LEH

WASTE FLOWS

A COMPREHENSIVE STUDY ON MUNICIPAL SOLID WASTE MANAGEMENT IN LEH

Ladakh Ecological Development Group (**LEDeG**)

December 2023

Federal Ministry
for Economic Cooperation
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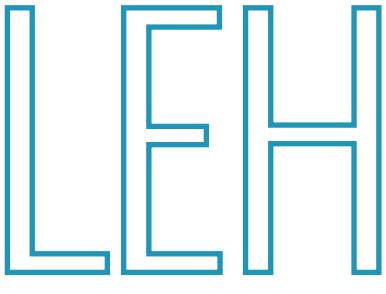

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EXECUTIVE SUMMARY

The waste flow diagram presented in this report provides a comprehensive overview of how waste is currently managed in Leh town. It illustrates the various stages that waste goes through, from generation to final disposal, and identifies key areas where improvements can be made.

One of the strengths identified in the current system is the existence of waste collection and disposal infrastructure. The report acknowledges that there are designated collection points and waste processing facilities, which are good starting points for waste management. However, it also highlights that the collection and transportation process can be made more efficient. For instance, the report suggests the implementation of smart waste collection technologies such as GPS tracking systems for waste collection vehicles. This would enable real-time monitoring of routes and optimize collection schedules, reducing fuel consumption and emissions while also ensuring timely waste pickup.

Furthermore, the report emphasizes the need for a collective effort from various stakeholders involved in waste management. This includes local authorities, waste collection agencies, and recycling facilities. Improved communication and collaboration between these entities can streamline the waste management process, leading to a more cohesive and effective system.

Another critical finding of the analysis is the potential for increasing waste diversion from landfills. The report points out that a significant portion of the waste that ends up in landfills could be diverted through recycling and composting efforts. Engaging community to raise awareness about proper waste segregation and recycling practices is important. Moreover, setting up community composting programs can help reduce the organic waste going to landfills and instead convert it into valuable compost for agricultural use.

The importance of this report cannot be overstated. It identifies the current shortcomings in the waste management system and offers practical solutions to address them. By adopting the recommendations outlined in this report, Leh town can significantly reduce its environmental impact, minimize waste going to landfills, and move towards a more sustainable and efficient waste management system.

Overall, the report represents a critical step towards making Leh, Ladakh, a role model for sustainable waste management practices, benefiting both the environment and the community's overall well-being. It has the potential to inspire positive change and set a precedent for other communities to follow.

TABLE OF **CONTENTS**

LIST OF **TABLES**

LIST OF **FIGURES**

ABBREVIATIONS

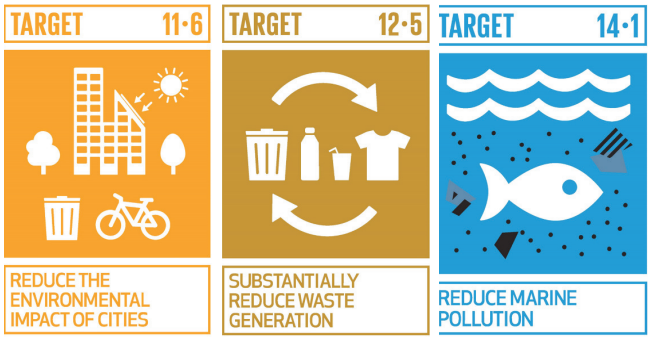
D2D	Door to Door
HDPE	High Density Polyethylene
HH	Household
LDPE	Low Density Polyethylene
LEDeG	Ladakh Ecological Development Group
MRF	Material Recovery Facility
MT	Metric Tonnes
MLP	Multi-Layer Plastics
MCL	Municipal Committee Leh
MSW	Municipal Solid Waste
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl Chloride
SDG	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
TPD	Tons Per Day
ULB	Urban Local Bodies
WFD	Waste Flow Diagram
WGR	Waste Generation Rate

1 CHAPTER 1: WASTE FLOW DIAGRAM

The adequate collection and disposal of Municipal Solid Waste (MSW) is a global challenge, particularly impacting low- and middle-income countries, as recognized by its inclusion in the United Nations Sustainable Development Goals (SDG 11 "Sustainable cities and communities"). Indicator 11.6.1 aims to monitor the "proportion of municipal solid waste collected and managed in controlled facilities out of total municipal solid waste generated by cities." According to current estimates, 2 billion people worldwide have no access to waste collection services, and 3 billion people's waste is managed in an environmentally unsound manner (Wilson, 2015). This severely impacts human health and the environment, combined with the rapidly emerging plastic pollution problem. (Velis C.A, 2020)

Plastic pollution is a reality and affects all ecosystems of our planet. It causes severe danger to animals and blocks drains and waterways, and results in the worsening of floods. Plastic pollution degrades landscapes and is already present almost everywhere, including the food chain. More than 6,300 million tonnes of plastic have been produced since the 1950s, of which 360 million tonnes were produced in 2018 alone. Currently, only 9% of the total global plastic waste is recycled, while 12% is burned or incinerated. The remaining significant share of nearly 79% accumulates on landfill sites or the natural environment. (Velis C.A, 2020)

FIGURE 1:
ADEQUATE SOLID WASTE MANAGEMENT IS LINKED TO VARIOUS SDG INDICATORS AND TARGETS



Oceans are thought to be the final major sink for most plastic waste. Research has found that about 80% of marine litter is believed to be derived from land-based sources (Eunomia, 2016). In the case of macro plastics, this is mainly due to lack of waste collection infrastructure and poor waste management practices. Furthermore, increasing populations

and consumption of resources exasperate these issues, with the need to better promote reduction, reuse, and recycling within solid waste management (SDG - 12.5). Once in the ocean, the larger macro plastics undergo degradation into innumerable secondary microplastics that are beyond any control and have deadly impacts on marine life and the health of the oceans (SDG - 14.1). Therefore, it is paramount to prevent microplastic pollution at the source before it becomes uncontrolled in the environment and potentially enters water bodies. To prevent pollution and leakages of waste into the environment, it is essential to understand the flow of waste from generation to end disposal/treatment, which would help identify the leakage points within the waste flow. Several approaches and methods can be adopted to understand the leakage points in the waste flow, and the Waste Flow Diagram is one such tool.

1.1 WHAT IS A WASTE FLOW DIAGRAM?

Understanding the leaks and pathways of waste into the environment is critical in developing effective measures to beat plastic pollution. The Waste Flow Diagram (WFD) tool estimates the amounts of solid waste that leak into nature and oceans from various points in the waste cycle from the generation source to the disposal end. Through a scenario function, it simulates how improved waste management could reduce environmental pollution and avoid marine litter. On behalf of BMZ, the tool was developed in cooperation with GIZ, the University of Leeds, Eawag-Sandec, and Waste Aware.

The WFD aims to provide a rapid assessment methodology for mapping the flows of macro waste in a municipal solid waste management system at the city or municipality level, including quantifying the sources and fate of any plastic entering the waste stream. This aim can be achieved through the below-mentioned objectives (Velis C.A, 2020):

- To provide a rapid assessment of the cities' or municipalities' municipal solid waste management system and visualise the waste flows, including informing the SDG 11.6.1 sub-indicators.
- To use observation-based assessments to quantify the sources of plastic leakage into the environment from the municipal solid waste management system and determine the eventual fate of this uncontrolled waste.
- To identify the high-priority sources of plastic pollution to make informed interventions.
- To allow benchmarking and comparison between cities.
- To run scenarios to gain approximate insights into how proposed interventions may impact the solid waste management system and plastic pollution.
- To quantify the effectiveness of applied interventions.

1.2 WASTE FLOW MODEL

The WFD is an excel based model that comprises of 6 sheets –

1. Baseline data entry
2. Scenario data entry
3. Calculations
4. Flow diagrams
5. Results Summary
6. Settings

The "**Baseline data entry**" sheet (Figure 2) provides the user interface for entering the data required to run baseline assessments. These baseline assessments aim to use primary data collection and local on-the-ground observations of the waste management system to map the current waste flows within the municipal solid waste management system. The "baseline data entry" sheet consists of 8-9 columns with each row indicating a separate data entry. In total, there are 5 main input sections as listed below,

a) Waste generation information
b) Waste treatment and disposal
c) Managed in controlled facilities
d) Plastic leakage potential levels per leakage influencer
e) Plastic pollution levels per fate

FIGURE 2: BASELINE DATA ENTRY SHEET

NOTE: All percentage units are in terms of weight %

Click the ⓘ symbols for more information and definitions

1. Waste generation information				Baseline			Data Reliability ⓘ
No.	Item	Description	Unit	Value	Information ⓘ	Metadata ⓘ	Value
1	Population ⓘ	How many people live in the area (city, urban district, region) you want to model?	Persons		Please use an estimate based on the last census or other official data.		
2	Municipal solid waste generation per capita ⓘ	How much municipal solid waste per person is produced per day ?	Kg/capita/day		This value should be measured at source using waste characterisation excercises as explained in the user manual. As a last resort, please use values from comparable areas.		
3.1	Municipal solid waste composition ⓘ	Paper	Weight-%		In the absence of waste characterisation data, default values by income level may be used: **High Income:** Paper = 24%, Plastics = 11%, Glass = 6%, Metals = 5%, Other = 20%, Organic = 34% **Upper Middle Income:** Paper = 19%, Plastics = 12%, Glass = 5%, Metals = 4%, Other = 14%, Organic = 46% **Lower Middle Income:** Paper = 11%, Plastics = 9%, Glass = 3%, Metals = 3%, Other = 21%, Organic = 53% **Low Income:** Paper = 6%, Plastics = 7%, Glass = 2%, Metals = 2%, Other = 30%, Organic = 53% (Source: UNEP, 2015. *Global Waste Management Outlook*)		
3.2		Plastics	Weight-%				
3.3		Glass	Weight-%				
3.4		Metals	Weight-%				
3.5		Other	Weight-%				
3.6		Organic	Weight-%				
-		Total	%	0%	Must be = 100%		

2. Waste treatment and disposal				Baseline			Data Reliability ⓘ
No.	Item	Description	Unit	Value	Information ⓘ	Metadata ⓘ	Value
4.1	How much MSW is disposed of in designated disposal sites? ⓘ	Paper	Tonnes/day		The methodology behind measuring the amount and composition of waste disposed of in designated disposal sites is outlined within the user manual.		
4.2		Plastics					
4.3		Glass					
4.4		Metals					
4.5		Other					
4.6		Organic					
5.1	How much MSW is sent to energy from waste? ⓘ	Paper	Tonnes/day		The methodology behind measuring the amount and composition of waste sent to energy recovery is outlined within the user manual.		
5.2		Plastics					
5.3		Glass					
5.4		Metals					
5.5		Other					
5.6		Organic					
6.1	How much MSW is sorted by the formal sector for recovery? ⓘ	Paper	Tonnes/day		Both the formal and informal recycling systems are often integrated with one another, making identification of the contribution of each difficult. The user manual gives details on how to measure the amounts sorted by each sector respectively. Here we define the formal sector as those registered or licensed by the municipality (i.e. have a contract with the municipality). Alternatively, the informal sector is defined as those unregistered or not licensed by the municipality. Only informal value-chain workers (i.e. not performing collection services) are counted here. This is due to informal collection services which transfer waste to the formal sector being considered under formal activities. Waste collected by informal collection service which do not transfer the waste to the formal sector but instead dump / burn the waste, is likewise considered as uncollected waste.		
6.2		Plastics					
6.3		Glass					
6.4		Metals					
6.5		Other					
6.6		Organic					
7.1	How much MSW is sorted by the informal sector for recovery? ⓘ	Paper	Tonnes/day				
7.2		Plastics					
7.3		Glass					
7.4		Metals					
7.5		Other					
7.6		Organic					
8.1	Informal service chain collection ⓘ	Do the informal collection services (service chain) separate plastic for recovery?	NA		Plastics may be separated by the informal service chain from the mixed waste they collect chain to supplement their income.		
8.2		What percent of the mixed waste collection was collected by informal collection services?	% of waste collected by collection services		If data is unavailable on the split between the informal and formal collection services, please use the percent of the study area covered by informal collection services compared to the formal sector as a proxy. See the user manual for details.		

The "**Scenario data entry**" sheet follows the same logic and formatting as the "Baseline data entry" sheet (Figure 3) but differs with respect to its purpose and the associated data inputs.

The purpose of the "Scenario data entry" is to provide a means to allow users to estimate the potential impact of applying interventions within the waste management system.

FIGURE 3: SCENARIO DATA ENTRY SHEET

NOTE: All percentage units are in terms of weight %

Click the ⓘ symbols for more information and definitions

1. Waste generation information				Baseline ⓘ	Scenario 1	Scenario 2	Scenario 3		
No.	Item	Description	Unit	Value	Value	Value	Value	Notes	Metadata ⓘ
1	Population ⓘ	How many people live in the area (city, urban district, region) you want to model?	Persons	*0*				Please use an estimate based on the last census or other official data and consider population growth rates for scenarios.	
2	Municipal solid waste generation per capita ⓘ	How much municipal solid waste per person is produced per day ?	Kg/capita/day	*0.00*				This value should be measured at source using waste characterisation excercises as explained in the user manual. As a last resort, please use values from comparable areas.	
3.1	Municipal solid waste composition ⓘ	Paper	Weight-%	*0%*				In the absence of waste characterisation data, default values by income level may be used: **High Income:** Paper = 24%, Plastics = 11%, Glass = 6%, Metals = 5%, Other = 20%, Organic = 34% **Upper Middle Income:** Paper = 19%, Plastics = 12%, Glass = 5%, Metals = 4%, Other = 14%, Organic = 46% **Lower Middle Income:** Paper = 11%, Plastics = 9%, Glass = 3%, Metals = 3%, Other = 21%, Organic = 53% **Low Income:** Paper = 6%, Plastics = 7%, Glass = 2%, Metals = 2%, Other = 30%, Organic = 53% (Source: UNEP, 2015. Global Waste Management Outlook)	
3.2		Plastics	Weight-%	*0%*					
3.3		Glass	Weight-%	*0%*					
3.4		Metals	Weight-%	*0%*					
3.5		Other	Weight-%	*0%*					
3.6		Organic	Weight-%	*0%*					
-		Total	%	0%	0%	0%	0%	Must be = 100%	

2. Waste collection, treatment and disposal				Baseline ⓘ	Scenario 1	Scenario 2	Scenario 3		
No.	Item	Description	Unit	Value	Value	Value	Value	Notes	Metadata ⓘ
4.1	What is the collection service coverage? ⓘ	All MSW	% of waste generated	#DIV/0!				This includes only waste collected by the formal sector, or collected by informal collection services if they transfer it later to the formal system.	
5.1	How much MSW is collected by the informal value-chain sector for recovery? ⓘ	Paper	% of waste generated	#DIV/0!				This includes only waste collected by the informal value-chain sector. This is due to informal service-chain collectors being included within the formal collection coverage as discussed above.	
5.2		Plastics		#DIV/0!					
5.3		Glass		#DIV/0!					
5.4		Metals		#DIV/0!					
5.5		Other		#DIV/0!					
5.6		Organic		#DIV/0!					
6.1	How much of the collected waste is sent to energy from waste? ⓘ	Paper	% of waste collected by collection services	0%				Includes incineration and advanced thermal treatments (gasification, pyrolysis etc.) but excludes the open burning of waste and the burning of waste as a fuel by residents.	
6.2		Plastics		0%					
6.3		Glass		0%					
6.4		Metals		0%					
6.5		Other		0%					
6.6		Organic		0%					
7.1	How much of the collected waste is sorted for recovery? ⓘ	Paper	% of waste collected by collection services	0%				As the unit for this input is "% of waste collected by collection services", this excludes waste collected by the informal value chain. If assigning a value for this is difficult to obtain due to the integration of the formal and informal sorting, use the baseline value as an indicator.	
7.2		Plastics		0%					
7.3		Glass		0%					
7.4		Metals		0%					
7.5		Other		0%					
7.6		Organic		0%					
8.1	How much of the collected waste is sent to designated disposal sites? ⓘ	Paper	% of waste collected by collection services	0%				Designated disposal sites (DDS) refer to disposal sites which are regularly used by the public authorities and private collectors, regardless of the level of control and legality. DDS can be officially designated or non-officially designated but still used regularly.	
8.2		Plastics		0%					
8.3		Glass		0%					
8.4		Metals		0%					
8.5		Other		0%					
8.6		Organic		0%					
9.1	Informal service chain collection ⓘ	Do the informal collection services (service chain) separate plastic for recovery?	NA	0%				Plastics may be separated by the informal service chain from the mixed waste they collect chain to supplement their income.	
9.2		What percent of the mixed waste collection was collected by informal collection services?	% of waste collected by collection services	0%				If data is unavailable on the split between the informal and formal collection services, please use the percent of the study area covered by informal collection services compared to the formal sector as a proxy. See the user manual for details.	

The "**Calculations**" sheet processes the data inputs to map the waste flow across the system. Although no data should be entered directly into this sheet, some important aspects remain to consider.

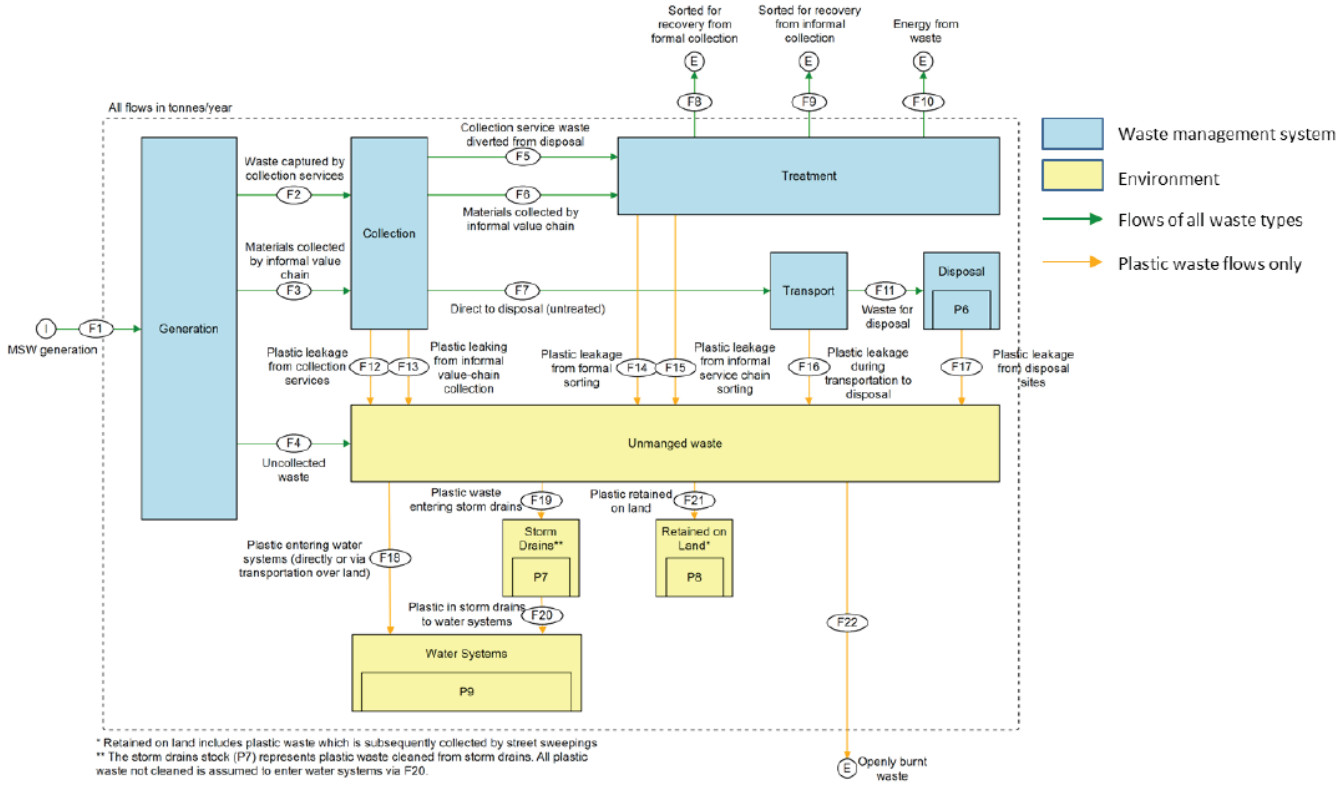
The "**Flow Diagram**" sheet is split into two sections:

a) Waste Flow Diagram

b) Sankey Diagram

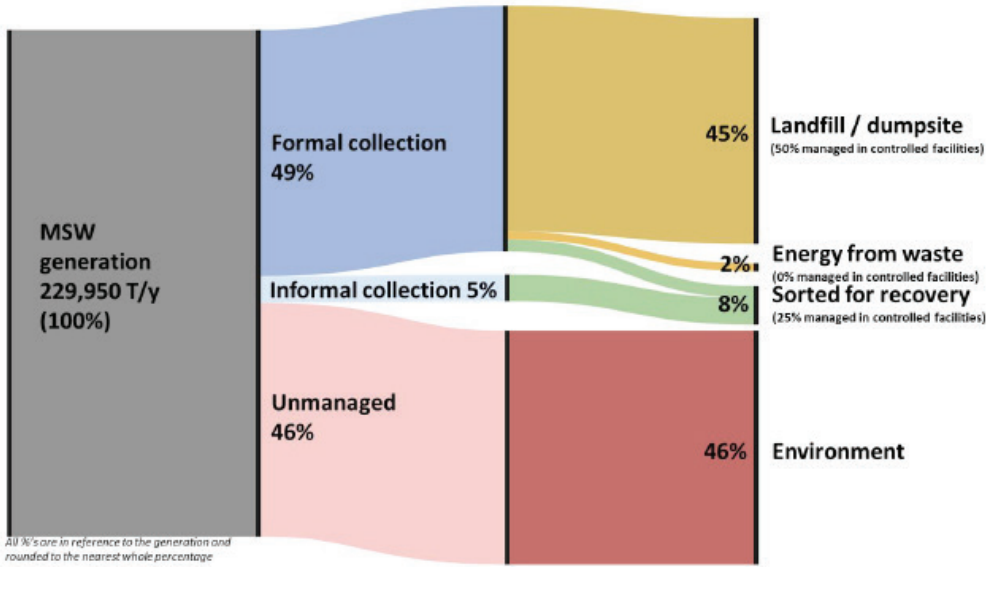
The Waste Flow Diagram depicts the system map shown in Figure 4. All flows are shown with the units 20 of tonnes per year. Through the drop-down boxes at the top, you can select the scenario or baseline as well as the type of waste to show (paper, plastics, glass, metals, other, organic or all MSW).

FIGURE 4: WASTE FLOW DIAGRAM SYSTEM MAP



The Sankey Diagram is an alternative, more intuitive visualisation output whereby the arrows are proportional to the mass. Depending on your needs, you can choose between a simple and a more complex diagram. The code is designed to directly provide input into www.sankeymatic.com.

FIGURE 5: BASIC SANKEY DIAGRAM FOR ALL MSW



The "**Results summary**" sheet displays the most important information from each model run in an easy-to-compare and printer-friendly dashboard.

FIGURE 6: RESULTS SUMMARY SHEET

	Plastic waste				Municipal Solid Waste				
	Baseline	Scenario 1	Scenario 2	Scenario 3	Baseline	Scenario 1	Scenario 2	Scenario 3	Unit
Municipal solid waste generation	20,696	20,696	20,696	20,696	229,950	229,950	229,950	229,950	Tonnes/year
Municipal solid waste generation	57	57	57	57	630	630	630	630	Tonnes/day
Collected waste	12,969	15,805	17,875	19,944	123,929	149,081	172,076	195,071	Tonnes/year
Collected waste	63%	76%	86%	96%	54%	65%	75%	85%	% of waste generation
Uncollected waste	7,727	4,890	2,821	751	106,021	80,869	57,874	34,879	Tonnes/year
Uncollected waste	37%	24%	14%	4%	46%	35%	25%	15%	% of waste generation
Waste sorted for recovery *(excludes energy from waste)*	5,110	5,352	5,680	6,008	17,520	18,172	19,350	20,527	Tonnes/year
Waste sorted for recovery *(excludes energy from waste)*	25%	26%	27%	29%	8%	8%	8%	9%	% of waste generation
Waste sorted for recovery by formal sector *(excludes energy from waste)*	7%	9%	10%	11%	2%	3%	3%	4%	% of waste generation
Waste sorted for recovery by informal sector *(excludes energy from waste)*	18%	17%	17%	18%	5%	5%	5%	5%	% of waste generation
Energy from waste	365	497	579	662	3,650	4,561	5,321	6,081	Tonnes/year
Energy from waste	2%	2%	3%	3%	2%	2%	2%	3%	% of waste generation
Disposal in disposal facilities	7,300	9,924	11,578	13,232	102,565	126,315	147,368	168,420	Tonnes/year
Disposal in disposal facilities	35%	48%	56%	64%	45%	55%	64%	73%	% of waste generation
Managed in controlled facilities	0	0	8,919	19,902	0	0	86,019	195,028	Tonnes/year
Managed in controlled facilities	0%	0%	43%	96%	0%	0%	37%	85%	% of waste generation

The "**Settings**" sheet contains the default non-user input data behind the model. Although this sheet is locked for editing, the transfer coefficients can still be viewed for transparency.

(Principal Investigator: Velis C.A. Research team: Cottom J., February 2020)

2 CHAPTER 2: ABOUT THE STUDY

2.1 NEED FOR THE STUDY

The municipality's effective management and safe disposal of municipal solid waste is a mandate (as per the 74th constitutional amendment under the 12th schedule). However, most small and medium towns across South Asia do not have sufficient and reliable data to plan for better municipal solid waste management. This often results in inadequate collection, multiple handling of waste during transport, and unsafe disposal of the waste, threatening public health as well as the environment. An added complexity is the rapid urbanization that leaves a gap in providing sufficient systems to respond to the increasing waste generated.

Understanding the flow of various municipal solid waste streams will help target impactful interventions to arrest pollution and create healthy and improved living conditions. Long-term planning to provide adequate infrastructure and adopting management practices towards safe handling & disposal of waste can be achieved through robust data collection and analysis of the existing practices.

2.2 OBJECTIVE

The waste flow diagram tool focuses on quantifying plastic leakage. However, this study focuses on quantifying the flow of municipal solid waste. The waste flow diagram is a rapid assessment tool; however, in this context, the attempt is to do a detailed study to understand the flow of waste to represent the ground realities best. This study has the following objectives –

- To provide a detailed assessment of the municipality's municipal solid waste management system and visualise the flows of waste.
- To use observational as well as empirically based assessments to quantify the sources of leakage into the environment from the municipal solid waste management system.
- To support in identifying potential interventions for effective management and safe disposal of municipal solid waste.

2.3 SCOPE

While reviewing the tool, it was observed that the default values listed in the tool did not necessarily apply to the South Asian context, considering the high wet waste component in the waste composition, low waste segregation levels, etc. Therefore, the study would generate primary data to develop the WFD rather than develop the WFD with the default values

provided in the tool. In this process, the study would attempt to contextualize the use of the tool for the South Asian countries and try to encompass all the categories of waste in place of just plastic. Thereby, the results from the tool can support the decision-making process in identifying interventions for improving municipal solid waste management in the town.

This study was carried out through two seasons- winter and summer. As Leh experienced stark differences in consumption patterns, floating population, and waste generation quantity during these two seasons, surveys were carried out in winter as well as summer months to capture the seasonal variation.

2.4 LIMITATION

The study terminates with generating the Sankey diagram for municipal solid waste. The detailed waste flow assessment diagram is not generated as it requires further detailed category-wise data. The various scenarios for the effectiveness of applied interventions are also not generated. Overall, it is to be noted that this study aims to capture overall waste flow and a special focus on plastic leakage is not carried out.

The study area considered is limited to the Leh Municipal Committee area.

The population is taken based on the projection of the estimated population in discussion with the municipality based on 2011 census data due to the unavailability of the latest census data. This study is not taking the army population and waste generation details due to the limited availability of data and the collection system is separate.

2.5 METHODOLOGY

DURATION & RESOURCES:

The study was conducted for a period of 2 weeks between September to October 2021 and for 2 weeks between July and August 2022. The study was carried out under the guidance of a senior sector expert supported by a junior sector expert and social mobilizer. There were 15 surveyors engaged for a period of 12 days and additionally, 15 surveyors were taken for commercial surveys during summer season due to increased quantum of waste generation owing to tourism.

DESK REVIEW:

The WFD tool was reviewed desk based to understand the tool and data requirement. The data requirement was assessed against the WASH baseline assessment reports prepared by LEDeG and other secondary sources. Data gaps were identified, and necessary data points and their collection method were discussed and reviewed with experts.

SAMPLING METHODS:

The sampling method used is stratified sampling. The waste generators identified are – a) domestic and b) non-domestic units. Domestic units were further classified ward-wise based on typology and character, which also reflects the income to an extent. Non-domestic units were classified into multiple categories as listed in table 2 given below. Samples were drawn from these strata based on convenience – accessibility, availability, and willingness to participate in the survey.

TABLE 1: CLASSIFICATION OF COMMERCIAL AND INSTITUTIONAL ESTABLISHMENTS FOR SURVEY

Classification of Commercial and Institutional Establishments	
Hotels	Fancy/crockery
Restaurant, Café, Bakery	Hardware/Spare parts
Guest Houses	Handicraft/Embroidery
General Store	Jewellery/Goldsmith
Tailor	Chemist/Optical
Travel Agency	Hair Salon/ Beauty Parlour
Car Accessories	School
Clinic	Vocational Training Institute
Electronics, Mobile	College

DATA COLLECTION & MANAGEMENT:

The data was collected using mixed methods to capture both quantitative and qualitative data. The solid waste management practices along the value chain were mapped through interviews and observations. This included interactions with officials from Municipal Committee Leh, sanitation workers, informal workers, waste collection truck drivers, community etc.

Based on the samples identified for waste generation and waste composition, multiple data points were generated through a detailed survey as described in Chapter 5:

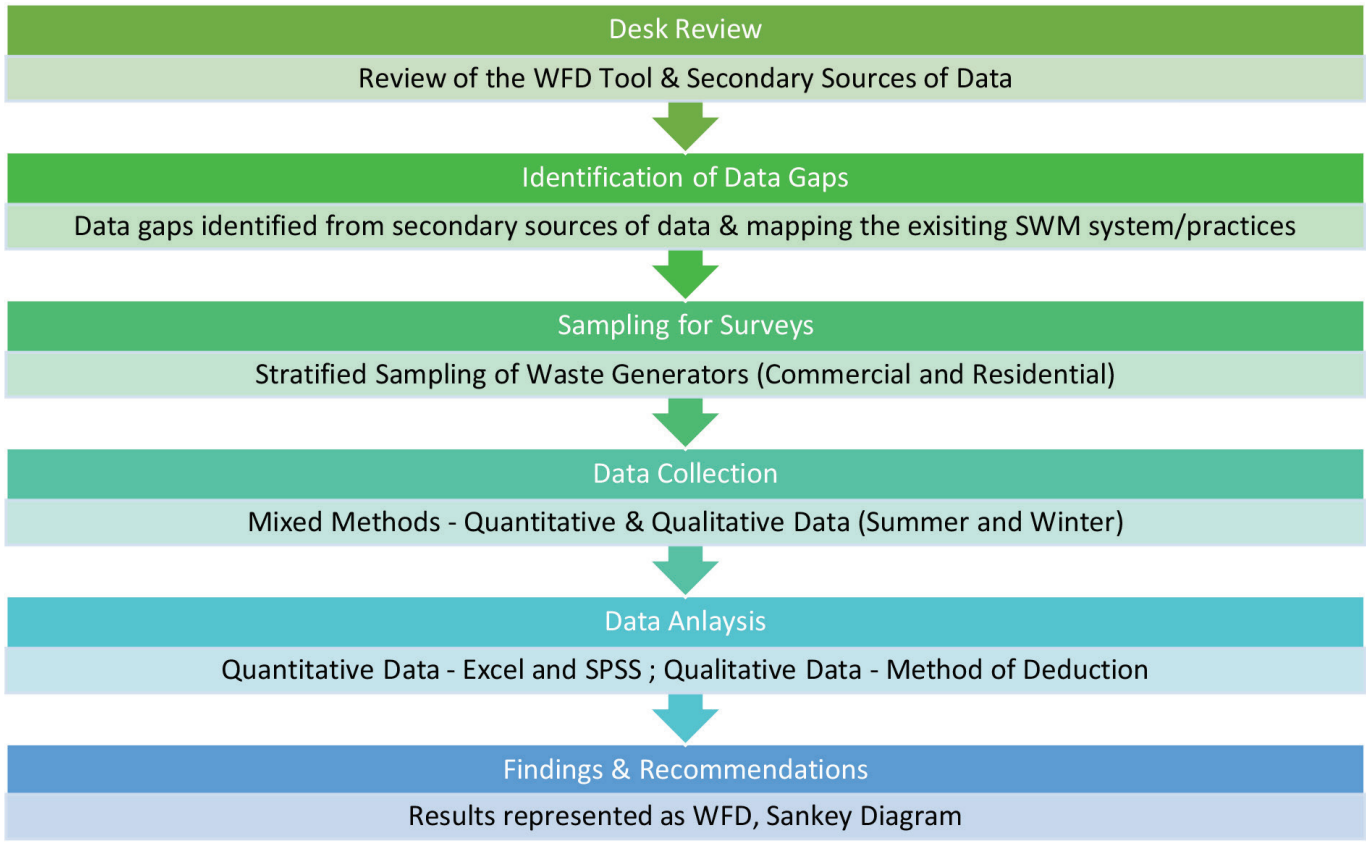
DATA ANALYSIS:

The recorded data was tabulated in Microsoft Excel, and the necessary calculations were carried out. The data points thus generated were analysed using tools such as SPSS and the Sankey diagram for waste flow was formulated.

FINDINGS & RECOMMENDATIONS:

Sector experts drew inferences from the Sankey diagram in conjunction with the current practices and the existing policy & governance mechanisms in Leh. Further discussions are to be held with the concerned government officials/ departments to make an action plan to improve the solid waste management in the town.

FIGURE 7:
WFD METHODOLOGY FLOW DIAGRAM



3 CHAPTER 3: TOWN PROFILE

Leh town, located in the Leh district, is the joint capital and largest town of the union territory of Ladakh in India. The town has been the historical capital of the Kingdom of Ladakh, and its seat was in the Leh Palace. This former residence of the royal family of Ladakh was built in the same style and at about the same time as the Potala Palace in Tibet. The nearest town to Leh is Kargil (217 km) which is connected via NH 1D for about 29 km.

Leh has a cold desert climate. During winter (November to April), average minimum temperatures drop as low as -15 °C (record low of -28.3°C), and there is occasional snowfall, although it is sunny on most days. The weather in the remaining months is pleasant, with strong sunlight in the day and cool evenings. The average annual precipitation in the Leh region is nearly 100mm. The area has low vegetation and resultantly low humidity. Along with intensive sunlight and low moisture content, the evapotranspiration rate in this area is also high.

TABLE 2: TOWN PROFILE

Name of the Town/City	Leh	
Province/District/State/UT	UT Ladakh	
Area of the Town (sq km)	19.15 sq km	
Number of Administrative Division (Ward)	13 Ward MC Leh	
Total Population (2011 census)	30,870	
	Male	Female
	21,669	9,201
Projected Population	2021 Winter	2022 Summer
	33,365	68,625*
Floating Population per Day	324	13,616
Population Annual Average Growth Rate: 2001-2011 (%)	0.78%	
No. of Notified Slum	0	
No. of Non-Notified Slum	0	
Literacy Rate	90.29 %	
Sex Ratio	987	

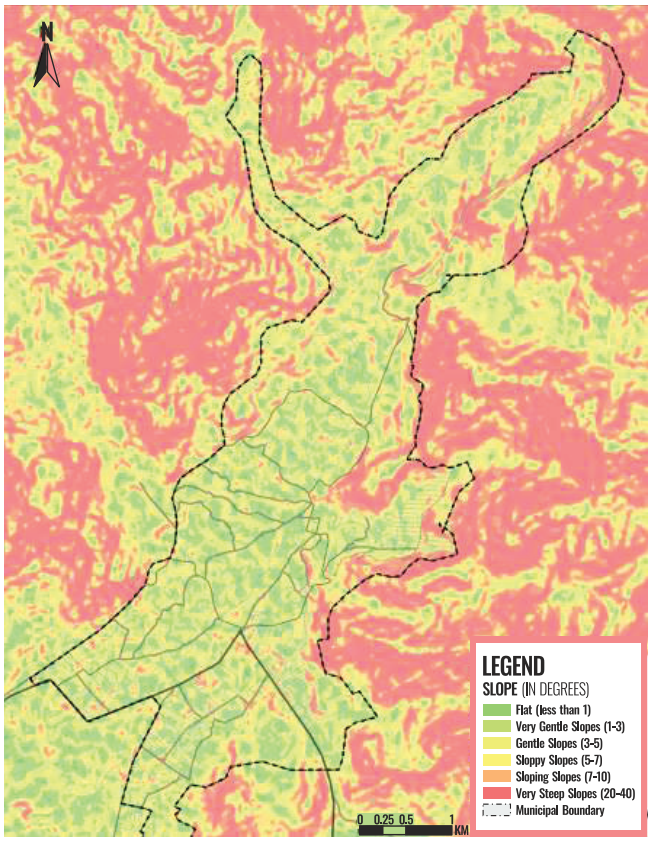
* (including migrant labour)

3.1 LOCATION

Leh is the Capital city of the newly formed Union Territory of Ladakh. Leh town lies in the trans-Himalayas at coordinates 34.16°N 77.58°E. Leh town is one of the largest towns located above an altitude of 3,500 m on an average. The town has an altitude of 3,310 m in the south and 3,915 m in the north. The average slope is 10.1° from north to south.

FIGURE 8: LOCATIONAL SETTING

(Source: Press release MoHA -Nov 2019 by PIB Delhi) and slope mapping (compiled by author)



Leh is connected via National Highway 1 to Srinagar in the southwest and to Manali in the south via the Leh-Manali Highway. These roads are open only from May-Nov, but local roads remain open throughout the year. Leh Kushok Bakula Rinpochee Airport has flights to Delhi, Srinagar, Jammu, and Mumbai. Leh is not connected by rail.

3.2 DEMOGRAPHY

Leh municipality has experienced exponential population growth. From 2401 residents in 1921, the population increased to 30,870 persons based on the last Census in 2011. According to Leh vision document 2023, the annual average growth rate of the population in the last ten years (2001-2011) is 0.78%, while it was 19% from 1991-2001. In the early days, there was no family planning or awareness of the benefits of having a nuclear family. The socio-economic fabric has changed from subsistent farming to modern economic means, and traditional institutions are breaking up because the younger generation has decided to have nuclear families. (C.phuntsog, 2020)

In the 1990s, Ladakhi's moved to Leh town, seeking better schools, hospitals, and livelihoods. Since 2008, tourism has driven the town's growth, and the population is likely to cross 55,000 by 2031 based on the present growth trends. The population growth has also resulted in the spatial development of Leh town, and "townships" have emerged on the town's periphery. The resident population drops by 15-20% from summer to winter as many residents travel to warmer places.

The town comprises 13 wards with a total population of 30,870. The habitation area is ~19.15 km^2 with an average population density of 1,612 person/km^2. The literacy rate is high at 90%, and most people are engaged in hospitality services and are self-employed. The primary driver of the town's economy is tourism. Leh has a sex ratio of 987 women per 1000 men.

According to the 2011 census, Buddhism is followed by over 43.8% of people, making it the most followed religion in Leh. Further, Hinduism is followed by 35.4% of the population, Islam by 15,14%, and Sikhism by 2.7% of the population. Buddhism is the oldest religion in the valley, practiced among Ladakhi people and several Tibetan people. Hinduism has the second largest number of followers after Buddhism.

3.3 ECONOMY

For centuries, the people of Ladakh thrived in this region's stark and fragile landscape by developing an entire way of life that respected the region's terrain, climate, and ecology. Historically, the religious practices and beliefs of the Ladakhi people led to harmonious and self-sufficient relationships, expressed in the traditional settlement patterns, agricultural practices, water and waste management, architecture, art, and culture. (C.phuntsog, 2020)

Ladakh started to change gradually after 1974 when the region opened to tourism and infrastructure development. In the last twenty years, Leh has been rapidly growing due to increased tourism, resulting in increased incomes, energy use, consumer products, automobiles, and a shift from the traditional way of living.

Leh's economy has been growing with tourism, construction, and government services as its key pillars. The economy is unbalanced, as it is heavily dependent on tourism, which is a fragile and unpredictable industry. The tourism sector is vulnerable to changes in the global economy, local geopolitical situations, and emergencies such as the COVID-19 pandemic. More importantly, the success of tourism depends on how well the destination protects and enhances its natural and cultural base that forms the key attractions. (C.phuntsog, 2020)

People visit Ladakh for its natural beauty and unique culture. Leh town is the primary gateway to Leh, and tourism has emerged as a significant driver for the local economy. Large investments have been made in hotels, guesthouses, restaurants, travel agencies, and other tourism-related businesses, fueled by land sales and loans. The Tourism Department reported 3,27,366 tourists in 2018; in 2008, it was 74,334 — a 440% increase in a decade. Growth will continue in the future, though the exact trajectory is unpredictable due to climate, geo-political, general economic conditions, and other reasons, as the past two years have demonstrated. The tourism sector creates a significant number of low-skill and medium-skill jobs along with some high-skill employment and entrepreneurial opportunities for local residents. It attracts many migrant workers and businesspeople during the summer season. Tourism currently remains concentrated in the summer months (May to September).

The town does not have much industry, though there are light industries, including metal and woodworking workshops in nearby areas. Local demand for products of local industries remains small and seasonal, and distance from larger markets has historically made it unviable to develop manufacturing industries in Leh. Consequently, nearly everything sold in Leh is brought in from Jammu, Delhi, Chandigarh, and other places.

Most families practiced small-scale agriculture until recently when people started selling their land or building hotels and guesthouses. Single-cropping is dominant (double-cropping is possible only in a limited area below an altitude of 3000m), and most farms are irrigated by natural springs or underground water from borewells. In the 1960s, only five types of vegetables were grown in the region, while today, it is feasible to grow 101 varieties. Ladakhi farmers grow over 23 kinds of vegetables commercially and are supplied through the Farmers' Cooperative Marketing Society. (C.phuntsog, 2020) The region produces broccoli, cabbage, cauliflower, and peas, but due to poor market linkage, large-scale production of vegetables as off-season crops has not gained momentum. Apricots and apples are the two significant fruits prized for their quality, and recently, high quality melons are also being grown organically. (C.phuntsog, 2020)

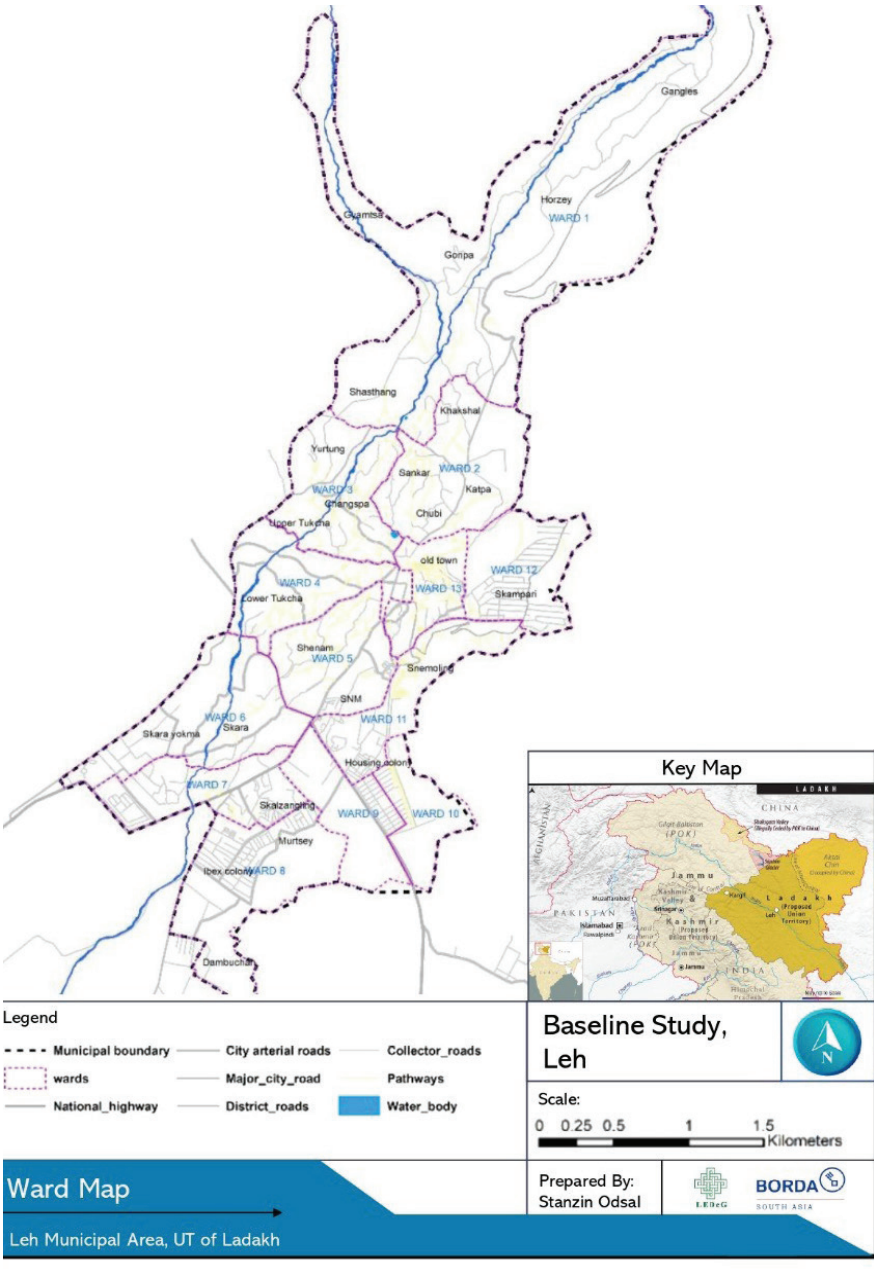
3.4 ADMINISTRATIVE DIVISION

The Municipal Committee Leh has 13 wards. Among these wards, ward numbers 8, 9, 10, and 12 are purely residential. Ward numbers 3, 4, and 5 have the most significant number of hotels and guest houses; these are the wards with the highest tourist population. Ward number 7 has the industrial area of Leh with 97 industrial units. Ward number 8 has the highest population as it is purely a residential area. Ward number 1 and 5 have the lowest population as most of the ward is covered in agricultural fields.

TABLE 3: WARD DETAILS

Ward No.	No. of Households	Sample Size
Ward no 1	175	5
Ward no 2	375	10
Ward no 3	180	5
Ward no 4	183	5
Ward no 5	125	3
Ward no 6	574	15
Ward no 7	450	12
Ward no 8	1711	44
Ward no 9	425	11
Ward no 10	778	20
Ward no 11	865	22
Ward no 12	950	25
Ward no 13	472	12
Total	**7263**	**189**

FIGURE 9: WARD MAP FOR LEH

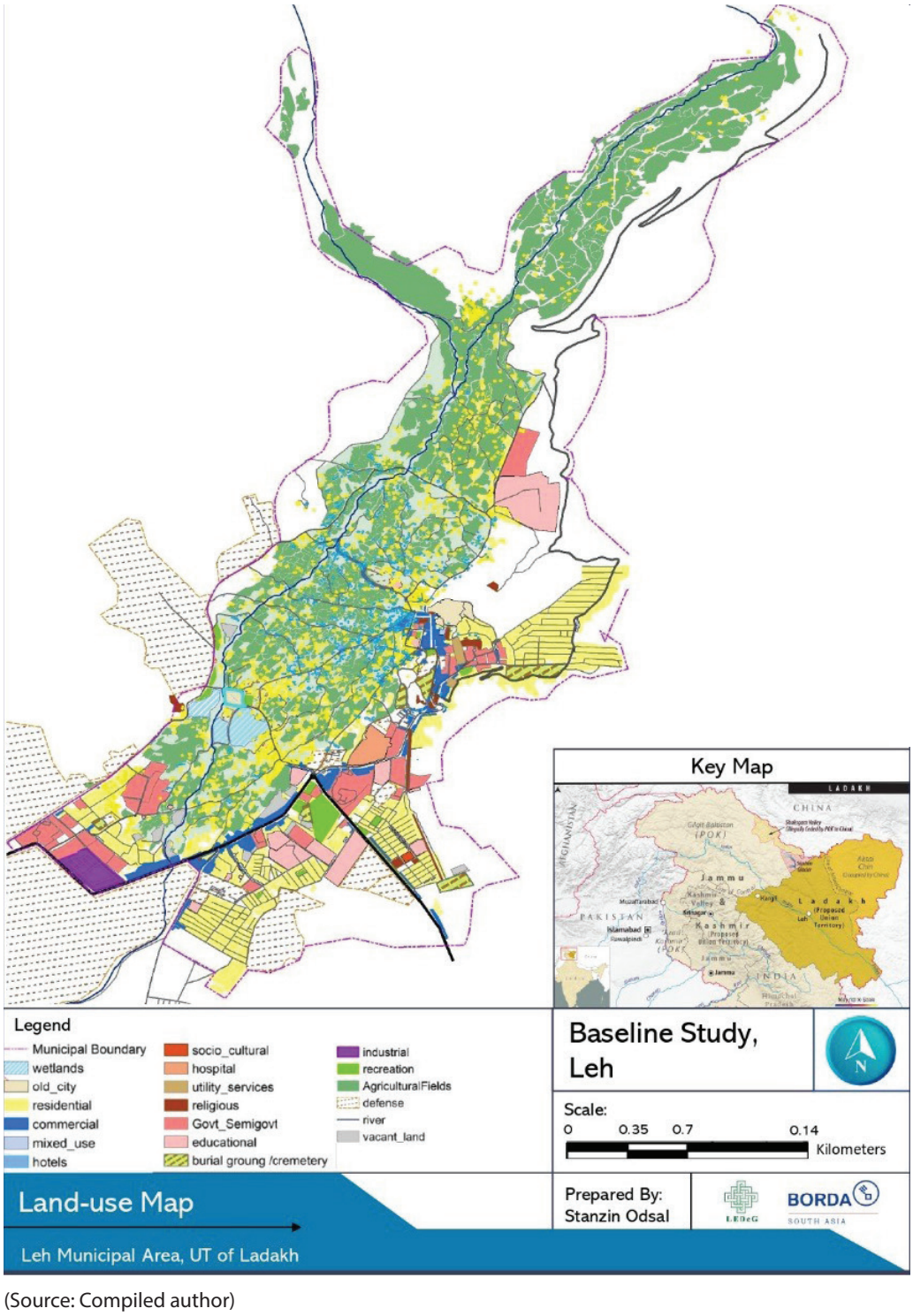


(Source: Compiled by Author based on data from MCL)

3.5 LAND USE

About 54% of the land in the municipal limits is agricultural land; 21% is predominantly residential and mainly located towards the south of the town; 12.37% of the area is under public space; 5.15% is under defense and only 3.09% 2.06% and 1.03% of the land are under commercial, mixed-use and industrial use respectively.

FIGURE 10: LEH LAND USE MAP



(Source: Compiled author)


HERBAL HENNA
555

4 CHAPTER 4: SOLID WASTE MANAGEMENT IN TOWN

In 2019, Leh generated about 40 Tons of waste each day during the tourist season and about 9 Tons per day during the winter (Rabgais, 2021). Leh was declared the Cleanest Town in Jammu and Kashmir, India, and 100th all over India in the 2017 Swachh Survekshan. However, the overall waste management process was ranked 1816 in the overall score for 2022 (ranked 70 under the north, 25,000-50,000 category). The city requires improvement as there are gaps in the current system, as discussed below. The solid waste management details listed below were collected from secondary data and a primary survey conducted with 195 Households and 98 commercial establishments. The secondary data available were not sufficient for the study hence a detailed primary survey was conducted to understand various aspects such as the disposal methods adopted by the people for various categories of waste, frequency of waste collection, segregation practices etc. The detailed questionnaire for these surveys are given in Annexure 6.

4.1 GENERATION

Leh has prepared a DPR for the Solid waste management plant. According to the report, nearly 55% of the solid waste comprises wet waste (or biodegradable waste), 29% is recyclables, and 16% is C&D waste (Sarabh agnihotri, 2019). However, in the interview with the executive officer of MCL, it was found that solid waste comprises 75% wet waste, 20% dry waste, and 5% construction and demolition waste. Within the 20% of dry waste, plastic is 3% (1.3TPD), paper is 5% (2.2TPD), glass is 10% (4.4TPD), and metals is 2% (0.8TPD). Due to the inconsistency in the data, a detailed survey was carried out to get legitimate data.

The population in Leh varies drastically in winters and summers due to the massive influx of floating population and increased consumption in summers. Due to this, the waste generation also differs in winters and summers. The main generators of waste during the summer are the tourism sector and the increased migrant population. Waste generation strongly depends on the local economy, lifestyle, and infrastructure.

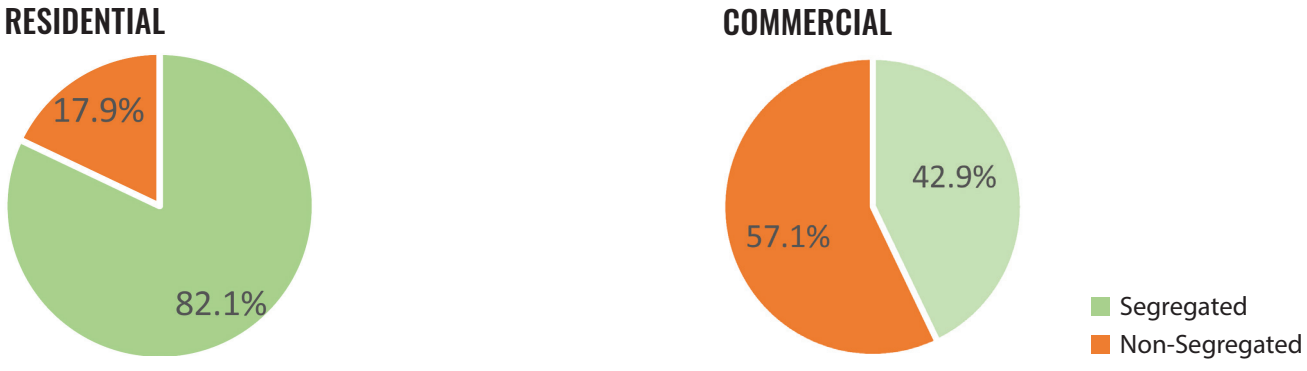
4.2 SEGREGATION AND COLLECTION

The MCL initiated door-to-door collection at various residential and commercial places in 2020. The waste collection is carried out using two trucks simultaneously, one for wet waste collection and the other for dry waste collection. The door-to-door collection is done daily only in the main commercial areas of Leh (such as the main market, Fort Road, etc.), and in other places, it's done weekly. The collection schedule

for different wards have been cumulated in discussion with the municipal authorities and given in Annexure 9. As per the commercial and residential primary surveys, it was understood that the wet waste and inorganic waste are collected in a segregated manner from the households. The collection frequency varies from zone to zone—from once in 7 days to daily. The shops and hotels bring their waste to the trucks in the morning. Manual loading is practiced at all levels for the transfer of waste.

There is no separate system for collecting and managing hazardous (medical, electronic, chemical, etc.) materials. The waste segregation data based on primary survey with sample population is shown in the graph below:

FIGURE 11: WASTE SEGREGATION

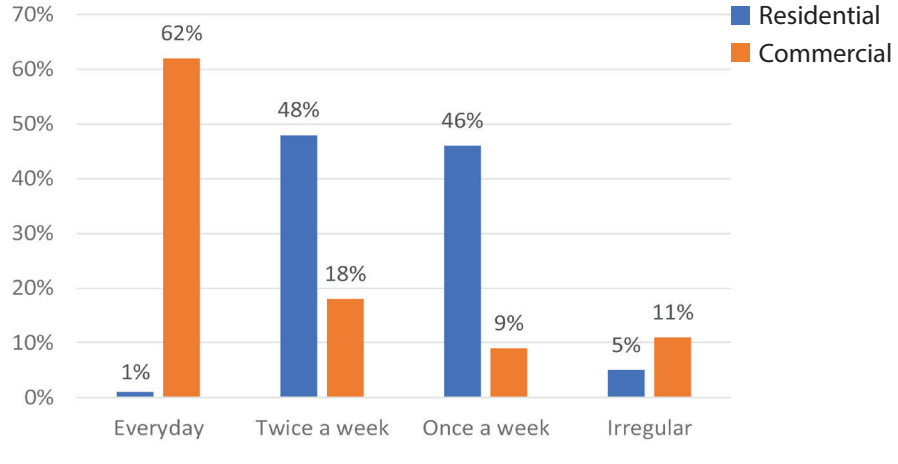


During the survey, most HHs (95.2%) responded that the waste was collected once or twice weekly. The waste collection waste reported as irregular by 5% of HHs. These HHs are primarily located in the upper Leh wards, where the population density is low and has very little to no urban characteristics.

In the commercial areas, 62% of establishments responded that the municipality collects waste daily. While 10% responded that the municipality is irregular in collecting the waste, and very few shops responded that the municipality doesn't collect waste from their shops.

The municipality levies the waste collection fee in commercial establishments. However, more than half of the respondents were not paying any fee.

FIGURE 12: WASTE COLLECTION FREQUENCY BASED ON PRIMARY SURVEY



A wet compactor collects wet waste for commercial establishments like restaurants and hotels around the market area. Initially, there were approximately 100 waste pickers who collected waste directly from the waste generators as well as from the dumpsite located at Bombgarh. However, after the dumpsite remediation (legacy waste remediation) and the functioning of the MRF facility, their number has gone down, and now there are very few waste pickers in Leh. The tendency to pick highly valuable waste like cardboard, pet bottles, and tin cans is prevalent at the source and dump site. Some waste generators like hotels/restaurants often keep such high-value waste on the premises and store it to be disposed of/sold later.

4.3 TRANSPORTATION

The Municipality of Leh has 13 vehicles which are deployed for the collection of waste. Among the 13 vehicles, 2 have a capacity of 5 MT; others have a capacity of 1 MT or less. As there are a lot of steep roads and hilly conditions, these vehicles often take less load than they can as per capacity or design. The municipality staff operate these vehicles under the supervision of the Assistant Sanitation Officer.

TABLE 4: TYPES OF TRANSPORTATION VEHICLES AVAILABLE WITH MCL

Type of truck	Quantity
Garbage Tipper	5
Garbage Compactor	5
Small garbage collection vehicles	3

The collection is often done in the morning (8 – 11 AM) in both winter and summer. Some of the vehicles also do multiple rounds as needed. The town's main market has a vehicle halt time of approximately 1 hour two times a day to address the bulk waste generation in public places and restaurants.

The vehicle routes are being planned to cover all types of waste generators like hospitals, restaurants, hotels, schools, and households in one locality.

The vehicles are deployed with a helper from the municipality who helps pick up the waste containers for emptying/ offloading. These helpers travel on the backside of the truck, and because of the height of the waste compartment, the helper often had to come down from the truck to pick up the waste from the roadside. These vehicles also collect road-sweeping waste along the route.

As these vehicles are not fully covered during transportation, it results in waste spillage from trucks en-route to the MRF facility due to unpaved roads. Often, these vehicles move over sharp objects like broken glass, resulting in maintenance requirements.

The collection, transportation, and treatment of waste are carried out by the 113 sanitation workers deployed by MCL. Apart from the sanitation workers deployed by MCL, the waste is collected and sold to vendors through the informal sector(kabadiwals). They buy the waste directly from the consumers and sell them to the vendors/recyclers.

4.4 TREATMENT

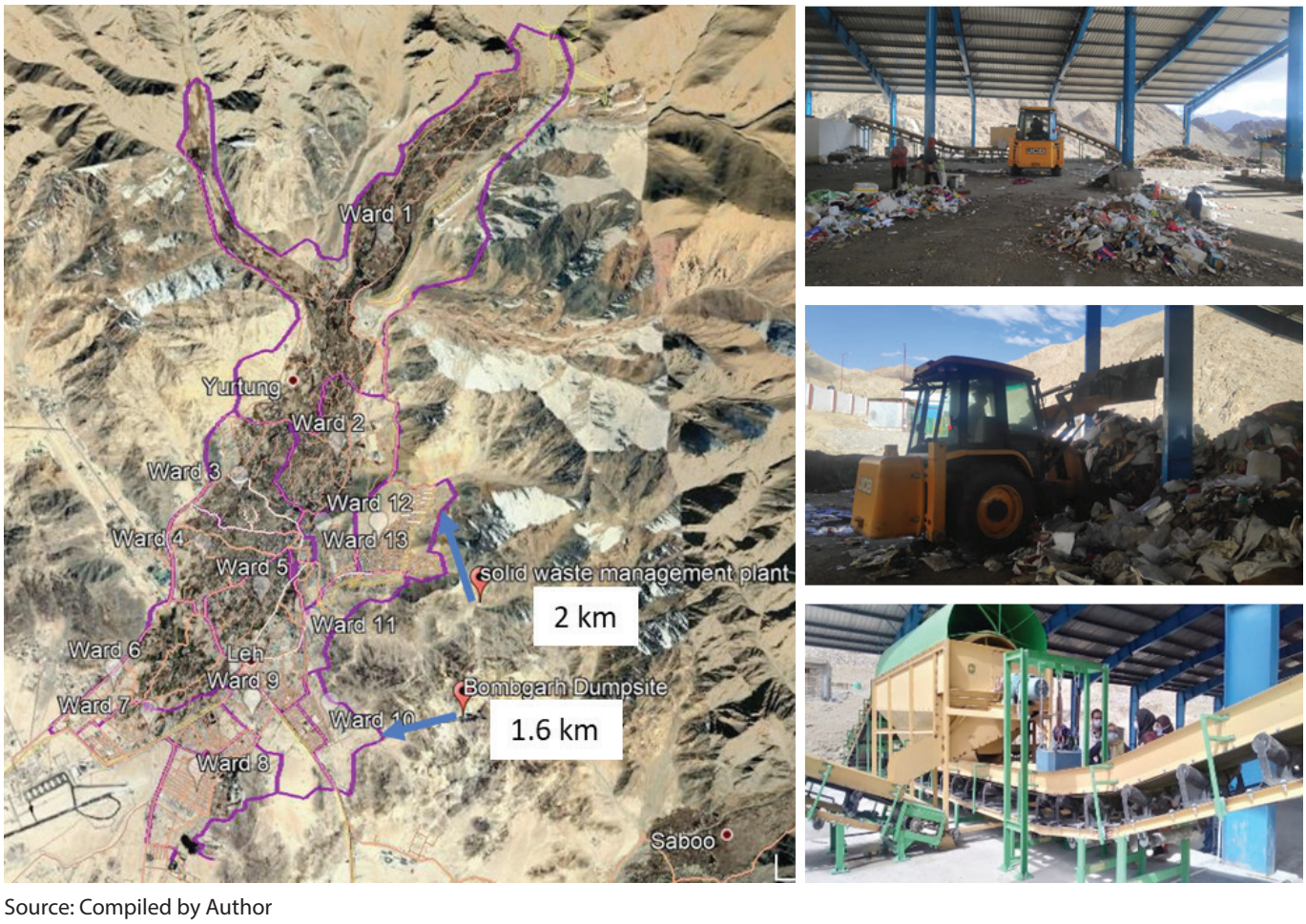
Leh has a Material recovery facility located in Skampari with a capacity of 30 TPD. The facility is partly functional and is solar-powered. MCL runs the plant and operates from 10:00 am in the morning to 06:00 pm in the evening. The waste is weighed at the weighing bridge and then taken up for manual segregation. The facility also has a picking belt and trommel, which are mostly not in use. These workers manually segregate the plastic bottles, paper, tetra packs, etc., which are bailed to compress and are stored until sold. Wet waste is collected and fed to the conveyor belt, which takes it to the shredder and then to the composting facility.

TABLE 5 : CAPACITY AND TYPE OF EQUIPMENT FOR SOLID WASTE MANAGEMENT

Sl No	Components of the 30 TPD SWM plant	Status
1.	Picking belt	Functional but not in use
2.	Trommel machine for deep segregation for less than 50mm waste	Functional but not in use
3.	2 Bailing machines	Functional and in use
4.	MLP machine for shredding of paper and Multi-Layer Plastics (MLP)	Functional and in use
5.	Glass shredding machine	Functional in use
6.	Composting facility of 3 TPD	Functional and intermittently used (in summers)

As a result of the indiscreet dumping, valuable items are often not picked up by rag pickers. The fresh waste gets tipped over the old waste at the landfill in a mixed manner. The stray dogs often create chaos by picking the animal waste and hospital waste including parts of the human body, at the dumpsite. This used to make waste pickers' jobs more challenging and results in low recycling of high-value waste compared to other towns and municipalities. In 2022, it was mandated that the hospital waste be disposed of separately and not taken to the MRF facility.

FIGURE 13: SOLID WASTE MANAGEMENT PLANT IN LEH



Source: Compiled by Author

4.5 REUSE/RECYCLE

The recovered bailed high-value plastic from MRF is sold to vendors, who take this waste to Srinagar or Delhi. The waste is manually segregated in many streams in the material recovery facility. The segregated tin, tetra packs, and plastics are sent to the bailing machine, where they are compressed and sold to the vendors. The informal waste collectors also collect the valuable materials directly from commercial establishments and households. These are sold to aggregators who transports it for recycling. The wet waste is composted in the MRF facility and sold as manure, however due to limited capacity of the composting machinery and low storage facility, the bulk of the wet waste is piled up as windrows near the MRF facility. These are sprayed with bio-digesters but lacks a scientific approach resulting in odour and long time for composting.

4.6 DISPOSAL

The waste disposal site was the legacy waste site in Bomb Guard until 2022. In March 2022, the legacy waste bioremediation was initiated and completed by October 2023. The distance from the city to Bomb Guard is approximately 4 km from the centre of town near Ward No. 10. The legacy waste site has households in close vicinity and doesn't have any buffer space. Since there is no designated place in the dumping yard, vehicles often unload the waste to areas where it is convenient annually.

The land reclaimed from the legacy waste site is planned for future Municipal Committee Leh SWM projects. The new scientific landfill is currently under construction and is not functional.

Data was collected through the primary survey as well to understand the waste flow and disposal practices further. It was observed that most of the household's dry waste is being collected through the door-to-door municipality collection. A small fraction is being burnt or sold directly to the Kabbadiwalas. The waste disposal practices in the commercial establishments were also similar as most respondents handed over the waste to the municipality, and very few were burnt or sold to Kabbadiwalas.

However, the wet waste disposal practice scenario for residential and commercial areas was quite similar as well. More than half of the wet waste was fed to the animals/cattle, and some part of it was composted at the site. This is especially evident in the upper Leh area (ward no 1, 2, 3, 4, and 5).

The hazardous wastes like batteries, light bulbs, tube lights, paints, pesticides, etc., are either disposed of by the municipality or sold to kabadiwala.

Leh's solid waste management (SWM) scenario necessitates a Waste Flow Diagram (WFD) study for various critical reasons. Firstly, there are leakages at multiple points in the waste management system, leading to improper disposal and potential environmental hazards. Secondly, the lack of comprehensive data regarding waste generation, collection, and disposal makes it challenging to devise effective waste management strategies. Moreover, the existing treatment facilities are often insufficient to handle the waste load adequately, exacerbating the problem. The fluctuations in the quantity and composition of waste further complicate the management process. All these factors create gaps in the waste flow that must be identified through a WFD study to formulate targeted policies and action plans to address the issues at hand and establish a more sustainable waste management framework for Leh.

FIGURE 14: BOMB GAURD LEGACY WASTE SITE

5 CHAPTER 5: DATA COLLECTION & ANALYSES

WFD (Waste Flow Diagram) helps in SWM improvement by clearly understanding the waste management system, identifying gaps, and facilitating targeted interventions for better waste handling. However, there was not sufficient reliable secondary data available for Leh. To overcome this, we conducted extensive surveys and collaborated with local authorities to create a comprehensive WFD, enabling us to implement effective measures for enhanced SWM in the area.

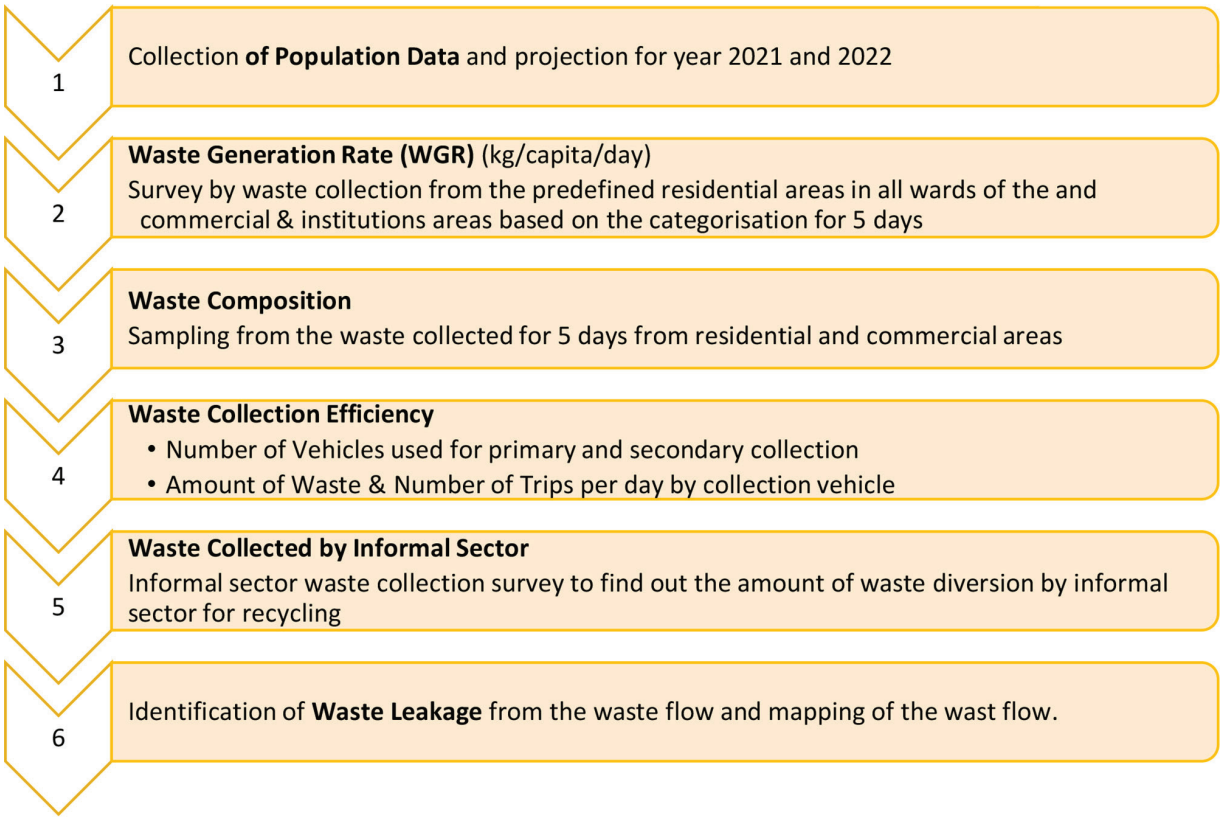
The Municipal Committee Leh faces various challenges when managing the waste generated in the city. While the waste generated in the winter months is about 7-8 tons per day, it rises to almost 30-40 tons per day in the summer months owing to the tourist and migrant worker population. In addition, the waste generated by the army and Air Force population gets sent to the MRF for processing since they do not have their own waste processing facility. Other issues related to solid waste management include:

- Clothes waste, construction waste, carcass of animals cannot be segregated, as people dump such waste in waste collection trucks without segregation.
- There are separate waste collection trucks for different waste, however segregation is not carried out effectively due to lack of awareness.
- Eco friendly biodegradable plastic bags are used by many shopkeepers, hotels, though it claims it is biodegradable but because of unique climatic conditions of Ladakh these plastic bags do not get decompose. (as per 3R company operation manager Mr. Tsewang Dorjey)
- Due to mixing of all waste by the public in same bins, the employees of solid waste management spent more time segregating these waste and due to lack of manpower wastes gets piled up.

Due to the aforementioned gaps and challenges, a thorough survey was conducted for both households and commercial units in Leh. The aim was to gather detailed data on waste management practices in the area, enabling a comprehensive analysis for the development of the Waste Flow Diagram (WFD). Due to the limited availability and reliability of data in Leh, a slightly different approach was adopted compared to the one outlined in section 2. The approach involved conducting primary and secondary surveys to gather comprehensive data on waste management practices from households and commercial units. These surveys played a crucial role in

generating the necessary information to develop an accurate Waste Flow Diagram (WFD) for the region. Despite the challenges, this adapted approach allowed for a more pragmatic and effective analysis of the SWM scenario in Leh.

FIGURE 15: APPROACH FOR WFD PREPARATION



5.1 COLLECTION OF POPULATION DATA AND UPDATE FOR CURRENT YEAR

Population data is needed for estimating the total waste generated in the town. For estimating the target population of Leh Municipality, the Census population data has been used (for local population) along with data from tourism department and data from urban local bodies department and Leh vision Document publication (for floating population). Since the information provided in the publication is based on the census year of 2011, the population data was updated for estimating the current population. For instance, if provisions are to be made for the population in the year 2021 and 2022, then the target population can be determined by the following formula:

$$P_t = P_o (1+r)^n$$

Where

P_t = Population of the projected year **t** (in this case 2021)

P_o = Population of the base year (in this case 2011)

r = growth rate

n = number of years

The base population is taken as 30,870 as per 2011 census and an annual average population growth rate of 0.78% is considered to arrive at the population for 2021 and 2022. The migrant population was estimated based in the data form Leh vision document and considered as residential population for summer. It is assumed that at least 70% of the migrant labour stay within Leh town and for a period of 6 months of summer from May-October. The tourism data was considered based on the assumption that a tourist stays in Leh town for atleast 5 days. The army population is not considered for this study.

The overall population for the **winter months of 2021** is estimated as **33,689** and the **summer months of 2022** is estimated as **82,241**

5.2 CALCULATION OF WASTE GENERATION RATE (WGR)

To estimate Municipal Solid Waste generation, data was collected from two main sources: domestic and non-domestic. For domestic waste, a sample survey was conducted in all 13 wards to determine the waste generation rate (kg/cap/day). Similarly, a sample size was selected for non-domestic waste from establishments like markets, hotels, guest houses, restaurants, schools, and offices. The survey spanned a minimum of 5 days in both residential and non-residential areas, conducted in two phases (summer and winter) to account for seasonal variations waste flow. This approach was adopted to ensure data accuracy and facilitate comprehensive waste management analysis.

The survey was based on random sampling method post finalising the categories of establishments. An account of the total number of establishments under different categories were taken from the MCL, based on this a sample size was finalised with 95% confidence level and 7% error. The sample selection approach is briefed in **Annexure 5**. Accordingly, a total of 111 samples were taken from commercial establishments and 189 samples were taken from households. The samples were taken as a percentage of the total households in that ward, to maintain the proportionality in the survey. Prior to the conduction of the survey, the surveyors were oriented on the methodology of the survey and the dos and don'ts during the survey. The details of the sample, including the sample size, location, type of establishment/household, are provided in the **Annexure 1**. The surveyors were assigned the specific categories based on the samples to be collected, as detailed in **Annexure 2**.

The survey entailed collection of segregated wet and dry waste from the predefined samples from residential and commercial establishments. The waste collected from each establishment was weighed and noted along with the type of establishment and number of people/users in the establishment to calculate the per capita waste generation across the categories. There were separate templates for households and commercial establishments for the daily waste data entry form. The template for the data collection for the survey is given in **Annexure 3**. After collection of these data points for 5 consecutive days including weekends to capture the weekly fluctuation, the average of the per capita generation was calculated. This will be used to understand the solid waste generation in Leh, among residential and commercial/institutional areas.

During the survey, total waste generation from household and commercial/industrial have been measured and summed up for individual categories. Then for the samples taken, the total waste have been divided by the total sample population for individual category.

$$\text{WGR (waste generation rate)} = \frac{\text{(Total waste generated by selected samples)}}{\text{(Total Sample Population)}} \text{ kg/capita/day}$$

The average of the waste generation rate was captured for the 4 days, excluding the first days values as the waste segregation was not effectively carried out in the sample sites in the beginning of the survey.

The waste generation rate for summer and winter is calculated separately by taking the average of the residential and commercial waste generation rate for the respective seasons. The total waste generation of Leh is then calculated by multiplying WGR in summer and winter for the respective populations. The waste generation for summer and winter was then added to reach at the waste generation in a year.

The waste generation rate for summer and winter is **0.24 kg/person/day** and **0.39 Kg/person/day**. Based on this waste generation rate and the population estimated for the respective seasons, the total waste generation in summer is **8.08 Tons per day** and winter is **32.07 tons**. This results in a total waste generation of **7317 tons in a year**. The waste generation per day in summer is 4 times the waste generation per day in winter.

FIG 16: SURVEYORS ON ROUTE FOR COLLECTION OF WASTE SAMPLES FOR WFD SURVEY

FIG 17: WEIGHING OF COLLECTED WASTE AND RECORDING DATA

FIG 18: NAMING OF THE WASTE SAMPLE FOR IDENTIFICATION

FIG 19: COLLECTION OF WASTE SAMPLE FROM SHOPS

FIG 20: WEIGHING THE WASTE COLLECTED FROM SHOPS

FIG 21: SAMPLE SELECTION FOR UNDERSTANDING WASTE COMPOSITION

5.3 ANALYSIS OF WASTE COMPOSITION

Physical and chemical composition of the waste is essential for the selection of suitable waste treatment approach/method, recycling and disposal options. Physical composition for the waste generated from the household and commercial areas were assessed separately from the sample collected. The waste from these sources have been segregated into the various categories for the physical composition.

The sample for composition analysis was selected from the waste generation survey samples in a proportionate manner based on the waste generator type. The segregation was done manually, for all the 5 days of the survey to get an average value and to incorporate the weekly variation in the composition. The template for data collection for the waste composition is provided in **Annexure 4**. Further, the survey was carried out for winter and summer months to understand the seasonal variation in the composition of waste.

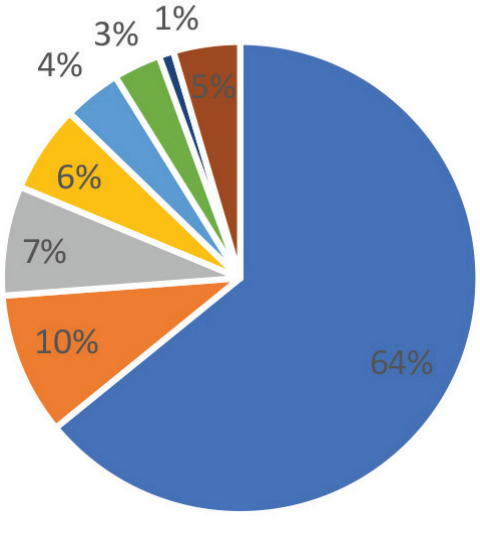
FIG 22: SELECTION OF WASTE SAMPLES FOR UNDERSTANDING WASTE COMPOSITION

FIG 23: SEGREGATION OF THE IDENTIFIED SAMPLE WASTE FOR WASTE COMPOSITION SURVEY

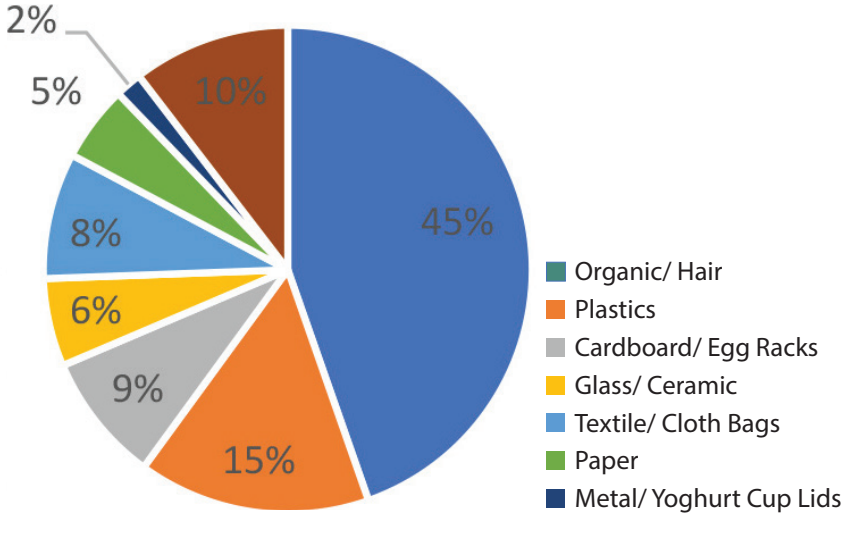
The waste composition for summer and winter shows the difference mainly in **high organic/wet waste in summer** due to increased consumption/availability of fruits and vegetables and the **high food waste from restaurants, hotels and guest houses** that become active during the tourist season.

FIGURE 24: WASTE COMPOSITION

SUMMER



WINTER



5.4 WASTE COLLECTION EFFICIENCY

The waste collection efficiency is measured as the collection to waste generation rate, which is important to understand the leakages in the waste collection system. The records from the weigh bridge were collected from the MRF site over a period of 24 hours for the same days in which the waste generation data was collected through the sample survey. The data collection template for MRF survey is given in **Annexure 8**. The waste was coming form the city as well as the army cantonment area (which we left out of the analysis). The data was collected for winter and summer separately. This was undertaken to assess the waste quantity collected by the municipal authority. Based on this data, the estimated amount of waste collected has been determined (number of trips X designed load carrying capacity of the truck). The efficiency of waste collection for the municipality was then assessed by using the following method:

$$\text{Efficiency} = \frac{\text{Total collected wastes by the waste collection vehicle}}{\text{Total Waste Generated in a Municipal}} \times 100\%$$

The waste collection efficiency for **winters** was calculated as **56%** and only **34%** during **summer.**

FIG 25 : THE MRF FACILITY

FIG 26 : WASTE DISPOSED AT MRF FACILITY BY WASTE COLLECTION & COMPACTOR TRUCKS

FIG 27 : HIGH LOAD AT THE MRF FACILITY DURING SUMMERS DUE TO HIGH INFLOW OF WASTE

FIG 28 : TROMMEL AT THE FACILITY FOR PRIMARY SEGREGATION OF DRY WASTE

FIG 29 : MANUAL SEGREGATION OF HEAVY OBJECTS

FIG 30 : BAILED RECYCLABLES PACKED FOR SALE & TRANSPORTATION AT MRF FACILITY

5.5 COLLECTION OF WASTE BY INFORMAL SECTOR

In order to assess the informal waste collection activity in the municipality, a reconnaissance survey has been conducted in the study area. The objective of this survey is to identify the stakeholders involved in waste recycling. Generally, several stakeholders are involved in the waste collection and recycling trade of small towns in developing countries. They generally include:

- Kabadiwalas(informal recyclers, who buys waste from residents and then sells to manufacturers)
- Rag Pickers (Collects waste from dumpsites or Legacy waste sites and sells to recyclers or kabadilwals)

Typically, shops and industries dealing with recyclable materials are clustered in certain areas of a town. Information about the location of these shops, numbers, and industries were collected from Municipal officials. After collection of the aforesaid information, a questionnaire survey was conducted amongst these groups to assess the amount and type of waste collected by the informal sector for recycling. Most of them being kabadiwals, who also collect only a very little amount of municipal waste, instead they are more focused on collecting automobile waste which is more lucrative. Also, since ragpickers are not allowed in the MRF site hence their numbers have decreased drastically in the recent years. The data from informal waste collectors were taken using a questionnaire survey given in **Annexure 7**.

The **informal waste collector** is minimal in number in Leh, collecting up to only **8%** of the total waste generated. The major items collected were **PET bottles, tin** and **iron**.

5.6 IDENTIFICATION OF WASTE LEAKAGE FROM HOTSPOTS AND QUANTIFICATION OF LEAKAGE

In the waste composition survey conducted to prepare the Waste Flow Diagram (WFD) for the municipality of Leh, it was found that an insignificant portion of the waste generated was not being managed at source or collected by neither the municipal authority nor the informal sector. Instead, these leftover wastes were being left on the roadsides, disposed of in waterbodies/streams or low-lying areas, or burnt.

This leftover waste, also referred to as "residual waste," is an important aspect of the waste management system that needs to be considered when preparing the WFD. Over time, the residual waste forms hotspots across the town resulting in unmanaged waste leakage into the environment. In Leh, there aren't hotspots as such, even though littering can be observed across the town. Therefore, in the case of Leh waste leakage from hotspots is not applicable. However, attention is to be paid to this aspect to avoid hotspots in the town in the future.

5.7 DATA ANALYSIS AND PREPARATION OF WFD

After the data was collected from the multiple secondary and primary data collection, it was carefully examined to identify any discrepancies or errors and to ensure that it was representative of the overall waste management situation in Leh.

Once the data was validated, the data collected through the surveys for the waste generation, waste composition, waste collection efficiency and disposal practices, the overall waste flow from source to disposal was represented visually with a Sankey Diagram.

6 CHAPTER 6: RESULTS & DISCUSSION

In total Leh generates 7,317 tons of waste per year. Out this only 3,293 tons/ year is collected by the municipality, and nearly 617 tons/year is collected by informal sector and the remaining 3,407 tons/year remains uncollected.

About 95% (3,134 tons) of the collected waste ends up in the MRF facility (as the dumping site Bombgaurd was undergoing bioremediation). This waste comprises of inert waste from the MRF and waste directly dumped in the MRF due to the inadequate capacity of the MRF for handling the waste. Nearly 4% (123 tons) of the collected waste is recovered and sold from the material recovery facility in Leh. The waste is collected by informal waste collectors (kabadiwalas and ragpickers) accounts to 8% (617 tons/year) of the total waste generated in a year.

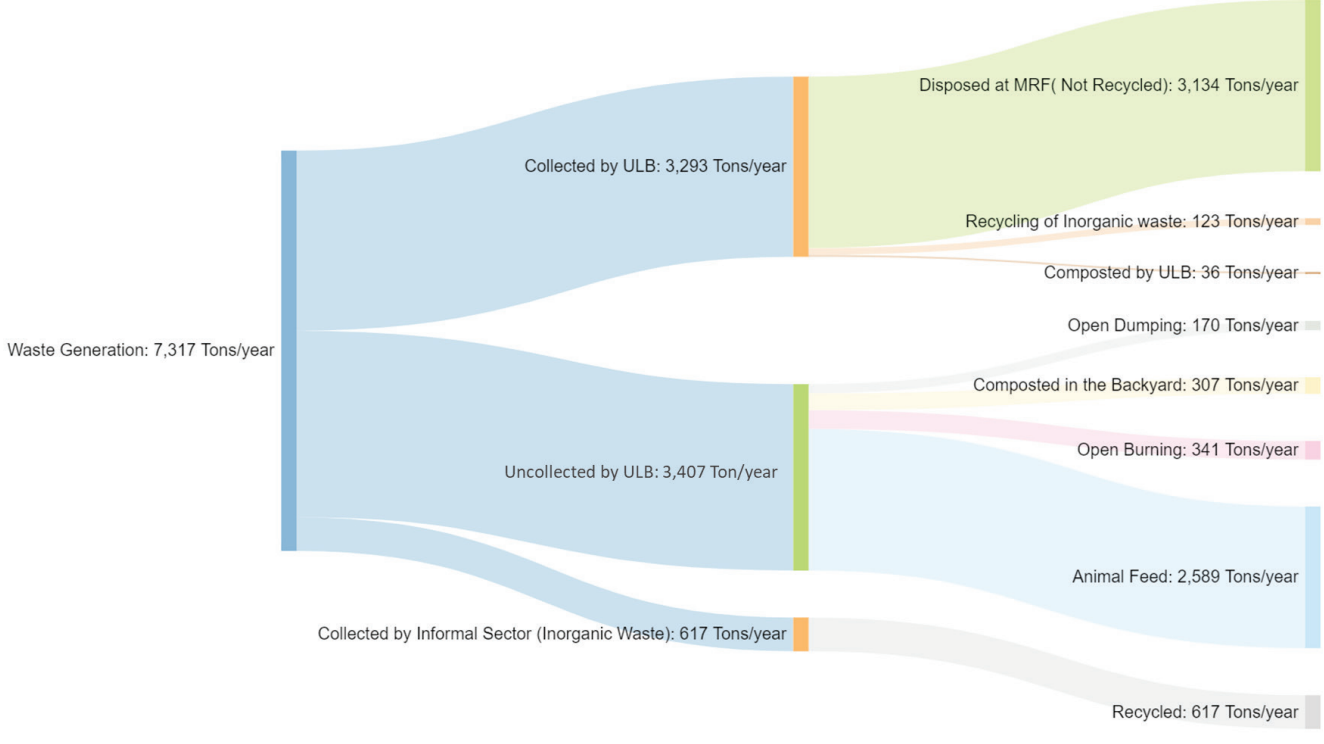
In summer the waste is composed of 64% of organic waste. 10% plastics, 7% cardboards and the remaining glass, paper etc. In winter the waste is composed of 45% of organic waste, 15% plastic, 6% of glass, 8% textile and remaining paper and metals. The generation of organic waste was higher by nearly 20% in the summer due to increased floating population and availability of more vegetables and fruits.

Uncollected waste should be tapped in the system by the municipality to reduce the impact on the local ecology. The various ways to do it are- increment in the number of segregated collections by means of truck or dustbins, strategic spatial distribution of the waste recycling plants eventually decreasing the landfill composition.

It is understood from the primary survey among residents that a major portion of the uncollected waste of 3,407 tons/year is due to the using the organic waste on site, for purposes like feeding animals and home composting. Nearly 76% of the uncollected waste is wet

waste which is being used as animal feed at household level itself. This along with the 9% of uncollected waste that is being composted at the household level reduces the load on the municipal waste collection and management system. Among the uncollected waste, 15% is being either burned or openly dumped in the surroundings. (LEDeG, 2021). The following figure shows the overall waste management situation of Leh Municipality. The figure is based on the waste flow analysis.

FIGURE 31: WASTE FLOW DIAGRAM LEH



6.1 OBSERVATIONS & LEARNINGS

The observations and learnings listed above highlight several key challenges and issues in solid waste management for small towns like Leh.

- ***Lack of availability of municipal solid waste data :***
  The lack of accurate data on the amount and composition of waste being generated and collected is a significant hurdle in understanding and addressing the waste management situation in Leh. Without this information, it is difficult to develop effective strategies for managing and reducing waste. To address this, at various point of the solid waste value chain measures should be taken to record data. For example, effective book keeping of waste collected at MRF, composition of waste processed & recycled, etc.
- ***Small towns do not have weigh bridge at the landfills - waste collected per day is not monitored :***
  Lack of weigh bridge at the landfill makes it difficult to monitor the amount of waste being collected per day, which is a key indicator of the efficiency of the waste management system. To address this, the municipality should invest in weigh bridges at the landfills to monitor the amount of waste being collected per day.

- ***Informal sector waste collection and recycling data not readily available:***
  Informal sector waste collectors and recyclers play an important role in solid waste management, but data on their activities is not readily available. This makes it difficult to understand the extent of their contribution to waste management, and to involve them in formal solid waste management. To address this, informal sector should be formalized to involve them in the solid waste management process by providing them with necessary permits, equipment, and incentives.

- ***Primary data is required for the preparation of waste flow diagram (WFD):***
  A WFD is a useful tool for understanding the flow of waste from its generation to disposal, but preparing it requires accurate primary data to arrive at effective solutions, which is difficult to obtain. In the absence of which, using the default values in the tool should be carried out with caution as it may misrepresent the reality on the ground.

- ***Time-consuming to conduct the survey and analysis of data:***
  In the absence of secondary data, collecting primary data on solid waste generation, collection, and disposal is a time-consuming process, taking around 1-1.5 months.

- ***Experienced teams and surveyors are required:***
  Conducting a survey and analysis of solid waste requires a skilled and experienced team and surveyors, who can accurately collect and analyze the data. This requires a skilled and experienced team to interpret the data to provide insights into improving solid waste management in a town.

- ***Solid waste composition varies with seasons, with no seasonal variation data available:***
  The composition of solid waste in Leh can vary significantly with the seasons, but there is no data available on these variations. This data can be useful to optimize the solid waste management system.

- ***Small towns do not have solid waste management plans, with no data and future targets available:***
  Without a solid waste management plan, it is difficult to set targets, measure progress, and adjust as necessary. Planning for the future needs and building infrastructure & systems in the town is critical to provide efficient services to the increasing demands thrust upon by rapid urbanization.

Overall, we understand that robust data can help us identify the opportunities and bottlenecks in the solid waste management system. This helps to build a holistic and integrated approach for an optimized and efficient solid waste management system in the town to minimize risks from unmanaged waste for public health and environment & contribute in achieving SDG 11.

7 CHAPTER 7: WAY FORWARD

A possible way forward for addressing the waste management situation in Leh is to focus on increasing the recovery and recycling of waste materials. This can be done by implementing several strategies:

- ***Increasing the capacity of the Material Recovery Facility (MRF):*** Under the current circumstances, the MRF is overwhelmed. Upgrading the MRFs can significantly increase the amount of waste that is recovered and sold generating a revenue stream for the municipality. Allocating the required human resources and mechanizing processes can result in increased volume of processed waste that can be recycled or reused.
- ***Improving the collection of waste materials by the municipality:*** Based on the data obtained from the WFD we understand the quantum & composition of waste generated in different typologies (households & commercial) which can support to optimise the routing of the trucks and placement of community dustbins to increase the collection efficiency, and reduce the amount unmanaged waste that ends up in the landfill.
- ***Encouraging residents to separate their waste at the source:*** In the WFD survey, it was observed that a significant quantity of wet waste is managed at household level. This practice has to be encourage and incentivised by providing support on home composting or community level composting with infrastructure and services. This reduces the load of waste that comes to the central processing units, where often it has been observed as a challenge to process & safely dispose.
- ***Formalising informal waste collectors like kabadiwalas and ragpickers:*** By providing informal waste collectors with the necessary permits and equipment, they can help to collect and recycle waste materials, ultimately reducing the amount of waste leakage from informal sources. This can be achieved by developing partnerships with these informal collectors and providing them with the training and resources they need to collect and recycle waste materials safely and effectively.
- ***Encouraging recycling of paper, plastics and metals:*** By providing incentives and education to the residents, it will increase the recycling rate of paper and plastics. This can be achieved by implementing 3R (Reduce-Reuse-Recycle) facilities that provide residents with financial or in-kind incentives for recycling.
- ***Digitising processes & management systems:*** Digitising various components in the waste management system can result in effectiveness that can be sustained in the long term. For instance, online billing system can contribute to improved user fee collection rate providing revenue for the management of the system. Using GPS & AI, route optimisation of trucks, data management systems to monitor the capacity utilisation in processing units, etc can result in optimisation of resources & increasing efficiency of the system.
- ***Regular monitoring and evaluation of the waste management system:*** It is critical to in-built monitoring & evaluation systems into the solid waste management value chain, that records data on collection, transportation, processing, recycling and reuse/safe disposal to ensure that the implemented strategies are working as intended to have sustained waste management system in Leh.

The data & observations from WFD can assist in developing a comprehensive approach to waste management and investing in necessary technologies and infrastructure, the municipality can significantly reduce the amount of waste that ends up in the landfill, while also increasing the recovery and recycling of waste materials, ultimately improving the waste management situation in Leh.

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Principal Investigator: Velis C.A. Research team: Cottom J., Z. I. Z. C. S. J. a. B. S., February 2020. ***User Manual: Waste Flow Diagram (WFD): A rapid assessment tool for mapping waste flows and quantifying plastic leakage. Version 1.0***. Eschborn, Germany: GIZ, University of Leeds, Eawag-Sandec, Wasteaware.

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ANNEXURES

ANNEXURE 1: SAMPLE SELECTION FOR THE SURVEY

TABLE 1: SAMPLE SELECTION FOR COMMERCIAL ESTABLISHMENTS

SHOPS

Use	Units	Sample Size	Bags
Fancy/ Crockery	975	26	369
Saloon/ Beauty Parlour	52	1	20
Restaurants, Café, Bakery	537	14	203
Tailor Shop	109	3	41
General Shop	695	19	263
Air ticketing/Cyber	12	1	14
Handicraft/ Emboidery	180	5	68
Electronics, Mobile	105	3	40
Optical/ Chemist	32	1	12
CarAccessories/ServiceCenter	20	1	8
Jewelery/ Goldsmith	136	4	51
Hardware/ Spare part	148	4	56
Travel Agency	294	8	111

GUEST HOUSES

Type	Sample Size
Economy Class	5
Medium Class	2
Upper Class	3
Grand Total	**11**

HOTELS

Type	Sample Size
3 Star	1
A	2
A +	1
B	1
C	1
D	1

INSTITUTIONAL

Type		Sample Size
Schools		2
	Private	1
	Public	1
Vocational Training Institute		1
College		1
Hospital		1
Clinics		1

TABLE 2: SAMPLE SELECTION FOR HOUSEHOLDS BASED ON WARD POPULATION

Ward Number	Sample Size
Ward No. 1	5
Ward No. 2	10
Ward No. 3	5
Ward No. 4	5
Ward No. 5	3
Ward No. 6	15
Ward No. 7	12
Ward No. 8	44
Ward No. 9	11
Ward No. 10	20
Ward No. 11	22
Ward No. 12	25
Ward No. 13	12
Total	**189**

ANNEXURE 2: SURVEYOR DISTRIBUTION FOR WFD DATA COLLECTION SURVEY

TABLE 3: SURVEYOR DISTRIBUTION FOR COMMERCIAL ESTABLISHMENTS

Use	Units	Sample Size	No. of Surveyors	Taxis
Fancy/crockery	975	25	3	1
Saloon/Beauty Parlour	52	1	2	1
Restaurants, Café, bakery	537	14		
General shop	695	18	2	1
Electronics, Mobile	105	3	2	1
Tailor shop	109	3		
Air ticketing/Cyber	12	1		
Handicraft/embroidery	180	5		
Optical/Chemist	32	1		
Car accessories/Service centre	20	1		
Jewellery/Goldsmith	136	4	2	1
Hardware/Spare part	148	4		
Travel agency	294	8		
Hotel	217	7	1	1
Guest House	392	10	2	1
Institutes	38	6	1	1

TABLE 4: SURVEYOR DISTRIBUTION FOR HOUSEHOLDS

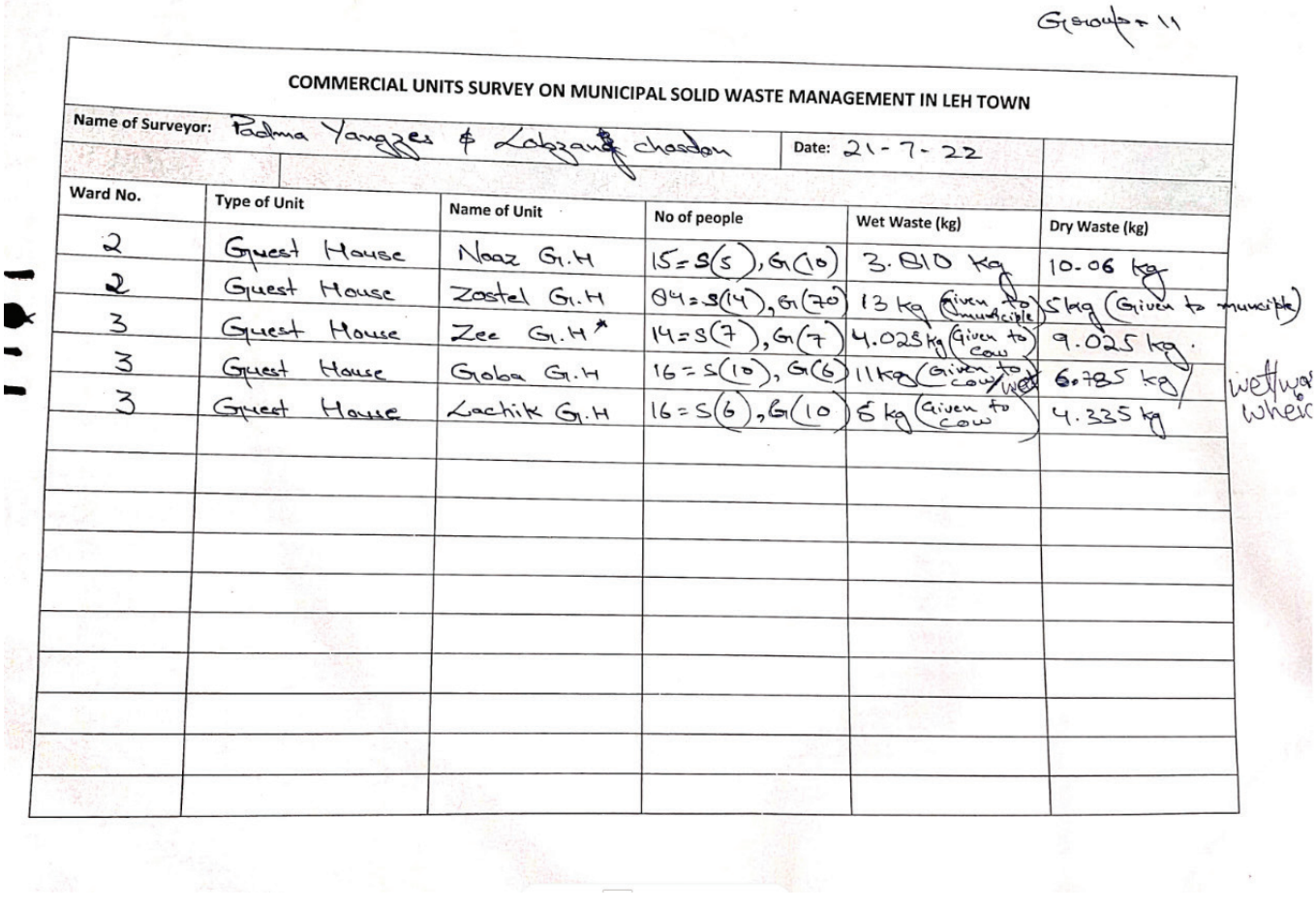
Ward No.	No. of households	Sample Size	Bags	No of surveyors	Taxis
Ward no 1	175	5	46	1	1
Ward no 2	375	10	98		
Ward no 3	180	5	47	1	
Ward no 4	183	5	48		
Ward no 5	125	3	33		
Ward no 6	574	15	149	1	1
Ward no 7	450	12	117	1	
Ward no 8	1711	44	445	3	2
Ward no 9	425	11	111	1	0
Ward no 10	778	20	202	2	1
Ward no 11	865	22	225	2	1
Ward no 12	950	25	247	2	1
Ward no 13	472	12	123	1	1
Total	7263	189	1888	15	8

ANNEXURE 3: WFD DATA COLLECTION FORMAT

Note: In the case of a commercial establishment, the form was similar; instead of ward no, the category of the establishment was recorded and household size was changed to No of people at the store (not visitors)

Name of Surveyor:			Date:		
Ward No.	Name of House Owner	Household Size	Wet Waste (Kg)	Dry Waste (Kg)	Remarks

The sample of a commercial survey sheet with collected data is given below:



Groups = 11

COMMERCIAL UNITS SURVEY ON MUNICIPAL SOLID WASTE MANAGEMENT IN LEH TOWN

Name of Surveyor: Padma Yangzes & Lobzang Chosdon | Date: 21-7-22

Ward No.	Type of Unit	Name of Unit	No of people	Wet Waste (kg)	Dry Waste (kg)
2	Guest House	Naaz G.H	15=S(5), G(10)	3.810 kg	10.06 kg
2	Guest House	Zostel G.H	04=S(14), G(70)	13 kg (Given to municipal)	5kg (Given to municipal)
3	Guest House	Zee G.H*	14=S(7), G(7)	4.025kg (Given to cow)	9.025 kg.
3	Guest House	Goba G.H	16=S(10), G(6)	11kg (Given to cow)	6.785 kg
3	Guest House	Lachik G.H	16=S(6), G(10)	5 kg (Given to cow)	4.335 kg

wet waste where

ANNEXURE 4: WASTE COMPOSITION DATA COLLECTED SAMPLE FROM WFD SURVEY

Note: Minimum 30 samples are to be taken; Samples should be representative

	Surveyor Name :	Odsal Stanzin									
No.	Type	Day 1		Day 2		Day 3		Day 4		Day 5	
		30/10/21	Sat	31/10/21	Sun	1/11/21	Mon	2/11/21	Tue	3/11/21	Wed
1	Paper	2.130	2.99%	5.000	10.44%	0.130	0.46%	0.465	1.05%	1.800	3.60%
2	Cardboard/ Egg Racks	7.195	10.09%	5.265	10.99%	1.795	6.34%	3.620	8.17%	1.900	3.80%
3	Plastics	9.120	12.79%	5.335	11.14%	3.635	12.84%	6.260	14.13%	4.950	9.91%
4	Glass/Ceramic	5.355	7.51%	0.805	1.68%	0.000	0.00%	0.315	0.71%	0.000	0.00%
5	Metals/ Yoghurt Cup Lids	0.740	1.04%	0.795	1.66%	0.525	1.85%	1.710	3.86%	0.170	0.34%
6	Textile/ Cloth Bags	9.696	13.60%	2.315	4.83%	4.640	16.39%	12.135	27.39%	0.205	0.41%
7	Organic	28.888	40.52%	22.551	47.08%	14.145	49.96%	15.025	33.91%	32.564	65.17%
8	Leather/ Rubber	0.000	0.00%	0.000	0.00%	0.000	0.00%	0.000	0.00%	0.000	0.00%
9	Other	8.175	11.47%	5.835	12.18%	3.445	12.17%	4.775	10.78%	8.380	16.77%
	Total	71.299	100.00%	47.901	100.00%	28.315	100.00%	44.305	100.00%	49.969	100.00%

No.	**Type of Plastic**	**Day 1**		**Day 2**		**Day 3**		**Day 4**		**Day 5**	
		30/10/2021	Sat	31/10/2021	Sun	1/11/2021	Mon	2/11/2021	Tue	3/11/2021	Wed
1	PET Bottles	2.06	22.59%	1.135	21.27%	1.3	22.17%	1.26	20.03%	1.73	34.95%
2	HDPE	1.515	16.61%	1.73	32.43%	0	0.00%	1.5	23.85%	0	0.00%
3	LDPE	3.230	35.42%	1.79	33.55%	3.635	61.98%	2.065	32.83%	2.37	47.88%
4	Tetrapack	2.315	25.38%	0.68	12.75%	0.93	15.86%	1.465	23.29%	0.85	17.17%
	Total	9.12	100.00%	5.335	100.00%	5.865	100.00%	6.29	100.00%	4.95	100.00%

ANNEXURE 5: SAMPLE SIZE FOR HOUSEHOLD AND COMMERCIAL PRIMARY DATA COLLECTION SURVEY

Total No. of HH	Required Sample Size Allowing 95% Confidence Level		
	±5% Sampling Error	±7% Sampling Error	±10% Sampling Error
100	50	50	49
250	152	110	70
500	217	141	81
750	254	156	85
1,000	278	164	88
2,500	333	182	93
5,000	357	189	94
10,000	370	192	95
25,000	378	194	96
50,000	381	195	96
100,000	383	196	96
1,000,000	384	196	96
100,000,000	384	196	96

Source: Enayetullah, I., Rothenberger, S., Zurbrugg, C., and Sinha, A.H.M.M. (2006): "Decentralized Composting for Cities of Low and Middle Income Countries, A User's Manual," EWAG, Switzerland and Waste Concern, Bangladesh.

ANNEXURE 6: QUESTIONNAIRE FOR PRIMARY SURVEY DATA COLLECTION FROM HOUSEHOLDS AND COMMERCIAL ESTABLISHMENTS

Note: For the residential survey, the Primary details collected included ward number, house name/number, number of residents, name of the resident

PRIMARY DETAILS	
1.	Name of surveyor
2.	Date
3.	Ward number
4.	Type of unit (as per the list in Annexure-1)
5.	Name of the unit
6.	Name of owner
7.	Number of people generating the waste
WASTE DISPOSAL PRACTICES	
1.	Do you segregate the waste?
a.	If yes , how many waste streams?
2.	What are the waste streams?
3.	How do you dispose of your waste?

Disposal Methods	**Wet Waste**	**Dry Waste**	**Hazardous Waste**
Burn			
Street			
D2D MCL collection			
Stream			
Sell to Kabadiwala			
Composting			
Feed Animals			

4.	How frequently do they collect in a week?
	a. Daily b. Twice a week c. Once a week d. Irregular
5.	What time do they collect the waste?
	a. 6 am-9 am b. 9 am-1pm c. 1pm-5pm d. 5pm-9pm
6.	Do you pay user fee?
7.	How much do you pay yearly?
8.	How do you reuse waste?
9.	Do you sell waste? And type of waste sold?
10.	What is the main reason for waste in the street?
11.	What is the main reason for waste in the water streams?
12.	Would you like to have a D2D collection?
13.	Which waste streams for D2D collection?
14.	What time do you prefer the waste to be collected?
15.	How frequently do you want the waste to be collected?
16.	How satisfied are you with the waste collection by MCL? (1 is dissatisfied and 5 is exceptionally satisfied)
17.	Are you willing to pay a monthly user fee?
18.	How much are you willing to pay monthly for D2D collection?

ANNEXURE 7: QUESTIONNAIRE FOR DATA COLLECTION WITH INFORMAL WASTE COLLECTORS/KABBADIWALLA

Primary Details	
1.	Respondent Name :
2.	Address:
3.	Occupation:
4.	Place of Survey:
5.	Gender :
6.	Age:
7.	Education:
8.	Number of male family members:
9.	Number of female family members:
10.	Any other persons of the family are involved in plastic recycling work?:
a.	No of male
b.	No of female
Work Details	
11.	Why you take this work as an occupation?:
12.	How many days do you work in a week?:
13.	Monthly income:
14.	Monthly Expenditure:
15.	How long have you been working in this job:
16.	Do you have any job apart from this?:
17.	How many people are in this occupation?:
Material Collected	
18.	Do you sell any type of materials?:

Details to be recorded- the terms such as PP, PS etc are explained with example to the individual.

Type of Material	Purchase Amount (Kg/Year)	Purchase Price (Rs/Kg)	Selling amount (Kg/Year)	Selling Price (Rs/Kg)
PET				
HDPE				
LDPE				
PVC				
PP				
PS				
Tin				
Iron				
Paper				

ANNEXURE 8: DATA COLLECTED FROM MRF

The data from MRF was collected for all the days of the survey in the below given format

No.	Type of Vehicle	Vehicle Capacity	No. of Trips in a day	Waste Collected in a day	Date	Remarks
1.	Tipper	5 tonnes	1	895 kg	16/07/21	Waste collected is the sum of waste collected in all trips.
2.	Tipper	5 tonnes	2	1345 kg	16/07/21	-do-
3.	Dumper	3 tonnes	3	1880 kg	16/07/21	-do-
4.	Dumper	3 tonnes	1	565 kg	16/07/21	-do-
5.	Tipper	5 tonnes	1	1050 kg	17/07/21	-do-
6.	Tipper	5 tonnes	1	990 kg	17/07/21	-do-
7.	Dumper	3 tonnes	2	1490 kg	17/07/21	-do-
8.	Dumper	3 tonnes	1	460 kg	17/07/21	-do-

ANNEXURE 9: WASTE COLLECTION FREQUENCY WARD-WISE

The data was collected from MCL based on primary discussions)

Ward Number	Name of the Ward	No. of Households	Population	Frequency of D2D Collection	Remarks
1.	Gonpa/ Gangles	175	850	On 15th and 30th of every month	Lowest Density Urban Villages – Agricultural Lands
2.	Sankar/ Yourtung	375	2,100	Monday and Thursday	Concentration of Tourist Population
3.	Changspa/ Karzoo	180	1,080	Monday and Thursday	Concentration of Tourist Population
4.	Tukcha	183	1,550	Saturday and Tuesday	Concentration of Tourist Population
5.	Shenam	125	1,700	Wednesday and Saturday	Concentration of Tourist Population
6.	Skara	574	2,870	Daily	Residential and few hotels are there.
		97 (Industrial units)	480	Daily	Airport is in this ward
7.	Skalzangling	450	1,400	Daily	Most of the vehicle workshops are here.
8.	Murtsey	1711	8,473	Monday	Govt has leased out land to govt employees for a very long term.
9.	Housing Colony B	425	1,550	Monday and Thursday	Most of the govt quarters are in this area
10.	Housing Colony A	778	3,580	Monday and Thursday	Most of the govt quarters are in this area
11.	Maneytselding	865	4,325	Daily	Highest Density
12.	Skampari	950	2,370	Tuesday and Friday	Most of migrant workers live here.
13.	Zangsti Skynos	472	2,470	Daily	Concentration of Tourist Population
TOTAL		**6,820**	**34,798**		

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LEH

WASTE FLOWS

A COMPREHENSIVE STUDY ON MUNICIPAL SOLID WASTE MANAGEMENT IN LEH

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