kg and an accuracy of ±10 g was used. The scale was caliberated and the error margin checked with a weight of 10 kg before it was used for quantification.

Step 4: Particle size distribution

The weighed waste was subsequently screened into three different size fractions using rectangular meshes with an edge length of 25x25 mm and 60x60 mm.

- Firstly, the weighed waste was emptied over the 60 mm mesh and sieved properly to extract the waste with less than 60 mm size. The reject remaining on the sieve was collected and weighed.
- The second stage was the 25 mm screening. The 60 mm extract was sieved with the 25 mm mesh. Both extract (<25 mm) and reject (25-60 mm) were separately collected and weighed.

Step 5: Sorting and quantifying

After the particle size analysis, the sample waste was sorted. A temporary platform with High-density polyethylene (HDPE) liner was made for the waste quantification at the sorting station. Two helpers and five sorters were engaged in carrying out the quantification exercise. The helpers and sorters were provided with appropriate personal protection equipment (PPE) for their safety. The sorting was conducted with the help of trained workers, who were first trained in sorting different types of wastes, including different types of plastics. A pictorial banner for the training purpose was developed and used. Firstly, the waste was quantified and separated into dry and wet waste. The dry waste was further sorted into seven primary sorting categories:

- Papers,
- Textiles,
- Rubbers & leathers,
- Metals,
- Glass,
- Plastics,
- and others.

Against the background of the objective of this assessment, the primary category plastics was further sorted into seven secondary sorting categories according to the BIS standard for plastic codification (IS 14534:1998) and adopted by the CPCB for plastic segregation (see Table 5).

Table 5: Different category of plastic as per BIS standards.

Category Type	Short Name	Uses
1	PET	Soft drink bottles, furniture, carpet, paneling, etc.
2	HDPE	Bottles, carry bags, recycling bins, agricultural pipe, base cups, playground equipment, etc.
3	PVC	Pipe, Window profile, fencing, flooring, shower curtains, lawn chairs, non-food bottles and children's toys, etc.
4	LDPE	Plastic bags, various containers, dispensing bottles, wash bottles, tubing, etc.
5	PP	Auto parts, industrial fibers, food containers, dishware, etc.
6	PS	Cafeteria trays, plastic utensils, toys, video cassettes and cases, clamshell containers, insulation board, etc.
7	Others	Multilayer Packaging and Laminates, Bakelite, Polycarbonate, Nylon SMC, FRP, etc.

Step 6: Waste quantification

The waste quantification was conducted following two approaches for cross-validation of the results, an extrapolation of per-capita generation data and an assessment of available collection and processing data.

1. For the waste quantification based on extrapolation of per-capita data, the survey data of the waste inventory was utilized. During the assessment and notification of waste generators prior to the survey and waste sampling, the number of inhabitants per household was noted. Waste samples from different households within one ward (PSU) were collected together and weighed at the temporary sorting center. The total weight of the daily collected samples was divided by the total number of persons connected to the respective households. Based on this, a daily waste generation per person value was calculated for different wards.
2. For the verification of the extrapolated data, actual waste management data can be used. In case of Rishikesh, weighing data at the landfill level were not available. However, the number of trips required for waste transportation was recorded over a period of seven days. Based on the vehicles' individual collection capacity, the maximum potentially transported waste amounts were estimated. For example, a mini garbage tipper (e.g. from Ashok Leyland) used in Rishikesh has a maximum transport capacity of 500 kg waste per trip.

To record the data on daily basis coming from different wards and commercial establishments, a recording sheet was developed in a tabular format and illustrated in the Annex, Table 20.

4.3. Analysis of Current Status of Waste Management

Assessment of the existing waste management infrastructure

For the analysis of the waste management infrastructure, available data from the Municipality were used. Parallelly, discussions were held with waste management officials and stakeholders in order to support the understanding of the city's waste management systems. The existing waste management infrastructure was additional investigated through on-ground assessments and field surveys as shown in the Annex Table 21.

The following categories help in capturing the existing infrastructure data at ward level and city level. The detailed surveys format for each category are listed in the Annex.

- City Level Information (Table 22 and Table 23)
- Assessment of municipality (Table 24)
- Finance data from the municipality (Table 25 and Table 26)
- Assessment of Private agency for waste collection and management (Table 27)
- Hotels (Table 28)
- Schools and Colleges (Table 29)
- Religious places (Table 30)

Assessment of plastic leakage

This assessment aims to set the basis for developing a sustainable and integrated plastic waste management system for Rishikesh. Strategies to prevent or reduce plastic waste leakage into the environment play an essential role when it comes to plastic waste management solutions. Plastic waste leakage can occur through diffuse emissions (e.g. waste littering on household/ citizen level) or accumulation along point, line or area sources. In multiple urban areas of India, open littering of waste can be observed across the city. Although littering is prohibited by law, it follows an inherent structure. Waste that is not collected or covered under the municipal collection system is disposed on certain points along roadsides or in open spaces. While these locations are not specifically marked or intended by authorities, they are usually known to the waste generators for disposal and the waste collectors for their clean-ups. These locations are usually open dumping points for waste, prone to dispersion by wind and attraction of vermin and larger animals. In particular, plastic waste items are commonly dispersed more easily by wind and other factors in the surrounding environment. Litter spots at or close to riverbanks additionally are a potential source for riverine plastic waste. Capturing or avoiding these point sources can have significant impacts on the reduction of urban plastic waste leakage. Due to the dynamic nature of these hotspots, an accurate quantification within the scope of this analysis was not conducted. In this assessment, these point sources are identified and mapped. The identification of major leakage spots supports the design of targeted management solutions for plastic waste diversion.

In this assessment, plastic waste hotspots are defined as major leakage points of plastic waste in the environment. The hotspots were identified through field surveys and interviews with municipal officials, citizens and community leaders. Field surveys and interviews were also used to determine the annual intensity of plastic waste leakage. The identification of plastic waste hotspots supports the design of adapted solutions to reduce plastic waste emissions into the environment. However, this assessment only allows for a qualitative evaluation of hotspots and does not incorporate diffuse plastic waste leakage along the collection and processing chain. To quantify these emissions, another methodology has to be applied. Due to the diffuse nature of waste emissions, an on-ground quantification for one entire city would require an immense financial, personnel and time effort. Besides data collection, the implementation of an on-ground quantification was considered as not feasible from an institutional perspective. As a result, a leakage quantification based on extrapolated data following a uniform methodology was applied. For this assessment, the Waste Flow Diagram recently developed by GIZ, University of Leeds, Eawag-Sandec and Wasteaware (2020) was applied.

Assessment of the informal waste sector and the plastic waste value chain

The informal waste sector has a fundamental role in managing and recycling the city's waste. Not being a part of the official waste collection system and waste management funding, informal waste workers and recyclers play a crucial role within the waste management system and operate only based on the financial value of collected waste materials. Informal workers are commonly marginalized groups with low income and education levels but drive an elaborated value chain for recyclables within the city and beyond its boundaries.

For any new plastic waste management system, the existing recycling networks of the informal sector form an important basis for understanding market demands and mechanisms and identifying potential opportunities for plastic waste management business cases. Due to the relevance of this sector, in particular for plastic waste collection and recycling, a detailed assessment has been conducted for the informal waste sector. Firstly, the existing informal waste collection structures and networks were identified based on interviews with municipal officials, community leaders and informal workers. Secondly, a survey was conducted for the informal waste sector, see Annex Table 31 and Table 32. The objective of the survey was to obtain detailed information on types of collected waste items, trading and markets of recyclables, income of waste aggregators, numbers of waste collectors employed and the overall plastic waste chain.

4.4. Stakeholder Perception, Knowledge and Capacity Assessment

Computer-Assisted Personal Interviewing was used for the perception study, in which the interviewer uses an electronic device to record the answer to the questions from the respondent, or the respondent uses an electronic device to answer the questions. The number of samples was calculated following the equation presented above in this chapter. For Rishikesh, 394 households and 89 commercial establishments participated in the perception survey

The perception questionnaire – in Hindi and English - was uploaded in an online form and was used by the enumerators on the ground. The questionnaire was designed to capture information on the knowledge and awareness levels of the respondents, their waste disposal habits and their perception regarding the existing waste management systems in the city. Two different forms of questionnaires were developed and used for households and commercial establishments respectively.

5. Waste Inventory

5.1. Size Distribution

The overall size distribution of solid waste in Rishikesh is presented in Figure 5, Figure 6 and Figure 7. The size distribution of all waste generators is 43% in the >60 mm fraction, 14% between 25-60 mm and 43% below 25 mm. The observation shows that most of the dry waste including plastic, paper and textiles is found in the >60 mm fraction. Below 25 mm, mostly wet waste is observed. In the fraction between 25 and 60 mm, a minor amount of plastic waste such as sachets are present.

The size distribution of household waste shows that 40% of the total waste is >60 mm in size and 45% is <25 mm in size; whereas for commercial establishments the waste below 25 mm in size is only 7% and 76% of the waste is >60 mm in size. This corresponds with the identified larger dry waste share present in commercial waste, which will be elaborated on in the following subsection.

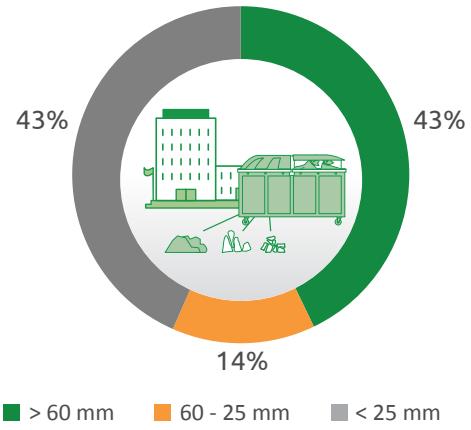

Figure 6: Municipal solid waste – Particle size distribution, Rishikesh.

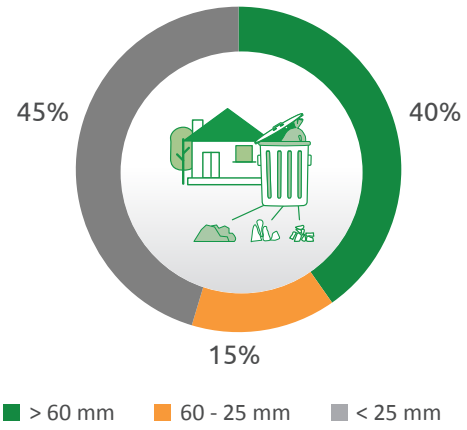

Figure 7: Household waste – Particle size distribution, Rishikesh.

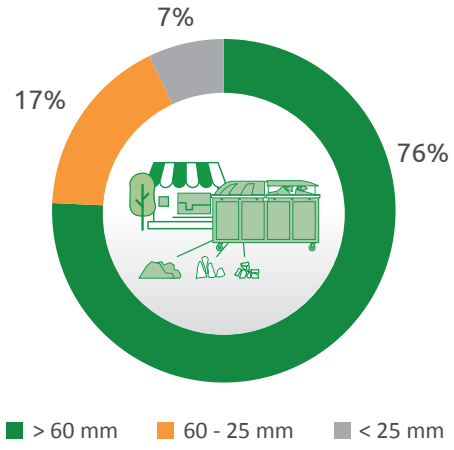

Figure 8: Commercial establishment waste - Particle size distribution, Rishikesh.

5.2. Waste Composition

The dry and wet waste composition of the waste shows that the waste generated from the commercial establishments is largely dry waste (62%), whereas 71% of the household waste is wet waste. By weight, household waste contains large shares of kitchen and food waste, partly also garden waste, due to daily household routines of food preparation. In commercial establishments (except restaurants and hotels), food preparation is not a core activity. When comparing the assessment results with previous studies in Rishikesh such as Rawat & Daverey (2018), the identified amount of wet waste (69%) is significantly higher than the value of 57% in the mentioned publication. Besides a different methodology, the study by Rawat et al. was conducted before COVID-19 and does also include significant amounts of waste from hotels, which may have been a reason for a higher dry waste share.

The overall plastic share in the total solid waste of Rishikesh amounts approx. 12% and is higher in waste from commercial establishments (16%).

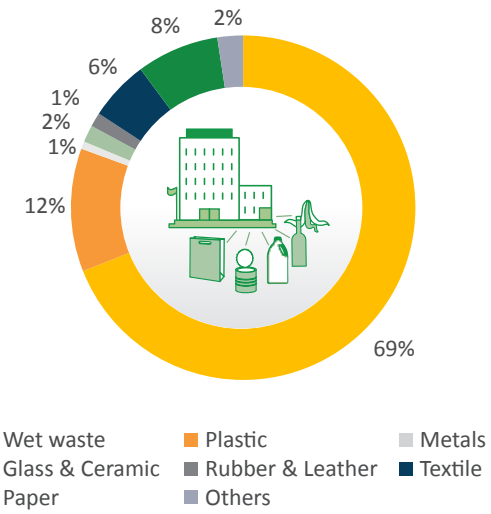

Figure 9: Overall composition of municipal solid waste, Rishikesh.

The composition of the dry waste fraction from households and commercial establishments are presented in Figure 9 and Figure 10 below. The assessment revealed that the share of plastic waste is the highest in the overall dry waste fraction from both waste generator types (37% in household dry waste and 41% in commercial dry waste). The second largest category of both generator types is paper waste. Apart from this, the dry waste compositions of households

and commercial establishments vary substantially. A notable difference is a comparatively high share of textile waste in the household dry waste, comprising of old rags and cloths. Waste from commercial establishments, however, have an increased share of inert glass and ceramic items.

The overall observations are that 37% of Rishikesh's dry waste is plastic waste. The detailed analysis of this plastic share is presented in the following chapter.

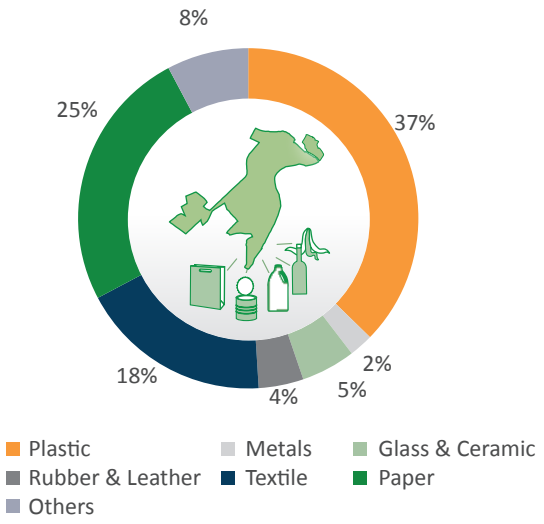

Figure 10: Overall composition of dry waste, Rishikesh.

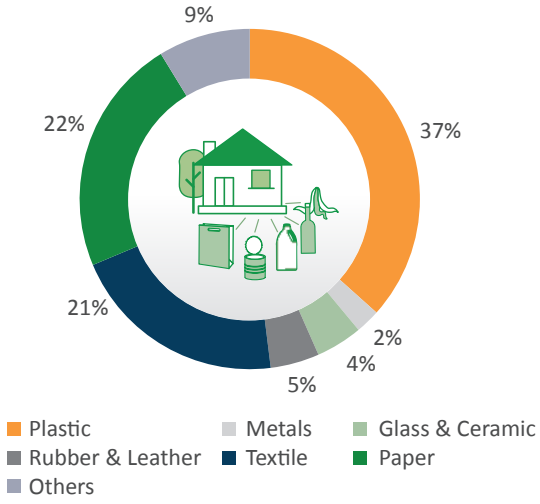

Figure 11: Dry waste composition of household waste, Rishikesh.

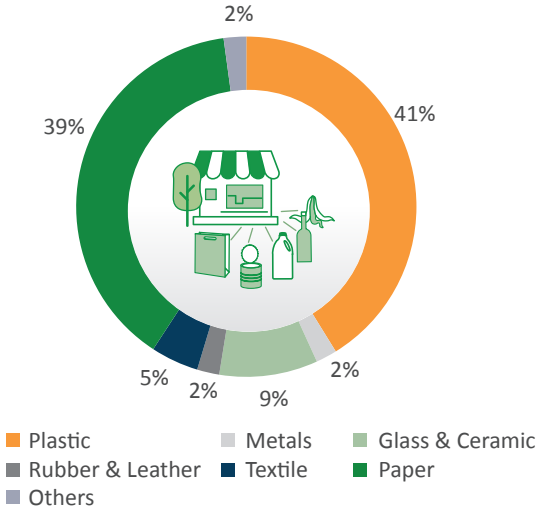

Figure 12: Dry waste composition of commercial waste, Rishikesh.

5.3. Plastic Typology

The results of the detailed analysis of the plastic share in seven categories show that for households 72% is LDPE and MLP. For commercial establishments, LDPE has a share of 52% and MLP only 9%. The overall share of plastic materials with a higher material value is generally higher in commercial waste. In household waste, plastic materials with a high recyclability like PET and HDPE have a low share of 11%. From all evaluated plastic categories, only MLP has a low material circularity suitable for subsequent downcycling processes. Considering this, almost 90% of the identified plastic waste materials are potentially suitable for a mechanical recycling process. In reality, a notable amount of LDPE waste is commonly found to be contaminated and degraded. For these materials, a recycling process within the existing recycling infrastructure is mostly economically unviable in India. While PET and HDPE are considered as valuable items by informal collectors and removed from the waste stream, LDPE and MLP mostly remain in the waste stream. This offers a great potential for treatment and business models focusing on MLP and LDPE.

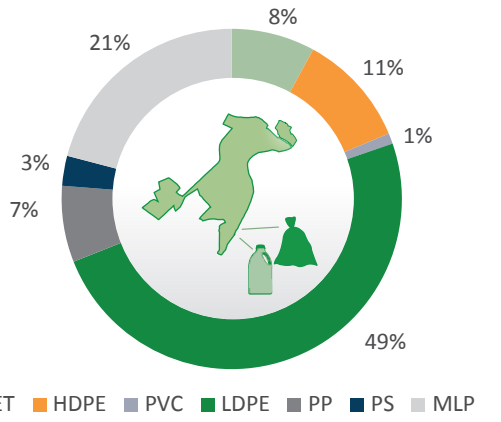

Figure 13: Plastic waste analysis, Rishikesh.

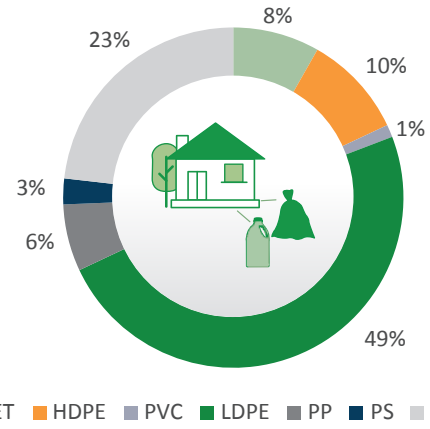

Figure 14: Plastic waste composition of household waste, Rishikesh.

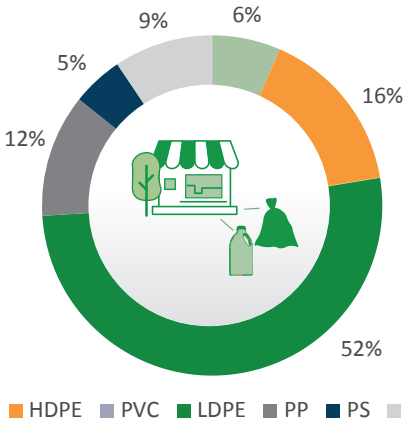

Figure 15: Plastic waste composition of commercial waste, Rishikesh.

With a total estimated waste generation in Rishikesh of 31.4 tons/day and a plastic share of approx. 12%, the amount of plastic waste generation can be concluded as 3.6 tons/day. Using the percentages of each type of plastic waste, their total amount in waste was calculated. Consequently, the total material flows and inherent material values are obtained and presented in Table 6.

Table 6: Material streams of plastic waste, Rishikesh.

Type of plastic waste	Share in total plastic waste (%)	Total mass flow (kg/day)
PET	8	288
HDPE	11	396
LDPE	49	1,764
MLP	21	756

5.4. Estimated Waste Generation

In pilgrimage cities like Rishikesh, there is a significant difference between waste generated and waste disposed. Out of a total of 40 wards in Rishikesh, 20 wards have a predominately rural setup in which wet waste input into the collection system is low as organic residues are generally fed to animals or in the case of waste flowers sent for incense making. By this, a significant part of organic waste is not collected in the urban waste collection system.

Waste quantification based on literature values

According to the Uttarakhand Urban Development Directorate, the estimated amount of waste generated in Rishikesh in 2017 was 26.44 tons/day (Urban Development Directorate Dehradun, 2017). The Uttarakhand Pollution Control Board estimated a solid waste generation of 41.4 tons/day in 2017 (UEPPCB, 2018). According to the RNN, the city generated about 60 tons/day of solid waste in 2020 (RNN, 2020). An analysis conducted by Rawat & Daverey (2018), however, identified an urban waste generation of 30 tons/day. Hence, the solid waste values from official sources as well as from recent literature range from 26 to 60 tons of solid waste per day, which underlines the high uncertainty of solid waste values in Rishikesh.

Waste quantification based on per-capita generation data

For this reason, the assessment conducted within this study was required. However, the following values were obtained during the COVID-19 pandemic and may be biased through different consumption and disposal behaviors. The assessment identified the average per-capita waste generation and extrapolated this value for the entire urban area. Based on this approach, residential waste generators generate an average daily amount of 0.12 kg/capita/

day. This value remains far below the common values for urban per-capita waste generation in India. However, also previous waste quantification surveys found that Rishikesh generates a comparatively low amount of waste per person for an Indian urban area (Rawat & Daverey, 2018). Possible reasons for these biased values could be the COVID-19 pandemic, which was ongoing during the assessment, or a change of the waste generators' behavior due to the prior notification about this assessment. Considering the value of 0.12 kg/cap/day and an urban population of 106,320 inhabitants, a total residential waste generation of 12.8 tons/day is estimated.

A similar assessment was conducted for commercial establishments. The analysis of 236 daily commercial samples with a total amount of 121.6 kg revealed a daily waste generation rate of commercial establishments of 0.52 kg/entity/day. Considering an approx. amount of 3,000 commercial establishments in Rishikesh, 1.6 tons/day are estimated from commercial waste generators.

For the daily population influx, a per capita waste generation could not be determined due to the reduced number of commuters during the COVID-19 pandemic. The daily waste generation of commuters within the city boundaries, however, is assumed to be significantly lower than of households. Parts of their daily activities (e.g. food preparation) occur outside of the city boundaries. This group is reflected in this assessment with 50% of the daily waste generation of Rishikesh's residents. Therefore, 7,500 daily commuters may contribute an additional amount of 0.5 tons/day to the urban waste generation.

The waste generation of hotel guests could not be evaluated due to the low presence of tourists and the closure of hotels during the COVID-19 pandemic. Over the course of this study, a three-day assessment at one hotel was conducted, which revealed a waste generation rate per tourist of 0.24 kg/capita. However, it has to be pointed out that this value has a high uncertainty. Due to the lack of alternative data or literature values, this estimated value was utilized to at least define the broader range of waste generation. For 4,800 daily tourists, an additional waste generation of 1.2 tons/day is therefore assumed. According to details provided by the RNN, a daily amount of approx. 10 tons of street sweeping is collected in the city. However, an estimation within this assessment calculated maximum amount of 5 tons/day through street sweeping based on the number of collection vehicle trips.

Table 7: Results of waste generation assessment, Rishikesh.

Waste generator	Daily waste generation per capita	Waste generation per day
	kg/capita/day	tons/day
Households	0.12	12.8
Commercial establishments	0.52 (per establishment)	1.6
Commuters	0.06	0.5
Tourists	0.24	1.2
Street Sweeping		5
Total	0.20 (average)	21.1 (total)

The calculated amount of 21.1 tons/day contains several assumptions with a high sensitivity of the result and may be affected by the COVID-19 pandemic, which resulted in a lower influx of external population and a strong decline in urban business activities. Hence, another estimation of daily waste quantities was conducted based on collection vehicle data.

Waste quantification based on collection vehicle data

The data collected on the number of trips by door-to-door collection vehicle shows that per day approx. 35-40 trips are made by all vehicles. Of all vehicles, the loading capacity was achieved in most cases. Based on the number of door-to-door collection trips, the loading volume and max. loading capacity, a total daily amount of approx. 20 tons/day is estimated. In addition to street sweeping, ten to twelve trips were made each day by community bin collection vehicles, carrying up to two community bins each. Based on the field survey, it is assumed that all community bins are emptied every day. Considering a waste amount of 0.4 tons/community bin, an additional waste amount of up to 6.4 tons/day is collected through community bins. This results in a total waste generation of 31.4 tons/day. Considering the literature values in the range of 26 to 60 tons/day, the calculated amount of 21.1 tons/day appears to be underestimated, while the estimated amount of 31.4 tons/day are in a similar range of previous studies. For the further calculations, the latter is utilized.

6. Current Status of Waste Management

6.1. System Overview

Rishikesh *Nagar Nigam* (RNN) is the responsible institution for urban solid waste management within the municipal boundaries as per the regulations of the Indian Solid Waste Management Rules, (2016). RNN is in charge of collection, transportation, processing, treatment and disposal of municipal solid waste in a scientific manner. Besides the already presented major sources of solid waste generation in the city (i.e. households, commercial establishments and the additional daily population influx), the municipality has over 375 hotels/restaurants, 155 ashrams, 25 schools and colleges and 30 hospitals. Large industries or manufacturing companies are not present in the area. In addition to this, the city has two vegetable and fruit markets. The bio-medical waste from hospitals and laboratories must be disposed according to the Indian bio-medical waste rules, which is not the responsibility of the municipality.

In Rishikesh, street sweeping is collected as a separate waste stream. Apart from littered waste, street sweeping contains a high inert fraction with sand, silt and stones from the streets. Along with street sweeping waste, drainage cleaning waste is collected, containing wastes with a comparatively high moisture content. Both inert fraction of street sweeping waste and moisture content of drainage cleaning contribute a major waste share to the overall waste stream composition. According to RNN, the municipal waste management staff comprises of 177 permanent waste collectors and 88 additional contractual waste collectors. For the contractual waste collectors, RNN has integrated previously informal sector workers into their waste management system. The on-ground staff is supervised by five sanitary inspectors, 14 supervisors and four municipal officers. RNN is currently facing challenges in handling and managing the generated urban solid waste amounts, especially processing, treatment and disposal of waste (RNN, 2020). Major constraints are observed in establishing source segregation and scientifically processing and disposal for the generated waste amounts.

According to the municipality, the revenue generated from the fees collection is not sufficient to cover the annual expenses for urban solid waste management. Additional funding is obtained through national government programs like the *Swachh Bharat Mission* and *Namami Gange*. The proposed waste management fees are presented in Table 26. However, according to discussions with municipal officials, category wise fee collection is currently not monitored, since the fees are deposited in one common account of the municipal corporation, together with other fees (like parking fees). RNN is working on streamlining this data for the future.

Table 8: Proposed waste collection fee rates, Rishikesh.

Categories	Annual waste fee in INR
Residential	600
Commercial (offices)	5,000
Hotels (on what basis area or room)	6,000
Hotels with restaurants facility	6,000
Schools/colleges	5,000 – 10,000
Ashram/Dharamshala	10,000
Shops	1,800
Restaurants	3,600 - 8,400
Vegetable/fruit mandis	18,000
Hospitals (on what basis)	25,000

6.2. Collection and Transportation

Waste collection and street sweeping is done by the RNN. From January 2021 onwards, a new contractor for waste collection will take up this task on behalf of the RNN. Segregation at source is not practiced in the municipality. Although few households collect waste in two different bins (dry and wet waste), the collection system mixes both streams together to transport the waste to the local dumpsite. Currently, neither the collection nor the treatment and disposal infrastructure are designed for two segregated waste streams.

The door-to-door collection is majorly carried out with the help of auto tipper vehicles. At present the municipality owns 29 tippers. Ten were recently purchased and are not yet in operation. Therefore, currently the collection is being carried out with the help of 16 tippers, and three are kept on standby and are used during maintenance periods of one of the 16 other vehicles. Tricycles and pushcarts are used in wards with narrow roads and alleys where tippers would not be able to enter. The waste collected through tipper vehicles is going directly to the local dumpsite. For collecting waste from street sweeping and drain cleaning, a dedicated tractor is used in coordination with the drain cleaning team.

Additionally, RNN is using 16 community bins of each 4 m^3 volume. The metal bins are rather old, mostly corroded and partly damaged. The community bins are emptied almost every day. In contrast to the initial survey and statements of RNN, the analysis of collection data and field observations of collection trips revealed that in Rishikesh, only approx. 70% of the daily waste is collected through the door-to-door collection system.

Table 9: Currently existing waste collection infrastructure in Rishikesh.

Number of vehicles with RNN	Number	Description
JCB – Black hoe loader	2	It is used to perform various works like excavation, loading, waste spreading and dozing, as well as for various miscellaneous municipal works. Bucket capacity: 1.1 m^3
Tipper	29	The four-wheeler tipper with a closed garbage box body is applied for door-to-door collection and transportation of municipal and other types of waste from the collection to the disposal point. Loading capacity: 2 m^3
Tractor trolley	4	It is used for various miscellaneous municipal works including garbage transportation, as well as drain cleaning. Loading capacity: 3 tons
Truck	4	Used for collection and transportation, Loading capacity: NA
Tricycle	28	A tricycle is a combination of a bicycle and a container, which is used for primary collection of community-based waste with human power (Oyindamola, 2015). Loading capacity: approx. 240 liters
Compactor (Refuse Compactor Vehicle (RCV))	1	A compactor is used to collect and compact waste from the community bins. Loading capacity: 4 m^3
Tata-407	1	Tata-407 is a type of truck, which is used for transport of waste storage containers. Loading capacity: 2.5 tons
Manpower per vehicle	1 driver and 1 helper	
Total vehicle manpower	36 drivers (31 contractual and 5 permanent) 15 helpers (all contractual)	

6.3. Treatment & Disposal

According to the Solid Waste Management Rules 2016, municipalities are mandated to ensure segregation of recyclable waste at source, reduce the amount of waste for disposal and dispose only on sanitary landfills. The municipality has thee composting pits at several locations in the city. Two are treating wet waste from seven wards, one is composting wet waste from the local vegetable and fruit market. The wet waste is transported to the facilities by the collection system.

Rishikesh does not have any facility for processing, sorting or treatment of dry waste. All dry waste and most wet waste are collected from household, commercial establishments, institutions, hotels, street sweeping, community bins and drain cleaning and transported to the dumping ground located at Govindnagar. The dumpsite covers an area of approx. 6.5 hectare and is an open disposal area without scientific provisions. Since the area is not scientifically designed, it does not have a specific capacity. However, since the land is located in the city center surrounded by settlements, further land extensions are not feasible. Instead, the waste is being piled up further. The dumpsite height is strongly fluctuating, which impedes a quantification of the disposed waste amounts.

At a four-hectare area at Lal Pani adjacent to the western boundary of the municipality, a new sanitary landfill is currently being planned for Rishikesh and several neighboring municipalities. The land is currently being prepared; further activities are envisaged to start in the second half of 2021. Both locations within Rishikesh are presented in Figure 15.

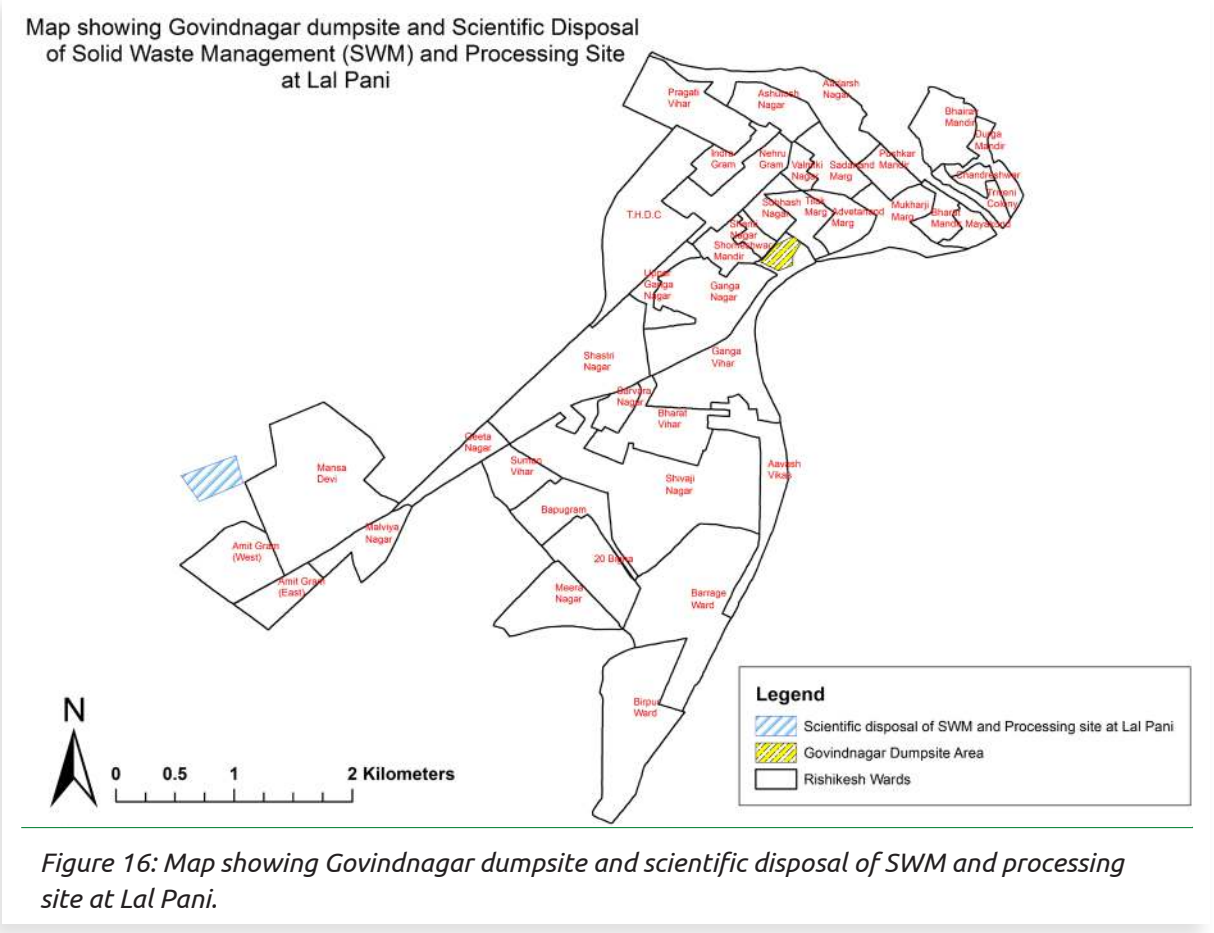

Figure 16: Map showing Govindnagar dumpsite and scientific disposal of SWM and processing site at Lal Pani.

6.4. Data Management Systems

RNN has no data collection, collation and analysis system for solid waste. Moreover, data on collected and disposed waste amounts are not available. Lastly, at the local dumpsite, no facilities are available for weighing the collected waste amounts.

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7. Plastic Waste Leakage

Plastic waste leakage in urban areas of India mostly occur through both point source and diffuse emissions along the collection and processing chain. The system analysis of plastic waste leakage in Rishikesh provides an estimation of existing leakage sources and amounts. The analysis shows that approx. 83% of the total MSW is collected by the official waste collection system. While approx. 10% are captured by the informal value chain collection, approx. 7% of the total plastic waste is directly leaked into the environment. Additional 2% of the total plastic generation is leaked from the collection system and a minor amount from the disposal side into the environment. In Rishikesh, a total mass flow of 130 tons are leaked into the environment every year. Of this amount, 58% remain in the terrestrial environment.

Table 10: Unmanaged plastic waste results summary from waste flow diagram, Rishikesh.

	Baseline	Unit
Unmanaged plastic waste	130	tons /year
Unmanaged plastic waste	9	% of plastic waste generation
Contribution from uncollected waste	73.01	% of mismanaged plastic waste
Contribution from collection service	22.08	% of mismanaged plastic waste
Contribution from informal value-chain collection	0.10	% of mismanaged plastic waste
Contribution from transportation	0.01	% of mismanaged plastic waste
Contribution from disposal facilities	4.80	% of mismanaged plastic waste

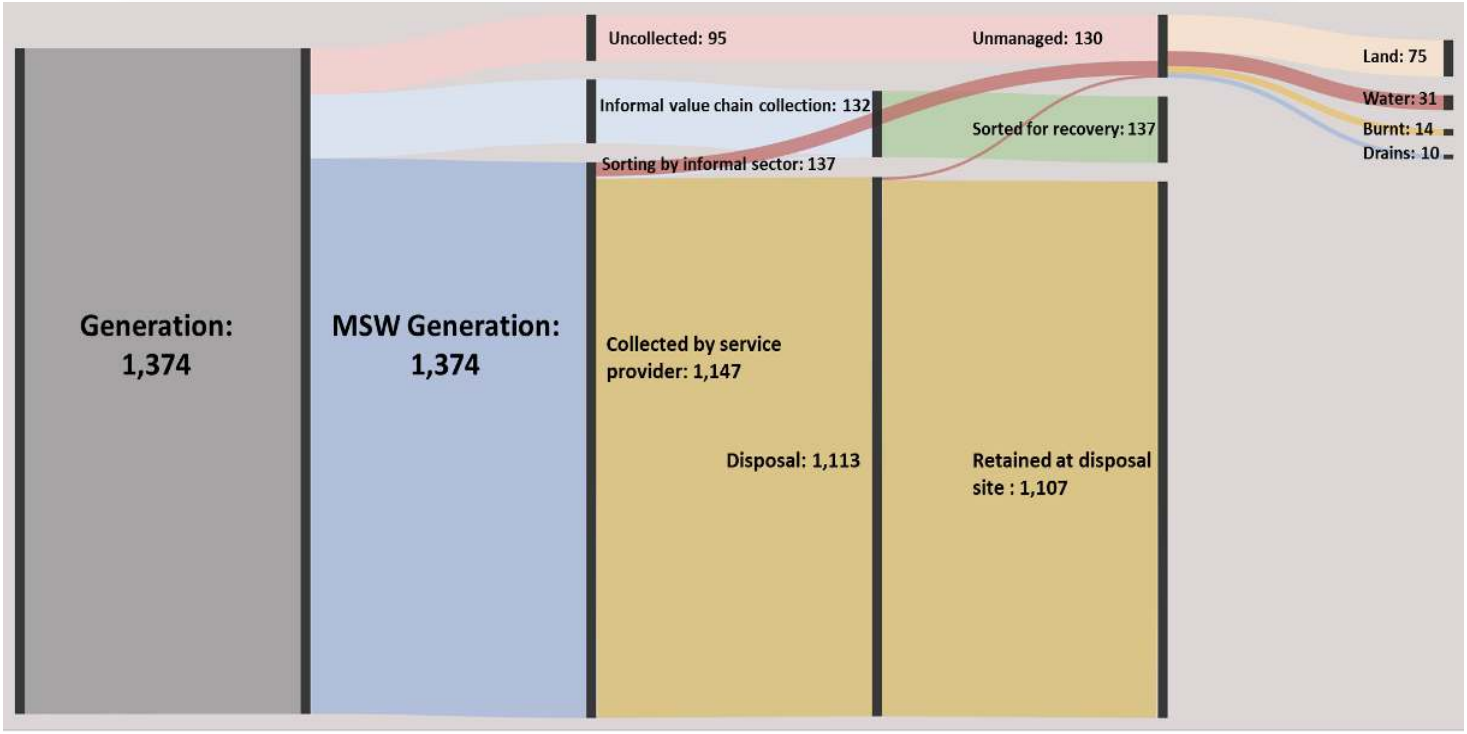

Figure 17: Plastic leakage flows, Rishikesh.

Table 11: Municipal solid waste generation, collected and uncollected waste as well as plastic generation of Rishikesh based on waste flow diagram data.

	Plastic waste	Municipal Solid Waste	Unit
	Baseline	**Baseline**	
Municipal solid waste generation	1,374	11,448	tons/year
Municipal solid waste generation	4	31	tons/day
Collected waste	1,279	11,353	tons/year
Collected waste	93	99	% of waste generation
Uncollected waste	95	95	tons/year
Uncollected waste	7	1	% of waste generation
Waste sorted for recovery (excludes energy from waste)	137	767	tons/year
Waste sorted for recovery (excludes energy from waste)	10	7	% of waste generation
Waste sorted for recovery by formal sector *(excludes energy from waste)*	0	0	% of waste generation
Waste sorted for recovery by informal sector *(excludes energy from waste)*	10	7	% of waste generation
Energy from waste	0	0	tons/year
Energy from waste	0	0	% of waste generation
Disposal in disposal facilities	1,113	10,557	tons/year
Disposal in disposal facilities	81	92	% of waste generation

In Rishikesh, twelve major plastic waste leakage hotspots were identified. The leakage hotspots can be differentiated into two categories – community bin locations and blackspots (illegal dumpsites). RNN has 16 community bins distributed across the city. The community bins, having a volume of approx. 4 m^3, attract additional waste disposed near the bins if they are full or out of negligence. Community bins are also used by the slum population for waste disposal. Additionally, mostly unmotorized primary collection vehicles use community bin locations for intermediate storage of their collected waste once their vehicle's capacity is reached. These hotspots are regularly cleaned by RNN and transported to the local dumpsite.

Apart from community bin locations, illegal dumping points were identified as plastic waste hotspots. Citizens who are not willing to participate in the city's collection system or to pay the waste collection fees, dispose their waste either in or near community bins or, in case the distance is too large, on illegal dumping points, called blackspots. These dumping points were identified mostly in the vicinity of slum settlements or residential areas of lower income. These blackspots are irregularly cleaned by RNN and transported to the local dumpsite. Both hotspot types are used by informal waste collectors to sort valuable materials like recyclable plastics out of the open waste.

It is observed that the majority of hotspots were found along the banks of the Chandrabhaga river and the adjoining wards with a high density of commercial establishments. Community bins in residential areas were found to be rather well-maintained. Containment activities and strategies for plastic waste leakage can therefore be focused on a rather small share of the entire urban area.

Additional hotspots of plastic accumulation are the two Sewage Treatment Plants (STP) as well as few blackspots on the bank of the Chandrabhaga river, which is a tributary to the river Ganga. One STP is located near the *Triveni Ghat*; the other one near a temple, the *Chandeshwar Mandir*, on the bank of the Ganga. The untapped drains leading to the two STP carry a significant amount of plastic. Some of this plastic waste gets trapped in a screen, which has been placed in the STP by the *Namami Gange* initiative, while the remaining parts leak into the river. Plastic which gets accumulated at the screen of the STP is collected and disposed of in the nearby community bins. From there it is transported to the dumpsite at Govindnagar. Rishikesh does not have any plastic producing, processing or utilizing industries. Hence, plastic waste leakage hotspots from plastic production or utilization along the value chain were not identified in the city. The major hotspots are as located in Figure 17.

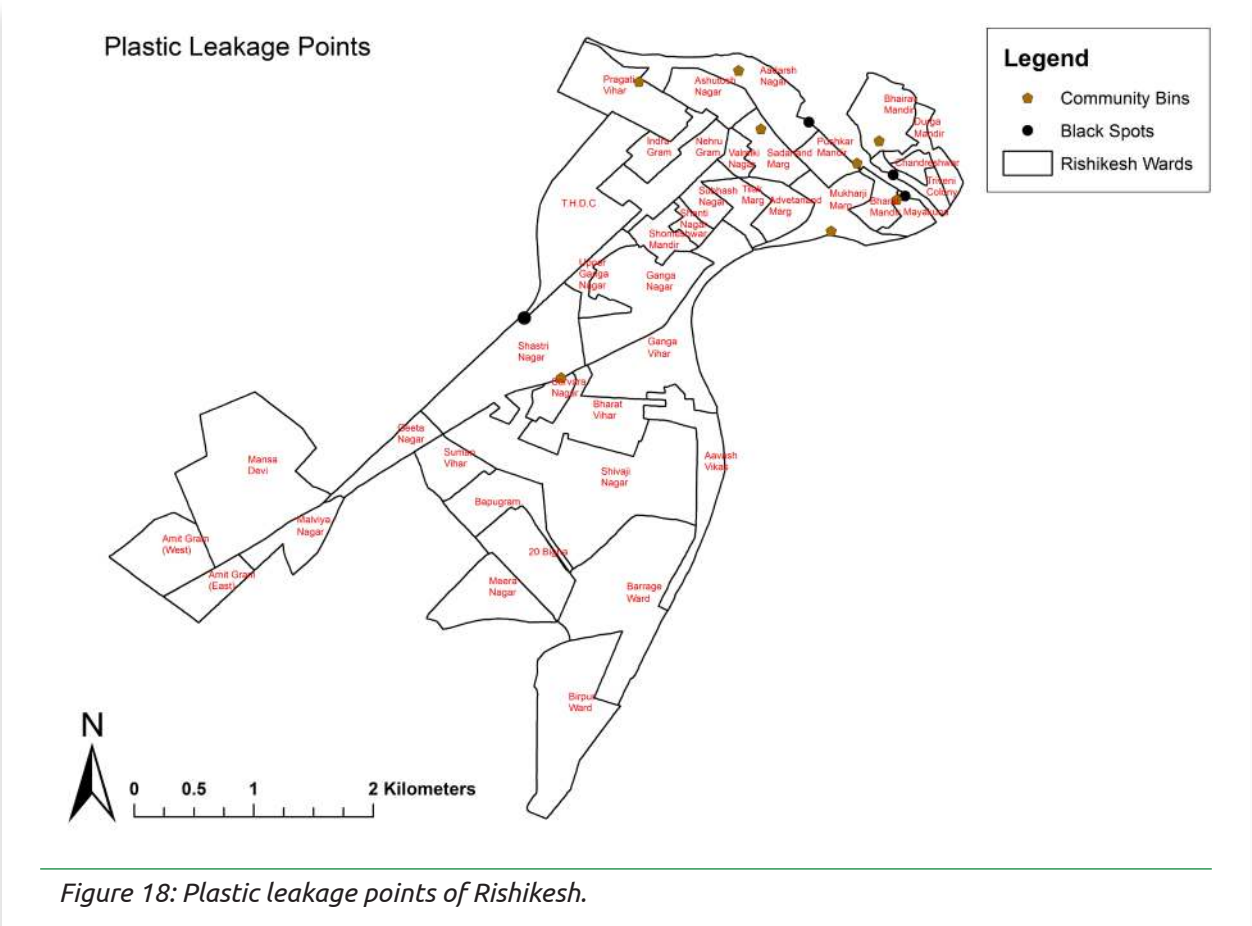

Figure 18: Plastic leakage points of Rishikesh.

Figure 19: Blackspot at the bank of the Chandrabagha river in Rishikesh.

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8. Assessment of Informal Sector

One essential element of the assessment was the detailed mapping of the informal waste sector in Rishikesh. Approx. 200 informal waste collectors are engaged in the city's waste management system. The informal waste collectors gather valuable items from community bins, illegal dumping points or the local dumpsite. From there, they sell their collected and sorted waste to *Kabadi Walas*. 20 *Kabadi Walas* (scrap vendors) were identified in Rishikesh, out of which twelve were operational at the time of the survey and eight where currently not in business (mostly due to the COVID-19 pandemic). The identified aggregators are traders who buy the material from informal waste collectors and sell them to recyclers in neighboring cities. Each day the informal waste collectors gather waste from commercial establishments, dumping points and other blackspots in the city and sell them to the *Kabadi Walas*. Based on the survey, the following outcomes regarding the economic structures of the informal waste system were identified.

Earnings

The earning of the *Kabadi Walas* ranges between 15,000-40,000 INR/month. Most of the *Kabadi Walas* have bank accounts, few of them also GST registrations. The business, therefore, is slowly getting formalized.

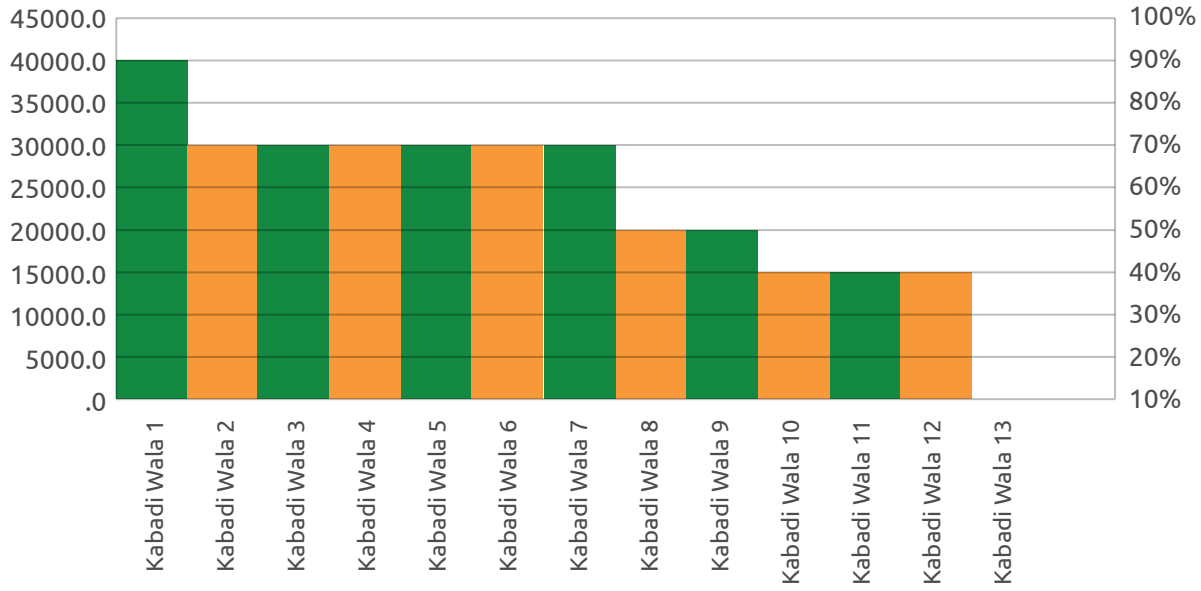
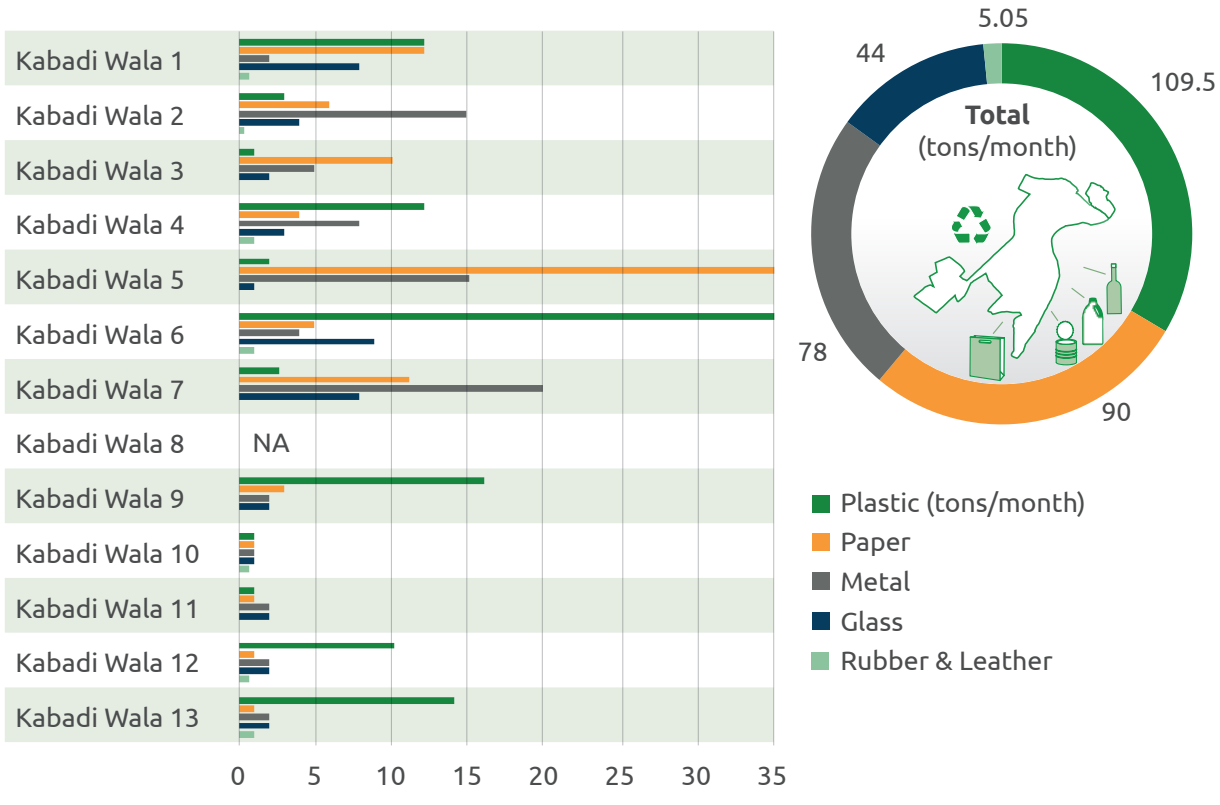


Figure 20: Monthly income (INR) of Kabadi Walas in Rishikesh.

Monthly dispatch of inventory

The different fractions of waste collected and sold and the respective amount in tons per month are listed in Table 30 below. Plastic waste has the largest share of the dry waste collected and sold by the informal sector. The survey shows that plastic waste is the largest share traded by the *Kabadi Walas*. An average of 3.6 tons of recyclable plastics are handled every day in the city. This is followed by paper, metal and glass. In general, *Kabadi Walas* sell around 1-2 tons/day of waste. The twelve *Kabadi Walas* surveyed under the study and willing to provide data, sold about 325-350 tons/month of dry waste. The mentioned values were provided by the vendors. However, the survey also revealed that *Kabadi Walas* located in Rishikesh are also buying waste from informal waste collectors of the neighboring municipalities. Hence, the identified amounts of recyclables cannot be entirely credited to Rishikesh.

Table 12: The average amount of collected and sold recyclable waste by informal waste workers in Rishikesh.



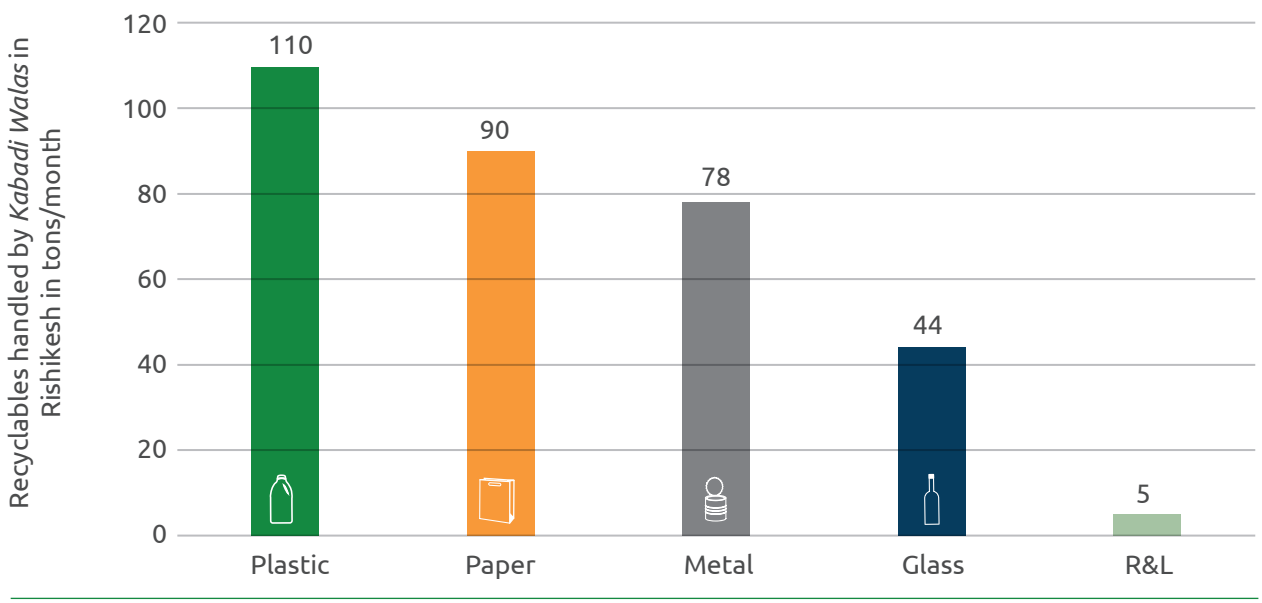


Figure 21: Waste handled by Kabadi Walas in tons/month, Rishikesh.

The globally increasing consumption of plastic has also been noticed by the *Kabadi Walas* in increasing shares of recyclables. The main plastic waste materials received and traded by the *Kabadi Walas* are PET and HDPE.

Although not all recyclables were procured in Rishikesh, the values mentioned in Table 13 give an indication of the recycling amount currently being traded in Rishikesh. Due to the significantly higher population of Rishikesh when compared to neighboring municipalities and a constant exchange of recyclables, the great majority of the 109.5 tons/month is assumed to be collected from Rishikesh. This equals a daily amount of 3.6 tons/day of plastic waste recycled and sold by the informal sector in the greater urban area of Rishikesh. Since households and commercial establishments sell recyclables directly to *Kabadi Walas* on the one hand and dispose them in the mixed waste on the other hand, an estimation of Rishikesh's recycling rate in percentage is not feasible from the existing data sets.

Pricing

The pricing of the material depends on the quality and level of segregation. The survey of the *Kabadi Walas* revealed that they maintain homogeneous pricing when purchasing waste from the informal collectors. Few small *Kabadi Walas* pay below their capacities. The rates can vary on a daily or weekly basis. There are certain factors which influence the rates, such as availability of transport, material quality and availability of material.

Recyclers

There are no recyclers in the vicinity of Rishikesh. The *Kabadi Walas* transport the material to recyclers in nearby cities like Mangalore, Bhagwanpur, Muzaffarnagar and Doiwala. Most of these places are more than 100 km away from Rishikesh, which increases the transportation cost of the materials and reduces the profit margin of the *Kabadi Walas* and informal waste collectors. This reduction of profit margin has a strong impact on low valuable plastic materials like LDPE and MLP, for which the collection and trading may become economically unviable.

Transportation

The *Kabadi Walas* have to arrange a regular transport of material, since they usually own only small facilities with low space availability for long-term storage. This increases the relative transportation expenses even further. The specific transportation costs were not revealed by the surveyed participants. The material gets dispatched on a fortnight or monthly basis. Small trucks, auto trucks and pickup vans are used for carrying the material.

Figure 22: Municipal waste collection vehicle.

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9. Public Awareness

9.1. Households

Household characteristics

In total, 394 households, with a total population of 2,219, completed the survey. Of the total 394 respondents, 129 were female and 265 were male. All respondents answered in Hindi. Only one-third of the respondents were graduates or above. More than 60% of the households were either self-employed or have their own business. The average household size varied from 4.6 person in high income wards to 6.5 in economically weaker section wards. The average household size in the mixed wards was 5.2 person.

Segregation at source

The vast majority of households use a single dustbin to store their unsegregated waste. At least 90% of households use a single bin; only 8% of the households store their waste separately in two bins and segregate between dry and wet waste. During the survey, 36% respondents said that they segregate the waste into valuable items and mixed waste. This segregation is largely for collecting valuables which is sold to the *Kabadi Walas*. Common items which are reused are plastic bottles, metal containers and certain types of paper. Among the items which are commonly sold to the *Kabadi Walas* are cardboards and paper, metals and high value plastic waste. More than 90% of the people also dispose left-over medicines in the same bin. More than 90% of the households stated a high willingness to segregate their waste into wet and dry if they are asked to do so by their service provider. Few respondents mentioned that they used to give segregated waste to the collector. However, since the waste collector mixes both waste streams in the same vehicle together, the respondents stopped segregating waste into dry and wet. The main reason for not segregating waste included habit, lack of awareness, and very little or no dry waste generation. As the main reason, more than 50% of the respondents stated habit and around 40% a lack of knowledge and awareness. About 10% said that they generate very little or no dry waste.

Disposal of waste

To understand the disposal behavior of the people, respondents were asked to rank their preferred places for waste disposal. The responses show that the households utilize the RNN collection system as their first preference. 58% of the respondents said that they use the RNN collection system to dispose their waste 23% of the household use community bins as their first choice.

Waste management responsibility

At the household level, it is a general understanding that women are responsible for managing the waste. To verify this assumption, a question was included in the survey to understand the ground reality. From the responses received, it emerges that in one-fourth of the households' men are responsible for managing the waste.

Additionally, more than 75% of the respondents believed that waste management is a joint responsibility of the citizens and the government.

Plastic waste prevention and perception

Most of the respondents were aware of the ban imposed by the government on the use of plastic bags. More than 75% of the respondents perceived a decrease in the use of plastic bags in households.

Waste collection services

More than 90% of the households stated that there is a regular waste collection service in their area. Few respondents in the economic weaker section wards felt that timing is an issue, as the vehicles do not maintain a fixed collection schedule. More than 90% of the respondents said that the collection vehicle comes daily. 85% of the people use the waste collection system regularly. Households which did not regularly use the system mentioned that the monthly charges are too high (mostly received in EWS wards). In general, people were satisfied with the current collection services, although improved time schedule with fixed collection times were suggested. In wards with narrow roads, respondents complained about the long distance they have to walk to the collection vehicle.

Public perception of urban waste management challenges

The main challenges identified by household residents for the current solid waste management in the city are as depicted in Figure 21.

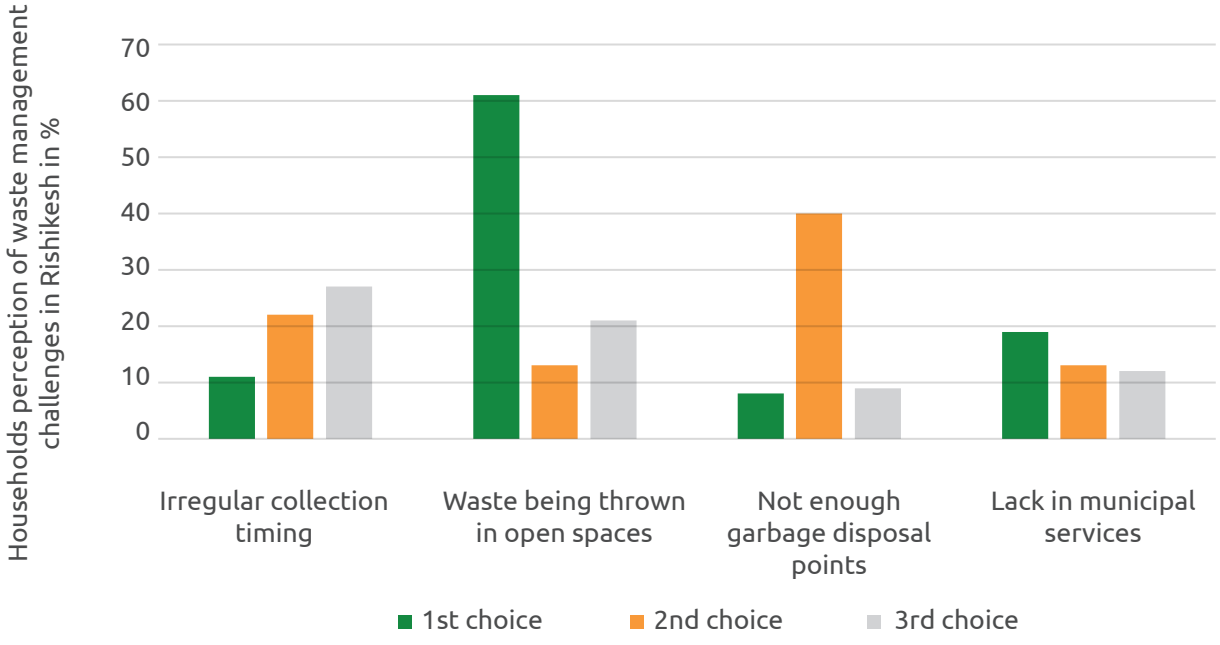


Figure 23: Households perception of waste management challenges, Rishikesh.

61% of all households stated that waste littering and leakage is the greatest challenge for waste management in Rishikesh. Based on this, a broad awareness for open littering and adequate disposal behavior can be assumed among half of the citizens. 40% of the respondents replied that public disposal points like community bins are not sufficiently available within the city.

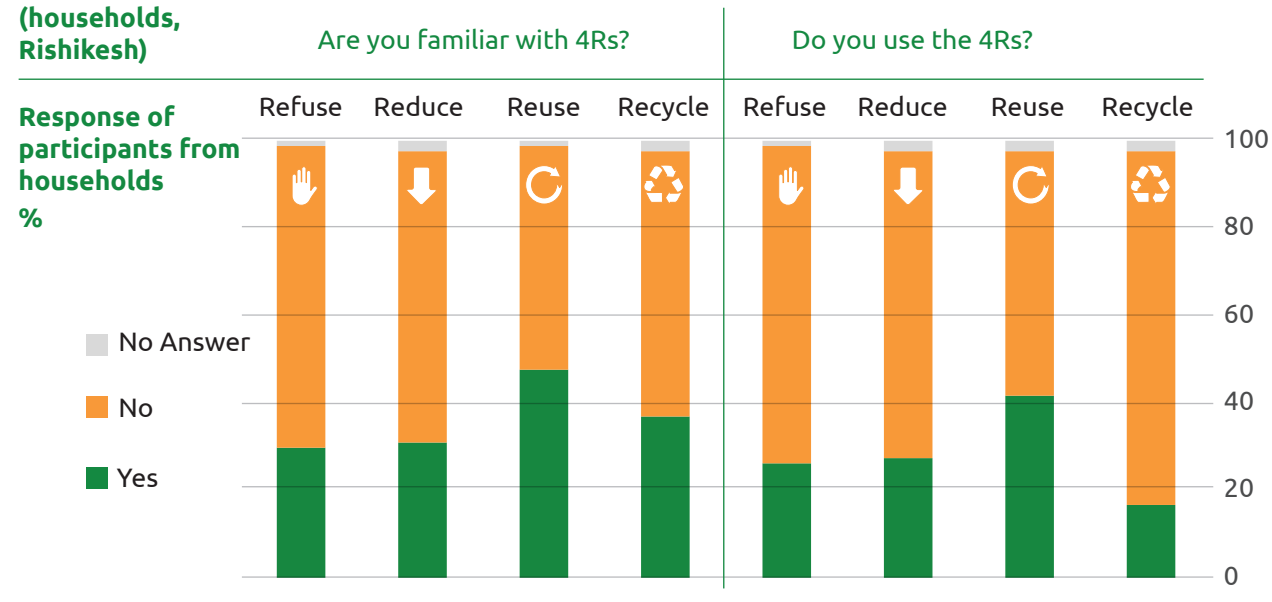
Collection fees

More than 80% of the household pay a monthly fee as waste management charges. Most of the people are willing to pay 50 INR/month for better waste management services.

Awareness

The general awareness of the 4Rs – Refuse, Reduce, Reuse and Recycle - was found to be low among the respondents. Only one in three persons was familiar with the waste hierarchy. Almost half of the respondents knew about the opportunities to reuse selected items like plastic or glass bottles, metal containers or paper. Few people also stated that they have now started refusing plastic items like bags given by vendors and started bringing their own bags.

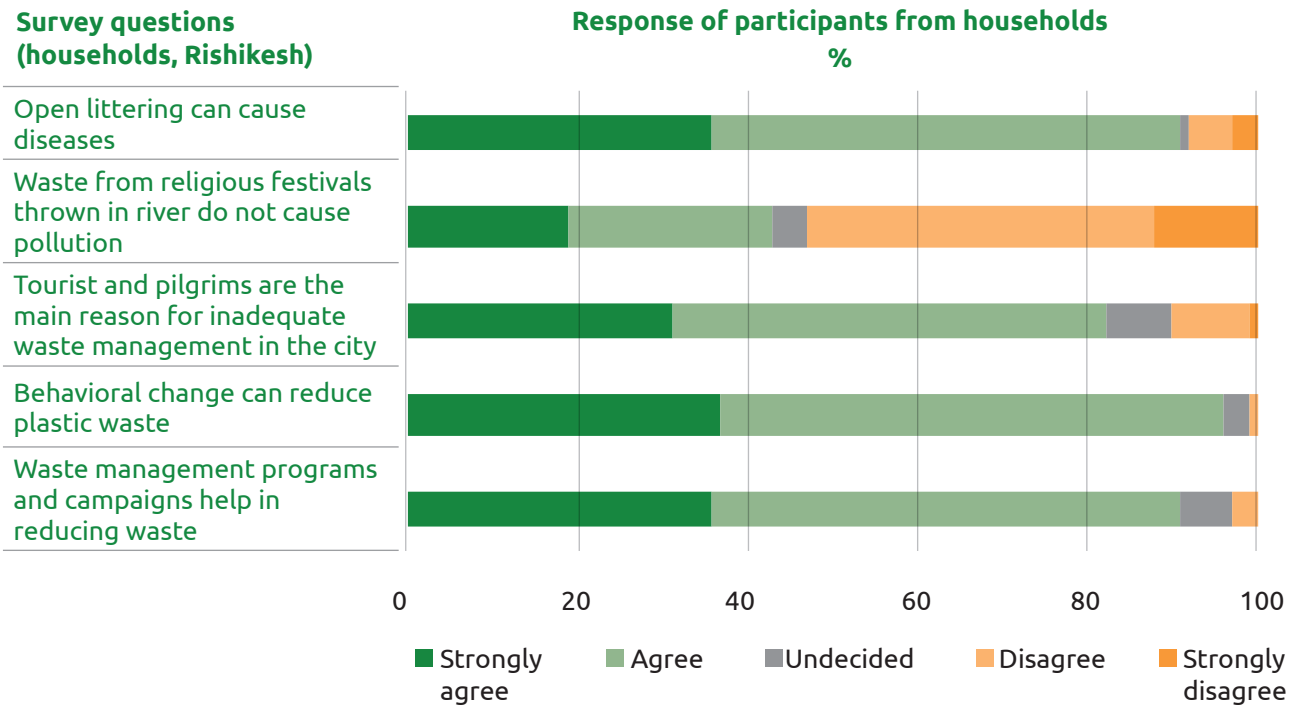
Table 13: Household responses about 4Rs knowledge and use in Rishikesh.



Most people understand the health implications of poor waste management and littering. Less than 50% the respondents were aware of the pollution in the river by the waste from religious places. In more than 60% of the households, at least one member participated in some form of campaign or cleaning programmed (mostly *Ghat* cleaning programs) in her/his life.

Most people stated that behavioral changes such as the use of environmentally friendly and reusable packing materials for shopping can reduce plastic waste. Door-to-door (52%) and cleanliness (18%) campaigns were identified as the two most effective waste management campaigns, followed by social media (13%) and television (12%). Only 3% of the respondents feel that school level campaigns are the most effective way of conveying waste management awareness.

Table 14: Summary of awareness, engagement and solution related questions, Rishikesh.



9.2. Commercial Establishments and Institutions

Commercial establishments characteristics

In total, 89 commercial establishments and institutions completed the survey. The establishments selected for the survey were diverse in their type of business and represent the nature of commercial activities in city. Shops dominate the commercial landscape of Rishikesh. Most of the respondents were shop owners from a wide variety of sectors including garments, electronics, sweet shops and eateries, plastic store, optical, utensils, pickle, flower and other religious item shops.

Segregation at source

85% of the establishments use a single dustbin to store their waste, while 7% are using two bins and 5% garbage bags. Only 1% admitted disposing their waste in open places. Only 18% segregate the waste into dry and wet, while 49% mixed both waste streams together and 33% stated to not have any wet waste. More than 80% of the establishments stated that they are willing to segregate their waste into dry and wet if they are asked to do so by their service provider. Among the answers why segregation at source is not established, half of the establishments responded that this is due to habit and 11% due to time constraints. Lack of awareness or a two-bin system were considered as minor reasons. The lack of an appropriate disposal facility was not considered as a reason for not segregating waste.

Disposal of waste

To understand the disposal behavior of the commercial establishments, respondents were asked to rank their preferred places for waste disposal.

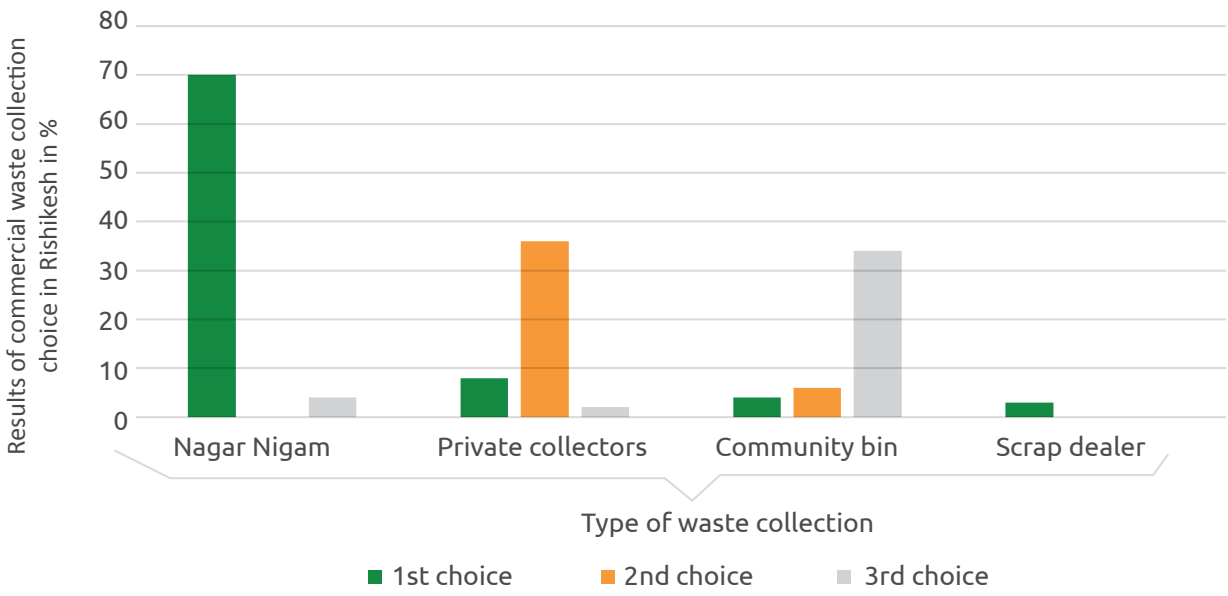


Figure 24: Results of survey question regarding the preference of waste collection systems in Rishikesh.

From all respondents, 70% hand their waste to the official collection system of RNN. 36% have private collectors as their second preferred choice, mostly for recyclables. 34% use community bins as a third option.

Plastic waste prevention and perception

64% of the establishments do not perceive any decrease in plastic waste generation from their establishments over the last years. Generally, 47% of the respondents mentioned that their PET consumption has increased, followed by poly bags (10%), Tetra Paks (6%) and plastic containers (4%).

Waste collection services

A regular waste collection facility is available for the commercial establishments. 82% of the establishments stated that they are connected to a daily waste collection, for 10% waste is collected on more than three days per week. 89% of the establishments use the collection system regularly.

Collection fees

More than 75% of the establishments pay a monthly fee as waste management charges. Current charges vary from 50-100 INR.

Awareness

The general awareness on the 4Rs was found to be poor among the respondents, however, slightly higher than in households. The participation rate of the 4R principles remained below 25%. Only the reuse rate was comparatively high with 42%, since they commonly reuse materials such as paper and cardboard (50%) and plastic containers (12%) in their day-to-day business. 67% of the respondents are willing to pay an additional amount for a product which has less packaging, creates less waste or contains certain amount of recycled material.

Table 15: Commercial establishments responses about 4Rs knowledge and use, Rishikesh.

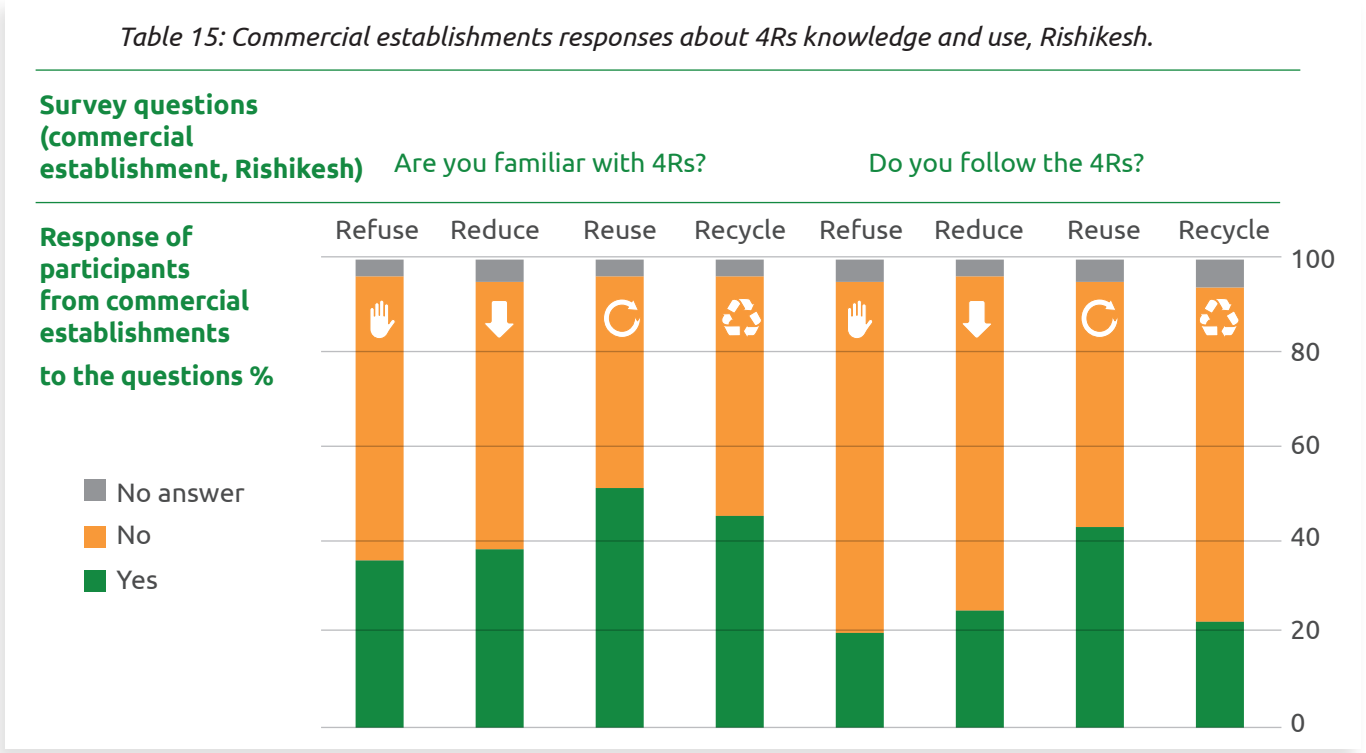
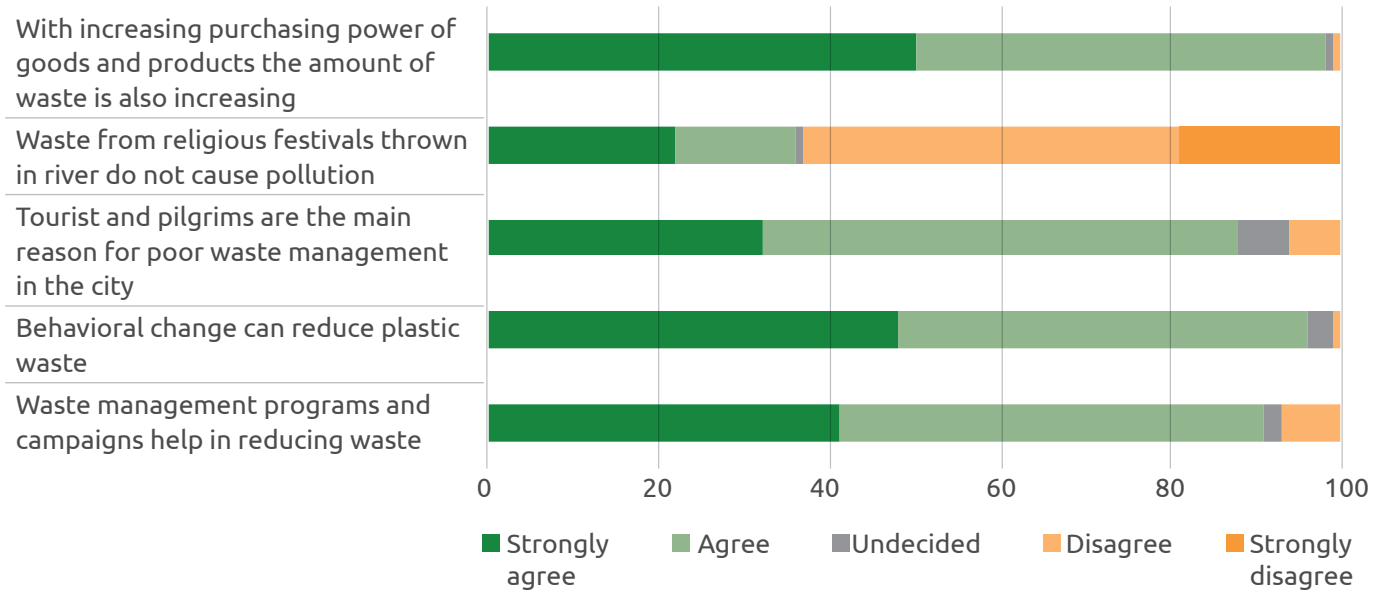


Figure 25: Project team during Door-To-Door segregation survey.

Most respondents identified an increase in income and more purchasing of goods and products as the reasons for an increased waste generation. Like households, most respondents from commercial establishments believe that religious waste is not responsible for the river pollution. Pilgrims and tourists were perceived as the main reason for an inadequate waste management in the city. 96% of all respondents believed that changes in their lifestyle are important to reduce plastic waste. 91% of the respondents believed that waste management campaigns and programs can help reduce waste, only 7% disagreed. Door-To-Door campaigns were identified as the most effective mode of waste management campaign with 52%, followed by cleanliness campaigns (18%), social media (13%) and television (12%).

Table 16: Summary of commercial establishments - awareness, engagement and solution related questions, Rishikesh.

Survey questions (commercial establishments, Rishikesh)	Response of participants from commercial establishments to the questions %



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10. Conclusion

In order to identify the data basis for project *Aviral*, a comprehensive assessment was conducted in Rishikesh. The baseline assessment included an investigation of the existing waste management system, a stakeholder analysis, a survey of public awareness levels, a characterization and quantification of municipal solid waste flows with a specific focus on plastic waste as well as an approximation of plastic leakage streams. The aim of the assessment was to develop a detailed understanding of current waste management practices in Rishikesh, identify potential areas of intervention and support the development of a city specific Plastic Waste Management Action Plan.

Currently, the city has not yet achieved full compliance with the regulations mandated by the Indian Solid Waste Management Rules 2016 and Plastic Waste Management Rules 2016 and 2018 (amended). One of the key elements of the Solid Waste Management Rules 2016 is the establishment and strengthening of segregation at source and the reduction of landfill inputs. Currently, only mixed waste is transported to the local dumpsites; alternative treatment infrastructures for dry waste are not available.

Although the collection rate in Rishikesh was officially described with 100%, major leakage streams were identified during this assessment. Generally, the capacities of the waste collection and transportation infrastructure was found to be sufficient. However, the entire infrastructure is designed to collect mixed waste and fails to provide any options for segregated waste. Hence, it is suggested to redesign the collection and transportation infrastructure to ensure the separation of collected waste during primary collection, transfer and secondary collection / transportation. In particular transfer points must be designed in an adequate way to prevent waste leakage.

At present, treatment or processing facilities for dry waste are not available in Rishikesh. The daily waste collected by the municipality is disposed at a dumping ground near the city center. According to the National Green Tribunal, this facility is lacking authorization and must be moved to another location soon. The municipality has constructed several decentralized composting pits at several locations in the city. However, the success of these facilities strongly depends on the successful establishment of segregation at source and the separate collection of wet/ organic waste. Generally, Rishikesh requires the establishment of the entire waste processing infrastructure, ranging from material recovery facilities for dry waste processing, composting or biogas facilities for organic waste treatment and engineered landfills for final disposal.

Basic data such as number of commercial establishments, households, number of institutions and others are not available or only as rough estimations. At present, a detailed mechanism for monitoring and quantification of generated urban waste amounts is not available. Without information on waste compositions and amounts, an adapted and sustainable design of a sustainable waste management system is not feasible. A cost-efficient system to quantify waste streams must be established in the city to identify leakage streams and to monitor the compliance of waste management contractors, with their contractual and legal requirements. Besides waste contractors, a monitoring system must be established for open littering, simultaneously to addressing the identified reasons for non-compliance with the existing waste management system. Hence, it is recommended to establish an unambiguous data management and monitoring system, operated by municipal officials and using calibrated equipment.

During this investigation, it was found that the informal sector has interest in collecting MLP/LDPE, provided they are compensated well and supported with infrastructural support. Considering the informal sector's crucial role in the city, it is recommended to integrated them into the collection of low-value plastic. For this, attractive economic incentives have to be identified for the collection of low value plastics through innovative business cases.

The waste management byelaws of the Rishikesh Municipal Corporation are detailed and extensive. However, the enforcement of the byelaws is barely done. From the investigation on ground it can be suggested that circle inspectors, municipal workers, sanitary inspectors, and supervisors are engaged in monitoring the compliance with the regulations at all waste generators, ensuring the sustainable removal of blackspots and issuing fines for non-compliance (e.g. littering).

An unambiguous, transparent and legal framework for all major waste streams, defining roles and responsibilities for each activity and determining infrastructure capacities as well as processes to each waste stream is suggested as a basis for further improvements of the waste management systems. The aim of this framework could contain communicating the city's strategies on plastic waste management to all citizens as well as public and private entities in order to increase public participation, reducing environmental impacts of plastic waste pollution and increasing the technical and economic efficiency of waste management systems. Further, funding and business opportunities within (plastic) waste management have to be further developed and identified, including the introduction of national EPR systems in Rishikesh. An open framework furthermore helps to increase accountability and traceability of plastic waste in the city and enables the municipalities to set development targets, timelines and roadmaps for improving plastic waste management within a predefined time horizon.

Although the municipality is obliged to conduct public awareness raising campaigns for waste generators at regular intervals, no concept or strategy for ensuring regular campaigns exists on a municipal level. Here, an unambiguous definition of roles and responsibilities within the municipality for public campaigns as well as for management of funding must be determined.

In order to improve the city's plastic waste management, a multilayered integrated approach is suggested, addressing various problems on multiple levels simultaneously. Since Rishikesh is currently restructuring their waste management system and has onboarded a new waste management contractor for collection, major changes of the existing systems are considered feasible through a close interaction between all relevant stakeholders and project *Aviral*.

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12. Annex

Table 17: Ward Mapping of Administration

Ward Number					
Name of ward					
Area of the Ward					
Type of ward (Commercial/residential /mixed residential and commercial)					
For residential wards (high income/ mixed income/ EWS)					
Population	Male				
	Female				
Number of Households					
Number of Schools					
Number of College					
Number of Hospital					
Number of Nursing homes/clinics					
Number of Hotels/dharamshala					
Number of shops					
Number of offices/banks/insurance/etc.					
Number of shopping complex/malls/cinema hall					
Number of marriage hall/community centre/ club					
Number of municipal market (vegetable & fruit market/mandi; poultry and slaughter house)					
Number of informal markets/street vendors					
Number of Restaurants					
Number of Temples/ places of worships					
Population of Informal settlements/slums/ unauthorised colonies					
Number of Industries					
Monitoring, Reporting, Compliant Redressal system					

Table 18: Details of tourist inflow in the city

Month	Number of tourists	National	International	Total number of bed nights
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
Total				

Table 19: Details of floating populations

Floating population per day (number)	

Table 20: Daily quantification of waste from different wards

Ward No. and Name	Area 1	Area 2	Area 3	Area 4	……..
Type of ward (Category)					
Number of HHs					
Total Population					
Total Waste (Kg)					
Waste > 60 mm size (Kg)					
60 – 25 mm size (kg)					
Waste < 25 mm size (kg)					
Total wet waste (Kg)					
Total dry waste (Kg)					
Metals (Kg)					
Glass & Ceramic (Kg)					
Rubber & leather (Kg)					
Textile (Kg)					
Paper (Kg)					
Others					
Total Plastic (Kg)					
PET (Kg)					
HDPE (Kg)					
PVC (Kg)					
LDPE (Kg)					
PP (Kg)					
PS (Kg)					
MLP (Kg)					

Table 21: Existing Status of Municipal Solid Waste Management at Ward level

Ward Number				
Responsible agency for MSW collection (pvt./local body)				
Whether waste is collected from door to door (Yes/No)				
Segregation of waste (dry, wet and domestic hazardous waste) – is being done or not				
Number of sanitary workers involved in waste collection				
Frequency of waste collection (daily/alternate days/ twice a week or thrice a week)				
Number of community bins and capacity				
Whether waste is collected in Dry and waste fraction at community bins				
Number of secondary storage facility (apart from community bins) and total capacity				
Any processing facility at ward level (composting, dry waste MRF, biogas, etc.)				
Black spots and dumping grounds				
Quantity of waste collected daily (in tonnes)				

Table 22: Existing waste management facilities at city level

Area and capacity of primary waste storage facility			
Location of primary waste storage facility			
Number of community bins			
Frequency of collection from community bins (Daily/ alternate days/weekly/etc.)			
Whether waste is collected in Dry and waste fraction at community bins			
Amount of waste collected from road sweeping and drain cleaning			
Details of waste collection vehicles	Numbers	Capacity	Number of trips made each day (all together)
Auto tipper			
Tractors			
Trucks			
Push carts			
Tri cycles			
Compactor			
Loader/Backhoe loader			

Table 23: City level data on Processing and Disposal

			Capacity	Area	Remaining Life	Technology adopted	Quantity of Waste Disposed Daily	Waste Types/ Characterisation	Rejects and Disposal Mechanism	
									Quantity	Characteristics
Waste Treatment/ Processing and Disposal Facility Present	Compost Pit/ Plant	windrow composting								
		vermicomposting								
		Others								
	Biogas Plant									
	Refuse Derived Fuel (RDF) Plant									
	Waste to energy plants									
	Special waste treatment facilities									
	Others									
	Illegal Dump Sites									
	Dump Site/ Sanitary Landfill									
Vacant Land Available with ULB for (centralized/ decentralized systems for waste treatment)								Location and Total land Area		
Vacant Land Available with ULB for sanitary landfill and dumping waste								Location and Total land Area		

Table 24: Infrastructure at Municipality level (excluding private agency)

Number of permanent staffs	
Number of contractual staffs	
Number of sanitary workers (permanent/contractual)	
Whether municipality has integrated informal workers to its municipal waste work? Share details of issuance of identity cards, contracts etc.	
Number of vehicles	
JCB	
Tipper	
Tractor trolley	
Truck	
Tricycle	
Compactor	
Tata-407	
Staffs for vehicles	
Does municipality collect MSW from any of the wards?	
If yes from how many wards, and their name/number	
Is road sweeping and cleaning done by municipality or some other contractual company? If done by some other company, name of the company.	
Quantity of waste collected from street sweeping	
Quantity of plastic waste collected from street sweeping	
What happens to the collected waste	
What happens to the collected plastic	
Fees collected from different categories	Charges (in Rs. Per month)
Residential	
Commercial (offices)	
Hotels (on what basis area or room)	
Hotels with restaurants facility	
Schools/colleges	
Residential schools/colleges (with hostel facility)	
Ashram/dharamshala	
Shops	
Restaurants	
Vegetable/fruit mandis	
Hospitals (on what basis)	
Does municipality has an engineered sanitary landfill site or a dumpsite? (Details and location)	
Average quantity of daily waste going to the landfill/ dumpsite (tons/day)	
Has municipality done any mapping of formal/informal recyclers in the city? If yes, share details	
Availability of funds under SBM/ Nmami Gange/ other state govt. schemes? Please mention	

Table 25: Finance data from municipality (Source of income)

Sources of Income	Amount (in INR)	Percentage of total
Tax revenue		
Rental income from municipal properties		
Fees & User Charges		
Sale & Hire Charges		
Interest Earned		
Other Income		
Revenue Grants, Contribution and Subsidies		
Total		

Table 26: Finance data from municipality (Source of expenditures)

Expenditures	Amount (in INR)	Percentage of total
Establishment Expenses		
Administrative Expenses		
Operation and Maintenance		
Interest & Finance Expenses		
Programme Expenses		
Misc. Expenses		
Depreciation		
Change in Inventory		
Total		

Table 27: Infrastructure with private sector agency outsourced for waste collection and management

Number of permanent staffs	
Number of contractual staffs	
Number of sanitary workers (permanent/contractual)	
Number of informal workers integrated?	
How many wards waste is collected from, and their name/number	
Whether collecting waste in a segregated manner?	
Total waste collected (per day in tonnes)	
Characterization of waste (percentage of dry and wet waste)	
Quantity of plastic in waste collected (per day in tonnes)	
What is done with the collected wet waste	
What is done with the collected dry waste	
What is done with the collected recyclable plastic waste	
Number of vehicles	
JCB	
Tipper	
Tractor trolley	
Truck	
Tricycle	
Compactor	
Tata-407	
Staffs for vehicles	
Does KRL collects MSW from slums as well?	
If yes from how many slums, and their name	
Road sweeping and cleaning, is it done by pvt agency or municipality? If done by pvt agency quantity of waste collected from street sweeping.	
Quantity of plastic in collected waste from street sweeping	
Fees collected from different categories	Charges (in Rs. Per month)
Residential	
Commercial (offices)	
Hotels (on what basis area or room)	
Hotels with restaurants facility	
Schools/colleges	
Residential schools/colleges (with hostel facility)	
Ashram/dharamshala	
Shops	
Restaurants	
Vegetable/fruit mandis	
Hospitals (on what basis)	
Average quantity of daily waste going to the landfill/dumpsite (tonnes/day)	
Contract modality with municipality?	

Table 28: Detailed data from hotels

Name of hotel	
Number of rooms	
Monthly average number of guests (or percentage occupancy)	
In-house kitchen/Restaurants (Yes/No)	
Number of staffs	
Per day waste generation from restaurant/kitchen	
Per day waste generation from hotel/guests	
On site treatment mechanism available or not (compost/sorting/etc.)	
Waste is collected from hotel doorstep or from a common collection point	
Frequency of waste collection (daily/alternate days/twice a week or thrice a week)	
Disposal mechanism for domestic hazardous waste	

Table 29: Detailed data from institutions (schools and colleges)

Name of school/college	
Number of students	
Number of teachers and overall administration in school	
Is it a Co-ed, girls or boys school	
Does school adopts segregation at source into wet, dry and domestic hazardous waste?	
Canteen facility available or not	
Has school kept two bins in campus in classroom/in canteen?	
Daily waste generation	
Hostel facility for students and teachers – yes or no	
How many (teachers/other staff and students) reside in the hostel on daily basis (during operation)	
How many (teachers/other staff and students) reside in the hostel on daily basis (during vaccation)	
How is school disposing domestic hazardous waste?	
On site treatment mechanism available or not (compost/sorting/etc.)	
Waste is collected from school doorstep or from a common collection point	
Frequency of waste collection (daily/alternate days/twice a week or thrice a week)	
Disposal mechanism for domestic hazardous waste	

Table 30: Detailed data for religious institution (temples, mosques, gurudwara, church, Ghats, etc.)

Name of place	
Type of religious place	
Segregation of waste at source (wet and dry)	
Average quantity of flower waste/day	
Total quantity of waste generated per day	
In house treatment facility for flower waste (compost/other)	
Frequency of waste collection (daily/alternate days/twice a week or thrice a week)	
Waste is collected from school doorstep or from a common collection point	
Frequency of waste collection (daily/alternate days/twice a week or thrice a week)	
Disposal mechanism for domestic hazardous waste	

Table 31: Ward wise data on informal waste collectors

Ward No.	No. of Waste Pickers/ collectors operating	Information on waste sale	
		Company/ Shop Name	Shop Address/ Location Details

Table 32: Data from informal waste collectors on the types and quantity of waste they collect

Ward No.								
Name of the Waste Picker								
	Paper	**Textile**	**Rubber**	**Leather**	**Metal**	**Glass**	**Plastic**	**Others**
Quantity of wastes collected								
Selling Price								
Details of recycler or aggregator where it is sold								
Plastic Types	**1- PET**	**2 - HDPE**	**3 - PVC**	**4 - LDPE**	**5 - PP**	**6 - PS**	**7 - Others**	
Quantity of plastic wastes collected								
Selling Price								
Details of recycler or aggregator where it is sold								

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Rishikesh Baseline Assessment Report

September to October 2020

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