TABLE OF CONTENTS

Sno.	Items	Document in folder
1.	Waste Management related Study	• Detailed study on fish processing waste, coconut shell waste, flower waste and sawmill waste in the city of Port Blair • Waste Characterization Study • Baseline and CAP for Organic Waste • Training material for NADEP Composting • Training Material for Crate Composting • Compendium on Best Practices of Port Blair • Material Recovery Facility for Port Blair • PBMC_ Situation Assessment, recommendation and roadmap • ANI Organic Waste Strategy • Green Marriage Concept
2.	Guide book and Guidelines	• Guide for the Tourism Sector to Combat Marine Litter • Standard Operating Procedure Clean-up Drives : Port Blair
3.	IEC Poster and Design	• Stickers
4	Video link-Best Practices of Port Municipal Council	Best Practices of Port Blair Municipal Council in Waste Management - YouTube
5.	case study on dry waste management initiative by Port Blair Municipal Council	(390) Case Study on Dry Waste Management in Port Blair Municipal Council - YouTube

Detailed study on fish processing waste, coconut shell waste, flower waste and sawmill waste in the city of Port Blair

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Global Project Export Initiative Environmental Protection
GreenTech „Made in Germany" (BMUV)

Registered offices Bonn and Eschborn

Management of Organic Waste in India

3rd Floor, B-5/5, Safdarjung Enclave
New Delhi 110029

T + 91 4949 5353
F + 91 4949 5391
E info@giz.de
I www.giz.de

Responsible
Mrs. Vaishali Nandan
Head of Project

Authors
Mr. Aviral Saxena
Dr. V. Shiva Shankar

Editors
Ms. Carla Rossitto
Ms. Soma Biswas

On behalf of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)

GIZ India is responsible for the contents of this publication.

New Delhi, India
August 2022

Contents

List of Figures

List of Tables

Abbreviations

ANI	Andaman and Nicobar Islands
ANPCC	Andaman and Nicobar Pollution Control Committee
BCWG	Bulk Coconut Waste Generators
BFPWG	Bulk Fish Processing Waste Generator
CBM	Cubic Meter
CW	Coconut Shell Waste
DTD	Door To Door
EEZ	Exclusive Economic Zone
FLC	Fish Landing Centre
FPW	Fish Processing Waste
FW	Flower Waste/ Floral Waste
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
MT	Metric Tons
NGT	National Green Tribunal
PBMC	Port Blair Municipal Council
SMW	Sawmill Waste

Executive summary

A detailed study on (1) Fish processing waste (FPW), (2) Coconut shell waste (CW), (3) Flower waste (FW) & (4) Sawmill Waste (SMW) in the city of Port Blair was carried as part of the project Management of Organic Waste in India (MOWI). There is enormous potential for converting organic waste into corresponding feeds like fishmeal, poultry feed, and compost manure. Thus, a detailed study was conducted to understand the quantum of organic waste generation, current practices, its disposal method, and to propose feasible alternate solutions to manage the aforementioned organic waste streams effectively. To accomplish the objective, requisite information was gathered through a predefined questionnaire, interviews with the concerned stakeholders, field observations, and consultation of relevant literatures.

Main recommendations:

- Setting up of a unit at Dollygunj industrial estate to manage not only fish processing waste but also other waste related to the meat industry.
- Setting up of a unit, comprising of a shredder and drier at Junglighat crematorium, which would help in the handling of coconut shell waste effectively.
- Floral waste can either be composted or used in the manufacture of incense sticks.
- The waste generated from the sawmill could be composted and utilized in forest nurseries, horticulture departments, and agricultural farming.

Structure of this report

Chapter 1: Introduction
Chapter 2: Study area at a glance
Chapter 3: Methodology
Chapter 4: Fish Processing Waste (FPW)
Chapter 5: Flower Waste (FW)
Chapter 6: Coconut Shell Waste (CW)
Chapter 7: Sawmill Waste (SMW)
Chapter 8: Other Meat Waste
Bibliography
Annexures

1. Introduction

Every year, the world creates 2.01 billion tons of municipal solid garbage, with at least 33% of it not being managed in an environmentally safe manner. Waste generated per person per day in the world averages 0.74 kg but varies greatly, ranging from 0.11 to 4.54 kg (Kaza et al. 2018). Globally, 50% of municipal solid waste comprises of organic waste. Middle-income countries like India generate 53% of organic waste (Kaza et al. 2018).

The Indian Union territory of Andaman and Nicobar Islands (ANI's) is situated in the Bay of Bengal. ANI is strategically important in terms of national security and geopolitical. Hence, a large population of tri-command defence personnel are deployed in the islands. Nearly half of ANI's population resides in Port Blair – with close to 150,000 inhabitants (Census of India, 2011), the municipality is the capital city of ANI and the centre for most of ANI's economic activities, being the entry point for tourists and fisheries.

Solid waste generated by the floating population like tourists and the defence personnel's, apart from the native resident population, is a pressure mounting scenario for the Port Blair Municipal Council (PBMC) waste management. A report by Kaladharan et al. (2017) indicates that 47% of ANI solid waste is unmanaged, as compared to the national average of 14%. An affidavit submitted by the Andaman and Nicobar Pollution Control Committee (ANPCC) to the National Green Tribunal (NGT) indicates that PBMC generates about 115 metric tons of municipal waste per day, of which organic waste accounts for 60% (ANPCC 2019). In terms of generated volume, the main organic waste streams identified in the ANI are fish processing waste (FPW), Coconut Shell Waste (CW), Flower Waste (FW), and Saw Mill Waste (SMW). In this regard, a detailed study was commissioned under the Indo-German technical cooperation project Management of Organic Waste in India, to assess the practicality of the uptake/recycling of the main organic wastes in Port Blair, A&N Islands, and contribute to the sustainable waste management in the islands.

Management of Organic Waste in India

India has the potential to produce 5.4 million tons of compost from urban organic waste annually, as about 50% of urban waste generation consists of organic waste fractions. According to MoHUA (2017), the country has 141 functional composting plants with a production capacity of 1.5 million tons per year. However, these plants are mostly underutilized and the actual annual production of municipal compost from these plants is only about 0.2 million tons/year. In addition, 150 plants with a capacity of 1.5 million tons/year are under construction/reconstruction or restart.

The government has already taken several initiatives to introduce a compost strategy to raise awareness of composting, improve the use and profitability of compost production from urban waste as a business model, and subsidize compost to encourage purchase by farmers. However, organic waste management remains a challenge for municipalities.

With a focus on integrated waste management, the Ind-German technical cooperation project Management of Organic Waste in India (MOWI) aims to improve sustainable organic waste management practices in the three cities of Kanpur, Kochi and Port Blair and their respective states. This includes centralised and decentralised systems of organic waste management like aerobic composting and biological methanation. The project interventions address issues of waste separation, quality control of compost, testing and linkage with marketing in urban and peri-urban areas, among others.

The MOWI project supports the Global Project Export Initiative Environmental Protection by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) in improving the framework conditions and the development of markets for the introduction and durable application of innovative, integrated environmental and climate protection technologies and the setting up of an innovative green infrastructure, thus contributing to the achievement of the UN Sustainable Development Goals (SDGs). For this purpose, the project implements measures for the expansion of environmental knowledge, awareness-rising and capacity building for the management of organic waste in India, offering demand-oriented specific technical advice services for players from the public and private sector and steering pilot projects for the use of modern environmental technologies in order to transfer technology.

2. Objectives

A detailed study to assess the current practices to oversee fish processing waste (FPW), Coconut Shell Waste (CW), Flower Waste (FW), and Saw Mill Waste (SMW); and accordingly, propose a feasible solution to effectively manage this type of organic waste in the future. Also, the study will rationally uncover the strengths and weaknesses of the proposed venture with regard to the recycling of FPW, CW, FW, and SMW. Environment Impact assessment posed by the organic waste generated from the aforementioned entities. The specific objectives of this study are:

1. To determine the quantum & processing of fish processing waste (FPW), coconut shell waste (CW), flower waste (FW), and sawmill waste (SMW).
2. To understand the current practices of fish processing waste (FPW), coconut shell waste (CW), flower waste (FW), and sawmill Waste (SMW).
3. To determine the possibility of utilizing and reducing the FPW, CW, FW & SMW from the island and minimizing its impact on the environment in Port Blair City.
4. To collect and review data on how the fisheries' waste, coconut Shell waste, flower waste, and sawmill waste are currently being managed in the city.

Alternative approaches might be- adopted to recycle and leverage the most value from the fisheries' processing waste, coconut shell waste, flower waste, and sawmill waste, without sending this valuable resource to the landfill.

3. Study area

The tropical archipelago Andaman and Nicobar Islands (ANI's) are a group of five hundred islands and Islets trending north-south over 700km in the Bay of Bengal. It is an Union Territory (UT) of Indian sovereignty with an area of 8249 km2. The ANIs are closer to Indonesian land than to mainland India (1200Km), with the southernmost island only 150 km from Sumatra and the northernmost landfall,190 km south of West Myanmar. The Andaman groups of islands are made up of the South, Middle, and North Andamans, whereas the Nicobar group is made up of several smaller islands. The region is bestowed with tropical, hot, and humid climate with 3074.3 mm of rainfall on average per year in 143 rain days. The average annual relative humidity and air temperature is about 81%, and 23.9°C to 30.2°C, respectively.

Port Blair Municipal Council (PBMC) is the only municipal council and is the capital of ANI's. It was promulgated on 15th August 1957 (GPPB-179a, 1957) with ten revenue villages as wards viz.,) Aberdeen village including Aberdeen Bazaar and Ross Island, 2) Phoenix Bay, 3) Delaneypur, 4) Bunyadabad, 5) Haddo, 6) Chattam, 7) Junglighat, 8) Shadipur, 9) South Point, and 10) Lillypur. Later during the three subsequent delimitation periods viz., 30th April 1985 (MGPPB-18, 1985), 6th May 1985 (AN Gazette, 1995), 23rd April 2015 (AN Gazette, 2015) one, seven, and six revenue villages respectively were annexed from the first formulated ten wards. Thus, as of today, the PBMC encompasses twenty-four wards. The current extent of the PBMC is 41.44 Km2, bounded by the geographical coordinates eleven°35'30" and 11°41'30" N and 92°41'30" and 92° 45' 30" E, with a perimeter of 55.31km (figure 1). The coastal frontiers of the study area are lined with sensitive and fragile wetland ecosystems such as coral reefs (Marina Park), sandy beaches (Crabyn's cove), and creek mangrove forests (Carbyn Cove, Garacharma, and Junglighat).

3.1. Background Rationale

The PBMC is the home to more than 1,44,430 individuals in 36309 households (Census of India, 2011). PBMC encompasses peoples of various ethnic groups like the Hindu, Christian, Muslim, Sikhs, Buddhists, etc., speaking different Indian dialects like Hindi, Bengali, Tamil, Telugu, Kannada, Malayalam, Punjabi, etc. Thus, it is known as mini-India wherein, people live here in perfect harmony.

Fish cuisines are the most cherished delicacies by the inhabitants in their daily diet. Junglighat is the major fish landing centre of ANI's, and the catch are made available to the public of PBMC at Bathubasti, Haddo, Junglighat, and Mohanpura fish markets, apart from door to door dispensing by the street vendors. Apart from the local consumption, fishes are exported as well. There are two fish processing units in South Andaman 1) Era fisheries products Pvt Ltd, in Dollygunj within the PBMC jurisdiction and 2) Monsoon fisheries on the outskirts of PBMC in Dhanikhari.

Port Blair is the entry point for both national and international tourists and the prevalent hot humid weather conditions enthuse almost everyone to have tender coconut to beat the heat and keep hydrated adequately. Thus, tender coconut is disposed at every nook and corner of the city by vendors.

Sustainable timber extraction has been adhered to, by the department of environment and forest with a strict workplan to meet the timber demands locally. Chattam Sawmill is a state-run establishment which supplies local timber needs. Also, there are numerous timber-based small-scale industries around the city.

The diverse ethnic fabric of the region is inseparably connected with rituals and practices. Flowers use is an integral and vital part in day-to-day activities, women adorn them in their hair, offerings to the almighty, etc.

The organic waste generated from fish, tender coconut, timber, and flowers is a menace to the aesthetic beauty of the city, warranting health risk, and is a grave threat to sensitive ecosystems like coral reefs, and mangrove forests as well.

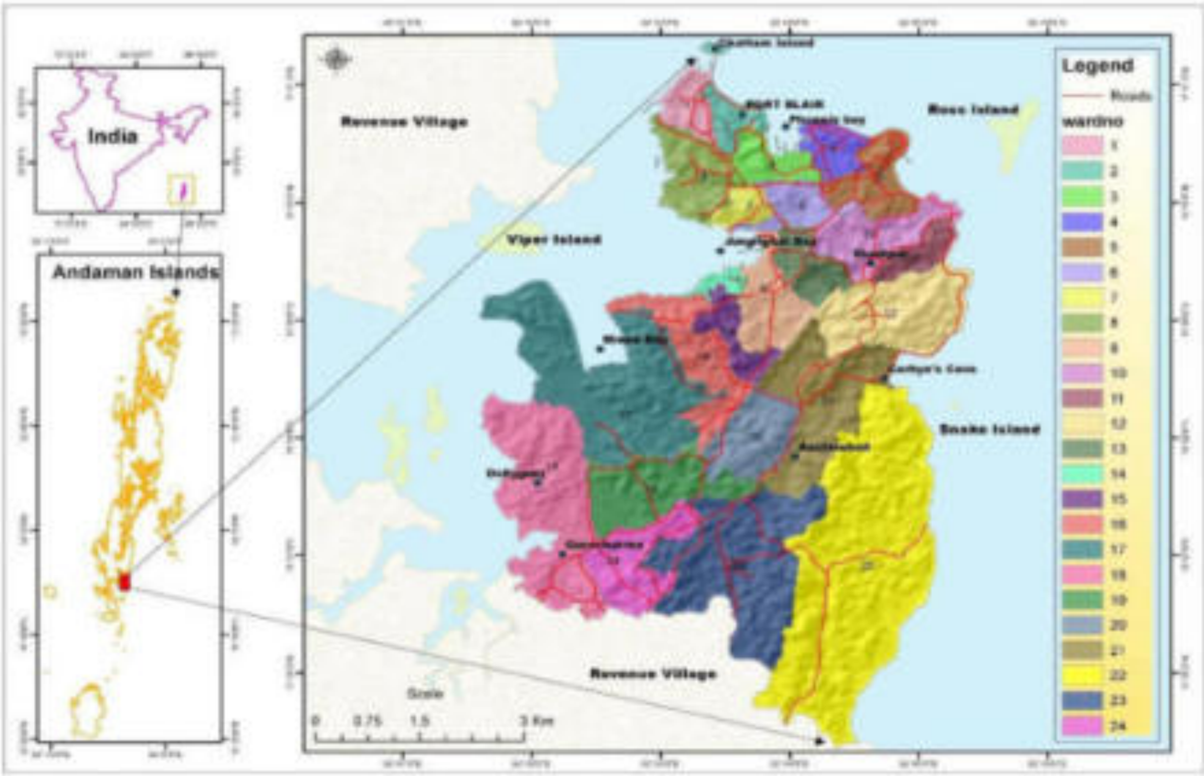


Figure 1 Map of the study area

The ward-wise population and household details are presented in the table below.

Table 1 Wardwise demographic details of PBMC

Ward No	Household	Population	Ward No	Households	Population
Ward -1	1607	6761	Ward -13	1410	5442
Ward -2	1582	6614	Ward -14	1770	6754
Ward -3	1717	6749	Ward -15	1712	6141
Ward -4	1680	5976	Ward -16	794	6449
Ward -5	1908	6504	Ward -17	2088	6041
Ward -6	1561	5717	Ward -18	1583	5853
Ward -7	1445	6027	Ward -19	1782	6302
Ward -8	823	5565	Ward -20	1537	6358
Ward -9	1902	6905	Ward -21	1206	5423
Ward -10	1470	5908	Ward -22	813	4631
Ward -11	1607	5625	Ward -23	1361	5453
Ward -12	1322	5348	Ward -24	1629	5884

4. Methodology

The study methodology entails:

1. Review and analysis of baseline situation, existing gaps, and development needs.
2. Develop a survey tool/ format/ methodology, in close coordination with GIZ and in consultationwith PBMC.
3. Gathering data (20% sample size) around FPW, CW, FW, and SMW quantum, processing, anddisposal in Port Blair City (Annexures A1-A7). The information was gathered over fifteen days (field visit).
4. Physical Characterization of Fish Processing Waste.
5. Conducting interviews with relevant stakeholders (small, medium, and large).
6. Geo-tagged photography of the sites viz., FPW, CW, FW, and SMW
7. Estimate amounts of FPW, CW, FW, and SMW being generated in Port Blair City.
8. Determination of the proximal composition of FPW.
9. Proposal of feasible products from FPW, CW, FW, and SMW.
10. Developing digital maps with all details of collected data marking the geolocation and statusof pollution.
11. Identify relevant initiatives existing in Port Blair to support the recycling/uptake of FPW, CW,FW, and SMW.
12. Analysis of all necessary legal, technological, managerial, financial, and social aspects of recycling/uptake of sawmill waste (SMW) in a detailed study.
13. Physical characterization of flower waste at temples and churches.
14. Conduct interviews with different stakeholders like; concerned government officials and other private stakeholders regarding FPW, CW, FW, and SMW.
15. FPW: Fisheries department and PBMC officials, market shopkeepers (Modern Fish market atJunglighat and Mohanpura and some small fish markets in the wards), street vendors, and fisherman at the fish landing facility.

Proximal Composition Analysis of fish waste

Fish processing waste comprise of head, gill slits, guts, fins, etc., this has the same nutritive values as the edible content of the fish. The nutritive values like crude proteins and lipids can be utilized for the production of fish meal and fish silage. The nutritive value in FPW can be assessed through proximal composition analysis.

Determination of moisture content

0.5 – 1g of the grounded sample of thrash fish was taken in a pre-weighted porcelain crucible for the determination of moisture by placing in an electric oven at 105°C for about 15 hours until a constant weight was obtained. During measuring sample placed in a desiccator untilit has become to room temperature. Then, a dried sample with a crucible was weighed accurately theloss of moisture was calculated as the percentage of moisture (AOAC 2005).

*Moisture% = (Sample Fresh weight with crucible – Crucible weight) - (Sample dry weight withcrucible – Crucible weight) / Sample fresh weight * 100.*

Determination of crude protein

Crude protein of trash fish was analysed by Kjeldahl method for that, 0.25g sample was accurately weighed and transferred into a Kjeldahl flask. One teaspoon of digestion mixer which is called a catalyst mixture was added to the sample. 5ml of con.H_2SO_4 added into that. After the Kjeldahl flask was placed on the digestion apparatus. And boil until the solution becomes clear. After it is allowed to cool. Then 25ml of 4% boric acid solution was added to each series of 250mlconical flasks and placed on the distillation apparatus. 5ml of distilled water was added to each tube. Then conical flask and Kjeldahl tube were attached to the distillation unit and preheated. Thedistillation continued till 100 ml of boric acid and ammonia solution was obtained. The flask containing boric acid was titrated with 0.1N H_2SO_4.

*Percentage of crude protein = (burette reading * Normality of H_2SO_4 * 8.75) / (Weight of sample * Dry matter%)*

Determination of crude lipids

1 g of dry sample was weighed and put in the asbestos thimble, Fat extracting beakers were

cleaned and weight accurately, 310 ml of acetone was added into the fat extracting beakers whichwere already dried. The beakers were fixed to the fat extracting apparatus with the sample tube and heated for 4-5 hours with a heating point 60ºC. After the extraction thimble with the extractedsample was removed and the fat extracting beakers were transferred into a vacuum oven at 80◦C.Beakers were weighed again.

*Percentage of Crude Fat = (weight of fat/weight of dry sample *dry matter) *100*

Determination of Ash

Porcelain crucible was weighed and placed in a drying oven for one hour to remove moisture Crucible was removed from the drying oven and placed in a desiccator for cooling then About 3-5g of prepared sample was taken and placed in a muffle furnace at 550 °C for six hours. Then the crucibles with ash were taken from the muffle furnace and cooled in desiccators. The sample was weighed after the cooling (AOAC 2002).

*Percentage of Ash (dry matter basis) = (sample ash weight / sample dry weight) *100*

Sampling Details

The details of sampling of FPW, CW, FW, SMW and other meat waste are precisely representedin table 2.

Table 2 sampling details of FPW, CW, FW and SMW

Sl No	Study	Survey	Sampling No
1	Fish Processing waste	Market	4
		Exporter	2
		Agent	1
		Fishermen	2
		FLC	1
		Shop owners	5
		Street vendors	2
		Aquarium	1
		Proximate composition	45

2	Flower waste	Flower vendors	7
		Temple	16
		Mosque	4
		Church	5
		Buddhist	1
		Gurudwara	1
3	Coconut waste	Vendors	19
4	Sawmill waste	Mills	6
5	Other organic waste	freshwater fish ponds	3
		Chicken	3
		Mutton	5
		Pork	1
		Beef	1
		Poultry farm	3
	Total		138

5. Fish Processing Waste (FPW)

The ANIs have a coastline of about 1,962 km, a continental shelf area of 35,000 km^2,and an exclusive economic zone of 6,00,000 km^2. It is estimated that the fishery potential is 1.48 lakh MT which is 3.8% of our country's total fishery potential. This fishery potential by and largely is untapped due to inclement tropical weather conditions. The Junglighat fish landing centre (FLC) is a major fish landing facility in ANI's. As per the records of the department of fisheries (Table 3) at Junglighat approximately 15618.58 tons of fish landed for the year (2021-2022).

Table 3 Fish landing at Junglighat FLC

Month	Fish landing (Tons)
Jan	1513.4
Feb	1558.4
Mar	435.18
Apr	941.1
May	866.8
Jun	1605
Jul	1350
Aug	1425
Sep	1443.1
Oct	1509.5
Nov	1565.8
Dec	1405.3
Total	15618.58

There are two major fish processing and exporting companies in south Andaman viz., Monsoon fisheries at Dhanikhari and Era fisheries products Pvt Ltd at Dollyjung (Figure 2 & 3).

Stakeholders

Monsoon Fisheries

They export approximately 1260 tons/year of whole round fishes such as mackerel, groupers, rays, sharks, and tuna to countries like Singapore, Malaysia, Thailand, etc. They adhere to procedures such as washing, sorting, grading, blast freezing (-40ºC), cold storing (-20ºC), packing, and exporting. The workforce in this unit is forty-five employees. The source of fish coming to this unit is mainly from Junglighat. However, a variety of fishes are also received from Dignabad, Wandoor, Guptapara, Burmanallah, Shoal Bay, Manjery, etc.

Figure 2 Monsoon Fisheries

Era fishery products Pvt Ltd

This processing and exporting unit has a workforce of twenty-two employees. They export around 1050 tons/year both processed fish and whole round fish to mainland India. The major source of fish for this unit is Junglighat apart from Dignabad, Wandoor, Guptapara, Burmanallah, Shoal Bay, Manjery, etc. The fishes such as grouper, mackerel, and emperor are exported the whole year-round while, fishes like tuna, mirgal, trevally are processed. The processing is as follows, washing, sorting, grading, gut cleaning, clipping of fins, beheading, blast freezing (-35ºC to - 40ºC), cold storing (-20ºC), packing, and exporting.

Approximately, in a month fifteen to 18 days fishes are received from the aforementioned sources. Around 700 to 800 Kg of waste is generated per day which is 50% fish processing waste. Annually around 1050 tons of waste is generated from this unit and the FPW makes its way to the landfill and Brookshabad.

Figure 3 Era fishery products Pvt Ltd

Fisheries Aquarium

The aquarium at various public and government offices (Table 4) is maintained by the fisheries department, Andaman, and Nicobar administration. Around 540 to 600kg/year of fresh fish are fed to the marine aquarium fishes and the waste accounts for 10% (~54-60kg) annually. Marine life forms such as clownfish, scorpionfish, lobster, snapper, surgeonfish, starfish, etc., are maintained in these aquariums.

Table 4 Details of Aquarium at various public and government offices in PBMC

Sl No	Location	Marine tank	Freshwater tank
1	Aquarium Dept Fisheries	14	2
2	Raj Niwas	2	3
3	Chief Secretary Office	0	2
4	Development Commissioner	0	1

Fish markets and street vendors

PBMC has one fishery product export company (Figure 3) and four major fish markets at Junglighat, Mohanpura, Bathubasti, and Haddo (Figure 4 & Figure 5). The Junglighat fish market is the biggest of all markets with around one hundred shops and Haddo is the smallest (10 shops). Similarly, 30 and 35 shops are at Bathubasti and Mohanpura, respectively. Also, there are fifteen dedicated freshwater fish shops at Bathubasti apart from the marine fish shops. In markets like Junglighat, Mohanpura, and Bathubasti, fresh dry marine fishes and freshwater fishes are available as well. The market analysis at these facilities indicate that 40kg to 50kg of fishes is sold every day in each shop with a 20% loss due to processing, that is 10kg of FPW generated by every shop. Scales, fins, guts, and gill slits are the waste generated during processing. Apart from these four markets as per the department of fisheries Andaman administration, there are eighty-one registered street vendors. Especially women play a pivotal role in dispensing fish to every nook and corner of PBMC. Further, there are unregistered street vendors as well. The street vendors sell around 10-15kgs of fish every day generating 20% of FPW. Whereas 40% of waste is generated per kg of lobster, prawn, and crabs. The FPW generated at Junglighat, Mohanpura and Bathubasti are scavenged by cats, dogs, and bandicoot's overnight. Later the FPW is dumped at Brookshabad by the PBMC. The waste generated by the street vendors lands either in the dust bin/gutter/sea at the end of the days' office, whichever is convenient. Also, stray cats and dogs happen to scavenge the FPW generated during the working hours of street vendors.

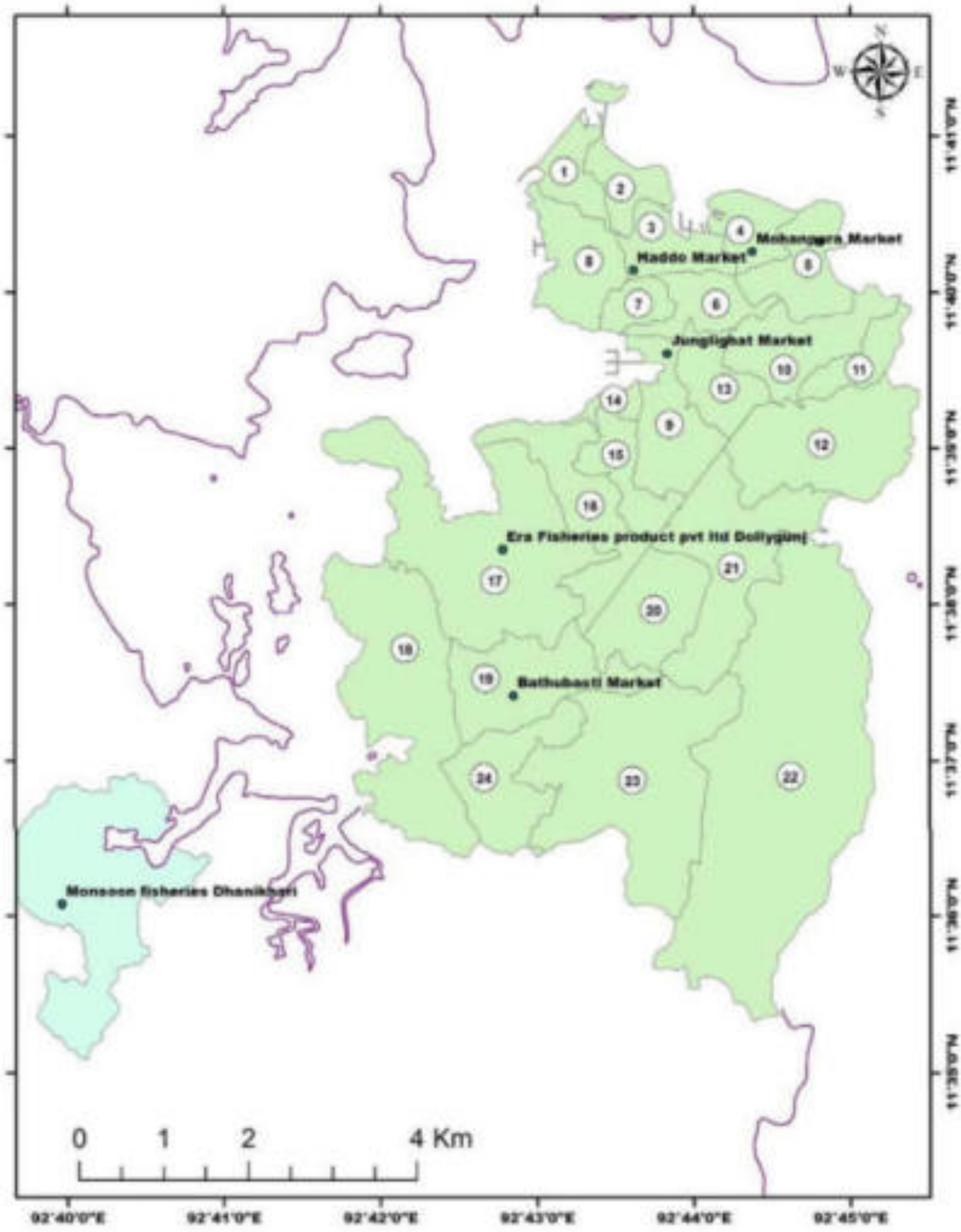


Figure 4 Map showing fish processing waste sampling locations

		
a) Bathubasti dumpsite	**b) With EswarRao (Agent)**	**c) Fisherman Jogi Rao**
		
d) Junglighat FLC	**e) FPW at Junglighat**	**f) Mohanpura Market**

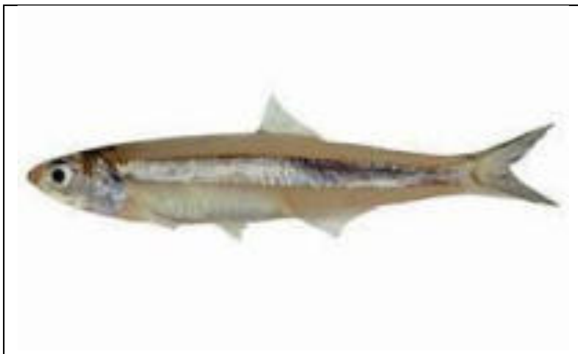
Figure 5 Field photos of FPW survey

Proximal composition analysis

Fifteen commonly encountered fishes in the market that are exported and locally consumed were chosen for proximal composition analysis (Table 5 and Figure 6). The Head, gills, and intestine of these fifteen fishes were subjected to proximal composition analysis like crude protein, crude lipids, moisture, and ash content. The laboratory analyticalreports are presented in Table 6.

Table 5 List of fishes for proximal composition analysis

S. No	Name English	Vernacular name	Scientific Name	usage (Local/Export)
1	Indian anchovy	Maya machi	Stolephorus indicus	Local
2	Milk fish	Rohi persa machi	Chanos chanos	Local
3	Gaint seaperch	Kural machi	Lates calcarifer	local/export
4	Brownspotted Grouper	Gobra machi	Epinephelus chlorostigma	local/export
5	Yellowtail scad	Kokari machi	Atule mate	local/export
6	Rusty Jobfish	Rohi machi	Aphareus rutilans	local/export
7	Checkered snapper	Hiran machi	Lutjanus decussatus	local
8	Deepbody Silverbiddy	Poti machi	Gerres abbreviatus	Local
9	Yellowfin tuna	Tuna machi	Thunnus albacares	local/export
10	Largeface emperor	Kushal machi	Lethrinus olivaceus	local/export
11	Yellowstripe goatfish	Dhadi machi	Mulloides flavolineatus	Local
12	Silver-batfish	Pamplet	Monodaatylus argenteus	Local
13	Largescale mullet	Persa machi	Liza macrolepis	Local
14	Indian mackerel	Bangadi machi	Rastrelliger kanagurta	local/export
15	Bigeye barracuda	Dundus machi	Sphyraena forsteri	Local



1) Indian anchovy

2) Milk fish

	
3) Gaint seaperch	4) Brown spotted Grouper
	
5) Yellowtail scad	6) Rusty Jobfish
	
7) Checkered snapper	8) Deep body Silverbiddy
	
9) Yellow fin tuna	10) Large face emperor

11) Yellowstripe goatfish

12) Silver-batfish

13) Largescale mullet

14) Indian mackerel

15) Bigeye barracuda

Figure 6 : Pictorial illustrations of the fishes available in markets of PBMC

Table 6 Proximal composition analysis laboratory report

Sl No	Fish name	SampleNo	Moisture	Crude Protein	Crude Lipids	Ash
1	Indian anchovy	1a	75.642	11.819	8.269	4.27
		1b	76.151	12.513	8.826	2.51
		1c	75.31	11.993	7.807	4.89
2	Milk fish	2a	72.18	20.37	3.43	4.02
		2b	72.38	20.23	3.41	3.98
		2c	72.4	20.34	3.4	3.86
3	Gaint seaperch	3a	70.49	20.73	4.91	3.87
		3b	70.49	20.79	4.89	3.83
		3c	70.49	20.89	4.87	3.75
4	Brownspotted Grouper	4a	74.69	16.93	4.89	3.49
		4b	74.66	16.91	4.93	3.5
		4c	74.91	16.99	4.9	3.2
5	Yellowtailscad	5a	76.48	20.47	2.12	0.93
		5b	76.45	20.49	2.18	0.88
		5c	76.59	20.5	2.19	0.72
6	Rusty Jobfish	6a	72.49	18.73	4.91	3.87
		6b	72.3	19.7	4.82	3.18
		6c	72.29	19.09	4.87	3.75
7	Checkered snapper	7a	71.18	20.37	4.43	4.02
		7b	71.38	20.23	4.41	3.98
		7c	71.4	20.34	4.4	3.86
8	Deepbody Silverbiddy	8a	71.58	20.37	4.03	4.02
		8b	71.39	20.23	4.8	3.58
		8c	71.56	20.52	4.6	3.32
9	Yellowfintuna	9a	77.3	18.8	2.4	1.5
		9b	77.2	18.9	2.5	1.4
		9c	77.3	18.8	2.5	1.4
10	Largeface emperor	10a	70.49	20.73	4.91	3.87
		10b	70.39	20.79	4.99	3.83
		10c	70.37	20.89	4.87	3.87
11	Yellowstripe goatfish	11a	72.18	19.37	4.43	4.02
		11b	72.38	19.23	4.41	3.98
		11c	72.4	19.34	4.4	3.86
12	Silver-batfish	12a	72.58	19.37	4.03	4.02
		12b	72.39	19.23	4.8	3.58
		12c	72.56	19.52	4.6	3.32
13	Largescale mullet	13a	72.58	19.37	4.03	4.02
		13b	72.39	19.23	4.8	3.58
		13c	72.56	19.52	4.6	3.32
14	Indian mackerel	14a	76.19	19.123	2.98	1.707
		14b	76.17	19.179	2.95	1.701
		14c	77.11	19.27	2.32	1.3
	Bigeye	15a	76.3	19.8	2.4	1.5
		15b	76.2	19.9	2.5	1.4

15	barracuda	15c	76.3	19.8	2.5	1.4

*Note: a- head, b-gills, and c-guts

The proximal composition of the fifteen fishes indicates moisture content is the highest and ash content is the least. Crude protein and lipids may be targeted for the production of fish meal and silage.

Current practice of managing FPW

The fishermen of south Andaman go on a fishing expedition to all islands in north Andaman and Little Andaman in the south except the tribal reserves. The fishing expeditionin big boats (>40HP) lasts for 10-15 days with a crew size of fifteen men and catch one ton of fish in a trip. On the other hand, a small boat (10-15HP) fishing expedition lasts for one to three days with a crew size of six zero to 200kg of fishes per trip. The amount of fish caught is not consistent as luck and weather play a pivotal role. The majority of the fish landings are in Junglighat. Also, fish from the outskirts of the city like Guptapara, Manjeri, and Wandoorreach the Junglighat market as well. Further export quality fishes reach Monsoon fisheries and Era fishery products processing unit. Ultimately the FPW generated at the market level to thehousehold level reaches the Brookshabad dump yard (figure bellow).

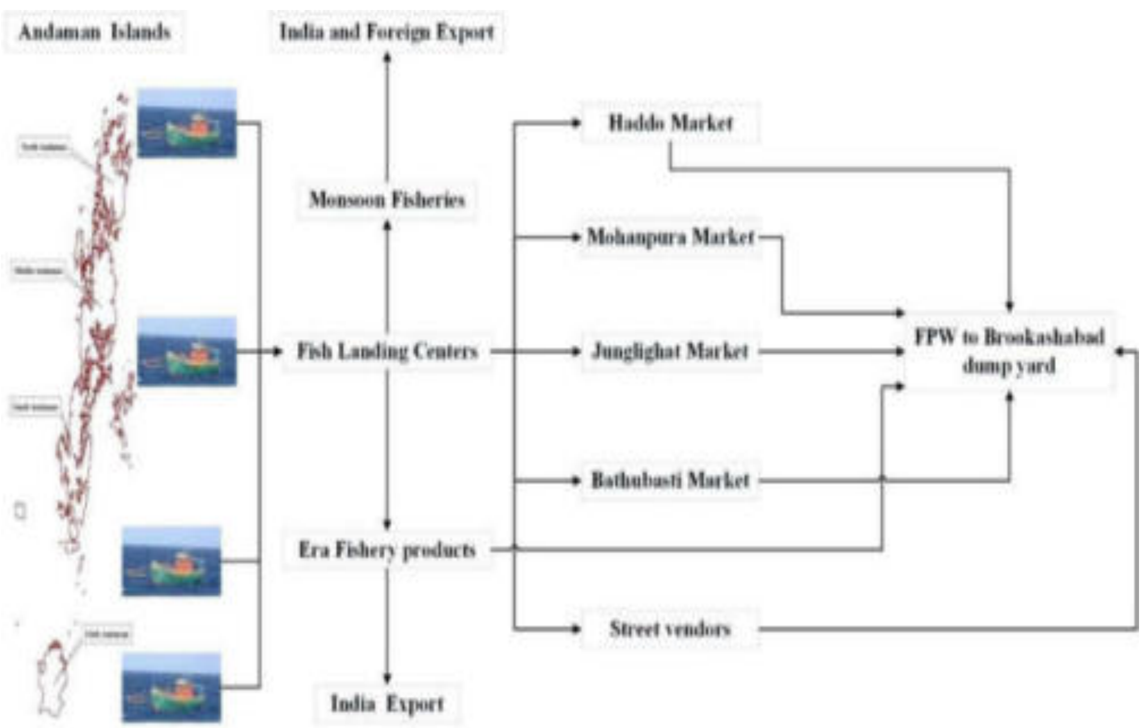


Figure 7 Pathway of fish and FPW

Annually the Junglighat fish landing facility receives approximately 15618.58 tons of fish (table 3). There after bulk fishery catch moves to various destinations within the city and out of the city as well. The annual distribution of fishes is depicted in table 7. From the table 7 it is understood that bulk of the fishes reach two destinations via., Monsoon fishery and Era fishery for exporting to foreign and mainland India respectively. Followed by various fish markets, street vendors and mobile vendors. It is noteworthy to mention that unregistered mobile street vendors not only dispense fish within the city limits but also the bordering revenue villages of the city. Most of the mobile street vendors are women, hire a pickup autoto reach the fixed destination and thereafter sell the fishes on foot. While there are few vendors who use two-wheelers, three-wheelers, and four-wheelers as well to sell the fishes in the remote villages of south Andaman.

Table 7 Detailed breakup of annual distribution of fishes from Junglighat FLC

Location	Distribution Tons/year
Monsoon fisheries	1026
Era Fishery	2100
Junglighat Market	1825
Mohanpura Market	638.75
Haddo Market	73
Bathubasti Market	547.5
Registered fixed Street vendors	591.3
Unregistered mobile street vendors	1204.5
Rural Supply	110
Tourist Take away	99
Dry Fish	1156.1
*Handling Loss big boats @ fifteen%	2342.78
*Handling Loss motorized boats @ ten%	1561.85
*Handling Loss Small boats @ three%	468.56
*Handling Loss at cold storage @ ten%	1561.87
**handling Loss by the vendor @ two%	312.37
Total	15618.58
Fish landing at Junglighat	15618.58
Note: 1) *The handling loss of fish are efficiently utilized as a supplement feed for local poultry, freshwater aquaculture, piggery andduckery by salting and sun-drying. 2)** 2% handling loss by the street vendor/mobile vendor go into the dustbin/gutter/fed to stray animals/into the sea	

A total of 40% fish handling loss is incurred from fishing boats to households. Out ofwhich 38% of handling loss are efficiently utilized as a supplement feed for local poultry, freshwater aquaculture, piggery and duckery by salting and sun-drying. This handling loss may be attributed to either lack of proper icing of the catch or the huge weight of the ice maydepilate the underling fishes. Approximately four lakhs tourists, of which 15000 are foreign tourists, visit Andaman annually. Of the four lakhs around fifty thousand to one lakh tourists visit the local fish market to carry home approximately 1kg to 2kg of any one or all of theseafoods like prawns, lobsters and crabs based on the availability. This direct take away by the tourist’s accounts to ninety-nine tons approximately yearly. Around 1156.10 tons of dry fish isprepared annually for local consumptions and a minor amount is exported as well (Basicstatistics 2010).

Figure 8 Junglighat fish compost unit

The present study identified five major Bulk Fish Processing Waste Generators (BFPWG) within the limits of PBMC. The details of BFPWG are depicted in table 8. From table 8 it was understood that 1666.8 5tonnes of FPW is generated in the city annually. Since the fish composting unit at Junglighat (Figure 8) is non- operational all the FPW generated is escorted to the Brookshabad dump yard. As on date, the nutritional values present in FPW are going in vain.

Table 8 Bulk Fish Processing Waste Generator in PBMC

FPW	No of Units	FPW (kg) /day	FPW (T) /Month	FPW (T) /Year
Era Fisheries	1	800	87.5	1050
Junglighat market @10kg/shop	100	1000	30	365

Mohanpura market @10kg/shop	35	350	10.5	127.75
Haddo market @ 10kg/shop*four	10	40	1.2	14.6
Bathubasti @ 10kg/shop	30	300	9	109.5
Register street vendors	81	243	7.29	118.26
Unregistered mobile street vendors	220	669	20.07	240.9
Dry Fish		642.27	19.26	231.22
Handling loss @ 2% by vendor/mobile vendor		855.80	26.03	312.37
	Total	4.9T	210.85T	2569.6T
Note: 1) * Only four shops are operational				

Recommendation for FPW

Globally there are many tested and proven methods for effectively managing FPW. Also, lots of research is underway for innovating eco-friendly products from the FPW. Such as:

- Fish lipids can be converted into biofuels.
- The lustrous fish scales can be pulverized to prepare glossy enamel for artificial ornamental beads and made available for the local handicraft industries.
- Production of bioplastics from fish scales. Reference: (https://www.smithsonianmag.com/innovation/bioplastic-made-from-fish-scales-just-won-james-dyson-award-180973550/)
- Fish scales are also a raw material in collagen-based products such as skin moisturizers, anti-aging creams, wrinkle removers, hand creams, cleansing gels, and all manner ofBotox knockoffs and raccoon-eye miracle cures. Reference: (https://agrowastehx.com/products/dried-fish- scales/278.html#:~:text=Fish%20scales%20are%20also%20a, and%20raccoon%2Deye%20miracle%20cures.).

The best feasible solution for managing FPW in Port Blair is enumerated below.

- FPW mixed with moss plant will result in an excellent organic manure.
- Fish silages can be produced from FPW (figure 9).

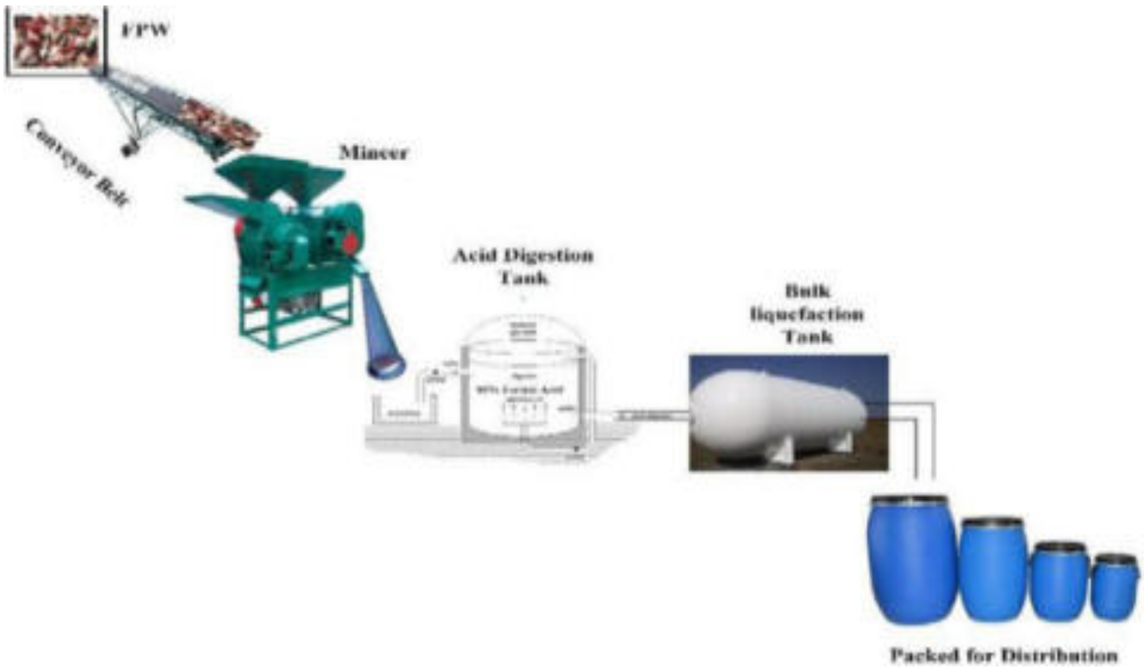


Figure 9 Model of fish silage unit

- FPW can be converted into fish meal (Figure 10).

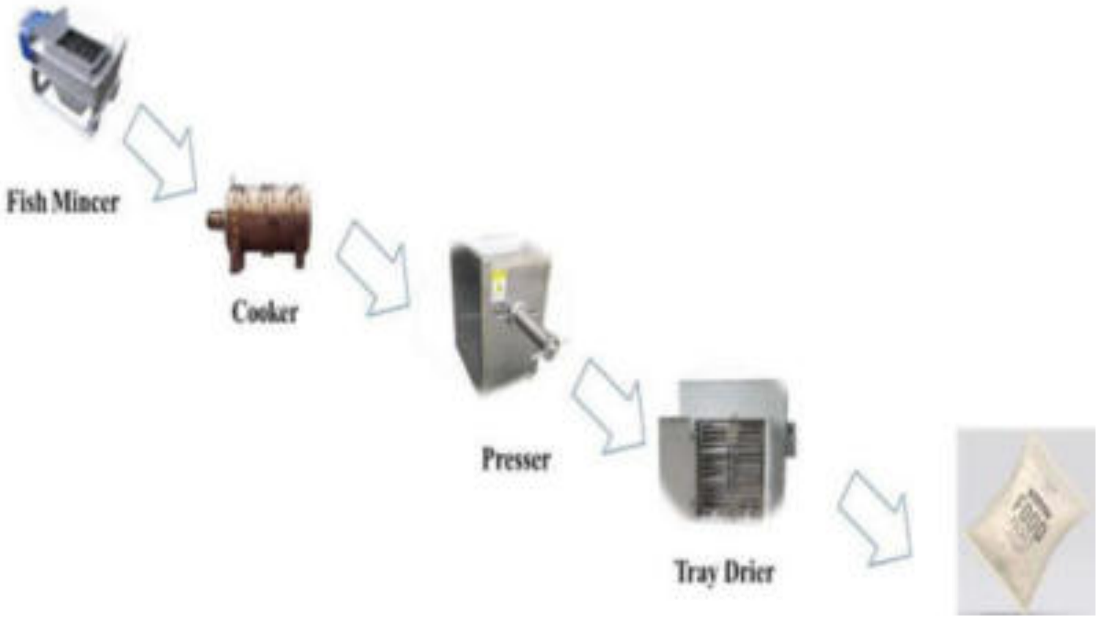


Figure 10 Model of fish meal unit

- Fish meal from FPW can be used as a feed for piggery.
- Fishbones are useful source of phosphorous, calcium, and magnesium can be convertedinto dissolvable pellets and may be used as good agricultural manure.

- Currently FPW are disposed at Brookshabad dump yard. Instead, it is highly recommended that an FPW unit may be set up at Dollygunj (figure 11).
- The proposed FPW unit at Dollygunj industrial estate (figure 11) will not only reduce the fuel cost but also efficiently manage the FPW.
- Further, there would not be any litigations from the public as well.

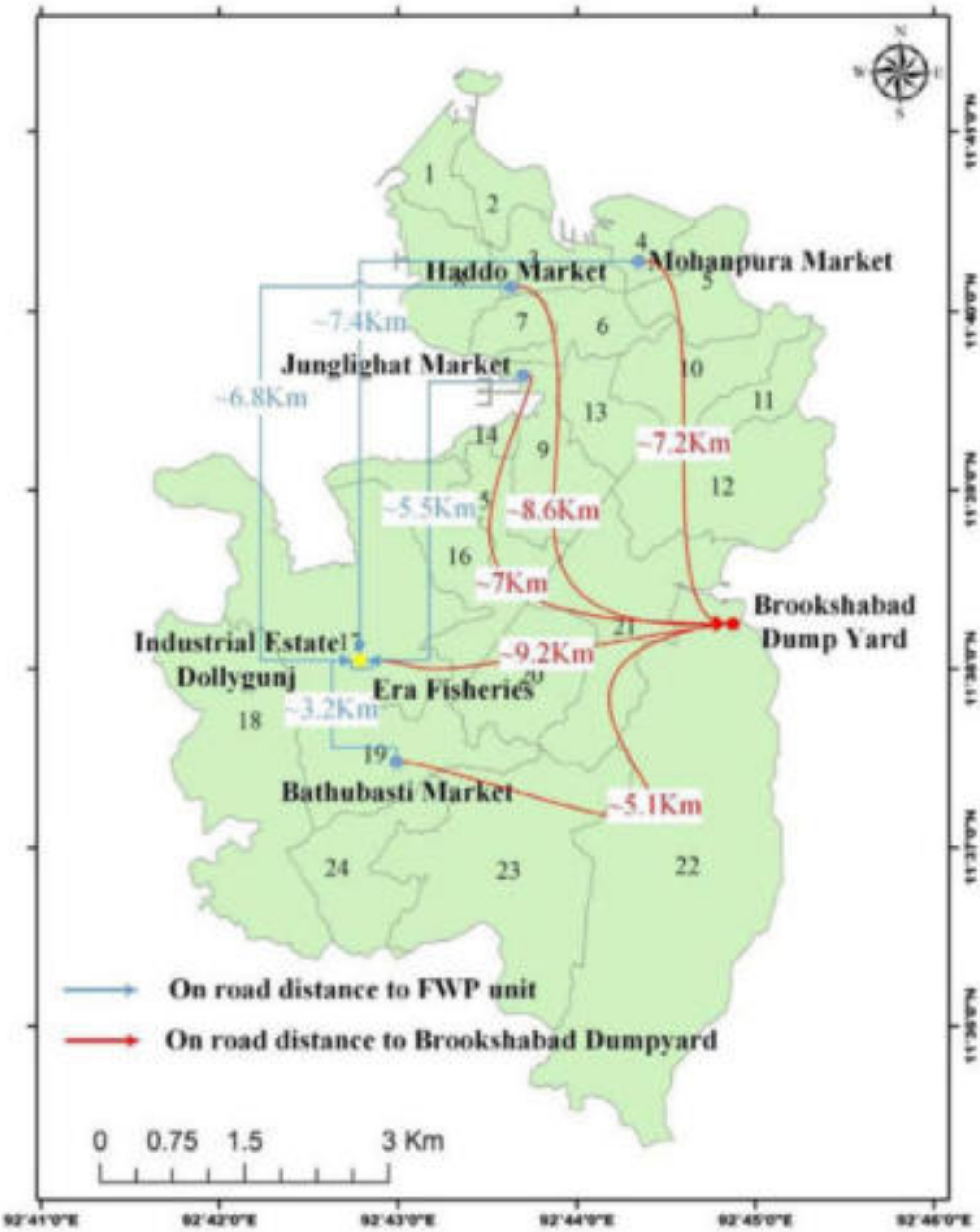


Figure 11 On road distance to existing Brookshabad Dumpyard and proposed FWP unit at Dollygunj Industrial estate

6. Flower Waste (FW)

The flora demands of the city, is met by importing them from mainland India, especially from Chennai, Tamil Nadu. There are around twenty-seven flower shops in the city. Flower shops can be encountered at places such as Aberdeen Bazar, Bathubasti, Dairy farm, Junglighat, and Austinabad. The flower shops at Dairy farm and Austinabad make their purchases from Aberdeen Bazar and Bathubasti, respectively. Owing to the short shelf-life of flowers, the interviews were conducted with seven flower shop keepers and a survey in twenty-seven separate places of worship like temples, mosques, churches, Buddhist temple, and gurudwara (figure 12) to understand the source and destination of flower waste.

Flower Vendors

There are around twenty-seven flower vendors in the city of which two are major, fifteen moderates, and the rest are small business. Interviews were conducted with seven flower vendors around the city. Out of the seven two vendors act as local agents, two moderate and three small vendors. Although the flowers are packed individually in the name of the vendors in Chennai. But it is dispatched in the name of these two vendors located in Aberdeen Bazar (Figure 13a and 13b). Also, a vendor based at Bathubasti (Figure 13c) makes some good business unlike the two located at the Aberdeen Bazar. All the vendors import the flowers from Chennai except one (figure 13a), who imports it from Madurai as well apart from Chennai. Five distinct types of flowers are commonly used viz., Marigold, Chrysanthemum, Rose, Jasmine, and Nerium to cater the local demands. Out of these five kinds of flowers, marigold is the most sought flower followed by chrysanthemum and Nerium, the least. As of now, flowers are imported thrice a week. The quantity of flower imports depends on the availability, demand and inhouse stock. The sales of flowers is quite high on Tuesday's and Fridays in comparison to other weekdays. Also, imports of flowers are high during festival months viz., October, November, January, and February. It was understood from the interview of the flower vendors that the common public takes the majority share through petty purchases 1) to be adorned over the head (ladies), 2) to decorate GODs at home and shops, and 3) to pay the last homage to the heavenly abodes. Further, flowers from the shops move out of the city limits to the rural areas as well. The surveyed seven flower vendors were categorized into big, moderate, and small and the floral waste generate per week at the first point of sales is depicted in table 9.

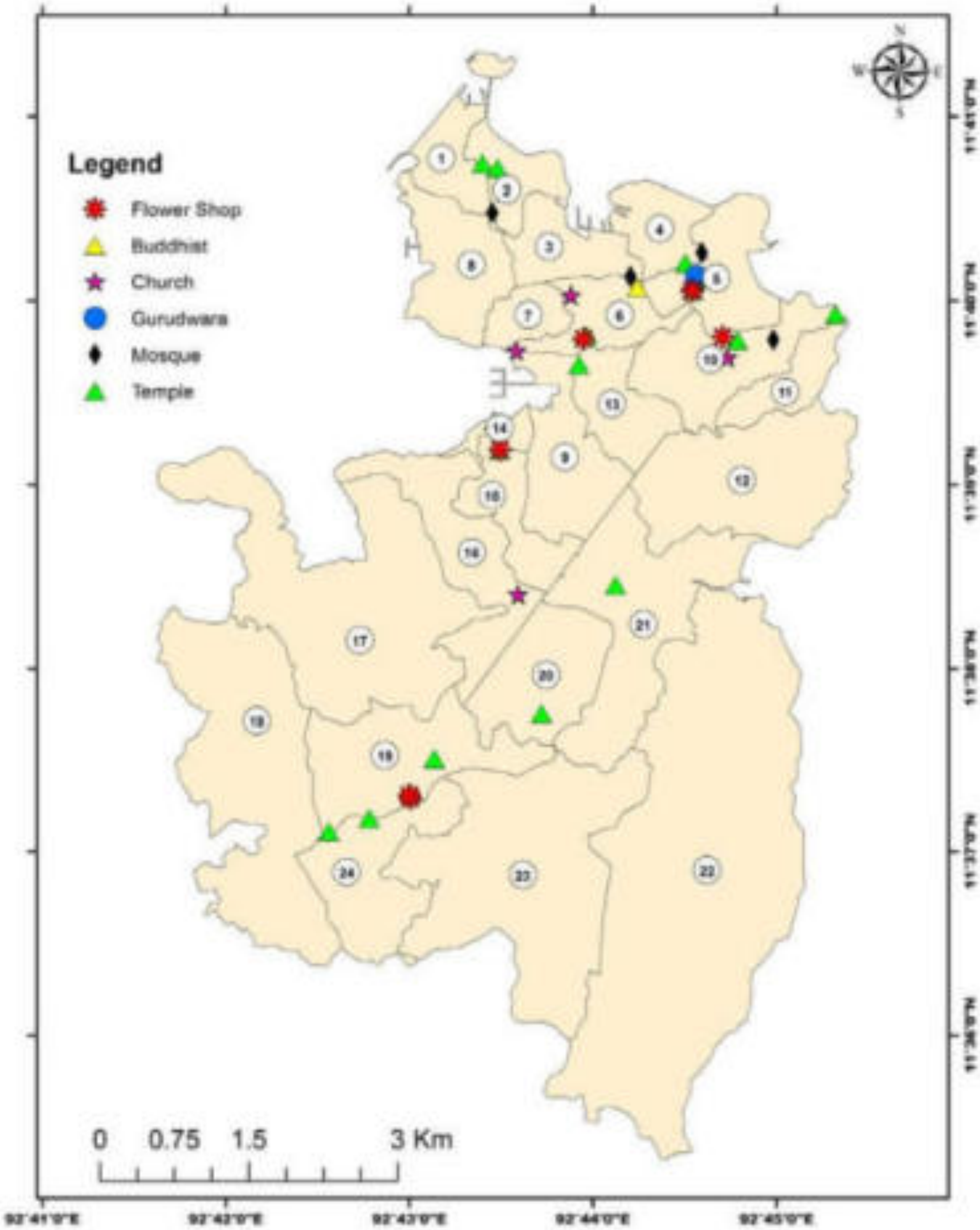


Figure 12 Map showing flower waste sampling locations

From the data of the below in table 9, the floral waste generated per year by the twenty-seven flower vendors was calculated and is presented in table 10. During the festive months viz., October, November, January, and February 10% extra floral waste is generated. Thus, the waste generated is disposed off to the Door to Door (DTD) PBMC garbage pick service.

		
a) Chandran Flowers	b) M.K. Kannan Flowers	c) SAS

Figure 13 Major flower vendors of PBMC

Table 9 Floral waste generated per week in PBMC at the shop level

Vendors	Sample Size	Marigold (Kg)		Chrysanthemum (Kg)		Rose (Kg)		Jasmine (Kg)		Nerium (Kg)	
		Im	Wa	Im	Wa	Im	Wa	Im	Wa	Im	Wa
Big	2	450	65	110	11	110	8	47	4.5	13	2.6
Moderate	2	200	20	70	8	40	8	30	3	5	1
Small	3	120	7	45	7.5	29	5.3	46	4	4.5	0.9
Total	7	770	92	225	26.5	179	21.3	123	11.5	22.5	4.5

Note: Im- import & Wa- waste

The annual waste generated by various flowers like marigold, chrysanthemum, rose, jasmine and nerium range from 1.82T to 3.38T, 0.572T to 3.12T, 0.416T to 3.12T, 0.234T to1.17T, and 0.135T to 0.39T respectively (table 10).

Table 10 Annual average floral waste generated in PBMC at the shop level

Vendors	No. Vendors	Marigold (T)		Chrysanthemum(T)		Rose (T)		Jasmine (T)		Nerium (T)	
		Im	Wa	Im	Wa	Im	Wa	Im	Wa	Im	Wa
Big	2	23.4	3.38	5.72	0.58	5.72	0.42	2.44	0.23	0.68	0.14
Moderate	15	78	7.8	27.3	3.12	15.6	3.12	11.7	1.17	1.95	0.39
Small	10	31.2	1.82	11.7	1.95	7.54	1.38	11.96	1.04	1.17	0.23
Total	27	132.6	13	44.72	5.65	28.86	4.91	26.10	2.44	3.79	0.76

Note: Im- import & Wa- waste

Floral Waste generated at worship places

A total of twenty-seven different worship places of worship like temples (16), mosques (4), churches (5), Buddhist temple (1) and, gurudwara (1) in the city limits were inspected and surveyed. Zero floral waste is generated from mosques and gurudwara. While a very minimalamount of FW is generated from the churches and Buddhist temple. The minimal FW wastegenerated in the churches is disposed of to the plants in their premises. Also, the church respondents preferred artificial decorative flowers. Thus, temples in the city limits generate FW. The sixteen temples surveyed are depicted in table 11.

Table 11 Floral waste generated in temples surveyed in the city

SI No	Temple name	Location	DFW	OW	SDFW
1	Shiv Mandir	Garacharma	0.5	Incense stick wrapper, match box	2
2	Ganesh temple	Bathubasti	1	Incense stick wrapper, match box, coconut	5
3	Radha krishna Mandir	Junglighat	2	Incense stick wrapper, match box	5
4	Veer Hanuman Temple	Junglighat	5	Incense stick wrapper, match box, coconut	10
5	Ganesh temple	Abreeden bazar	5	Incense stick wrapper, match box, coconut	15
6	Vaikund Dham Police Temple	Abreeden bazar	0.5	Incense stick wrapper, match box	2
7	Mariamma temple	Austinabad	2	Incense stick wrapper, match box, coconut	25
8	Aynnar temple	South Point	2	Incense stick wrapper, match box, coconut	20
9	Ganesh temple	Pathergudda	2	Incense stick wrapper, match box, coconut	10
10	Shree ganesh temple	Golghar	2	Incense stick wrapper, match box, coconut	10
11	Saibaba temple	Chargaon	2	Incense stick wrapper, match box, coconut	10
12	Selva vinayagar temple	Haddo	2	Incense stick wrapper, match box, coconut	10
13	Neelkanteswar temple	Machibasti	0.5	Incense stick wrapper, match box	1
14	Sri Vetrimalai Murgan temple	RGT road	5	Incense stick wrapper, match box, coconut	50

Sl No	Temple name	Location	DFW	OW	SDFW
15	Shakthi Vinagar temple	Dairy Farm	2	Incense stick wrapper, match box, coconut	10
16	Venkateswara temple	Haddo	2	Incense stick wrapper, match box, coconut	10
		Total	35.5	Total	195

Note: DFW- Daily Flower Waste, OW- Other Waste, SDFW-pecial Day Flower Waste

From table 11 it can be inferred that a minimum of 0.5kg to a maximum of 2kg FW is generated per day from each of surveyed temples. Other wastes include incense stick wrappers, empty matchboxes, and coconut shell. All the FW waste generated is disposed of to the DTDgarbage pick service. Since the data pertaining to the temples in PBMC is not available, estimating the average FW generated per day or per year is not possible. However, from the surveyedsixteen temples it was understood that 35.5 Kg of FW is generated every day.However, on festive days,195kg of FW is generated. It is understood from this study that worship places do notgenerate a high quantum of FW. Only two respondents from (Ayyanar temple and VetrimaliaMurugan temple) opined to compost in the future. While other respondents prefer to disposeoff the waste to the DTD garbage pick service. Also, it was observed that FW was dumped in the temple premises along with other waste like incense stick wrappers, empty matchboxes, andcoconut shell, etc., in the surveyed sixteen temples. In fact bulk of FW is generated at the household level because of the petty purchase made by the individuals.

Current practice of managing FW

The pathway of FW is depicted in the flow chart (Figure 14)

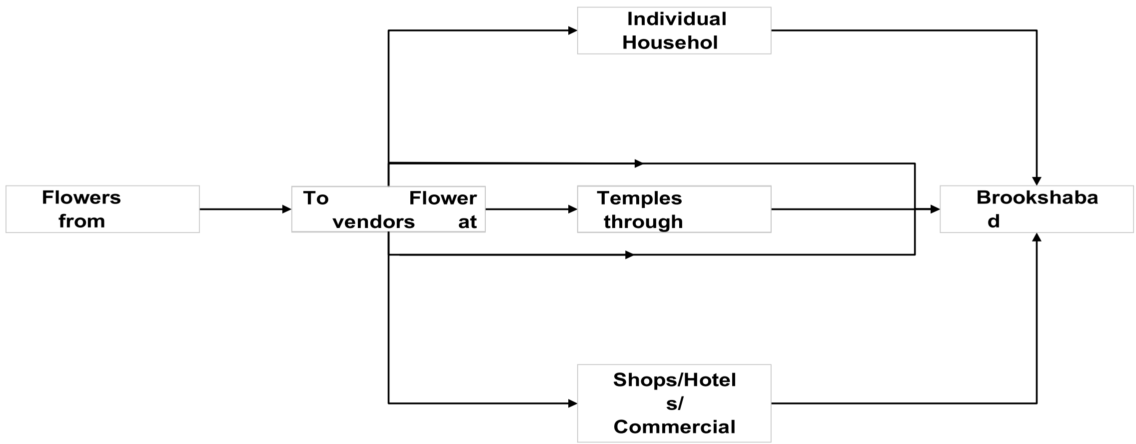


Figure 14 Pathway of floral waste in the city

Recommendation for FW

The bulk of the FW is generated by the flower vendors followed by the temples. The twenty-seven flower vendors and temples may be targeted. The FW has a broad array of eco-friendly produces suchas

- It can be used in the production of biogas and biofuels.
- It can be used in the manufacture of bioethanol, organic acids, pigments, dyes, etc.
- FW can be converted into florafoam that can replace Thermocol. Reference: (https://www.ideassonline.org/public/pdf/IndiaRecyclingFlowers-ENG.pdf).
- Flower waste can be converted into floor cleaner by mixing it will baking soda, salt, and fragrant oil. Reference: (https://swachhindia.ndtv.com/heres-can-treat-flower-waste-turn- every day-use-items-9773/).

The feasible recommendation suited for the island setup are enumerated below.

- FW can be converted into effective compost with coconut fiber, moss, and arecanut fiber.
- It can be used in the production of charcoal-free incense sticks.

7. Coconut Shell Waste (CW)

A total of nineteen coconut vendors were interviewed within the city limits (Figure 15). The respondents were grouped under the categories of - full-time dedicated vendors (Figure 16a & 16c), part-time dedicated vendors (Figure 16d), and petty shop vendors (Figure 16e). The full-time dedicated vendors can be encountered at PBMC headquarters, opposite to head post office, Carbyn cove, and Anthropological Museum. While Petty shops vendors can be located across the interior parts of the city. Part-time dedicated vendors are found around Rithika hospital Garacharma. It was understood that most of the tender coconuts were brought into the city from outskirt areas like Wandoor, Manglutan, Sippighat, Tylerabad, and Chouldari. Furthemore, they are purchased within the city limits.

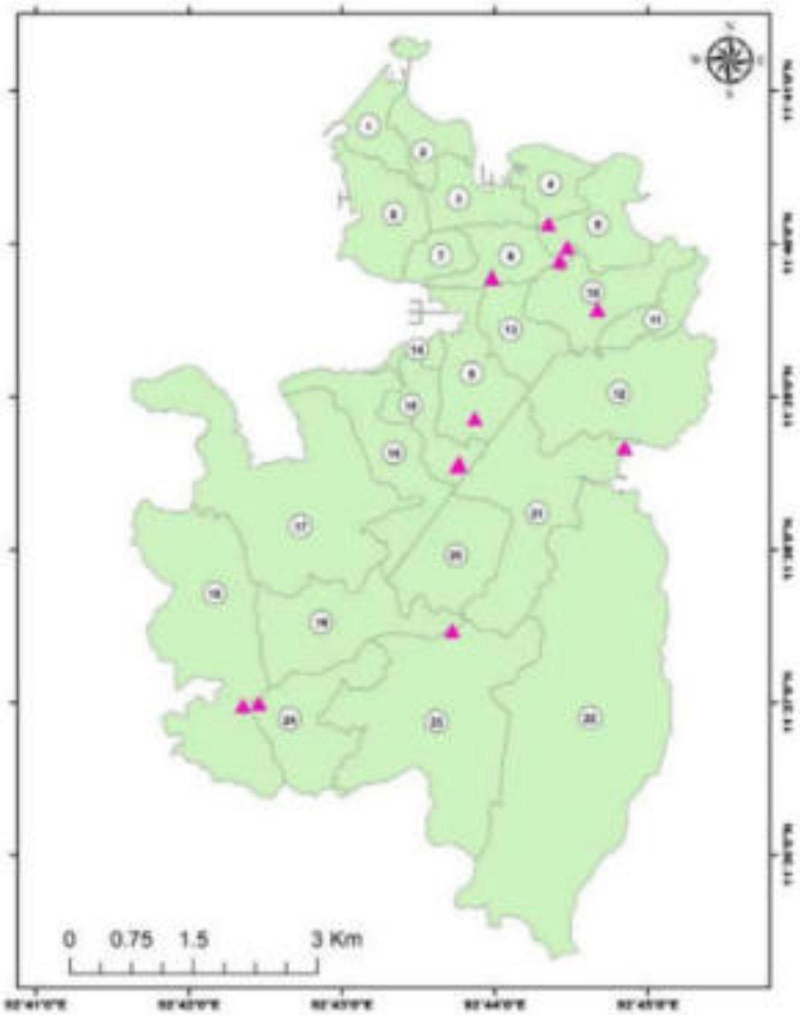


Figure 15 Map showing coconut-shell waste sampling locations

Based on the sales during dry days (Sunny days) the nineteen respondents were classified into three groups viz., High (~150/per day/vendor), Moderate (75/per day/vendor), and Low (~40/per day/vendor). The respondents reported that sales will be at their peak during the summer season and will drop by 60% during the rainy days. A tender coconut weighs around 1 to 1.5kg of which 400ml to 500ml of natural electrolyte is available for drinking. Thus, 600gm to 1kg of organic waste is generated per tender coconut.

The highest sales of tender coconut is around the PBMC head office followed by the four tender coconut shops opposite to head post office and one around the Anthropological Museum. At the aforementioned three locations, there is a dedicated waste pick-up service (Figure 16a-16c). However, the rest of the tender coconut waste in the city is collected and dumped together (figure 16f).

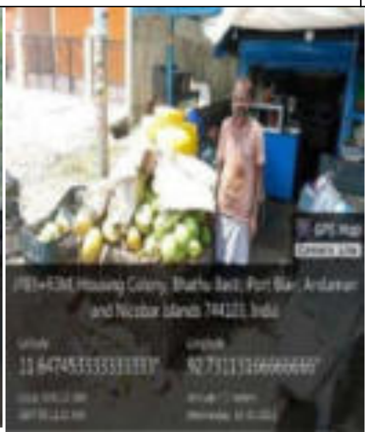
		
a) Opposite to PBMC Hq	b) Dedicated Collection service	c) Opposite to Head Post office
		
d) Part-time vendor	e) Petty-shop vendor	f) Mixed garbage collection

Figure 16 Snapshot of tender coconut shops and waste generated in the city

Data is deficient regarding the number of tender coconut vendors in the city. However, based on the response from the nineteen respondents it is understood that 1.375 tons and 0.825 tons of CW is generated per day during the summer and rainy seasons respectively (Table 12). According to the meteorological statistics, the annual average rain days in Port Blair is 143 days. An annual approximation can be made based on the meteorological statistics (Table 13). Evidently, this waste is landing up in the SLRM.

Table 12 Coconut waste generated at surveyed sites in the city

Type of vendors	**No of vendors**	**Sale/day/vendor**	**~1kg of waste generated/ tender coconut**	
			Dry day	Rain day (@sixty% drop)
High	4	150	600	360
Moderate	5	75	375	225
Low	10	40	400	240
Total	**19**		**1375 Kg/day**	**825 kg/ day**

Table 13 Annual approximate coconut waste generated at surveyed sites in the city

Type of vendors	**CW generate/year in Tons**	
	Dry days (222)/year	Rain days (143)/year
High	133.2	79.92
Moderate	83.25	49.95
Low	88.8	53.28
Total	305.25	183.15

Recommendations for Coconut Waste

The tender coconut fiber is converted into coir, soil erosion control matting along the hill slope, and importantly it is extensively used in producing cocopeat for hydroponic agriculture practices globally. Exporting the coir, incurs significant financial expenditure. Also, use of cocopeat for hydroponic agriculture has proven unfruitful in this tropical climatic condition. The feasible solution for combating CW in the city is enumerated below.

The high and moderate bulk coconut waste generators (BCWG) is located in the heart of the city. Instead of transporting the CW to Brookshabad dump yard which is at a distance of ~6.3km, a simple and small unit comprising of a shredder and a drier (Figure 17) at the crematorium, Junglighat (~2.2km) would create fuel from burning human corpses and organic fertilizer as well. Thus, reducing the 1) the firewood consumption and 2) fuel consumption for mobilizing the CW.

Mumbai's success story of effectively managing CW may be considered as an example. Reference: (https://timesofindia.indiatimes.com/city/mumbai/tender-coconut-shell-garbage-to-turn- into-gold-at-reay-road-crematorium/articleshow/68446494.cms).

Figure 17 Tender coconut waste managing unit at Reay Road crematorium, Mumbai

Even if the CW reaches the Brookshabad dump yard, it may be sorted and sent back through the empty waste disposal trucks to the proposed Junglighat facility.

Additionally, during the field survey, it was observed that the thick edible part (endocarp) of the tender coconut is also disposed of. This endocarp has good nutritive value that may be extracted and used as feed in the piggery. As the Nicobari tribes traditionally follow this in their piggery.

8. Sawmill Waste (SMW)

A total of five sawmills were surveyed. Chattam sawmill is owned by the Andaman administration, Department of Environment and Forest. There are around four empaneled sawmills in south Andaman. Out of which three are located within the city limits and one on the outskirts of the city at Dhanikari. There is one imported timber sales depot (figure 18).

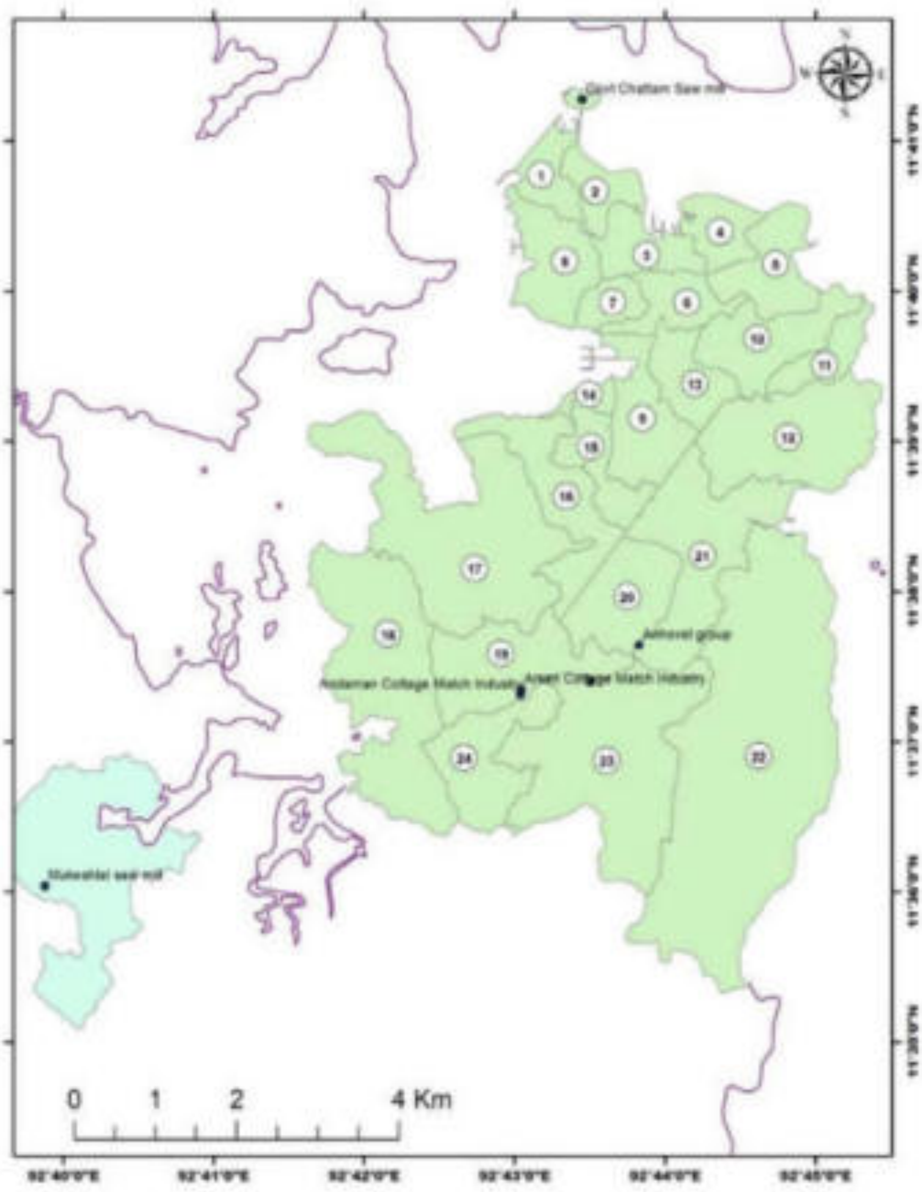


Figure 18 Map showing sawmill survey location

The department of environment and forest executes sustainable timber extraction as per the forest working plan. At present timber, extraction is underway at Manarghat and Manglutan ranges. The extracted category-I timber is escorted to Chattam sawmill. While the rest of the timber belonging to other categories is allotted evenly to the empaneled sawmills by the Vansadan. Table 14 enumerates the category-wise timber extracted. However, the empaneled sawmill receives category-I timber from private parties.

Table 14 Category-wise timber extracted in ANIs

Botanical Name	Trade
CATEGORY-I ORNAMENTAL WOOD	
1. Diospyros marmorata	Marblewood
2. Murraya exotica	Satinwood
3. Pterocarpus dalbergioides	Padauk (Andaman redwood)
4. Sagaeria elliptica	Chooi
5. Tectona grandis	Teak
6. Terminalia bialata	Silvergrey
7. Podocarpus nerifolia	Thitmin
CATEGORY-II SUPERIOR HARDWOOD	
1. Albizzia lebbek	Koko/Siris
2. Lagerstroemia hypoleuca	Pyinma
3. Prunus martabanica	Thingam (Red)
4. Terminalia manii	Black Chuglam
5. Artocarpus chaplasha	Taungpeing/chaplash
6. Dipterocarpus sps.	Gurjan
CATEGORY-III STANDARD HARDWOOD	
1. Artocarpus lakucha	Lakuch
2. Adenanthera pavonina	Ywegi
3. Amoora wallichii	Lalchini/Lali
4. Chakrasia tabularis	Chakrasia
5. Calophyllum inophyllum	Poon
6. Duabanga sonneratiodes	Mau
7. Hopea odorata	Thingam (White)
8. Lannea grandis	Nabble
9. Madhuca butyracea	Hill Mohwa
10. Mesua ferrea	Gangwa / Iron Wood
11. Mangifera andamanica	Jungli Aam
12. Mimusops littoralis	Sea Mohwa / Bullet Wood
13. Nauclea gageana	Thinkla
14. Pajanelia longifolia	Jhingam
15. Planchonia andamanica	Red Bombwe / Lal Bombwe
16. Parishia insignis	Red Dhup
17. Terminalia procera	Badam
18. Terminalia bialata	White Chuglam
19. Miliusa tectona	Jungli Sagwan
20. Crataxylon formosum	Ye-Paduak
21. Ganophyllum falcatum	Jungli Neem
CATEGORY-IV SOFTWOOD	
1. Anthocephalus chinensis	Kadam
2. Albizia stipulate	Bombeza
3. Ailanthus kurzii	Ailanthus
4. Canarium euphyllum	White Dhup
5. Endorspermum chinense	Bakota

Botanical Name	Trade
6. Evodia glabra	Evodia
7. Pterocymbium tinctorium	Papita
8. Salmalia insignis	Didu or Semul
9. Sideroxylon longipetiolatum	Lambapathi
10. Sterculia alata	Letkok
11. Tetrameles nudiflora	Thitpok
12. Zanthoxylum budrunga	Myanin
NON- COMMERCIAL TIMBER	
1. Dillenia species	Zambium
2. Enterolobium saman	Siris (Rain Tree)
3. Ficus species	Gular
4. Myristica species	Jaiphal
5. Pometia pinnata	Thitkandu
6. Xanthophyllum andamanicum	Letphew
7. Spondias mangifera	Ambara
8. Bracantomalum mangifera	Chinyok
9. Syzigium species	Jamun
10. Antiaris toxicaria	Jungli Lakuch
11. Ganophyllum falcatum	Jungli Neem
12. Baccaurea sapida	Kattaphal
13. Pongamia pinnata	Karanj
14. Sterculia villosa	Lal Chilka
15. Aglaia andamanica	Letauk

*Source: Forest Statistics 2017. Department of Environment and Forests Andaman and Nicobar Islands

Approximately around 1535 CBM of scrap wood and 817 CBM of sawdust is generated annually by the sawmills within the city limits. Out of the abovementioned values majority scrap wood (1160 CBM) and sawdust (739 CBM) are generated by the Chattam sawmill (Table 15). During the survey, it was observed that the sawdust was on the floor of the sawmill. Also, the respondents opined about 25% and 5% of scrap wood and sawdust is generated per 500 CBM, respectively.

Table 15 Annual Sawmill waste generated in the city

Sl No	Establishment	Scrap (CBM)	Saw dust (CBM)
1	Govt Chattam Sawmill	1160	739
2	Andaman Cottage Match Industry	125	25
3	Anhovel group	0	3
4	Arsan Cottage Match Industry	125	25
5	Andaman Cottage pencil wood industry	125	25
	Total	1535	817
6	Mukeshlal sawmill (Dhanikhari)	125	25

*Note 1CBM= 333Kg

Current practice of managing SMW

Scrap wood is sold as firewood while the sawdust is sold to the poultry farm for carpeting of the floor. When the sawdust load increases in the mills it is disposed at the Brookshabad dump yard. At Chattam Sawmill scrap wood is converted into charcoal.

Recommendation for SMW

The recommendations made below are globally followed and are well applicable in Andamanas well.

- A pulp made from sawdust can be used in making papers.
- Power generation by burning the scrap wood.
- Bark and sawdust mixed with rice husk to produce growing medium.
- The scrap wood and sawdust can be composted and utilized as manure in forestry andhorticulture.
- Scarpwood can be converted into activated charcoal, and it can used as a contaminant filter.
- Woodcrafts can made from scrap wood
- Sawdust and scrap wood can used to produce pencils.

9. Other meat waste

The investigation was further extended to understand the quantum of organic waste generated from mutton, pork, beef and chicken in the city. Around 120.9 Tons of organic waste is generated annually from mutton, pork, and beef meat (Table 16). Data is deficient regarding the number of chicken meat centers in the city. However, according to M/s RSN, one of the major suppliers of chicken in the city and owner of nine chicken shops, ~1.5 tons of chicken processing waste is generated from their nine shops per day. That is ~547.5 tons of chicken processing waste generated from nine shops annually. Out of the daily 1.5 tons of chicken processing waste, around 500 kg is taken by the freshwater aqua culturist to feed their fishes (figure 19 and figure 20). It is indicated that all other meat waste is dumped at the Brookshabad dump yard, unlike the FPW.

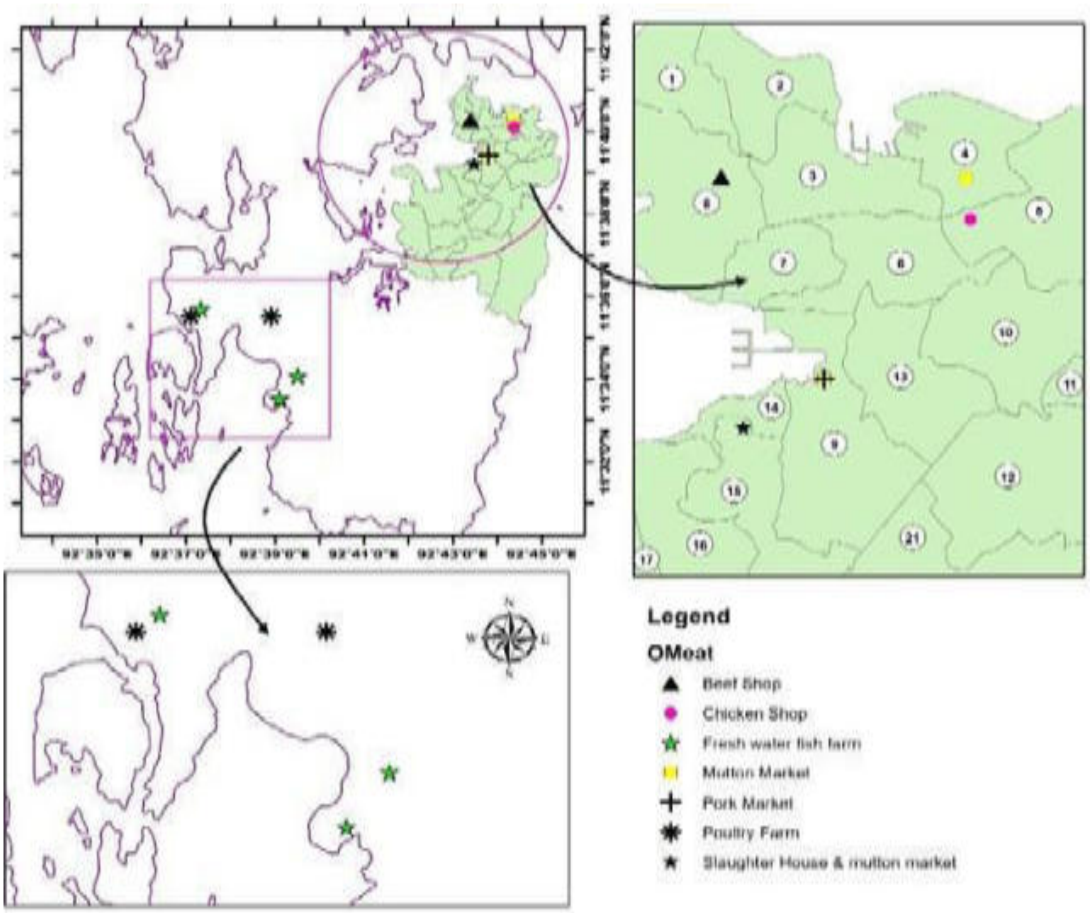


Figure 19 Other meat surveying locations

Table 16 Annual processing waste generated from other meat sources

Type	Live wt (Kg)	waste wt(kg)	No slaughter/ week	Type of waste	waste/year in tons
Mutton	~20	10	~125	horns, hoofs, skin, gut	65
Pork	~100	25	~7	hoof & gut	9.1
Beef	~350-500	100	~9	horns, hoofs, skin, gut,bones	46.8
Chicken	Avg 1.5	0.4	---	head, feather, skin, legs, gut	---
				Total	120.9

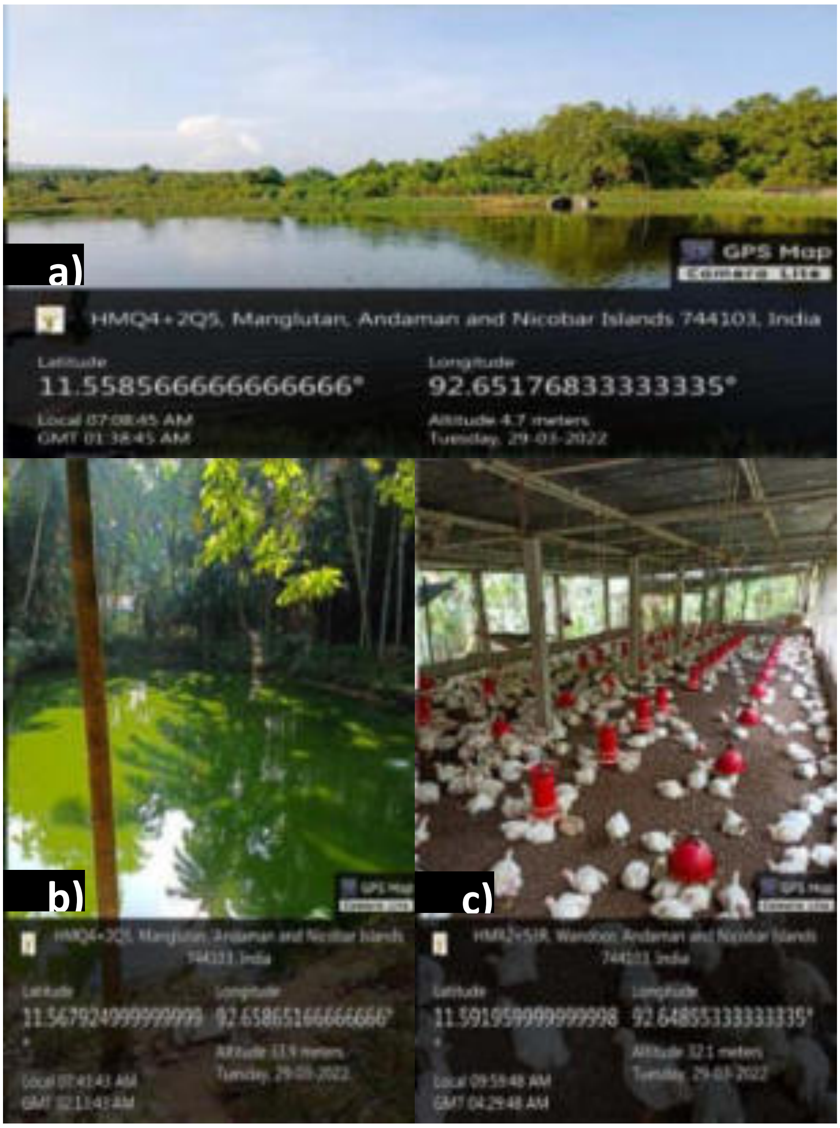


Figure 20 a) Freshwater fish farm with natural feed, b) Eutrophication in the freshwater fish farm due to poultry processing waste, c) Poultry farm carpeted with sawmill waste.

Pathway of Organic waste and its implications

The waste generated from fish, mutton, pork, beef, and chicken in the city is dumped at Brookshabad (figure 21).

Organic waste is leached out from the dump yard by the tropical rains into the adjacent sea resulting in an open invitation to the saltwater crocodiles, resulting in human-animal conflicts.

The sawmill waste (dust) is used as a carpet in poultry farms. The fecal material of the poultry birds contains some number of steroids that are used as manure in agricultural farms.These steroids not only enter the soil but also into the agricultural produce and into the humanbody.

The chicken processing waste especially the gut contents is fed to freshwater fish like Chinese pomfret (local name: Roopchand) and shark catfish (common name: Pangasius). There are 533 freshwater ponds in the south Andaman tehsil (fisheries policy 2018). Consumption of these freshwater fish results in the increase of steroid levels in the human body.

Also, chicken processing waste like gut is fed to the pigs. Steroids enter the human body, i.e. this as well.

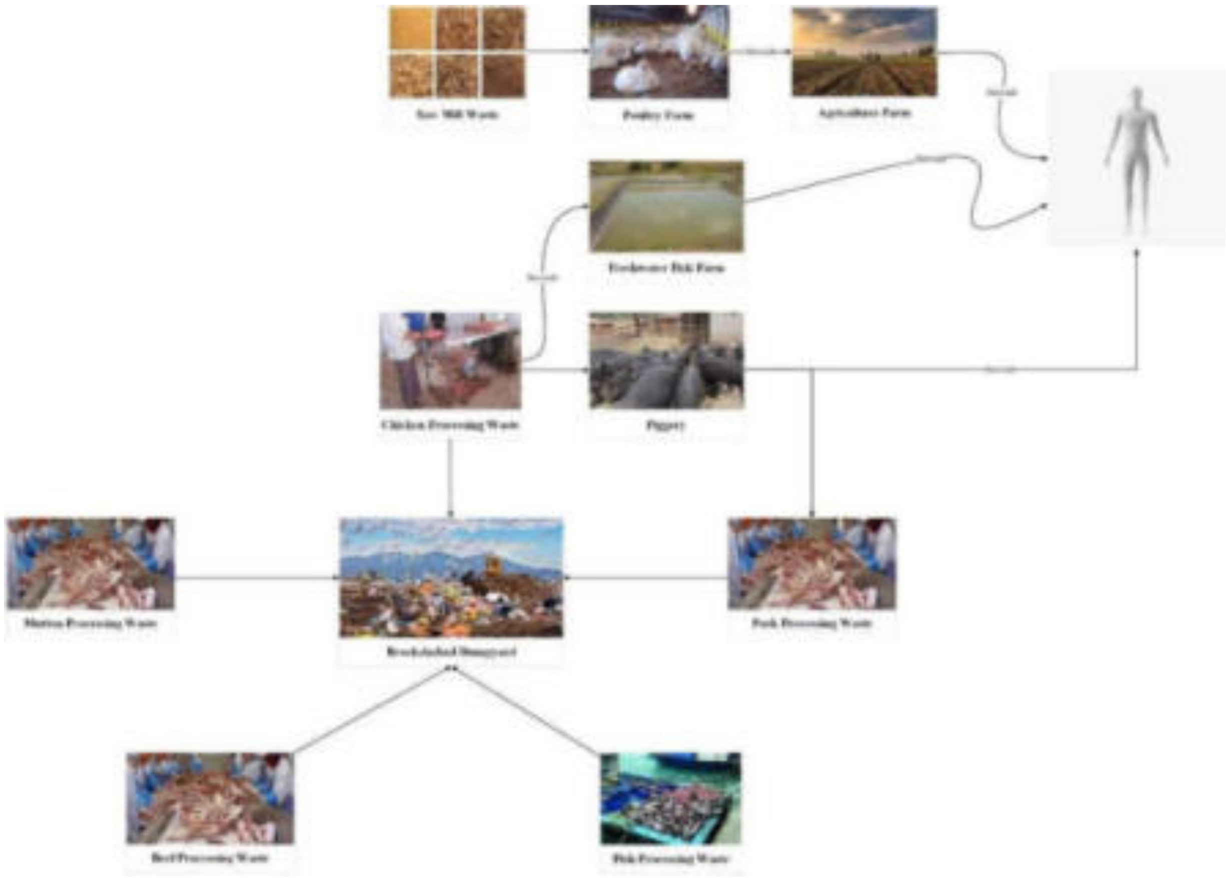


Figure 21 Pathway of Organic waste in the city

Recommendations for other meat waste

The other meat waste can be directed to the proposed FPW unit at Dollygunj for similar processing as the FPW, using the same facility.

Mixing of FPW and other meat wastes in a calculated proportion would not only result in an excellent feed for poultry, piggery, and freshwater aquaculture farms, but also, minimize the steroid levels.

Bibliography

AN Gazette (1995). Andaman and Nicobar Gazette, Extraordinary-92, 6-5-1995.

AN Gazette (2015). Andaman and Nicobar Gazette, Extraordinary-5-29/EC/A & N/2015, 23-4-2015.

ANPCC (2019). Affidavit submitted by Andaman and Nicobar Pollution Control Committee(ANPCC) to the NGT in April 2019.

AOAC (2002). Ash, 981.12. Official Methods of and calorific content of Analysis (17 ed.).Gaithersburg, Maryland 2002

AOAC (2005). Official methods of analysis. 8 End, Association of Analytical Chemists,Gaithersburg, Maryland.

Basic Statistics (2010). Directorate of economics and statistics, Andaman, and NicobarAdministration.

Census of India (2011). District census handbook Andaman and Nicobar Islands. Directorate of census operations Andaman and Nicobar Islands, Series-36, Part XII-A.

CPCB Annual Report (2017-2018). Central Pollution Control Board, Ministry of Environment,Forest & Climate Change. Website: www.cpcb.nic.in/annual-report.php.

Fisheries Policy (2018). Andaman and Nicobar Islands fisheries policy.

Forest Statistics (2017). Department of Environment and Forests Andaman and Nicobar Islands.GPPB-179(a) (1957). C.C., Port Blair-22-8-1957,

Kaza S., Yao, L., Bhada-Tata, P., Woerden. V.F., (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Urban Development Series. Washington, DC: World Bank.https://doi.org/doi:10.1596/978-1-4648-1329-0.

MGPPB-18 (1985). Gztt/85-200., 30-4-1985.

Annexures

Questionnaire for finfish/shellfish

Name of Responder: ………………………..…………………………………… Date: ………………………………

Location: ……………………………..………… Lat (N)……………..……..…..……Long (E)……………………….…

Retailer/wholesale dealer……………………………………………………………………………………..

1) Direct purchase/ Agent purchase:

2) Door delivery/ personal collection:

3) Types of Fish

Sl No	Type of fish	Purchasing Cost of the fish (Kg)	Selling price of the fish (Kg)	Waste generated/kg

4) Extensively used fish(s):

5) Mode disposal of fish processing waste:

6) Are fish waste scavenged by stray animals?

7) How does the collection agent receive the fish waste (sorted/commonly dumped)?

8) Do you pay for collection services (Y/N) if yes how much?________________________

9) *Any waterbody/ open drain/ grilled drain/closed drain:

10) *Any decomposed fish wastes:

Observations & Additional Remarks:

………

………

………

………

Sign of Surveyor _________________________________ Date & Time: …..………………

Questionnaire for flower waste (vendor)

Name of Responder: ……………………..…………………………………… Date: ....

Location: …………………………..………… Lat (N)……………..……..…..…Long (E)…………………….…..

1) Direct purchase/ Agent purchase:
2) Source of flowers:
3) Types of Flowers

SI No	Type of flower	Weight of flower (Kg)	Purchasing Cost of the flower (Kg)	Selling price of the flower(Kg)	Waste generated

4) Extensively used flowers:
5) Types/ Size of finished flower products:
6) Cost of finished flower products as per size:
7) Materials used for furnishing flower products:
8) Mode of delivery raw flower:
9) Storage of finished flower products:
10) Mode of disposal of flower waste:
11) Periodicity of disposal of flower waste:
12) How does the collection agent receive the flower waste (sorted/commonly dumped)?
13) Do you pay for collection services (Y/N) if yes how much?_________________
14) *Any waterbody/ open drain/ grilled drain/closed drain:
15) *Any decomposed flower wastes:

Observations & Additional Remarks:

………

………

Sign of Surveyor ________________________________ Date & Time: …..………………

Questionnaire for flower waste at worship places (Temple/Church/Mosque/others)

Name of Responder: …………………..……………………………………… Date: ....

Location: …………………….............. Lat (N).……………..……..…..…..Long (E).………………………..….

Type of worship place: ………………………….

1) Direct purchase/ Agent purchase (Vendor):
2) Source of flowers (Worshipper/ garden):
3) Types of Flowers

Sl No	Type of flower	Weight of flower (Kg/Day)	Waste generated (Kg/Day)

4) Extensively used flowers:
5) Extensively used fruits:

Sl No	Type of fruit	Weight of fruit (Kg/Day)	Waste generated (Kg/Day)

6) Approx. weight flower products:
7) Mode of decomposed flower/fruit:
8) Availability of Compost:
9) Mode of disposal of flower /fruit waste:
10) Periodicity of disposal of flower/fruit waste:
11) How does the collection agent receive the flower waste (sorted/commonly dumped)?
12) Do you pay for collection services (Y/N) if yes how much?________________

13) Food offerings on regular/special occasions

Sl No	Type of food		Weight of food (Kg/Day)	Waste generated (Kg/Day)

14) Probable month of food offering:

15) No of persons attending the food offering:

16) Where is the temporary dumping site food waste?

17) Does stray animals scavenge the food waste:

18) How does the collection agent receive the flower waste (sorted/commonly dumped)?

19) Do you pay for collection services (Y/N) if yes how much?_________________

20) *Any waterbody/ open drain/ grilled drain/closed drain:

21) *Any decomposed flower wastes:

Observations & Additional Remarks:

………

………

………

………

Sign of Surveyor ________________________________ Date & Time: …..………………

Questionnaire for tender coconut waste

Name of Responder: …………………….…………………………………… Date: ....

Location: …………………….……….… Lat (N)……………..………..……Long (E)………………………..…

1) Direct purchase/ Agent purchase:
2) Source of Coconut:
3) Wholesale price of coconut:
4) Transportation cost:
5) Selling price of the coconut:
6) Average no. coconut sold per day:
7) Average whole weight of the coconut:
8) Average empty weight of the coconut:
9) Storage of empty shell:
10) Mode of disposal of empty shell:
11) Periodicity of disposal of empty shell:
12) How does the collection agent receive the empty shell (sorted/commonly dumped)?
13) Do you pay for collection services (Y/N) if yes how much?________________
14) *Any waterbody/ open drain/ grilled drain/closed drain:
15) *Any water collected in the empty shell:

Observations & Remarks:

………
………
………

Sign of Surveyor ______________________________ Date & Time:

Questionnaire for Sawmill and Furniture waste

Name of Establishment: ………………………………………

Name of Responder: …………………..…………………………………… Date: ....

Location: …………………….....………… Lat (N)……………..……..…..……Long (E)…………………………..…

1) Source of timber to Mill/Shop:

2) Types of Timber (Category wise)

Category	Name of the wood

3) Annual intake/purchase of Timber (Category wise) inclusive of CBM with cost

Sl No	Name of wood log	Annual Intake (CBM)	Cost/ CBM	Wastage / CBM

4) Quantum of timber waste generated (kg/month/annum):

5) Utility of Timber waste (scrap wood):

6) Selling price/kg of scrap wood:

7) Quantum of Sawdust generated (kg/month/annum):

8) Utility of sawdust:

9) Selling price/kg of sawdust:

10) Mode of preservation of sawn wood:

11) Storage mode of Sawn wood:

12) Storage of scrap wood (roofed/ open dumping):

13) Storage of Saw dust (roofed/ open dumping):

14) Any water body around the establishment:

15) Periodicity of disposal of sawdust

16) Is it in compliance with Pollution Control Board:

17) Do you pay for collection services (Y/N) if yes how much?________________

Observations & Remarks:

……
……

Sign of Surveyor ______________________________ Date & Time:

Questionnaire for chicken waste

Retailer / wholesale dealer………………………………………………………………………………………...

Name of Responder: ……………… ……………………………………... Date: ....

Location: ……………………...………… Lat (N)……………..…….……Long (E)………………………..….

1) Direct purchase/ Agent purchase:
2) Door delivery/ personal collection:
3) Types of chicken weekdays/weekends

Sl No	Type of chicken	Purchasing Cost of the chicken (Kg)	Selling price of the chicken(Kg)	No chicken sold/day	Waste generated/ kg

4) How many purchases with/ without skin?
5) Chicken processing waste include what:
6) Mode disposal of chicken processing waste:
7) What is done with feathers
8) Are chicken waste scavenged by stray animals?
9) How does the collection agent receive the chicken waste (sorted/commonly dumped)?
10) Do you pay for collection services (Y/N) if yes how much?________________
11) *Any waterbody/ open drain/ grilled drain/closed drain:
12) *Any decomposed chicken wastes:

Observations & Additional Remarks:

………
………
………

Sign of Surveyor ______________________________ Date & Time:

Questionnaire for Mutton/Pork/Beef waste

Mutton ☐ Pork ☐ Beef ☐

Retailer / wholesale dealer...

Name of Responder: .... Date: ....

Location: .... Lat (N)...................................Long (E)..................................

1) Direct purchase/ Agent purchase:
2) Door delivery/ personal collection:
3) Periodicity of slaughtering in a week:
4) How many slaughters in a week?
5) Waste generated per animal (kg):

Sl No	Purchasing Cost of Animal	Selling price(Kg)	No Kg sold/ day	Weekday ssales	Weekend sales

6) What is done with the skin of the Animal:
7) Animal processing waste include what:
8) Mode disposal of Animal processing waste:
9) Are animal waste scavenged by stray animals?
10) How does the collection agent receive the animal waste (sorted/commonly dumped)?
11) Do you pay for collection services (Y/N) if yes how much?________________
12) *Any waterbody/ open drain/ grilled drain/closed drain:
13) *Any decomposed chicken wastes:

Observations & Additional Remarks:

....

....

....

Sign of Surveyor ______________________________ Date & Time:

Legal Information

Disclaimer

All indications, data and results of this study have been compiled and carefully reviewed by the authors. Nevertheless, errors may occur with regard to the content. Therefore, neither GIZ nor the authors will be liable for any claims, losses or damages, direct or indirect, arising from the use of or reliance on the information contained in this study.

The reproduction or duplication of the study (including transfer of data to multimedia storage systems) and distribution for non-commercial purposes is permitted, provided that GIZ is acknowledged as the source of the information. For other commercial use, including duplication, reproduction or distribution of all or part of this publication, written permission from GIZ is required.

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Management of Organic Waste in India
Global Project "Export Initiative Environmental Protection GreenTech „Made in Germany" (BMUV)

Third Floor, B 5/5
Safdarjung Enclave
New Delhi, 110029
India

T + 91 4949 5353
F + 91 4949 5391
E giz-indien@giz.de
I www.giz.de

Port Blair Municipal Solid Waste Characterization

Ministry of Housing and Urban Affairs
Government of India

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices Bonn and Eschborn

Cities Combatting Plastic entering Marine Environment

3rd Floor, B-5/5, Safdarjung Enclave
New Delhi 110029

T + 91 4949 5353
F + 91 4949 5391
E info@giz.de
I www.giz.de

Responsible
Mrs. Vaishali Nandan
Head of Project

Authors
Mr. Aviral Saxena
Mr. Nirbhaya Kumar Singh – Foursome Enterprises

Editors
Ms. Carla Rossitto
Ms. Soma Biswas

On behalf of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

GIZ India is responsible for the contents of this publication.

New Delhi, India
August 2022

Contents

List of Figures

List of Tables

1. Introduction

The world witnessed the industrial revolution resulting in an exponential number of innovations post World War II (Provencher, 2014). The cheap manufacturing cost, durability, and flexibility of plastics are considered as a wonderful invention of the 20th century (PrasunGoswamia, Valsalan, Vinithkumara, & GopalDharani, 2020). Owing to the extraordinary properties, the annual production of plastics had escalated dramatically from 0.5 million tons in the 1940s to 550 million tons in 2018 and has overwhelmingly become an integral part of human day-to-day life (Jeyasanta, 2020).

A baseline study indicates that 192 coastal countries generated 275 million metric tons of plastic waste, of which significant amounts (4.8–12.7 million metric tons) entered the marine systems from land-based sources like rivers, sewage, surface street runoff, etc. (Jambeck, 2015). Given the non-biodegradable nature of plastics, this material is currently encountered on every habitat of the earth and their prevalence threatens all life forms (Landrigan, 2020);(Chassignet, 2021) resulting in death of mammals, seabirds, turtles, and fishes via entanglement, plastic ingestion and others (T.Kaviarasan, 2020).

Cities Combatting Plastic entering Marine Environment (CCP-ME)

The objective of the CCP-ME project is to prevent plastic waste at source through sustainable waste management practices in cities by upgrading infrastructure, strengthening digital monitoring, behaviour change and exchange mechanisms, and supporting the development of national framework conditions.

The project is working in the three cities of Kochi, Kanpur and Port Blair and their respective states and union territory. The overall project is working on interventions to enable selected cities to improve collection, segregation and marketing of plastic waste, to prevent plastic disposal to water bodies, and to improve handling of port and marine waste. This needs to be combined with new tracking, data management and reporting systems, civil society involvement and increased cooperation with the recycling industry. This is in line with the Municipal Solid Waste Management rules of 2016 which stipulates the segregation of waste at source in order to enable its recovery, reuse and recycling. The project activities are also in line with Plastic Waste Management rules of 2016 and its subsequent amendment in 2018 and 2021.

At National level, the project is housed with the Ministry of Housing and Urban Affairs (MoHUA) and works towards the development of a national digital platform together with MoHUA to establish links between states/UTs, cities and the recycling industry. The platform will also enable the monitoring of recycling and reuse quantities of plastic and non-biodegradable waste by standardising reporting mechanisms for cities and states/UTs to the national level related to quantities of different fractions of recycled dry waste (in particular plastics).

Andaman and Nicobar Islands (ANI's) is a Union territory belonging to India situated in the Bay of Bengal. A report indicates ANI's account for 47% unmanaged solid waste as compared to the national average of 14% (Kaladharan, 2017). Port Blair is the capital and single municipal body of ANI, where half of the Islands population lives. Further, Port Blair is the entry point for tourists since the economy of the archipelago revolves around it. ANIs are strategically important in terms of national security and geopolitically as well hence, a huge population of tri-command defence personnel are deployed here along with the family. Thus, solid waste generated by the floating population like tourists and the defence personnel's apart from the native resident population is a pressure mounting scenario to the Port Blair Municipal Council (PBMC) in handling waste. Thus, a baseline study was initiated by GIZ in collaboration with PBMC to effectively combat the solid waste menace in Port Blair.

2. Objective

The support provided by the CCP-ME project at the national, state, and local levels for the plastic and non-biodegradable waste starts with demonstration of material recovery facility (MRF) at city level which can help divert non-biodegradable waste to circular economy loops and also make MRF operations sustainable.

Earlier interactions with various stakeholders have helped the CCP-ME project to identify around 70 subcategories of non-biodegradable materials which have market potential for recycling. A need was felt to conduct physical characterisation at every stage of waste management in the city of Port Blair, to estimate the characteristics of non-biodegradable waste which will be available to city MRFs if decentralised MRF units are established.

Thus, the objective of the study was to undertake a Municipal Solid waste generation at household and non- households' level in PBMC area and its characterization at different levels including dumpsite, to estimate the characteristics of non-biodegradable waste which will be available for city Solid & Liquid Resource Management Centre (SLRM)/MRFs.

During the tenure of the project, it is also envisaged to develop various knowledge products based on the learnings and this waste characterisation study will aid in developing such relevant documents (knowledge product) to help conduct characterisation studies in other cities of the country.

3. Methodology

The study is an adaptation from the **Waste Wise Cities Tool (WaCT)** (Step by Step Guide to Assess a City's Municipal Solid Waste Management Performance through SDG indicator 11.6.1 Monitoring). The WaCT contains 7 steps to collect data on municipal solid waste (MSW) generated, collected, and managed in controlled facilities. The tool provides a household survey guide for total MSW generation, a questionnaire to identify the MSW recovery chain and criteria to check the environmental control level of waste management facilities in a city.

The sampling methodology from WaCT was adopted fully for the household waste survey, adapted for the commercial waste and extended to dumpsite areas.

Initially, the team involved in waste characterization was oriented by providing an onsite training on waste sample collection, waste fractions and different sub-components (with specific focus on their particular target categories during characterization study, which was followed by orientation on using data entry formats by the team member responsible to record the findings, and safety precautions to be taken.

Households Waste Study

For waste study at household's level total 90 households selected from three categories (HIG, MIG, LIG) in three different locations (Corbyn, RK Mission and Junglighat areas). After the consent of concerned Households, samples were collected daily for 8 days from all 90 households. Collected wastes were studied and sorted into 71 categories of effluents to obtain waste generation rates and household-level waste characteristics.

Non-households Waste Study

For Quantification and Characterization study of non-households, selected stakes were big and small shops (5# total), Hospital (big, small and dispensary- 3# total), restaurant (2#), hotel (3# total), school (1# big), office (2#) with characterization analysis for representative sample from each category of commercial.

Dumpsite Waste Study

For the dumpsite area, 5 samples of each, around 100 Kg was selected from the five different waste transportation vehicles using quartering method. These samples were manually sorted in 71 different categories for waste characterization study. Basic details of waste source were collected from the driver of waste vehicle.

Characterization

The steps followed for the sorting of waste samples included:

1. A precise location was selected to place the sorting table and weigh scale.
2. Site was prepared, the location was cleaned for setting up the tables (with cover sheet), and other necessary equipment were also placed appropriately.
3. The waste containers/bags used for collecting different waste types were marked with numbers and empty weights were recorded (to mark tare weights on specific data sheet).
4. Total 71 pre-weighed bins/bags were kept around the sorting table for depositing the sorted material into different material types.
5. A sample as per Waste Wise Cities Tool EN-7.1 was collected and weighted (for dumpsite using quartering method for determination of composition of unprocessed Municipal Solid waste). Then it was unloaded onto table for further sorting into different categories.
6. Each team member was given responsibility to segregate and collect certain subcategories of waste.
7. After weighted, waste samples were spread out on the sorting table, hand sorted by the team members and collected in bins assigned for different material categories.
8. Once sorting of waste sample was done and no visual traces of any other material category were observed, the remaining sample was swept into the 'Fines' fraction for it to be accounted in others category.
9. The waste containers/bags with the sorted material were weighed on a calibrated scale to obtain gross weights. These weights were noted in the waste sample record sheet for each sample and net weight of each sorted category, correct up to two significant digits, was

obtained by subtracting the tare weight (empty container weight) of each bin from the gross weights.

10. At the end of each waste characterization, the segregated recyclables/materials were disposed off (or diverted to recyclers) as per directions from GIZ team or PBMC officials.

11. Site was cleaned and tables were prepared for next sample.

The above procedure was followed for the characterization of each day of the study.

Table 1 Categories of waste as per TOR and responsible person for waste sorting

S.No.	Material	Sub-Materials	Responsible member
1.1	Plastic	PET Bottle	**Team members 01 and 08**
1.2		LDPE-Thickness less than 60microns	
1.3		LDPE-Thickness between 60-120 microns	
1.4		LDPE-Thickness more than 120microns	
1.5		HDPE	
1.6		Polypropylene	
1.7		Polycarbonate	
1.8		Polystyrene	
1.9		Multi-layered Plastics	
1.10		HDPE Milk Packets	
1.11		Fiber-reinforced plastic	
1.12		PVC	
1.13		Other plastics	
2.1	Paper& Cardboard	Newspaper	**Team member 02**
2.2		White Paper	
2.3		Colored Paper	
2.4		Books	
2.5		Magazines	
2.6		Cardboard-3ply	
2.7		Cardboard-5ply	
2.8		Duplex board	
2.9		Other paper and cardboards	
3.1	Metal	Iron	**Team member 03**
3.2		Steel	
3.3		Aluminum	
3.4		Zinc	
3.5		Brass	
3.6		Copper	
3.7		Tin	
3.8		**Other metals**	

S.No.	Material	Sub-Materials	Responsible member
4.1	Glass	Plain Glass	**Team member 04**
4.2		Colored Glass	
4.3		Mirror	
4.4		Glass cullet (Broken glass)	
4.5		Other glass	
5.1	Rubber& Tyre	2& 3-wheeler tyre	**Team member 05**
5.2		4-wheelerpassenger	
5.3		4-wheelercommercial	
5.4		Rubber -Chappal	
5.5		Rubber -Gloves	
5.6		Rubber –Tubes/pipes	
5.7		Rubber –Shoe Bottoms	
5.8		Other rubber and tyre	
6.1	E-waste	Batteries-Lithium Ion	**Team member 06**
6.2		Batteries-Conventional	
6.3		Wires	
6.4		Electrical Appliances	
6.5		Cell Phones	
6.6		Laptops	
6.7		Other e-waste	
7.1	Textile	Rags	**Team member 07**
7.2		Clothes	
7.3		Others	
8	Used Beverage Cartons		
9	Leather		
10	Coconut Shell		
11	Ceramic		
12	Wood (engineered)		
13.1	Hair –Length more than 6inch		
13.2	Hair –Length-less than 6inch		
14	**C&D waste**		

S.No.	Material	Sub-Materials	Responsible member
15.1	Organics	Food scrap waste	**Team member 08**
15.2		Green/garden waste	
15.3		Wood waste (tree branches)	
15.4		Other Bio-degradables	
16.1	Domestic hazardous waste	Sanitary waste -diapers	**Team member 04**
16.2		Sanitary waste –Sanitary pads	
16.3		Bio-medical waste (generated from households)	
16.4		Other domestic hazardous waste	
17	Fines (Un-sortable small fragments (generally less than 5 cm or less in diameter); mainly composed of organic material and miscellaneous fines and dirt		**Team member 08**
18	**Others (Any other material that does not specifically fit in other 17 Categories)**		**Team member 08**

4. Findings of the study

Households Waste Study

A field survey was conducted from 8th of March to 9th of March 2022. Waste sample collection started from 10th March 2022 with the support from PBMC. Prior to the study, Shadipur Community Hall was selected with adequate space was to conduct the study. The study was conducted for 71 subcategories of waste.

Figure 1: PBMC - Ward boundary map with study locations

Findings of Households level waste study and overall characteristics of the study are as follows:

Table 2 Population of 10 households selected from each income group of three different areas

Area	Population		
	High Income (10)	Middle Income (10)	Low Income (10)
Corbyns’	38	41	49
R K Mission	45	43	50
Junglighat	38	34	44
Total Population	**121**	**118**	**143**

Table 3 Average Daily Organic Waste Generation per Capita in Kg from different categories

Date	High Income	Middle Income	Low Income
11/3/2022	0.1198	0.0947	0.0900
12/3/2022	0.1312	0.1369	0.0731
13/3/2022	0.1856	0.0948	0.0722
14/3/2022	0.1991	0.1527	0.1509
15/3/2022	0.1679	0.1356	0.1004
16/3/2022	0.1642	0.2111	0.1431
17/3/2022	0.1419	0.1095	0.1093
Average Per Capita Daily Organic Waste Generation Rate (Kg)	0.1585	0.1336	0.1056

Table 4 Households Waste Generation rate (income group wise)

S. No	Area	Income Group (Average Waste Generation (Kg/C/Day))		
		HIG	MIG	LIG
1	Corbyn	0.24734	0.20213	0.14900
2	Junglighat	0.25832	0.27433	0.24463
3	R K Mission	0.18550	0.12901	0.16755
Overall Waste Generation in all areas		**0.23039**	**0.20182**	**0.18706**

Figure 2 Households bags distribution

Figure 3 Door to door sample collection

From Table 4 Households Waste Generation rate (income group wise), it was found that total waste generation for high income group is maximum (0.230Kg/C/D) and for low-income group is 0.187Kg/C/D.

Below the **Error! Reference source not found.**show the average waste characteristics in d ifferent income groups.

Table 5 Port Blair average waste characterization data for different income group (Households),

S.N.		WASTE MATERIALS	HIG	MIG	LIG
			7.44%	6.82%	8.05%
1	1.1	PET Bottle	0.870%	0.619%	1.324%
2	1.2	LDPE - Thickness less than 60 microns	1.466%	1.623%	2.003%
3	1.3	LDPE - Thickness between 60-120 microns	1.495%	1.445%	1.394%
4	1.4	LDPE - Thickness more than 120 microns	0.000%	0.000%	0.000%
5	1.5	HDPE	1.209%	0.888%	0.672%
6	1.6	Polypropylene	0.423%	0.301%	0.281%
7	1.7	Polycarbonate	0.079%	0.039%	0.000%
8	1.8	Polystyrene	0.037%	0.026%	0.000%
9	1.9	Multi-layered Plastics	1.140%	0.745%	0.983%
10	1.1	HDPE Milk Packets	0.360%	0.817%	0.010%
11	1.11	Fibre-Reinforced plastic	0.000%	0.000%	0.298%
12	1.12	PVC	0.000%	0.000%	0.000%
13	1.13	Other plastics	0.360%	0.318%	1.085%
		Paper & Cardboard	7.568%	6.085%	6.270%
14	2.1	Newspaper	1.419%	1.409%	1.284%
15	2.2	White Paper	0.983%	0.716%	1.092%
16	2.3	Colored Paper	0.300%	0.586%	0.209%

17	2.4	Books	0.365%	0.000%	0.096%
18	2.5	Magazines	0.000%	0.065%	0.109%
19	2.6	Cardboard- 3 ply	1.293%	0.875%	1.520%
20	2.7	Cardboard-5 ply	0.901%	0.117%	0.122%
21	2.8	Duplex board	2.223%	2.067%	1.559%
22	2.9	Other paper and cardboards	0.084%	0.249%	0.278%
		METAL	2.381%	1.121%	0.913%
23	3.1	Iron	0.145%	0.000%	0.000%
24	3.2	Steel	0.533%	0.013%	0.212%
25	3.3	Aluminum	0.297%	0.920%	0.228%
26	3.4	Zinc	0.000%	0.000%	0.000%
27	3.5	Brass	0.000%	0.000%	0.000%
28	3.6	Copper	0.000%	0.000%	0.000%
29	3.7	Tin	0.893%	0.136%	0.076%
30	3.8	Other Metal	0.512%	0.052%	0.397%
		GLASS	0.991%	1.827%	2.880%
31	4.1	Plain Glass	0.773%	1.730%	0.947%
32	4.2	Colored Glass	0.000%	0.000%	1.831%
33	4.3	Mirror	0.000%	0.000%	0.000%
34	4.4	Glass cullet (Broken glass)	0.218%	0.097%	0.103%
35	4.5	Other Glass	0.000%	0.000%	0.000%
		RUBBER AND TYRE	0.318%	0.314%	0.864%
36	5.1	2 & 3-wheeler tyre	0.000%	0.052%	0.000%
37	5.2	4-wheeler passenger	0.000%	0.000%	0.000%
38	5.3	4-wheeler commercial	0.000%	0.000%	0.000%
39	5.4	Rubber - Chappal	0.000%	0.185%	0.000%
40	5.5	Rubber - Gloves	0.000%	0.000%	0.000%
41	5.6	Rubber - Tubes	0.032%	0.000%	0.000%
42	5.7	Rubber - Shoe Bottoms	0.286%	0.039%	0.000%
43	5.8	Other rubber and tyre	0.000%	0.039%	0.864%
		E-WASTE	0.368%	0.868%	0.285%
44	6.1	Batteries- Lithium Ion	0.013%	0.049%	0.152%
45	6.2	Batteries- Conventional	0.011%	0.000%	0.000%
46	6.3	Wires	0.000%	0.013%	0.000%
47	6.4	Electrical Appliances	0.344%	0.807%	0.132%
48	6.5	Cell Phones	0.000%	0.000%	0.000%
49	6.6	Laptops	0.000%	0.000%	0.000%
50	6.7	Other e-waste	0.000%	0.000%	0.000%
		TEXTILE	1.022%	1.500%	3.426%
51	7.1	Rags	0.725%	1.183%	1.721%
52	7.2	Clothes	0.289%	0.000%	1.705%

53	7.3	Other textile	0.008%	0.318%	0.000%
		Other Non-Biodegradable materials	4.853%	4.212%	3.135%
54	8	Used Beverage Cartons	1.500%	0.894%	1.794%
55	9	Leather	0.000%	0.000%	0.060%
56	10	Coconut Shell	1.238%	2.019%	0.391%
57	11	Ceramic	0.184%	0.000%	0.288%
58	12	Wood (Engineering wood)	1.369%	0.075%	0.546%
59	13.1	Hair - Length more than 6 inches	0.087%	0.606%	0.056%
60	13.2	Hair - Length less than 6 inches	0.476%	0.606%	0.000%
61	14	C&D waste (including earthen pots)	0.000%	0.013%	0.000%
		Other- Organics	68.994%	66.990%	70.002%
62	15.1	Food waste	68.994%	66.854%	69.985%
63	15.2	Green garden waste	0.000%	0.136%	0.017%
64	15.3	Wood waste (Tree branches etc.)	0.000%	0.000%	0.000%
65	15.4	Other biodegrables	0.000%	0.000%	0.000%
		Other- Domestic hazardous waste	5.148%	8.615%	2.900%
66	16.1	Sanitary waste - diapers	3.876%	6.574%	2.132%
67	16.2	Sanitary waste - sanitary pads	0.268%	0.551%	0.089%
68	16.3	Bio-medical waste (generated from households)	0.660%	1.183%	0.652%
69	16.4	Other domestic hazardous waste	0.344%	0.308%	0.026%
		Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)	0.920%	1.646%	1.275%
70	17	Fines (Unsortable small fragments (generally less than 5 cm or less in diameter); mainly composed of organic material and miscellaneous fines and dirt	0.920%	1.646%	1.275%
71	18	Others (to be defined)	-	-	-

Figure 4 Weighing of households waste samples

Figure 5 waste sample transfer to the table for sorting

Waste Study for Non-households-

Field survey, collection, and study of waste from the selected stakeholders were as follows:

Table 6 Schedule for Non-household's waste study

S. No	Stakeholders	Date of Survey	Date of sample collection and waste study
1	Shops	19/03/2022	20/03/2022
2	Hospital	19/03/2022	20/03/2022
3	Hotel	21/03/2022	22/03/2022
4	Office	23/03/2022	24/03/2022
5	Restaurants	23/03/2022	24/03/2022
6	School	24/03/2022	25/03/2022

Figure 6 Selected Shop for waste sampling

Figure 7 Selected Restaurants for waste sampling

Table 7 % of dry and wet waste in different stakeholders of non-households

Stakeholders	Dry Waste	Wet Waste
Shops	95.874%	4.126%
Hospitals	67.750%	30.748%
Hotels	48.105%	50.801%
Schools	8.722%	91.278%
Office	72.025%	23.347%
Restaurants	24.801%	69.032%

Given *Table 8 Average Waste Generation in Non-households' stakes*, shows the total waste generation per day in Kg for commercials with different respective.

Table 8 Average Waste Generation in Non-households' stakes

Stake Holders	No of stakes selected	Total received waste (KG)	Average Total Waste Generation Rate	Unit
Shops	5	55.791	1.93	**Kg/Staff/Day**
Clinic	1	1.73	0.02	**Kg/Patient/Day**
Hospitals	2	12.765	0.38	**Kg/Bed/Day**
Hotels	3	18.95	0.77	**Kg/Room/Day**
Schools	1	16.52	0.01	**Kg/Capita/Day**
Office	2	12.162	0.28	**Kg/Staff/Day**
Restaurant	2	22.87	0.34	**Kg/Seat/Day**

After sorting the collected waste sample from different commercial stakeholders in 71 categories, results are showing below in Table 9 Port Blair waste characterization Study for Non-households' stakes

Table 9 Port Blair waste characterization Study for Non-households' stakes

S.N.		WASTE MATERIALS	Shops	Hospitals	Hotels	Schools	Office	Restaurants
			Weight Percentage					
		PLASTIC	6.607%	15.420%	31.207%	0.151%	7.025%	9.461%
1	1.1	PET Bottle	2.508%	5.841%	1.815%	0.000%	0.372%	2.653%
2	1.2	LDPE - Thickness less than 60 microns	0.458%	0.699%	2.670%	0.000%	0.661%	3.028%
3	1.3	LDPE - Thickness between 60-120 microns	0.692%	0.454%	0.828%	0.000%	0.413%	1.105%
4	1.4	LDPE - Thickness more than 120 microns	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
5	1.5	HDPE	0.090%	7.511%	0.988%	0.000%	3.430%	0.818%
6	1.6	Polypropylene	0.036%	0.454%	8.329%	0.000%	0.496%	0.420%
7	1.7	Polycarbonate	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
8	1.8	Polystyrene	0.090%	0.000%	9.237%	0.000%	0.413%	0.000%
9	1.9	Multi-layered Plastics	1.816%	0.461%	7.154%	0.091%	0.702%	0.597%
10	1.1	HDPE Milk Packets	0.917%	0.000%	0.000%	0.000%	0.413%	0.000%
11	1.1	Fibre-Reinforced plastic	0.000%	0.000%	0.000%	0.061%	0.124%	0.000%
12	1.1	PVC	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
13	1.1	Other plastics	0.000%	0.000%	0.187%	0.000%	0.000%	0.840%

		Paper & Cardboard	86.277%	42.863%	8.035%	6.844%	61.116%	1.790%
14	2.1	Newspaper	0.413%	0.349%	0.214%	0.000%	3.306%	0.398%
15	2.2	White Paper	0.405%	1.642%	0.908%	5.360%	35.248%	0.000%
16	2.3	Colored Paper	0.000%	0.000%	0.240%	1.121%	12.521%	0.000%
17	2.4	Books	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
18	2.5	Magazines	0.000%	0.349%	0.214%	0.000%	0.165%	0.000%
19	2.6	Cardboard- 3 ply	39.228%	7.336%	0.694%	0.000%	1.901%	0.420%
20	2.7	Cardboard-5 ply	45.260%	28.296%	0.854%	0.000%	0.000%	0.000%
21	2.8	Duplex board	0.971%	2.515%	4.271%	0.000%	1.198%	0.752%
22	2.9	Other paper and cardboards	0.000%	2.375%	0.641%	0.363%	6.777%	0.221%
		METAL	0.832%	0.419%	0.934%	0.000%	0.000%	4.576%
23	3.1	Iron	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
24	3.2	Steel	0.000%	0.000%	0.000%	0.000%	0.000%	0.243%
25	3.3	Aluminum	0.374%	0.419%	0.614%	0.000%	0.000%	0.663%
26	3.4	Zinc	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
27	3.5	Brass	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
28	3.6	Copper	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
29	3.7	Tin	0.000%	0.000%	0.320%	0.000%	0.000%	0.000%
30	3.8	Other Metal	0.458%	0.000%	0.000%	0.000%	0.000%	3.669%
		GLASS	0.000%	0.000%	3.737%	0.000%	0.000%	1.768%
31	4.1	Plain Glass	0.000%	0.000%	1.548%	0.000%	0.000%	0.000%
32	4.2	Colored Glass	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
33	4.3	Mirror	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
34	4.4	Glass cullet (Broken glass)	0.000%	0.000%	2.189%	0.000%	0.000%	1.768%
35	4.5	Other Glass	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
		RUBBER AND TYRE	0.000%	0.000%	0.000%	0.000%	0.083%	3.139%
36	5.1	2 & 3-wheeler tyre	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
37	5.2	4-wheeler passenger	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
38	5.3	4-wheeler commercial	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
39	5.4	Rubber - Chappal	0.000%	0.000%	0.000%	0.000%	0.000%	1.503%
40	5.5	Rubber - Gloves	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
41	5.6	Rubber - Tubes	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
42	5.7	Rubber - Shoe Bottoms	0.000%	0.000%	0.000%	0.000%	0.000%	1.636%
43	5.8	Other rubber and tyre	0.000%	0.000%	0.000%	0.000%	0.083%	0.000%

		E-WASTE	0.000%	0.000%	0.000%	0.000%	0.661%	0.000%
44	6.1	Batteries- Lithium Ion	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
45	6.2	Batteries- Conventional	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
46	6.3	Wires	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
47	6.4	Electrical Appliances	0.000%	0.000%	0.000%	0.000%	0.661%	0.000%
48	6.5	Cell Phones	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
49	6.6	Laptops	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
50	6.7	Other e-waste	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
		TEXTILE	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
51	7.1	Rags	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
52	7.2	Clothes	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
53	7.3	Other textile	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
		Other Non-Biodegradable materials	0.279%	0.629%	0.507%	1.726%	3.058%	3.603%
54	8	Used Beverage Cartons	0.279%	0.629%	0.427%	1.726%	3.058%	3.603%
55	9	Leather	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
56	10	Coconut Shell	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
57	11	Ceramic	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
58	12	Wood (Engineering wood)	0.000%	0.000%	0.080%	0.000%	0.000%	0.000%
59	13	Hair - Length more than 6 inches	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
60	13	Hair - Length less than 6 inches	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
61	14	C&D waste (including earthen pots)	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
		Other- Organics	4.126%	30.748%	50.801%	91.278%	23.347%	69.032%
62	15	Food waste	4.126%	30.748%	50.801%	30.769%	23.347%	69.032%
63	15	Green garden waste	0.000%	0.000%	0.000%	60.509%	0.000%	0.000%
64	15	Wood waste (Tree branches etc.)	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
65	15	Other biodegrables	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
		Other- Domestic hazardous waste	1.879%	8.419%	3.684%	0.000%	0.083%	0.464%
66	16	Sanitary waste - diapers	0.000%	7.301%	0.000%	0.000%	0.000%	0.000%
67	16	Sanitary waste - sanitary pads	0.000%	0.000%	0.641%	0.000%	0.000%	0.000%
68	16	Bio-medical waste (generated from households)	0.000%	1.118%	0.294%	0.000%	0.000%	0.000%
69	16	Other domestic hazardous waste	1.879%	0.000%	2.750%	0.000%	0.083%	0.464%
		Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)	0.000%	1.502%	1.095%	0.000%	4.628%	6.167%

70	17	Fines (Un-sortable small fragments (generally less than 5 cm or less in diameter); mainly composed of organic material and miscellaneous fines and dirt	0.000%	1.502%	1.095%	0.000%	4.628%	6.167%
71	18	Others (to be defined)	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%


Figure 8 Team sorting the waste sample

Figure 9 Selected shop for non-household sampling

Dumpsite waste sampling and its study

PBMC area divided into 24 wards, and each ward has a waste transportation truck, which are used for transporting the waste from secondary collection Centre to Brookshabad dumpsite. And two trucks are available for two commercial area Bathu Basti and Golghar market.

For waste sampling at the dumpsite, 5 different waste transportation trucks were selected. Four trucks were from different wards and one from the commercial area (Bathu Basti).

Waste transported from the truck was adjusted into a square and divided into four square parts using JCB Hitachi. The diagonal portion was discarded, and other diagonal part of waste are again mixed and divided into four parts. And the sample was collected from the one part. Figure 10 Waste Sampling using quartering method, showing the quartering method for waste sampling.

Figure 10 Waste Sampling using quartering method

Table 10 Dumpsite Waste Samples, vehicle and schedule Information

S. No	Transportation Vehicle No	Date	Area for the collection	Location type	Sample Weight (Kg) (G. wt.- Tier wt.)
Dumpsite 1	AN01L1819	24-03-2022	Ward - 5	Residential	102.565
Dumpsite 2	AN01I3186	25/03/2022	Ward- 19	Residential	101.559
Dumpsite 3	AN01D1922	26/03/2022	Ward- 23	Residential	100.202
Dumpsite 4	AN01K8621	23/03/2022	Bathu Basti and nearby area	Commercial	101.045
Dumpsite 5	AN01E0820	25/03/2022	Ward-10	Residential	101.203

Table 11 Dumpsite Waste Characterization study result

S.N.		WASTE MATERIALS	Dumpsite 1	Dumpsite 2	Dumpsite 3	Dumpsite 4	Dumpsite 5	Average Percentage
			Weight Percentage					
		PLASTIC						
1	1.1	PET Bottle	2.623%	0.379%	1.712%	2.148%	3.765%	**2.125%**
2	1.2	LDPE - Thickness less than 60 microns	3.135%	2.777%	2.879%	4.087%	1.507%	**2.877%**
3	1.3	LDPE - Thickness between 60-120 microns	1.341%	2.570%	2.275%	3.711%	2.683%	**2.516%**
4	1.4	LDPE - Thickness more than 120 microns	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
5	1.5	HDPE	3.022%	0.773%	0.903%	2.722%	2.451%	**1.974%**
6	1.6	Polypropylene	0.400%	0.300%	0.215%	1.103%	1.151%	**0.634%**
7	1.7	Polycarbonate	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
8	1.8	Polystyrene	0.175%	0.005%	0.339%	0.000%	1.077%	**0.319%**
9	1.9	Multi-layered Plastics	1.243%	0.847%	0.753%	1.415%	5.005%	**1.853%**
10	1.1	HDPE Milk Packets	1.009%	0.404%	2.101%	1.287%	2.031%	**1.366%**
11	1.11	Fibre-Reinforced plastic	0.073%	0.921%	0.085%	0.000%	2.233%	**0.662%**
12	1.12	PVC	0.463%	0.905%	0.000%	0.000%	0.000%	**0.274%**
13	1.13	Other plastics	0.877%	0.975%	1.113%	2.083%	1.067%	**1.223%**
		Paper & Cardboard						
14	2.1	Newspaper	1.584%	2.063%	0.594%	2.276%	2.307%	**1.765%**
15	2.2	White Paper	0.551%	1.196%	1.198%	1.574%	1.151%	**1.134%**
16	2.3	Colored Paper	0.000%	0.266%	0.324%	1.781%	1.047%	**0.684%**
17	2.4	Books	0.000%	0.000%	0.130%	0.000%	0.000%	**0.026%**
18	2.5	Magazines	0.000%	0.000%	0.983%	0.000%	0.000%	**0.197%**
19	2.6	Cardboard- 3 ply	1.072%	0.197%	1.502%	1.351%	1.077%	**1.040%**
20	2.7	Cardboard-5 ply	6.235%	2.604%	4.236%	4.731%	1.556%	**3.873%**
21	2.8	Duplex board	3.271%	1.305%	2.989%	3.395%	3.686%	**2.929%**
22	2.9	Other paper and cardboards	1.419%	0.197%	0.409%	0.475%	5.983%	**1.697%**
		METAL						
23	3.1	Iron	0.000%	0.000%	2.066%	0.000%	0.000%	**0.413%**
24	3.2	Steel	3.690%	0.000%	0.000%	1.593%	0.000%	**1.057%**
25	3.3	Aluminum	0.341%	0.660%	0.384%	1.267%	1.695%	**0.869%**
26	3.4	Zinc	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
27	3.5	Brass	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
28	3.6	Copper	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
29	3.7	Tin	0.760%	0.438%	1.347%	1.692%	2.791%	**1.406%**
30	3.8	Other Metal	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
		GLASS						
31	4.1	Plain Glass	3.578%	3.909%	1.163%	2.915%	2.134%	**2.740%**

32	4.2	Colored Glass	0.278%	0.000%	0.464%	0.000%	1.700%	**0.488%**
33	4.3	Mirror	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
34	4.4	Glass cullet (Broken glass)	1.965%	0.551%	0.559%	0.000%	2.480%	**1.111%**
35	4.5	Other Glass	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
		RUBBER AND TYRE						
36	5.1	2 & 3-wheeler tyre	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
37	5.2	4-wheeler passenger	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
38	5.3	4-wheeler commercial	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
39	5.4	Rubber - Chappal	0.000%	0.414%	0.000%	3.345%	1.512%	**1.054%**
40	5.5	Rubber - Gloves	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
41	5.6	Rubber - Tubes	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
42	5.7	Rubber - Shoe Bottoms	1.238%	0.478%	0.000%	0.000%	0.000%	**0.343%**
43	5.8	Other rubber and tyre	0.000%	0.975%	3.784%	0.000%	1.462%	**1.244%**
		E-WASTE						
44	6.1	Batteries- Lithium Ion	0.044%	0.000%	0.190%	0.000%	0.000%	**0.047%**
45	6.2	Batteries- Conventional	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
46	6.3	Wires	0.000%	0.000%	0.015%	0.000%	0.000%	**0.003%**
47	6.4	Electrical Appliances	0.570%	0.202%	1.602%	1.351%	1.401%	**1.025%**
48	6.5	Cell Phones	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
49	6.6	Laptops	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
50	6.7	Other e-waste	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
		TEXTILE						
51	7.1	Rags	5.002%	2.275%	0.459%	11.935%	1.117%	**4.157%**
52	7.2	Clothes	1.014%	1.487%	2.485%	3.360%	0.000%	**1.669%**
53	7.3	Other textile	2.038%	0.064%	0.000%	3.612%	0.000%	**1.143%**
		Other Non-Biodegradable materials						
54	8	Used Beverage Cartons	1.014%	0.901%	0.314%	0.000%	1.927%	**0.831%**
55	9	Leather	0.000%	0.000%	2.495%	0.000%	0.000%	**0.499%**
56	10	Coconut Shell	0.980%	5.017%	4.172%	11.990%	0.000%	**4.432%**
57	11	Ceramic	0.205%	0.000%	0.000%	0.000%	0.000%	**0.041%**
58	12	Wood (Engineering wood)	0.127%	0.246%	1.113%	0.000%	3.019%	**0.901%**
59	13.1	Hair - Length more than 6 inches	0.000%	0.153%	0.035%	0.000%	2.935%	**0.624%**
60	13.2	Hair - Length less than 6 inches	0.000%	0.000%	0.000%	0.000%	0.000%	**0.000%**
61	14	C&D waste (including earthen pots)	2.969%	9.891%	1.627%	6.364%	0.000%	**4.170%**
		Other- Organics						
62	15.1	Food waste	13.967%	36.964%	26.337%	4.557%	13.715%	**19.108%**
63	15.2	Green garden waste	18.320%	4.249%	8.842%	2.850%	4.723%	**7.797%**
64	15.3	Wood waste (Tree branches etc.)	0.000%	0.000%	0.000%	1.425%	2.806%	**0.846%**
65	15.4	Other biodegrables	0.000%	0.000%	0.000%	1.099%	0.000%	**0.220%**

		Other- Domestic hazardous waste						
66	16.1	Sanitary waste - diapers	6.157%	1.541%	2.540%	1.757%	3.572%	**3.113%**
67	16.2	Sanitary waste - sanitary pads	0.000%	0.359%	1.991%	0.871%	1.453%	**0.935%**
68	16.3	Bio-medical waste (generated from households)	0.000%	1.310%	1.642%	1.658%	1.235%	**1.169%**
69	16.4	Other domestic hazardous waste	0.751%	0.000%	0.928%	1.133%	1.739%	**0.910%**
		Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)						
70	17	Fines (Un-sortable small fragments (generally less than 5 cm or less in diameter); mainly composed of organic material and miscellaneous fines and dirt	6.498%	9.236%	8.707%	1.089%	6.808%	**6.468%**
71	18	Others (to be defined)	0.000%	0.000%	0.000%	0.000%	0.000%	**-**

Table 12 Broad characteristics of individual samples of dumpsite

Waste Categories	Dumpsite1	Dumpsite2	Dumpsite3	Dumpsite4	Dumpsite5
PLASTIC	14.362%	10.855%	12.375%	18.556%	22.969%
Paper & Cardboard	14.133%	7.828%	12.365%	15.582%	16.808%
METAL	4.792%	1.098%	3.797%	4.552%	4.486%
GLASS	5.821%	4.460%	2.186%	2.915%	6.314%
RUBBER AND TYRE	1.238%	1.866%	3.784%	3.345%	2.974%
E-WASTE	0.614%	0.202%	1.806%	1.351%	1.401%
Textile	8.053%	3.825%	2.944%	18.907%	1.117%
Other Non-Biodegradable materials	5.294%	16.207%	9.755%	18.353%	7.880%
Organics	32.287%	41.212%	35.179%	9.931%	21.244%
Domestic Hazardous Waste	6.908%	3.210%	7.101%	5.418%	7.999%
Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)	6.498%	9.236%	8.707%	1.089%	6.808%
Others (to be defined)	0.000%	0.000%	0.000%	0.000%	0.000%

Table 12 Broad characteristics of individual samples of dumpsite shows the broad categories of waste in all individual samples of the dumpsite.

5. Results and discussions

Waste Study at Households level

Given Table 13 Overall Waste Characteristics in broad category shows that organic waste has the highest amount. Percentage of plastic waste in generated waste at house-holds level is maximum in low-income group.

Table 13 Overall Waste Characteristics in broad category

Waste Categories	Waste Characteristics		
	HIG	MIG	LIG
PLASTIC	7.439%	6.820%	8.050%
Paper & Cardboard	7.568%	6.085%	6.270%
METAL	2.381%	1.121%	0.913%
GLASS	0.991%	1.827%	2.880%
RUBBER AND TYRE	0.318%	0.314%	0.864%
E-WASTE	0.368%	0.868%	0.285%
Textile	1.022%	1.500%	3.426%
Other Non-Biodegradable materials	4.853%	4.212%	3.135%
Organics	68.994%	66.990%	70.002%
Domestic Hazardous Waste	5.148%	8.615%	2.900%
Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)	0.920%	1.646%	1.275%
Others	0.000%	0.000%	0.000%

Legend: HIG – High Income Group; MIG – Middle Income Group; LIG – Low Income Group;

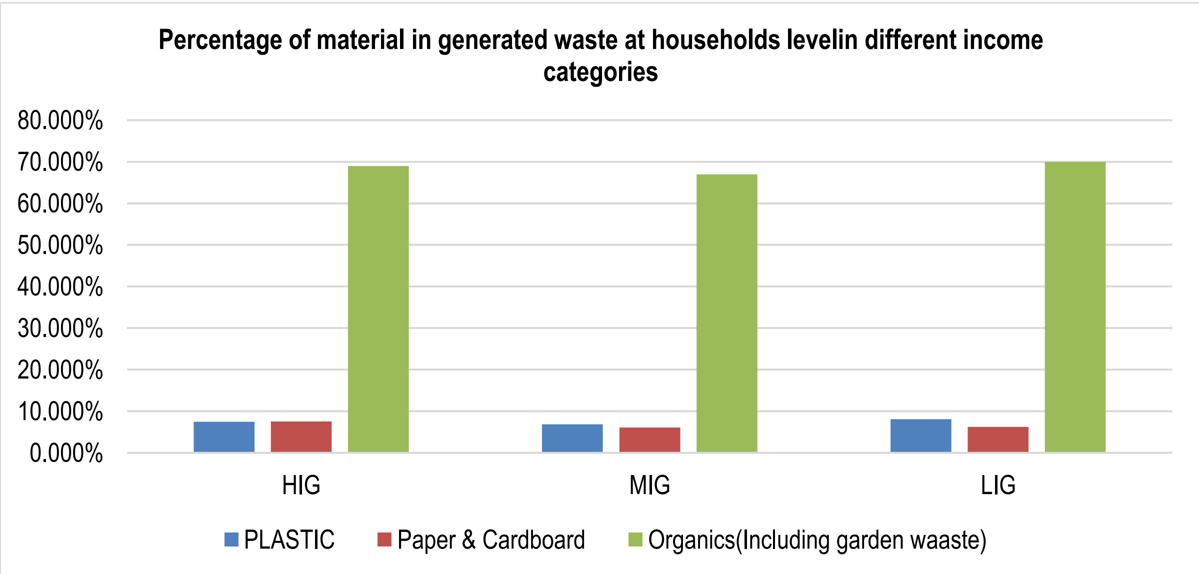


Figure 11 Percentage of material in generated waste at household's level

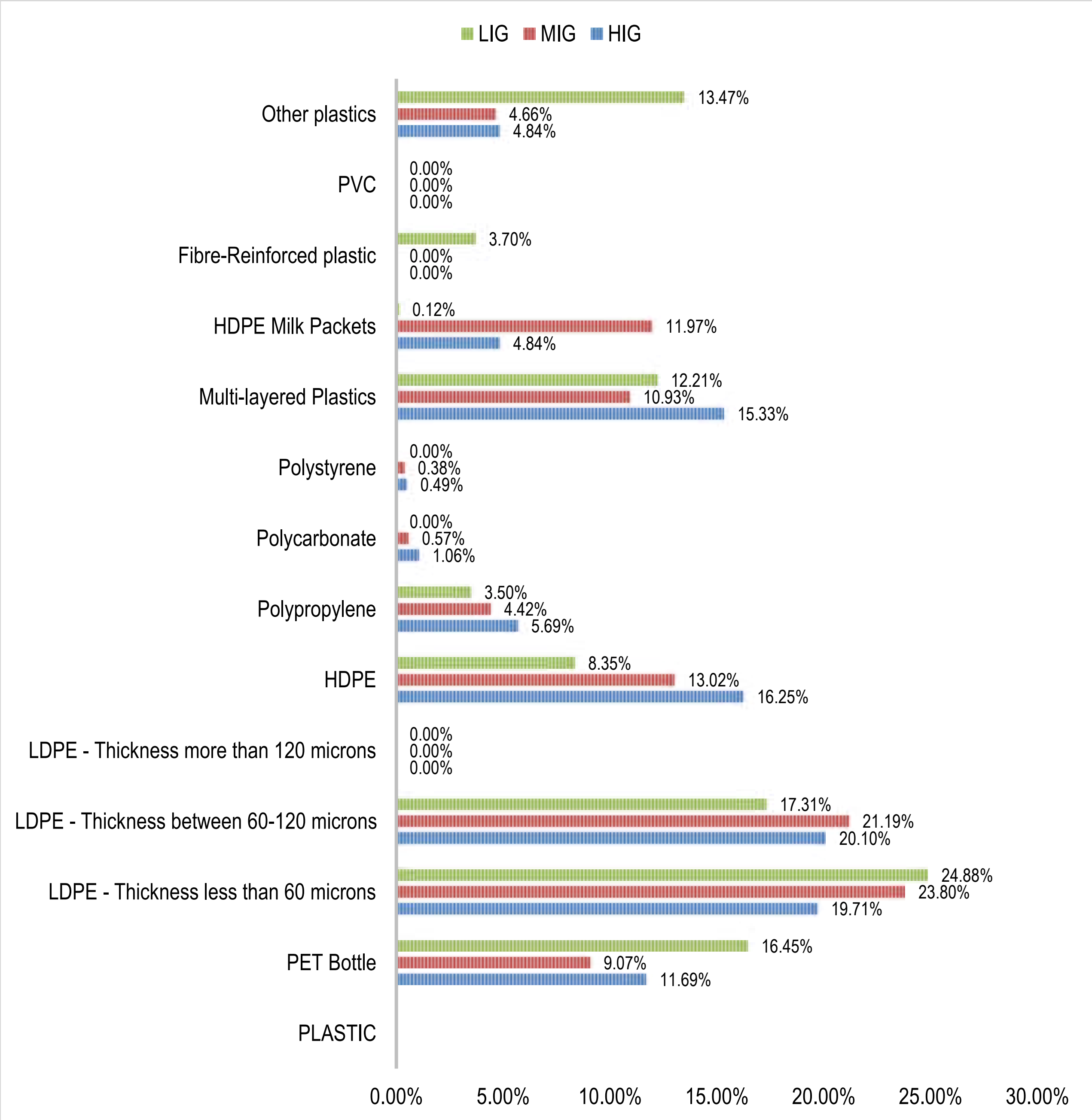


Figure 12 Percentage of different types of plastics in overall plastic waste generation at household level

In above Figure 12 Percentage of different types of plastics in overall plastic waste generation at household level, percentage of LDPE (<60 microns) is maximum.

Figures 13, 14 and 15 are showing the PI chart broad waste characterization for different income group.

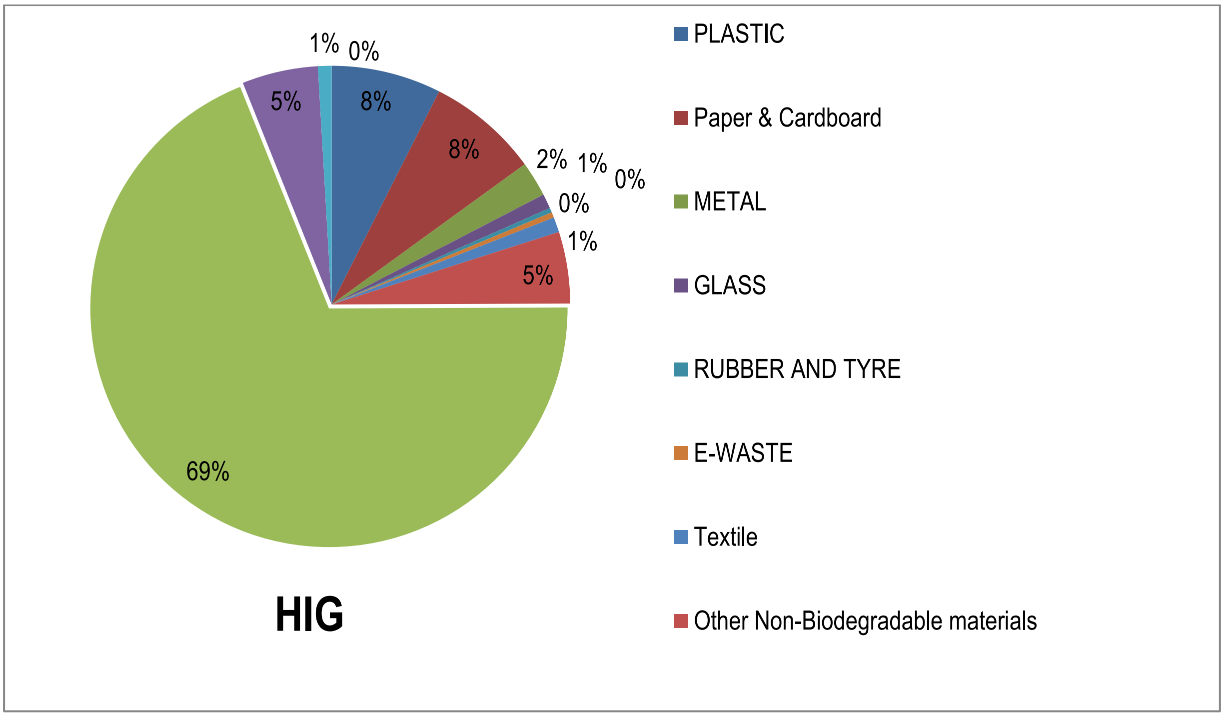


Figure 13 Broad waste characterization for high income group

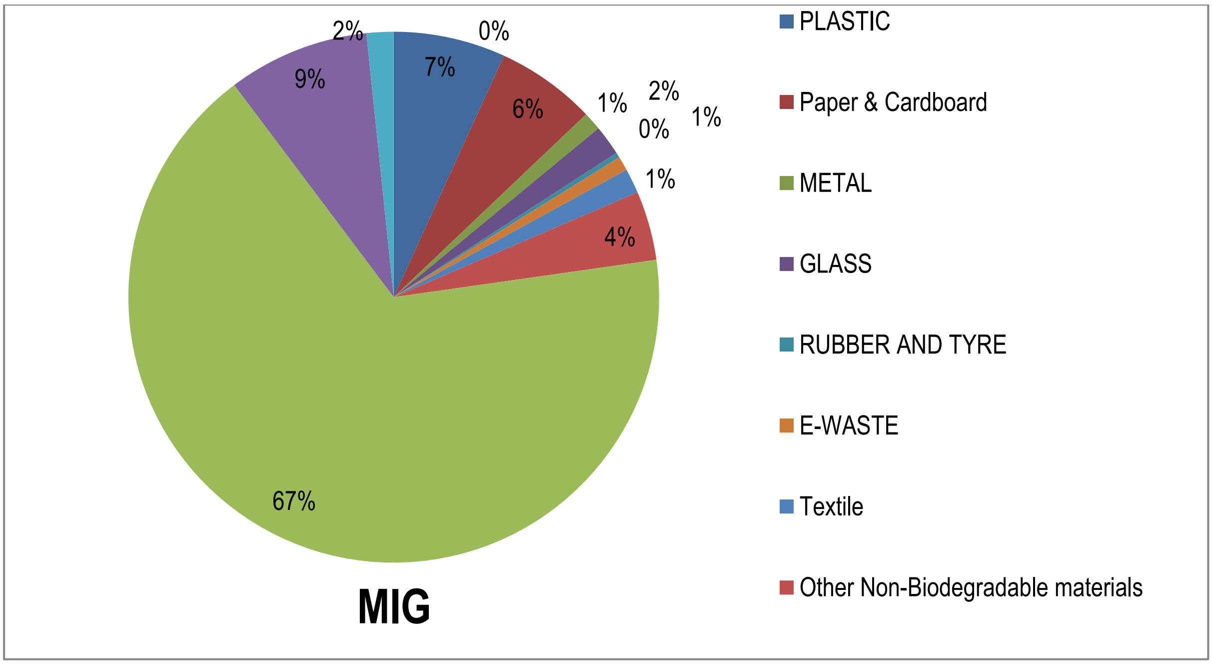


Figure 14 Broad waste characterization for middle income group

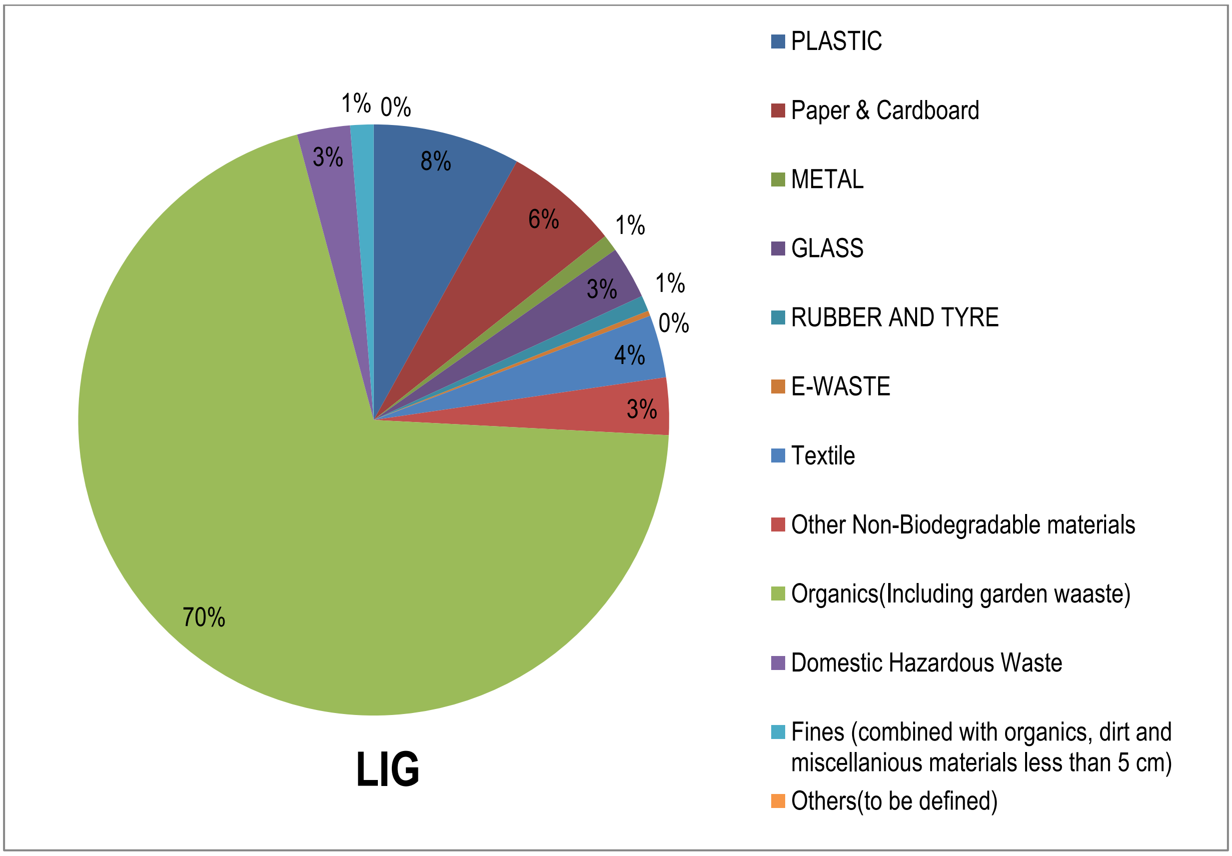


Figure 15 Broad waste characterization for low-income group

Waste Study for Non-household's level

Below table 14 are showing the broad characterization of waste from different stakeholders of commercial area. The average characteristic of non-households in broad categories is calculated by weight average.

Table 14 Individual Stake Non households broad Waste Characterization

Waste Material	Shops	Hospitals	Hotels	Schools	Office	Restaurants	Average characteristic from nonresidential source
PLASTIC	6.61%	15.42%	31.21 %	0.15%	7.02%	9.46%	10.54%
Paper & Cardboard	86.28%	42.86%	8.04%	6.84%	61.12%	1.79%	46.15%
METAL	0.83%	0.42%	0.93%	0.00%	0.00%	4.58%	1.24%
GLASS	0.00%	0.00%	3.74%	0.00%	0.00%	1.77%	0.79%
RUBBER AND TYRE	0.00%	0.00%	0.00%	0.00%	0.08%	3.14%	0.51%
E-WASTE	0.00%	0.00%	0.00%	0.00%	0.66%	0.00%	0.06%
Textile	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Other Non-Biodegradable materials	0.28%	0.63%	0.51%	1.73%	3.06%	3.60%	1.29%
Organics	4.13%	30.75%	50.80 %	91.28%	23.35%	69.03%	35.54%
Domestic Hazardous Waste	1.88%	8.42%	3.68%	0.00%	0.08%	0.46%	2.18%
Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)	0.00%	1.50%	1.09%	0.00%	4.63%	6.17%	1.70%
Others (to be defined)	0.000%	0.000%	0.000 %	0.000%	0.000%	0.000%	0.000%

Waste Study at Dumpsite

Figure 16 Sampling of Waste using quartering method at dumpsite

Figure 17 weighing and collection of sample from dumpsite.

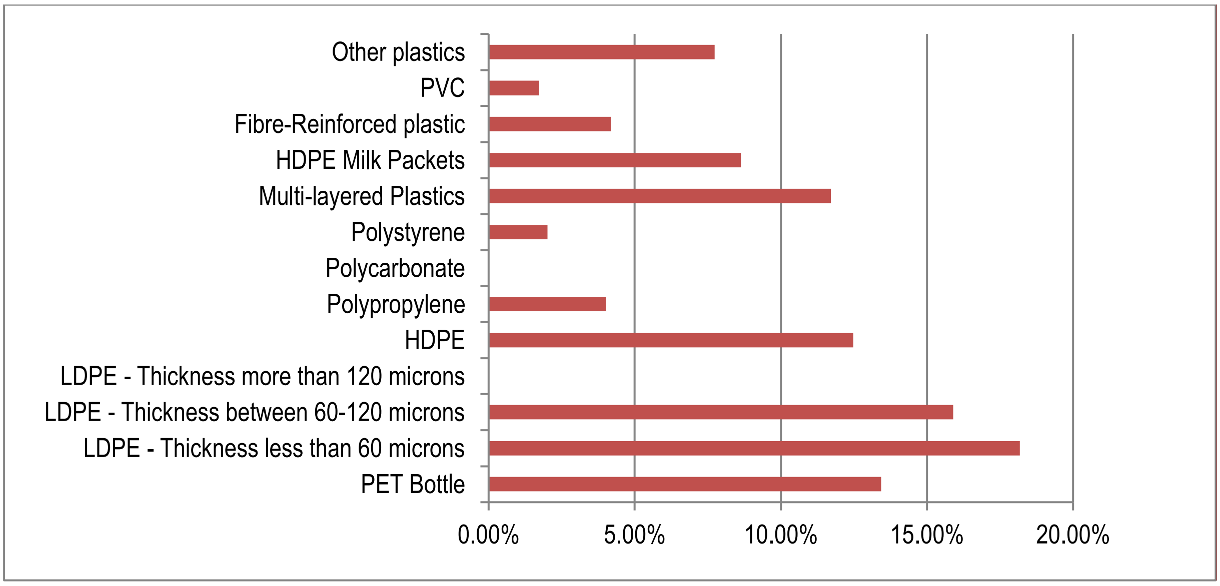


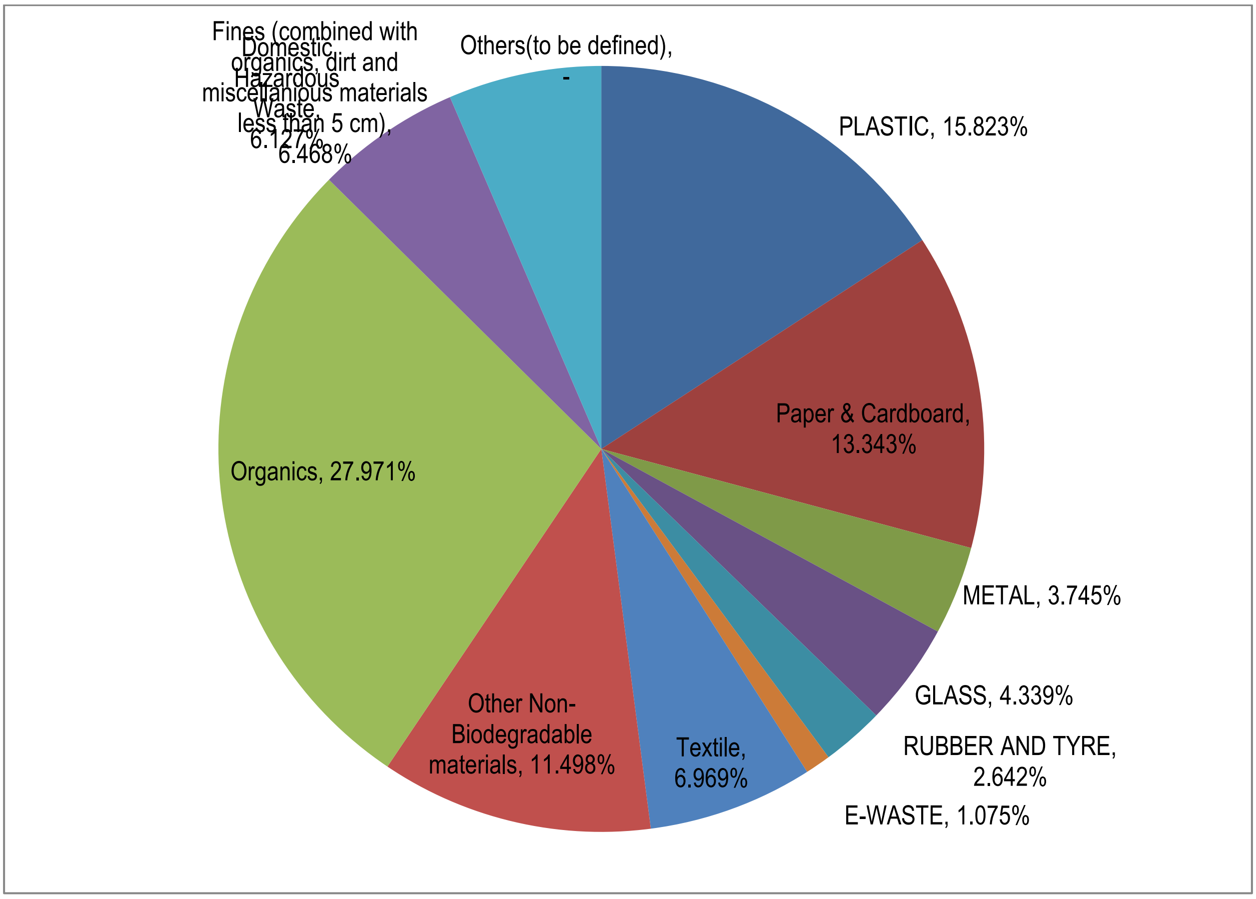
Figure 18 Percentage of different types of plastics reaching at dumpsite

From Figure 18 Percentage of different types of plastics reaching at dumpsite, It is seen that the percentage of LDPE (< 60 microns) is highest among all types of plastics that are being disposed of at dump sites.

In below Table 15 Overall Dumpsite Waste Characteristics in broad category showing that percentage of organic waste is maximum and then plastic waste that are being disposed of at dump sites.

Table 15 Overall Dumpsite Waste Characteristics in broad category

Waste Categories	Percentage
PLASTIC	15.823%
Paper & Cardboard	13.343%
METAL	3.745%
GLASS	4.339%
RUBBER AND TYRE	2.642%
E-WASTE	1.075%
Textile	6.969%
Other Non-Biodegradable materials	11.498%
Organics	27.971%
Domestic Hazardous Waste	6.127%
Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)	6.468%
Others (to be defined)	-



Statistical analysis of data:

Arithmetic mean: The arithmetic mean of a data set is what is usually called the average of the values, or in other words, the sum of the values divided by the number of values in the data set.

Standard deviation: a parameter that indicates the way in which a probability function or a probability density function is centered around its mean and that is equal to the square root of the moment in which the deviation from the mean is squared

Best Estimate of Precision Analysis: It is the sum of squares of the errors, which are the function of true value.

Best estimate of uncertainty in data: It represents the extent of random error in the measured values.

Table 16 Statistic analysis of Dumpsite waste study

	Landfill 1	Landfill 2	Landfill 3	Landfill 4	Landfill 5	MEAN	STANDARD DEVIATION	Best Estimate of Precision Analysis	Best estimate of uncertainty in data
PLASTIC									
PET Bottle	2.623%	0.379%	1.712%	2.148%	3.765%	0.02125126	0.01240568	0.013869977	0.006202842
LDPE - Thickness less than 60 microns	3.135%	2.777%	2.879%	4.087%	1.507%	0.02876931	0.00924455	0.010335717	0.004622273
LDPE - Thickness between 60-120 microns	1.341%	2.570%	2.275%	3.711%	2.683%	0.02515979	0.00851274	0.009517538	0.004256372
LDPE - Thickness more than 120 microns	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
HDPE	3.022%	0.773%	0.903%	2.722%	2.451%	0.01974136	0.01057639	0.011824763	0.005288195
Polypropylene	0.400%	0.300%	0.215%	1.103%	1.151%	0.0063385	0.00455519	0.005092855	0.002277594
Polycarbonate	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Polystyrene	0.175%	0.005%	0.339%	0.000%	1.077%	0.00319356	0.00446105	0.004987608	0.002230526
Multi-layered Plastics	1.243%	0.847%	0.753%	1.415%	5.005%	0.01852679	0.01783172	0.019936465	0.008915858
HDPE Milk Packets	1.009%	0.404%	2.101%	1.287%	2.031%	0.01366141	0.00714355	0.007986727	0.003571773
Fibre-Reinforced plastic	0.073%	0.921%	0.085%	0.000%	2.233%	0.00662347	0.00955708	0.010685138	0.004778539
PVC	0.463%	0.905%	0.000%	0.000%	0.000%	0.00273603	0.004059	0.004538101	0.002029501
Other plastics	0.877%	0.975%	1.113%	2.083%	1.067%	0.01223088	0.00489238	0.005469842	0.002446188
Paper & Cardboard									
Newspaper	1.584%	2.063%	0.594%	2.276%	2.307%	0.01764892	0.00715614	0.008000811	0.003578071
White Paper	0.551%	1.196%	1.198%	1.574%	1.151%	0.01133902	0.00367925	0.004113523	0.001839623
Colored Paper	0.000%	0.266%	0.324%	1.781%	1.047%	0.00683797	0.0072601	0.008117044	0.003630052
Books	0.000%	0.000%	0.130%	0.000%	0.000%	0.00025948	0.00058021	0.00064869	0.000290103
Magazines	0.000%	0.000%	0.983%	0.000%	0.000%	0.00196603	0.00439617	0.004915072	0.002198087
Cardboard- 3 ply	1.072%	0.197%	1.502%	1.351%	1.077%	0.01039863	0.00505781	0.005654799	0.002528903
Cardboard-5 ply	6.235%	2.604%	4.236%	4.731%	1.556%	0.03872551	0.01831901	0.020481271	0.009159503
Duplex board	3.271%	1.305%	2.989%	3.395%	3.686%	0.02928982	0.00941854	0.010530249	0.004709271

Other paper and cardboards	1.419%	0.197%	0.409%	0.475%	5.983%	0.01696555	0.02441793	0.027300072	0.012208963
METAL						#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Iron	0.000%	0.000%	2.066%	0.000%	0.000%	0.00413165	0.00923866	0.010329135	0.00461933
Steel	3.690%	0.000%	0.000%	1.593%	0.000%	0.01056738	0.01625878	0.018177864	0.008129388
Aluminum	0.341%	0.660%	0.384%	1.267%	1.695%	0.00869312	0.00591013	0.006607722	0.002955063
Zinc	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Brass	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Copper	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Tin	0.760%	0.438%	1.347%	1.692%	2.791%	0.01405935	0.00916268	0.010244186	0.004581339
Other Metal	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
GLASS									
Plain Glass	3.578%	3.909%	1.163%	2.915%	2.134%	0.02739759	0.01112951	0.012443175	0.005564757
Colored Glass	0.278%	0.000%	0.464%	0.000%	1.700%	0.00488298	0.00705138	0.007883682	0.00352569
Mirror	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Glass cullet (Broken glass)	1.965%	0.551%	0.559%	0.000%	2.480%	0.01111009	0.01055411	0.011799855	0.005277056
Other Glass	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
RUBBER AND TYRE									
2 & 3-wheeler tyre	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
4-wheeler passenger	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
4-wheeler commercial	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Rubber - Chappal	0.000%	0.414%	0.000%	3.345%	1.512%	0.01054082	0.01422189	0.015900552	0.007110943
Rubber - Gloves	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Rubber - Tubes	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Rubber - Shoe Bottoms	1.238%	0.478%	0.000%	0.000%	0.000%	0.00343159	0.00541411	0.006053163	0.002707057
Other rubber and tyre	0.000%	0.975%	3.784%	0.000%	1.462%	0.01244313	0.01554722	0.017382325	0.007773612
E-WASTE									
Batteries-Lithium Ion	0.044%	0.000%	0.190%	0.000%	0.000%	0.00046698	0.00082122	0.000918149	0.000410609
Batteries-Conventional	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Wires	0.000%	0.000%	0.015%	0.000%	0.000%	2.994E-05	6.6947E-05	7.48488E-05	3.34734E-05
Electrical Appliances	0.570%	0.202%	1.602%	1.351%	1.401%	0.01025203	0.00605103	0.006765262	0.003025517
Cell Phones	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Laptops	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
Other e-waste	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
TEXTILE									
Rags	5.002%	2.275%	0.459%	11.935 %	1.117%	0.04157433	0.04681818	0.052344311	0.023409088
Clothes	1.014%	1.487%	2.485%	3.360%	0.000%	0.01669136	0.01301222	0.014548107	0.006506111
Other textile	2.038%	0.064%	0.000%	3.612%	0.000%	0.01142797	0.01633622	0.018264451	0.008168111

Other Non-Biodegradable materials									
Used Beverage Cartons	1.014%	0.901%	0.314%	0.000%	1.927%	0.00831226	0.00741059	0.008285292	0.003705295
Leather	0.000%	0.000%	2.495%	0.000%	0.000%	0.00498992	0.0111578	0.012474801	0.005578901
Coconut Shell	0.980%	5.017%	4.172%	11.990 %	0.000%	0.04431587	0.04719338	0.052763799	0.023596688
Ceramic	0.205%	0.000%	0.000%	0.000%	0.000%	0.0004095	0.00091566	0.001023741	0.000457831
Wood (Engineering wood)	0.127%	0.246%	1.113%	0.000%	3.019%	0.0090087	0.01261894	0.014108406	0.006309471
Hair - Length more than 6 inches	0.000%	0.153%	0.035%	0.000%	2.935%	0.00624449	0.01292988	0.014456041	0.006464938
Hair - Length less than 6 inches	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0
C&D waste	2.969%	9.891%	1.627%	6.364%	0.000%	0.04169973	0.03963553	0.044313865	0.019817763
Other- Organics									
Food waste	13.967 %	36.964 %	26.337 %	4.557%	13.715%	0.19107934	0.12632501	0.14123565	0.063162503
Green garden waste	18.320 %	4.249%	8.842%	2.850%	4.723%	0.07796877	0.06291597	0.070342194	0.031457985
Wood waste (Tree branches etc.)	0.000%	0.000%	0.000%	1.425%	2.806%	0.0084627	0.01257483	0.014059092	0.006287417
Other biodegrables	0.000%	0.000%	0.000%	1.099%	0.000%	0.00219704	0.00491273	0.005492602	0.002456366
Other- Domestic hazardous waste									
Sanitary waste - diapers	6.157%	1.541%	2.540%	1.757%	3.572%	0.03113318	0.01878598	0.021003361	0.009392988
Sanitary waste - sanitary pads	0.000%	0.359%	1.991%	0.871%	1.453%	0.0093476	0.00805074	0.009000999	0.004025369
Bio-medical waste (generated from households)	0.000%	1.310%	1.642%	1.658%	1.235%	0.01168817	0.00680613	0.007609482	0.003403064
Other domestic hazardous waste	0.751%	0.000%	0.928%	1.133%	1.739%	0.00910221	0.00630667	0.007051069	0.003153334
Fines (combined with organics, dirt and miscellaneous materials less than 5 cm)									

Fines (Un-sortable small fragments (generally less than 5 cm or less in diameter); mainly composed of organic material and miscellaneous fines and dirt	6.498%	9.236%	8.707%	1.089%	6.808%	0.06467692	0.03229981	0.036112289	0.016149907
Others (to be defined)	0.000%	0.000%	0.000%	0.000%	0.000%	0	0	0	0

6. Key observations and learnings

- MLP and LDPE (less than 60 micron thick) constituted around half of the total plastic waste that reached these transfer stations – indicating a scope of banning single use plastics more efficiently and linking MLPs with combustion units.

- Waste collection fleet often removed easy recyclables with high value like cardboard and metals from collected waste.

- During Non-household's waste sampling, people gave the waste in segregated manner. So, that percentage of fines are less.

- Sanitary waste and other domestic hazardous waste were mixed with other wastes in packets from households. There was a need to have better awareness regarding the appropriate management of domestic hazardous waste.

- Residual waste, termed as fines, was non-segregable fraction of waste which mostly consisted of organic fractions laden with inert materials like dirt and ashes. If better segregation could be achieved, quantity of fines will automatically reduce.

- All the arrangements were done on time to avoid last hour hassles.

- All the samples (dumpsite) were collected in a manner that overall weight of the entire sorted sample was greater than 90 kgs.

- PVC material was found in the study and non-woven plastic carry bags were also found in a good quantity.

- Separate collection of waste from city in bags lead to ease of segregation. Thus, indicating an increase in MRF efficiency for segregating.

- During sorting, sanitary pads were found in wrapped in paper or plastic carry bags while diapers (Child and adult) were found open or in plastic carry bags.

- Metals like zinc and brass were not found in the waste that indicated that metals did not come with waste.

7. Annexure

7.1 Template of public consent

No.: 71/EE-III/SWM/MC/2018-19/ 350

नगरपालिका परिषद् का कार्यालय

OFFICE OF THE MUNICIPAL COUNCIL

पोर्ट ब्लेयर

PORT BLAIR

Port Blair, dated 08.03.2022

LETTER OF INTRODUCTION

Sir/ Madam,

We are glad to inform you that M/s Foursome Enterprises is conducting a survey to collect data on the Sustainable Development Goal indicator 11.6.1 with the permission of Port Blair Municipal Council in Port Blair Municipal Council area under the supervision of GIZ India.

This includes collecting information and waste from households and institutions. The objective of the Contract is to undertake a Municipal Solid waste generation & Characterization within the Municipal limits of Port Blair Municipal Council. This analysis will contribute to analysing feasibility of MRF at these zones and will also help GIZ under the project to develop standard operating procedures for undertaking the waste generation & characterisation studies in other parts of the country.

During the study, surveyor will collect your 08 days daily households waste (organic, non-organic, domestic hazardous and sanitary waste) for the study. The data obtained from the survey will be used to develop strategies and plans to improve waste management and achieve better urban living environment for residents in Port Blair Municipal Council.

We would appreciate your collaboration in allowing M/s Foursome Enterprises staff to collect the information & material, necessary for assessing SDG indicator 11.6.1.

Yours Sincerely,

Executive Engineer-III (Works & SWM)
Municipal Council

Declaration of consent for the use photographs taken during in the waste characterisation study: *With your attendance, you are confirming your awareness of the fact that any photo taken of you in the context of this study may be used by GIZ for PR and documentation purposes, both in print and online. You therefor confirm that you do not object to or limit this usage in temporal or spatial terms. If you do not agree, please contact the study organisers.*

Name of Person-

Ward No-

Address-

Contact No-

Email-

Signature -

Name of Surveyor with Signature-

List of surveyor is attached

7.2 Template for tare weight of waste containers

CONTAINER TARE WEIGHT TRACKING WASTE CHARACTERISATION STUDY Sample No. Vehicle Details: Sample Location:			Date/Time:…………….
CONTAINER NO.	TARE WEIGHT	CONTAINER NO.	TARE WEIGHT
1.		36.	
2.		37.	
3.		38.	
4.		39.	
5.		40.	
6.		41.	
7.		42.	
8.		43.	
9.		44.	
10.		45.	
11.		46.	
12.		47.	
13.		48.	
14.		49.	
15.		50.	
16.		51.	
17.		52.	
18.		53.	
19.		54.	
20.		55.	
21.		56.	
22.		57.	
23.		58.	
24.		59.	
25.		60.	
26.		61.	
27.		62.	
28.		63.	
29.		64.	
30.		65.	
31.		66.	
32.		67.	
33.		68.	
34.		69.	
35.		70.	

7.3 Table for sample collection

WASTE SAMPLE RECORD				
WASTE CHARACTERIZATION STUDY				
SAMPLE INFORMATION:				
Date: Sample No:				
		Bucket/container no	**Bucket/container weight**	**net weight**

7.4 Waste sample record sheet

WASTE SAMPLE RECORD					
WASTE CHARACTERIZATION STUDY					
SAMPLE INFORMATION:					
FACILITY:		SAMPLE SIZE:			
VEHICLE INFORMATION:		DATE/TIME:		WEATHER:	
VEHICLE NO.		**VEHICLE TYPECOLLECTION LOCATION**			

S.N.		**WASTE MATERIALS**	**GROSS WEIGHTS**	**CONTAINER NUMBER OR TYPE**	**Tare Weight**	**Net Weight**	**COMMENTS**
	PLASTIC						
1	1.1	PET Bottle					
2	1.2	LDPE - Thickness less than 60 microns					
3	1.3	LDPE - Thickness between 60-120 microns					
4	1.4	LDPE - Thickness more than 120 microns					
5	1.5	HDPE					
6	1.6	Polypropylene					
7	1.7	Polycarbonate					
8	1.8	Polystyrene					
9	1.9	Multi-layered Plastics					
10	1.10	HDPE Milk Packets					
11	1.11	Fibre-reinforced plastic					
12	1.12	PVC					
13	1.13	Other plastics					
	Paper & Cardboard						
14	2.1	Newspaper					
15	2.2	White Paper					
16	2.3	Colored Paper					
17	2.4	Books					

18	2.5	Magazines					
19	2.6	Cardboard- 3 ply					
20	2.7	Cardboard-5 ply					
21	2.8	Duplex board					
22	2.9	Other paper and cardboards					
	METAL						
23	3.1	Iron					
24	3.2	Steel					
25	3.3	Aluminum					
26	3.4	Zinc					
27	3.5	Brass					
28	3.6	Copper					
29	3.7	Tin					
30	3.8	Other Metal					
	GLASS						
31	4.1	Plain Glass					
32	4.2	Colored Glass					
33	4.3	Mirror					
34	4.4	Glass cullet (Broken glass)					
35	4.5	Other Glass					
	RUBBER AND TYRE						
36	5.1	2 & 3-wheeler tyre					
37	5.2	4-wheeler passenger					
38	5.3	4-wheeler commercial					
39	5.4	Rubber - Chappal					
40	5.5	Rubber - Gloves					
41	5.6	Rubber - Tubes					
42	5.7	Rubber - Shoe Bottoms					
43	5.8	Other rubber and tyre					
	E-WASTE						
44	6.1	Batteries- Lithium Ion					

45	6.2	Batteries-Conventional					
46	6.3	Wires					
47	6.4	Electrical Appliances					
48	6.5	Cell Phones					
49	6.6	Laptops					
50	6.7	Other e-waste					
	TEXTILE						
51	7.1	Rags					
52	7.2	Clothes					
53	7.3	Other textile					
Other Non-Biodegradable materials							
54	8	Used Beverage Cartons					
55	9	Leather					
56	10	Coconut Shell					
57	11	Ceramic					
58	12	Wood					
59	13.1	Hair - Length more than 6 inches					
60	13.2	Hair - Length less than 6 inches					
61	14	C&D waste					
	Others- Organics						
62	15.1	Food waste					
63	15.2	Green garden waste					
64	15.3	Wood waste (Tree branches etc.)					
65	15.4	Other biodegrables					
	Others- Domestic Hazardous waste						
66	16.1	Sanitary waste - diapers					
67	16.2	Sanitary waste – Sanitary pads					
68	16.3	Bio-medical waste (generated from households)					

69	16.4	Other domestic hazardous waste					
70	17	Fines (Unsortable small fragments (generally less than 5 cm or less in diameter); mainly composed of organic material and miscellaneous fines and dirt)					
71	18	Others (any other material)					
COMMENTS/OBSERVATIONS:							

7.5 Items required during study

S.N.	Material/PPEs used during study	Quantity	Remarks
	Materials		
1	Dustbin*Large	2	
2	Dustbin*small	30	
3	Garbage bags	60 pcs	1 pc contains 15 garbage bags
4	Table	4	
5	Chair	5	
6	Weighing machine	3	
7	Polythene	16 mtr *5 ft	Used for spreading out on table
8	Shovel	1	For collection of samples
9	House- broom	1	
10	Dustpan	1	
11	Duster cloth	2	
	PPEs		
1	Safety Gloves*Latex	125 pair	
2	Safety Gloves*Cotton	18	Rubber coated gloves
3	Safety mask (N95)	12	
4	Safety mask (Surgical)	120	
5	Safety goggles	12	
6	Safety vest	10	Reflective jackets
7	Shoe cover	100	
8	Head cap	100	
9	Hand Sanitizer Liquid	3 Bottle	500 ML per bottle
10	Hand Sanitizer Gel	2	100 ML per bottle
11	Hand wash	1	
12	First Aid kit	1	
13	Tissue paper	4 box	200 pulls per box

Bibliography

Chassignet, E. P. (2021). Tracking Marine Litter With a Global Ocean Model: Where Does It Go? Where Does It Come From? *frontiersin* .

Jambeck, J. R. (2015). Plastic waste inputs from land into the ocean. *Science* .

Jeyasanta, I. (2020). Macro-, meso- and microplastic debris in the beaches of Tuticorin district, Southeast coast of India. *Marine Pollution Bulletin* .

Kaladharan, P. (2017). Prevalence of marine litter along the Indian beaches : A preliminary account on its status and composition. *Marine Biological Association of India* .

Landrigan, P. J. (2020). Human Health and Ocean Pollution. *annalsofglobalhealth* .

Lebreton, L. (2019). Future scenarios of global plastic waste generation and disposal. *Humanities & Social Sciences Communications* .

M.Cavalcante, R. (2020). Marine debris on a tropical coastline: Abundance, predominant sources and fate in a region with multiple activities (Fortaleza, Ceará, northeastern Brazil). *Elsevier* .

PrasunGoswamia, Valsalan, N., Vinithkumara, & GopalDharani. (2020). First evidence of microplastics bioaccumulation by marine organisms in the Port Blair Bay, Andaman Islands. *Marine Pollution Bulletin, 155*.

Provencher, J. F. (2014, May 15). Prevalence of marine debris in marine birds from the North Atlantic. *Marine Pollution Bulletin* .

T.Kaviarasan. (2020). Assessment of litter in the remote beaches of Lakshadweep Islands, Arabian Sea. *Elsevier* .

Legal Information

Disclaimer

All indications, data and results of this study have been compiled and carefully reviewed by the authors. Nevertheless, errors may occur with regard to the content. Therefore, neither GIZ nor the authors will be liable for any claims, losses or damages, direct or indirect, arising from the use of or reliance on the information contained in this study.

The reproduction or duplication of the study (including transfer of data to multimedia storage systems) and distribution for non-commercial purposes is permitted, provided that GIZ is acknowledged as the source of the information. For other commercial use, including duplication, reproduction or distribution of all or part of this publication, written permission from GIZ is required.

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Cities Combatting Plastic entering Marine Environment

Third Floor, B 5/5
Safdarjung Enclave
New Delhi, 110029
India

T + 91 4949 5353
F + 91 4949 5391
E giz-indien@giz.de
I www.giz.de

Situational Analysis and City Action Plan for Port Blair
For Support for Management of Organic Waste under Project MOWI

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Address
GIZ Management of Organic Waste in India
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
2nd Floor, B-5/2, Safdarjung Enclave
New Delhi 110029
T + 91 4949 5353
F + 91 4949 5391

E info@giz.de
I www.giz.de

Responsible
Mrs. Vaishali Nandan
Head of Project, Climate Smart Cities, GIZ

Submitted by
Saahas Waste Management Private Limited

Authors
Dr Bharat B. Nagar, GIZ
Dr Supreet Kaur, GIZ
Ms. Carla Rossitto, GIZ
Aviral Saxena, GIZ
Ms Soma Biswas, GIZ
Mrs. Wilma Rodrigues, Saahas Waste Management Private Limited
Ms. Annie Phillip, Saahas Waste Management Private Limited
Ms. Garima Poonia, Saahas Waste Management Private Limited

Saahas Waste Management Private Limited is responsible for the content of this publication
April, 2022

Contents

Abbreviations

Sno	Abbreviation	Full Form
1.	ACCI	Andaman Chamber of Commerce and Industries
2.	ANI	Andaman and Nicobar Islands
3.	ANPCC	Andaman and Nicobar Pollution Control Committee
4.	BCC	Behaviour Change Communication
5.	BWG	Bulk Waste Generators
6.	CBO	Community Based Organisation
7.	CCP-ME	Cities Combating Plastic entering Marine Environment
8.	CPCB	Central Pollution Control Board
9.	CPHEEO	Central Public Health and Environmental Engineering Organisation
10.	DBRAIT	Dr B R Ambedkar Institute of Technology
11.	GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
12.	Govt.	Government
13.	IEC	Information Education Communication
14.	MCC	Mysore City Corporation
15.	MoEF&CC	Ministry of Environment, Forest and Climate Change
16.	MoHUA	Ministry of Housing and Urban Affairs
17.	MOWI	Management of Organic Waste in India
18.	NGO	Non-Governmental Organisation
19.	NSKFDC	National Safai Karamcharis Finance and Development Corporation
20.	OWM	Organic Waste Management
21.	PBMC	Port Blair Municipal Council
22.	PPE	Personal Protective Equipment
23.	PWM Rules	Plastic Waste Management Rules, 2016
24.	SAT	Sanitary Awareness Team
25.	SBM	Swachh Bharat Mission
26.	SI	Sanitary Inspector
27.	SLRM	Solid and Liquid Resource Management
28.	SOP	Standard Operating Procedure
29.	SZW	Saahas Zero Waste
30.	SWM	Solid Waste Management
31.	SWM Rules	Solid Waste Management Rules, 2016
32.	VMC	The Vengurla Municipal Council

33.	ToR	Terms of Reference for support for management of organic waste under MOWI by GIZ
34.	TOT	Training of Trainers
35.	ULB	Urban Local Body
36.	UN SDGs	United Nations Sustainable Development Goals

List of Figures

List of Tables

1. Introduction

India generates 1,50,761 MT of municipal waste per day, out of which approximately 96% of waste is collected but only 47% is processed or treated and the remaining is disposed of in landfills, dumpsites and other open areas[1]. This waste quantity is expected to double by 2030 and increase up to 165 million tonnes per annum[2]. It is estimated that approximately 50%[3] of the total municipal solid waste generated in India is organic waste. Due to the lack of proper SWM systems (including sub-optimal performance of waste processing facilities) and increasing urbanisation, significant quantities of organic waste are disposed of in open areas, dumpsites and landfills. The dumping of organic waste in landfills/ dumpsites has been identified as a factor towards increase in greenhouse emissions in urban areas due to the production of methane at these sites. As per India's Third Biennial Update Report to the United Nations Framework Convention on Climate Change, in 2016, 5,93,72,000 MT of solid waste reached landfills, resulting in 7,54,000 of methane which is equivalent to 15,831.84 CO2 equivalent while in 2015, 5,80,93,000 MT of solid waste reached the landfills which generated 7,36,000 of methane in 2015. There is some research to suggest that landfills are third largest contributors to the total methane emission in the country[4] and emissions from the waste sector make up to 3% of total GHG emissions in the country[5].

In light of this growing problem, the Government of India launched its flagship program Swachh Bharat Mission in 2014 envisaging measures to improve conditions of solid waste management both in rural and urban areas. The first phase of program was focused on open defecation and solid waste management including source segregation and promotion of city compost. The present second phase of the program is focused on setting up of de-centralised systems for management of organic waste, onsite management of waste by bulk waste generators, bio-methanation of organic waste and remediation of legacy waste. In addition, the notification of Solid Waste Management Rules, 2016 strengthened this vision, by creating obligations on stakeholders including urban local bodies (ULBs), Gram Panchayats (GPs), waste generators and waste processing facilities among others in order to regulate the waste management system in the country. The SWM Rules have imposed several obligations on different stakeholders regarding management of organic waste such as source segregation, management of organic waste at household and community levels, transportation of segregation organic waste, setting up of de-centralised and centralised organic waste processing facilities and prohibition on disposal of organic waste in landfills.

In this context, GIZ has launched "Management of Organic Waste in India (MOWI)" in partnership with MoHUA to improve sustainable organic waste practices in the city of Port Blair and provide technical support to the Union Territory of Andaman and Nicobar Islands. It is planned as a complementary measure to the project "Cities Combating Plastic entering Marine Environment (CCP-ME)" with the intended goal to improve plastic waste management. Under the MOWI project, GIZ and its partners have carried out situational and gap analysis of the organic waste management systems in the city of Port Blair and prepared a roadmap of recommendations in the form of a city action plan.

Geography and administration of Andaman and Nicobar Islands

The Andaman and Nicobar Islands (ANI) are situated in the Bay of Bengal, about 1300 kms away from mainland India. They are a group of over 800 islands[6] out of which 38 islands are inhabited presently. Owing to the presence of a large number of islands, ANI has the longest coastline in India at nearly 2,000 km. The ecological sensitivity of these islands has also led to the notification of 10 (ten) national parks including marine

[1] CPCB Annual Report on Solid Waste Management 2019-20 available at https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2019-20.pdf
[2] https://pib.gov.in/newsite/printrelease.aspx?relid=138591
[3] https://www.epw.in/engage/article/institutional-framework-implementing-solid-waste-management-india-macro-analysis
[4] "Quantitative analysis of the methane gas emissions from municipal solid waste in India" available at https://www.nature.com/articles/s41598-018-21326-9
[5] https://unfccc.int/sites/default/files/resource/INDIA_%20BUR-3_20.02.2021_High.pdf
[6] https://www.andaman.gov.in/about

parks[7]. In addition, ANI lies within the seismic zone V which means that they are susceptible to earthquakes of magnitude of 8 or more and earthquakes up to the magnitude of 5 are a common occurrence in the islands.[8]

Administratively, ANI is a union territory and therefore, administered and controlled directly by the Central Government of India i.e., all legislative and executive powers in case of ANI lie with the Central Government.

Map data ©2022 Google

Figure 1: Map of ANI and location of Port Blair

The Andaman and Nicobar Islands are unique in terms of their biodiversity and ecological sensitivity and therefore, large parts of the islands are protected under different environmental regulations. In addition, several parts of the islands are controlled by the Indian military and are not open to general public. However, the inhabited islands have, emerged as a popular hotspot for tourists from all over the world. Today, tourism is one of the most important sources of revenue in the islands. Port Blair is the only city and capital of ANI and holds more than one third of the entire population of the state. ANI generates 165 MT[9] solid waste per day out of which the highest waste production is in Port Blair, generating 115 MT[10] solid waste per day.

2. Methodology and Approach

The city action plan includes an analysis of the existing OWM systems in Port Blair including gaps and best practices and recommendations for improvement of management of organic waste. The methodology that is used to prepare the city action plan includes the following:

[7] https://andamanbeacon.com/andaman_national_parks
[8] http://www.and.nic.in/Announcements/Master%20Plan%20Web%20format%20New/English/5.%20Chapter-%201.pdf
[9] Data submitted to NGT in affidavit dated April 2019 filed by the Union Territory of Andamans and Nicobar Islands, p.57
[10] Data submitted to NGT in affidavit dated April 2019 filed by the Union Territory of Andamans and Nicobar Islands, p.57.

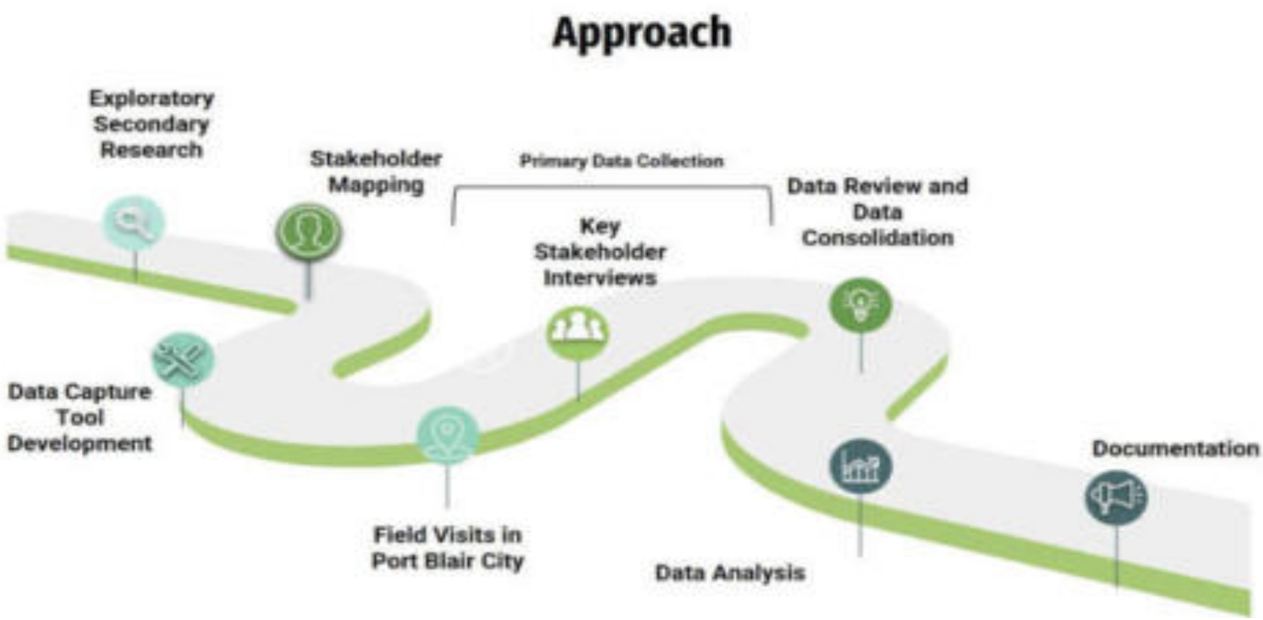


Figure 2: Approach & Methodology

2.1. Exploratory Secondary Research

The survey team conducted desk based secondary research and reviewed existing secondary data available in the public domain such as government reports and studies, relevant laws, policies and guidelines applicable on a national and relevant state and city level, reports and studies undertaken by credible agencies including data available with GIZ relating to Port Blair. The secondary research was conducted in a targeted manner, focusing on the baseline assessment parameters shown in *Figure 3.* The list of secondary research documentation and secondary data is set out in Part A of **Annexure 1.**

Figure 3: Baseline Assessment Parameters

In addition, the secondary research was used to identify source segregation levels, collection and transportation infrastructure systems, OWM facilities (both centralised and decentralised) for site visits, IEC and capacity building activities among others.

2.2 Stakeholder Mapping

Based on the secondary research, relevant stakeholders were identified which included officials from health departments of the ULBs, waste management agencies, waste processing facilities, community-based organisations and resident associations, who are involved across the value chain with respect to organic waste management. The team also identified ancillary departments/bodies such as Pollution Control Committees, Fisheries Department, Agriculture Department among others to understand their roles in OWM at the city. In depth Interviews with key stakeholders identified in Part B of **Annexure 1**

2.3 Tools for capturing data

On the basis of above-mentioned secondary research, SZW's organisational experiences and inputs from GIZ, structured questionnaires were prepared for in-depth interviews with different stakeholders in the city. The questionnaires prepared for the stakeholder interviews/meetings are annexed as **Annexure 2**

2.4 Field Visits- Site visits and In-depth stakeholder interviews in Port Blair

The survey team carried out site visits to understand the segregation levels, collection and transportation systems including primary collection from different waste generators and secondary transfer, processing and final disposal of organic waste, market linkages for end products, and financial feasibility of OWM systems. It was also carried out to verify, correct and/or corroborate the SWM data sets and information identified through secondary research. The details of the field visits which are set out in Part C of **Annexure 1** while the key stakeholders for in-depth interviews are identified in Part C of **Annexure 1.**

2.5 Data Review and Analysis

The survey team collated the primary data sets received from the stakeholders, GIZ and its project partners under various heads/themes relating to organic waste management. Thereafter, the data was reviewed and consolidated and categorised as quantitative (i.e., numerical and statistical data) and qualitative (first-hand observation during site visits, in depth interviews using questionnaires and review of similar case studies). The primary data sets that have been reviewed by the survey team are identified in Part D of **Annexure 1.** For gap analysis of organic waste management in the city, the survey team referred to the (a) "Template for Gap Analysis of Municipal Solid Waste Management Infrastructure and Services in Urban Local Bodies" issued by the Ministry of Housing and Urban Affairs on November 09, 2017 and (b) Considerations for Gap Analysis contained in Municipal Solid Waste Management Manual Part II: The Manual, CPHEEO, Ministry of Urban Development, 2016.

3. Overview of the City

3.1 City Profile

Port Blair is located in South Andaman district and its current population is estimated to be 1,40,472 persons[11], which is more than one-third of ANI's total population. It also acts as a gateway for nearly 5,00,000 tourists every year, which is more than the entire population of ANI.

The climate in Port Blair is tropical with temperatures ranging between 23 degrees to 31 degrees Celsius and it receives rainfall for almost 7 (seven) months and the annual rainfall is approximately 3900mm[12].

Port Blair generates about 115 MT[13] of municipal solid waste per day out of which organic waste generation is estimated at 69 TPD[14]. As per the SWM Rules 2016, the primary responsibility for management of organic waste is of the local body which is Port Blair Municipal Council in this case. The city is divided into 24 administrative wards where the topography of the wards is a mix of hilly and coastal areas.

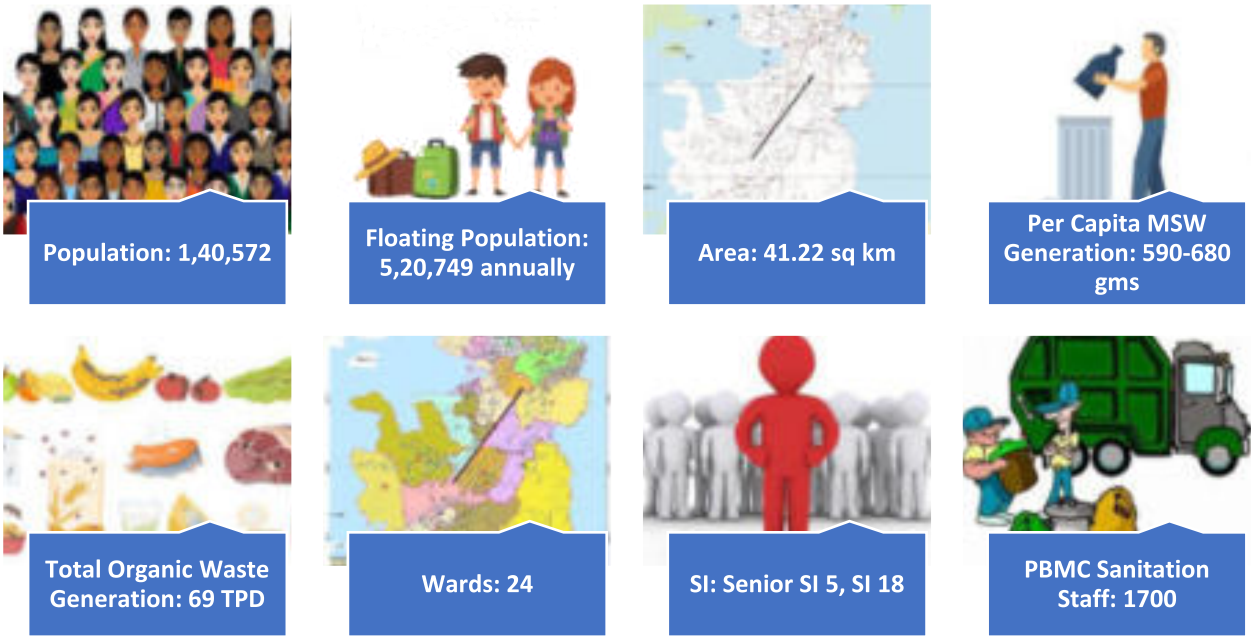


Figure 4: City Profile of Port Blair

[11] https://pbmc.gov.in/about.html
[12] https://www.andaman.gov.in/tourism/about
[13] Affidavit submitted by Andaman and Nicobar Pollution Control Committee (ANPCC) to the NGT on April 2019
[14] Data submitted to NGT in affidavit dated April 2019 filed by the Union Territory of Andamans and Nicobar Islands

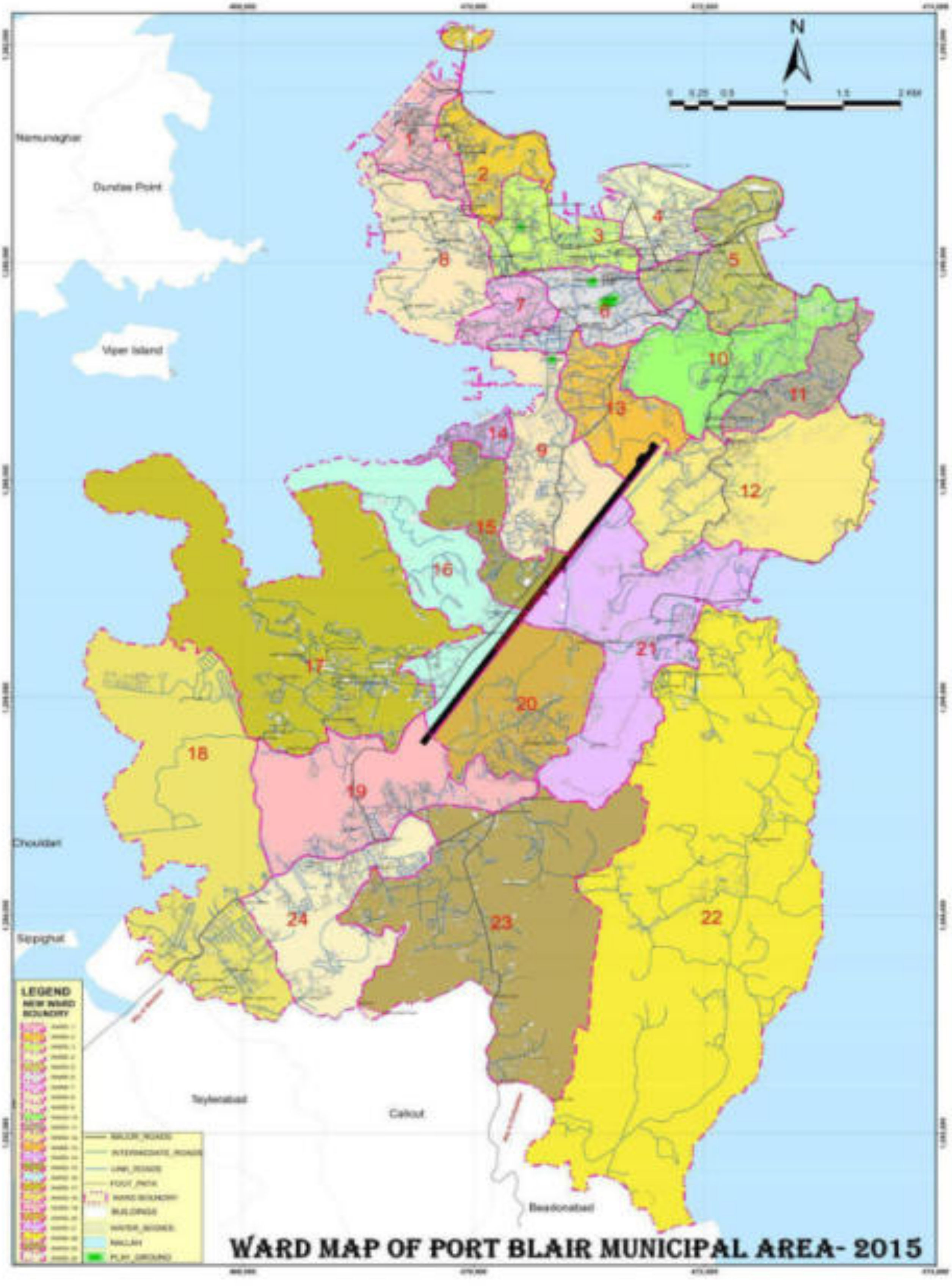


Figure 5: Ward Map of Port Blair

3.2 Key Stakeholders for SWM in Port Blair

The organic waste ecosystem in Port Blair consists of various stakeholders who are involved in different segments of the waste value chain. PBMC is in-charge of management of organic waste in the city, however, it has delegated some of its responsibilities to other stakeholders. The table below contains the details of the stakeholders along with the activities that they currently carry out with respect to organic waste[15]:

Sno	Stakeholder	Activity
Collection and transportation of organic waste		
1	PBMC	DTD collection from HHs and public places such as markets using crates and auto-tippers
2	Friends SHG	DTD from commercial establishments in Wards 17-24
3	Venkateshwara SHG	DTD from commercial establishments in Wards 1-16
Processing of organic waste		
1.	PBMC	Onsite composting in sanitary offices
2	Stree Hausala SHG	In charge of composting facility at Gandhi Park
3.	Friends SHG	In charge of composting unit at Brookshabad
4.	Private Piggeries	Private parties that operate piggeries within and outside PBMC jurisdiction

Table 1: Key Stakeholders for SWM in Port Blair

3.3 Different streams of organic waste

The organic waste generated within Port Blair can be categorised into 5 (five) major categories. In addition to the streams of food waste and horticulture waste, given that the city is a coastal town, it also produces significant quantities of coconut and meat (including fish) waste.

[15] Information received during n-depth interviews and discussions with stakeholders and field visits in Port Blair during December 2021.

Figure 6: Organic Waste Streams in Port Blair

Table 2: Estimation for Organic Waste Generation in Port Blair

S. No.	Type of organic waste	Quantity (TPD)[16]
1.	Horticulture waste	13[17]
2.	Fish Meat	10.5[18]
3.	Other Meat	5
4.	Flower Waste	2[19]
5.	Organic waste from Markets	3[20]
6.	Cow dung	2[21]
7.	Organic waste from Households	22[22]
8.	Organic waste from BWGs	9.33[23]
9.	Tender coconut	4[24]
	Total Organic Waste	**70.94**

[16] Please note that this data does not include the organic waste generated by small commercial establishments such as tea-shops, small food vendors etc.
[17] Waste generation survey by PBMC (February 2022)
[18] Methodology for calculation provided in Section 4.4 of the CAP
[19] Waste generation survey by PBMC (February 2022)
[20] Based on data provided by PBMC sanitary inspectors
[21] Waste generation survey by PBMC (February 2022)
[22] Organic waste generation survey carried out by PBMC (March 2022)
[23] It has been assumed that at least 50% of 622 hotels, guesthouses, restaurants, bakeries etc. in Port Blair qualify as BWGs and produce about 30 kgs of organic waste per day.
[24] Based on data provided by PBMC sanitary inspectors

4. Waste Generators and current levels of source segregation

4.1 Households

Currently, there are 49,656 households in the city of Port Blair with a population of 1,66,783[25] which produce an estimated quantity of 22 MT[26] organic waste per day. The figure below contains details of household distribution among the 24 wards[27]:

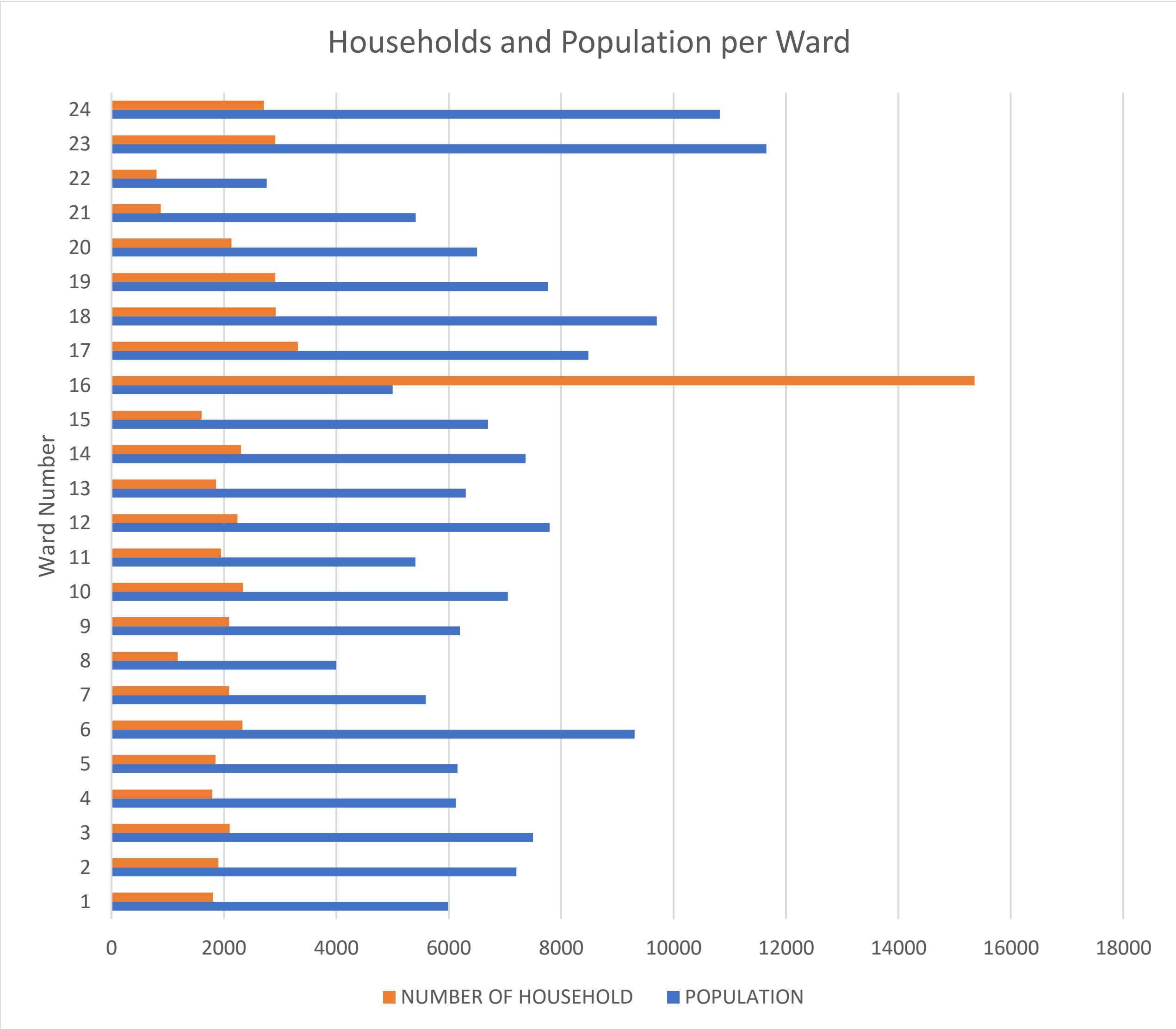


Figure 7: HHs and Population per Ward

As per the data received from PBMC, the overall level of source segregation in Port Blair is 85% and as per data given in affidavit submitted by ANPCC to the NGT[28] it is 75% for households. However, during the field visit in Port Blair, open dumps of mixed waste were seen in most wards which indicate that the source segregation levels may be lower than the reported figures. In addition, door to door collection from households

[25] As per data provided by PBMC for number of HH and population in each ward.
[26] Information provided by PBMC as responses to the stakeholder questionnaire.
[27] A list of wards is included in the ANI State Policy submitted to the NGT as a part of the affidavit by ANPCC, which also contains information on the number of households however, the data for households and population are not in accordance with the information furnished by PBMC.
[28]Affidavit submitted by Andaman and Nicobar Pollution Control Committee (ANPCC) to the NGT on January 2019

was observed during field visit in Ward 6 and 7 where PBMC workers were seen segregating mixed waste from certain households into organic waste and dry waste categories. During discussions with PBMC staff, the field team was told that source segregation has increased in the last few months but several households are still giving mixed waste.

Figure 8: Segregation of waste from HH by PBMC Sanitation Staff

The following MSW data has been obtained from a study conducted by PBMC.

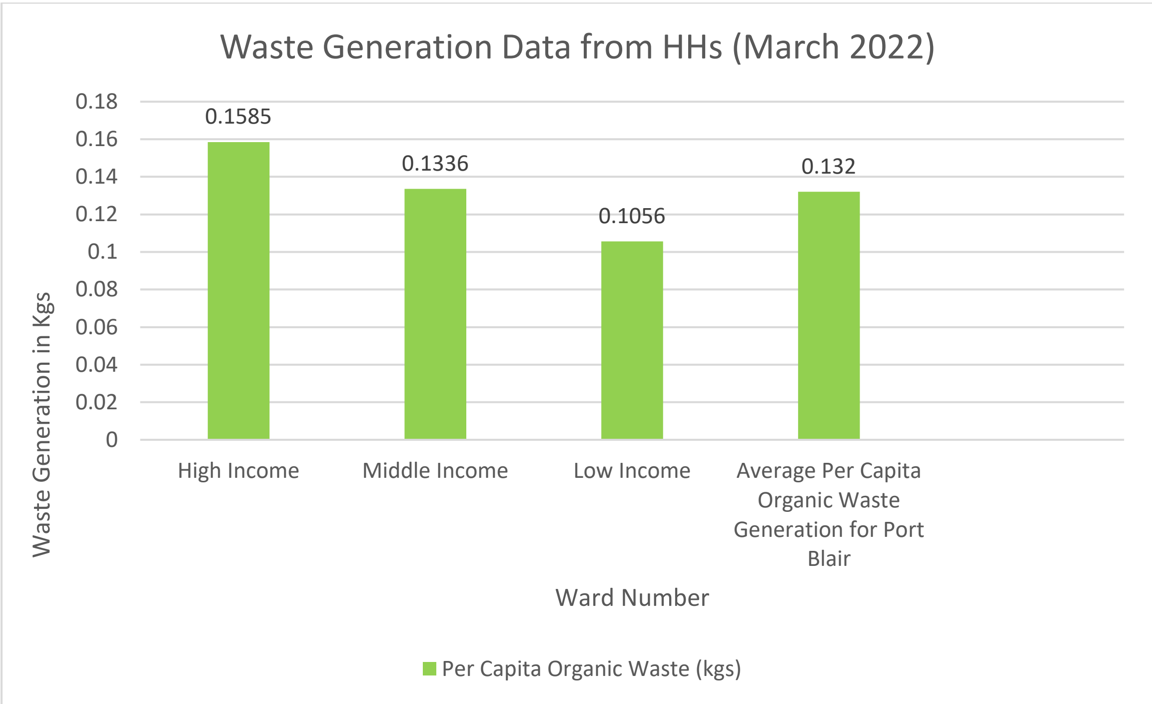


Figure 9: Organic waste collection Data from Households

The above data was collected during a survey undertaken in four areas of Port Blair, namely, Corbyn's Cove, RK Mission, and Junglighat where 30 households were selected in each area with equal representation from high, middle and low-income areas. As per this data, the average per capita organic waste generation from households in Port Blair city is 0.132 kgs per household which can be extrapolated to 22 TPD for all 49,656 households in the city of Port Blair. The details if this survey have been added in **Annexure 1 (Part E)**.

To estimate the population of Port Blair in the next 20-25 years, the team has referred to census data and the arithmetic increase method provided in the CPHEEO manual to arrive at the following figures.

Table 3: Population Projection

Projected Population[29]						
Year	1991	2001	2011	2021	**2031**	**2041**
Population	74,955	99,984	1,08,058	1,40,572	**1,73,086**	**2,05,600**

Gaps

- **Population and household data**: There are contradictions in the data with respect to ward population and number of households in each of the wards within different governmental documents/publications issued by ANI authorities, PBMC and documents submitted to the NGT.

- **Segregation levels, waste characterisation and quantification**: There seems to be lack of accurate data with respect to source segregation levels among households, waste quantification and characterisation because no comprehensive study on the basis of recognised methodologies has been carried out in the city of Port Blair.

- **Lack of enforcement and monitoring**: Currently, the PBMC has not put in place any enforcement and formal monitoring mechanism for ensuring source segregation among households.

4.2 Commercial waste generators including Bulk Waste Generators

(i) **Small Commercial Shops**

In accordance with the data provided by PBMC, Port Blair has 6,500 commercial shops (including bulk waste generators) and they are divided into 39 categories. Out of these categories, the survey team has identified 14 categories as potential sources of organic waste. On this basis and from the data provided by PBMC, it is estimated that there are 2,288 commercial establishments that generate organic waste, the details of which are set out below:

[29] Based on census data

Table 4: Number of commercial waste generators that generate organic waste

		Ward																								Total
Sno	Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
1	Vegetable shop	4	1	9	10	60	4	1	2	41	3	1	1	2	1	9	2	4	10	60	3	0	0	2	2	**232**
2	Fast Food	0	0	0	10	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**
3	Hotels and Lodge	9	6	0	38	49	23	10	2	14	7	2	3	7	7	3	11	2	5	24	6	0	0	4	8	**240**
4	Bar & Restaurant	1	4	15	9	3	9	10	0	11	0	0	9	10	4	0	0	10	6	98	31	19	0	12	2	**263**
5	Bakery	2	2	0	3	3	0	0	0	1	0	0	3	2	3	1	1	5	3	30	14	5	8	18	1	**105**
6	Grocery	7	23	19	34	0	13	12	4	32	20	7	35	8	20	17	0	27	30	19	0	3	1	5	27	**363**
7	Medical/ Clinic	1	3	18	5	17	16	0	0	11	4	1	2	6	1	0	2	5	2	42	0	10	5	0	3	**154**
8	Meat	1	0	0	69	0	7	2	0	6	0	0	1	1	15	1	0	1	3	0	1	2	1	0	4	**115**
9	Govt & Pvt Establishment	4	0	0	36	78	0	2	0	7	6	0	8	42	2	0	5	9	15	42	0	0	4	2	0	**262**
10	Hostel and Guest houses	2	0	0	0	5	0	0	0	0	0	0	0	0	2	0	0	3	2	0	0	0	0	0	0	**14**
11	Schools	3	4	4	2	5	15	1	1	3	2	3	3	3	0	2	2	6	6	10	1	2	4	1	2	**85**
12	Community Halls & Club	2	0	4	2	7	1	0	1	0	2	1	0	1	1	1	0	0	1	2	2	2	0	1	0	**31**
13	Aanganwaadi	9	7	6	7	3	2	7	5	5	4	3	6	4	13	9	6	5	7	8	5	2	2	6	4	**135**
14	Religious	6	12	11	11	14	13	13	6	15	15	11	11	9	11	14	7	11	18	15	10	8	6	9	8	**264**
	Total	**51**	**62**	**86**	**236**	**259**	**103**	**58**	**21**	**146**	**63**	**29**	**82**	**95**	**80**	**57**	**36**	**88**	**108**	**350**	**73**	**53**	**31**	**60**	**61**	**2288**

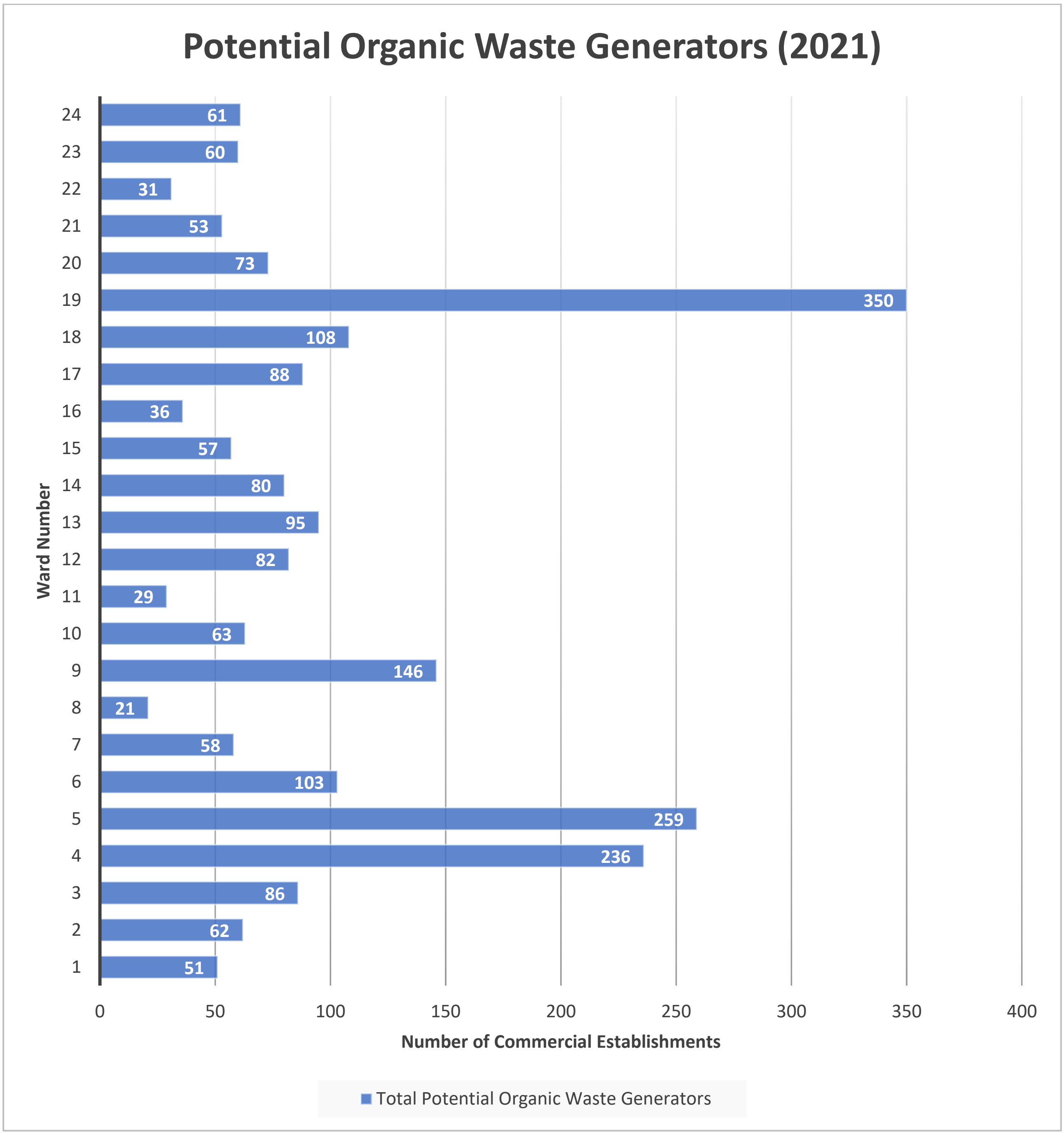


Figure 10: Potential Organic Waste Generators Including BWGs

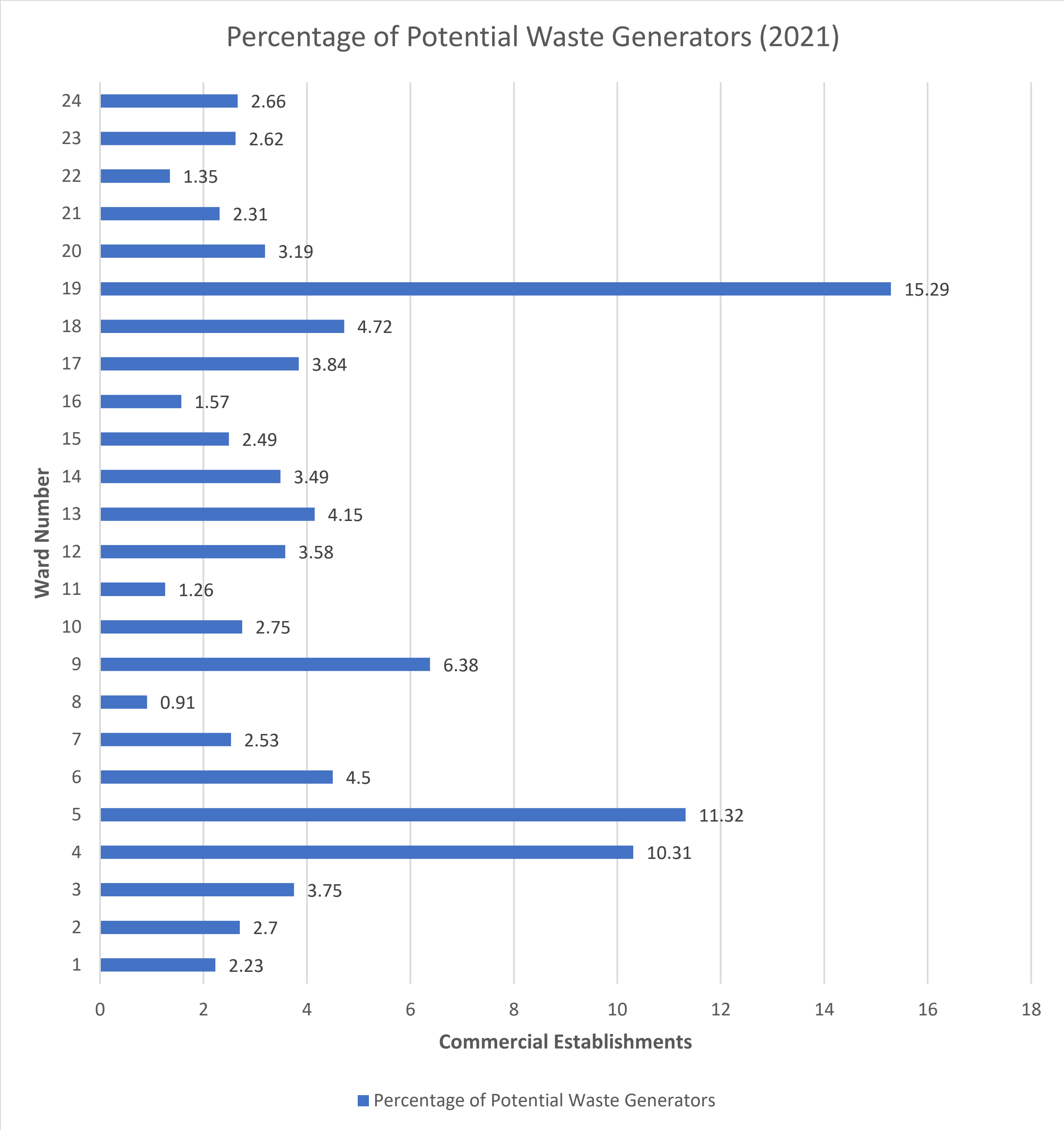


Figure 11: Potential Organic Waste Generators Including BWGs

According to the data presented in Table 3 and Figure 11, Ward 19 has the highest percentage of commercial establishments that possibly generate organic waste (16%), followed by Ward 5 (11%), Ward 4 (10 %), and Ward 9 (6%). Overall, they constitute about 43% of the commercial waste generators in Port Blair that potentially generate organic waste.

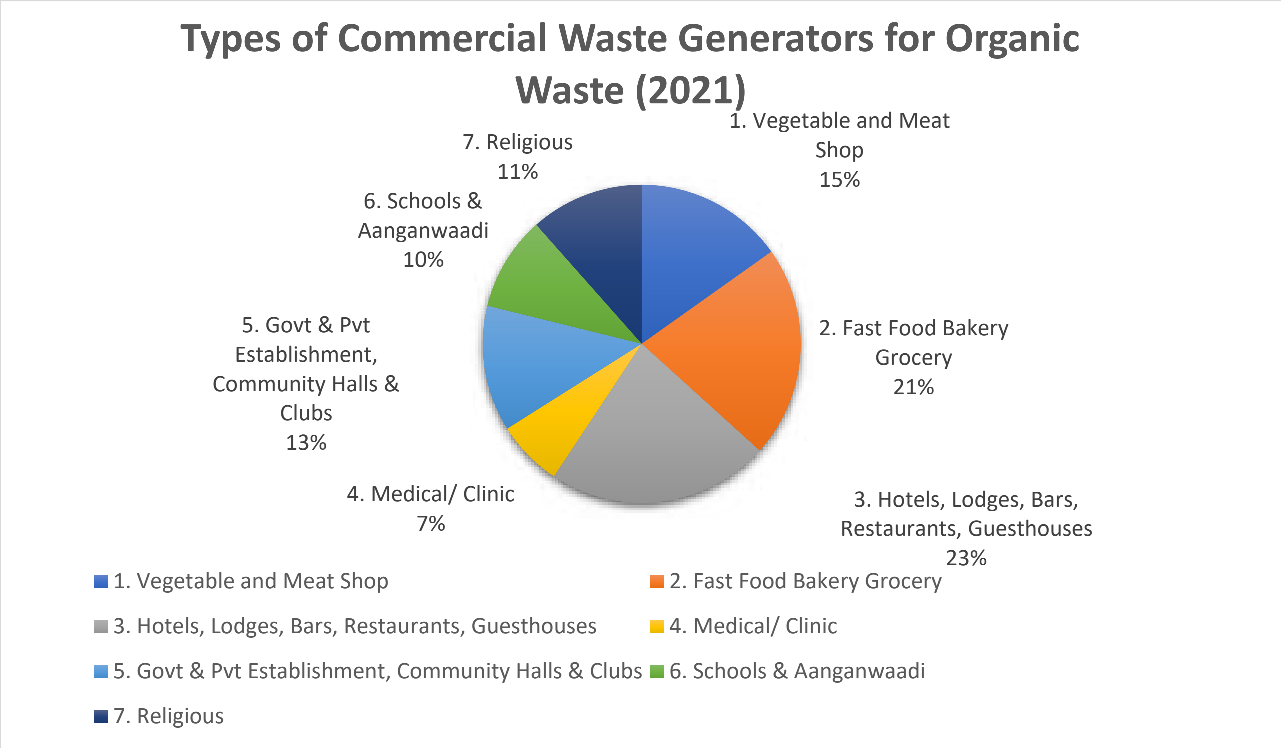


Figure 12: Types of Commercial Waste Generators for Organic Waste (Percentage)

In Figure 12, the 14 categories of commercial waste generators that generate organic waste have been grouped into 6 (six) categories for the purposes of analysis. As per this analysis, hotels, lodges, restaurants and guesthouses (23%) form the largest group of organic waste generators, followed by the group of fast food, bakery and grocery stores (21%) and by government & private establishments, community halls and clubs (13%). The data corroborates the assumption shows that for a tourist destination like Port Blair, hotels, lodges, guesthouses and restaurants contribute significantly to the organic waste in the city.

(ii) **Bulk Waste Generators**

According to the SWM Bye Laws for the PBMC[30], "Bulk Waste Generators" means and includes buildings occupied by the Central Govt department or undertaking, State Government departments or undertaking, local bodies, public sector undertakings or private companies, hospitals, nursing homes, schools, colleges, universities, other educational institutions, hostels, hotels, commercial establishments, markets, places of worship, stadium and sports complexes having an average waste generation rate exceeding 50 kg per day. The PBMC has shared the following information with respect to BWGs in Port Blair along with their approximate organic waste generation. As per this table, there is very limited data available with respect to the names, locations of Bulk Waste Generators along with quantity of organic waste generated by them. In the absence of this information, the survey team has reviewed the list of hotels received from Shree Venkasteshwara and Friends SHG and supplemented that list with secondary research to formulate a list of potential BWGs in Port Blair, which is included as **Annexure 3**.

ANI is a global tourist spot with Port Blair serving as the only gateway into the other islands for tourists and therefore, the city is visited by more than 5,00,000 tourists on an annual basis. Given the high number of tourists, there is a large tourism industry which includes hotels, resorts, restaurants and similar establishments in Port Blair. These establishments typically generate large quantities of organic waste because of the amount of food being cooked in them and the number of people that they cater to. From Figure 13, it can be concluded that these establishments form 23% of all the commercial establishments that potentially generate organic waste. Therefore, the organic waste from these establishments forms a significant portion of the entire organic

[30] http://db.and.nic.in/pbmcwebsite/gazette/SolidWasteManagement.pdf

waste generated in Port Blair city. The table below shows the distribution of hotels, resorts, restaurants and similar establishments across the various wards in Port Blair.

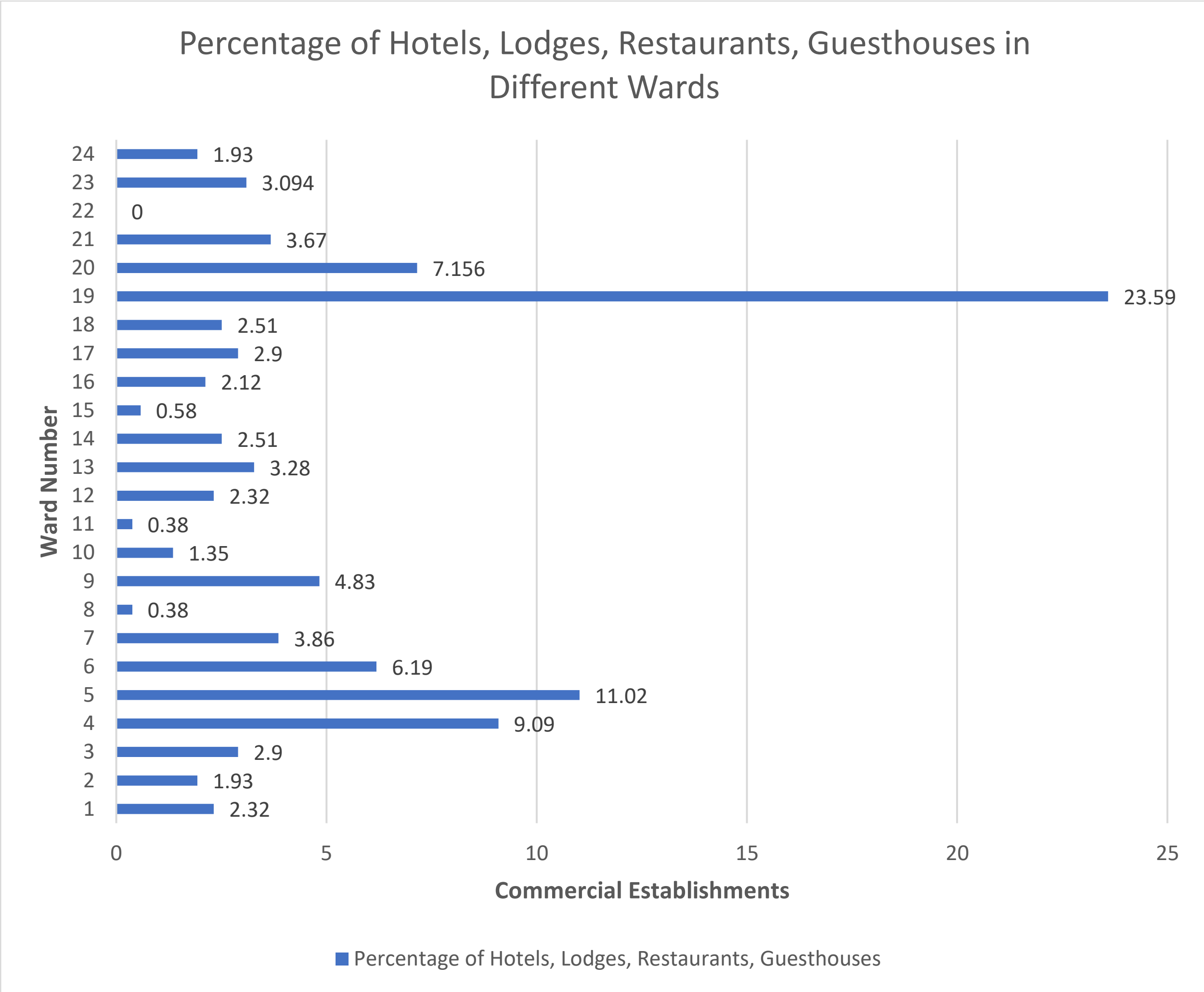


Figure 13: Percentage of Hotels, Lodges, Restaurants, Guesthouses in Different Wards

Figure 13 shows that Ward 19 has the highest number of hotels (24%), followed by Ward 5 (11%), Ward 4 (9%) and Ward 20 (7%). These four wards account for half of the total number of hotels, lodges, restaurants and guesthouses in Port Blair.

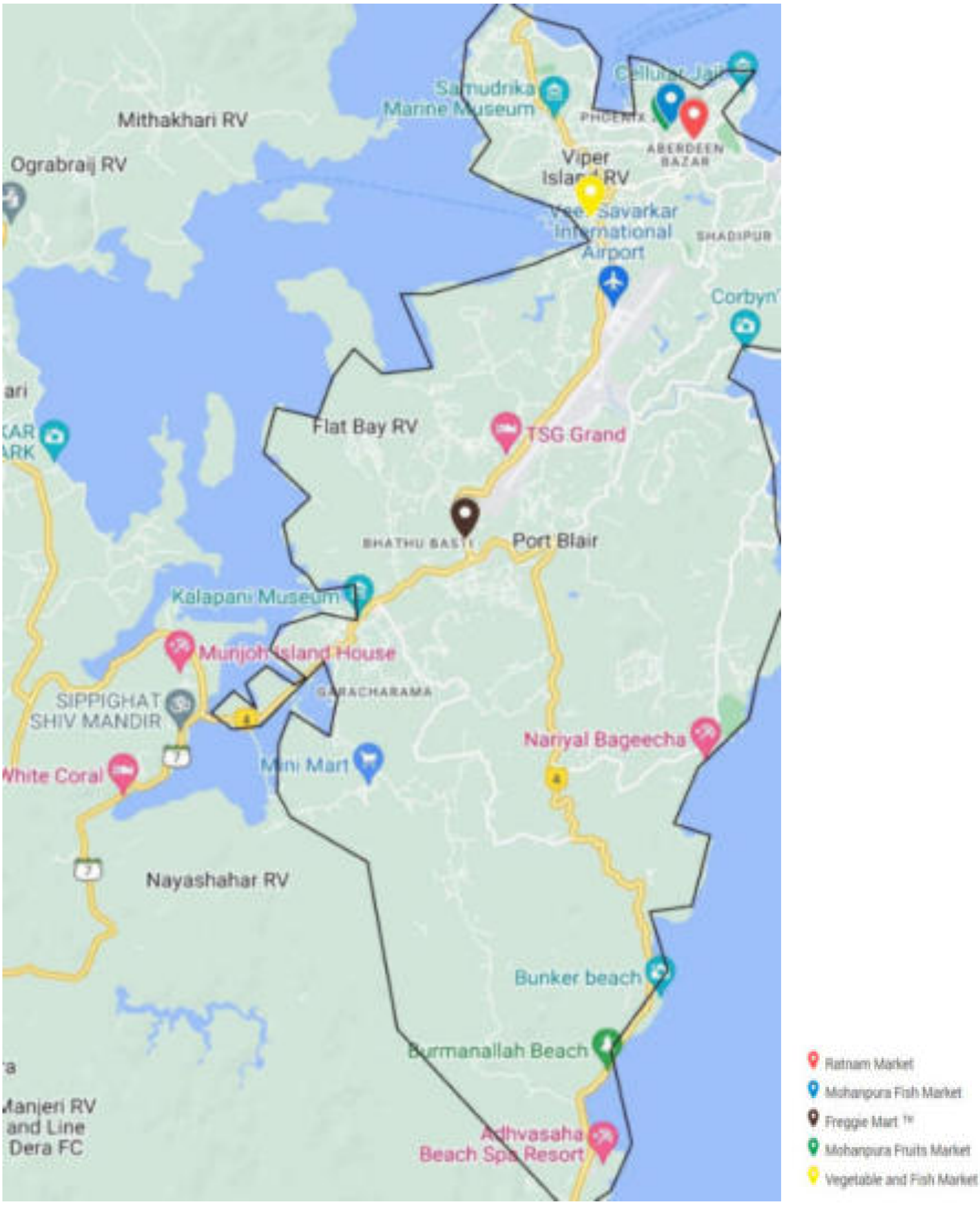
Gaps

- **Lack of data with respect to organic waste for commercial establishments including BWGs:** There is lack of data with respect to (a) number of commercial shops and bulk waste generators in the city; (b) source segregation levels among commercial shops and bulk waste generators; (c) amount of organic waste generated by the commercial shops and bulk waste generators; and (d) characterisation of waste generated by the commercial shops and bulk waste generators.

- **Lack of Infrastructure to store segregated waste:** As per information received from SHGs, several BWGs do not have proper bins or storage containers to keep organic waste separately. Majority of hotels are using garbage bags to store their waste which are difficult to handle and also tear easily causing leakage of waste. Additionally, as part of PBMC's bin free city strategy, bins from several market and commercial areas in Port Blair have been removed.

- **Lack of enforcement and monitoring**: Currently, the PBMC has not put in place any enforcement and formal monitoring mechanism for ensuring source segregation among commercial establishments including bulk waste generators. Further, there is no provision for penalising the SHGs collecting from commercial establishments if they fail to collect from all the commercial establishments in the wards and/or transport waste in a mixed manner.

4.3 Markets



Map data ©2022 Google

Figure 14: Main markets in Port Blair

The PBMC shared a list of 10 (ten) markets along with estimated waste generation at these markets i.e., an aggregate of 2 TPD of fish waste and 2 TPD of other streams of organic waste. It is however, unclear the methodology that has been used by the PBMC to arrive at these waste generation estimations. The survey team conducted field visits to these markets and the following gaps were identified in the 5 (five) of the largest markets:

Table 5: Gaps relating to Source Segregation at Markets

S. no	Name of Market	Estimated waste generation (kgs)	Current status	Gap/ Issue at each of the markets	Photographs
1	Ratnam Market (Primarily vegetable)	600[31]	Two designated places for keeping waste but there is no segregation practiced at source and/or during disposal.	- Lack of awareness about source segregation among waste generators. - The designated places have no infrastructure such as containers or bins, labels for waste categories, boundaries/walls to store waste in a segregated manner. - Lack of monitoring of source segregation and storage of waste in a segregated manner. - Access to stray animals is available.	 
2	Fruit Market near Gandhi Statue	No data	One designated place to keep waste, but there is no segregation practiced at source and/or during	- The designated place is a plot behind the fruit stalls and no formal structure or bins have been placed to keep segregated waste. - Lack of monitoring of	

31 Information received from sanitary office, Ward (4&5)

			disposal.	source segregation and storage of waste in a segregated manner. - Access to stray animals is available. - Lack of awareness about source segregation among waste generators.	
3	Junglighat Market (fish and vegetables)	No data	Separate dumping points for meat and vegetables, however, fish waste was seen in the drains.	- Fish waste in drains suggests leakages in disposal and collection.	 
4	Mohanpura Market (vegetable and meat)	900[32]	Separate dumping points for meat waste and vegetable waste. A very large dump of waste was seen on the main road near this market on the bus-stand road and the designated	- Lack of awareness about source segregation among waste generators. - The designated places have no infrastructure such as containers or bins, labels for waste categories, boundaries/walls to store waste in a segregated manner.	 

32 Information received from sanitary office, Ward 4&5

			space for meat waste is being used for mixed waste.	- Lack of monitoring of source segregation. - Access to stray animals is available.	
5	Bathubasti Marke (vegetable and fish)	No data	There are two formal waste dumping points and one informal one and mixed waste was found in all of them.	- Lack of awareness about source segregation among waste generators. - Lack of disposal/storage infrastructure such as bins. - Lack of monitoring and enforcement for segregation. - Access to stray animals is available.	 

4.4 Special waste streams

Fish waste

Since Port Blair is a coastal city, considerable sections of the population consume fish and according to the data received from the Fisheries Department, 90% of the population in ANI eats fish and per capita fish consumption is estimated at 6.49 kgs per month. Specifically in South Andamans where Port Blair is located, as per records maintained by the Fisheries Department, the total fish capture from mainland and inland sources for financial year 2020-21 is 2,66,65,289 kgs. It is estimated by the Fisheries Department that 29.5% of the of total fish capture is non-food wastage. Therefore, it can be estimated that there is at least 78,66,260 kgs of non-food fish waste in South Andamans on an annual basis, which is equivalent to 21.55 MT of non-food fish waste per day.

In addition, the quantity of fish consumed in Port Blair by resident population can be estimated to be 1,09,47,747 kgs[33] on an annual basis. In the event it is assumed that 35% of the fish is wasted in cleaning, bones and other waste (i.e., 65% of the fish is edible)[34], the fish waste (food) generation will be 38,31,711 kgs on an annual basis i.e., approximately 10.5 MT per day. However, there is no data available with PBMC or the Fisheries Department on the amount of fish waste that is generated at a waste generator level.

[33] Per capita fish consumption annually X population of Port Blair.
[34] https://www.fao.org/3/t0219e/t0219e01.htm (FAO Yearbook of Fishery Statistics, Catches and Landings, Volume 64)

Figure 15: Fish waste in market areas

Coconut waste

Coconut water is one the most popular locally available drinks in the islands and coconut is also consumed in local cuisine. The survey team identified at least three major areas that produce large quantities of tender coconut waste i.e. near the Main Post Office, near Golghar crossroads, and near Gandhi Statue. As per information received from Sanitary Inspector in Ward 4 and 5, these two wards produce about approximately 4-4.5 MT of coconut waste every day. There is no city level data for available with PBMC with regard to the quantities of coconut waste generated

Figure 16: Coconut waste on the side of the road

Flower Waste

Flower waste is generated in large quantities from religious places such as temples, churches, dargahs and also from flower markets or shops. Presently, Port Blair city has multiple, small flower stalls in markets such as Aberdeen and Bathubasti markets, however, there is no accurate data to estimate the generation of floral waste in the city of Port Blair. As per estimates given by PBMC, the city produces about 2 TPD of floral waste and this is based on interviews conducted with local stakeholders in Port Blair who are engaged in procuring fresh flowers for sale in the city.

Gaps

- **Lack of data:** There is no data available with respect to (i) waste generators that generate large amounts of these special waste streams such as coconut waste, floral waste and fish waste and (ii) quantities of these waste generated.

- **Lack of segregated collection**: These waste streams are not treated differently in terms of collection and transportation and are often, mixed with other municipal solid waste streams during collection.

5. Flow of organic waste in the city

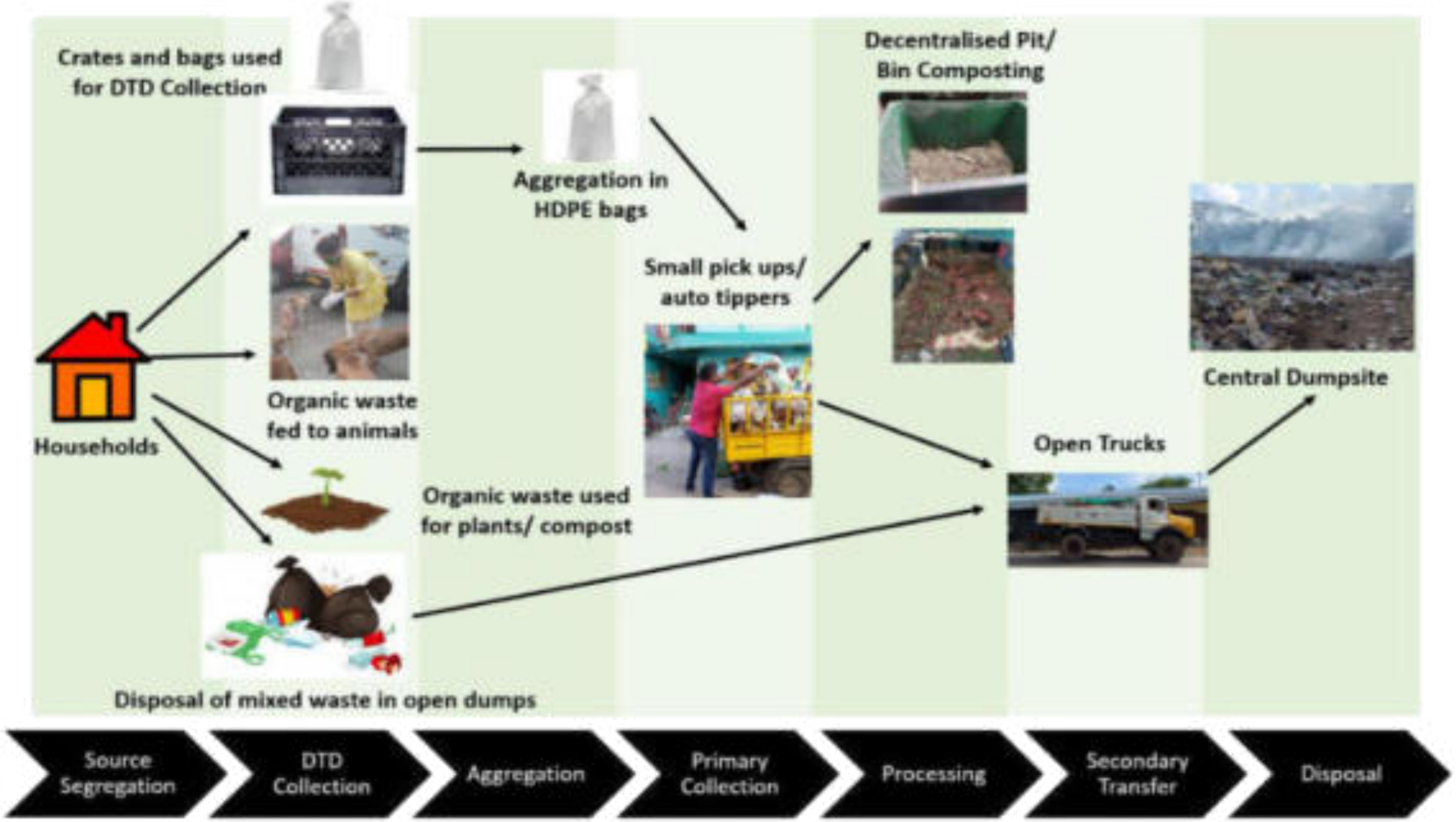


Figure 17: Flow of Organic Waste from Households

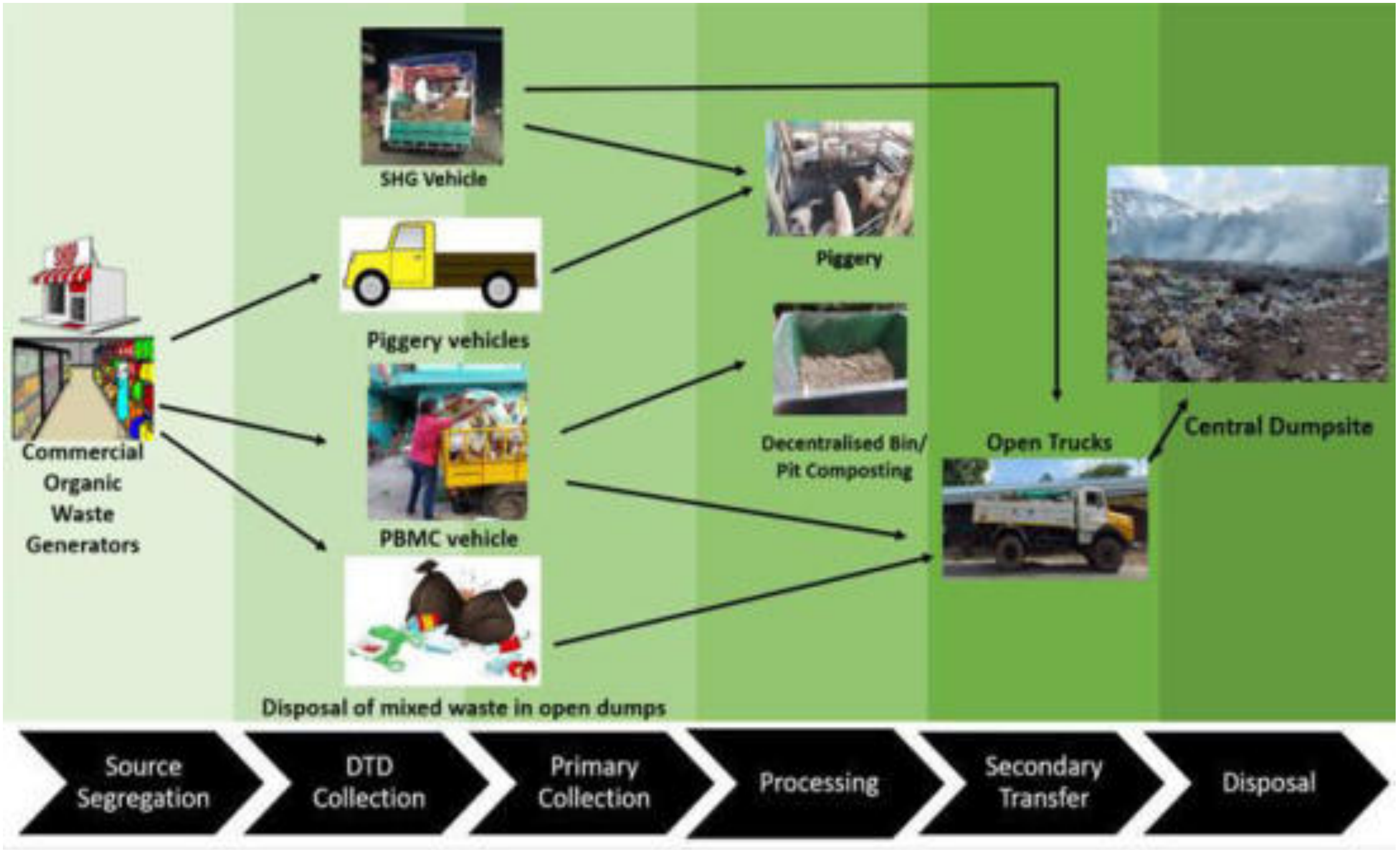


Figure 18: Flow of Organic Waste from Commercial Establishments

6. Primary Collection of Waste (DTD collection)

6.1 Households

According to the information in the affidavit submitted by ANPCC to NGT in February 2021, the overall status of DTD collection in Port Blair is 100%. However, during the field visit several open dumps of mixed waste were seen in the city and their presence indicates that there may be leakages in the primary collection of waste from all waste generators.

As per information gathered during interviews with PBMC staff and from field visits, primary waste collection from households in Port Blair is a two-step process. As the first step, all DTD collection for households is undertaken by PBMC sanitation staff in hand-pulled plastic crates and/or HDPE bags. The organic waste collected during DTD process is aggregated at open spots near the road side. The second step involves the collection of all aggregated waste by PBMC vehicles typically, light commercial vehicles such as auto tipper and twin compartment vehicles. As per information received from PBMC, 31 – 36 such vehicles are used for primary collection of organic waste for all 24 wards in Port Blair. The details of the vehicles are provided below:

Table 7: Details of Vehicles Used by PBMC

Sno	Vehicle Type	Number	Ownership	Labour
1.	Twin Compartment Vehicles	8	PBMC	76
2.	Auto tipper	26	Hired	
		2	PBMC	

Crates Being Used for DTD Collection

Primary Collection Vehicle for HH Waste

Figure 19: Primary collection for households

All DTD collection for households in Port Blair is carried out by PBMC sanitation staff. As per PBMC's information, there are a total of 1593 sanitation staff for 24 Wards or an average of 66 workers per ward. Out of these, 607 are engaged in DTD collection, 76 are assigned to primary collection vehicles, and 71 are working as acting supervisors or supervisors. Thus, the total staff engaged in primary collection of solid waste (including organic waste) from households is 754 or an average of 31 workers per ward. 47% of all sanitation staff is currently engaged in primary collection of organic waste. The details of their ward wise distribution are given below.

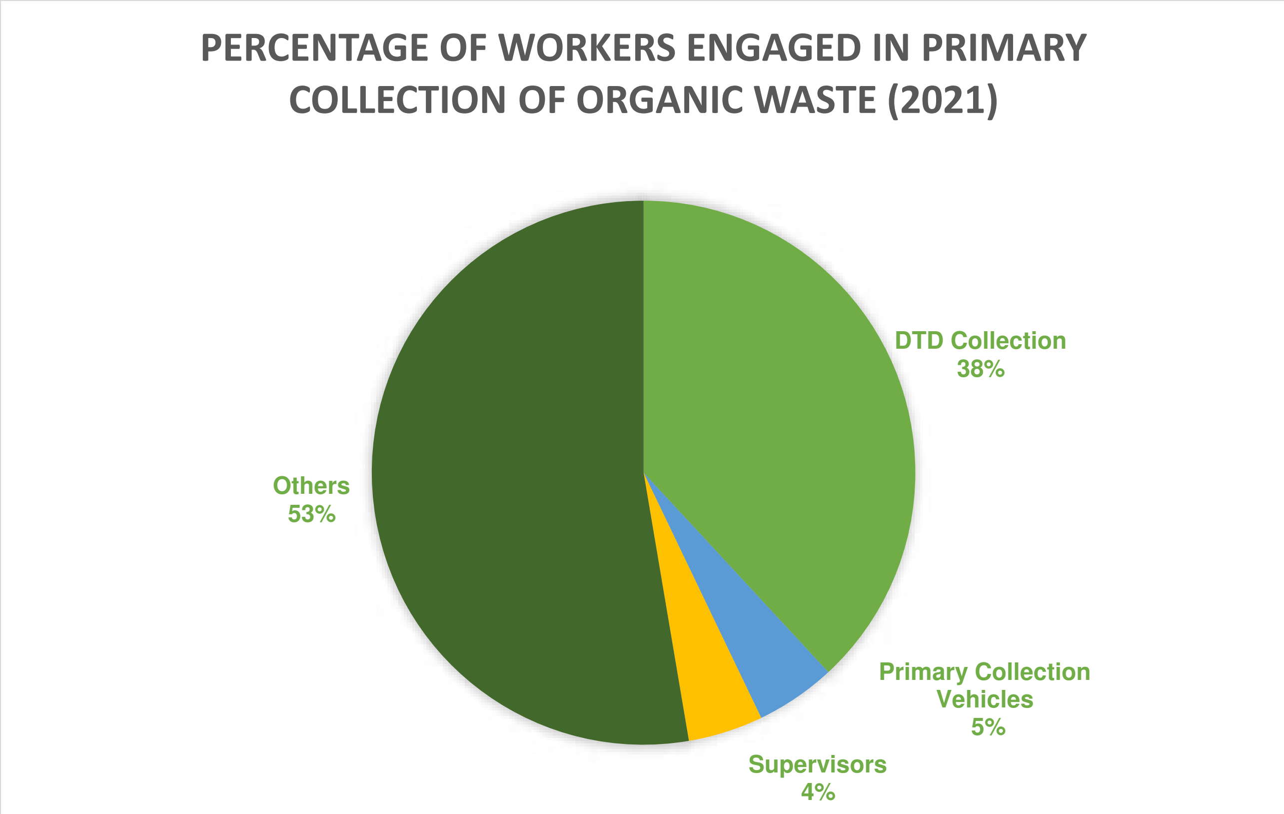


Figure 20: Percentage of workers engaged in Primary Collection of Organic

Table 8: Details of Labour Engaged in Collection of Organic Waste

Ward	HHs	Total Staff	DTD Collection Staff	Average no: of HHs per DTD collection staff	Primary Collection Vehicles Staff	Supervisors/ Acting Supervisors	Total Staff for Primary Collection
1	1800	57	18	100	3	4	25
2	1900	58	33	57.57	3	4	40
3	2104	69	26	80.92	6	6	38
4	1772	124	31	57.16	3	0	34
5	1852	144	38	48.73	4	1	43
6	2458	79	27	91.03	2	1	30
7	2093	58	22	95.13	3	5	30
8	1174	64	16	73.37	3	6	25
9	2090	70	39	53.58	2	2	43
10	2342	73	25	93.68	4	2	31
11	1950	60	29	67.24	3	3	35
12	2240	60	25	89.6	3	5	33
13	1860	65	26	71.53	5	2	33
14	2306	54	26	88.69	3	3	32
15	1600	53	24	66.66	2	3	29
16	1535	69	21	73.09	2	1	24
17	3313	64	26	127.42	4	6	36
18	2919	57	24	121.62	4	3	31

Ward	HHs	Total Staff	DTD Collection Staff	Average no: of HHs per DTD collection staff	Primary Collection Vehicles Staff	Supervisors/ Acting Supervisors	Total Staff for Primary Collection
19	2915	61	27	107.96	2	3	32
20	2136	60	26	82.15	3	2	31
21	876	55	11	79.63	3	5	19
22	800	33	8	100	3	2	13
23	2912	51	27	107.85	4	1	32
24	2709	55	32	84.65	2	1	35
Total	**49656**	**1593**	**607**	81.80	**76**	**71**	**754**

Gaps

- **Lack of infrastructure for primary collection:** Port Blair's geography and terrain in large part, is hilly and there are steep and narrow slopes in many areas. In addition, there are steps and lack of properly constructed paths in several wards. Such conditions make dragging of crates and bags for DTD collection inefficient, time consuming and ergonomically challenging for the waste collection staff. Due to these challenging conditions, it is observed that a waste collection staff can only collect from 50-120 households in a day resulting in large manpower for DTD collection from households.

- **Mixing of waste during transportation**: HDPE bags and crates do not have any proper mechanism towards ensuring that waste segregated at source, i.e., at households, does not get mixed during collection. The autos responsible for collecting waste from aggregation points are also not equipped with any mechanism to keep waste segregated and/or to prevent leakage of leachate during transportation.

6.2 Commercial Waste Generators

As part of PBMC's initiative to create self-sustaining models for waste management, the responsibility of DTD collection from commercial establishments has been delegated to two SHGs namely, Shree Venkateshwara and Friends. During interviews with stakeholder representatives at the PBMC and representatives of both SHGs, it was learnt that the SHGs must have their own infrastructure for collection and transportation of waste.

From interviews with representatives of Friends SHG and the list of establishments provided by them, it was understood that they are currently providing primary collection service to a total of 307 commercial establishments, including bulk waste generators such as hotels, restaurants and bars[35]. Most of the commercial establishments generating organic waste including bulk waste generators store unsegregated organic waste in garbage bags outside their premises for collection. The collection timings are between 5 P.M to 12 P.M every evening/night. As per interviews with representatives of Friends SHG, they are presently using 3 (three) light commercial vehicles (i.e., two Tata 709 vehicles and 1 Mahindra Bolero pick up) to collect organic waste. The SHG collects organic waste from commercial establishments and such waste is directly taken to the city dumpsite in Brookshabad without any secondary transfer mechanism.

[35] However, as per the use fee data provided by Friends SHG, the maximum number of commercial establishments receiving DTD coverage is 164.

Figure 21: Collection of waste by SHG

During interviews with representatives of Shree Venkateshwara SHG, it was understood that they are currently providing primary collection service to approximately 1000 commercial establishments, including bulk waste generators. At the beginning of their operations, the SHG was using 3 (three) hired light commercial vehicles (Tata 709) for collection of waste. In 2021, they bought 2 (two) light commercial vehicles (Tata 712) on loan and presently hire only 1 (one) vehicle (Tata 709). However, it was not explained during the interviews the reason for the same number of vehicles i.e., 3 (three) for the two SHGs even though Shree Venkateshwara SHG is allotted twice as many wards as Friends SHG.

During the in-depth stakeholder interviews with members of the SHGs, it was highlighted that most commercial shops and bulk waste generators such as hotels are giving mixed organic waste to the waste collection vehicle. The SHG does not maintain any records for organic waste collected by them. According to estimates shared by them, they are collecting approximately 1-1.5 TPD of organic waste, out of which about 500 kgs is diverted to a piggery located at the Brookshabad dumpsite[36] and the remaining organic waste is sent to the dumpsite. During field visits, it was noted that in many areas, there was no door-to-door collection of waste from commercial shops and the waste generated by commercial shops were kept outside the premises or dumped at the nearest dumping point. The waste from these open spaces were thereafter, collected by the waste collection vehicle operated by Venkateshwara and Friends SHG and in some cases, by PBMC. The survey team noted that the collection mechanism from these open spaces is dynamic and based on vehicle and manpower availability and other work such as clearance of waste from other wards etc. In addition, it was noted that several commercial establishments are not covered by SHGs' DTD collection service and therefore, PBMC provides collection service to them on a need basis to avoid waste piling up on roadside and other public places.

Figure 22: Waste deposited in the open outside commercial establishments

[36] There is no reliable data on the amount of waste that is being diverted to Brookshabad piggery.

Currently, from interviews it was concluded that both PBMC and the SHGs do not have a system for maintaining any records for the quantity of organic waste collected by them, transported to the piggery and Brookshabad dumpsite. The representatives of the SHGs estimated that they collect approximately 2 MT of organic waste every day however, given that there is no weighment mechanism available with them and there is no weighbridge at the Brookshabad city dumpsite, this information cannot be relied upon.

Gaps

- **Very low coverage of DTD collection from commercial establishments**: As per information provided by PBMC, both SHGs have been given the charge of providing DTD collection service for all commercial establishments in Port Blair. During interviews with PBMC staff and through observations on field visits it was found that presently the SHGs are providing service to a limited number of commercial establishments (approximately 1200[37] out of a total of 6500 i.e., less than 20% of total commercial establishments in the city). As a result, a significant portion of commercial establishments are either left out of the DTD collection service and/or are being serviced by PBMC sanitation staff and vehicles.

- **Dumping of waste by commercial establishments:** The commercial establishments that are not receiving DTD collection service from SHGs, are leaving their waste on the roads and other open areas where it is prone scavenging by animals, rains and mixing with soil and other waste streams. The mixed waste is eventually collected by collection vehicles; however, this is often unfit for resource recovery.

- **Inadequate number of vehicles to provide 100% DTD coverage to commercial establishments:** Currently there are only 6 (six) light commercial vehicles to provide door to door collection of waste from more than 6500 commercial establishments and bulk waste generators. In addition, it is noted that both the SHGs have the same number of vehicles i.e., 3 (three) light commercial vehicles each even though Shree Venkateshwara SHG covers twice the number of wards as compared to Friends SHG. This disparity in the number of vehicles operated by SHGs vis-à-vis number of wards to be covered under DTD collection was not clarified during field visits.

- **Inadequate infrastructure to transport segregated waste**: The vehicles currently being used by the SHGs to collect waste do not have any partitions or mechanism to ensure that the waste remains segregated during transportation.

- **Lack of data**: The PBMC does not maintain any data which can be used to estimate coverage of DTD collection, frequency of collection of organic waste, number of trips within each ward and amount of organic waste collected among others.

- **Lack of monitoring of SHGs:** There is lack of monitoring of operations being undertaken by the SHGs and therefore, there are data and operational gaps in relation to waste collection, DTD coverage and segregation levels among commercial establishments.

7. Aggregation of Organic Waste and Secondary Transfer

7.1 Aggregation points and Collection

After the completion of the DTD collection, waste from households and some commercial establishments is transferred to an auto tipper. The auto tipper thereafter, transfers the waste to secondary transfer vehicles, such as trucks shown in Figure 23. The organic waste collected by PBMC vehicles from markets and public

[37] This number has been calculated by adding the average number of commercial establishments that pay user fees to Friends and Shree Venkateshwara SHG.

places is also transferred to these vehicles. During field visits these vehicles were seen collecting mixed waste from roadsides and several open dumps as well. It was also observed that the trucks have no infrastructure to transport the waste in a segregated manner and therefore, the waste is getting mixed during transportation. These trucks finally dispose of all the collected waste at the city dumpsite in Brookshabad.

Figure 23: Secondary Transfer Vehicle

7.2 Vehicles and manpower involved in secondary transfer and collection

As per information received from PBMC in the responses to the questionnaire, PBMC is currently making use of 24 tipper trucks and 186 personnel for (i) secondary transfer of waste; and (ii) collecting waste from road sweeping and mixed waste from open dumps on main roads of the city. These trucks are hired along with a driver from a third-party agency. In addition to these vehicles, PBMC uses a refuse compactor vehicle as well for secondary collection of waste.

Gaps

- **Lack of infrastructure**: The secondary collection vehicles have no infrastructure such as partitions, bins or bags to transport the waste in a segregated manner and therefore, the waste is getting mixed during transportation. In addition, these vehicles are not covered and typically, do not have any mechanism to cover the waste from rain during its transportation.

- **Lack of DTD collection service resulting in additional waste collection from open dumps**: It was observed that due to lack of DTD collection for all waste generators, waste is deposited in the open which is being collected by the secondary collection vehicles. Given that the there are no bins in the city, the waste is on the ground and typically mixed. This also leads to additional responsibilities on the PBMC staff towards frequent collection of waste from these open dumps to ensure cleanliness of the city.

8. Processing and disposal of organic waste

8.1 Processing facilities under PBMC

As per information provided by PBMC to ANPCC in the NGT affidavits[38], a total of 6 (six) decentralised OWM facilities have been constructed by PBMC to process organic waste. In 2021, PBMC has also taken steps to engage SHGs in processing of organic waste generated within Port Blair. Consequently, it has given, operational charge for two OWM facilities i.e., Brookshabad Compost Unit and Gandhi Park Vermi Compost Facility to Friends SHG and Stree Hausala SHG respectively. During field visits it was observed that none of these facilities are currently functional except for Gandhi Park Vermi Compost facility which takes only horticulture waste. The details of these facilities along with main field observations are given below.

Table 9: Details of OWM Facilities under PBMC

S. no	Name/ Location/ Technology	Capacity (TPD)[39]	Present status	Field Observations
1	Gandhi Park Vermi Compost Facility	0.70	Operational	Only takes horticulture waste and not food waste. The facility seemed to be functioning well and more than two thirds of the pits were full of compost at various stages.
2	Brookshabad Compost Facility	0.62	Non-operational	Expired food items such as wheat, potatoes and packaged food were seen at the site. None of the pits had fresh organic waste or compost in them.
3	Anarkali Compost Facility	0.082	Non-operational	Only cow dung and horticulture waste has been used as input and the pits are currently full.
4	Junglighat Electric Composting Unit	0.25	Non-operational	The unit is placed within the fish market building but has not been used due to odour concerns and malfunctioning of the unit.
5	Mohanpura Electric Composting unit	0.25	Non-operational	The unit is placed within the fish market building but has not been used due to odour concerns and malfunctioning of the unit.
6	Dollygunj SLRM	Not available	Non-operational	Composting pits in the SLRM[40] centres are being used for storing dry waste

8.2 New initiative by PBMC towards Decentralised OWM

In the month of December 2021, PBMC has started new initiatives to manage and process organic waste within premises of Sanitary Inspectors' offices through decentralised composting. Brief details of these initiatives are given below:

Table 10: Details of Composting at SI offices

Sno	Ward Office/ Location	Method	Total Capacity (kgs)	Size	Field Observations
1	24, Garecharma	Bin Composting (aerobic)	880 & 180		Two large bins with a capacity of about 440 kgs are being used to make compost with food waste from HHs located in the ward. Three smaller bins with a capacity

[38] NGT affidavit submitted by ANPCC in April 2019 and November 2019

[39] The processing capacities mentioned for these facilities in the NGT affidavits are contradictory.

[40] PBMC has constructed 9 Solid and Liquid Resource Management (SLRM) Centres to process solid waste. Some of these SLRM centres such as the ones in School Lines and Dollygunj have compost pits but they are all being used for storing dry waste.

					of 60 kgs each are also being used to make compost as per liquid composting technique[41].
					
2	5, Near Stadium	Pit Composting (aerobic)	1000	(1.8 x 1.2 x 1) m	Two unlined pits have been dug in the ground at this office. The pits are currently being used for composting food waste from HHs and markets in Wards 4 and 5. The pits have been covered with makeshift tents to avoid water seepage during rainfall. Each of these pits has a capacity of about 500 kgs.
					
3	7, Junglighat	Bin Composting (aerobic)	1760		Four large bins, each with a capacity of about 440 kgs are being used to make compost with food waste from HHs of Ward 7

[41] Liquid composting technique proposed by Muskan Jyothi Samita under SBM.


In January 2022, the PBMC has shared the following information regarding scaling of decentralised composting initiatives implemented in the sanitary offices from four to ten wards.

Table 11: Details of Composting at SI offices

S. No	Ward number	No of Pit/Bins	Capacity (Per day) in TPD	Capacity	Remark
1	20	1	0.0084[42]	Capacity of 1 bin is 660 litres or 462 kg	Bin composting (aerobic) in sanitary office premises.
3	6	1	0.0084	Capacity of 1 bin is 660 litres or 462 kg	Bin composting (aerobic) in sanitary office premises.
4	7	4	0.032	Capacity of 1 bin is 660 litres or 462 kg	Bin composting (aerobic) in sanitary office premises.
5	12, 13	1	0.0084	Capacity of 1 bin is 660 litres or 462 kg	Bin composting (aerobic) in sanitary office premises.
6	22	Not available	Not available	10Kg of organic Waste is coming per day	Bin composting (aerobic) in sanitary office premises.
7	9	1	0.0085	Capacity of 1 bin is 660 litres or 462 kg	Bin composting (aerobic) in sanitary office premises.
8	14	Not available	Not available	Not available	Pit Composting

Gaps

- **Lack pf processing capacity:** The current organic waste generation in Port Blair is estimated at approximately 71 TPD per day, while the current processing capacity is less than 5 TPD[43]. Therefore, there is a significant gap between organic waste generated in the city and the processing of such waste where existing processing facilities have capacities to manage less than 10% of the organic waste generated in the city. In addition, most of the organic processing facilities are not functional due to various reasons highlighted above. Consequently, majority of the organic waste in Port Blair is dumped in the Brookshabad dumpsite. As per U.S. Environment Protection Agency's Waste Reduction Model (WARM), landfilling of 1 (one) MT of organic waste results in 0.54 MTCO2 equivalent of GHG emissions[44]. In the

[42] Composting cycle of approximately 65 days
[43] This has been calculated by adding the processing capacities of all processing facilities (functional and non-functional).
[44] Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM), Management Practices Chapter, US EPA, October 2019 available at: https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-energy-and-economic-factors-used-waste

event that 66 MT of organic waste is dumped in Port Blair every day, there is a potential GHG emission of approximately 35 MTCO2 on a daily basis.

- **Limited inputs for composting process:** During the visits it was observed that inputs for aerobic compositing such as accelerators (microbes and cocopeat) and equipment such as rakes, shovels and trowels were not available with the staff. The bins that were being use for the composting were not perforated and there was no mechanism for leachate collection in most cases. These limitations would affect the quality of the compost and time taken for conversion of organic waste into compost.

- **Limited knowledge and capacities of the staff:** It was also observed that there were no personnel dedicated for processing of organic waste and the persons involved in the composting processes were some of the collection staff and that too, on an adhoc basis. In addition, all the sanitation staff that were carrying out composting did not have the required knowledge and/or capacities to understand holistic composting processes. The staff had not been provided any trainings on the processes nor were they provided any educational/learning tools such as videos, guides or booklets on composting.

- **Lack of infrastructural capacity for organic waste and inappropriate techniques**: Currently, most sanitary offices have 1 (one) to 4 (four) bins for composting while compost cycles are typically 60-90 days. Therefore, once these bins and pits are filled, the organic waste will need to be diverted elsewhere for processing. In addition, pit composting is being carried out in some sanitary offices, is not recommended in high rainfall areas such as Port Blair.

8.3 Gandhi Park Vermi Compost Facility

This facility was constructed in 2015 as an initiative by PBMC to manage organic waste in Port Blair in a decentralised manner. From 2015 to 2021, PBMC directly managed this facility and approximately 10 (ten) women were hired as workers for this facility with honorariums from PBMC. In 2021, PBMC reorganised its solid waste management systems by engaging SHGs for collection, transportation and processing of waste in an attempt to create self-sustainable models of handling municipal waste. In this regard, these 10 (ten) women were organised into an SHG by the name of Stree Hausala which is now officially managing this facility. Since the formation of the SHG the women are no longer paid honorariums by PBMC and the understanding is that the facility will be operated on an ‘entrepreneurship model’ where the SHG will retain the revenue through the sale of compost from this facility. However, the equipment and other inputs for the compost process are continued to be supplied by PBMC. Currently, about 6-7 women work at the facility on a daily basis. In March 2022, a decision was taken to engage the SHG women to provide training regarding composting to other workers engaged by PBMC. As per this order, the women will be provided with an honorarium of INR 5000 per member per month for these training activities.

1. Gandhi Park Vermi Compost Facility 2. Compost Pits inside the facility

Figure 24: Gandhi Park Vermi Compost Facility (1)

The facility contains 30 raised, concrete pits with a total capacity of 113 m^3. The facility can manage about 0.70 TPD of organic waste. Prior to COVID-19 in the year 2020, the primary inputs for compost consisted of cow dung, tea leaves, eggshells, dry leaves, and grass. These wastes were collected by PBMC staff from hotels, commercial establishments and parks. From 2020 onwards, only cow dung, dry leaves and grass (horticulture waste) are used as inputs for the compost and no waste from commercial establishments, such as tea leaves, is being diverted to this facility. According to the members of the SHG, food waste has never been brought to this facility to be used as input for making compost.

In terms of process, PBMC workers bring in the required inputs of cow dung, leaves and grass to the facility. The empty pit is first layered with dry leaves and grass, followed by some cow dung which is mixed with water. After this, the mixture is left for about 4-5 days and is frequently sprayed with water to keep the contents in the pit moist. This process is repeated until the pit is full and water is added every 4-7 days for a period of about 30-45 days to ensure that the contents remain moist enough for composting to take place. After completion of this period, worms are introduced into the pits and it takes approximately another 30 days for the worms to complete the process of composting. The total time taken for completion of the compost process in one pit ranges between 60 to 75 days. Once the compost is ready it is sieved to remove larger particles before it is ready to be sold. During the field visits, almost all pits were observed to be full of compost at various stages and the compost seemed to be of good quality through visual, texture and smell analysis.


Figure 25: SHG members at Gandhi Park Vermi Compost Facility

From 2015 until transfer of operations of the facility to Stree Hausala SHG, most of the compost from the facility was given free of cost by PBMC to be used within government and public premises such as parks and offices. From August 2021, the compost is mostly sold to individual buyers (either at the facility or from stalls set up by the SHG at different markets). Stree Hausala has determined the selling price for the compost as the following:

- Rs 50/ kg if the requirement is less than 100kgs
- Rs. 45 if the requirement is between 101 kgs and 1000 kgs
- Rs. 32 if the requirement is more than 1000 kgs

From the data provided by the facility for August to December 2021, it seems that revenue generated by the facility is between INR 6500 to INR 17,880 per month. The following table includes the quantity of compost sold by the facility in the last 3 (three) years.

Table 12: Quantity of compost made at Gandhi Park OWM Facility

Year	Total Compost Sold (kgs)	No of months[45]	Average quantity of compost sold per month (kgs)
2019	4,436	9	492.88
2020	10,396	11	945.09
2021	4,066	6	677.66
Post SHG formation	3,122[46]	6	520.33

Social Impact

This facility set up by PBMC has the potential to become a good case study and a best practice with reference to creating social impact for women in the area of organic waste management. Through PBMC's initiatives the women of the Stree Hausala SHG have acquired skills in managing organic waste through the technique of vermi composting and the quality of compost produced by them seems to be of good quality. Their work at the Gandhi Park Vermi Compost facility has also given them the chance to be empowered financially. However, since the formation of the SHG the women's income have reduced significantly due to lack of market linkages. Consequently, PBMC's recent decision to engage these women as trainers for OWM is expected to both provide income and motivate them to continue this work. It can be expected that once market linkages are created for their compost, their revenues will increase and the facility as well as the SHG can potentially become financially independent.

Horticulture waste for making compost

SHG members during field visit

Figure 26: Gandhi Park Vermi Compost Facility (2)

Gaps

- **Lack of knowledge with respect to making compost from food waste**: This facility is an excellent case study for OWM, however, a significant portion of organic waste in urban areas consists of food waste, which is currently not being processed here. The SHG members are highly experienced in making

[45] Reference is to the number of months the data is available for in the register maintained at the facility.
[46] 2023 kgs of compost was given for Gandhi Park and Marina Park in October 2021 and the SHG is yet to receive payment for the compost.

vermicompost from horticulture waste but they expressed that they do not have the knowledge to make compost with food waste and are thus reluctant to attempt it without training.

- **Decrease in income**: Since the formation of the SHG the average total monthly revenue for the facility from sale of compost has been approximately Rs 11,000/-. This results in significant reduction in individual income for each member of the SHG who were earlier receiving an honorarium of Rs 11,000 per month from PBMC. This is a major cause of concern for the women of the SHG.

- **Lack of market linkages**: During multiple discussions conducted with the members of the SHG, it was highlighted that current sales of the compost do not provide sufficient revenues. At current highest selling rate of compost i.e., Rs 50/kg, the SHG will need to find buyers for at least 2 MT of compost every month for each member of the SHG to receive an income of Rs. 10,000 per month. They are currently selling approximately 500 kgs of compost per month, which is 1/4th of that requirement.

  The Joint Secretary, Department of Agriculture, highlighted during the interview that the department requires approximately 300 MT of compost every year which is currently being procured from mainland India through a tender process. However, the details of the price of compost being procured through this process was not shared with the team. The staff at the Agriculture Department also highlighted that the selling price of the compost at Rs. 50/kg was too high and that it should be lowered.

  During the meeting with the ex-Chairman of ACCI and member of the Hotel Association, it was pointed out that, there is a large demand for vermi-compost on the islands by commercial establishments such as hotels and resorts, which require as much as 50 MT of compost at a time. At present, many of these hotels are sourcing compost from other islands and mainland India.

  Therefore, it seems that there is significant demand for vermicompost in the city and ANI, however, the linkages for supply and demand have not been created by PMBC and/or the SHG. Given that the SHG members were paid an honorarium until August 2021, they do not have the relevant experience or capacities to operate the facility on an "entrepreneurship" model. In addition, no trainings on entrepreneurship, business models, marketing and financial sustainability have been provided to the SHG members to build their capacities for sustainable operations of the facility.

- **Requirement of equipment:** The SHG members mentioned that some of the basic equipment required for daily activities in the facility is either broken or short in supply, which impacts their ability to function at full efficiency. According to the SHG members, the following items and equipment are required at the facility:

Table 13: Requirement of equipment at Gandhi Park OWM Facility

Sno	Equipment	Available currently	Additional requirement for a year
1.	Weighing Machine	1	1
2.	Gloves	4 pairs	20 pairs
3.	Mask	0	30
4.	Wheelbarrow	2	2
5.	Broomstick	3	10
6.	Boots	1 pair	2
7.	Multi-pronged shovel	1	2
8.	Kanta patthu (pointy shovel)	1	2
9.	Hand rake (khurpi)	1	2
10.	Iron mesh for sieving	1 piece	1 bundle
11.	Water pumping motor	0	1
12.	Water hose	2 bundle	3 bundles

13.	Bags for packing compost	0 (currently using cement bags whenever available)	As per requirement
14.	Bag sealing machine	0	1

8.4 Home Composting

In an effort to encourage on site management of organic waste, PBMC has begun encouraging residents to initiate composting within their household premises. Presently, as per the data provided by PBMC, 843 households have set up such on-site composting systems, thus managing about 0.556 TPD of organic waste. The techniques for home composting that are being practiced are pit composting, bin composting and crate composting. During field visits it was also observed that several households directly discard some organic waste into their plant containers or pots.

Crate Composting Bin Composting Pit Composting

Figure 27: Household Level Composting

Gaps

- **Limited on-site OWM by HHs:** Currently, 843 HH are practising composting within their household premises which is less than 2% of all households in Port Blair.

- **Limited awareness about composting process:** A number of households are directly discarding some of their organic waste in the soil of their plant containers or pots. This may reflect a need for awareness about proper composting methods for households.

- **Lack of incentives:** There are currently no incentives provided by the PMBC and/or ANI governmental authorities to encourage management of organic waste at home.

8.5 Processing of floral waste

The implementation of proper source segregation protocol to isolate flower waste enables local bodies and other agencies or entrepreneurs to process such waste to manufacture several kinds of products. In February 2022, a local organisation in Port Blair, namely Daksha Cooperative Society started an initiative to manage floral waste. As part of their initiative, they have begun collection of floral waste from shops in the city for making incense[47] and compost. Since this was the first time for such a project in the city of Port Blair, the team faced challenges towards collection of floral waste from shop owners who were hesitant to provide waste to

[47] The organization has segregated, collected, dried and stored floral waste to make incense and are awaiting certain products to make the incense as a final product

agencies other than PBMC. However, they were able to convince some shop owners and managed to collect mixed waste consisting of non-biodegradable waste (such as thread, plastic, paper) along with flower waste. The collection was organised in Bathubasti market and approximately 5-6 kgs of flower waste was eventually collected. The processing of this waste was undertaken in an informal setting in the backyard of one of the organisation member's households. A total of three batches of floral waste have been collected so far and no formal equipment has been sourced yet. A summary of the processes followed by them is given below,

Figure 28: Process for Making Incense and Compost from Floral Waste

8.6 Privately Owned Animal Feed Systems

Animal feed systems are traditional systems of consuming organic waste, especially food waste in India. During field visits, 3 (three) private piggeries were identified which are currently taking organic waste from Port Blair city; 2 (two) of these are operating in rural areas outside the jurisdiction of PBMC and 1 (one) is located at the Brookshabad dumpsite. A summary of these piggeries is given below:

Table 14: Piggeries in Port Blair

Sno	Location	No: of pigs	Quantity of waste processed	Source and type of waste
1	Lal Mitti	Approximately 80 adult pigs	1.5 TPD[48]	Vegetable and meat waste from individual shops in Port Blair
2	Manglutan	66 adult pigs	330 Kgs per day	Meat waste from 16 individual shops in Port Blair

[48] According to the owner, each adult pig consumes at approximately 20kgs of organic waste per day. This quantity has been arrived on that basis.

3	Brookshabad	500-700 adult pigs	No data available[49]	During field visits the pigs were observed as feeding on mixed waste at the dumpsite. In addition, some amount of organic waste collected by Shree Venkasteshwara SHG is being diverted to this piggery.

Piggery at Lal Mitti

- **Year of commencement:** 2013
- **Distance from Port Blair**: Approximately 15 kms
- **Area**: 15-20 acres
- **Number of pigs**: Approximately 80 adult pigs
- **Other animals**: 15 goats, 4 chickens and 8 fish ponds
- **Organic waste consumed**: approximately 1.5-2 TPD (out of which 1 MT per day is from PBMC limits)
- **Type of organic waste used**: Vegetable and fruit waste and chicken waste
- **Source of waste**: Individual vegetable and meat shops located at Aberdeen Market, Minni Bay Military Area, Prothrapur, Kalighat, Dairy Farm and Junglighat etc.
- **Selling price for pork**: Rs 350/ kg
- Manpower: 4 (four) full time labour apart from the owner

Nirmal Sardar owns and operates this piggery which is located at Lal Mitti, near Chidiyatapu. It consists of about 15-20 acres of leased land which divided into two parts: one half is the pig farm with fish ponds and compost pits, while the other half is a vegetable farm.

Figure 29: Pigs at Lal Mitti Piggery

The collection of the organic waste for the piggery is carried out by the owner in his own vehicle at no cost to the waste generator. From the field visit it was observed that the piggery and the farm have several aspects of circular economy in action. The pigs at the farm eat both chicken waste and vegetable and fruit waste while the other animals such as goats eat any kind of leftover vegetable waste. Any waste that is not consumed by the animals is composted in the 10 compost pits, each with a capacity of approximately 12 MT[50]. The compost from these pits is used for the vegetable farm which grows a variety of vegetables such as bitter gourd, cucumber, chillies, long beans, and Indian squash.

[49] PBMC and SHGs have both been requested to share logs of organic waste being diverted to Brookshabad Piggery, however as per discussions conducted with both agencies, this data is not presently not maintained by them.
[50] This is as per the in-depth interview with the owner of the piggery during field visits.

Figure 30: Compost Pits at Lal Mitti Piggery

The owner also stated that the piggery is a profitable venture where the main source of revenue is pork which is bought directly from the farm at Rs 350/kg. There are no transportation or market rental costs as the meat is sold directly from the farm. The sale of vegetables and fish from the ponds are an additional source of revenue.

Figure 31: Fish Pond at Lal Mitti Piggery

During discussions, the owner highlighted the support received from PBMC for creating the necessary linkages to sources of organic waste in different markets of Port Blair and assistance for loan through National Safai Karamcharis Finance and Development Corporation (NSKFDC) for the collection vehicle. The owner proposes to increase the number of pigs on his farm from 1000 pigs in the year 2022 and therefore, will require additional organic waste to feed these additional pigs.

Gaps

- **No treatment of waste**: The chicken waste and/or food waste that has been in contact with human fluids (such as saliva) is not treated i.e., heated to kill pathogens before it is fed to the pigs. This increases the risk of disease/infection to the animals.

- **No infrastructure for slaughter waste management**: The piggery has not installed any mechanism towards ensuring that waste from slaughtering is treated before disposal. Currently, this waste is being disposed in the compost pits.

- **Ownership of farm land**: The lease for the farm is based on a verbal agreement and there is no formal written agreement for the land. Therefore, it may be risky for the PBMC to become dependent on this farm for processing/ disposal of large quantities of organic waste.

Piggery at Manglutan

- **Year of commencement:** 2018
- **Distance from Port Blair**: 23 kms
- **Area**: half an acre
- **Number of pigs**: Approximately 66 adult pigs
- **Other animals**: Ducks and one fish pond
- **Organic waste consumed**: Approximately 330 kgs daily
- **Type of organic waste**: Vegetable and Chicken waste
- **Source of waste**: Individual vegetable and meat shops
- **Selling price for pork**: Rs 250/ kg
- **Manpower:** 2 (two) full time labour apart from owner and 2 (two) additional persons on a need basis for butchering and sale of pork.

This piggery is owned by Vikas Sarkar and it is located next to the tide line in a village named Manglutan. The current input for the farm is approximately 330 kgs of organic waste per day from 14 meat shops and 2 (two) vegetable shops. The owner collects organic waste from these shops in a personal vehicle without charging the latter. The vehicle has been equipped with 12 drums of a capacity of 50 kgs each. The linkages with these shops for collection of organic waste were created by the owner and collection of waste is undertaken between 7:00 P.M. to 10:00 P.M. every night.

Figure 32: Piggery at Manglutan

Figure 33: Fish Pond and ducks at Manglutan Piggery

From in depth interview with the owner, the piggery and the farm have the following business model:

Table 15: Income and Expenditure for Piggery: Manglutan

Head	INR per month
Expenditure	
Labour (Two)	30,000
Fuel (1 vehicle)	15,000
Miscellaneous (butcher, maintenance)	Approximately 1500 per pig for butcher
Revenue	
Sale of pork, duck meat and fish	60,000 to 80,000
Estimated profit	10,000 – 30,000

According to the owner, each of the adult pigs require a minimum of 5 to 10 kilos of organic waste or a cumulative of about 660 kgs on a daily basis which is the twice the amount that he is able to source at present. The best feed for the pigs would be food and vegetable waste, which is available in large quantities only at markets, hotels and restaurants. However, these have not been channelised to the piggery till date.


Figure 34: Collection of meat waste from shops in Port Blair

Gaps

- **No treatment of waste**: The chicken waste and/or food waste that has been in contact with human fluids (such as saliva) is not treated i.e., heated to kill pathogens before it is fed to the pigs. This increases the risk of disease/infection to the animals.

- **No infrastructure for slaughter waste management**: The piggery has not installed any mechanism towards ensuring that waste from slaughtering is treated before disposal.

- **Limited supply of organic waste**: Currently, markets hotels and restaurants within PBMC jurisdiction are not handing over organic waste to agencies other than PBMC and their authorised vendors. Therefore, there is no linkage between organic waste generated in the city to this piggery.

- **Proximity to tideline and mangroves**: The tsunami in 2004 has resulted the sea water to come very close to the farm and has resulted in mangrove growth. This new proximity to the ocean has caused concern for the Forest Department who have asked the owner multiple times to relocate the farm.

9. Processing Organic Waste Management by Bulk Waste Generators

As per the SWM Bye Laws for the PBMC, all BWGs are mandated to take responsibility of managing the organic waste generated on their premises by setting up appropriate facilities. The Bye Laws also state that those BWGs that have space constraints towards setting up an OWM facility on their premises must deliver their waste to a collection vehicle or a biodegradable waste storage container from where PBMC will collect such waste daily. According to information shared by PBMC officials, no BWG is currently managing their organic waste at source and consequently all of them rely on the waste collection service provided by the PBMC. This was also confirmed during interviews with the representatives of SHGs Friends and Shree Venkateshwara who are currently collecting waste from some commercial establishments. In an NGT affidavit[51] submitted by ANPCC, it is mentioned that 10 schools and 1 college in Port Blair have OWM facilities on their premises, but no information regarding these educational institutions (including daily organic waste generation, processing techniques and use of final products) was available with the stakeholders during field visits.

Gaps

- **Lack of on-site management of organic waste by BWGs:** All BWGs in Port Blair (including the ones that have space) are dependent on the organic waste collection service provided by PBMC and have no system for onsite management of waste. All of this organic waste is currently going to the central dumpsite at Brookshabad.

- **Lack of incentive for onsite OWM**: The current SWM Bye Laws for PBMC do not have any incentives for BWGs who are managing their organic waste on site.

10. Final Disposal of Organic Waste at Brookshabad Dumping Site

As per estimates given by PBMC and research undertaken by survey team, Port Blair produces approximately 71 TPD of organic waste. At present, none of the OWM facilities are operational except Gandhi Park Vermicompost Facility which processes about –0.68 TPD of horticulture waste. The new OWM facilities which have been set up under PBMC's new initiative towards decentralised OWM have a total capacity of approximately 6 MT, however, the per day capacity for these new facilities is only 0.086 MT.

The two privately owned piggeries located at Lal Mitti and Manglutan are respectively handling about 330 kgs and 1 MT of organic waste generated within Port Blair every day. As per information gathered during field visits and through discussions with PBMC representatives, nearly all organic waste produced from markets[52] is being sent to Brookshabad dumping site. Majority of the organic waste collected by the two SHGs Friends and Shree Venkateshwara is also currently being routed to the central dumpsite with the exception of unquantifiable amount going to the piggery at Brookshabad. Therefore, currently, about 62.3 TPD of organic waste generated within Port Blair city remains unprocessed.

As per affidavits[53] submitted to the NGT by ANPCC, the central dumping site at Port Blair is classified as a landfill. The affidavits further states that this landfill has been closed and only about 16% of reject waste goes to the site. However, during field visits in December 2021, it was observed that the dumping site was operational and mixed waste is still being dumped at the site. In addition, large patches of the dumpsite were on fire during the field visit and it was not clear if it was intentional or because of a methane flare up. There

[51] NGT affidavit submitted by ANPCC dated January 2020
[52] Unquantifiable quantities of meat waste from markets and households are fed to stray animals and some quantity of organic waste is also used by households for their plants.
[53] NGT affidavit submitted by ANPCC dated January 2020

are discussions with respect to carrying out bio-remediation of legacy waste at the dumpsite and a private party has been selected by PBMC for this[54].

In terms of monitoring the quantity of waste that is being sent to the dumpsite on a daily basis, a check post has been set up by the PBMC. All vehicles carrying waste to the dumpsite are required make an entry at the checkpoint. Therefore, the checkpoint has a record of number of vehicles going to the dumpsite each day along with the number trips. However, there is no weighbridge at the dumpsite and therefore, there is no data available on the amount of waste going into the dumpsite.

Current dump site on fire

Pigs from the piggery feeding at the dumpsite

Figure 35: Brookshabad Dumping Site

Gaps

- **No weighbridge at check point**: Given the dumpsite does not have a weighbridge, PBMC is unable to determine the quantities of organic waste going to the dumpsite despite keeping records of the number of vehicles that come to the site every day.

- **Lack of data**: The checkpoint register does not capture details about the type of vehicle entering the dumpsite. Therefore, estimation of waste through volume (linked to capacity of the collection vehicle) and density of waste is also not possible.

- **Requirements of sanitary landfill are not complied with:** A major ecological feature of the ANI is its corals and marine life and the central dumpsite at Brookshabad is located less than 150 meters from the coast. The SWM Rules set out the requirements of sanitary landfills and have given ULBs (having population less than 5,00,000 persons) time until 2019 to set up sanitary landfills. The Brookshabad dumpsite does not comply with the requirements of a sanitary landfill and at present there is no structure installed at the dumpsite to prevent the leachate and other potential hazardous run-offs from entering the ocean, especially during monsoons. Therefore, there can be adverse environmental impact[55] from the continued operations of the Brookshabad dumpsite and non-compliance of requirements of sanitary landfill.

[54] As per information provided by GIZ city representative.
[55] The adverse environmental impact can include ingestion of hazardous substances by marine life, depletion of oxygen in water and resultant hypoxic zones among others.

11. Financial Sustainability of OWM Systems

Expenditures by PBMC

The survey team has received very limited data on the financial aspects of the organic waste management system being implemented by PBMC by itself and/or through the SHGs. The team received information with respect to expenditure on primary and secondary collection vehicles, user fee and expenditure incurred by the SHGs and capital cost of infrastructure that has been set up by PBMC to manage organic waste.

Table 17: Expenditure on Primary and Secondary Collection Vehicles by PBMC

S. No	Description	Total Number	Ownership	Cost per day per unit	Monthly Cost (INR) per unit[56]	Annual Cost for all units (INR)
1.	Twin compartment Vehicle (Primary Collection+ DTD possibly).	08	PBMC	8,240[57]	2,55,440	2,45,22,240
2.	Auto tipper (HH, commercial, from aggregation points)	26	Hired	2,165	67,115	2,09,39,880
		2	PBMC	8,240	2,55,440	61,30,560
3.	Tipper trucks (secondary transfer)	24	Hired	3700	1,14,700	3,30,33,600
	Total	60		22,345	6,92,695	84,626,280

Certain capital and operating expenditure heads

The PBMC has shared the following information regarding some capital and operating expenditures relating to SWM systems:

Table 18: Financial information provided by PBMC

S. No	Description	Number	Unit Rate (Rs.)	Amount (Rs.)
1.	Land (Include Dumpyard)	3600 sq.m. (SLRMC) 12141 sq.m. for Dumpyard	5000sqm	7,87,05,000
2.	Buildings (capital cost) (SLRMC & Compost Yards)	16	15,30,000[58]	3,23,86,309
3.	Process equipment (trommel, sieves, separators)	0		
4.	Material handling (conveyors, loaders, elevators)	0		
5.	Pollution control equipment	0		
6.	Transport (tippers, tractors)	28 (Owned - 2 & Hired - 26)	Please refer table	
7.	Material recovery facility	24 (functional 16, others are in pipeline) (SLRMC & Compost Yards)		
8.	Sanitary landfill	0		

[56] This figure includes the cost of vehicle hiring if applicable, fuel and driver's salary
[57] The unit rate for owned vehicle is much higher than the hired vehicles because it includes the salaries of the drivers at PBMC which can be as high as INR. 90,000 per month.
[58] This figure represents capital cost for Gandhi Park Vermi Compost Facility

9.	Rainwater management (drains, ponds)	0		
10.	Diesel Generator set, transformer yard, cables	0		
11.	Weighbridge	0		
12.	Security	6	500*365Days*6	10,95,000
13.	Office, management information system, or laboratory	5	30000*12months*5	18,00,000

While the survey team did not receive data on expenditure related to salaries for 754 sanitation staff involved in primary collection of waste from households, this expenditure has been assumed to be INR 11,92,70,736 on annual basis[59]. Therefore, the annual operating expenditure by PBMC on SWM systems appears to be at least INR 20,67,92,016 on the basis of the information provided for annual costs for vehicles and salaries of sanitation staff, security and office staff.

PBMC has provided no information regarding revenues earned by it through the SWM system, however, it was informed to the survey team during field visits that PBMC is not collecting user fees from households for waste collection services even though there is a potential to recover INR 24,82,800 per month or INR 2,97,93,600 per annum from households based on current user fee charges at INR 50 per household. In addition, there has been no revenues from sale of compost because the functional compost units are under the control of SHGs (and are therefore, entitled to the revenues from the sale of compost) and the new facilities at the sanitary offices have not generated compost as yet. Therefore, currently, there is no source of revenue for PBMC from OWM systems. From this preliminary analysis of the rudimentary financial data available, it seems that currently, the collection, processing and disposal of organic waste in the city of Port Blair is not financially viable without governmental funding.

Financial information relating to SHGs

As per the SWM bye-laws (Urban) of ANI, user fee charges have been fixed for various waste generators. However, the SHGs have been authorized to collect user fees from commercial waste generators at different rates, set out below:

Table 19: Door to Door Monthly User Charges for Stakeholders

S. No	Agencies	User Charges per month (INR)
1.	Commercial establishments such like pan shops, flower shops, other small unit not greater than 4sq.mtr area	100
2.	Grocery Dept. and other shops medium unit not greater than 10sq.mtr area	150
3.	Private / Govt. establishment medium unit not greater than 15sq.mtr area	300
4.	Wholesale and big establishments like textile, footwear etc. and Pharmacy.	500
5.	Vegetable & meat shop	500
6.	All vehicle showrooms	1000
7.	Bakery’s & small hotels	1000
8.	Hotels attached with bars, restaurants	3000

[59] This has been computed assuming all staff are paid minimum wages of unskilled workers as per Minimum Wages Act, 1948 applicable at ANI which is INR 13,182 per month.

It was informed to the survey team that the Port Blair SWM Bye-laws have not been updated to reflect these revised user fees. In addition, the survey team has received the following limited data on user fee collection by the SHGs along with the operating expenses incurred by them:

Friends SHG

The survey team received the following information regarding the operating costs incurred by Friends SHG for collection of waste from commercial establishments in 8 (eight) wards i.e., Ward 17-24 in Port Blair.

Table 20: Operating costs incurred by Friends SHG

Sno	Expense Head	Units	Unit Cost per month (INR)	Expense per month (INR)
1	Vehicle (Hired)	2	35,000	70,000
a)	Fuel Cost	2	30,000	60,000
2	Vehicle (Own)	1	0	0
a)	Diesel	1	30,000	30,000
3	Maintenance for all vehicles	Not required every month. Such expenses can be up to INR 20,000 for one maintenance visit as required.		
4	Salary for Driver	3	15,000	45,000
5	Salary for Supervisor	3	12,000	36,000
6	Salary for Labour	12	14,000	1,68,000
7	Salary for Extra Labour for User Fee Collection	2	5000	10,000
8	**Total**			**4,39,000**

The survey team received the following information regarding the user fee collected by Friends SHG from commercial establishments:

Table 21: User fee collected by Friends SHG

Sno	Month	Number of establishments	Total monthly collection (INR)
2021			
1.	February	105	53,000
2.	March	119	96,840
3.	April	164	13,64,30
4.	May	15	9750
5.	June	NA	NA
6.	July	32	1,17,707
7.	August	72	1,36,307
8.	September	96	1,30,380
9.	October	80	1,99,557
10.	November	21	30,900
11.	December	81	89,850
2022			
1.	January	143	1,16,500
	Total		11,17,221

There is significant variation in the user fee collected across different months and the survey team has not received any explanation for this variation.

Shree Venkateshwara SHG

The survey team received the following information regarding the operating costs incurred by Shree Venkateshwara SHG for collection of waste from commercial establishments in 16 wards i.e., Wards 1-16.

Table 22: Operating costs incurred by Shree Venkateshwara SHG

Sno	Expense Head	Units	Unit Cost per month (INR)	Expense per month (INR)
1	Vehicle (Hired)	1	45,000	45,000
2	Vehicle (Own)	2		
a)	Loan monthly instalment	2	18,000	36,000
b)	Diesel	2	20,000	40,000
3	Maintenance for all vehicles	3	20,000 per month	
4	Salary for Driver*	3	15,000	45,000
5	Salary for Supervisor	2	15,000	30,000
6	Salary for Labour	16	14,000	2,24,000
7	Total			4,40,000

The survey team received the following information regarding the user fee collected by Shree Venkateshwara from commercial establishments:

Table 23: User fee collected by Shree Venkateshwara SHG

Sno	Month	Total no: of establishments	Total Collection (INR)
2021			
1.	February	156	1,37,700
2.	March	214	1,77,600
3.	April	231	3,43,150
4.	May	59	42,450
5.	June	0	0
6.	July	143	57,300
7.	August	156	2,83,945
8.	September	131	1,30,600
9.	October	131	2,71,945
10.	November	156	1,28,307
11.	December	992	11,45,800
2022			
	January	605	1,70,207
	Total	2974	28,89,004

There is significant variation in the user fee collected across different months and the survey team has not received any explanation for this variation.

The survey team along with GIZ city representative calculated the approximate user fee that can potentially be collected from all the commercial establishments and this amount is approximately INR 42,16,950 per month or INR 5,06,03,400 per annum.

Gaps

- **Lack of reliable data**: The survey team has not received the following data from PBMC and/or the SHGs providing DTD collection service:
  (i) Salaries of the PBMC staff involved in solid waste management
  (ii) Operating costs such as fuel and maintenance incurred by PBMC
  (iii) Revenues earned by PBMC with respect to SWM systems
  (iv) Rationale for significant variation in user fees collected by SHGs
  (v) Revenues earned by SHGs

  In absence of the abovementioned data, it is not possible to evaluate the financial viability/sustainability of the OWM systems in the Port Blair with accuracy and certainty.

- **Lack of financial viability of PBMC run SWM system**: The annual operating expenditure by PBMC on SWM systems appears to be at least INR 20,67,92,016 and PBMC currently, does not collect user fees from households and there is no revenue from sale of compost at PBMC run facilities. There is a potential annual revenue of INR 2,97,93,600 per annum in terms of user fee from households that PBMC is not collecting. Therefore, it seems that the OWM systems are completely dependent on governmental grants and funds for its functioning. Such heavy dependence on these funds will lead to lack of financial viability of the SWM system in the long term.

- **Lack of financial viability of SHG run SWM system**: From an analysis of the operating costs and user fee data provided by the SHGs, it seems that Friends SHG does not receive sufficient revenues through user fees to cover its monthly operating costs. For Shree Venkasteshwara, with the exception of December 2021, the revenues from user fee are not sufficient to meet its monthly operating costs. Unless there are other funds available to these SHGs from PBMC, their operations are currently not financially viable. In addition, the potential to collect user fees from all commercial establishments is much higher i.e., INR 42,16,950 per month or INR 5,06,03,400 per annum as compared to what is currently being collected by the SHGs in Port Blair.

- **No part of the user fee is considered for processing of organic waste:** Currently, it seems that the user fee is being considered only for collection and transportation of organic waste and no portion of it is diverted towards processing organic waste. Therefore, there are limited sources of revenue for processing of organic waste which has a detrimental impact on its financial viability and sustainability.

- **Requirement for amendment of bye- laws to reflect new user fee charges:** PBMC has revised the user fee charges for commercial waste generators, however the same has not been amended in the SWM bye-laws.

12. IEC and Capacity Building Initiatives

Initiatives such as IEC, behavioural change and capacity building activities with regard to waste management are a major component of the Swachh Bharat Mission because it supports sustainability of waste management systems. These activities need to be recognized as a continuous process since behaviour change requires consistent efforts over a long period of time. According to the guidelines on SBM-Urban, it is noted that effective SWM systems require cooperation and input from a variety of stakeholders; such as community-based organisations, NGOs, other agencies involved in waste management, students among others. The guidelines encourage the involvement of such stakeholders in the creation of interventions with respect to IEC and behavioural change.

PBMC has not provided any information about the IEC and capacity building activities undertaken by it towards engaging and training its own staff and the Port Blair community. In the course of field visits, meetings and discussions were conducted with Mr Vijay, a Senior Sanitary Inspector and the head of the Sanitary Awareness Team (SAT) of the PBMC. Based on the information he provided, SAT includes 12 members who conduct outreach programs with PBMC sanitation staff and the local community. They have conducted training sessions for the sanitation staff about different types of waste and how to engage with community members on source segregation. Additionally, SAT engages in activities through which they interact with households to raise awareness about waste management, resource recovery and effects of improper disposal of waste. The group has also provided training to hotel managers to enable them to initiate source segregation in their establishments.

In addition, during interviews with representatives of the SHGs involved in the different aspects of the waste value chain i.e., Friends SHG, Shree Venkateshwara and Stree Hausala, it was informed that they had not received any training with respect to SWM processes, resource recovery options, entrepreneurship, business models, marketing and financial sustainability.

Gaps

- **Lack of targeted awareness generation activities for different stakeholders**: Different types of waste generators require specific types of trainings to initiate source segregation and onsite management of organic waste within their premises. In addition, the target audience within these waste generators are also different and therefore, require varied engagement activities for behavioural change. For instance, BWGs such as hotels and restaurants will have different requirements as compared to households with respect to management of organic waste. These different types of IEC and BCC activities seemed to be missing in Port Blair and therefore, there is an absence of focussed strategy for these activities.

- **Lack of expertise with respect to OWM**: While the SAT members seemed to have knowledge about different types of waste and source segregation, they did not seem to have sufficient knowledge and training about OWM systems such as composting, biomethanation, processing of coconut waste among others.

- **Lack of capacities of the SHG**: The capacities of the SHG members are not built sufficiently such that they can independently operate SWM systems that are sustainable and financially viable, and those that result in maximum resource recovery from waste and address issues relating to occupational health and safety among others.

13. Monitoring and Evaluation

The PBMC is responsible for setting up monitoring and evaluation mechanism in compliance with the SWM Rules 2016. As per the administrative structure provided by the PBMC, the council is head by the Chairperson who is an elected representative. All operations for SWM are administered by the Secretary of PBMC who is assisted by the Public Health and Sanitation Wing, Superintendent Engineer and Executive Engineers. All Sanitary Inspectors and sanitation staff come under the Public Health and Sanitation Wing, and all SWM related operations are handled by the Executive Engineer who also has the charge of Nodal Officer for SBM (Urban). The Executive Engineer is assisted by a Junior Engineer in the implementation of SWM Rules 2016 in the city of Port Blair. Currently, the PBMC has not established any monitoring and evaluation mechanism for its SWM operations.

14. Summary of gaps under the SWM Rules 2016

The regulatory framework with respect to organic waste includes laws at national, state and municipal levels. At the national level, the main law relating to the environment is the Environment Protection Act 1986 (EPA). The main regulation pertaining to organic waste at the national level is the Solid Waste Management Rules, 2016 framed under the EPA. The Ministry of Forest, Environment and Climate Change has formulated these rules and its implementation has been delegated to several agencies such as CPCB, State Pollution Control Board, state governments and municipalities.

At the state level, ANI has formulated *UT Policy and Strategy on Solid Waste Management for Andaman and Nicobar Islands* in 2018. In addition, PBMC has also drafted Port Blair Municipal Council Solid Waste (Management & Handling) Bye-Laws 2017 which have been approved by the Lt Governor and notified as well. The table below contains the main provisions with respect to organic waste in SWM Rules and its current compliance levels in Port Blair.

Table 24: Overview of gaps vis-a-vis SWM Rules

Compliance Requirement	**Details**	**Key Gaps identified**
Source Segregation	As per Rule (4) of SWM Rules, 2016, waste generators have to segregate waste into three streams i.e., biodegradable, non-biodegradable and domestic hazardous waste.	▪ As per field observations, especially relating to open dumps in the city and interviews with various stakeholders, the waste segregation levels are lower than reported figures. There is no accurate data in relation to segregation levels in the city and PBMC has not put in place any formal monitoring mechanism for monitoring source segregation.
Primary waste collection from households	As per Rule 15 (b) of SWM Rules, the ULBs have to arrange for door-to-door collection of segregated solid waste from all households including slums and informal settlements, commercial, institutional and other non-residential premises.	▪ In Port Blair, the current coverage of DTD collection from households is reported at 75%. However, during field visits several open dumps of mixed waste were seen in the city, suggesting that actual figures may be lower. ▪ In addition, primary collection from households happens in crates and bags by workers on foot which due to the terrain in Port Blair is inefficient, time consuming and ergonomically challenging for the waste collection staff. Due to these challenging conditions, waste collection staff can only collect from 50-120 households in a day resulting in large manpower for DTD collection from households. ▪ Inadequate infrastructure to keep the waste segregated during transportation.
Primary waste collection from	As per Rule 15 (b) of SWM Rules, the ULBs have to arrange for door-to-door collection of segregated solid waste	▪ The reported figure for DTD collection for commercial establishments is 100%, however, as per data shared by

Compliance Requirement	Details	Key Gaps identified
commercial establishments	from all households including slums and informal settlements, commercial, institutional and other non-residential premises.	SHGs and information collected during in depth interviews, less than 20% of total commercial establishments in the city are covered under DTD coverage. ▪ Currently there are only 6 (six) light commercial vehicles to provide door to door collection of waste from more than 6500 commercial establishments and bulk waste generators. In addition, it is noted that both the SHGs have the same number of vehicles i.e., 3 (three) light commercial vehicles each even though Shree Venkateshwara SHG covers twice the number of wards as compared to Friends SHG. ▪ Inadequate infrastructure to keep the waste segregated during transportation.
Secondary transportation of waste	As per Rule 15 (q) of SWM Rules transportation of segregated bio-degradable waste to the processing facilities like compost plant, bio-methanation plant or any such facility has to be carried out by ULB.	▪ It was observed during field visits that secondary transfer vehicles were carrying mixed waste due to lack of infrastructure such as partitions, bins or bags to transport the waste in a segregated manner. ▪ Due to the presence of open dumps in the city, secondary collection vehicles are used to collect mixed waste from open dumps.
Organic waste Processing at Source	Rule 6 specifies that the composting/biomethanation should be done for treatment of the organic matter by waste generators.	▪ The current organic waste generation in Port Blair is estimated at 71 TPD per day, while the current processing capacity is less than 5 TPD[60]. Therefore, there is a significant gap between organic waste generated in the city and the processing of such waste where existing processing facilities have capacities to manage less than 10% of the organic waste generated in the city. Therefore, majority of the organic waste in the city is getting dumped currently.
Decentralised processing of organic waste	Under Rule 15(v) of the SWM Rules, preference is required to be given to decentralised processing such as biomethanation, microbial composting,	▪ Out of the 6 (six) reported facilities for decentralised organic waste management, only one facility is functional at Gandhi Park.

[60] This has been calculated by adding the processing capacities of all processing facilities (functional and non-functional).

Compliance Requirement	Details	Key Gaps identified
	vermi-composting, anaerobic digestion or any other appropriate processing for bio- stabilisation of biodegradable wastes to minimize transportation cost and environmental impacts	▪ As part of a new initiative, organic waste from 10 wards is routed to decentralized OWM facilities at Sanitary Inspectors' offices. However, most sanitary offices have 1 (one) to 4 (four) bins for composting while compost cycles are typically 60-90 days. Therefore, once these bins and pits are filled, the organic waste will need to be diverted elsewhere for processing. In addition, there seemed to be limited inputs for the composting processing such as accelerators (microbes and cocopeat) and equipment such as rakes, shovels and trowels. In addition, all the sanitation staff that were carrying out composting did not have the required knowledge and/or capacities to understand holistic composting processes and had not been given trainings on the process.
Management of organic waste from bulk waste generators	Under Rule 4(6), 4(7) and 4(8) of SWM Rules, resident and market associations, gated communities and institutions with more than 5000 sqm area, hotels and restaurants are required to segregate organic waste and set up a system where organic waste shall be processed, treated and disposed off through composting or bio-methanation within the premises as far as possible.	▪ All BWGs in Port Blair (including the ones that have space) are dependent on the organic waste collection service provided by PBMC and have no system for onsite management of waste. ▪ There are no incentives for or enforcement of onsite organic waste management by bulk waste generators. ▪ No specific training and capacity building sessions for bulk waste generators regarding onsite management of organic waste.
Decentralised Waste management	As per Rule 16 (m) of SWM Rules, waste from vegetable, fruit, flower, meat, poultry and fish market has to be collected on day-to-day basis and promote setting up of decentralised compost plant or bio-methanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions.	▪ There is no separate collection or processing of special organic waste streams or from vegetable and fruit markets, at a decentralised level in Port Blair by PBMC.
Processing of organic waste at	Under Rule 15(t), ULBs are required to involve communities in waste	▪ Currently, less than 2% of households are practising onsite management of

Compliance Requirement	Details	Key Gaps identified
home and community levels.	management and promotion of home composting, bio-gas generation, decentralised processing of waste at community level subject to control of odour and maintenance of hygienic conditions around the facility. Under Rule 15(zg) of the SWM Rules, ULBs are create public awareness through information, education and communication campaign and educate the waste generators on home composting, vermi-composting, bio-gas generation or community level composting	organic waste such as home composting. ▪ There is lack of supporting documentation for the IEC activities carried so far in PBMC city. Therefore, it is challenging to assess their suitability and impact among different stakeholders. ▪ There appear to be very few waste generators who undertake home or community composting. Therefore, there appears to be lack of promotion, awareness and incentives being provided to waste generators to undertake organic waste management at source. There are no subsidies, rebate on taxes/user fees or any other incentive for onsite management of organic waste.
Compost standards	As per Schedule II (A) of SWM Rules, the end product compost shall meet the standards prescribed under Fertilizer Control Order notified from time to time	▪ Currently, compost is not generated at any facility except Gandhi Park. Therefore, no testing of compost has been carried out recently.
Market linkage for compost	Under Rule 7 of the SWM Rules, the Department of Fertilisers, Ministry of Chemicals and Fertilizers should provide market development assistance on city compost and ensure promotion of co-marketing of compost with chemical fertilisers in the ratio of 3-4 bags is to 6-7 bags by the fertiliser companies to the extent compost is made available for marketing to the companies.	▪ The sale of compost from the Gandhi Park Vermicompost Facility is limited to individuals presently. ▪ The Department of Agriculture is presently procuring approximately 300 MT of compost from the mainland on an annual basis. ▪ There is a lack of market linkages between establishments such as hotels/resorts which require significant quantities of compost on a regular basis, and the composting units such as Gandhi Park Vermi compost facility.
User fees	Under Rule 15(f) ULB is required to prescribe appropriate user fee and collect it from the waste generators on its own or through authorised agency.	▪ While PBMC has prescribes user fees for different types of waste generators, it is not collected from households. Even among commercial establishments, user fee is collected from a limited number of establishments.

Compliance Requirement	Details	Key Gaps identified
Enforcement and review of implementation of SWM Rules by State Pollution Control Committee	As per Rule 16, ANPCC is responsible for enforcing SWM Rules in ANI through local bodies in their respective jurisdiction and review implementation of these rules at least twice a year in close coordination with concerned Directorate of Municipal Administration or Secretary-in-charge of State Urban Development Department.	▪ As per information received from ANPCC, no such enforcement, review, or monitoring activities are carried out by the department for organic waste management in the union territory due to scarcity of staff.

15. Climate Change perspective of present organic waste management in Port Blair

Over the last hundred years, GHG emissions from anthropogenic sources have been on the rise. The emissions for the last forty years, account for nearly half all GHG emissions from anthropogenic sources between 1750 and 2010[61]. These emissions have been linked to rising global temperatures with consequences such as rising sea levels and increase in the rate and frequency of natural disasters such as wildfires, droughts, floods etc. Such events are leading to damaging of coastlines and crops, thereby creating pressure on already scarce resources such as food, water and energy. According to The Paris Agreement, efforts are required to ensure that global temperatures remain below 2 degrees Celsius from pre-industrial levels. This requires all countries to identify the sources of GHG emissions and devise frameworks and strategies to monitor and reduce them.

Relation between improper management of organic waste in Port Blair to Climate Change

Loss of biodiversity: Islands nations/ states are recognised as especially vulnerable to climate change due to their geography. From a biodiversity perspective, island ecosystems have small and specialised populations of different species which can be driven to extinction with the smallest interference. It is estimated that out of all species to have become extinct since the 17th century, islands species account for nearly 75% animals and 90% birds[62]. Many islands are also surrounded by coral reefs which are extremely sensitive to temperatures and chemicals. It is estimated that coral reefs house more than 25% of all fish populations[63] and it is known that island populations are heavily dependent on fish for food and livelihood. As a result of rising global temperatures more than two thirds of coral reefs across the world have seen bleaching events[64] and 30% have been impacted fatally. As per observations by Indian National Centre for Ocean Information Services (INCOIS)[65], coral reef sites around Port Blair such as those near Chattham Jetty, near Channel Beacon, and North Bay are already showing signs of bleaching.

Reduction in fisheries: As per data received from the Department of Fisheries, more than 90% of population in ANI consumes fish. Additionally, the coral reef sites in ANI are recognised as a global tourist spot for their variety of marine life. Any damage to the sites due to increasing temperatures will both impact food security and tourism which is one of the most important industries in ANI.

Loss of land: Rising sea levels are a major consequence of global warming, with many islands nations like Maldives already reporting significant loss of land due to the same[66]. It is estimated that the ANI may not be

[61] *How Can Biogas Help Mitigate Climate Change? Factsheet 2*, World Biogas Association (https://www.worldbiogasassociation.org/wp-content/uploads/2018/07/WBA-Climate-Change-Biogas-factsheet-2.pdf)
[62] *Island Biodiversity And Climate Change*, Convention of Biological Diversity
[63]https://www.epa.gov/coral-reefs/basic-information-about-coral-reefs#:~:text=Coral%20reefs%20are%20among%20the,point%20in%20their%20life%20cycle.
[64] https://www.climate.gov/news-features/understanding-climate/unprecedented-3-years-global-coral-bleaching-2014%E2%80%932017
[65] https://incois.gov.in/WEBSITE_FILES/CoralReef/CB_Andaman.pdf
[66] https://www.climatehotmap.org/global-warming-locations/republic-of-maldives.html

habitable by 2050 due to rising sea levels accompanied by severe cyclones[67]. The current dumpsite at Port Blair is located less than 150 meters from the coast and this may have an impact on usability of the site in the near future due to factors such increased erosions, cyclones and flooding.

Leachate and waste leakage from dumpsite into the ocean: The present dumpsite at Port Blair has no provisions to manage leachate. Additionally, with more than five months of rainfall, the amount of leachate generated at the dumpsite would increase. Currently, due to the location of the dumpsite unquantifiable quantity of leachate is expected to be released into the ocean. The leachate contains several toxic chemicals that can impact marine life adversely in coastal environments, through processes such as deoxygenation, eutrophication, direct toxicity, or toxicity as a result of biomagnification/ bioaccumulation[68]. In an event of flooding or erosion it is also possible that some quantities or parts of the landfill may enter/ fall into the ocean which will release all toxins that have accumulated at the site due to improper management of waste into marine ecosystem. The ingestion of marine life which has ingested such toxins will have negative impact on human health due to biomagnification of toxins.

Ground water pollution: The lack of a properly lined pit in dumpsites leads to leakage of leachate into ground water. The dumpsite at Port Blair is located on a hill near the coastline and it is expected that leachate run off may be high due to this reason, especially during rainy season. Such contamination of ground water poses several risks to the environment and health of humans, especially those living in the vicinity of the landfill.

GHG emissions reductions through management of organic waste in Port Blair

There are two main methods to manage organic waste, depending on the quantity of waste generated and local conditions such as climate, geography, and infrastructure. The first is to capture such waste and compost it, thereby also returning nutrients and organic content to soil. The second method is to produce renewable energy or bio-gas from bio methanation plants. Bio-methanation plants use anaerobic process to treat organic waste leading to generation of methane which can be used for purposes such as cooking or electricity (depending on the quantity produced). However, their capital and operational costs are significantly higher than composting plants/ facilities along with the requirement of highly trained staff to manage these facilties. Further, their cost rises up with the increase in the capacity of the bio-methanation plant.

Presently, about 66MT of organic waste is not being processed and is dumped at the Brookshabad dumpsite. As per U.S. Environment Protection Agency's Waste Reduction Model (WARM), landfilling of 1 (one) MT of organic waste results in 0.54 MTCO2 equivalent of GHG emissions[69]. In the event that 66 MT of organic waste is dumped in Port Blair every day, there is a potential GHG emission of approximately 35 MTCO2 on a daily basis. Additionally, the mixing of organic waste with other kinds of waste contaminates the former and leads to lower recovery for recyclables such as paper and plastic. Consequently, this drives up the demand for virgin plastic and paper and leads to higher GHG emissions.

According to the Waste Reduction Model (WARM tool) by the EPA, the dumping of 1 MT of organic waste releases 0.55 MT of C02. If, however, the waste is composted then it reduces 0.13 MT of C02 equivalent emissions, thereby leading to a total reduction of 0.67 MT of C02 for each MT of organic waste. In case of Biomethanation, the reduction in GHG emissions per tonne is 0.05 MT of C02 equivalent GHG emissions and thus total reduction is 0.59 GHG. Based on these calculations, estimates have been provided for reducing GHG emissions in Port Blair through proper management of organic waste. As can be seen in the Table 24, OWM systems based on composting will lead to an additional 5MT of GHG reductions per day as compared to biomethanation.

---

[67] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC),

[68] *Potential Pollution Risks Of Historic Landfills On Low-Lying Coasts And Estuaries*, James H. Brand,Kate L. Spencer,Francis T. O'shea,John E. Lindsay

[69] Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM), Management Practices Chapter, US EPA, October 2019 available at: https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-energy-and-economic-factors-used-waste

Table 25: Potential GHG reductions from OWM

Sno	Processing Type	Quantity (TPD)	GHG emissions reduction (MT)
1.	Composting	66.6	44.6
2.	Bio methanation	66.6	39.3

16. Action Plan

On the basis of the secondary research, primary research and gap assessment of OWM systems in Port Blair city, several recommendations are being put forth as part of the City Action Plan. The recommendations have been designed after conducting discussions with various stakeholders in the city and by keeping in mind the local variables for Port Blair. All recommendations have been divided into four categories: Short Term Recommendations (1–2 years), Medium Term Recommendations (2-5 years) and Long-Term Recommendations (More than 5 years). Further, recommendations within each section have been further bifurcated into different processes that are part of the flow of the waste from source of generation to point of processing or disposal.

15.1 Short Term Recommendations

(i) Waste survey and audit

Presently, there is lack of reliable data with the PBMC with respect to different aspects of its SWM system. Hence, a study must be carried out to get accurate data and establish a baseline with respect to the following aspects. In addition, such studies must be carried out every 3-5 years.

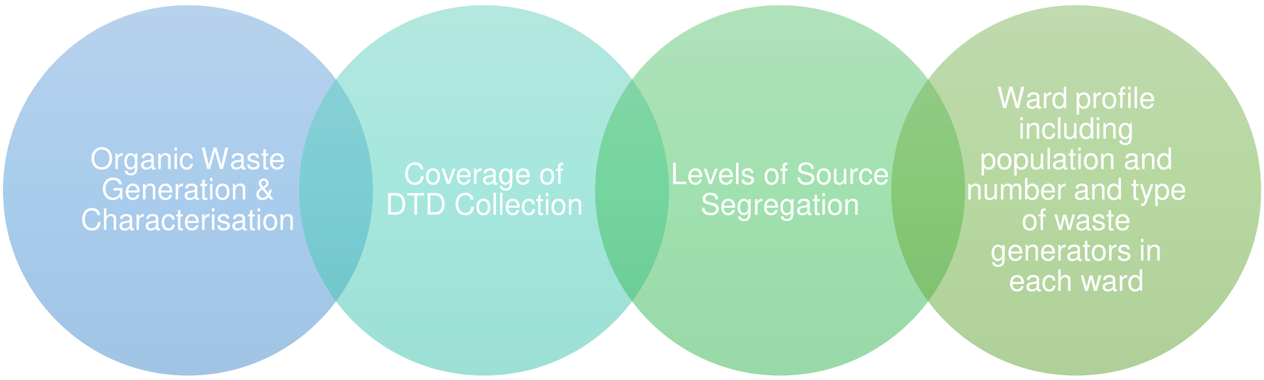


Figure 36: Data Collection

- **Mapping and tabulation of current resident and tourist population and number of waste generators for every ward**: This data can be captured along with the population census that is proposed in 2022. In addition, the data for households, government offices, public places such as markets can be collected by PBMC staff while the data with regard to the commercial establishments and bulk waste generators can be collected by the Friends and Shree Venkateshwara SHGs.

- **Quantity and characterisation of organic waste generated within Port Blair city:** All types of waste generators such as households, commercial establishments, bulk waste generators such as hotels, restaurants and markets etc. should be surveyed using appropriate methodology provided in CPHEEO manual to get reliable data about organic waste generation along with waste type. The selected methodology should take into account the following factors:

- Samples of organic waste must be taken from different types of waste generators such as households, markets, bulk waste generators such as hotels and restaurants, meat shops etc.
- The sample size of different types of waste generators should be commensurate to the total number of such waste generators in the wards and/or city.
- The samples must be taken from different wards in Port Blair which can be clubbed in groups in terms of economic status, population density, type of housing among others for the purpose of sampling.
- Waste samples from different types of waste generators across a 7-day period during different seasons to understand the seasonal variations in waste generation and characteristics especially given the tourist influx in the city from September to March.
- The waste survey and audit should identify bulk waste generators and the amount of waste generated by them separately. This is to ensure that the waste data from exceptional sources such as "bulk waste generators" does not distort the data from regular waste generators such as households and small shops.

This exercise is relevant for implementing decentralised organic waste management systems and assessing the infrastructure requirements for each ward including collection vehicles, manpower etc.

Table 26: Details of different waste generators

S.No.	Particulars	Number	Type of organic waste (Food/ horticulture waste, coconut waste, slaughterhouse waste, fish waste, flower waste)	Daily Organic waste generation – category wise (in Kg/MT)
1.	**Households**			
2.	**Small Commercial establishments and institutions**			
2.1.	Small canteen, lodges, hotel, restaurants and similar establishments which generate less than 50 kgs of waste every day.			
2.2.	Schools, colleges and other educational institutions without kitchen that generate less than 50 kgs of waste every day.			
2.3.	Small commercial shops			
2.4.	Vendors including mobile vendors			
2.5.	Temples, churches, mosques and other places of worship with kitchen and that generate less than 50 kgs of waste every day.			
2.6.	Government /private offices with kitchen and that generate less than 50 kgs of waste every day.			
3.	**Bulk waste generators**			
3.1.	Markets			
3.2.	Marriage halls			
3.3.	Canteen, lodges, hotel, restaurants and similar establishments which			

	generate more than 50 kgs of waste every day.			
3.4.	Temples, churches, mosques and other places of worship with kitchen and that generate more than 50 kgs of waste every day.			
3.5.	Government /private offices with kitchen and that generate more than 50 kgs of waste every day.			
3.6.	Schools, colleges and other educational institutions with kitchen that generate more than 50 kgs of waste every day.			
4.	**Meat/slaughterhouse/Fish waste**			
4.1.	Chicken, mutton, fish and other meat shops			
5.	**Horticulture waste**			
5.1.	Tourist attractions			
5.2.	Parks			
6.	**Coconut waste**			
6.1.	Coconut stall owners			
6.2.	Households			
6.3.	Canteen, lodges, hotel, restaurants			
7.	Any other category of waste generator			
	Total			

- **Coverage of Primary Collection:** A baseline needs to be established for the number of waste generators, that are covered by door-to-door waste collection service. This will enable the PBMC to increase their coverage in the long run and monitor areas that are being left out of their collection service. In addition, there should be clear data available with respect to the manpower and vehicles involved in primary and secondary collection of waste in each ward.

- **Levels of source segregation:** Source segregation levels among different types of waste generators should be mapped on a continuous basis.

(ii) Recommendations relating to waste value chain

Table 27: Recommendations – Short Term

Sno	Process	Recommendation
1.	Planning at ward level	For each ward in the city, a ward level micro plan should be created with the following details: - Number of households, commercial establishments (non-bulk generators), bulk waste generators and institutions including governmental, educational and religious. - Creation of collection routes among PBMC staff and SHGs in a block/cluster wise manner such that 100% of waste generators are covered. - Identification of routes where motorised primary collection vehicles are feasible and routes where manual DTD collection is required. - Assessment and allotment of appropriate primary collection vehicles and manpower in the ward for daily organic waste collection along

Sno	Process	Recommendation
		with collection timings. The ULB can plan for **(a)** separate collection days for different waste streams, **(b)** separate vehicles for different waste streams and/or **(c)** collection in a partitioned vehicle. Refer to Part A of **Annexure 5** for guidance on selection of appropriate vehicle and number of personnel for collection. - Assignment of secondary aggregation points/transfer stations in each ward. - PBMC should assess the number of large commercial establishments including bulk waste generators to determine the total number (and capacity) of waste collection vehicles for DTD collection[70] from all the commercial establishments in the city. Once this analysis is completed, SHGs should be required to hire or purchase appropriate number of collection vehicles to ensure 100% DTD coverage of commercial establishments.
2.	Source Segregation	- More than 50% of adult population in Port Blair work in governmental services and there is significant governmental housing in the city. Source segregation among the employees should be mandated through the various departmental levels. - Appropriate IEC and BCC activities such as inter personal/door-to-door awareness programs must be conducted towards increasing awareness regarding source segregation among waste generators. - Enforcement of source segregation among waste generators through imposition of fines for non-compliance provided under the SWM Bye-laws.
3.	Primary Collection from households	- Appropriate collection vehicles for door-to-door collection of waste from households to replace the crate system should be procured in at least 50% of the wards in Port Blair. These vehicles can be sturdy pushcarts, tricycles and auto-tippers depending on the terrain and accessibility of streets in the wards. - In areas where vehicles are not feasible, DTD collection may be carried out on foot and workers may be equipped with small containers which can be carried easily. Given that Port Blair has been declared a bin free city, community bins or dumpers cannot be placed. - PBMC to procure ergonomically designed gloves and shoes for occupational safety of the workers engaged in primary collection of waste. - HDPE Drums can be used in primary collection vehicles to store organic waste in segregated manner during transport
4.	Primary Collection from commercial establishments	- Wards 4, 5, 19 and 20 seem to have the highest number of commercial establishments that possibly generate organic waste (including hotels) in Port Blair. PBMC should consider having separate vehicles for collection of organic waste from the commercial establishments including bulk waste generators located in these wards. - SHGs should increase the DTD coverage to at least 50% of commercial areas in the city. The number of collection vehicles should be sufficient to ensure regular and complete coverage to these areas.

[70] One light commercial vehicle (having capacity between 500 -700 kgs) can collect solid waste from approximately 1500 small commercial establishments.

Sno	Process	Recommendation
		- SHGs should have compartments or HDPE drums for organic waste in their vehicles for keeping waste segregated during transportation.
5.	Aggregation, Secondary Collection and Transfer	- All the waste aggregation points should have covering to protect the aggregated waste during rains. - Secondary collection vehicles should have compartments or HDPE drums for organic waste for keeping waste segregated. - Bin to bin transfer system can be adopted to aggregate waste and transport the same in secondary transfer vehicles to avoid use of plastic garbage bags which contaminate organic waste.
6.	Management of organic waste at home	- Home compost and/or biogas systems should be mandated in governmental housing with space. - PBMC should consider engaging citizens who are practising home composting to provide training to other members of their community/ ward.
7.	Processing of Organic Waste	- Pit composting should no longer be used as a composting technique for processing of organic waste at a community/ward level. - Every ward should identify additional places similar to Sanitary Inspector offices where decentralised composting can be initiated. However, the composting technique should be suitable for the climate in Port Blair i.e., aerobic bin, in vessel composting or vermi-composting with lining and roof/covering for protection from rainfall. These additional units should process at least 1 MT of organic waste per day. Details of some of these composting techniques are included in **Annexure 6.** - The staff processing organic waste should be provided with appropriate equipment and trainings to ensure proper and efficient organic waste processing systems. - Brookshabad compost facility should be restarted after providing trainings to the SHG staff. - SLRM centres with additional space such as Dollygunj 1 and 2 should set up decentralised composting systems with a processing capacity of at least 1-2 MT per day. As short-term recommendations, PBMC should set up at least 2 decentralised units as pilot projects. An overview of the proposed OWM facilities is set out below. - Households must be encouraged towards onsite OWM by promoting home composting especially in wards where the houses have space through ward level trainings. - Until such time, processing facilities which have the capacity to treat 100% of the organic waste, linkages should be created for private piggeries to enable them to obtain organic waste such as fruit and vegetable waste from PBMC areas instead of only chicken waste. - Initiating a pilot for composting of food waste in Gandhi Park Vermi Compost Facility. - All processing facilities should have mechanism to weigh the incoming waste. - PBMC must identify local organisations such as Daksha Cooperative Society that are willing to undertake processing of any kind of organic waste. Once identified, it must provide access of the relevant organic waste streams to such organisations. - Some part of horticulture waste such as dry leaves and dry coconut husk must be stored for use in other OWM facilities to aid composting process in rainy season where dry leaves and husk may be not be

Sno	Process	Recommendation
		available. These inputs are required for carbon content in the compost and to remove excess humidity. - In addition, cow dung generated within the city can be used to as an accelerator to activate composting process in all decentralised and centralised OWM facilities as per requirement.
8.	Disposal	- Commencement of technical feasibility studies for construction of sanitary landfill in Port Blair. - Till such time that requirements of sanitary landfill are put in place, there should be protective structures around Brookshabad dumpsite to ensure that there is no run-off from the dumpsite into the sea especially during the monsoons. - A weighbridge needs to be installed at the checkpoint for the Brookshabad dumpsite such that there is a mechanism to accurately quantify the waste being diverted to the site on a daily basis. - Until such time a weighbridge is installed, PBMC to ensure that the check point at dumpsite to maintain logs for type of vehicle entering the dumpsite for the purpose of calculation of volume and hence, carrying capacity of vehicles. - The check point to also maintain records for organic waste being diverted to Brookshabad piggery. - Bio-remediation of at least 25% of the legacy waste in Brookshabad should be completed.
9.	Market linkages for compost	- There should be requirement that Agriculture Department procure 15-20% of their requirement of compost for distribution to farmers from compost generated in Port Blair. - Creation of linkages between decentralised processing systems and with hotels and resorts in Port Blair and ANI for sale of compost. - GIZ may consider providing support to Gandhi Park Vermi Compost Facility for marketing and branding of their products which could enable them to sell more compost and generate additional revenues.
10.	Monitoring and Evaluation	- PBMC sanitation staff engaged in DTD collection from households should record (i) number of households that are giving organic waste for door-to-door collection; (ii) source segregation levels and (iii) amount of organic waste collected every day. Refer to the Part B of **Annexure 5** below for details. This data should be reported to relevant authority in the PBMC such as the Public Health and Sanitation Wing and/or the Executive Engineer on a monthly basis. - The SHG staff providing DTD collection to commercial establishments should record (i) number of commercial establishments that are giving organic waste for door-to-door collection; (ii) source segregation levels; (iii) amount of organic waste collected every day and (iv) amount of user fee collected along with the number of commercial establishments that have paid them. Refer to the Part B of **Annexure 5** below for details. This data should be reported to relevant authority in the PBMC such as the Public Health and Sanitation Wing and/or the Executive Engineer on a monthly basis. - PBMC must use the above data to create a system of penalties for the SHGs/ third party agencies involved in collection of waste in case of poor performance such inadequate collection, mixing of waste etc. - PBMC must maintain logs for total organic waste collected every day from all markets, parks and other public areas.

Sno	Process	Recommendation
11.	IEC activities and Capacity Building Initiatives	- Separate awareness activities and behavioural change content should be created for different kinds of organic waste generators such as HHs, markets/ public places, hotels and restaurants, schools, government offices etc. - Involvement of different stakeholders especially community-based organisations, educational institutions and government offices in IEC programs within the city. - Exposure visits to well-functioning processing facilities for staff at OWM facilities to understand best practices for OWM.
12.	Special measures with respect to BWGs	- PBMC must identify all BWGs where onsite OWM is possible through composting or biomethanation. Ward 19, 5, 4 and 20 cumulatively account for half of BWGs such as hotels, lodges, restaurants and therefore, such establishments with space in these wards may be considered on priority basis for on site management of organic waste. - Until such time onsite organic waste management is commenced, all BWGs must follow source segregation protocol and use segregated containers to store organic waste before it is collected by the PBMC or the SHGs. SHGs should also require stringent monitoring from PBMC in the short term to ensure that they are segregating their waste. - A targeted SOP for all BWGs needs to be created, especially or hotels and restaurants which will include a training module with focus on source segregation and on site OWM. - Until such time, processing facilities which have the capacity to treat 100% of the organic waste, linkages should be created for private piggeries to enable them to obtain organic waste from bulk waste generators. Food in contact with fluids from humans (such as saliva etc.) should be heated to 100 degrees Celsius before feeding to pigs.
13.	Financial sustainability	- PBMC should amend the SWM bye-laws to reflect the current rate of user fees to ensure that there is no contradiction between the actual collection of user fees and the rates provided in the SWM bye-laws. - PBMC must consider collecting user fee from all commercial establishments directly instead of the SHGs. This will allow them to recover revenues of approximately Rs 42,16,950 per month. Thereafter, PBMC can disburse payments to the SHGs on the basis of key performance indicators such as coverage of DTD collection, segregation during transportation among others. - PBMC should commence collection of user fee from at least 50% of the households in Port Blair which will provide them a revenue of approximately Rs 12,41,400 per month to cover operating costs.[71] - PMBC should maintain details of costs, revenue and fund/grant details for solid waste management separately with further bifurcation in relation to organic waste and non-biodegradable waste management in its budgets and financial statements. - Once above data is available, analysis should be carried out to understand financial viability of the SWM systems and mechanisms to reduce dependency on governmental funding.

[71] User fee for households is INR 50.

(iii) Capacity building

Capacity building initiatives for management of organic waste must involve all stakeholders in the waste value chain from the point of waste generation to its processing or final disposal. The capacity building of the stakeholders is critical for effectiveness of improvements in SWM infrastructure and processes and without such capacity building, these improvements will not yield expected results.

There are different levels of staff who are involved in solid waste management at PBMC and the SHG levels, and they require specialised training that is different in scope, duration and specialisation. In addition, stakeholders such as households, commercial establishments and bulk waste generators require trainings which enable such waste generators to manage their organic waste onsite, adopt other sustainable waste management practices and take an active part in the decision making and implementation processes for management of organic waste in their city. A broad overview of the topics to be covered on the capacity building trainings are set out below:

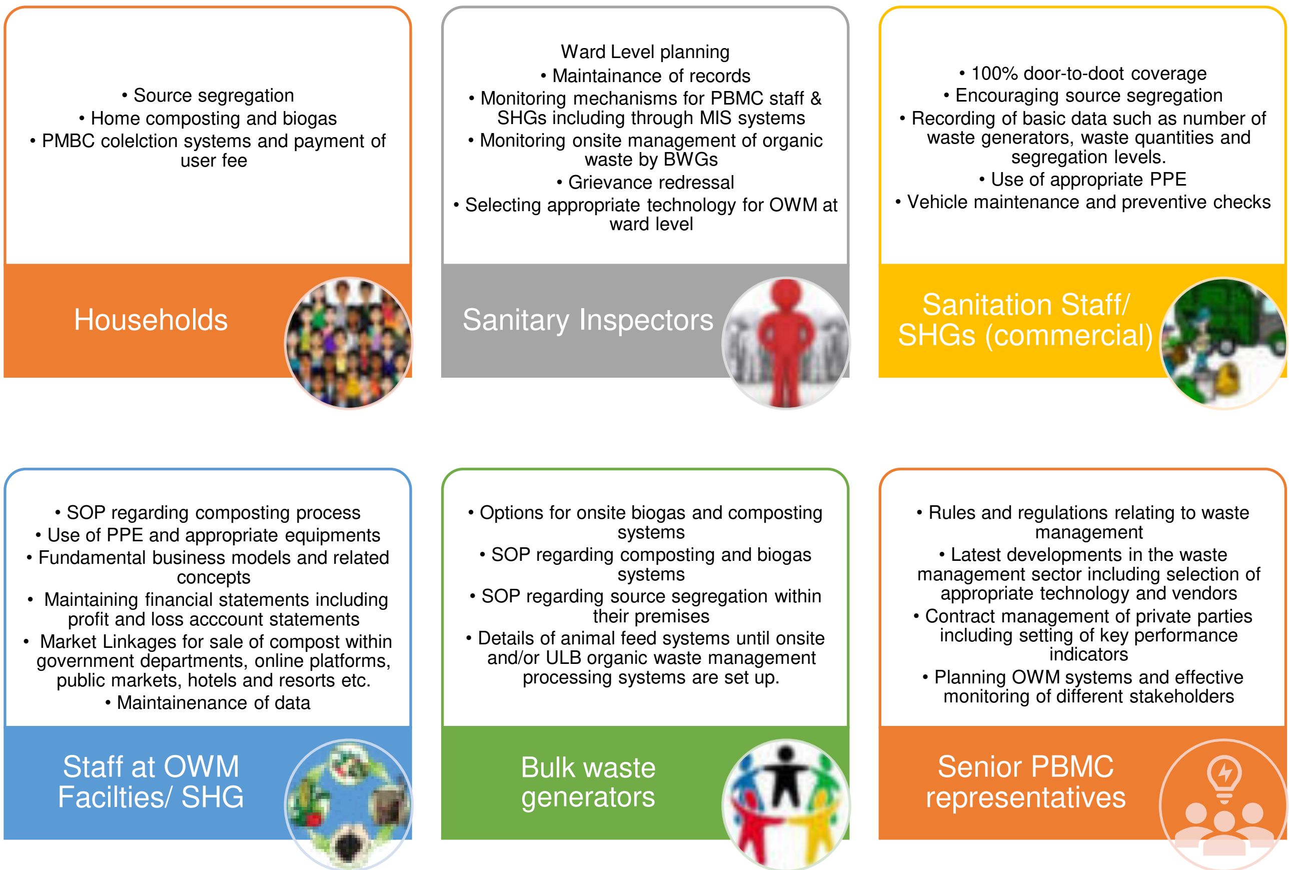


Figure 37: Stakeholders for Capacity Building

In addition to the above, PBMC should consider engaging a third-party agency to provide training to piggery owners for best practises in proper management of a pig farm. These should include the types of organic waste that can be fed to animals, heat treatment i.e., boiling all organic waste that has come in contact with meat and human fluids for an hour at 100 degrees Celsius to prevent possible spread of disease[72] and basic slaughterhouse management techniques among others.

15.2 Medium Term Recommendations

The medium-term recommendations will primarily consist of continuation and scaling up the efforts under the short-term recommendations to additional parts of the city i.e., to a greater number of wards across Port Blair.

(i) Recommendations relating to waste value chain

Table 28: Recommendations – Medium Term

Sno	Process	Recommendation
1.	Primary Collection	- Continued procurement of appropriate primary collection vehicles for DTD collection from households in remaining 50% of the wards of the city. - SHGs should increase the DTD coverage to at 100% of commercial areas in the city. The number of collection vehicles should be sufficient to ensure regular and complete coverage to these areas.
2.	Processing of Organic Waste	- Setting up at least half of the decentralised composting systems included in Point 15.2 (ii) below at a community/ward level. - Shifting of Brookshabad piggery to another location or creating infrastructure to ensure that the pigs are feeding in the city dumpsite. - The vermi-composting facility at Gandhi Park should be financially sustainable where its revenues through sale of compost cover its operating costs. - Setting up 4 (four) facilities for horticulture waste management within premises of public places such as parks, the design for which has been provided in Annexure 6 (Part C). - PBMC and ANPCC must not provide licenses and approvals to upcoming hotels/ restaurants that do not have a plan for on site OWM.
3.	Monitoring and Evaluation	- Data from monitoring and evaluation efforts in the previous 2 (two) years must be used to assess the impact of any interventions. - The PBMC should set up a formal grievance redressal system relating to organic waste systems for citizens. Records should be maintained for number of complaints received per day along with the rate of resolution of such complaints. - PBMC must ensure that compost from all OWM facilities is sent for testing to authorised labs on a monthly basis. These test results should be used to make changes in the composting process at the compost facilities, if required. - PBMC should continue evaluating the operations of the SHGs on a monthly basis to ensure 100% DTD coverage of commercial establishments, and transportation of segregated waste to processing facilities.
4.	Special measures with respect to BWGs	- PBMC SWM Bye-Laws should provide with incentives for all BWGs managing their organic waste on site. Currently, SWM Bye Laws for

[72] The Ministry for Primary Industries, New Zealand (https://www.mpi.govt.nz/animals/animal-feed-preventing-disease-transfer/feeding-food-waste-to-pigs-and-preventing-disease/#:~:text=If%20you%20can't%20be,that%20could%20potentially%20cause%20illness).

		rural ANI provides a subsidy of 30% on user fee for hotels and restaurants which are managing their organic waste on site[73]. - Setting up of onsite OWM infrastructure and operations for all BWGs in Port Blair that have to space. - Enforcement of onsite OWM among BWGs having space through imposition of fines for non-compliance provided under the SWM Bye-laws. -
5.	Market linkages for compost	- There should be requirement that Agriculture Department procure at least 50% of their requirement of compost for distribution to farmers from compost generated in Port Blair. - Creation of additional market linkages for the compost generated at decentralised facilities including with online retailers/platforms, hotels and resorts in ANI and other buyers of such compost. - PBMC should organise compost fairs/markets which have stalls for different types of composting techniques, ICC/BCC activities about onsite management of organic waste and sale of compost by SHGs and other decentralised facilities in some of the parks and public markets in Port Blair. - PBMC must procure at least 75% of all the compost required for use in public parks, government offices and other similar establishments under its jurisdiction from its own OWM facilities on a payment basis.
6.	Studies for sanitary landfill and Management of legacy waste	- PBMC should complete technical feasibility of a sanitary landfill and should commence its construction, if feasible. - Completion of bioremediation of legacy waste at Brookshabad dumpsite.
7.	Financial sustainability	- PBMC should endeavour to plan in a way that funds are always available for (a) operation and maintenance costs of waste management systems and (b) meeting replacement cost of equipment, vehicles, machinery at the end of their lifetime. This is especially critical because collection and processing equipment is relatively short-lived and operating and maintenance costs are substantial. - The operation and maintenance costs of the waste management typically include the following: (i) The typical components of operating expenditure budget are: (a) Overall program management cost such as salaries of health officers, environmental engineers and other management level ULB officials in charge of SWM activities. (b) Fuel for the primary and secondary transportation vehicles (c) Utility cost such as power and water etc., for processing and other infrastructure (d) Vehicle and equipment maintenance (e) Financial cost such as depreciation, interest on debt, income taxes, sinking fund for refurbishment, insurances, bank guarantees etc. (f) Recurring costs towards MIS systems (g) Consumables such as personal protective gear, uniform and shoes etc.

[73] SWM Bye Laws for rural areas in Andaman and Nicobar Islands

		(h) IEC activities (i) Direct and contracted staff cost for: ▪ for primary and secondary collection such as waste collection staff, drivers, helpers and loaders, ▪ secondary sorting and handling of waste material ▪ waste processing and disposal - PBMC should aim to recover at least 30% of its operations and maintenance costs from user fees collected from households. -
8.	Disposal	- Bio-remediation of at least 60% of the legacy waste at Brookshabad dumpsite should be completed.

(ii) Recommendations with respect to organic waste management for communities and/or bulk waste generators

As per the Municipal Solid Waste Management Manual by the Central Public Health and Environmental Engineering Organisation (CPHEEO), ULBs with a population between 1,00,000 – 5,00,00 or MSW generation between 25-150 TPD, should opt for decentralised waste management systems. The SWM Rules 2016 and SBM (Urban) guidelines also require that organic waste must be processed on site through methods such as composting or biomethanation. Some of the advantages of such decentralised systems have been given below:

- Reduction in time taken for collection and transportation and expenditure for waste collection and transportation infrastructure
- Significant reduction in the possibility of mixing of waste during transportation
- Decrease in leachate leakages during transportation of organic waste
- Decreased dependency on a central facility especially in case of technical failure or breakdown
- Ease in creating market linkages for relatively lower quantities of final products such as compost within vicinity of the OWM facility
- Increased possibilities for tailoring OWM facilities for special waste streams as per local conditions
- Small decentralised OWM facilities such as compost plants, biomethanation (biogas) plants, vermicomposting, and bin-composting are easy to set up and operate and have low operational costs.
- Decentralised OWM systems may also encourage greater community involvement and entrepreneurship towards the management of organic waste

Port Blair has a population of 1,66,637 persons and it produces approximately 71 TPD of organic waste, therefore, PBMC should set up multiple decentralised facilities for management of organic waste. Given that Port Blair is an island city where spares for equipment, machinery and repairs could be challenging, it is proposed that PBMC considers composting systems rather than biomethanation where operations and maintenance costs and requirements are higher. The different techniques for community composting are provided in **Annexure 6.** In addition, there are case studies for best practices from different parts of the country and internationally in **Annexure 7** that PBMC can refer to for appropriate replication in Port Blair. These case studies have been selected on the basis of similar local contexts such as population, area, proximity to the sea, high rainfall among others. A possible action plan in terms of upgrading existing infrastructure and setting up new systems is given below.

Table 29: Upgradation of Current OWM Facilities

Sno	OWM Facilities	Type	No: of units	Total Capacity (MT)	Per Day Capacity (TPD)	Total units after upgradation	Per Day Capacity (TPD)	Remarks
1.	Gandhi Park	Vermi Composting	30	33	0.68	Same	0.68	
2.	Brookshabad	Pit Composting (above the ground)	13	1	0.5	To be made operational for composting	0.62	To compensate for extreme humidity in Port Blair, perforated pipes may be inserted in the pits to speed up composting by increasing aeration[74] (Annexure 6, Case study for Indonesia).
3.	Ward 5	Pit Composting	2	0.462	0.015	0	0	Pits below ground level are not recommended for Port Blair due to heavy rainfall and high possibility of rain water seepage.
4.	Ward 6	Bin Composting	1	1.76	0.007	10	0.07	The number of bins in these facilities can be increased further as per availability of space. The bins should be perforated which allow for circulation of air and appropriate inputs such as microbial agents, carbon content in terms of cocopeat/dry leaves etc. should be added. In addition, the bins should be placed under a roof to protect it from rains.
5.	Ward 7	Bin Composting	4	0.462	0.027	10	0.067	
6.	Ward 9	Bin Composting	1	0.462	0.007	10	0.07	
7.	Ward 12, 13	Bin Composting	1	0.462	0.007	10	0.07	
8.	Ward 20	Bin Composting	1	1.06	0.007	10	0.07	
9.	Ward 24	Bin Composting	2	0.55638	0.016	10	0.079	
10	Home Composting	Bin+pit+crate composting	843	0.33	0.55638	19,862	13.10	This is assuming 19,862 households i.e., 40% of tital number of households commence home composting. This will also decrease GHG emissions from transportation of organic waste.
11	Piggery Manglutan	Piggery	66	1	0.33	Same	0.66	The piggeries may increase capacity by acquiring more pigs if input is assured. PBMC may consider diverting all vegetable waste from markets here.[75]
12	Piggery Lal Mitti	Piggery	80		1	Same	1.5	
13	**Total**			**85**	3.145	**NA**	17.85	
14	**Gap**						53.14	

[74] The intervention with the pipes is required since the pits do not have perorated walls for sufficient air flow.
[75] Source segregation of vegetable waste from markets and segregated transportation of the same to piggeries will ensure that waste does not need to be heated before being fed to pigs (this is required only in the scenario where food/ vegetable waste has come in contact with meat).

Table 30: Recommendations for new infrastructure for OWM Management in Port Blair[76]

Sno	OWM Facilities	No of units per facility	Capacity per unit (MT)	Total Capacity of OWM facility (MT)	Per Day Capacity of OWM Facility (TPD)	Total number of OWM Facilities required	Total Daily Capacity of all OWM Facilities (TPD)	Remarks
1.	Aerobic Composting[77]	30	2.2	66	1	5	5	These facilities can be set up multiple locations as per availability of land. The number of facilities and units per facility can be tailored as per requirement.
2.	Composting for Horticulture waste	8	0.28	2.24	0.034	5	0.136	Such facilities can be set up within park premises/ public places along with a shed to avoid rainwater seepage into the units. Number and size of the units can be tailored.
3.	Crate Composting	250	0.02	5	0.075	4	0.375	Plastic crates were seen dumped in many areas in the city. They can be used for composting, thereby reducing such dumping and aiding in OWM.
4.	Windrow Composting					1	15	One such facility can be set up near Brookshabad dumpsite
5.	BWGs					As per no: of BWGs	3.6	On Site OWM as required under regulations
6.	Fish Waste						10.5	Deep Burial/ Fish waste processing facility (15.3.ii)
7.	Meat Waste						5	Deep Burial
8.	Flower Waste						2	Linkages with third party agencies
9.	Tender Coconut						4	Coconut waste processing facility (15.2.iii)
10.	Managed by Upgrading existing facilities						17.85	
	Total						73.46	

[76] The calculations are based on a 66-day compost cycle
[77] Allepey model (Annexure 7)

(iii) Recommendations relating to coconut waste

Port Blair produces significant quantity of coconut waste which is currently being diverted to the city dumpsite with recovery of resourced from it. However, there are several products that can be made from coconut waste through different processing techniques and the chart below provides an overview of these products:

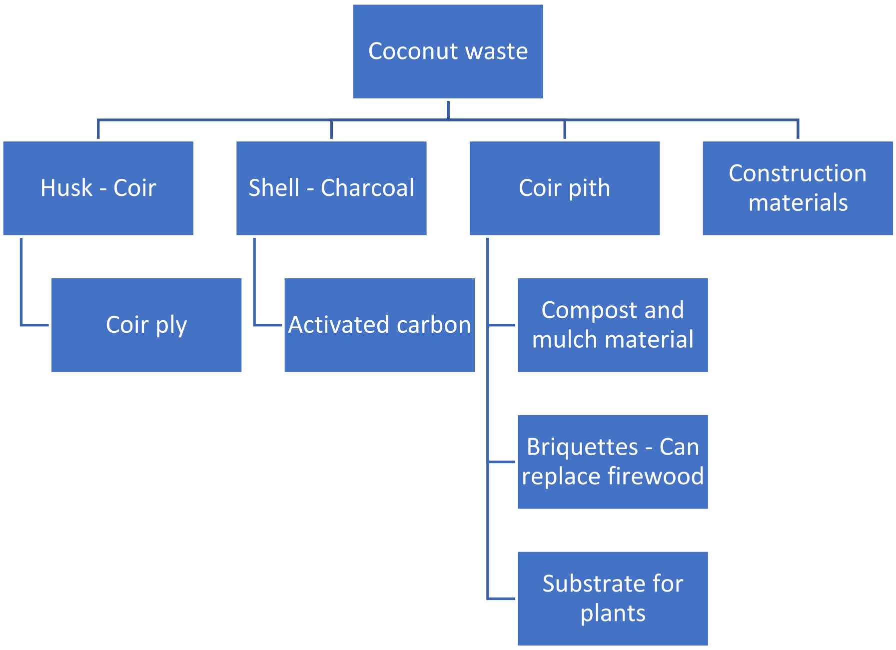


Figure 38: Products from processing of coconut waste

During field visits and interviews with local stakeholders in Port Blair it was found that there is a high demand for compost in the city. Coir pith/coco peat can be used as an input for compost by different kinds of agencies, such as nurseries, green houses, government departments such as Horticulture and Agriculture Department, households, hotels and resorts among others. The coco peat produced can also be used in all the decentralised compost units that has been set up (and will be set up) in the city of Port Blair. Therefore, it is recommended that PBMC explores setting up of coir pith production unit for coconut waste management in Port Blair. PBMC should conduct stakeholders' meetings with local people such as entrepreneurs and businessmen who may be interested in setting up infrastructure for processing of coconut waste. The main highlights for setting up a coir Pith production unit are:

- Capacity: 10 TPD
- Space: 10,000 square feet
- Capital expenditure: Rs. 25,00,000 – 28,00,000
- Manpower: 15-17 persons
- Operating expenditure: Rs. 2,30,000


Tender coconut being loaded on conveyor


Shredding machine


Coir and coco peat conveyor belts


Roller mesh 1


Compost from coco peat


Drying of coir


Compost bags **Baling machine and coir bales**

Figure 39: Coir pith making process

15.3 Long Term Recommendations

The long-term recommendations will primarily consist of scaling up the efforts under the short terms and long-term recommendations to all the wards across Port Blair.

(i) Recommendations relating to waste value chain

Table 31: Recommendations – Long Term

Sno	Process	Recommendation
1.	Secondary Collection	- PBMC may consider procuring compartmentalised vehicles for collection and transportation of segregated waste from aggregation points in wards.
2.	Home composting	- PBMC should target that 100% of the governmental housing with space in Port Blair have home composting systems.
3.	Processing of Organic Waste	- In the event there is a constraint regarding land availability to set up decentralised OWM facilities, PBMC can set up a windrow composting unit near Brookshabad with a capacity of 10-20 TPD as per requirement. The compost from all the decentralised facilities should have market linkages such that 100% of the compost from these facilities is sold.
4.	Monitoring and Evaluation	- Monitoring and evaluation efforts in the previous 5 (five) years must be reviewed to assess the impact of interventions, course correct any of the short-term and medium-term recommendations and devise new solutions/system on the basis of this data.
5.	Market Linkages for Compost	- There should be requirement that Agriculture Department procure 90% of their requirement of compost for distribution to farmers from compost generated in Port Blair.
6.	Construction of sanitary landfill	- As per the feasibility studies, the construction of a sanitary landfill at an appropriate location in Port Blair in accordance with the requirements of SWM Rules and other CPCB regulations should be completed. - No organic waste or waste stream mixed with organic waste

		should be diverted to the landfill.
7.	Financial systems	- PBMC should aim to recover at least 75% of its capital, operations and maintenance costs from user fees collected from households, commercial establishments, sale of compost, fines and other revenue streams for solid waste management. - PBMC may consider revising its user fee model to ensure that waste generators, especially BWGs pay an amount that is directly corelated to the quantity of waste produced by them. This can be done by using Area Base System where the user fee is decided on the basis of the area of the waste generating establishment and/ or using a system similar to rural ANI wherein user fee for BWGs such as hotels is decided as per number of rooms in each establishment.

(ii) Recommendations with respect to fish waste

Port Blair generates at least 10.5 TPD of fish waste and currently it is being dumped in open seas and areas, drains and city dumpsite in Brookshabad. While processing of fish waste is at a nascent stage in India, there are different products which can be obtained from fish waste and they include:

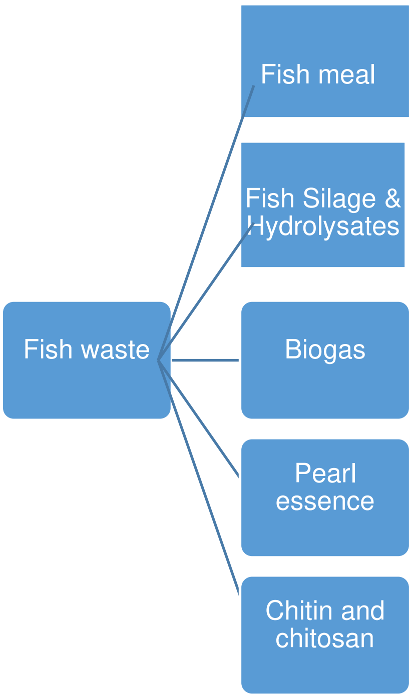


Figure 40: Products from processing of fish waste

PBMC could consider producing fish meal which is a feed supplement for farm animals. It consists of protein, minerals and other nutrients and is produced by cooking, pressing, drying and grinding fish waste (i.e., rendering of fish waste). Fish waste can be reduced by either dry rendering or wet rendering process.

Annexure 1

Part A: Details of Secondary Research

Sno	Title of Document	Issued/Submitted/Authored by	Date of Publication/Issue
1	Action Taken Report (ATR) with Annexures - O.A No. 606 of 2018 order (NGT affidavit)	Andaman and Nicobar Pollution Control Committee	April 2019
2	ATR with Annexures - O.A No. 606 of 2018 order (NGT affidavit)	Andaman and Nicobar Pollution Control Committee	November 2019
3	ATR with Annexures - O.A no. 606 of 2018 order (NGT affidavit)	Andaman and Nicobar Pollution Control Committee	January 2020
4	ATR with Annexures - O.A No. 606 of 2018 order (NGT affidavit)	Andaman and Nicobar Pollution Control Committee	August 2020
5	ATR with Annexures - O.A No. 606 of 2018 order (NGT affidavit)	Andaman and Nicobar Pollution Control Committee	November 2020
6	ATR with Annexures - O.A No. 606 of 2018 order (NGT affidavit)	Andaman and Nicobar Pollution Control Committee	February 2021
7	UT Policy and Strategy on Solid Waste Management for Andaman and Nicobar Islands		2018
8	Solid Waste Management Bye Laws	Port Blair Municipal Council	16 February 2017
9	Ward Sanitation/ Cleanliness Competition Report	GIZ	5 November 2021

Part B: In depth interviews with stakeholders

Sno	Stakeholder	Department
1	Junior Engineer	PBMC office at Shadipur
2	Executive Engineer/ SBM Nodal Incharge	PBMC office at Shadipur
3	Joint Director	Department of Agriculture
4	Deputy Director	Department of Fisheries
5	Sanitary Inspector	Ward 24
6	Sanitary Inspector	Ward 4&5
7	Senior Sanitary Inspector	Ward 1, 2, 3, 7 & 8
8	Sanitary Inspector	Ward 6 & 7
9	Members of Stree Hosala SHG	Gandhi Park
10	Secretary, Friends SHG	SHG for door-to-door collection from commercial establishments in Wards 17 to 14
11	Venkateshwara SHG	SHG for door-to-door collection from commercial establishments in Wards 1 to 16
12	Girish Arora	Member of ACCI and Andaman Hoteliers Association

Part C: OWM facilities visited during field visits

Sno	Site
1.	Central Dumping Site, Brookshabad
2.	SLRM Center I Dollygunj
3.	SLRM Center II Dollygunj
4.	SLRM Center Anarkali
5.	SLRM Center Junglighat
6.	SLRM Center School Line
7.	Gandhi Park Vermi Compost Facility
8.	Composting Unit Brookshabad
9.	Bathubasti Market
10.	Ratnam Market
11.	Aberdeen Market
12.	Junglighat Market
13.	Private Piggery at Lal Mitti
14.	Private Piggery Manglutan
15.	Private Piggery Brookshabad Dumpsite
16.	Door-to-door collection in Ward 6 and 7
17.	Onsite composting at Sanitary Office at Ward 24, 4 and 6

Part D: Primary data sets reviewed

Sno	Name of Document	Stakeholder
9.	Compost Yard Details	PBMC
10.	Partial list of BWGs	PBMC
11.	Partial list of Government Offices	PBMC
12.	Minutes of Meeting: PBMC on self-sustaining model for management of Organic Waste by SHGs	PBMC
13.	Provisional order for Shree Venkateshwara and Friends SHG to start collecting waste from commercial establishments	PBMC
14.	Overview of all vehicles used by PBMC	PBMC
15.	PBMC Ward Map	GIZ
16.	Records of commercial establishments	Friends and Shree Venkateshwara SHG
17.	Partial records of user fee collection	Shree Venkateshwara SHG
18.	Ward Abstracts containing basic information such as population, HH, commercial establishments, sanitation staff etc	PBMC
19.	Waste Collection Data from HHs for a period of thirteen days	Ward 4, 5, 6, 7, 24
20.	Estimates for per capita fish consumption	Department of Fisheries
21.	Records for compost sold from Gandhi Park Vermi Compost Facility from Jan 2019-Jan 2022	PBMC and Stree Hausala SHG

22.	List of Main Markets in Port Blair	PBMC
23.	Primary data relating to organic waste and responses to questionnaires by GIZ representative	GIZ Representative, Port Blair

Part E: Organic Waste Generation Data from HH

Population of 10 households each selected from each income group of three different areas			
Area	*High Income*	*Middle Income*	*Low Income*
Corbyns Cove	38	41	49
R K Mission	45	43	50
Junglighat	38	34	44
Total Population	121	118	143

Average Organic Waste Generation per Capita in Kg from different categories			
Date	High Income (kg)	Middle Income (kg)	Low Income (kg)
11/3/2022	14.5	11.18	12.87
12/3/2022	15.88	16.155	10.46
13/3/2022	22.455	11.19	10.325
14/3/2022	24.095	18.015	21.575
15/3/2022	20.31	16.005	14.355
16/3/2022	19.87	24.91	20.465
17/3/2022	17.165	12.92	15.625
Total	134.275	110.375	105.675
Average Per Capita Organic Waste Generation for each category	0.158	0.133	0.105
Average Per Capita Organic Waste Generation for Port Blair	0.132		

Annexure 2: Questionnaire for Stakeholder Consultation

WASTE GENERATION AND MANAGEMENT OF WASTE AT SOURCE

1. According to the NGT affidavit dated April 2019 filed by A&N Islands, Port Blair Municipal Corporation (PBMC) handles 100-115 TPD waste every day (along with per capita waste generation between 590-680 gms per day) and as per NGT affidavit dated November 2020, only rejects amounting to 16.66 percent of total waste are landfilled. What is the general composition of waste that is being generated within PBMC jurisdiction, specifically, wet waste? How is the wet waste being processed?

2. What is the current population of Port Blair? In addition, as per the abovementioned affidavit, 5 lakhs tourists visit A&N Islands annually. How much wet waste is generated by tourists (per capita and total)? Has any study been done to ascertain this number? If yes please share details and a copy of the study.

3. How many waste generators currently exist in the city along with data on waste generation?

Sno	Particulars	Number	Approximate waste generation/day
1.	Households		
2.	Vegetable/fruit/flower market		
3.	Hotels and lodges including room capacity		
4.	Homestays including room capacity		
5.	Restaurants including seating capacity		
6.	Educational institutions		
7.	Halls for marriage and festivals		
8.	Hospitals along with bed capacity		

4. What is the status of segregation of waste at source level?

5. OWM at household level and bulk waste generator data.

6. Are there any incentives for bulk waste generators to manage their wet waste?

7. Are there any areas within the municipal area that are not provided waste collection service by the municipality? (eg. Port, military areas)

8. Please provide quantities of special waste streams such as slaughterhouse/meat waste, fish waste, coconut waste etc.

COLLECTION OF WASTE

9. How many vehicles does PBMC have for collection of wet waste in Port Blair? Please mention type and capacities of the vehicles.

10. How many of these are functional?

11. How many vehicles have separate compartments for dry and wet waste?

12. For collection of wet waste commercial and bulk waste generators, are different vehicles used? Or the same ones used for HHs are used for them?

13. Are there any other agencies who collect waste in Port Blair besides the ULB?

14. What is the flow of waste from source to the end destinations including handling of waste transfer stations/intermediary points?

15. How many manpower is involved in collection and transportation of MSW in PBMC along with break-up of drivers and helpers?

PROCESSING OF WET WASTE

16. What are the existing processing facilities for wet waste within PBMC and the technologies used for the processing of wet waste?

17. What wet waste facilities are planned for the future including proposed technologies, capacity, operational model (PPP, BOT etc.), budgets allocated and location.

OWM FACILITY

The visit to centralised and decentralised OWM facilities should cover the following data points:

Sno	Particulars	Details
(i)	Name and location of the facility	
(ii)	Type of technology used (short description)	
(iii)	Name of the operator along with contact details of the POC	
(iv)	Area covered by the facility and available around the facility	
(v)	Records of incoming, processed and reject waste for the last one month	
(vi)	Capacity of the plant	
(vii)	Actual use of capacity of the plant	
(viii)	Reasons for gap/excess in the use of capacity, if any	
(ix)	Where all does the waste come from to the facility?	
(x)	Number of manpower in the facility	
(xi)	Capex of the OWM facility	
(xii)	Monthly opex including break-up of the heads and related expenses	
(xiii)	Monthly revenues for the facility including break-up of heads of revenue	
(xiv)	Use of/Market of end products	
(xv)	Testing of end products	

18. Are there any non-governmental agencies such as SHGs, Asha workers, NGOs, community organisations etc involved in OWM? If yes, please elaborate along with working model (infrastructure + financial).

19. Are there any piggeries, gaushalas where organic waste is used as animal feed by the ULB and/or by bulk waste generators? If yes, please provide details.

20. How is the waste generated at fish landing sites handled? How many such sites are there in Port Blair and how much wet waste do they produce?

STATUS OF LANDFILL

21. According to the NGT affidavits filed by A&N Islands, only reject waste amounting to 16.66 percent of total waste are landfilled. What is the current status of the landfill? Is any non-reject waste being sent there

currently? How many vehicles go to the landfill daily and what are their capacities? Please share logs of the vehicles for the last 6 months.

FINANCIAL SUSTAINABILITY

22. What is the status of funds allocated under various schemes like SBM (U) & (G), Finance commission grants etc for wet waste management?

23. Is there any provision or planning of charging SWM cess or user fee from the waste generators? If yes, what are the rates of user fee?

24. What is the amount spent by PBMC on collection, transportation and processing of wet waste per month? This should include manpower, fuel, maintenance, facility costs etc.

25. What are the sources of revenue along with amounts to cover the above-mentioned costs?

IEC AND CAPACITY BUILDING

26. Is there any training and capacity building carried out for personnel engaged in SLWM?

27. Is there any training provided to public and bulk waste generators regarding OWM at source?

IMPLEMENTATION AND MONITORING

28. Who is the responsible department within the ULB for management of solid waste in the city? What is organisation chart (including manager and nodal officers) being followed in this regard? Is there a shortage in manpower and if yes, how does the ULB propose to address this issue?

29. How are the projects and progress of SWM projects being monitored?

Annexure 3: List of potential Bulk Waste Generators in Port Blair[78]

Sno	Name	Location	Number of Rooms
1	A G Residency	Garecharma	23
2	A T Villa	Attam Pahad	34
3	Ami Grace	Gurudwara Lane	40
4	AMR	Bhathubasti, Port Blair	40
5	Anbu International	Dollygunj	12
6	AR Pride Residency	Junglighat	27
7	Bay Island Hotel	Marine Hill	46
8	Bipasha	Garecharma	19
9	Blue Bird Nest	Garecharma	8
10	Blue Mountain	Dollygunj	21
11	Coral Cove	Minnie Bay	40
12	Coral Reef	Bathubasti	31
13	De Pebbles	Jawarhal Lal Nehru road	20
14	De- Marina	Atlanta Point	19
15	Driftwood	88 Jn Road	23
16	Excel Bar & Restaurant+ Lalaji Hotel	Aberdeen Bazaar	17
17	F hotel	Garecharma	10
18	G International	Dollygunj	14
19	GKM	Near Jogger's Park	45
20	Haywiz hotel	Phoenixbay	20
21	Hotel Ariees Grand	Nayagaon	37
22	Hotel Aries	Nayagaon	10
23	Hotel Rishabh	Marine Hill	20
24	Hotel Sentinel	Phoenix Bay	53
25	Hotel SR Castle	Dollygunj	24
26	J Hotel	Aberdeen Bazaar	32
27	KPN Hotel	Austinabad	49
28	Lemon Tree Hotel	Lamba Line	48
29	My Island Residency	Bathubasti	20
30	North Reef	Dollygunj	28

[78] This list has been collated through secondary research.

31	Peerless Resort Portblair	Corbyn's Cove	50
32	Rajadeepam	Dollygunj	20
33	Rayan residency	Dollygunj junction	7
34	Reef Atlantis	Marine Gate	14
35	S L	Prothrapur	18
36	Sea Hills Hotels & Resorts	Shadipur	21
37	Sea Port	Polytechnic Road, Dollygunj	34
38	Sea Shell	Marine Hill	34
39	Shompen	Middle Point	32
40	Shree Karpagam Dreams	Kamaraj Nagar, Bird Line	46
41	SRM Diamond	Aberdeen Bazaar	15
42	TSG Emerald View Hotel	Phoenix Bay	50
43	TSG Grand	Dollygunj	56
44	Vivek	Garecharma	61
45	Welcome hotel Bay Island	Marine Hill	46
Total			**1334**

Annexure 4: Estimation for user fee collection from Commercial Waste Generators

Sno	Category	User Fee[79] (monthly)	Total Establishments	Total User Fee Potential (monthly)
1	Tea & Panshop	100	628	62800
2	Tailor	200	127	25400
3	Parlour	200	53	10600
4	Salon	200	114	22800
5	Vegetable shop	500	232	116000
6	Fast Food	200	25	5000
7	Hotels and Lodge	3000	240	720000
8	Flour Mill	200	19	3800
9	Bar & Restaurant	3000	263	789000
10	Bakery	1000	105	105000
11	Electrical	200	755	151000
12	Grocery	150	363	54450
13	Tours and Travels	200	177	35400
14	Furniture	200	81	16200
15	Medical/ Clinic	200	154	30800
16	Printing & Press	200	74	14800
17	Godown	200	837	167400
18	Fancy & Stationary	200	534	106800
19	Cloth Store	500	104	52000
20	Studio	200	41	8200
21	Jewellery	200	32	6400
22	Tuition/ computer	200	116	23200
23	Hollow Block	200	23	4600
24	Foot wear	500	88	44000
25	Cold Drinks Fruits	200	102	20400
26	Xerox	200	32	6400
27	Meat	500	115	57500
28	Govt & Pvt Establishment	300	262	78600
29	Sea shell & Bamboo	200	21	4200
30	Show room	200	15	3000
31	Service for vehicles	200	64	12800
32	Banks & ATMs	200	75	15000
33	Hostel and Guest houses	1000	14	14000
34	Schools	200	85	17000
35	Community Halls & Club	200	31	6200
36	Aanganwaadi	200	135	27000
37	Religious	200	264	52800
38	Other shops	200	111	22200

[79] Based on the user fee charges provided by PBMC for 8 categories of commercial waste generators. For the rest, an average of Rs 200 per month has been taken for calculations.

39	Petrol Stations	200	5	1000
	Total		6516	2959950

Annexure 5

Part A: Normative standards for primary collection vehicles

Type of vehicle	Population density (per sq. Km) and terrain	Carrying Capacity	Number of vehicles	Basis of manpower allocation
Primary collection				
Pushcarts[80]	Dense (>400 persons per km^2), flat terrain and narrow streets	125 Kg	1 pushcart per 200 households and small shops	Door to Door collection @1 worker per 150 households and small shops
				Along the street mechanism with a whistle or announcement @1 worker per 240 households and small shops
Pedal Tricycle[81]	Moderately dense (<400 persons per km^2), flat terrain and narrow streets	250 Kg	1 pedal tricycle per 300 households and small shops	Door to Door collection @1 worker per 150 households and small shops.
				Along the street mechanism with a whistle or announcement @1 worker per 240 households and small shops.
Electric vehicle/any smaller motorized vehicle[82]	Sparse (<200 persons per km^2) persons, hilly terrain and wider roads/streets	350 Kg	1 electric /motorised vehicle per 200 households and small shops	One driver and helper per vehicle
Light commercial vehicles such as Auto tippers[83]	Irrespective of population density and terrain but should be deployed in wider streets (may have to supplement with pushcarts for access to narrow lanes)	500-750 Kg	One per 1000 households and small shops.	One driver and one helper/loader per vehicle

Part B: Organic Waste Log

Sno	Date	Total Organic Waste Collected	Number of Commercial Establishments/Households	Source segregation levels	Remarks
1					
2					

80 Secondary collection vehicle needed if the waste unit is more than 500m away from the farthest collection point.
81 Secondary collection vehicle needed if the waste unit is more than 2km from the farthest collection point
82 Secondary collection vehicle may not be needed if the waste unit is within 5km of the farthest collection point
83 Secondary collection vehicle may not be needed if the waste unit is within 5km of the farthest collection point

Annexure 6: Techniques for onsite management of organic waste at community/ward level

Part A: Aerobic Bin Composting:

This aerobic composting system is used in Allepey and Trivandrum Municipal Coporation to convert organic waste into compost as part of its decentralised OWM systems. The aerobic bins may constructed using one or different kinds of material such as wood, concrete, or metal.

Figure 41: Aerobic Composting Bins at Trivandrum Municipal Corporation

Space: Approximately 2 square meters for one unit
Capacity: 1 TPD in each bin
Infrastructure:
Size of the bins: – 1.45m x 1.45m x 1.2m (L x B x H)
Leachate pipe: 110mm diameter
Slurry tank chamber: 45 x 45 x 45cm

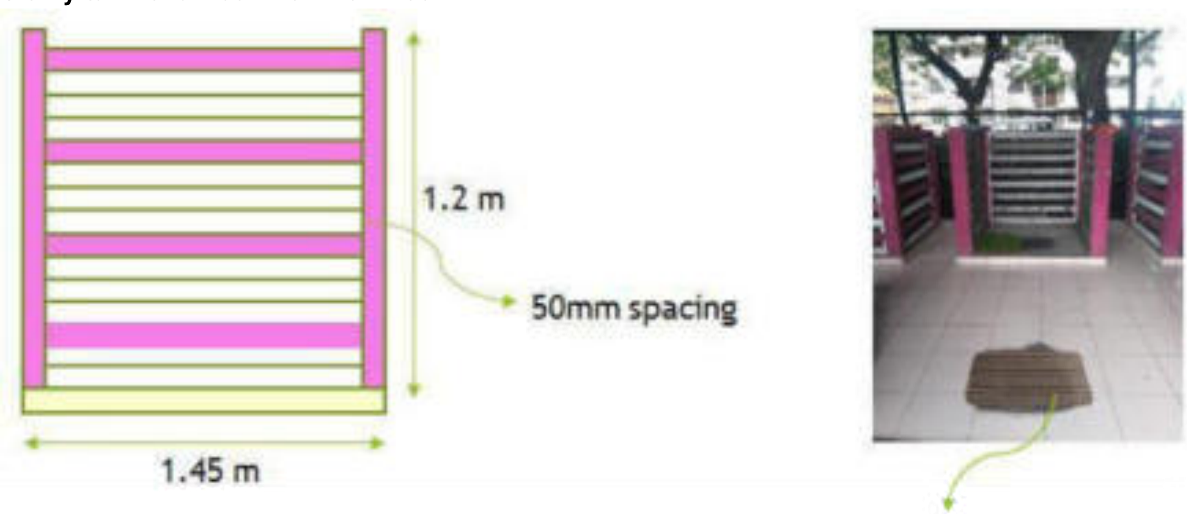


Figure 42: Aerobic Composting Bins at Trivandrum Municipal Corporation (2)

Process:

- A 6-inch layer of fresh cow dung is laid as the first layer and thereafter, a 6-inch layer of dried leaves is laid on top of the cow dung layer.
- On top of the cow dung and dried leaves layer, 6-inch layer of organic waste is added.
- An inoculum containing enzymes made from cow dung is sprayed to hasten the composting process. Alternatively, cow dung slurry made by mixing 1 (one) part of cow dung with 5 (five) parts of water can also be used instead of inoculum.
- Once the first bin is full, it will require between 45-90 days to convert into compost. Thus, it is advisable to set up multiple units in the same shed to ensure that at least one bin is always available for the intake of daily organic waste.
- The method of layering the waste with thick layers of dry leaves ensures a sufficient supply of carbon and allows the absorption of extra moisture. This method does not require any manual turning.
- The compost generated should be tested on a monthly basis for compliance with the FCO standards 2009/requirements under SWM Rules 2016 from an accredited laboratory.
- The compost can be sold to the Agriculture Department, hotels and resorts, farmers, nurseries and/or members of general public.

Part B: Tank and Crate Composting

Communities and bulk waste generators can process organic waste onsite through crate composting or tank composting method. Crate composting can handle lesser quantities (up to 300 kgs per day) and require more space while each tank can store up to 1 TPD of waste.

Figure 43: Wet Waste Segregation and Composting Process

1.1. TANK COMPOSTING:

Space:5,620 square feet
Capacity: 2 MT per day
Infrastructure:

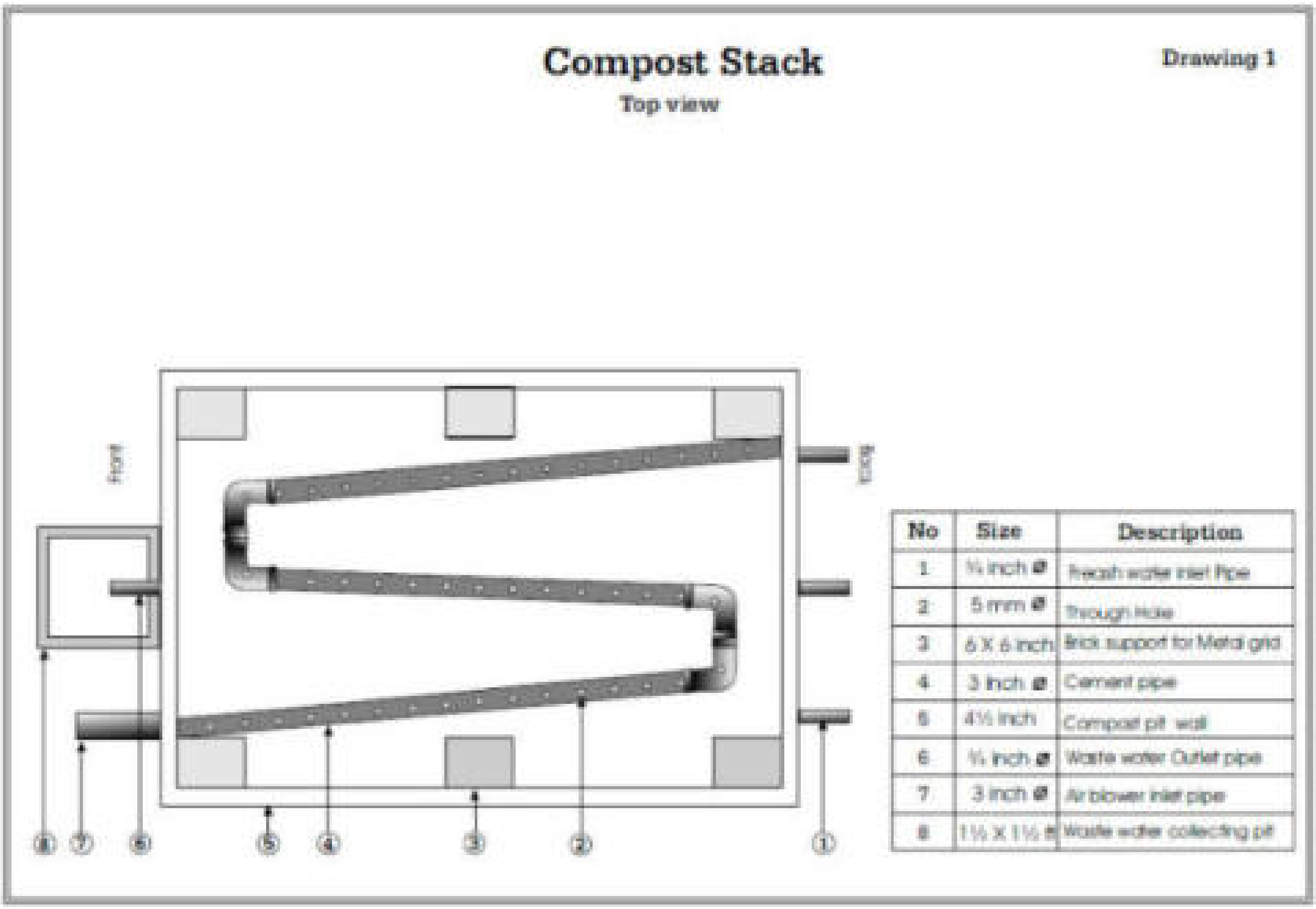
Building

- The roof should be of durable material such as galvanised steel, projected beyond the wall edge to ensure that rain water does not get into the processing space. The height of the roof should be 9 feet high with translucent panels making up about 10 % - 15 % of the roof area, to further improve natural light into the space, without the glare of direct sunlight.
- Direct sunlight should not come straight in (except for very short periods in the mornings and evenings), to allow for comfortable working conditions.
- The floor should be designed as a cement floor for easy maintenance and the floor should be nominally sloped to floor drain points to allow the entire area to be washed periodically.
- Sump and overhead tanks should be provided along with the basic plumbing for water distribution and collection of leachates.
- Toilets along with washing areas should be provided for the workers.

Tanks

- Tank composting system consists of permanent cement structure and a diffuser network for aeration.
- Each permanent cement structure is 6ftX4ftX3ft (L,W,H) which can take in approximately 1 MT of shredded organic waste. At about 9 inches above the ground level, there is a metal mesh base on which the waste rests in the tank.
- Underneath this metal mesh, there is a diffuser network i.e., PVC pipes with holes in them. The pipes are laid in zigzag fashion on the floor of the tank and is connected to a 0.5 HP motor blower on the outside of the tank system. It blows air into the pile through the holes in the pipe.
- It is also fitted with a water inlet to supply fresh water to clean the floor tank.
- The tank floor is at a slight slope and allows the leachate to flow down towards the outlet.
- On top of each tank, there are perforated trays to avoid rodents and other animals from accessing the waste.

Figure 44: Tank Composting (1)



No	Size	Description
1	½ inch Ø	Fresh water inlet Pipe
2	5 mm Ø	Through Hole
3	6 X 6 inch	Brick support for Metal grid
4	3 inch Ø	Cement pipe
5	4½ inch	Compost pit wall
6	½ inch Ø	Waste water Outlet pipe
7	3 inch Ø	Air blower inlet pipe
8	1½ X 1½ ft	Waste water collecting pit

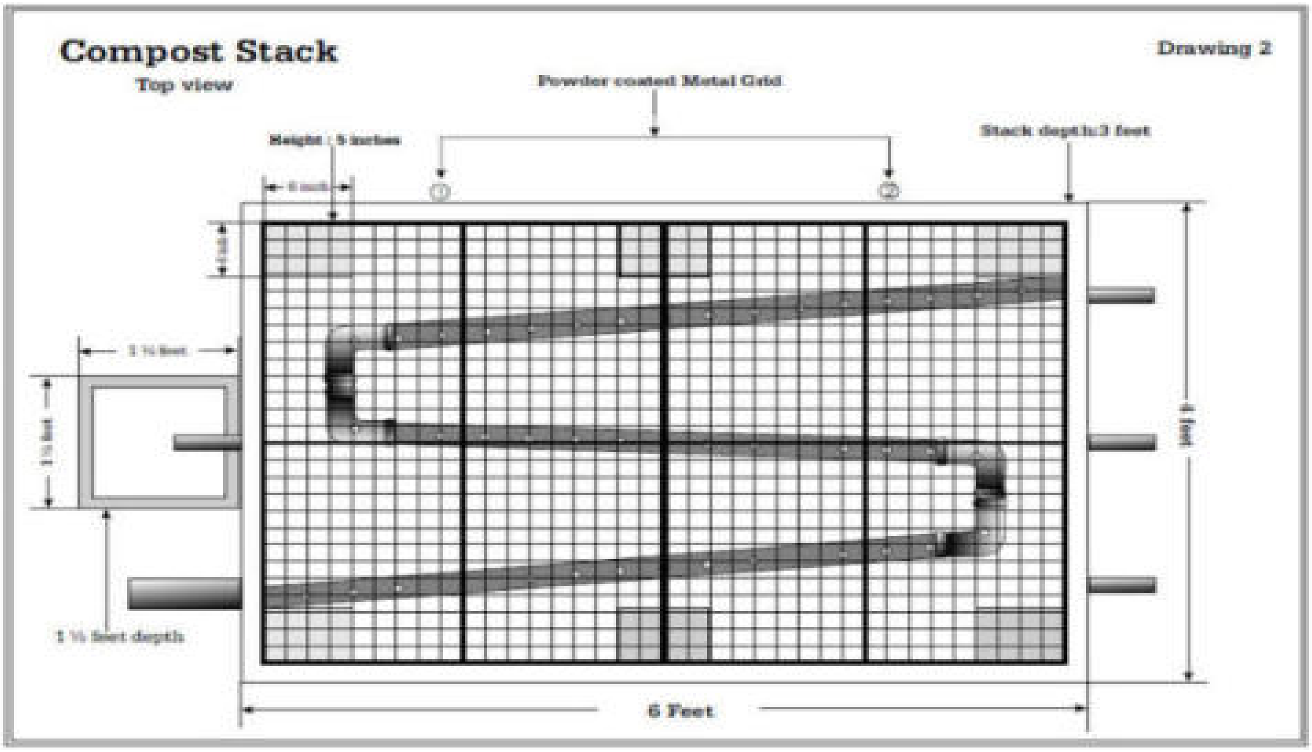


Figure 45: Tank Composting (2)

Equipment

- Shredder with a minimum capacity of 200kg per hour, 5 HP power with stainless steel (SS) blades. A shredder is needed to cut the organic waste into smaller pieces to expedite the composting process.
- Waste trolleys to transfer waste to the composting tanks
- Rotating sieve with a capacity 50kg per hour
- Weighing machine for recording incoming waste and compost generated
- Waste trough for examining waste for contamination

Process

- Incoming organic waste should be checked for contamination such as plastic, glass pieces, aluminium foil and other waste streams in the waste trough. Such contamination should be removed in the waste trough.
- Large organic waste streams should be chopped in the shredder.
- The shredded and other organic waste should be added to the tank/crate. Dry leaves, cocopeat, old compost, sawdust and/or cow dung should also be added along with bioculum. Mix/turn the waste well.
- Cover the layer of organic waste with a layer of dry leaves to avoid flies and smell.
- Sprinkle 5L of water daily into the compost tank.
- Turn the compost heap every 4th day. Turning the compost heap should be done in such a way that the bottom part of the compost heap should come on top and the top part of the compost should come below.
- The temperature of the compost should be checked regularly and before the compost is turned. To check the compost temperature, make a hole (approximately 1.5 ft deep) in the compost heap using a wooden stick. Insert the thermometer and check the temperature. The temperature of the compost heap after 10 days should rise to 60-70 Celsius degrees[84].
- Fill the tanks in order and maintain a record of the start date of the compost.
- Empty tank after approximately 40 days or any time after the organic waste has been decomposed and there is no smell emanating from the waste.
- Heap the semi-compost in storage area and leave it for 7-10 days. Thereafter, it should be pulverized and sieved using a 2-4mm sieve.
- Place the compost in a ready to use compost area, cover with gunny bags or pack it in bags
- The compost generated should be tested on a monthly basis for compliance with the FCO standards 2009/requirements under SWM Rules 2016 from an accredited laboratory.
- The compost can be sold to the Agriculture Department, hotels and resorts, farmers, nurseries and/or members of general public.

Figure 46: Tank Composting (3)

[84] Temperature control is critical not only to maintain ideal conditions for composting but also to ensure that pathogens are killed. The temperatures need to rise to 60-70°C to enable this.

1.2. CRATE COMPOSTING

Building requirements remain the same as tank composting. In addition, the following area is needed for the crates:

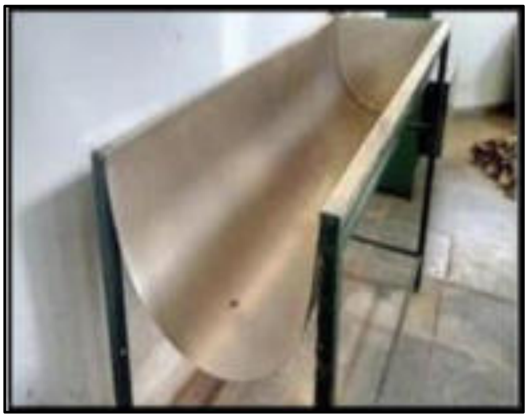
Area for the crates

Waste (Kg)	Curing System (No. Of Racks)	Total Room Area		Curing Area		Machine & Storage Area	
		Length (M)	Breadth (M)	Length (M)	Breadth (M)	Length (M)	Breadth (M)
100	1	6	3.6	5.2	1	6	2.6
200	2	6	4.5	5.2	1.8	6	2.7
300	3	6	6.6	5.2	3.6	6	3
400	4	6	7.6	5.2	4.6	6	3

Equipment:

- Shredder with a minimum capacity of 200kg per hour, 5 HP power with stainless steel (SS) blades. A shredder is needed to cut the organic waste into smaller pieces to expedite the composting process.
- Portable Sieve to sieve the compost
- Weighing machine for recording incoming waste and compost generated
- Crates where 1 crate has a capacity of 18 – 20 kgs
- Racks for the crates

Food Chopper Machine



Organic waste sorting trough Crates

Process

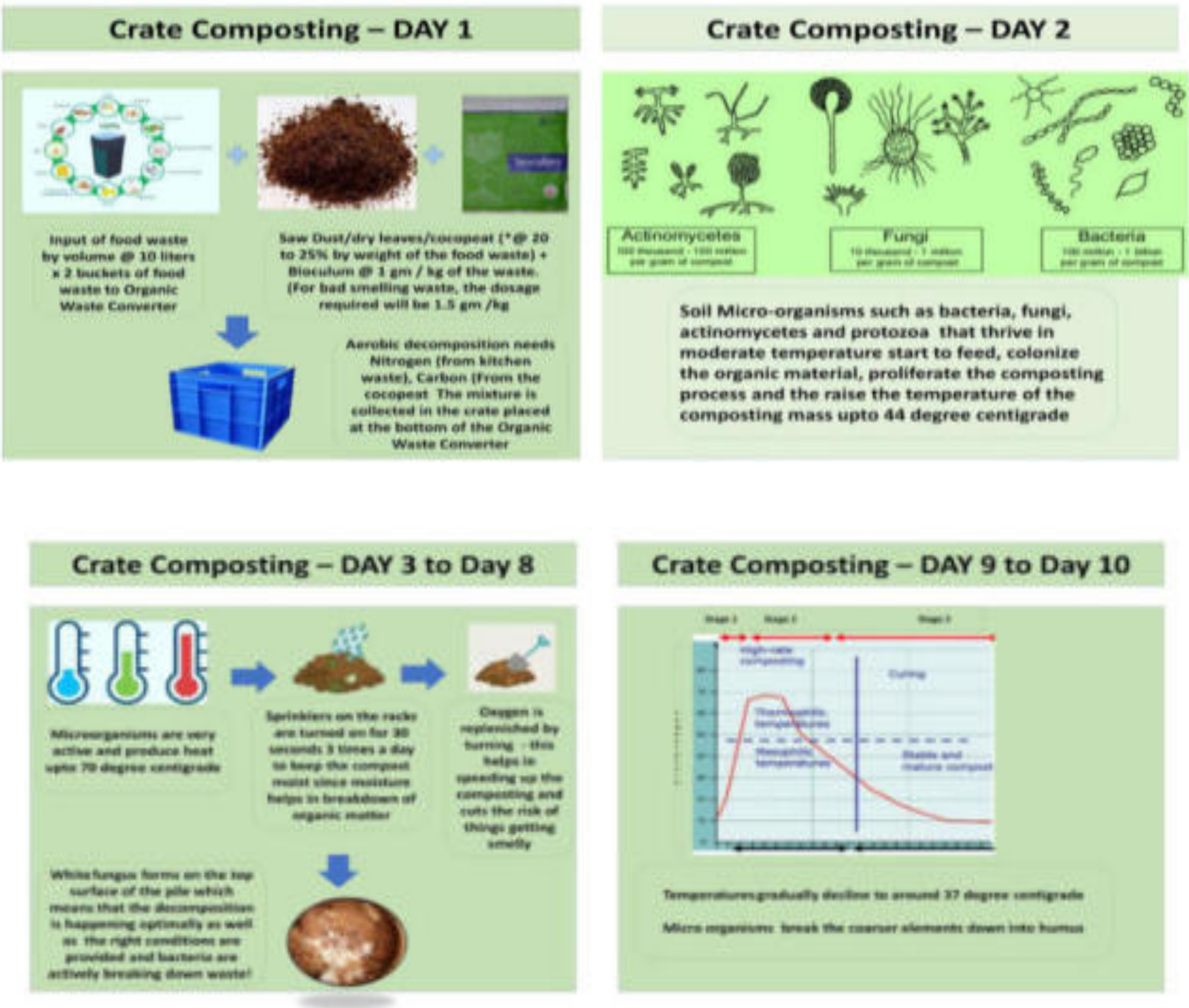


Figure 47: Crate Composting

- Incoming organic waste should be checked for contamination such as plastic, glass pieces, aluminium foil and other waste streams in the waste trough. Such contamination should be removed in the waste trough.
- Large organic waste streams should be chopped in the shredder.
- The chopped and other organic waste needs to be mixed with dry leaves/cocopeat/sawdust along with bioculum. Mix/turn the waste well.

- The mixture is put in the crate for 10 days and then removed from the crates and left for curing for another 15 days.
- The compost generated should be tested on a monthly basis for compliance with the FCO standards 2009/requirements under SWM Rules 2016 from an accredited laboratory.
- The compost can be sold to the Agriculture Department, hotels and resorts, farmers, nurseries and/or members of general public.

Part C: Aerobic Composting for Horticulture Waste

Size: Approx. 4 ft diameter x 3 ft height for each mesh bin

Capacity: Approximately 110 kgs for one bin made of wire mesh, wood such as bamboo and/or concrete. The size of the bin can be increased to process larger quantities of waste.

Infrastructure requirements: Galvanised iron/steel wire mesh of 1 inch which is painted with waterproof paint and/or wood such as bamboo and/or concrete and cement. In areas with high humidity and rainfall, such as Port Blair, a shed must be constructed for the bins to avoid rainwater seepage.

Processing time: 3-8 months

Figure 48: Management of horticulture waste

Process

- Set cement blocks/ tiles to prepare a platform on which the composter will be set up. Ensure that the composter has an opening at the bottom with a door to remove ready compost while fresh organic waste can be added from the top.
- Once the bin has been set in place, water is poured onto the bottom of the bin.
- Following this step, horticulture waste such as leaves, lawn trimmings, branches and flowers are added.
- A shredder can be used to reduce the size of large pieces of horticulture waste such as branches and twigs. This will increase the speed of composting.
- Accelerators such as cow dung slurry, old compost, or sour butter milk to be added in the bin occasionally to increase the rate of composting.
- Water is also sprinkled in the bin to ensure that the contents are moist and this process is repeated every day or as per requirement.
- The compost can take up to 3-8 months to be completely ready. This is dependent on variables such as size of leaves/ flowers, weather, humidity etc.

- In case of mixed horticulture waste, kitchen waste such as fruit and vegetable peels to be added (approximately 20% of total waste) to ensure nitrogen content in the compost. In case the bin is used only for leaves, no kitchen/ food waste is required.
- In case of use for composting temple flowers, separation of threads and/or any other non-biodegradable waste from flowers would be required before they are put in the bin. If that is not possible the non-biodegradable waste can be removed during harvesting of compost.
- In case of areas with high rainfall such as Kochi, the bin must be set up inside a shed and/or a roof/covering from the rain must be provided.

Annexure 7: Case studies/ best practice examples for the mitigation of the assessed gaps in Port Blair

Part A: Alapuzha/ Alleppey

Population: 174,164
Area: 46.77 square km
Number of wards: 23
Organic Wase Generated: 43 TPD
Best Practice: Source segregation and decentralised OWM systems at household and community level

The town of Alleppey is recognised as a tourist spot due to the presence of a large number of canals, backwaters, lagoons and beaches. A project called "Nirmala Bhavanam Nirmala Nagaram" (Clean Home Clean City) has been implemented to handle solid waste by AMC since 2012. The main highlights of this project are:

(i) Focus on source segregation among waste generators
(ii) Encouragement for home OWM systems
(iii) Waste generators without access to onsite OWM systems deposit organic waste to community centres.

(i) Source segregation

The ULB has conducted extensive awareness drives to educate the local citizens about the negative impacts of lack of source segregation on water bodies. Dedicated door-to-door awareness campaign was carried out, residents of Alapuzha were educated about the many benefits of waste segregation. As part of these drives, nearly 48,000 households were issued notices in addition to implementation of fines and penalties for non-compliance. Local SHGs were involved in the process of awareness generation.

(ii) OWM systems at household level

Biogas units

Local citizens with access to space in their premises were encouraged to set up biogas systems for managing their organic waste on site. Both portable biogas plants and fixed biogas plants were recommended for this. The fixed biogas plant was designed by Agency for Non-conventional Energy and Rural Technology (ANERT) and it costs upto Rs. 17,500 and can process about 8 to 10 kg of organic waste per day[85]. The portable biogas plant was designed by Integrated Rural Technology Centre (IRTC) and it costs up to Rs. 13,500 and can treat 5 to 7 kgs of organic waste per day. The Suchitwa Mission also made a provision for 75% subsidy on biogas plants in order to tackle the cost constraints which stopped people from taking the initiative.

Pipe Composting[86]

Those households which had space constraints and less than 5 (five) members were advised to adopt pipe composting. The system comprises two PVC pipes (length – 1.25 m and diameter – 8 inches) along with lids and they are fixed in the ground vertically and about ¼ m of the pipes is buried under ground. Initially a layer of gravel is filled in the pipe for up to 30cm to absorb the leachate. Organic waste can be fed into the pipe and

[85] Implementation of Decentralised Waste Management in Kerela, A comparative analysis of Alappuzha and Trivandrum (https://ppri.org.in/wp-content/uploads/2018/05/PPRI-Working-Paper-Decentralized-Waste-Management-in-Kerala.pdf)
[86] Implementation of Decentralised Waste Management in Kerela, A comparative analysis of Alappuzha and Trivandrum (https://ppri.org.in/wp-content/uploads/2018/05/PPRI-Working-Paper-Decentralized-Waste-Management-in-Kerala.pdf)

it typically takes 30 to 35 days to get full. By the time the second pipe gets full the waste in the waste in the first pipe will be converted to compost.

(iii) Decentralised OWM at community level

The waste generators that cannot adopt home composting or home biogas systems have the option of directly depositing their organic waste in 36 aerobic composting units with 426 (Thumburmuzhi). At full capacity, the units are able to treat about 80% of the biodegradable waste generated in Alapuzzha, producing 9 tonnes of compost daily[87]. A single unit has a varying number of bins, from 50 to 7, according to the necessity of the region[88]. Each Thumburmuzhi tank is 4 feet long, 4 feet broad and 4 feet deep and has the capacity to accommodate 2 MT of organic waste. The aerobic composting units are placed in accessible locations including areas which were dumping spots previously. Approximately, 10,000 households along with small shops are connected with these units along. Each unit has specific collection timings and this enables waste generators to deposit the organic waste at the composting units with ease.

The construction of two tanks may cost around Rs. 2 lakhs, including the cost of a shed[89]. 168 contingent workers have been assigned for the maintenance of these units. The compost produced from the decentralised aerobic composting units are given to farmers for free and/or sold.

Thumboormuzhi aerobic composting model-Photo courtesy- CSE – Not in my backyard

Part B: Tiruchi/Trichy

Population: 10,00,000
Area: 167.2 km²
Number of wards: 65
Best practice: Decentralised community composting and financial incentives for onsite OWM systems

Tiruchi is a coastal town in Tamil Nadu and has similar climatic conditions to Port Blair. The Trichy Corporation has set up 32 Micro Composting Centres (MCC) and each centre is equipped with aerobic composting units. The operations for the MCCs have been handed over to women Self Help Groups and a total of 677 women

87 https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf
88 https://www.thenewsminute.com/article/why-states-are-lining-study-alappuzha-s-model-waste-management-system-105341
89 http://sanitation.kerala.gov.in/wp-content/uploads/2017/11/Aerobic-Composting-Unit-Thumboormuzhi-Model-MODEL-ESTIMATE-and-DRAWING.updated-on-04.11.2017.pdf

are currently associated with these centres. On an average, one center is managed by 21 women. The details for one of the MCCs located at Kulimikkarai are given below[90]:

Size of one unit/ pit: 3.05*1.50*0.90m
Incoming organic waste/day: Approximately 1.2 MT
Capacity of one pit: 1.98 MT
No of pits in MCC: 30
Total Capacity of all the units: 59.3 MT
Total Area of the facility: 500.87 sq.m

This centre accepts organic waste from two wards (i.e., 4000-4500 HHs) and makes use of raised pits for aerobic composition of waste. Trichy Municipal Corporation provides DTD collection to HHs and transports the organic waste generated by them to this MCC. The composting facility is managed by four people including one supervisor[91]. Their salaries are provided for by TMC and they also earn a revenue through sale of dry waste.

During operations of this facility, it was found that since the pits do not have perforated walls the rate of composting is slow due to less air flow. Thus, the managerial team decided to make use of pipes which have been put vertically in the pits to increase air flow.

The corporation aims to sell compost from these facilities at Rs 1 per kg to farmers[92].

On site composting by households and bulk waste generators

As part of Tiruchi's decentralised waste management plan, the city corporation has ensured that several bulk waste generators such as offices and hotels/ restaurants set up compost yards within their premises. It has been reported that some of the BWGs are able to sell their compost for Rs 20 per kg[93].

The corporation has created an intensive incentive program under which HHs that set up composting facilities get health insurance and can also avail gift vouchers. The city aims to cover at least 20 percent HH in this manner and the initiative has already led to several thousand HHs setting up composting facilities in their

[90] Each of the 32 centres have a different number of pits as per requirement. Consequently, the area, manpower and capacity of each facility is different.
[91] The facility is handled by 11 eleven people who take care of both dry and organic waste. Out of these, four people are involved in organic waste management.
[92] B Chandrasekaran, *Trichy's Initiatives to Enhance Ease of Living*, Centre for Public Policy Research (https://www.cppr.in/wp-content/uploads/2020/03/Trichy%E2%80%99s-Initiatives-to-Enhance-Ease-of-Living.pdf)
[93] B Chandrasekaran, *Trichy's Initiatives to Enhance Ease of Living*, Centre for Public Policy Research (https://www.cppr.in/wp-content/uploads/2020/03/Trichy%E2%80%99s-Initiatives-to-Enhance-Ease-of-Living.pdf)

premises. The health insurance for HHs with their own composting facilities are up to Rs 1,00,000[94] and the premium for the same is sponsored through corporate social responsibility funds.

Part C: Udupi, Karnataka

Population:25,306 (2011 census)
Area: 68.23 km²
Number of wards: 35
Organic Wase Generated: 40TPD
Best practice: Source segregation and collection of segregated waste

In December 2018, door to door awareness was conducted including the use of flipcharts, pamphlets, and banner designs to implement source segregation in 2 wards and later increased to 8 wards of Udupi City Municipal Council (CMC). As on February, 2022, 85.14% segregation has been achieved on an average in 35 wards, where in 13 wards more than 90% of segregation levels have been achieved.

With regard to collection of waste, for 27 wards, CMC has engaged 14 SHGs to undertake collection and transportation of waste and the remaining 8 wards are undertaken directly by the CMC. For HH, non-biodegradable waste is collected twice a week, organic waste is collected 4 times a week, and domestic hazardous waste is collected on a daily basis. For commercial establishments, non-biodegradable waste is collected twice a week while organic waste and domestic hazardous waste is collected on a daily basis. CMC collects waste from 7:00AM to 1:00PM while SHGs collect waste from 8:30AM to 5:30-6:00PM.

The SHGs have 30 light commercial vehicles i.e., Tata Ace wherein a driver with 1 or 2 helpers undertake door to door collection, whereas the CMC has 8 Tata Ace (1 for each ward) wherein a driver and a helper undertake door to door collection. The supervisors conduct surprise checks on the waste collection vehicles and help them with enforcing source segregation among waste generators. The vehicles are used for transportation of waste collected during the primary collection by both the SHGs and the CMC to the transfer stations. There are 3 transfer stations, each having 1 mobile compactor for dry waste, 1 mobile compactor for wet waste and a small vehicle to aggregate and transport domestic hazardous waste. There is a separate drum for meat waste. As on February, 2022, the waste collection coverage is 87%, with 16 wards having more than 90% coverage with respect to waste collection.

For 27 wards handled by the SHGs, the user fee is collected by the SHGs itself and there are no payments made between SHGs and CMC. The Tata Ace used by the SHGs for collection and transportation are owned by the CMC, for which the SHGs are supposed to pay a prescribed fee. For 8 wards handled by the CMC, the user fee is collected by the CMC along with the yearly taxes.

Part D: Mysuru, Karnataka

Population: 9,80,000
Area: 155 km²
Number of wards: 65
Organic Wase Generated: 247.5 TPD[95]
Best practice: Decentralised organic waste management

[94] B Chandrasekaran, *Trichy's Initiatives to Enhance Ease of Living*, Centre for Public Policy Research (https://www.cppr.in/wp-content/uploads/2020/03/Trichy%E2%80%99s-Initiatives-to-Enhance-Ease-of-Living.pdf)
[95]https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf

In 2009, the Mysore City Corporation (MCC) initiated a decentralised organic waste management system under their zero-waste management strategy. As part of this strategy, decentralised organic waste management facilities have been constructed at zonal level in 9 (nine) zones. The city also has one central SWM plant at Vidyaranyapuram with a processing capacity of 200TPD[96]. Therefore, the city practices a combination of centralised and decentralised techniques for management of its organic waste.

The decision to set up decentralised facilities was taken to reduce load on the centralised SWM plant, reduce mixing of waste during transportation and reduce operational and maintenance costs for solid waste management.

Decentralised processing at Zero Waste Management Plants

There are 7 (seven) operational zonal facilities for organic waste management across the city of Mysuru. Each facility accepts waste from 5-6 wards and processes between 3-4 MT of organic waste every day through aerobic composting and/or vermi-composting techniques where cow dung is used as activator for processing.

The centres are operated on a public private partnership where infrastructure for the facility along with vehicles for waste collection are provided by the MCC while the manpower for the operations of the zero-waste plant is provided by a local community-based organisation. MCC provides the following support:

(i) diverting organic waste to these facilities through their own vehicles
(ii) financial support of Rs 95,000 for each facility[97].

Being a small unit, it is more inclined towards manual labour rather than machinery and therefore, the main costs for operations are staff salaries.

The compost from the facilities is sold to nearby farmers at a cost of approximately Rs 1,200/MT. In the event the buyer arranges for the transportation of the compost from the facility, the selling rate of compost is between Rs. 200-400/MT. Under this system, each decentralised unit generates a revenue of approximately Rs 15,000-30,000 per month through sale of recyclables and compost.

[96] https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf
[97] https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf

Part E: Vengurla, Maharashtra

Population: 12,392
Area: 13 sq km
Number of wards: 14 administrative 8 electoral
Organic Wase Generated: 2.7 TPD[98]
Best Practice: Decentralised OWM at community level through financial incentives and onsite processing by bulk waste generators

Decentralised processing

Households

The Vengurla Municipal Council (VMC) incentivises households, residential societies and apartment complexes to process their organic waste. The waste generators processing their waste onsite are provided a rebate of 10% on their property tax. This has encouraged about 274 households to initiate composting in their premises and are using a combination of pit and in-vessel composting.

BWGs

As per the SWM Bye-Laws for VMC, any establishment producing more than 50 kgs of waste per day is categorised as a BWG. Accordingly, VMC has ensured that two BWGs in the town set up on site OWM facilities. Accordingly, the first BWG which is a restaurant that produces 90 kg waste per day has installed a biogas plant which produces gas for about four and half hours and it is used for the restaurant's kitchen. The second BWG is a fruit research centre that produces 60 kg of waste per day and it has set up a vermicomposting system wherein most of the compost is utilised by the establishment and any surplus is sold to local farmers at the rate of Rs 12,000 per tonne to local farmers.

Part F: Java, Indonesia

Scope of Project: 8600 HH
OWM Method: Aerobic Composting
Best practice: Focus: Decentralised Organic Waste Management at community level
Capacity: About 2 MT per unit (8 units in one set up)

The project was initiated with the support of the German development association BORDA with the intention of setting up an organic waste system for poor HHs in Java. As part of the project, community-based organizations were trained to operate decentralized MRFs. There are 15 MRFs[99] in the areas surrounding Jakarta, Yogyakarta and Surabaya with each MRF catering to 300-1000 HHs[100] under a programme called *Kita Pro Sampah* (KIPRAH), which translates to *We pro Waste*. With per capita waste generation levels at 0.250 kgs per capita per day, each MRF would receive about 375-1250 kgs of organic waste daily. There are at between 2-8 employees in each of the MRFs[101].

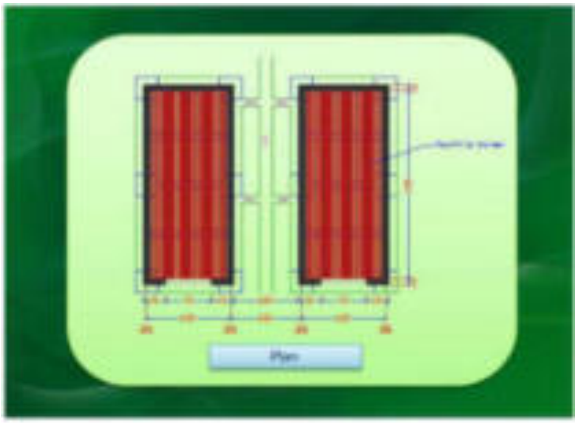
Under the program, households are required to bring their waste to the MRFs where the organic waste is composted. At the beginning of the project, windrow composting was initiated at some of the MRFs, however,

[98] https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf
[99] https://www.atmosfair.de/en/climate-protection-projects/biogas-biomass/indonesia/
[100] *The Carbon Market and Integrated Waste Solutions: A Case Study of Indonesia,* IDRC and CRDI (https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/50583/IDL-50583.pdf)
[101] *The Carbon Market and Integrated Waste Solutions: A Case Study of Indonesia,* IDRC and CRDI (https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/50583/IDL-50583.pdf)

the technique was found to be very time consuming and labour intensive. The methodology was thus changed to aerobic composting in a perforated structure.

Infrastructure of the composting units

Dimension of the unit: 5m*1.2m*1.2m
Space required: 96 m^2
Numbers of unit: 8 boxes
Capacity: Approximately 2 tonnes of organic waste per unit/ box
Cost: 2,400,000 Indonesia Rupee per unit or INR 12850.
Materials: bricks, PVC pipes, 4 perforated pipes

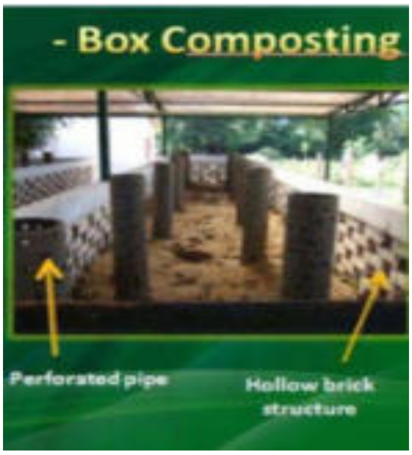


Box Composting [102]

Details of Methodology

Process

The method of Box Composting processes organic waste under aerobic conditions. This is done by piling up organic waste into hollow brick structures which allow for air flow for aerobic composting. To further aid ventilation, porous pipes are installed within the boxes. This construction methods lets air flow through the holes in the wall, and through vertical pipes in the pile. This creates sufficient ventilation for the compost from all sides and helps increase the rate of composting. A hole between the pipes at the bottom of the structure acts as a drainage system for excessive water or leachate.



[102] *The Carbon Market and Integrated Waste Solutions: A Case Study of Indonesia,* IDRC and CRDI (https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/50583/IDL-50583.pdf)

Organic waste is spread into the box in layers of about 20 cm thickness and this process is repeated until the box is full and then the box is left for 30-40 days. Regular monitoring is required to check moisture content. After the end of the 40-day period, the compost is taken out of the box and spread on the floor for a couple of days. Once this is done, the compost is ready to be sold/ used. The compost from all these MRFs is certified by the Ministry for Agriculture.

Financials

The average construction cost for each of the 15 MCFs was about 620 million IDR or Rs/- 33,14,592[103]. These costs are covered by local government and some operational costs are also provided by donors. Each household that is serviced by MRFs pays a user fee between 50 cents to 1 (one) Euro per month (approximately between Rs 50-100)[104]. Another part of revenue for the MRFs comes from the sale of recyclables like glass and plastic. Most of the compost generated within the MRFs is sold to neighbours/ farmers/ municipal for use in gardens or parks. Sale from this compost generated approximately 50€ per month[105] or Rs 4200.

Part G: Kunnamkulam, Kerala

Population: 54,071
Area: 34.18 km^2
Number of wards: 34
Best practice: Aerobic windrow Composting at community level
Capacity: About 4 MT per unit

Green Park is a waste management facility of Kunnamkulam municipality, a town in Thrissur district of Kerala. This facility is run by an all-women Self Help Group (under Kudumbashree) under the guidance of IRTC (Integrated Rural Technology Centre) a grant-in-aid institute of Kerala State Council for Science Technology and Education, Government of Kerala. This facility is situated on a land that was previously a dump yard. In the last 5 years, this place has been converted to a waste management site.

This facility receives approximately 4 MT of organic waste from commercial establishments and some households. The organic waste bought here is first fed into an organic shredder machine, which breaks it down into smaller particles. In addition to vegetable, fruit and food waste, approximately 300-400kg chicken waste is received at the facility.

The following ratio is followed for organic waste, coir pith and microbial bioculum:

(i) For 1 MT of organic waste, 150 kg of coir pith mixed with 3kg of innoculum is required. In place of coir pith, old sieved compost can also be added to the organic waste as a feedback system. (ratio of 10:1.5:0.03)
(ii) For 1 MT chicken waste, approximately 250 kgs coir pith is added along with 4 kgs of inoculum.

This broken down organic waste is laid on a bed of coir pith in the form of windrows. This coir pith is mixed with microbial inoculum developed by Dr. Joshy Cherian to speed up the process of composting. The windrows are about 1-1.5 feet in height, 2-3 feet wide and about 15 feet long. This coir pith bed absorbs the liquid content in the organic waste. One windrow has about 1.5 MT of organic waste. The windrow is rotated after 10 days. After 20 days the leachate production will be reduced after which it is merged with another windrow to make a windrow of about 4-5 feet width.

---

103 Based on cost figures provided for every MCF in *The Carbon Market and Integrated Waste Solutions: A Case Study of Indonesia,* IDRC and CRDI (https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/50583/IDL-50583.pdf)
104 *The Carbon Market and Integrated Waste Solutions: A Case Study of Indonesia,* IDRC and CRDI (https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/50583/IDL-50583.pdf)
105 https://www.atmosfair.de/en/climate-protection-projects/biogas-biomass/indonesia/


After 30 days, the semi composted organic waste is put into a pulverizer cum shredder. and then it is sieved to increase the organic carbon. This will help the fibre content also to decompose. After sieving the compost, it is left in the corner for about 10 days. Before packing the compost into sacks, Trychoderma & pseudomonas also added into it. In addition, the compost made from chicken waste is added to the compost made from organic waste in the ratio 4:1 to balance out the nutrients. 1 MT of organic waste reduces to 250-300 kg of compost and the compost is sold at Rs.12/kg.

Financial information:

Particulars	Quantity (MT)
Organic waste handled Per day	3
Organic waste handled Per month	90
Qty of coir pith & inoculum required per day	0.5
Qty of coir pith & inoculum required per month	15

Expenditure	Amount (INR)
Cost for coir pith & inoculum per day	5,000
Cost for coir pith & inoculum per month	1,50,000
Manpower cost per month (for 6 Staffs)	72,000

Maintenance & other expenses per month	30,000
Total cost	**2,52,000**

Revenue	Amount (INR)
Output from compost (end product)	25% of raw material
Compost obtained for a month (MT)	22.5
Revenue per kg of compost (Rs)	12
Total Revenue per month (Rs)	**2,70,000**
Gross Margin per month (Rs)	**18,000**
Gross Margin %	**7%**

In order to reduce the costs, IRTC has helped in setting up of a de-husking facility from where the coir pith is supplied to the organic waste facility.

Annexure 7 - Pending Information

Sno	Pending Information	Remarks
1.	*Details of OWM facilities*	As per the latest responses, cumulative capital cost has been shared for Buildings of all SLRMC & Compost Yards. No information has been shared for operating costs.
	Per month opex of Gandhi Park Vermicompost Facility	
2.	Vehicle logs for dumping site at Brookshabad	During field visits it was observed that the checkpoint at the dumpsite has a system for maintaining logs for number of vehicles that pass every day. However, these logs have not been shared with the survey team yet.
a)	Break-up of expenditure incurred by PBMC in SWM works	Expenditure details have been received for primary and secondary collection, however, there are inconsistencies in the data.
b)	Manpower/ Labour (only for those workers who are engaged in SWM works)	Expenditure incurred on salaries has not been shared.
c)	PPE for workers	No information has been shared
d)	Maintenance	
e)	Any other equipment or expenditure heads	
3.	Logs for wet waste being sent to Brookshabad Piggery	As per information gathered during interview with piggery owner, he does not have records about organic waste being sent to the piggery. However, he mentioned that the such information will be available with PBMC since the checkpoint at the dumpsite would maintain records of the same. This information has not been shared with the survey team.
	Clarifications Required	
4.	Vehicles for primary and secondary collection (separate figures for rent, fuel, driver)	As per information provided in ward abstract, 31 vehicles are engaged in primary collection. The expenditure details for vehicles mention 36 vehicles being used for primary collection. The status of 5 vehicles is unclear.
5.	Ward Area	The ANI State Policy which has also been included in NGT affidavits contains a list of wards with areas. However, there is significant difference between this data, and that provided by PBMC.
6.		
	More Information Required	
7.	Details of Fines imposed on commercial establishments	PBMC is has been requested to share the details of fines imposed on commercial establishments for not giving segregated waste (total fine imposed for a period of one year)
8.	Details of IEC activities	PBMC has been requested to provide the details of IEC initiatives taken by them in the last one year
9.	Gender wise break up of sanitation staff	PBMC has been requested to share the gender wise break-up of the sanitation staff engaged in SWM systems.

Technical Concept Trainings

NADEP Composting at Raj Niwas & Secretariat, Port Blair

Project Management of Organic Waste in India | November 2022

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

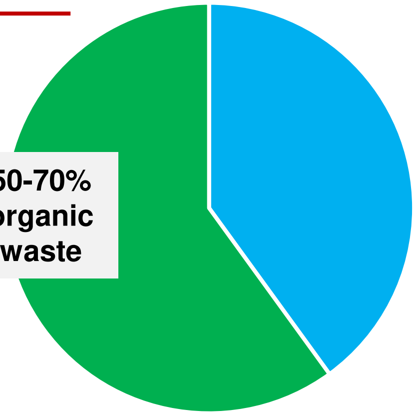
of the Federal Republic of Germany

Supported by

Saahas Zero Waste

Contents

Introduction



1

Daily Municipal Solid Waste Generation in Port Blair: 69-71 MT

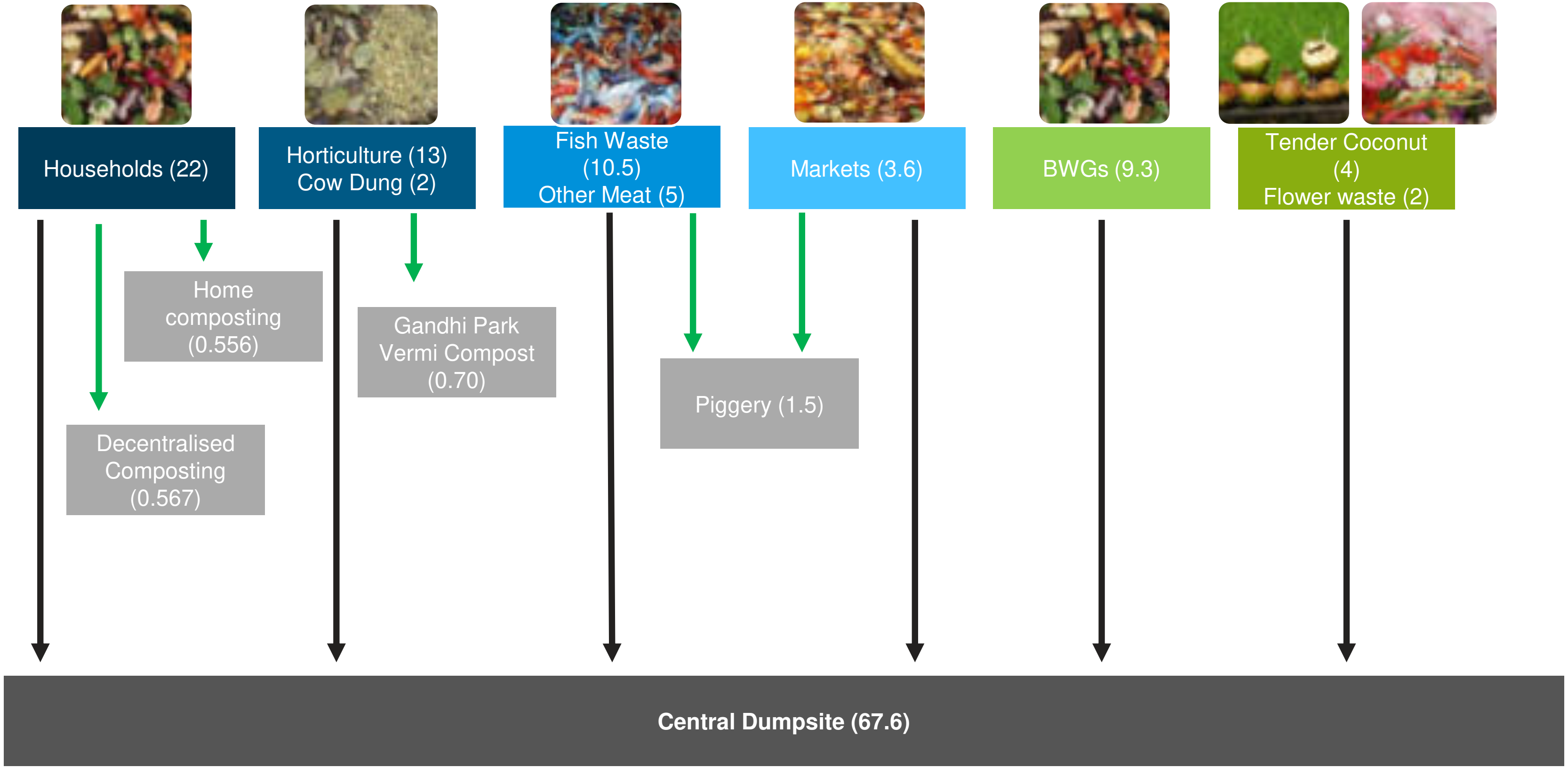
2

Dumping of Organic Waste leads to GHG emissions, pollution (including marine pollution) & diseases

3

PBMC bye laws: Setting up of Decentralised OWM Facilities

Organic Waste Streams & Generation (TPD)



Organic Waste Streams in Port Blair

Food Waste

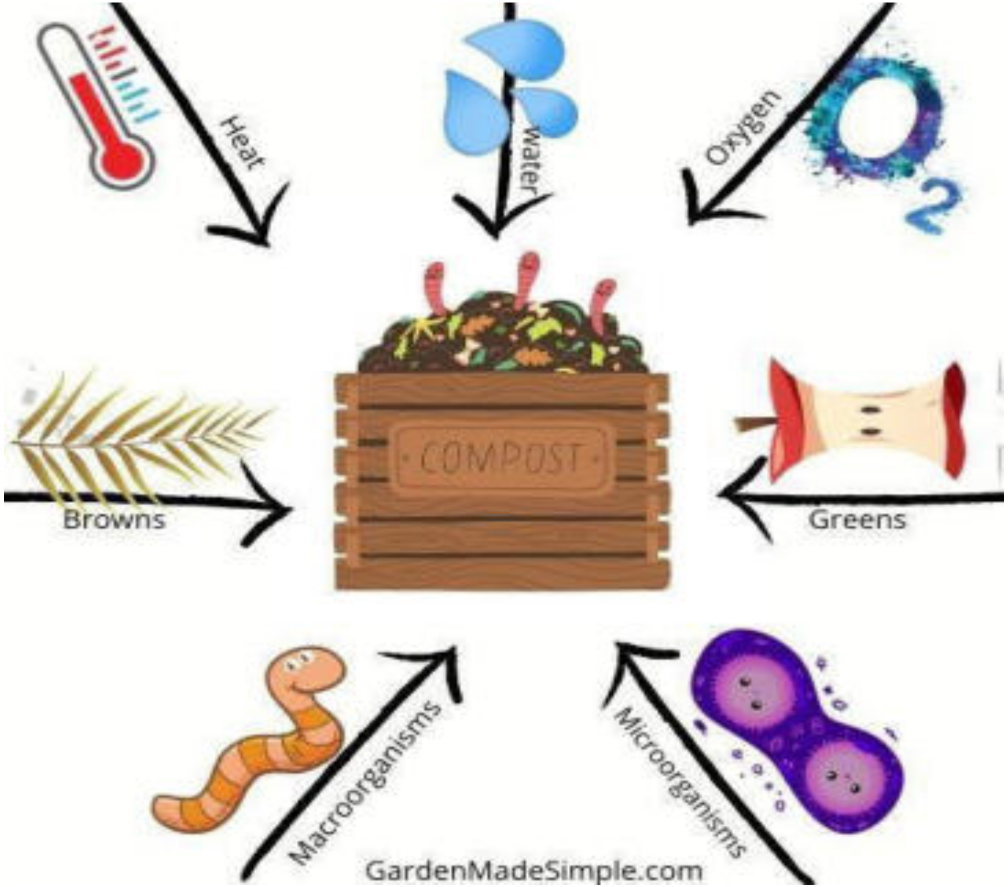
Horticulture Waste

Coconut Waste

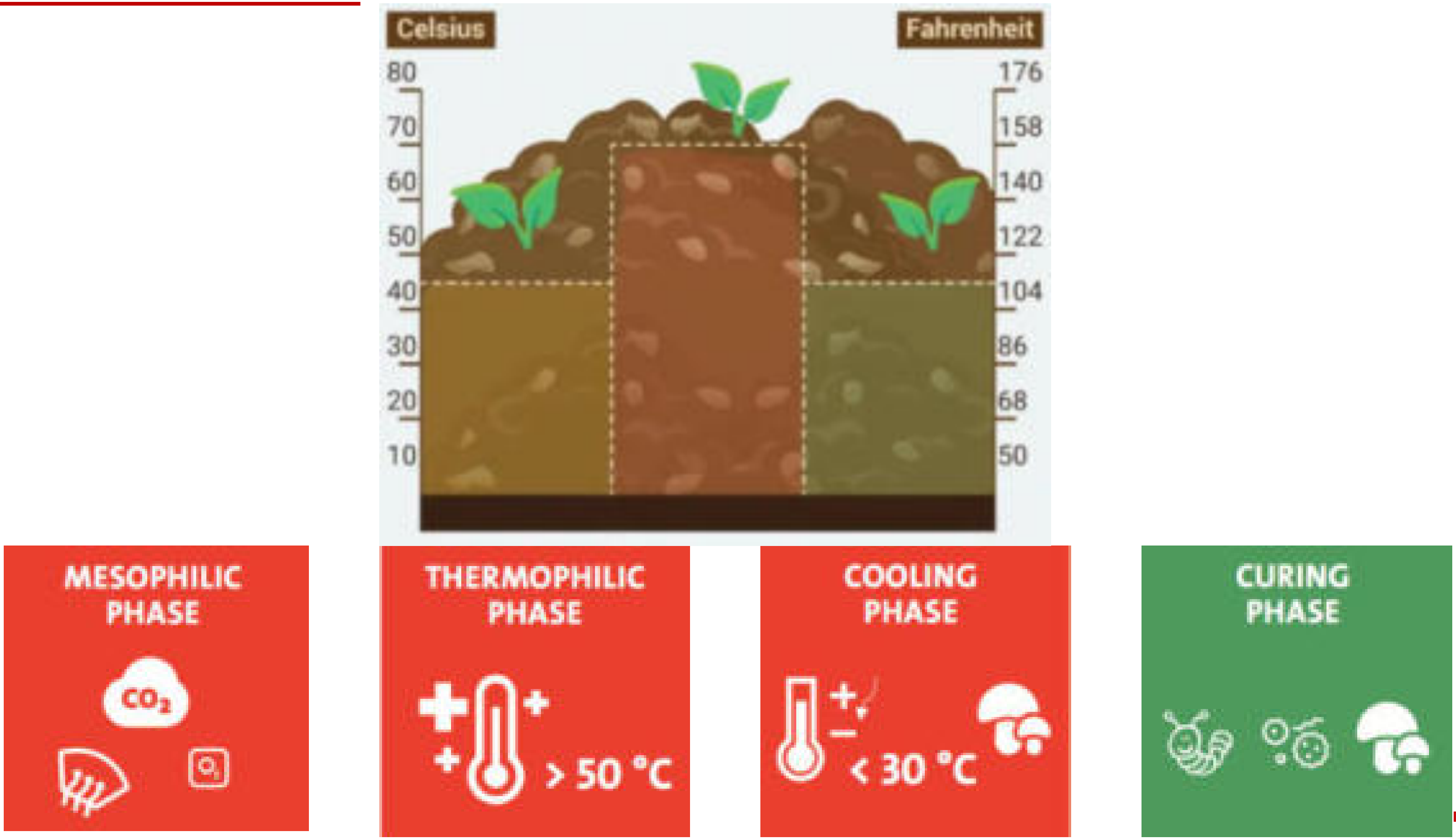
Fish and Meat Waste

Flower Waste

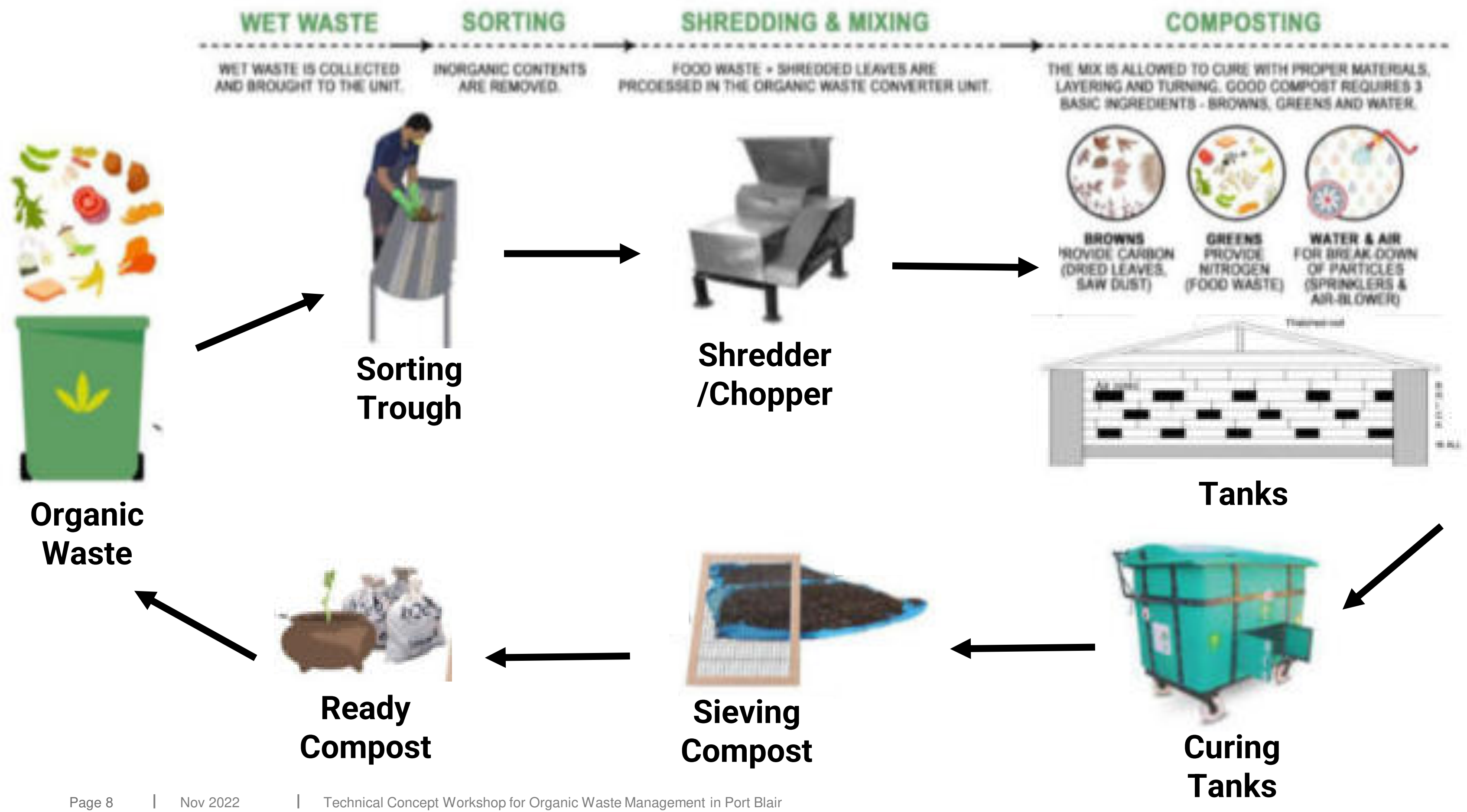
Introduction to Aerobic Composting



Stages in Composting



Introduction to NADEP Composting



Expenditure (INR): Raj Niwas

Equipment (1,93,000- 2,35,000)	Civil Works (13,42,800)	Monthly Operational Expenditure (81,473)
Waste Trolley	Tanks & Shed: 3,042^2 ft	Input: culture, brown matter etc
Weighing Scale	Curing, Equipment & Storage area	Human Resources
Waste Sorting Table/ Trough		Cleaning Consumables
Shredder/Chopper		Minor Equipment
Curing tanks/ area		PPE
		Miscellaneous

Expenditure (INR): Secretariat

Equipment (1,93,000-1,95,000)	Civil Works (2,35,000)	Monthly Operational Expenditure (34,180)
Waste Trolley	Tanks & Shed: 400^2 ft	Input: culture, brown matter etc
Weighing Scale	Curing, Equipment & storage area	Human Resources
Waste Sorting Table/ Trough		Cleaning Consumables
Shredder/Chopper		Minor Equipment
Curing tanks/ area		PPE
		Miscellaneous

Equipment for NADEP Composting

Waste Trolley

Weighing Machine

Sieve

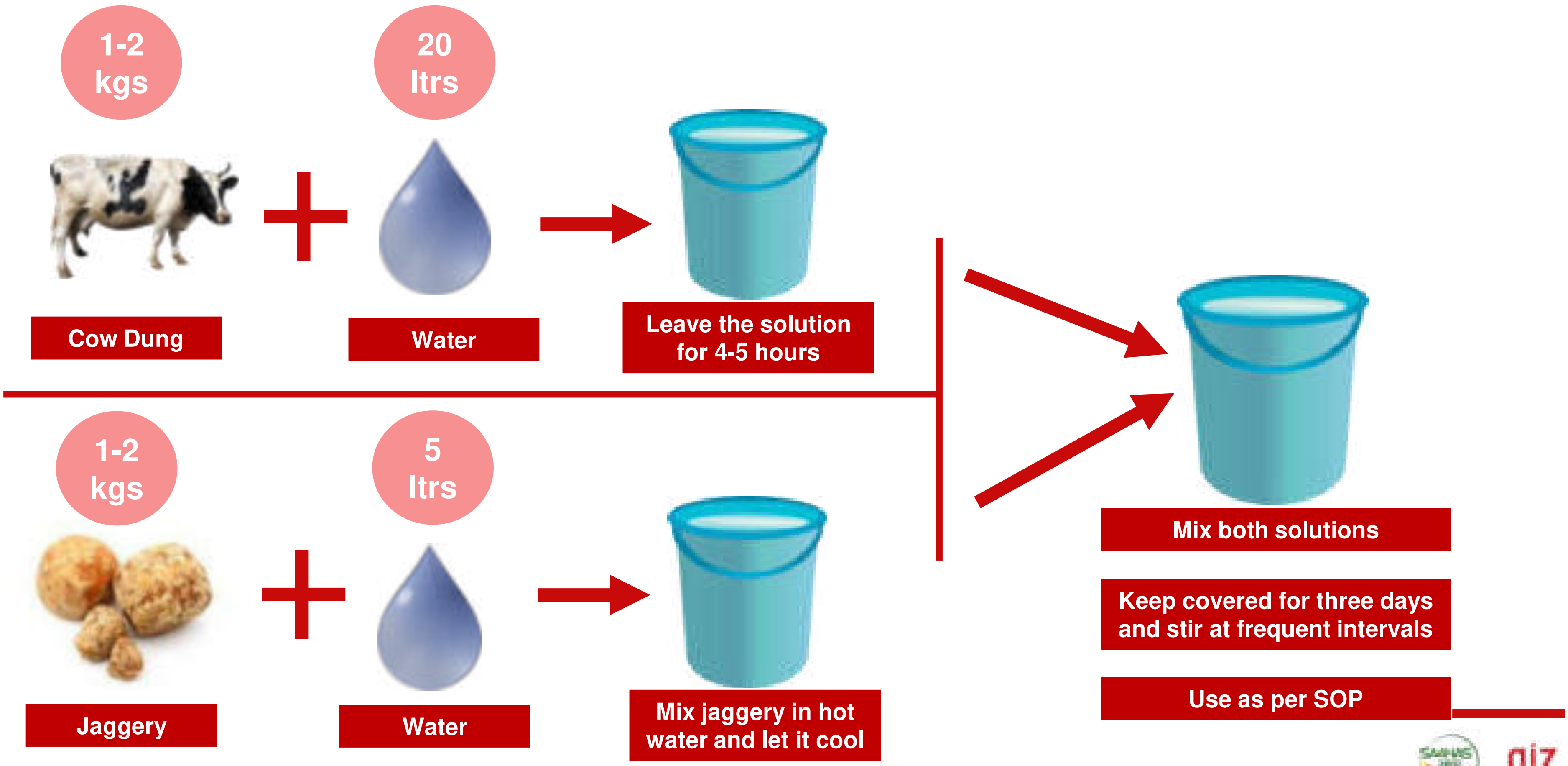
Shredder

Sorting Trough

Curing Tank

Process: NADEP Composting (Videos followed by discussion with ppt)

Different Process in NADEP Composting : Making Accelerator/Culture



Process of NADEP Composting

Pre-processing of organic waste

Raj Niwas

1. Sort incoming waste
2. Weigh the waste
3. Add first layer of brown matter
4. Ensure that large pieces of food such as pineapples, melons are cut before being added to tank as next layer

Secretariat

1. Sort incoming waste
2. Weigh the waste
3. Add first layer of brown matter
4. Ensure that excess liquid has been drained, especially with reference to waste from canteen, before it is added to the tank

Process of NADEP Composting

Processing of organic waste

Raj Niwas

1. Add the layer of processed organic waste over the layer of brown matter
2. In case of different kinds of organic waste, such as food, peels, horticulture, dairy, ensure everything is mixed well
3. Add a layer of cow dung slurry or culture
4. If incoming horticulture waste is a good mix of dry and green leaves, then the same can be mixed with food waste. No separate layering of brown matter and organic waste is required.
5. Add layers of brown matter if compost is too wet
6. Repeat untill tank is full, cover the tank, and leave it for 4-5 months. Sprinkle water to ensure moisture

Secretariat

1. Add the layer of processed organic waste over the layer of brown matter
2. In case of different kinds of organic waste, such as food, peels, horticulture, dairy, ensure everything is mixed well
3. Add a layer of cow dung slurry or culture
4. Add a layer of brown matter, followed by organic waste, and repeat the layering process until the tank is full
5. Leave it for 4-5 months. Sprinkle water to ensure moisture

Layers of Waste in NADEP tank

- ✓ Continue to layer the waste and brown matter until the tank is full
- ✓ Last layer should be filled in heap form with brown matter and covered with gunny bag.

Side View of the tank

- ✓ Progress of compost making can be tested by pushing a stick into the tank and placing back in the hand.

Warm or hot and smell is pleasant	Good decomposition has begun
Cool, dry and there is a smell	Sprinkle water on each layer
Warm, wet and smells like ammonia	Add more brown matter

Common Problems & Solutions in Composting

Common Problems & Solutions (Activity I)

Excess Moisture	Bad Smell	Flies & Pests	Maggots & Leachate	Machine Malfunction
Add brown matter	In case of meat & dairy products, mix with other kinds of organic waste before adding to tanks	Regular cleaning	Manual removal using gloves	Regular cleaning of equipment
	Add brown matter	Chopping fruits into smaller pieces before adding to tanks	Remove extra liquid from waste before adding to tanks	Following SOP for equipment
		Waste should be covered with leaves when waiting to be processed.	Adding brown matter	Using dry leaves
		Installation of fly catchers		Keeping a stock of different kinds of brown matter

Activity with Participants : Puzzle (Activity II)

Data Management & Monitoring

Data Management & Monitoring

INCOMING WASTE LOG			
Sno	**Heads**	**Responses**	**Remarks**
1	Date		
2	Time of arrival		
3	Vehicle number and type		
4	Source of waste		
5	Types of waste		
6	Total quantity received (in kg)		
7	Total organic waste (in kg)		
8	Total reject waste or non-organic material (in kg)		
9	Types of reject waste or non-organic		
10	Moisture present in the waste	(Y/N)	

Date of Test of Compost	Place of Testing	Results

Date	OUTGOING WASTE COMPOST LOG		
	Total ready compost available	Total compost in curing process	Compost that got transferred from curing to ready on this date

Multiple Choice Questionnaire (Activity III)

Feedback Session

Technical Concept Trainings

Crate Composting at Junglighaat, Port Blair

Project Management of Organic Waste in India | November 2022

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

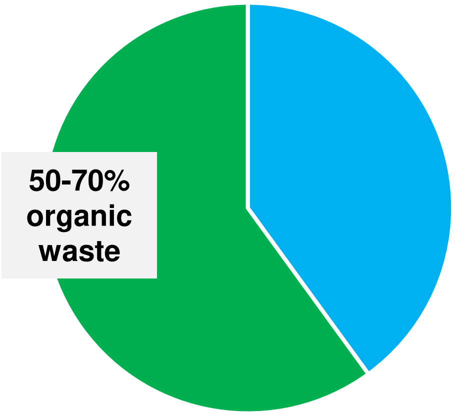
of the Federal Republic of Germany

Supported by

Saahas Zero Waste

Contents

Introduction



1

Daily Municipal Solid Waste Generation in Port Blair: 69-71 MT

Dumping of Organic Waste leads to GHG emissions, pollution (including marine pollutuion) & diseases

2

3

PBMC bye laws: Setting up of Decentralised OWM Facilities

Organic Waste Streams in Port Blair

Food Waste

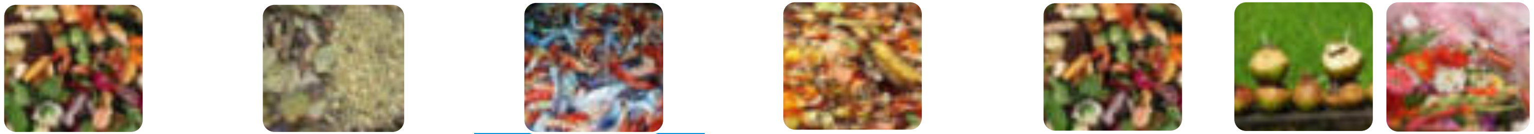
Horticulture Waste

Coconut Waste

Fish and Meat Waste

Flower Waste

Organic Waste Streams & Generation (TPD)



Households (22)

Horticulture (13)
Cow Dung (2)

Fish Waste (10.5)
Other Meat (5)

Markets (3.6)

BWGs (9.3)

Tender Coconut (4)
Flower waste (2)

Home composting (0.556)

Decentralised Composting (0.567)

Gandhi Park Vermi Compost (0.70)

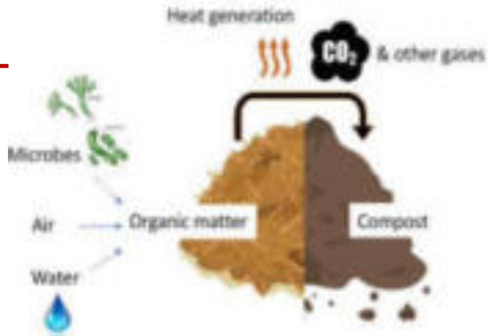
Piggery (1.5)

Central Dumpsite (67.6)

Introduction to Aerobic Composting

Organic waste

1



Microbial Action

3

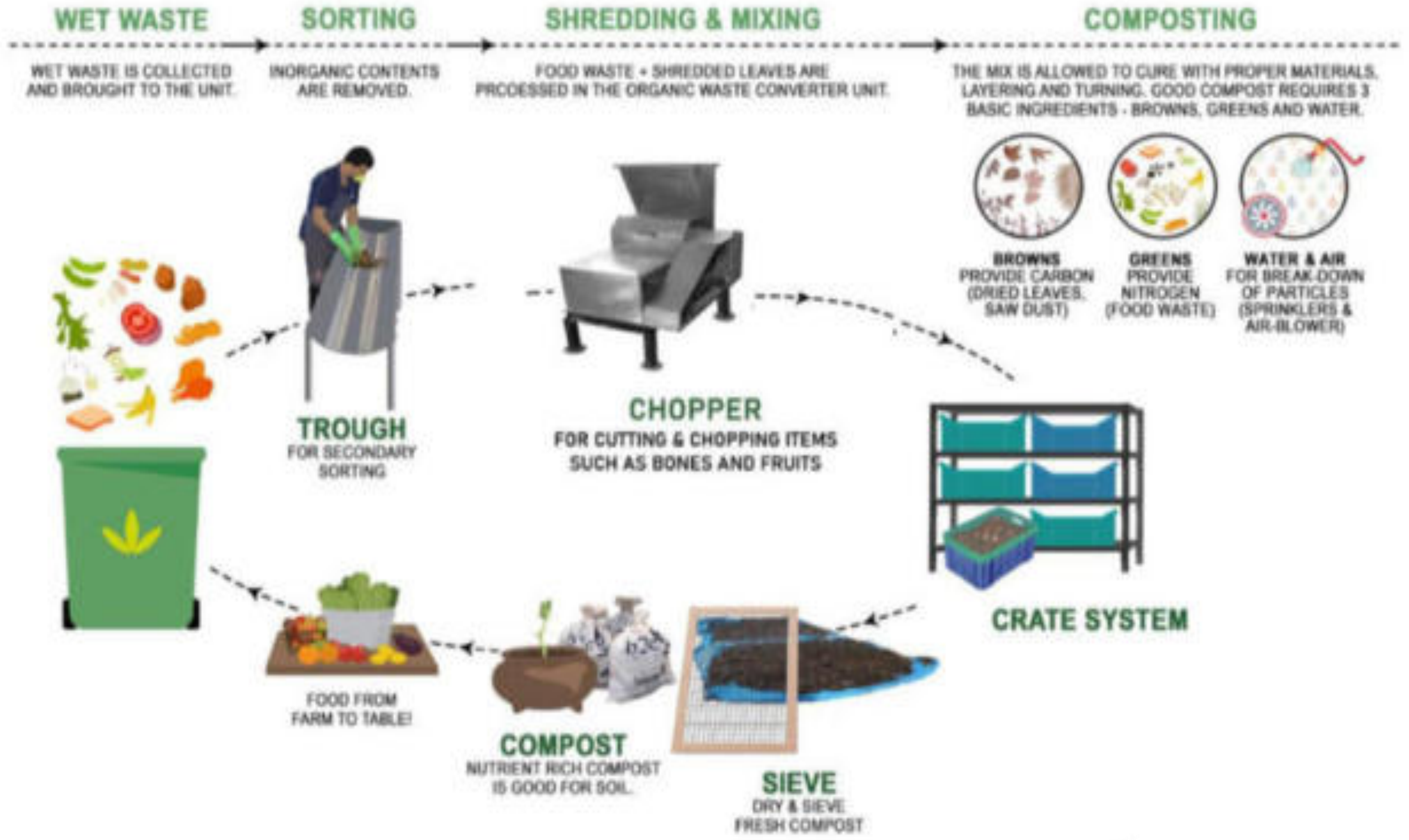
2

Waste in Composting Containers

4

Aeration

Introduction to Crate Composting



Expenditure (INR)

Equipment (8,07,000-8,41,000)	Civil Works (13,42,000)	Monthly Operational Expenditure (50,636)
Weighing Machine	Building of 63^2 mtrs	Input: culture, brown matter etc
Sieve	Curing Area, Storage Area, Toilet, etc	Human Resources
Food Chopper		Cleaning Consumables
Leaf Shredder		Minor Equipment
Racks & Crates		PPE
Curing Tanks		Miscellaneous

Equipment for Crate Composting

Chopper

Weighing Machine

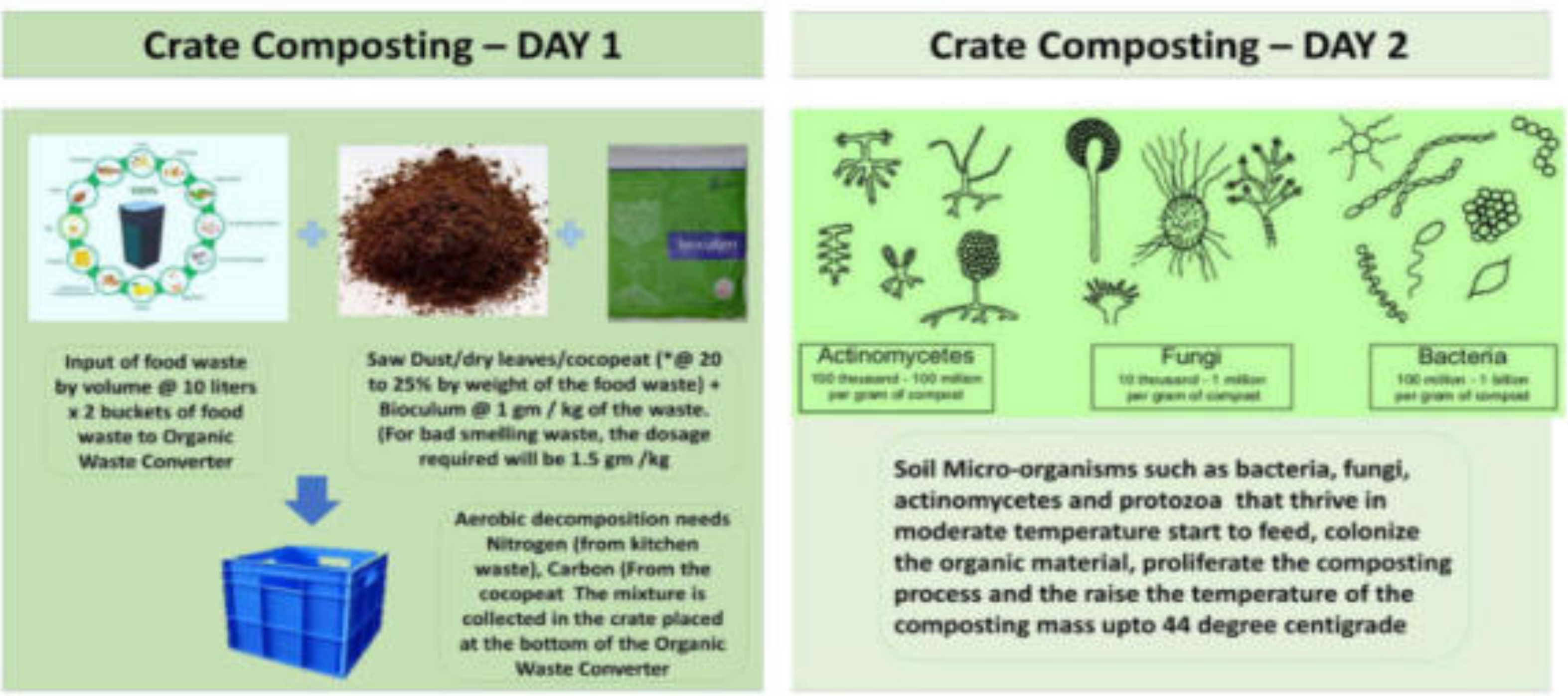
Sieve

Racks & Crates

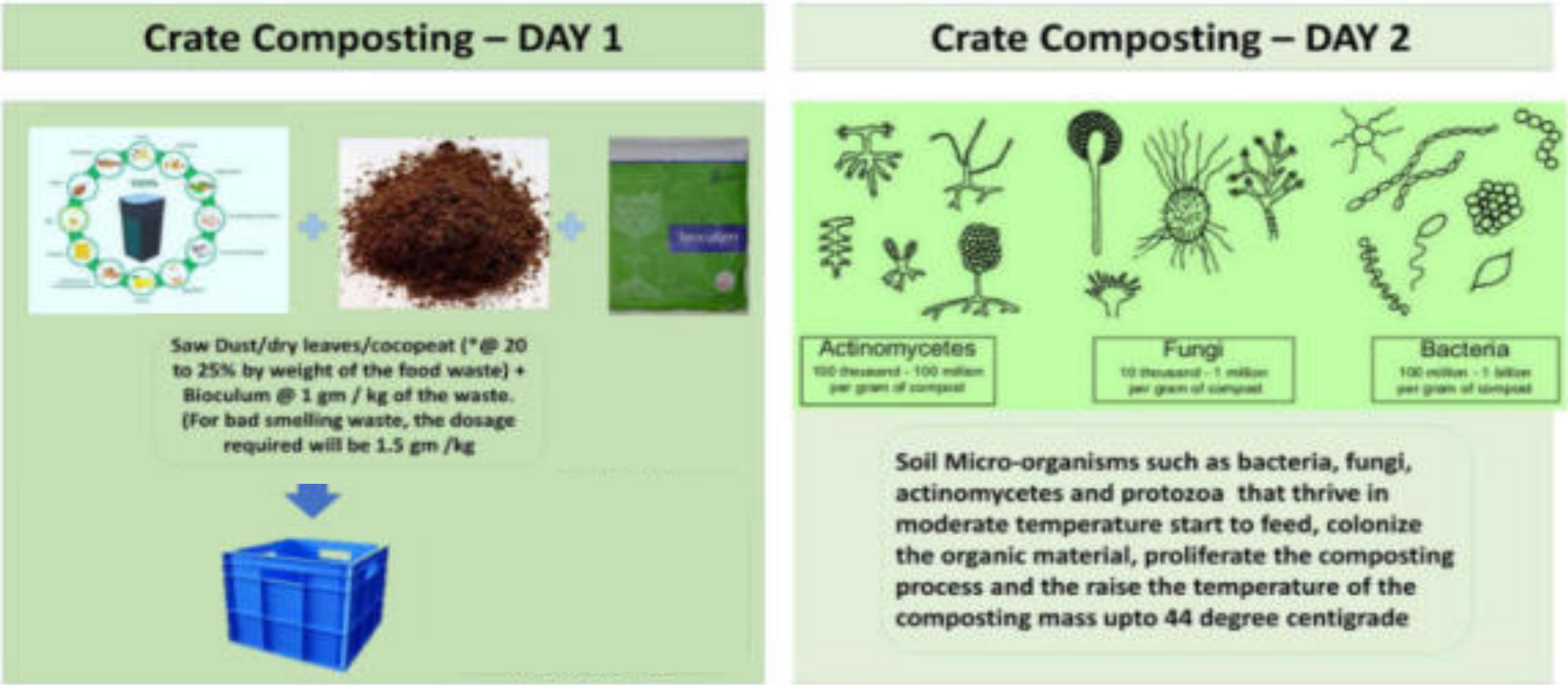
Sorting Trough

Curing Tank

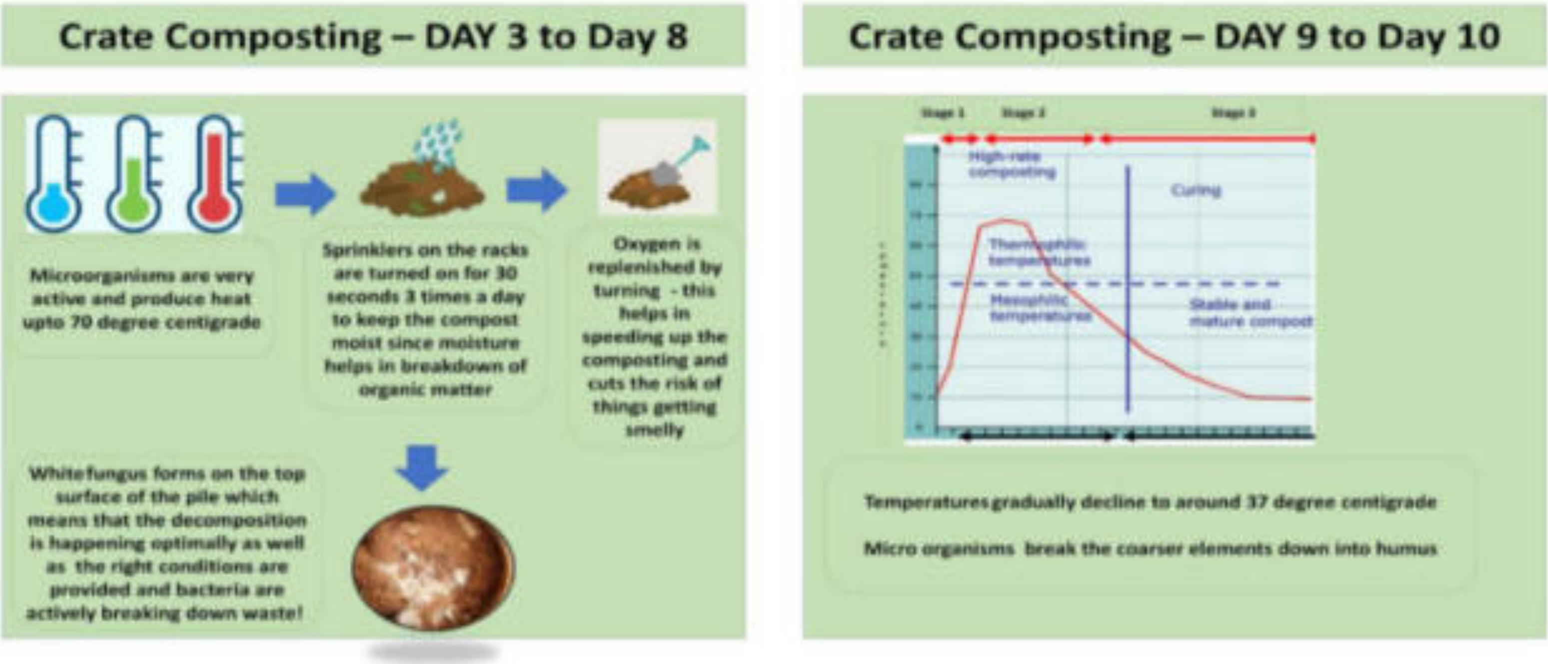
Crate Composting Overview



Crate Composting Overview



Crate Composting Overview



Different Process in Crate Composting

1 Handling Waste

2 Removing non-biodegradable material

3 Chopping Organic Waste

4 Layering food waste in crates

5 Adding Brown Matter

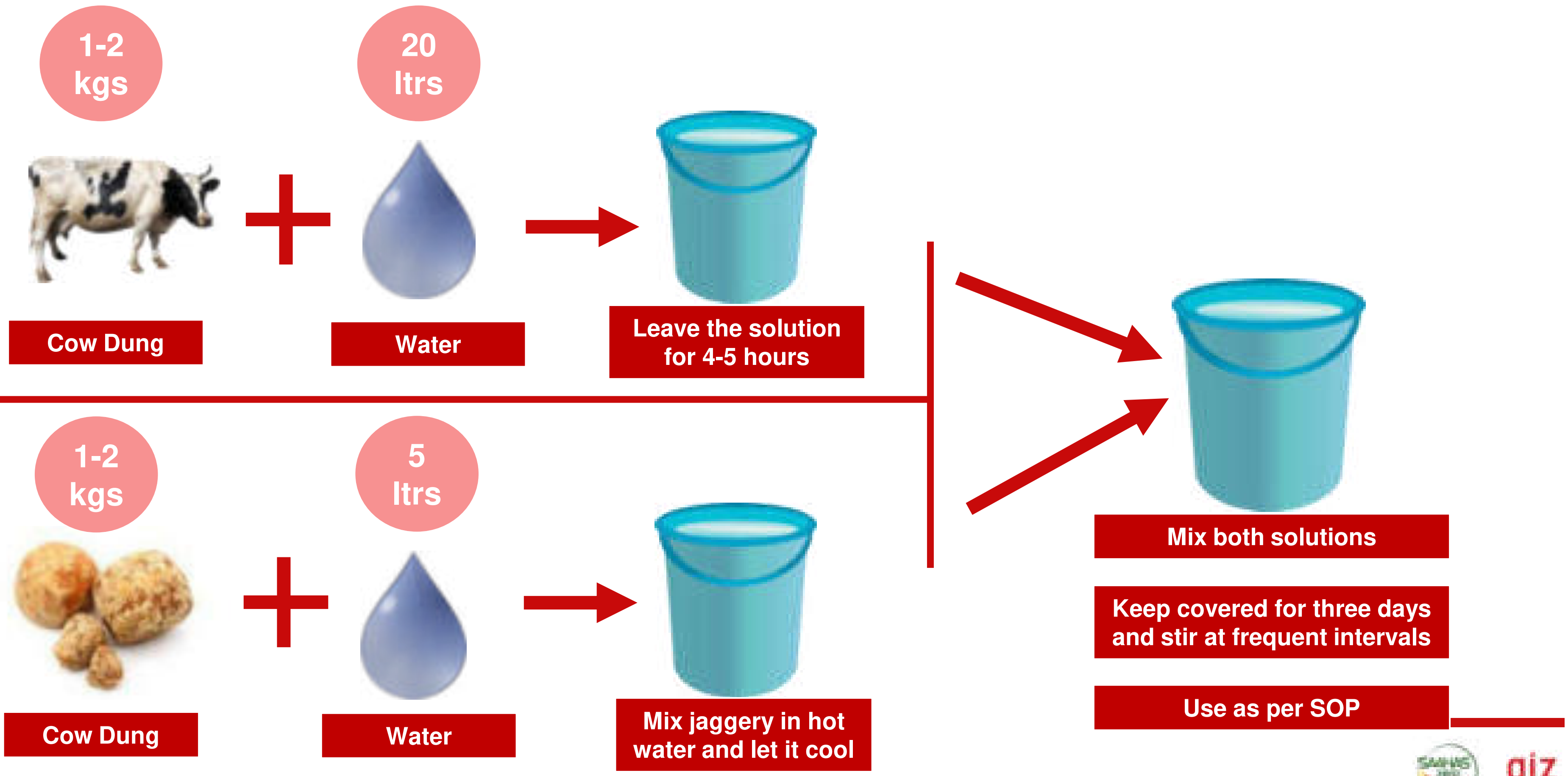
6 Occupational Safety

7 Use of Personal Protective Equipment

8 Cleaning & Maintenance of the unit

9 Data Monitoring

Different Process in Crate Composting : Making Accelerator/Culture



Data Management & Monitoring

Data Management & Monitoring

INCOMING WASTE LOG			
Sno	**Heads**	**Responses**	**Remarks**
1	Date		
2	Time of arrival		
3	Vehicle number and type		
4	Source of waste		
5	Types of waste		
6	Total quantity received (in kg)		
7	Total organic waste (in kg)		
8	Total reject waste or non-organic material (in kg)		
9	Types of reject waste or non-organic		
10	Moisture present in the waste	(Y/N)	

Date	OUTGOING WASTE COMPOST LOG		
	Total ready compost available	Total compost in curing process	Compost that got transferred from curing to ready on this date

Sno	COMPOST SALE LOG				
1	Quantity of compost sold (kgs)	Price per kg (INR)	Name & Contact details of buyer	Total remaining compost at end of the day (kgs)	Total monthly revenue (INR)

Practical Demonstration: Crate Composting

Trouble shooting & Solutions

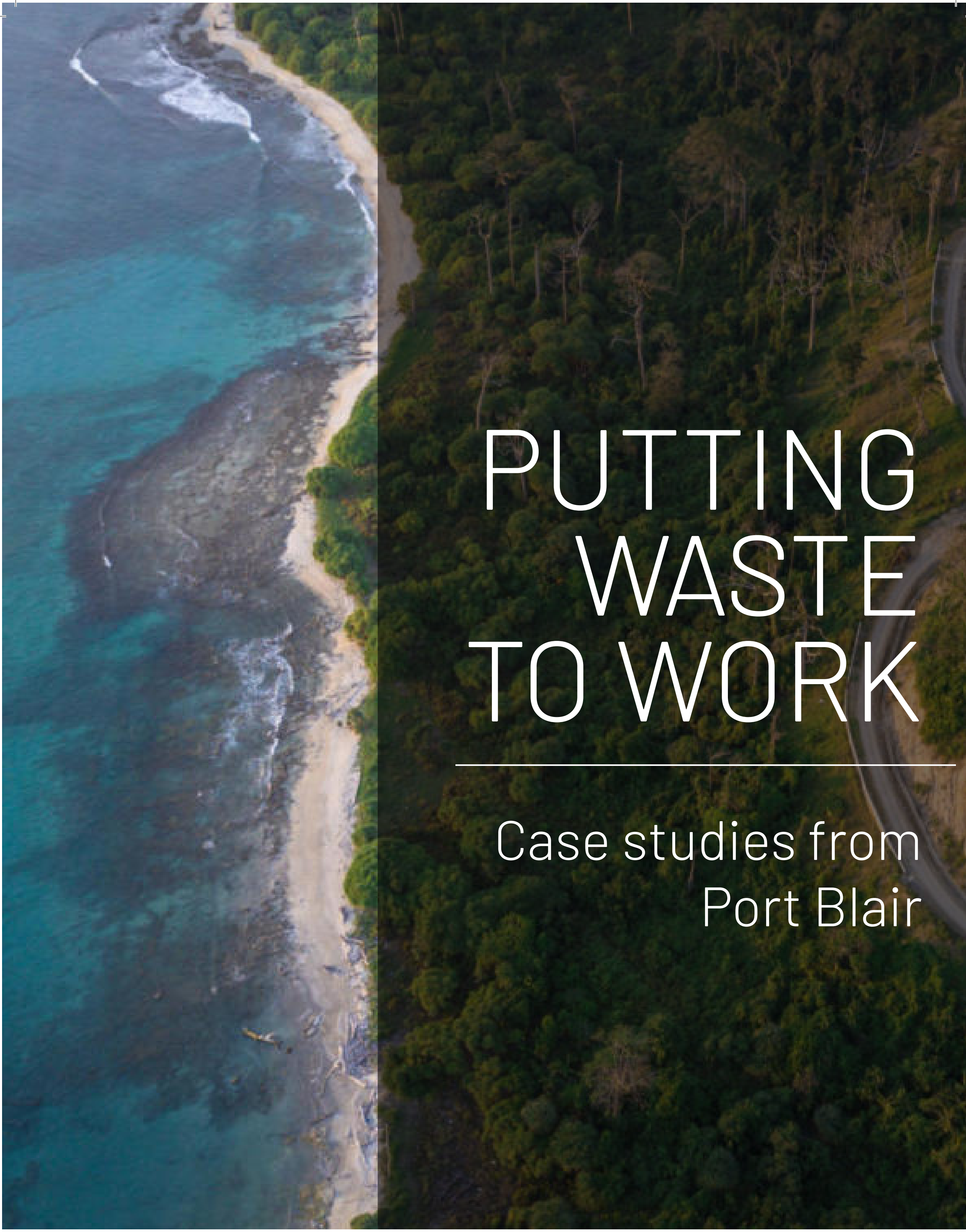
Common Problems & Solutions (Activity I)

Excess Moisture	Bad Smell	Flies & Pests	Maggots & Leachate	Machine Malfunction
Add brown matter	In case of meat & dairy products, mix with other kinds of organic waste before adding to crate	Regular cleaning	Regular cleaning	Regular cleaning of equipment
	Add brown matter	Chopping fruits into smaller pieces before adding to crate	Remove extra liquid from waste before adding to crates	Following SOP for equipment
		Waste should be covered with leaves when waiting to be processed.	Adding brown matter	Manually chopping food
		Installation of fly catchers		Keeping a stock of different kinds of brown matter

Activity with Participants : Puzzle (Activity II)

Multiple Choice Questionnaire (Activity III)

Feedback Session



PUTTING WASTE TO WORK

Case studies from Port Blair

On behalf of

Federal Ministry
for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

of the Federal Republic of Germany

Government of Andaman and Nicobar Islands

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Cities Combatting Plastic Entering Marine Environment
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
B-5/5, Safdarjung Enclave
New Delhi 110 029, India
T + 91 4949 5353
F + 91 4949 5391

Responsible:
Mrs Vaishali Nandan
E Vaishali.nandan@giz.de

Author:
Mr Aviral Saxena, Technical Expert GIZ India

Editor:
Ms Soma Biswas, GIZ India
Ms Yashasvini Rajeshwar, AuxoHub

Design and layout:
Wishbox Studio

GIZ is responsible for the content of this publication.

India 2022

CONTENTS

01 | INTRODUCTION

The union territory of Andaman & Nicobar is widely popular for its many beautiful islands. The islands and their beaches host thousands of tourists every year from India and abroad. While the visitors bring economic growth, they also usher in a related problem. The authorities in Andaman & Nicobar, particularly the municipality of Port Blair, have experienced an increase in the volume of waste generated on the island. In 2020, the municipality of Port Blair generated 121 tonnes of waste per day. Of the solid waste generated, 328.5 metric tonnes (MT) was plastic waste. In order to deal with such waste effectively, the Port Blair Municipal Council (PBMC) adopted various measures. It established five decentralised composting units and two bio-methanation plants. There was also a focus on door-to-door collection of waste and segregation. Additionally, the Port Blair Municipal Council (PBMC) undertook measures to collect plastic waste and use it for the construction of roads.

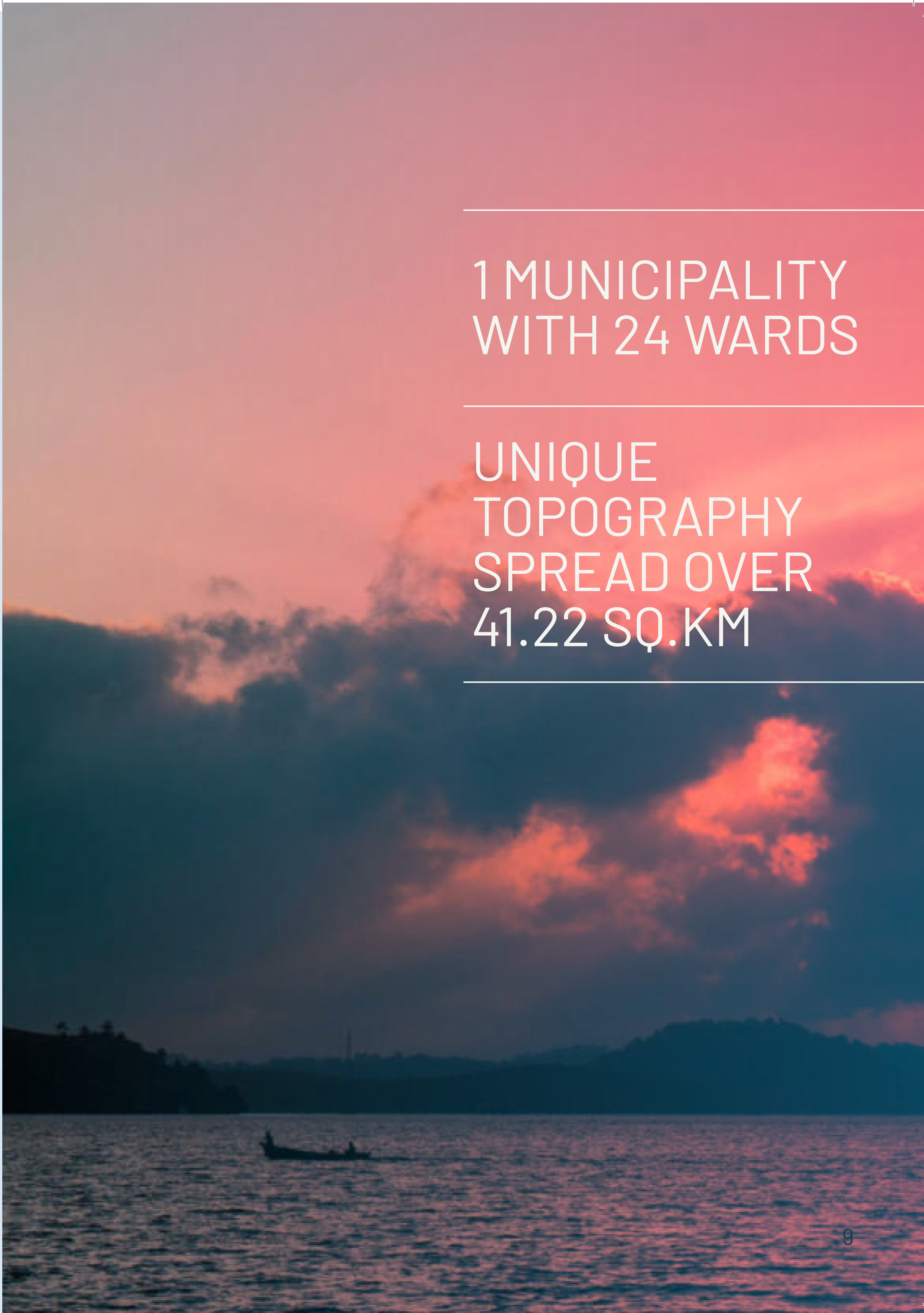
Apart from the various measures adopted by the Port Blair Municipal Council (PBMC) for solid waste management, the municipality decided to adopt two specific strategies for further managing waste effectively, given the challenges for the municipality. The first involved establishing Solid and Liquid Resource Management Centres (SLRMCs) across the different wards of Port Blair. These centres helped manage dry waste before it got shipped to the mainland for recycling. The second strategy involved setting up and training self-help groups (SHGs) to assist with commercial waste management. The Solid and Liquid Resource Management Centres (SLRMCs) significantly helped reduce the rate of resource depletion and virgin raw material extraction. The self-help groups (SHGs) aided commercial waste management while also generating livelihoods for the locals. Thus, the two strategies adopted by the Port Blair Municipal Council (PBMC) contributed significantly towards protecting and preserving Port Blair. The union territory's capital city is now better prepared to welcome tourists and be the gateway to the islands' pristine beauty.

02 | PORT BLAIR

Focus on dry waste management

India is known globally for its diversity – of its people, culture, foods, geographies, and topographies. The island city of Port Blair, located in the Union Territory of Andaman and Nicobar Islands, is an example of this diversity. For a long time now, Port Blair has been a popular tourist attraction, inviting tourists to visit the city's sights and hosting travellers en route to the islands making up Andaman and Nicobar. Understandably, tourism is at the core of Port Blair's economy. However, economic growth and increased tourist footfall have brought with them a civic problem for Port Blair's authorities – waste. From organic and inert waste to recyclable waste, Port Blair generates a large volume of compostable waste. To tackle the problem before it got out of hand, the Port Blair Municipal Council (PBMC) decided to adopt and implement long-term measures addressing the issue of compostable waste.

TOURISM IS AT THE CORE OF PORT BLAIR'S ECONOMY


1 MUNICIPALITY WITH 24 WARDS
UNIQUE TOPOGRAPHY SPREAD OVER 41.22 SQ.KM

Setting up centres for waste management

The Port Blair Municipal Council (PBMC) began by first reviewing existing waste management practices in the municipality. Authorities then studied the waste management efforts of states in other parts of India to identify strategies best suited to Port Blair's specific challenges. All this led to the decision to set up Solid and Liquid Resource Management Centres (SLRMC) in all wards across Port Blair. These Centres would be crucial for the effective processing of waste generated in the municipality. As a first step, suitable land was identified for setting up these centres. Following this, the construction of the Solid and Liquid Resource Management Centres (SLRMCs) began. To ensure the proper operation of each centre, competent external vendors were selected. These vendors were responsible for maintenance as well as installation of bailing machines and other necessary equipment in their respective centres. Plans were carefully devised to collect waste from all households as well as commercial areas and other institutions daily. Such collection was enabled through the involvement of sanitary workers and private rag pickers. Additionally, commercial and industrial establishments were strongly encouraged to segregate waste before handing it over to the municipal workers. Such waste was then sent to the Solid and Liquid Resource Management Centres (SLRMCs) for dry waste management before being shipped to the mainland for recycling. While all this mostly took care of dry waste management, the Port Blair Municipal Council (PBMC) went a step further and sold the dry waste to vendors. This ensured an additional revenue stream and increased the sustainability of the Port Blair Municipal Council's waste management efforts.

Achievements of Solid and Liquid Resource Management Centres (SLRMCs)

1. Reduction in the rate of resource depletion and virgin raw material extraction
2. Utilising segregated plastic for construction of roads
3. Minimal waste disposal at dumpsites thereby resulting in a reduction of air, water and soil pollution
4. Generation of livelihoods for low-income workers from the informal sector by involving them in the waste management efforts
5. Revenue generation for the Port Blair Municipal Council (PBMC) by selling recyclable materials to vendors
6. Transportation of recyclable material to the mainland including a total of 14223.621 metric tonnes of plastic waste, 1077.234 metric tonnes of cardboard waste and 568.9 metric tonnes of glass

The Solid and Liquid Resource Management Centres (SLRMCs) enabled the much-needed adoption of a decentralised waste management approach in the municipality of Port Blair. All of this was made possible by strong leadership, including the Executive Engineer, Assistant Engineer and the Junior Engineer of the Solid Waste Management (SWM) department.

Conclusion

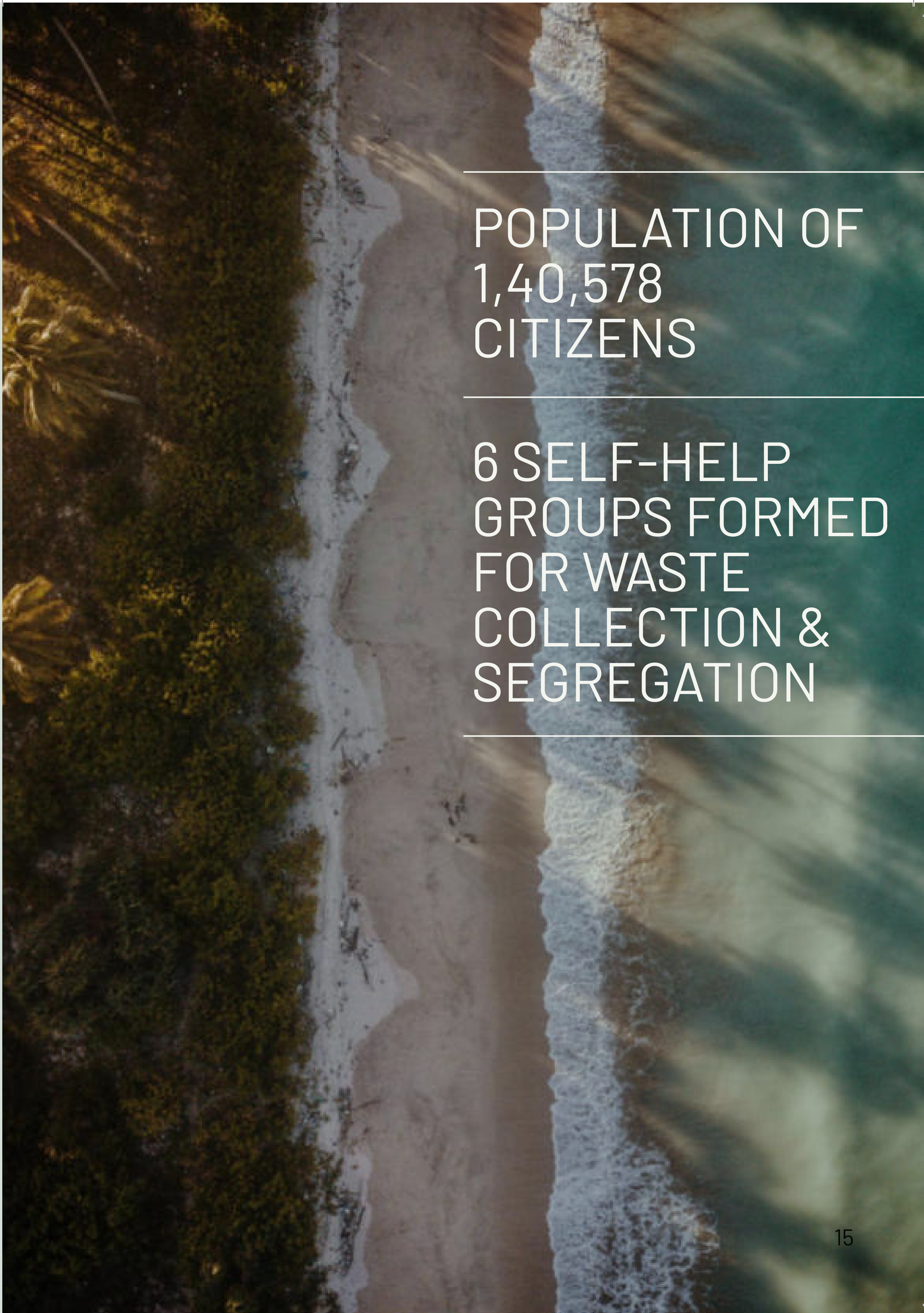
While the consistent waste management efforts of the municipality made a significant difference, 100% waste segregation at the source remains a challenge. In order to ensure sustained, impactful and long-term effort at reducing and managing waste generated in Port Blair Municipal Council (PBMC) on capacity building of the municipal staff in the future while integrating self-help groups (SHGs) into its waste management efforts. The municipality also hopes to soon have Solid and Liquid Resource Management Centres (SLRMCs) functional in all 24 wards as opposed to the 13 centres that are currently functional. The municipality is leaving no stone unturned to ensure that they keep Port Blair as pristine and waste-free as possible. The city is all set to continue acting as a gateway to the natural paradise that is Andaman and Nicobar.

03 | PORT BLAIR

A sustainable approach to waste management

As one of the largest peninsular nations in the world, India is a land of many magnificent beaches. Our coastlines attract a large number of tourists throughout the year. When such beaches are found on an island, the charm is unparalleled! The Union Territory of Andaman and Nicobar Islands is one such charming, picturesque tourist hotspot. These islands are connected to mainland India via the municipality of Port Blair. As with any other municipality, urbanisation and changing lifestyles over the years have led to the establishment of a lot of commercial businesses in the locality. While such businesses boost the economy of any place, they inevitably lead to challenges related to its governance. In the case of Port Blair, dealing with commercial waste became one such challenge. The Port Blair Municipal Council (PBMC) soon realised that other stakeholders would need to be involved in an integrated approach to address this problem. It was this need for collaborative waste management that resulted in the introduction of self-help groups (SHGs).

IN THE CASE OF PORT BLAIR, DEALING WITH COMMERCIAL WASTE BECAME ONE SUCH CHALLENGE.



POPULATION OF 1,40,578 CITIZENS

6 SELF-HELP GROUPS FORMED FOR WASTE COLLECTION & SEGREGATION

Active involvement of self-help groups (SHGs)

Introducing self-help groups (SHGs) into the municipality's waste management approach achieved two goals. Firstly, the city's waste management strategy got strengthened. Secondly, the project offered a means of livelihood for the members of the self-help groups (SHGs). It was a win-win situation for everyone involved!

The Port Blair Municipal Council (PBMC) approached this process in a phased manner. First, a database was created, recording all the informal workers in the municipality. The self-help groups (SHGs) were then formed and approved by the municipality. As a next step, city ordinances needed to support the program over the long run were drafted. Additionally, the workers were given the training to understand the city's waste management strategies before they were developed into cooperatives. Finally, the Port Blair Municipal Council (PBMC) enabled the registration of these workers in a governmental skill training program, the Deendayal Antyodaya Yojana (under the National Urban Livelihoods Mission). Once the self-help groups (SHGs) had been formed and trained, the only step left was the accreditation and affiliation of the self-help group workers with recyclers to legalise their operations. Following the successful formation and training of the self-help groups (SHGs), the next phase involved piloting the initiative. The pilot aimed to identify any irregularities or problems in the operations and make necessary changes. After the successful pilot, the self-help groups (SHGs) were adequately equipped to undertake commercial waste management efforts. They helped with the collection and composting of waste from commercial centres as well as the sorting of recyclable materials at Port Blair's Solid and Liquid Resource Management Centre (SLRMC).

Integrating self-help groups in Port Blair Municipal Council's waste management efforts

Phase One: Establishing a database of the workers, drafting ordinances and conducting trainings

Phase Two: Organising the workers into cooperatives and legalising their operations

Phase Three: Running a pilot to make any necessary changes to the process

Phase Four: Implementing waste management collection by the informal workers

Throughout the process, the Port Blair Municipal Council's focus was to ensure the longevity of its strategy. Apart from being thoroughly trained, self-help group members also received identity cards that authorised them to collect waste from commercial areas. The municipality further supported the self-help groups (SHGs) with any recycling needs and facilitated the sale of compost. These grew to be additional revenue streams for the self-help groups (SHGs). At every step of the way, the Port Blair Municipal Council (PBMC) prioritised sustainability and self-sufficiency. The introduction of self-help groups (SHGs) into the waste management strategy was not a short-term fix. It was a long-term solution.

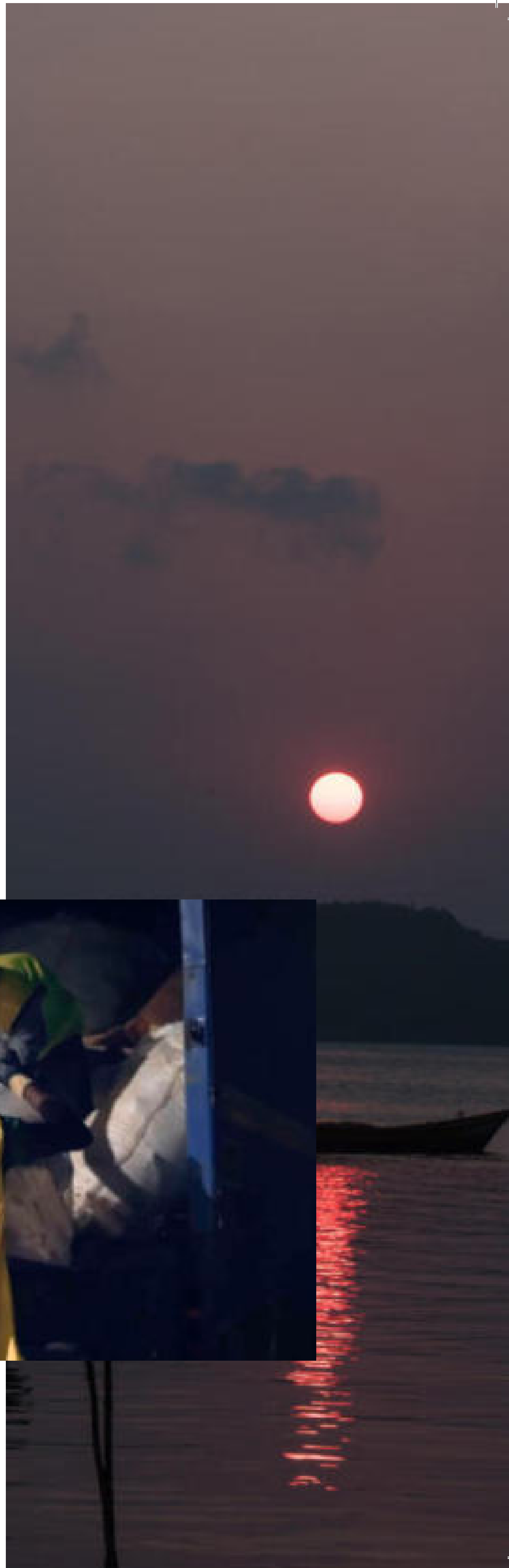
Benefits of involving self-help groups in waste management

1. Managing recyclable waste in a decentralised manner
2. Enabling sustainable livelihoods for waste pickers
3. Providing waste pickers with municipal recognition and legitimacy
4. Efficient utilisation of municipality's Solid and Liquid Resource Management Centres (SLRMCs)
5. Restructuring solid waste management to include labour, governance and environmental concerns
6. Upcycling of waste into dustbins and jute materials

Apart from its role in strengthening the municipality's waste management strategy, this focus on sustainability had a large positive impact on the self-help group members as well. Scrap collectors were now recognised as authorised workers, giving them public visibility. This particularly benefited self-help group members from marginalised backgrounds.

Conclusion

While the municipality of Port Blair has made significant strides in commercial waste management efforts, the Port Blair Municipal Council (PBMC) realised that there is more to be done. Selling compost by the self-help groups (SHGs) remains a struggle and there is a need for more thorough training of the workers on waste collection. There are also plans in pipeline to sell compost to agricultural departments to sustain the self-help groups (SHGs) better. Over time, the municipality envisions the self-help groups (SHGs) covering all wards with Solid and Liquid Resource Management Centres (SLRMCs), minimising the need for intervention from municipal authorities. Even as the authorities iron out and strengthen the details of the strategy, the municipality's determination and unwavering focus on sustainability and social impact is sure to propel Port Blair over the finish line!



Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Cities Combatting Plastic Entering Marine Environment
Third Floor, B 5/5
Safdarjung Enclave
New Delhi, 110029, India

T + 91 4949 5353
F + 91 4949 5391
E giz-indien@giz.de I www.giz.de

Port Blair Municipal Council (PBMC)

Mohanpura
Port Blair, 744101,
Andaman & Nicobar Islands, India

@PBMC_ANI
Port Blair Municipal Council
@PBMC_ANI
PBMC_ANI






Concept for 5TPD Pilot MRF at Brookshabad, Port Blair, A&N

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Cities Combatting Plastic Entering Marine Environment (CCP-ME) Project
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
3rd Floor, B-5/5, Safdarjung Enclave
New Delhi 110029

T + 91 4949 5353
F + 91 4949 5391
E info@giz.de
I www.giz.de

Responsible
Ms. Vaishali Nandan
Head of Project, CCPME, GIZ

Authors
Dr Bharat Bhushan Nagar, Mr. Liju Mathew, Mr Aviral Saxena| GIZ
Mr. Brian McCarthy, Mr. Pradeep Dadlani | RWA-Deloitte

GIZ is responsible for the content of this publication.

July 2022

Contents

LIST OF FIGURES

LIST OF TABLES

1. Executive Summary

The leakage of non-biodegradable waste from the Municipal Solid Waste (MSW) management system is contributing to marine litter in and around Port Blair and the wider Andaman and Nicobar Islands. Strengthening the collection, recovery and controlled management of these waste materials is essential to mitigating the environmental, social, and economic impacts of this. Decentralized Material Recovery Facilities (MRF), that enable the recovery of resources from dry waste are required under the Solid Waste Management (SWM) Rules to facilitate improved control wastes. Port Blair Municipal Corporation (PBMC) has made great effort in implementing these rules through the establishment of 12 Solid and Liquid Resource Management (SLRM) centers. However, the efficiency and effectiveness of material recovery at these facilities is low and requires assistance to optimize operation and enhance the quantity and quality of materials recovered, processed, and marketed from the waste stream.

Based on an assessment of the existing SWM system, SLRM facilities, site operations and anticipated waste flows, the following activities are proposed as part of a demonstration project to be established at the Brookshabad Dry Resource Centre (DRC) to enhance material recovery and Garacharama SLRM to enhance recovery of coconut husk waste.

Brookshabad DRC:

1. Design an optimized layout and site plan for the DRC – to include optimization of existing SLRM operators, operator models and clarify stakeholder responsibilities
2. Clear and dispose of historic, degraded, and other materials with no use / value currently discarded throughout site. To include bush clearance and space revival.
3. Provide clearly identified and contained covered and uncovered storage space for incoming unsorted materials, and recovered and baled / bagged materials. To include installation of storage bays for various high-volume materials, including glass (uncovered bay), paper & cardboard (covered bay), plastics (covered bay) and mixed dry waste (covered bay) as well as covered storage bays for processed and baled / bagged materials and separate bay for rejected materials to be transferred for disposal. Instigate proper organization and housekeeping on site.
4. Establish new covered structure/s to house a conveyor belt picking line to optimize efficiency of material recovery (recommended to be a 40-foot shipping container canopy).
5. Establish new / upgrade existing structures to house material processing equipment (identified in point 7 below).
6. Upgrade existing glass shredding structure, to include dust extraction and filtration, separate from main sorting line and material processing area to prevent nuisance from dust and noise. To be undertaken in the existing structure or, if found to be unsuitable, through provision of dedicated contained vessel (i.e. 20 foot shipping container with air extraction and HEPA filter) for glass crushing activities.
7. Supply additional equipment to optimize processing and marketability of potentially recoverable materials (conveyor belt sorting line, recovered material containers, reject material containers, baler, plastic shredder, plastic wind sifter, Expanded Polystyrene processor, glass crusher, etc. and all electrical fittings and machine installations).
8. Install weighbridge on main access road to Brookshabad adjacent to gate to the DRC.

Garacharama SLRM:

1. Supply the existing SLRM structure with a coconut husk hammer mill.

Relevant to both facilities:

1. Strengthen segregation of materials during waste collection, transport and transfer, including improving / upgrading secondary waste collection locations with wet/dry waste segregation and covered storage.
2. Develop robust contracts with clearly defined Operational Standards (including performance indicators) and stakeholder roles and responsibilities for Collection service, transfer service and SLRM operators with supervisory oversight and enforcement mechanisms.
3. PBMC to monitor and enforce operational standards
4. Implement outcome of training to integrate service chains and connect to material markets.

To achieve this, the following equipment is recommended to be purchased by the CCP-ME project.

List of equipment and materials for MRF pilot project

#	Item	Number of units	INR / Unit	Total INR
1	Conveyor system (1.1m wide by approximately 9m long) with loading hopper	1	850,000	850,000
2	Wind sifter / Air density separator / Phatka Machine (placed after last conveyor - plastics contaminant removal air cleaner)	1	200,000	200,000
3	Plastics shredder with loading hopper– for light plastics	1	500,000	500,000
4	Agglomeration Machine with loading hopper	1	350,000	350,000
5	Gatta Machine with loading hopper	1	300,000	300,000
6	Containers - Recovered material (0.75m^3 capacity)	16	14,000	224,000
7	Containers – Rejected material (1m^3 capacity)	4	18,000	72,000
8	Container – Hazardous Waste (250ltr capacity)	4	8,000	32,000
9	Vertical or horizontal Baler (1 tonne, minimum)	1	500,000	500,000
10	Jumbo Sacks (1m^3)	20	400	8,000
11	Fire extinguishers (9 kg ABC foam type)	6	1,000	6,000
12	Pressure washer (130 Bar, 3 HP / 1500 Watt) with all hoses and attachments	1	18,000	18,000
13	Industrial platform weigh scales	2	15,000	30,000
14	Glass shredder / hammer mill	1	364,000	364,000
15	Exhaust fans with HEPA filter and ducting	3	50,000	150,000
16	Evaporative air cooler (with all attachments)	2	70,000	140,000
Sub-total				***3,744,000***
17	Green coconut husk hammer mill	1	230,000	230,000
Sub-total				***230,000***
TOTAL				**3,974,000**

SLRM structures already exist at the Brookshabad DRC, however, site operational and infrastructure improvements are required to enhance and optimise the facility. The following infrastructure improvements are recommended to be provided and installed at the Brookshabad DRC site to enhance operational efficiency and effectiveness of provided equipment. Installation costs have not been factored in at this time.

Indicative infrastructure requirements for proposed MRF

#	Item	Number of units	INR / Unit	Total INR
1	Shipping container – 20-foot standard	3	179,000	537,000
2	Shipping container – 40-foot standard	2	280,000	560,000
3	Shipping container canopy shelter (6m x 8m) – Galvanized steel piping structure with UV, flame, tear, and rain resistance made from 720 g/m2 PVC, or where not required to be fire resistant it can be reduced to 350 g/m2 heavy PE plastic	1	148,000	148,000
4	Shipping container canopy shelter (12m x 8m) Galvanized steel piping structure with UV, flame, tear, and rain resistance made from 720 g/m2 PVC, or where not required to be fire resistant it can be reduced to 350 g/m2 heavy PE plastic	1	240,000	240,000
5	Lighting		90,000	90,000
6	Drinking water station		25,000	25,000
7	Electrical and machine installation works		TBD	
8	Power backup generator (optional)		Optional / TBD	
TOTAL				**1,600,000**

Once the equipment and infrastructure are agreed to and installed, the CCP-ME project will provide Standard Operating Procedures along with specific practical training to the site operator and related stakeholders to assist build capacity to operate, maintain and supervise sustainable material recovery and marketing.

Further details and background to the design considerations are provided in the subsequent main document.

2. Background

This document summarizes the background, proposed scope and equipment specifications for a decentralized Material Recovery Facility (MRF) demonstration project as a means to reduce dry / non-biodegradable waste leakage from the Municipal Solid Waste (MSW) in Port Blair.

The project is being implemented under the Cities Combatting Plastic Entering the Marine Environment (CCPME) project which is funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and anchored at the Ministry of Housing and Urban Affairs (MoHUA), Govt. of India. The objective of the CCP-ME project is to prevent plastic waste leakage at source through sustainable waste management practices in cities by upgrading infrastructure, strengthening digital monitoring and exchange mechanisms and supporting the development of national framework conditions.

The project is being implemented in the three cities of Kochi, Kanpur and Port Blair and their respective states. The project will work on interventions to enable selected cities to improve collection, segregation and marketing of plastic waste, to prevent plastic disposal to water bodies, and to improve handling of port and marine waste. This needs to be combined with new tracking, data management and reporting systems, civil society involvement and increased cooperation with the recycling industry. This is in line with the amendment of the Municipal Solid Waste Management rules in 2016 which stipulate the segregation of waste at source in order to enable its recovery, reuse and recycling. The project activities will also be in line with Plastic Waste Management rules 2016.

The approach of the project also includes strengthening of state level authorities in selected states to assume their role in managing plastic waste, in scaling up good practices and in facilitating experience exchange between ULBs. This further includes harmonized reporting systems and the establishment of digital exchange platforms for marketing recyclable materials as well as support in the roll out of state level efforts towards extended producer responsibility.

At National level the project is working with MoHUA and will develop and introduce a national digital platform together with MoHUA to establish links between states, cities and the recycling industry. It will also be used to monitor recycling and reuse of plastic and non-biodegradable waste. In addition, standardized reporting mechanisms for cities and states to the national level related to quantities of different fractions of recycled dry waste (in particular plastics) will be developed.

3. Introduction

With a population of around 150,000 combined with daily commuters and tourists, Port Blair generates some 76 Tonnes of MSW per day. Under the SWM Rules and UT by-laws, ULBs are required to establish decentralized material recovery and composting initiatives. PBMC have made significant efforts in this regard, with **12 operational Solid Liquid Resource Management (SLRM) centers established across the city,** each with a capacity of ~1.5 - 2.0 TPD. While the infrastructure at these sites are owned by the PBMC, their operation and equipment are outsourced to private operators with the 12 sites currently having 7 different operators. The SLRMs undertake, (a) segregation and packaging of dry waste received from secondary collection/ transfer points (b) operation of the plant developed by PBMC (c) sale of segregated recyclables and non-recyclables waste (d) Transportation of segregated waste to mainland, and (e) Transportation of rejects to authorized disposal site.

Despite these initiatives, the waste management system, including operation of these SLRMs, remains sub-optimal with the following challenges identified (annexure 1 has additional details):

Challenges in managing dry and non-biodegradable waste in Port Blair

1. **Low segregation level at source:** Low levels of segregation at the household level combined with insufficient segregated collection impact the quantity and quality of dry waste reaching the SLRMs

2. **Low capacity utilization and poor operational efficiency:** The existing SLRMs are underutilized with utilization as low as 30-35%. Development of new MRF without improvement in overall efficiency of the SWM system will impact the sustainability of the existing SLRMs.
3. **Limited waste categories handled at SLRMs:** The SLRMs units are acting as aggregating center with limited categories of waste being handled, mainly paper, board, tetra pack, glass and cans.
4. **Limited processing of segregated waste:** Limited processing of waste is observed at the SLRMs and there is a need to increase material value by providing additional processing.
5. **Commercial waste dumped at dumping site:** Commercial waste, generally containing higher value materials is not directed to SLRMs and taken directly to the dumping site.
6. **Large quantities of coconut waste generated which is not processed:** Processing of coconut waste generated in Port Blair which accounts for 23.3% of total waste generated in the city.
7. **Weak market linkages:** Market linkages for segregated material are weak and need to be strengthened, waste shipped to mainland.

In addition to the above stated challenges, at the individual SLRM level, the lack of space to stockpile incoming waste, process waste, and safely store baled/bagged processed waste as well as rejected waste for disposal also cause considerable challenges (Figures 1 and 2).

Figure 1: Over filled SLRM (left), uncontained rejected waste dumping beside SLRM (right)

Figure 2: Uncovered baled waste disorganized and loosing value due to exposure to elements

To address some of these challenges, the CCP-ME rapid assessment identified and recommended (a) channeling adequate amount of waste to these SLRMs / MRFs by improving segregation at source, (b) Improve operational standards and efficiency of SLRMs (through performance indicators within operator contracts), (c) stimulate an increase processing capacity for valuable waste at SLRM units (e.g. Low value plastic, coconuts, glass etc.) resulting in reduced rejects from SLRM and valuable waste ending up in dumping site, (d) improve financial viability of SLRMs and (e) develop market linkages for the outputs, to mention a few.

To this end, the CCP-ME project intends to assist PBMC establish a demonstration decentralized MRF with the aim to illustrate a means of increasing the quantity, quality, and efficiency of dry waste/ non-biodegradable waste recovery, reduce leakage from the MSW management service chain to the environment, and minimize the uncontrolled disposal of reject material. This demonstration is intended to provide lessons to PBMC on how to replicate good practice in other existing and planned SLRMs.

Following presentation of options for the demonstration MRF project to overcome these challenges, PBMC has selected Option 3, (as per letter in Annexure 3) which covers:

A. **Strengthen and increase efficiency of the existing SLRMs + establish a demonstration with augmentation of one pilot MRF/ SLRM with better segregation platforms, processing of low value waste for market linkages.**
B. **Establish a glass processing option**
C. **Solution for low value plastic materials processing**
D. **Green coconut recycling**

For success of the above-mentioned interventions, our recommendations are for PBMC to focus on planning and service administration (collection and SLRM operations) to optimize the inter-connectivity of the links and stakeholders in the service chain as well as the efficient and clean operation of services without material leakage to the environment.

4. Proposed demonstration MRF location and site characteristics

Based on discussions with the PBMC, the proposed SLRM to be enhanced as a demonstration site through equipment augmentation is the SLRM at DRC Brookshabad while coconut waste processing equipment will be supplied to the SLRM at Garacharama. Both locations are highlighted in Figure 3 in relation to the PBMC area as well as the PBMC waste disposal site, also located at Brookshabad.

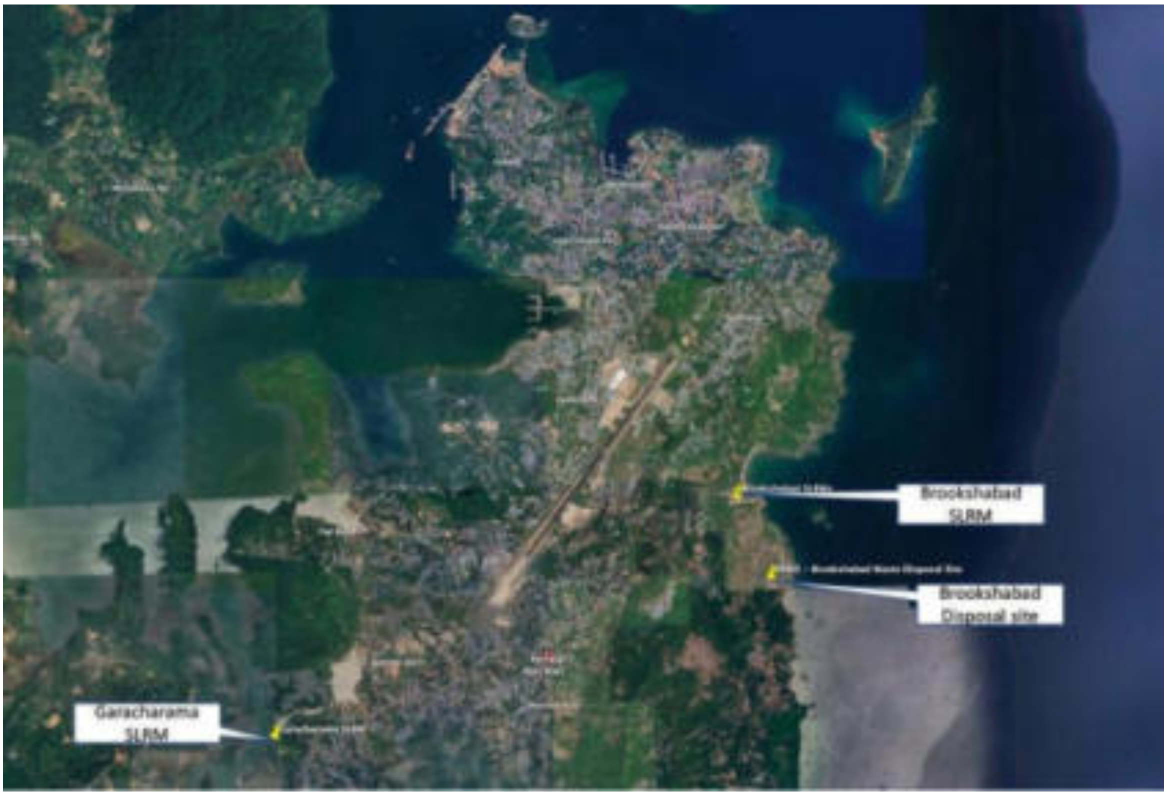


Figure 3: Location of proposed demonstration SLRM sites within Port Blair Municipal Corporation area (Google Earth)

4.1. Brookshabad Dry Resource Centre (DRC) / SLRMs:

The Brookshabad DRC is located beside the access road to the Brookshabad waste disposal area, which is currently an uncontrolled dump site but has great potential to establish an engineered landfill. This makes the DRC well positioned both to receive source segregated dry waste without adjusting the waste collection routes that would otherwise be taking it to disposal as well as enabling access to collection vehicles to remove residual materials from the DRC / SLRM to disposal as required.

As illustrated in Figure 4, the DRC covers roughly 12,000 m^2 with ten structures occupying some 10% of the area (1270 m^2) as indicated in Table 1. Four structures currently process dry waste, plus one glass shredding unit, and one wet waste composting building. An electronic waste / hazardous waste material store is also located on site.

Table 1: Brookshabad DRC structures, uses and area.

Structure Purpose	Area (m^2)
Worker room	50
New administration / guard house	50
WEEE / Hazardous waste store	100
Cardboard & Plastic SLRM	200
Compost SLRM	150

Structure Purpose	Area (m^2)
Plastic & Cardboard SLRM	320
Glass shredder structure	80
Plastic SLRM	150
Plastic SLRM	150
Water tower	20

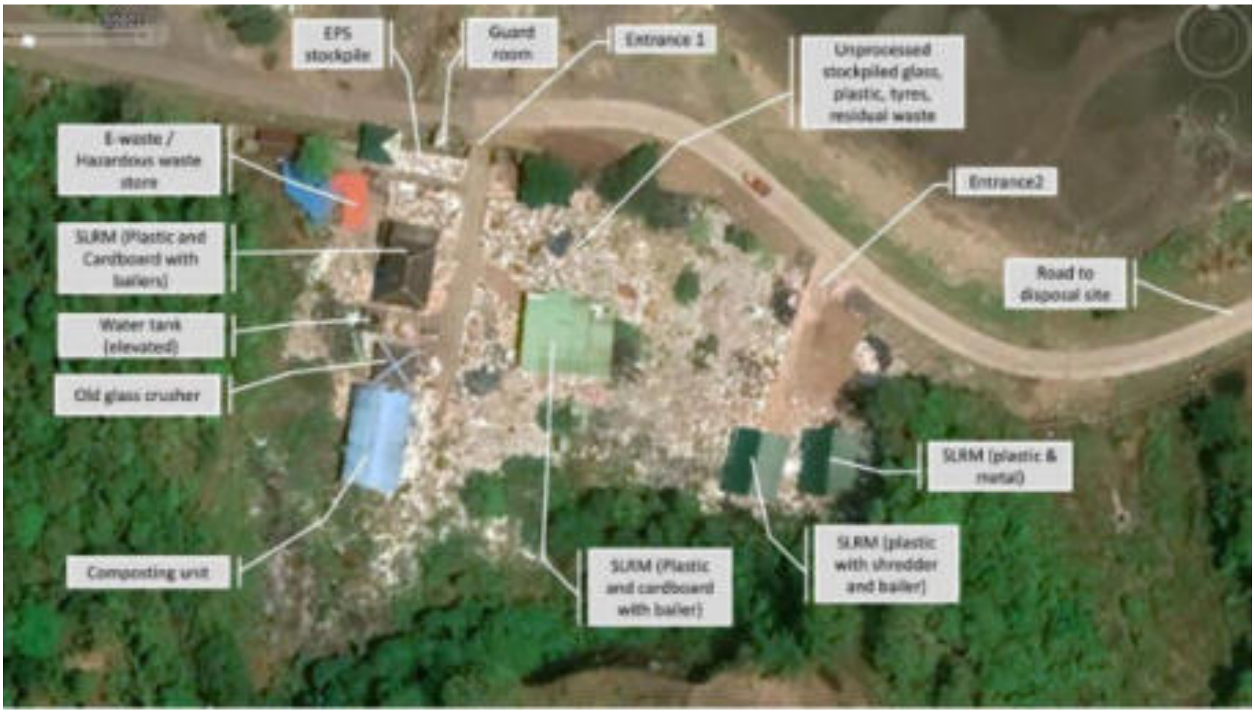


Figure 4: Brookshabad DRC layout and main features (Google Earth, 2022)

The SLRM units located on site are operated by two private operators, through contracts administered by PBMC. The private operators are responsible for providing the equipment to recover and process the waste that is delivered to the SLRM by PBMC, and identify markets for the materials. The operator pays PBMC a fee per ton of material processed.

Figure 5: Glass shredder unit within structure (Left) with unprocessed glass stockpiles outside (Right)

Much of the site is open land that has become an extensive storage area for unprocessed dry waste, in particular vast quantities of glass have been, and continues to be stockpiled on site, mainly without organization or planning (Figure 6). A glass shredder(Figure 5) located on site is not in use due to health issues reported from its operation as well as financial disputes on the payments due from/to PBMC, the operator and EPR systems for the handling and processing of glass.

Figure 6: Unorganised and exposed stockpiling and discarded materials throughout Brookshabad DRC

Glass and other unprocessed dry waste materials occupy some 80% of the open area on site (Figure 7) with decreasing room for maneuvering and limited room for processed material storage. This is in part due to limited markets for material, in-efficiencies in processing, contractual / financial disputes and lack of operator role and responsibilities with associated supervision and enforcement. Contracts are short and do not specify performance standards, quantity of material to be processed, organization or maximum storage time / maximum quantity of materials allowed to be stored on site, or roles and responsibilities for disposing of rejected materials. This lack of clarity along with lack of supervision / enforcement mechanisms has resulted in the site

Figure 7: Expanded Polystyrene (Left) Hazardous waste stored in open (Centre and Right).

A priority for the Brookshabad DRC is to demonstrate means to improve general housekeeping and organized storage of unprocessed and processed dry waste, and assist with equipment to demonstrate how to process materials including how to access markets for those materials efficiently.

In addition, as identified during the rapid assessment phase, training is required both to the operators, contract administrators, and PBMC supervisors.

Broad site characteristics of the proposed MRF location are detailed in Table 2.

Table 2: General characteristics of proposed MRF demonstration site at Brookshabad DRC

#	Site Parameters	Brookshabad
1.	Location	Brookshabad
2.	Space availability Dimensions, surroundings, potential for expansion	DRC area is 12,000m^2 with 10 buildings currently occupying 10% of area. Remaining area available for re-organisation.
3.	Availability of recyclable material	Available, Dry wastes from commercial dry waste collection. Rejected materials (single use plastics, glass etc) from SLRM centers
4.	Approach road/ connectivity	Site is adjacent to the road
5.	Adequate road widths and curb space for vehicles	Available
6.	Proximity trader/ processor	Two SLRMs centers within the DRC facility itself.
7.	Proximity of transfer station	Not available at present, although space available and transfer vehicles operating adjacent to site to incorporate collection and transfer of residuals from site.
8.	Proximity of disposal site	0.8 km away
9.	Storage space availability	Yes
10.	Availability of small scrap dealers in proximity	Yes

Garacharama SLRM:

Located in ward number 18 of PBMC, currently consists of two buildings, one designated as a wet waste composting facility and one for dry waste processing (Figures 9). The facility designated for wet waste composting is currently utilized as a storage facility for dry waste (predominately carboard), while the dry waste unit is currently vacant with some equipment being installed including a horizontal baler and some wood working / carpentry equipment.

Figure 8: Garacharama SLRM location, dry waste processing (left), wet waste composting (Right). (Google Earth)

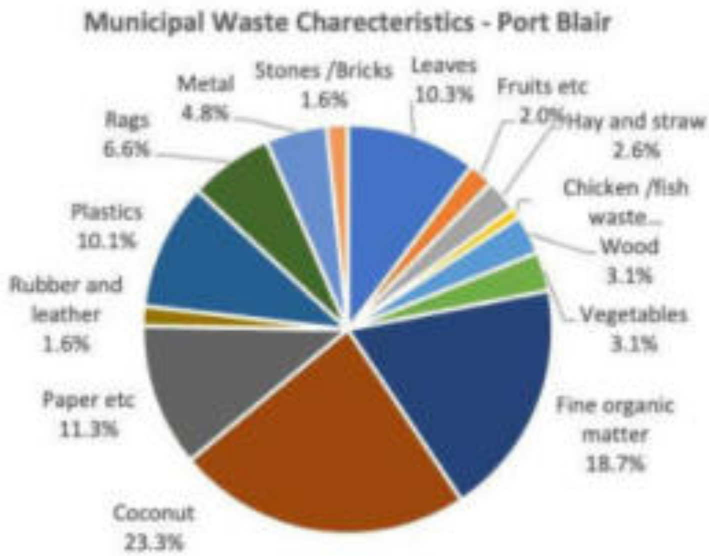
Some 17.5 TPD of coconut waste is generated in Port Blair city representing a significant waste stream to manage. It has therefore been proposed to provide and install a coconut husk hammer mill to process the husks into coir fibres for marketing. The activities at this demonstration will be limited to provision of the equipment item and MRF administration training. Broad site characteristics of the proposed MRF location are detailed in Table 3:

Table 3: General characteristics of proposed MRF demonstration site at Garacharma SLRM

#	Site Analysis Parameters	Garacharma
1.	Location	Ward Number 18, near cremation ground
2.	Space availability Dimensions, surroundings, potential for expansion	Plot dimensions: Approx. 140sqm, two sheds are constructed one for wood waste another for coconut waste

5. Waste flow to the MRF Facility

53% of MSW generation in PBMC is identified to be wet / organic waste. Total dry waste is estimated at 25.4 TPD. Paper and plastics form the major share of non-biodegradable waste, constituting 31% and 28% respectively. Other major categories include rags and metals, constituting 18% and 13% respectively. Other categories such as rubber, leather and stones and brick constitute to 9% of the total non-biodegradable waste. A broad characterization of biodegradable waste in Port Blair is presented in Figure 9.



Composition of waste	%
Leaves	10.3%
Fruits etc	2.0%
Hay and straw	2.6%
Chicken /fish waste	0.9%
Wood	3.1%
Vegetables	3.1%
Fine organic matter	18.7%
Coconut	23.3%
Paper etc	11.3%
Rubber and leather	1.6%
Plastics	10.1%
Rags	6.6%
Metal	4.8%
Stones /Bricks	1.6%
Total	100.0%

Figure 9: Port Blair Municipal Solid Waste Composition

Limited information is available on the waste flow to Brookshabad DRC. It was mentioned by PBMC that the dry waste from commercial areas from ward 4 & 5 will be directed to the proposed facility, in addition to the rejects from the SLRMs would be further processed in the demonstration project.

A broad waste flow for the proposed demonstration projects is presented in Figure 10. It is estimated that 9.5 TPD is available from commercial areas, however, only 5.0 TPD of dry waste is estimated to be diverted to the proposed SLRM/ MRF, with the remainder anticipated to be diverted to existing SLRMs. In addition, rejected waste from the existing SLRM's is also anticipated to be diverted to the demonstration SLRM/ MRF, mainly constituting low value RDF material, glass and other reject waste. Glass waste from the commercial areas and the SLRMs is expected to reach the proposed facility, however quantification of waste is not available. It is assumed that 4-5 TPD of glass waste will be available at the proposed facility. In addition, 17.5 TPD of coconut waste is generated in the city, with 4 TPD of coconut waste expected to be processed at the proposed demonstration coconut treatment facility.

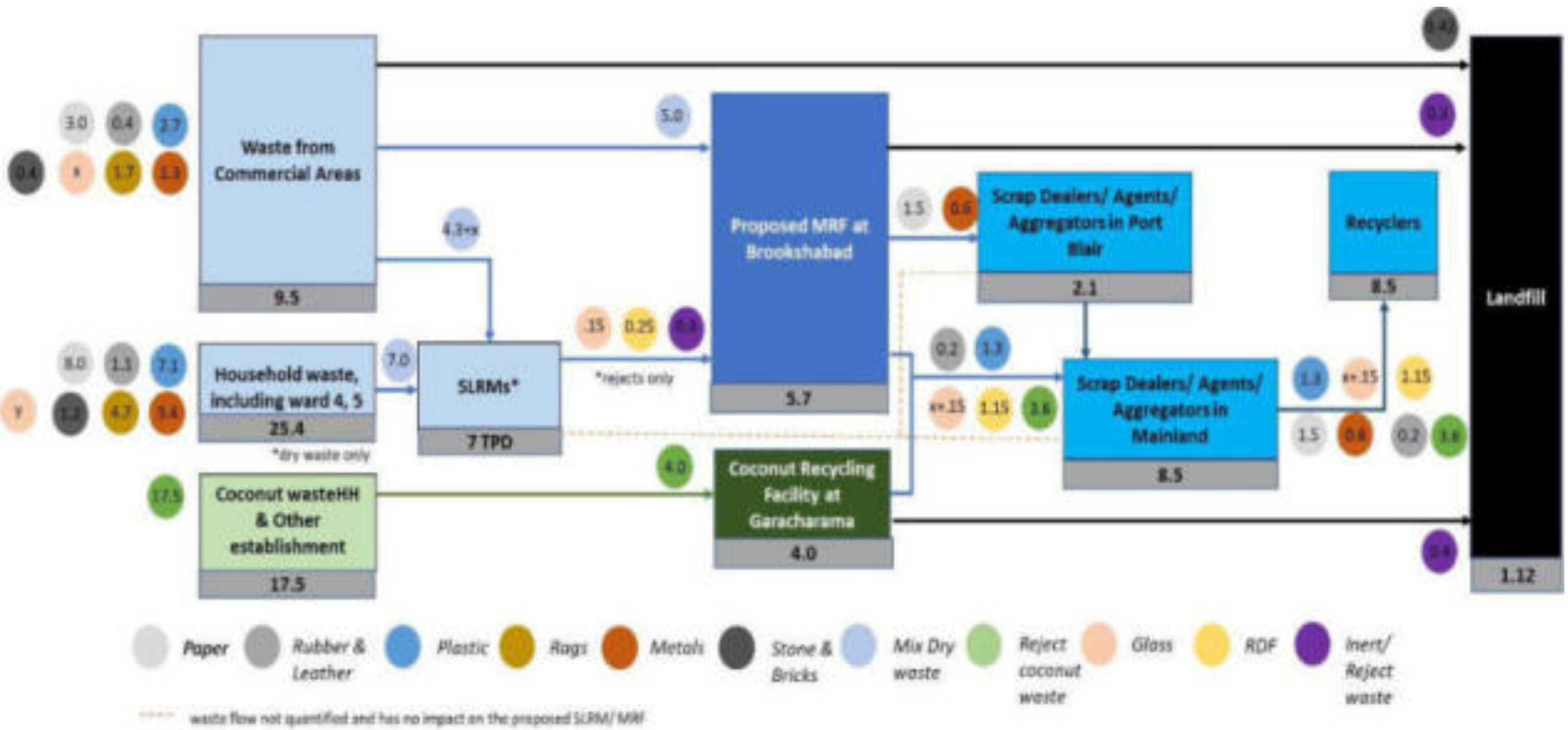


Figure 10: Predicted potential material flows through the demonostration MRF sites

Notes:

1. 6-7 TPD of dry waste is reaching the SLRMs.
2. In wet waste, only coconut waste component has been considered for waste flow assessment.
3. Estimates of glass waste is not available, however it is assumed that 4-5 TPD of glass waste will reach the proposed MRF/ SLRM.
4. Above waste flow is waste flow is a broad estimate based on experiences from similar Indian cities and benchmarks and a study on waste characterization and quantification is required before finalization.

6. Demonstration MRF function and design

Based on the assessment of the existing facilities, site operations and anticipated waste flows, the following activities are proposed requirements to make the demonstration project at Brookshabad DRC and Garacharama SLRM:

6.1. Brookshabad DRC:

1. Design an optimized layout and site plan for the DRC – to include optimization of existing SLRM operators, operator models and clarify stakeholder responsibilities
2. Clear and dispose of historic, degraded, and other materials with no use / value currently discarded throughout site. To include bush clearance and space revival.
3. Provide clearly identified and contained covered and uncovered storage space for incoming unsorted materials, and recovered and baled / bagged materials. To include installation of storage bays for various high-volume materials, including glass (uncovered bay), paper & cardboard (covered bay), plastics (covered bay) and mixed dry waste (covered bay) as well as covered storage bays for processed and baled / bagged materials and separate bay for rejected materials to be transferred for disposal. Instigate proper organization and housekeeping on site.
4. Establish new covered structure/s to house a conveyor belt picking line to optimize efficiency of material recovery (recommended to be a 40-foot shipping container canopy).
5. Establish new / upgrade existing structures to house material processing equipment (identified in point 7 below).
6. Upgrade existing glass shredding structure, to include dust extraction and filtration, separate from main sorting line and material processing area to prevent nuisance from dust and noise. To be undertaken in the existing structure or, if found to be unsuitable, through provision of dedicated contained vessel (i.e. 20 foot shipping container with air extraction and HEPA filter) for glass crushing activities.
7. Supply additional equipment to optimize processing and marketability of potentially recoverable materials (conveyor belt sorting line, recovered material containers, reject material containers, baler, plastic shredder, plastic wind sifter, Expanded Polystyrene processor, glass crusher, etc. and all electrical fittings and machine installations).
8. Install weighbridge on main access road to Brookshabad adjacent to gate to the DRC.

6.2. Garacharama SLRM:

1. Supply the existing SLRM structure with a coconut husk hammer mill.

6.3. Relevant to both facilities:

1. Strengthen segregation of materials during waste collection, transport and transfer, including improving / upgrading secondary waste collection locations with wet/dry waste segregation and covered storage.
2. Develop robust contracts with clearly defined Operational Standards (including performance indicators) and stakeholder roles and responsibilities for Collection service, transfer service and SLRM operators with supervisory oversight and enforcement mechanisms.
3. PBMC to monitor and enforce operational standards
4. Implement outcome of training to integrate service chains and connect to material markets.

To provide the recommended additional covered equipment space at Brookshabad DRC, it is proposed that shipping container canopy shelters (Figure 11) are installed at the site. This is a flexible solution with 20-foot and 40-foot container options that is quick to install, movable, and relatively cheap, providing shelter from sun and rain between the containers as well as secure storage within the containers. Glass crushing / shredding operations can be undertaken within one of the shipping containers to minimize nuisance provided sufficient extraction and air filtration is provided.

Figure 11: Example shipping container canopy / shelters recommended

This solution can be replicated at other SLRMs and transfer points to provide additional covered storage or waste transfer containment (including transfer site at Mohanpura area of PBMC). Being non-permanent and relocatable in a matter of hours, they serve as a good demonstration for replication. Additional bay configurations and types can be used to expand the covered area for use in storing / containing multiple materials / tasks including transfer activities (Figure 12 & 13).

Figure 12: Example of how multiple shipping containers and canopies can be combined to establish larger partitioned and organised storage

Figure 13: Example processed and unprocessed material storage bay concepts

The current unorganized material storage and operations at the Brookshabad DRC requires to be planned and organized. Figure 14 illustrates, using an example layout with organized storage bays.

Figure 14: Example planned layout for integrated Brookshabad DRC and SLRM demonstration site (not all items to be procured or installed under project, illustration only, white dialogue balloons indicate project focus areas). (GoogleEarth).

7. Material recovery process flow

Within the two demonstration MRF facility, waste material will be processed through a flow of activities as presented in the schematic in Figure 15.

The first flow is for soft mixed low value plastics, the Phatka machine cleans dirt and dust off the plastic and separates out any heavy contaminants, the agglomeration machine then shreds the plastic into fine material than enables it to be fed into the Gatta Machine which lightly melts the plastic into dense ingots for more efficient marketing. The same process is also used for Expanded Polystyrene (EPS).

Homogenous plastics, such as LDPE film, PET and HDPE bottles, PP tubs as well as cardboard can be directly segregated and baled into a densified blocks for transport to market. Harder plastics including PP crates and ABS car parts, pipes etc. can be shredded and bagged for economical transport.

Glass can be crushed through a hammer mill and sent as cullet for recycling into glass or further processing into sand or construction aggregate.

The separate Coconut waste processing will involve a hammer mill that pulverizes the coconut husk to break the coir fibres apart for marketing as fibres.

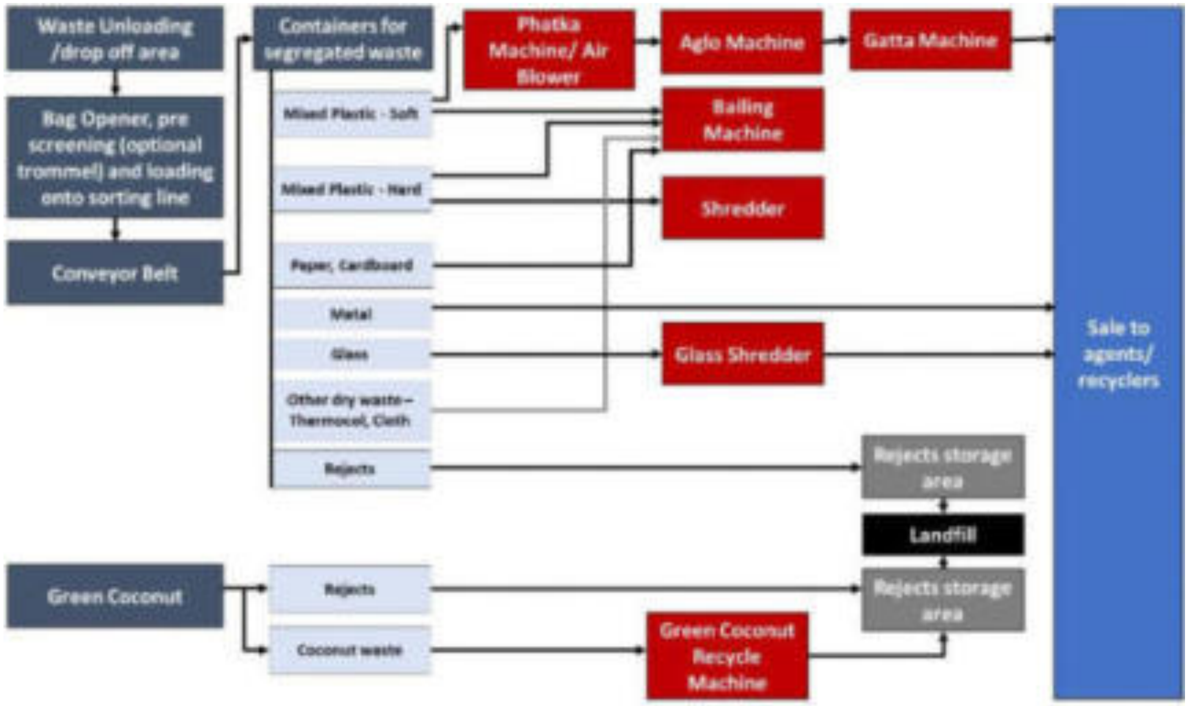


Figure 15: General schematic process flow of proposed MRF with optional equipment included

8. Equipment layout within the MRF facility

Figure 16 presents an indicative layout for the Brookshabad demonstration MRF. This aligns with the features highlighted in Figure 14 as demonstration project focus points. If funds are available, then procurement of additional storage bays is highly recommended.

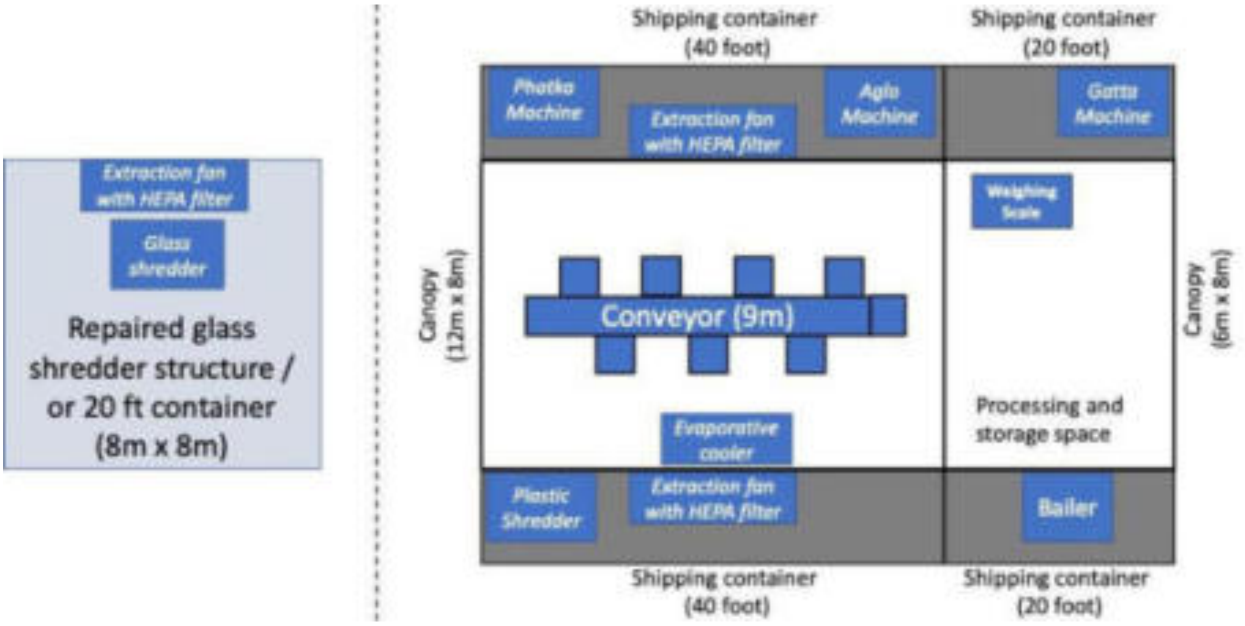


Figure 16: Proposed layout and extension to existing facility

It is recommended that the existing glass processing structure is rehabilitated, and a proper extraction ducting and HEPA extraction filter and fan installed to enhance operator safety. If this structure is deemed beyond repair, it's recommended to install the glass shredder within a 20foot container with extraction fan and filter installed within it.

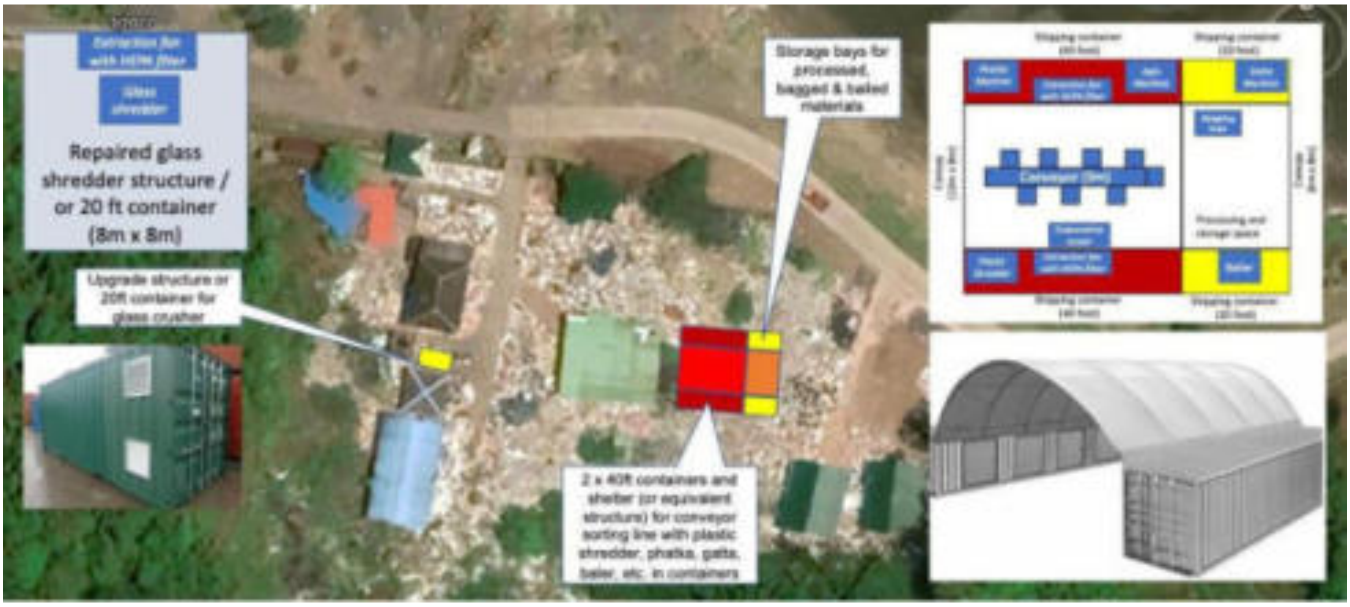


Figure 17: Immediate interventions recommended for Brookshabad DRC


Figure 18: Individual shipping containers can be modified to improve working conditions / access to machines (example only)

To demonstrate a fast and effective means of establishing a facility, it's recommended to establish the demonstration MRF within a shipping container and canopy structure (Figure 17 and 18). This will greatly expedite the establishment of the facility and also allow the demonstration of such concept for adoption in other areas of the waste management service to optimize service provision.

9. Equipment specifications

Proposed equipment for the MRF is presented in Table 4. More detailed specifications for each item is provided in the subsequent tables. Tables 4 also presents approximate equipment prices as obtained from initial requests from the Indian Market to assist decisions to be made on which equipment and layout option to pursue. Note that the prices presented DO NOT INCLUDE transportation, packaging, GST or installation which are required to be factored in separately.

Table 4: List of equipment and materials for MRF pilot project

#	Item	Number of units	INR / Unit	Total INR
1	Conveyor system (1.1m wide by approximately 9m long) with loading hopper	1	850,000	850,000
2	Wind sifter / Air density separator / Phatka Machine (placed after last conveyor - plastics contaminant removal air cleaner)	1	200,000	200,000
3	Plastics shredder with loading hopper– for light plastics	1	500,000	500,000
4	Agglomeration Machine with loading hopper	1	350,000	350,000
5	Gatta Machine with loading hopper	1	300,000	300,000
6	Containers - Recovered material (0.75m^3 capacity)	16	14,000	224,000
7	Containers – Rejected material (1m^3 capacity)	4	18,000	72,000
8	Container – Hazardous Waste (250ltr capacity)	4	8,000	32,000
9	Vertical or horizontal Baler (1 tonne, minimum)	1	500,000	500,000
10	Jumbo Sacks (1m^3)	20	400	8,000
11	Fire extinguishers (9 kg ABC foam type)	6	1,000	6,000
12	Pressure washer (130 Bar, 3 HP / 1500 Watt) with all hoses and attachments	1	18,000	18,000
13	Industrial platform weigh scales	2	15,000	30,000
14	Glass shredder / hammer mill	1	364,000	364,000
15	Exhaust fans with HEPA filter and ducting	3	50,000	150,000

16	Evaporative air cooler (with all attachments)	2	70,000	140,000
Sub-total				***3,744,000***
17	Green coconut husk hammer mill	1	230,000	230,000
Sub-total				***230,000***
TOTAL				**3,974,000**

9.1. Technical specifications of recommended equipment

Item	**1a. Loading hopper**
Description	Feed hopper connected to conveyor to enable loading of waste manually and mechanically onto waste picking conveyor line.
Technical specifications	• Mild steel construction • 2000 mm loading opening reducing to 1100 mm opening to meet width of conveyor belt • Can be integrated into conveyor as one unit or designed to mount on top of sorting conveyor. • Loading height to be suitable for conveyor and accessible by both mechanical and manual loading (no greater than 1.5m above ground level for manual loading, loading door access acceptable)
Example	• 

Item	**1b. Conveyor – for Waste picking**
Description	Conveyor belt suitable to conveying mixed municipal waste past manual waste pickers who shall manually pick materials from the conveyor. The belt must have room for a minimum of 3 waste picker stations and recovered material containers on each side.
Technical specifications	• Operation: 1 TPH • Connected Load: 4 kW • Working width: 1100 mm • Working length: minimum 7000 mm • Belt: Mechanically jointed 3-ply PVC UV stabilised. • Belt Speed: Flexible adjustment • Working places for 6 persons with 1m^3 container • Machine must have emergency stop accessible to all workers either by overhead or waste height pull wire that immediately stops the machine.
Example	

Item	**2. Wind Sifter / Air Density Separator / Phatka Machine**
Description	Located at end of sorting conveyor to blow off light plastic fraction for recovery and leaving the heavier materials to fall into reject material bin. Machine to process

	recovered light plastic fraction, cleaning off dirt and abrasives prior to material shredding.
Technical specifications	• Connected Load: 7.5 kW • Processing all soft plastics • Output - 500 kg/hr

Item	**3. Plastics Shredder**
Description	Machine to shred recovered plastics to a small 50mm diameter for more efficient bagging or onward processing.
Technical specifications	• Incorporated loading hopper • Connected Load minimum 25 kW • 250 - 500 kg / hour • Mild Steel construction • Minimum twin Sharpenable and replaceable blades • Integrated loading hopper

Item	**4. Agglomeration Machine**
Description	Processing light plastic material into fine densified material for processing through Gatta Machine
Technical specifications	• Minimum 35 kW • 250 - 500 kg / hour • Mild Steel construction • Minimum twin Sharpenable and replaceable blades • Integrated loading hopper

Item	**5. Gatta Machine**
Description	Processing agglomerated plastics into extruded ingots
Technical specifications	• Minimum 15 kW • 200 kg / hour • Integrated loading hopper 50 kg automatic feed • Mild Steel construction • Electric heating elements – replaceable • Integrated or separate Water basin for ingot cooling to be included

Item	**6 & 7. Containers – Recovered materials and Rejected materials**
Description	0.75 and 1m^3 Metal or plastic waste material containers with open top and capable of being tipped or opened on one side. The containers are to sit alongside the waste pickers working on the sorting conveyor line for them to drop recovered materials into. Also to be placed at end of sorting conveyor to receive rejected materials directly from the end of the conveyor belt.
Technical specifications	• Volume: 0.75m^3 and 1m^3 • HDPE or similar Polymer Injection moulded • UV-stabilised and resistant to decay, heat and chemicals • Wheels optional – trolley to be provided if no fixed wheels included. Any wheels and attachments to be corrosion resistant steel components (Wheel fork, wheel bearings, swivel brackets) • Uniform colour, but specific colour not important • To include trolley if robust wheels not integrated

Item	**6B, 7B. Container trolley / Pallet truck (Optional)**
Description	Trolley capable of aiding the manoeuvring of 1m^3 and 0.75m^{3}containers (listed in item 3 & 4) when empty or full throughout the MRF facility and capable to tipping contents out without over exerting operator.

Technical specifications	• Hand / manual operation • Load capacity: 3000 kg • Lift height: minimum 200mm • Compatible with containers identified in items 3 and 4

Item	**8. Containers – Hazardous Materials**
Description	250 litre (0.25 m^3) wheeled bins, to be placed alongside waste pickers working on picking line for them to drop hazardous waste into.
Technical specifications	• Robust plastic wheeled bin container with lid • 250 litre (0.25 m^3) volume • HDPE or similar Polymer Injection moulded • UV-stabilised and resistant to decay, heat and chemicals • Red or Yellow in colour. .

Item	**9. Vertical Baler**
Description	Vertical baler for densifying recovered recyclable materials including plastic (hard and soft), Carboard, Paper, and potentially metals.
Technical specifications	• Pressure: Minimum 60 MT • Capacity: 2.5 to 3 TPOD • Heavy duty steel construction • Electric operated - connected load 7.5 kW • Hydraulic pressure: minimum 120 BAR • Feed opening: minimum 1500mm x 600 mm • Bale size: Minimum 1500 mm x 760mm x 1200 mm • Production rate: no greater than 10 minutes per bale • Safety controls and emergency stop integrated • Processable materials: Paper, Cardboard, hard plastic, soft plastic, steel and alu cans, non-ferrous metals.

Item	**10. Jumbo Sacks**
Description	1m^3 woven sacks for storing and transporting recovered materials and shredded plastics
Technical specifications	• Material: Polypropylene • Loading Capacity: 1000kg • Colour: White • Size: 95*95*110 cm • Material strength: minimum 170 GSM • Full open top with skirt cover • Bottom Flat bottom / with discharge spout • Woven Side-seem loops
Example	

Item	**11. Fire Extinguishers**
Description	Fire extinguishers to be located at strategic locations throughout MRF facility in order to rapidly respond to and extinguisher any fire. Must be suitable for electrical and material fires.
Technical specifications	• Fire Class: A, B, C • Discharge Range (meters): 4 • Capacity: 9 kg • Fire Extinguisher Type: A B C Dry Powder Type • Material: Mild Steel • Discharge Time (Second): 15 - 20 Sec • Temperature Range (deg. Celsius): -20 to +55 Degree Celsius • Working Pressure (bar): 15 • Propellant: Nitrogen

Item	**12. Pressure Washer**
Description	Pressure washer and all required attachments to connect to on site water supply and to clean the facility floor, containers, equipment and vehicles.
Technical specifications	• Pressure rating: 130 BAR • 3 HP / 1500 Watt • 240 V, Single phase • Input water supply: Standard tap water • Input hose: minimum 10m length • Output water hose: minimum 15m length • Adjustable output spray nozzle
Example	 

Item	**13. Industrial Platform Weigh Scales**
Description	Platform type weight scales to weigh incoming and outgoing waste materials and bales. Required to be capable of weighing up to 600kg with 100g intervals.
Technical specifications	• Electronic weigh scale • Industrial platform type • Minimum measure: 600kg • Accuracy maximum: 100g

Example	

Item	**14. Glass Shredder / Hammer Mill**
Description	Convert glass into small pieces (10-20mm)
Technical specifications	• Cutter - Upto 1 rotary and 2 stationary as per application (Cutters with HCHCr blades) • Motor - 30 HP 3 Ph • Floor Area x Height - 1400 mm x 800 mm x 1800 mm height

Item	**15. Exhaust Fans with HEPA filter and ducting**
Description	Extraction fan with filtration to extract, filter and exhaust dust contaminated air from glass crusher area
Technical specifications	• Power: 520W, Voltage: 220V, Frequency: 60 Hz, Material: Steel, Motor Speed: 3300 RPM, Air Flow: 2295 CFM / 3900 m³/h, Fan Diameter: 12 inch / 300 mm, • To include ducting that shall be minimum length: 16 ft / 5 m, Thickness: 0.012 inch / 0.3 mm, • Axial Fan Bearing Type: Ball Bearing, • Noise: 71 dB(A), • Static Pressure: 373 pa, • Current: 4.622A, • Fan Dimensions(L x W x H): 15 x 14 x 16 inch / 381 x 356 x 406 mm, • Net Weight: 27.56 lbs / 12.5 kg. • 520W Pure Copper Motor: high-velocity, high-volume output, 100% copper winding motor. 3300 RPM motor speed • Noise not to exceed 80 dB (A). • User serviceable and cleanable HEPA filter inbuilt

Item	**16. Evaporative cooler**
Description	Free standing evaporative cooler for providing workers with outdoor space cooling
Technical specifications	Air • **Fan diameter:** 30" / 762 mm • **Airflow:** 10,595 CFM • **Water Consumption: in region of** 2.65 - 3.96 Gal/Hr • **Water reservoir Capacity: in region of** 16 Gal Cooling • **Cooling Area:** 2,000 - 2,500 sq. ft. • **Wet Media Pad Size:** 43" (W) x 46" (H) x 4" (D) Power • **Power Supply:** 220V / 50Hz / 1Ph • **Consumption:** 1,000 Watts

	• **Cord Length: in region of 5 m** Decibels • Not to exceed 70 db

Item	**17. Green coconut recycling machine**
Description	Green coconut can be shredded and converted into Cocopeat (Compost) and coir fiber extracted to make other products (rope, toys, etc.)
Technical specifications	• Size of Shredder – 600X1150X1400mm • Motor – 15 HP make BBL • Processing Capacity – 0.5 TPH • Blade - AR 600/32NOS • Output – 10mm-20mm

9.2. Infrastructure Requirements

SLRM structures already exist at the Brookshabad DRC, however, as discussed, site operational and infrastructure improvements are required to enhance and optimise the facility. An indicative list of the suggested infrastructure components for improving the MRF demonstration as well as improving the general Brookshabad DRC site operations are provided in Table 5. Installation costs have not been factored in at this time.

Table 5: Indicative infrastructure requirements for proposed MRF

#	Item	Number of units	INR / Unit	Total INR
1	Shipping container – 20 foot standard	3	179,000	537,000
2	Shipping container – 40 foot standard	2	280,000	560,000
3	Shipping container canopy shelter (6m x 8m) – Galvanized steel piping structure with UV, flame, tear, and rain resistance made from 720 g/m2 PVC, or where not required to be fire resistant it can be reduced to 350 g/m2 heavy PE plastic	1	148,000	148,000
4	Shipping container canopy shelter (12m x 8m) Galvanized steel piping structure with UV, flame, tear, and rain resistance made from 720 g/m2 PVC, or where not required to be fire resistant it can be reduced to 350 g/m2 heavy PE plastic	1	240,000	240,000
5	Lighting		90,000	90,000
6	Drinking water station		25,000	25,000
7	Electrical and machine installation works		TBD	
8	Power backup generator (optional)		Optional / TBD	
TOTAL				**1,600,000**

Annexure 1: Expended details on SWM challenges

Low levels of segregation at the household level impact the quality of dry waste reaching the SLRMs

Segregation at source has reportedly been initiated in all 24 wards. However, in practice, it was observed that segregation at source and segregated collection of wet waste (organic, food and garden waste) and dry waste (recyclables and non-recyclables) was not consistently maintained (particularly following a weekend). The municipal authority also notified that bulk waste generators (generating more than 50 kg per day) present in the city require to manage their own waste. However, only a few bulk waste generators (around 9) have been identified across the city of which only 2 of them are managing their own waste. Low levels of consistent quality of dry waste segregation impact the quality and quantity of waste reaching the SLRM units and only a fraction of ~25 TPD of dry waste generated ends up at the SLRMs.

Cumulative capacity of the SLRMs is estimated at ~20 TPD, however 6-7 TPD of waste is reaching the SLRM, indicating towards low utilization (30-35%) of the existing capacity and poor operational efficiency

Around 180 MT of segregated recyclables and non-recyclables was transported to the mainland from these 12 SLRMs in the month of August 2021. Accordingly, it is estimated that the dry waste managed by these SLRMs combined is around 6 to 7 TPD. However, a recent study by GIZ in March-April 2022 on SLRM estimates that the SLRMs receive 5 to 6 TPD of waste per day.

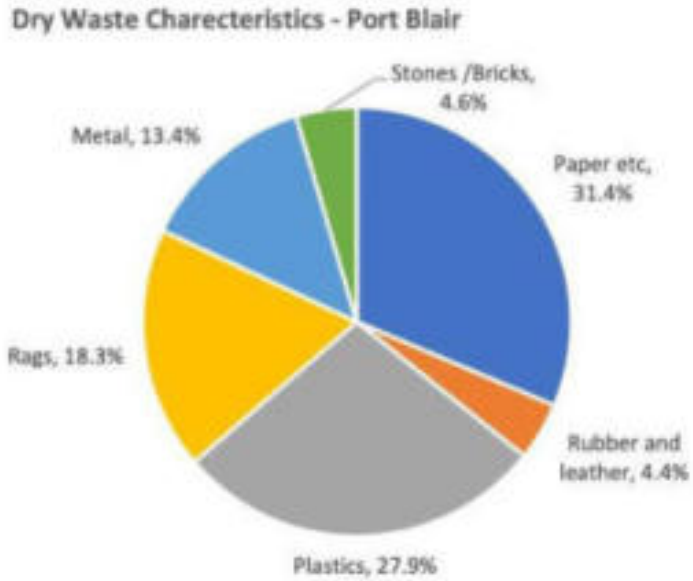
Considering that the average input capacity of the individual SLRM units is around 1.5 to 2 TPD, the total combined capacity of all 12-current operating SLRM units is estimated to be around 20 TPD. However, the actual quantity of dry waste managed in two (2) SLRM units is around 1.2 TPD with operational efficiency of 60%. The dry waste managed in other 10 SLRMs are in the range of 300 to 400 kg each with operational efficiency of 25%. In addition, there is a lack of focus on adoption of performance-based contracts for the O&M of the SLRMs - there are no key performance indicators (performance standards) defined and monitored by PBMC.

SLRM units are functioning as aggregation centers with limited categories of waste categories are handled and processed at SLRM units and 8-10% of the waste received by the SLRMs is sent to the dumping site as rejects.

A rapid assessment by GIZ of the reject waste from the SLRMs indicated that chipped pieces of MLP, other low value plastic, glass and cloth rags are the major rejects generated from the SLRMs. It constitutes to 8-10% of the waste receiving the SLRMs. The high share of rejects is mainly due to limited categories of waste being segregated and processed at the SLRM units, mainly paper, board, tetra pack, glass and cans. This indicates towards the demand for additional facilities to process the rejects from SLRMs as well as the waste not processes at the SLRMs such as low value plastic, glass, coconut waste etc.

Dry waste from commercial areas (9.6 TPD) is directly dumped at dumping site without further processing, hence critical for the proposed MRF facility

The dry waste is collected from the households and deposited at the SLRMs for further processing. However, the waste from the commercial areas is collected by SHGs/ DTDC operator and dumped at dumping site. The dry waste from commercial areas accounts to ~9.6 TPD, and discussed with PBMC the waste from the commercial areas can be directed to the proposed SLRM. With the rejects from SLRM being 8-10% of the waste received at SLRM, they accounts to 0.5 – 0.7 TPD of rejects, and with increase in the waste received at SLRM this may increase to 1.5 – 2.0 TPD of rejects. These rejects are mostly low value and have low recyclable components. Hence, is critical for channeling the waste from commercial areas to proposed SLRM/ MRF for optimum utilization and operation of the facility. A broad characterization of dry waste in Port Blair is presented below:



Composition of waste	%
Paper etc	31.4%
Rubber and leather	4.4%
Plastics	27.9%
Rags	18.3%
Metal	13.4%
Stones /Bricks	4.6%
	100%

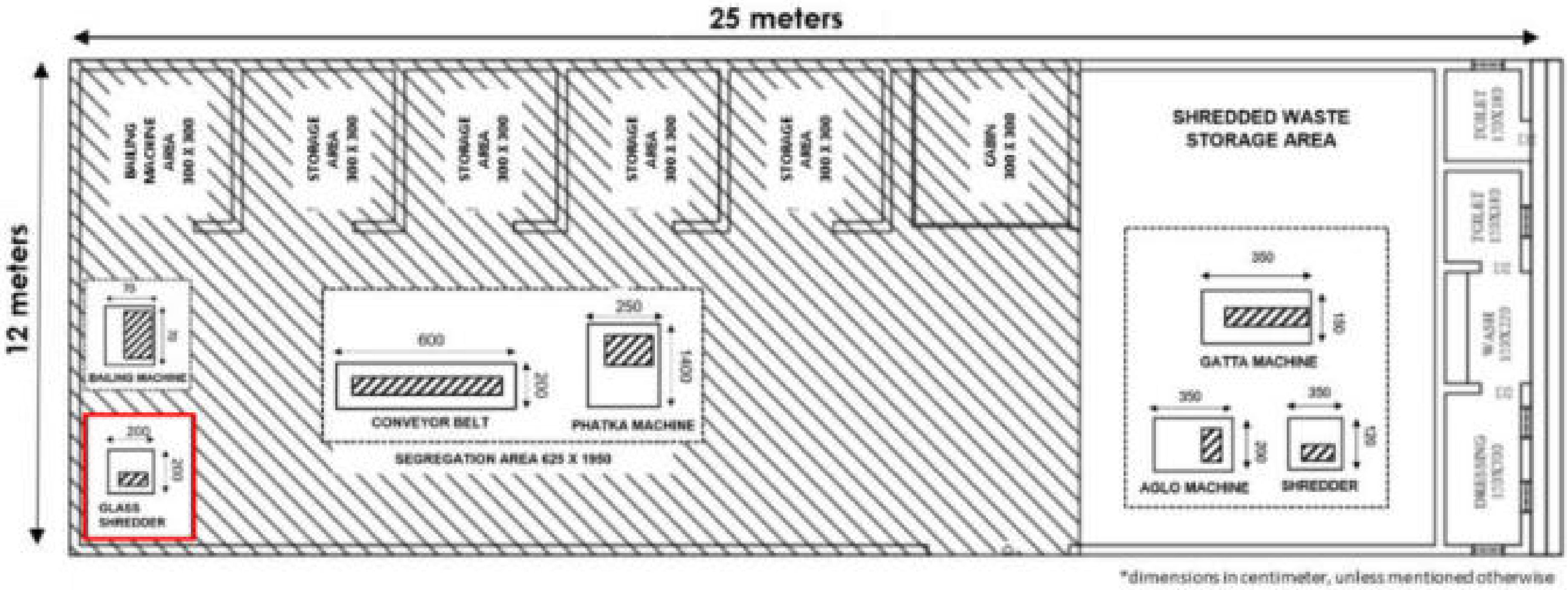
In addition to the dry waste, coconut waste is major concern for Port Blair, with 17.5 TPD of coconut waste generated.

It is observed that coconut waste share is considerable high in the wet waste and constitutes 23.3% of the total waste generated in the city. Hence, coconut waste recycling/ processing has been highlighted as one of the focus areas by PBMC.

There is very limited to no market for the segregated dry waste in the city/ UT hence waste is transported to mainland via shipping lines

Paper and metals are the only categories which undergo some form of processing in the city. Moreover, there is no market for the segregated dry waste (any category) in the city/ UT, and is transported to mainland - mainly to Chennai, Kolkata and Vishakhapatnam through 2 major shipping lines. Main waste categories transported to mainland include plastic, cardboard, glass, hazardous waste and metal.

Annexure 2: Proposed layout



Annexure 3: Letter by PBMC on MRF study

No.: 71/EE-III/SWM/MC/2018-19/
नगरपालिका परिषद् का कार्यालय
OFFICE OF THE MUNICIPAL COUNCIL
पोर्ट ब्लेयर
PORT BLAIR

Port Blair, dated [illegible].02.2022

To

The Project Head,
CCPME & MOWI Project,
GIZ-India, New Delhi

Sub: GIZ support to Andaman & Nicobar Islands under the CCP-ME project field visit for MRF Site selection and presentation of Gap Analysis report-reg.

Ref.: Your letter dated 18.02.2022

Sir,

This is to inform you that, during the visit of GIZ India to Port Blair from 20th to 22nd February 2022 to discuss the establishment of MRF in PBMC and discussed various Options for PBMC to meet the future requirements. The PBMC team after detailed discussion, it was proposed to go with Option-3 which are;

1. ***"Strengthen and increase efficiency of existing SLRMs + Establish a demonstration with augmentation of one pilot MRF/ SLRM with better segregation platforms, Processing of low value waste for market linkage",***
2. Establishment of Glass processing option,
3. Solution for Low Value Plastic Materials Processing- Polystyrene & Single Usage Plastics, and
4. Solution for Low Value Materials Processing-Green Coconut Recycling.

In view of above Option 2.0, i.e. Establishment of Glass processing option, it was explained during presentation by the GIZ team that, the crushed glass may be used for the construction & road laying purposes.

However, it is to inform that, earlier PBMC's authorized waste vendor had established a glass crushing unit at Brookshabad, but due to non-experience in operation, it affected some worker's health.

Therefore, for the management of glass, a detailed guidelines and exposure visit for successful implementation of the project, is required for PBMC officials, for making further decisions.

Encl.: As above.

Superintending Engineer
Municipal Council

www.giz.de

DRAFT REPORT

Port Blair SWM Situation Rapid Assessment, Recommendations and Roadmap

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

पोर्ट ब्लेयर नगरपालिका परिषद
Port Blair Municipal Council

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Cities Combatting Plastic Entering Marine Environment (CCP-ME) Project
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
2nd Floor, B-5/2, Safdarjung Enclave
New Delhi 110029

T + 91 4949 5353
F + 91 4949 5391
E info@giz.de
I www.giz.de

Responsible
Ms. Vaishali Nandan
Project Head –CCP-ME, GIZ

Authors
Mr Liju Mathew, Mr Sourabh Manuja, Mr Aviral Saxena-GIZ
Mr. Pradeep Dadlani, Mr. Agarwal Sourav, Mr. Nithin Aradhya, Ms. Pallavi Palsokar, Mr. Brian McCarthy, and Mr. Sanjay Gupta - RWA/Deloitte

GIZ is responsible for the content of this publication.

Contents

List of Tables

List of Figures

Abbreviations

ATM	:	Automated Teller Machine
ATR	:	Advance Tax Ruling
BBMP	:	Bruhat Bengaluru MahanagaraPalike
BOOT	:	Build Own Operate Transfer
BWG	:	Bulk Waste Generators
CBO,	:	Community Based Organisation
CC	:	City Corporation
CCP-ME	:	Cities Combating Plastics Entering Marine Environment
CMC	:	City Municipal Council
CPCB	:	Central Pollution Control Board
CPHEEO	:	Central Public Health and Environmental Engineering Organization
DCC	:	Dhaka City Corporation
DCDC	:	Dhaka's Community-based Decentralized Composting
DPR	:	Detailed Project Report
DSD	:	Duales System Deutschland
DTDC	:	Door to Door Collection
EHS	:	Environment Health and Safety
EPR	:	Extended Producer Responsibility
FCTS	:	Fixed Compactor Transfer Station

GHMC	:	Greater Hyderabad Municipal Corporation
GIZ	:	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GPS	:	Global Positioning System
GSM	:	Grams per Square Meter
GVMC	:	Greater Visakhapatnam Municipal Corporation
GVP	:	Garbage Vulnerable Points
HH	:	Household
HR	:	Human Resources
IEC	:	Information, Education and Communication
IMC	:	Indore Municipal Corporations
INR	:	Indian Rupee
IS	:	Indian Standard
ISWM	:	Integrated solid Waste Management
KSPCB	:	Karnataka State Pollution Control Board
LD	:	Liquidation Damages
MIS	:	Management Information System
MLP	:	Multi-Layered Plastic
MOHUA	:	Ministry of Housing and Urban Poverty Alleviation
MRF	:	Material Recovery Facility
MSW	:	Municipal Solid Waste
MSWM	:	Municipal solid Waste Management
MT	:	Metric Tonnes
MTS	:	Mobile Transfer Station
NGO	:	Non-Governmental Organisation
NMC	:	Nashik Municipal Corporation
NURM	:	National Urban Renewal Mission
PBMC	:	Port Blair Municipal Council
PCB	:	Pollution Control Board
PCC	:	Pollution Control Committee
PET	:	Polyethylene Terephthalate
POP	:	Persistent Organic Pollutant
PP	:	Polypropylene
PPE	:	Personal Protective Equipment
PPP	:	Plasma Pyrolysis Technology
PRO	:	Producer Responsibility Organization
PSP	:	Private Sector Participation
PW	:	Plastics Waste
PWD	:	Public Works Department
PWM	:	Plastic Waste Management
RDF	:	Refuse Derived Fuel
RFID	:	Radio-frequency identification
RFP,	:	Request for Proposal

RWA	:	Resource and Waste Advisory Group
SBM	:	Swachh Bharat Mission
SCF,	:	Solid Recovered Fuel
SHG	:	Self Help Group
SLB	:	Service Level Benchmarks
SLF	:	Sanitary Landfill Site
SLRM	:	Solid and Liquid Resource Management centre
SOP	:	Standard Operating Procedure
SPCB	:	State Pollution Control Board
SW	:	Solid Waste
SWM	:	Solid Waste Management
SWOT	:	Strengths, Weaknesses, Opportunities and Threats
TPD	:	Tonnes Per Day
UD	:	Urban Development
ULB	:	Urban Local Body
UN	:	United Nations
UNDP	:	United Nations Development Programme
UNEP	:	United Nations Environment Programme
UT	:	Union Territory
WC	:	Western Concern
WM	:	Waste Management

Executive Summary

Marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed off or abandoned in the marine and coastal environment. It threatens ecosystems and adversely affects fishery and tourism industries around the globe. In addition to negative economic impacts, it affects public health as the concern about micro-plastic and the increased risk of particles entering food webs is growing. In recent times, the level of plastic waste that has accumulated in our oceans and marine ecosystems through the increasing production and use of durable synthetic materials has alarmed the public and policy makers alike.

On a global scale, the problem of marine litter is rooted in the currently dominant linear take-make-dispose production and consumption patterns and unsustainable waste management practices. Marine litter is largely associated with human activities and mainly originates from land-based, riverine and ocean-based sources. Current estimates are based on a limited number of modelling studies; yet, these suggest that some 9-10 million tonnes of plastics enter the oceans annually to become marine litter. Moreover, it is estimated that 15-20% of all plastics are entering oceans via riverine ecosystems of which 90% are contributed by 10 of the world's most polluting rivers only. Two of these rivers are located in India, namely Ganga and Indus.

Cities Combatting Plastic Entering the Marine Environment (CCP-ME) is being implemented by GIZ on behalf of Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) with support of Ministry of Housing and Urban Affairs (MoHUA). The objective of the CCP-ME project is to prevent plastic waste leakage at source through sustainable waste management practices in cities by upgrading infrastructure, strengthening digital monitoring and exchange mechanisms and supporting the development of national framework conditions.

The project will be working in the three cities of Kochi, Kanpur and Port Blair and their respective states. The project will work on interventions to enable selected cities to improve collection, segregation and marketing of plastic waste, to prevent plastic disposal to water bodies, and to improve handling of port and marine waste. This needs to be combined with new tracking, data management and reporting systems, civil society involvement and increased cooperation with the recycling industry.

The approach of the project also includes strengthening of state level authorities in selected states to assume their role in managing plastic waste, in scaling up good practices and in facilitating experience exchange between ULBs. This further includes harmonized reporting systems and the establishment of digital exchange platforms for marketing recyclable materials as well as support in the roll out of state level efforts towards extended producer responsibility.

At National level the project is working with MoHUA and will develop and introduce a national digital platform together with MoHUA to establish links between states, cities and the recycling industry. It will also be used to monitor recycling and reuse of plastic and non-biodegradable waste. In addition, standardised reporting mechanisms for cities and states to the national level related to quantities of different fractions of recycled dry waste (in particular plastics) will be developed.

This document presents the **Rapid Assessment Report for the City of Port Blair**, conducted under the project "**Cities Combatting Plastic Entering Marine Environment (CCP-ME)**" in India during September to October 2021. It includes our understanding and assessment of the waste management service and value chain operating in Port Blair, as well as our review of city, Union Territory and national level policy framework and related documentation. The key findings from the study can be summarized as follows:

UT SWM policy and PBMC Bye laws applicable for the city are comprehensive and appropriate although there would be benefit in strengthening them in terms of coverage and enforcement

In addition to the PBMC Bye laws (2017), Andaman and Nicobar Islands introduced UT SWM Policy in 2018 in line with the SWM Rules 2016 to ensure sustainable waste management in the urban areas. The policy and bye laws are comprehensive and are in line with the SWM Rules 2016 covering aspects such as decentralized management of wet waste, user charge collection, identifying responsibilities of bulk waste generators, integration of informal sector, private sector participation, ban on single use plastic, EPR implementation for plastic (PET bottles), plastic in road construction IEC, capacity building of stakeholders etc.
This current policy and legislative framework establishes a solid foundation upon which to establish a successful waste management system. However, the system would benefit from strengthening local policy/legislation to promote segregated collection and management of sanitary waste, action plan for data management system, preparation and implementation of IEC and citizen engagement plan etc. On the other hand, PBMC is facing challenges in enforcement of policy directives related to aspects such as segregation at source, identification of bulk waste generators and their responsibility, sanitary landfill for disposal, legacy waste management, private sector participation etc.

PBMC has ensured door to door collection (DTDC) from all waste generators in all 24 wards; However, there is need to strengthen monitoring mechanisms to ensure 100% DTDC

While DTDC from households is performed by PBMC, the DTDC from the commercial and institutional establishments is carried out by 2 private SHGs. Although all the wards and waste generators are expected to be covered, there are no technological interventions or other monitoring mechanisms to ensure 100% DTDC. This is resulting in unserved waste generators especially the commercial and institutional establishments present in the internal roads of the wards. There is need for technological interventions such as RFID tracking, GPS tracking and monitoring mechanism such as vehicle movement plan and performance-based contracts to assist ensure 100% DTDC.

There is an immediate need for improving segregation and waste minimization at source

It is observed that some households segregate waste into wet waste (biodegradable) and dry waste (non-biodegradable). However, the segregation at source is low at an estimated 40 to 50%. The waste is further segregated at secondary collection /transfer points in unsanitary and unsafe condition leading to inefficient, ineffective and unsafe management of waste. To ensure scientific management of waste and improve operational efficiency of the processing units, there is a need to improve segregation at source and establishing system for segregated collection of waste ensuring that it is compatible with both DTDC and onward processing. It is observed that there is no system for segregated collection and management of sanitary and domestic hazardous waste. Also, despite having the highest per-capita waste generation, there are very limited initiatives actively promoting waste minimization at source.

PBMC has established 12 SLRM units for management of dry waste; However, these suffer from low operational efficiencies

There are 12 SLRM units established under Swachh Bharat Mission for decentralized management of dry waste. Instead of functioning as sorting and recovery facilities, they are operating as simple bailing and shredding units with low level of value-added activities. Further, inequality in distribution of segregated dry waste among the SLRM units, unbalanced financial model, lack of performance-based contracts and lack of monitoring mechanism is leading to poor operational efficiency of these units. While the total capacity of these units is estimated at 20 TPD, only 6 to 7 TPD of dry waste is being sorted and shipped to mainland from these units. Assuming SLRMs can operate at 90% efficiency, there is still a need for additional infrastructure to manage remaining 7 to 10 TPD of dry waste in 2021 and 10 to 15 TPD in 2031. (excluding the dry waste generated by tourists which is not included at this time).

Unscientific management of waste at secondary collection /transfer points and disposal site is raising environmental concerns

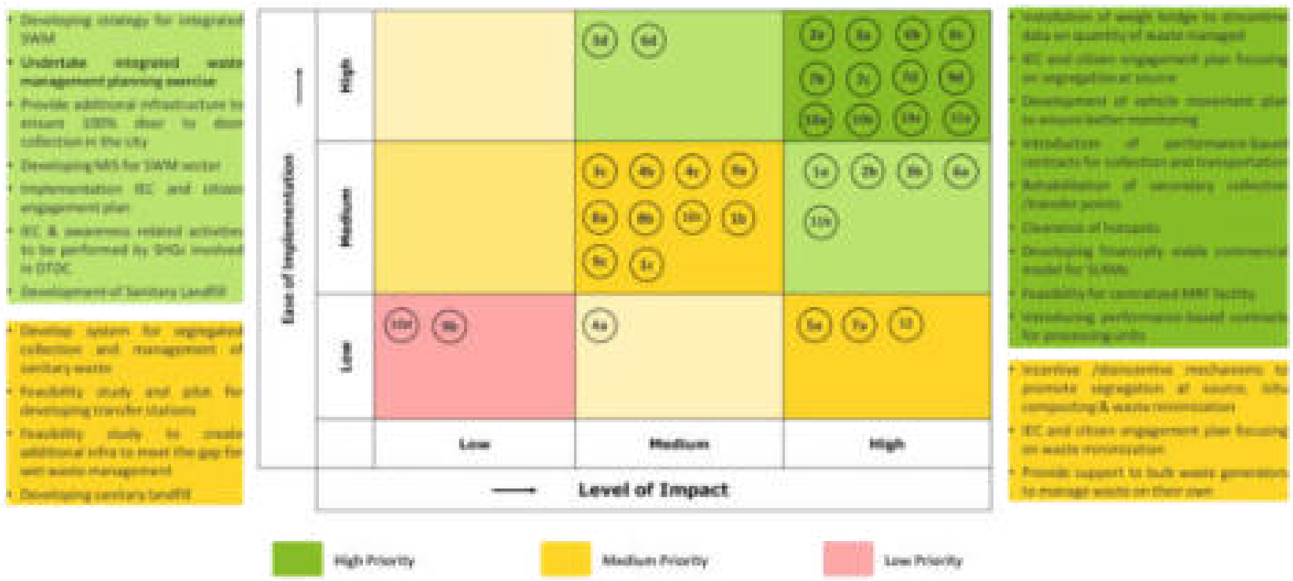
There are around 120 secondary collection /transfer points across 24 wards. Currently, the waste is unscientifically handled at these ill-defined points leading to creation of hotspots and leakage of waste into open environment and drains. Also, the city does not have a sanitary landfill with impermeable base liner and leachate management system as specified SWM manual (CPHEEO guidelines). The waste is openly dumped with limited operational controls and is creating severe environmental concerns. In addition, absence of weigh bridge at the disposal site is resulting in unreliable estimation of waste being disposed.

12 recommendations with specific action points have been identified and prioritized to address prevailing gaps and challenges

Sr No	Gap /Challenge /Need	Proposed Recommendations
A	**Strategy and Governance**	
1	No strategy and action plan developed by PBMC for integrated SWM, no dedicated department /cell for SWM	**Recommendation 1: Develop Integrated SWM strategy and action plan**
2	No integrated MIS for data management and no reliable estimate for waste being managed at various stages of SWM value chain as there are no weigh bridge present	**Recommendation 2: Develop integrated data collection and management system and reliable estimates of waste managed –** weigh bridge at select locations, MIS for SWM sector
B	**Waste Generation and Segregation**	
3	Low segregation at source, segregation at multiple stages, limited role of SHGs	**Recommendation 3: Improve segregation levels at source –** preparation and implementation of IEC and citizen engagement plan, incentive mechanisms, involvement of SHGs
4	Despite having one of the highest per capita waste generation in the country, there are limited efforts undertaken for waste minimization at source. No incentive /disincentive mechanism introduced by PBMC to encourage waste minimization techniques	**Recommendation 4: Ensure waste minimization at source – mandating through** policy and regulatory framework, preparation and implementation of IEC and citizen engagement plan focusing on waste minimization at source
5	There is no system present for segregated collection and management of sanitary waste, domestic hazardous waste and e-waste	**Recommendation 5: Ensure scientific management of sanitary waste generated as per SWM Rules 2016**
C	**Collection and Transportation**	
6	Lack of monitoring mechanisms to ensure 100% and performance-based contracts. There are no technological interventions to monitor DTDC.	**Recommendation 6: Introduce /strengthen monitoring systems to ensure 100% door to door collection -** Undertake integrated waste management planning exercise and feasibility study, vehicle movement plan, RFID tagging and GPS tracking, performance-based contracts linking payments /LDs /incentives to the defined key performance indicators, additional infrastructure
7	The city lacks transfer stations leading to unscientific management of waste at secondary collection /transfer points resulting in leakage of waste into open environment and water systems.	**Recommendation 7: Ensure scientific management of waste at the secondary collection /transfer points –** Feasibility for Transfer stations, rapid enhancement / rehabilitation of existing secondary collection / transfer points to ensure scientific management of waste (fencing, creation of platform, reducing leakage etc.)
8	Only 4-5 bulk waste generators are identified out of which 2 bulk waste	**Recommendation 8: Provide support to bulk waste generators to manage waste on their own -** technical and financial support to establish and

Sr No	Gap /Challenge /Need	Proposed Recommendations
	generators are managing wet waste generated on their own	operate treatment facilities, incentive /disincentive mechanisms
D	**Processing and Recovery**	
9	Lack of infrastructure for processing entire fraction of wet waste generated –It is estimated that there is gap of 25 TPD in the city (2021) to ensure complete processing of wet waste	**Recommendation 9: Ensure 100% processing of wet waste generated in the city -** Feasibility study to be undertaken to evaluate need for creation of additional infrastructure to meet the gap, creation of market for compost, incentive mechanisms
10	Infrastructure gap to manage 7 to 10 TPD of dry waste (2021). Low operational efficiency of the SLRMs due to unequal distribution of dry waste among the SLRM units. Absence of performance-based contract and incentive mechanism to create market for by products.	**Recommendation 10: Improving operational efficiency of the existing SLRM units -** financially viable model, performance-based contracts, equal distribution of dry waste across units, vehicle movement plan, creation of market for recyclables and non-recyclables, feasibility study for centralized MRF
E	**Disposal**	
11	Unscientific disposal of waste in the dumpsite due to absence of sanitary landfill	**Recommendation 11: Ensure scientific disposal of waste**
12	Around 1 lakh MT of legacy waste to be remediated	**Recommendation 12: Remediation of legacy waste**

Upon identifying suitable recommendation and action points under each of the recommendation, they have been prioritized based on two parameters – ease of implementation and level of impact. The prioritization matrix is presented below:



Based on the prioritization matrix, PBMC can focus on short term[1] high priority recommendations /action points such as:

- development of strategy and action plan for integrated SWM
- utilisation of portable vehicle axel scales and / or installation of weigh bridge at important location (transfer points, processing units and disposal site) to get the reliable estimate of waste managed
- preparation and implementation of IEC and citizen engagement plan for improving source segregation and waste minimization

[1] *Shot term interventions are defined as the interventions that can be implemented in less than 1 year*

- developing financially viable commercial model for SLRM units thereby increasing their operational efficiency
- rapid enhancement / rehabilitation of existing secondary collection / transfer points to ensure scientific management of waste and removal of hotspots
- vehicle movement plan for improving monitoring mechanisms (door to door collection and waste to SLRM units)
- feasibility study for decentralised versus centralized MRF facility
- introduction of performance-based contracts across value chain etc.

1. Introduction

1.1 Background

Marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed off or abandoned in the marine and coastal environment. It threatens ecosystems and adversely affects fishery and tourism industries around the globe. In addition to negative economic impacts, it affects public health as the concern about micro-plastic and the increased risk of particles entering food webs is growing. In recent times, the level of plastic waste that has accumulated in our oceans and marine ecosystems through the increasing production and use of durable synthetic materials has alarmed the public and policy makers alike.

On a global scale, the problem of marine litter is rooted in the currently dominant linear take-make-dispose production and consumption patterns and unsustainable waste management practices. Marine litter is largely associated with human activities and mainly originates from land-based, riverine and ocean-based sources. Current estimates are based on a limited number of modelling studies; yet, these suggest that some 9-10 million tonnes of plastics enter the oceans annually to become marine litter. Moreover, it is estimated that 15-20% of all plastics are entering oceans via riverine ecosystems of which 90% are contributed by 10 of the world's most polluting rivers only. Two of these rivers are located in India, namely Ganga and Indus.

Cities Combatting Plastic Entering the Marine Environment (CCP-ME) is being implemented by GIZ on behalf of Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) with support of Ministry of Housing and Urban Affairs (MoHUA). The objective of the CCP-ME project is to prevent plastic waste leakage at source through sustainable waste management practices in cities by upgrading infrastructure, strengthening digital monitoring and exchange mechanisms and supporting the development of national framework conditions.

The project will be working in the three cities of Kochi, Kanpur and Port Blair and their respective states. The project will work on interventions to enable selected cities to improve collection, segregation and marketing of plastic waste, to prevent plastic disposal to water bodies, and to improve handling of port and marine waste. This needs to be combined with new tracking, data management and reporting systems, civil society involvement and increased cooperation with the recycling industry.

The approach of the project also includes strengthening of state level authorities in selected states to assume their role in managing plastic waste, in scaling up good practices and in facilitating experience exchange between ULBs. This further includes harmonized reporting systems and the establishment of digital exchange platforms for marketing recyclable materials as well as support in the roll out of state level efforts towards extended producer responsibility.

At National level the project is working with MoHUA and will develop and introduce a national digital platform together with MoHUA to establish links between states, cities and the recycling industry. It will also be used to monitor recycling and reuse of plastic and non-biodegradable waste. In addition, standardised reporting mechanisms for cities and states to the national level related to quantities of different fractions of recycled dry waste (in particular plastics) will be developed.

1.2 Introduction

This document presents the **Rapid Assessment Report for the City of Port Blair**, conducted under the project "**Cities Combatting Plastic Entering Marine Environment (CCP-ME)**" during September to October 2021. It includes our understanding and assessment of the waste management service and value chain operating in Port Blair, as well as our review of city, Union Territory and national level policy framework and related documentation.

Marine litter has emerged as a global challenge with respect to its vast health and environmental impacts. Marine litter not only harms ocean ecosystems and wildlife, it also affects humans through negatively impacting health, safety, and economy.

UNEP defines Marine Litter as,
'Any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment; including all materials brought indirectly to the sea by rivers, sewage, storm water, waves, or winds.' Marine litter originates from many sources and causes a wide spectrum of environmental, economic, safety and health impacts. The slow rate of degradation of most marine litter items, primarily plastics, together with the continuously increasing quantity of the litter and debris disposed, is leading to a gradual increase in marine litter found at the sea and on the shores.

87 percent of Plastic waste inadequately managed, India is the 12th largest contributor of plastic waste into ocean. According to Jambeck et al (2015), India has nearly 87 percent of plastic waste that is inadequately managed, which have a high risk of polluting rivers and oceans. Although the per capita consumption of plastics in India is only 13.6 kilograms per capita per annum[2] (less than the global average of 30kilograms per capita per annum), the country's anticipated growth rate coupled with increasing population results in high future trend of plastic production/consumption and correspondingly plastic waste.

Beach littering and runoff from drains /river systems are the major routes for marine litter in coastal cities. The unmanaged waste present in the open environment of the coastal cities is prone to enter nearby drains or river system, further entering the marine system. The commercial and tourism related activities along the beaches are one other major reason for marine littering along the coastal line.

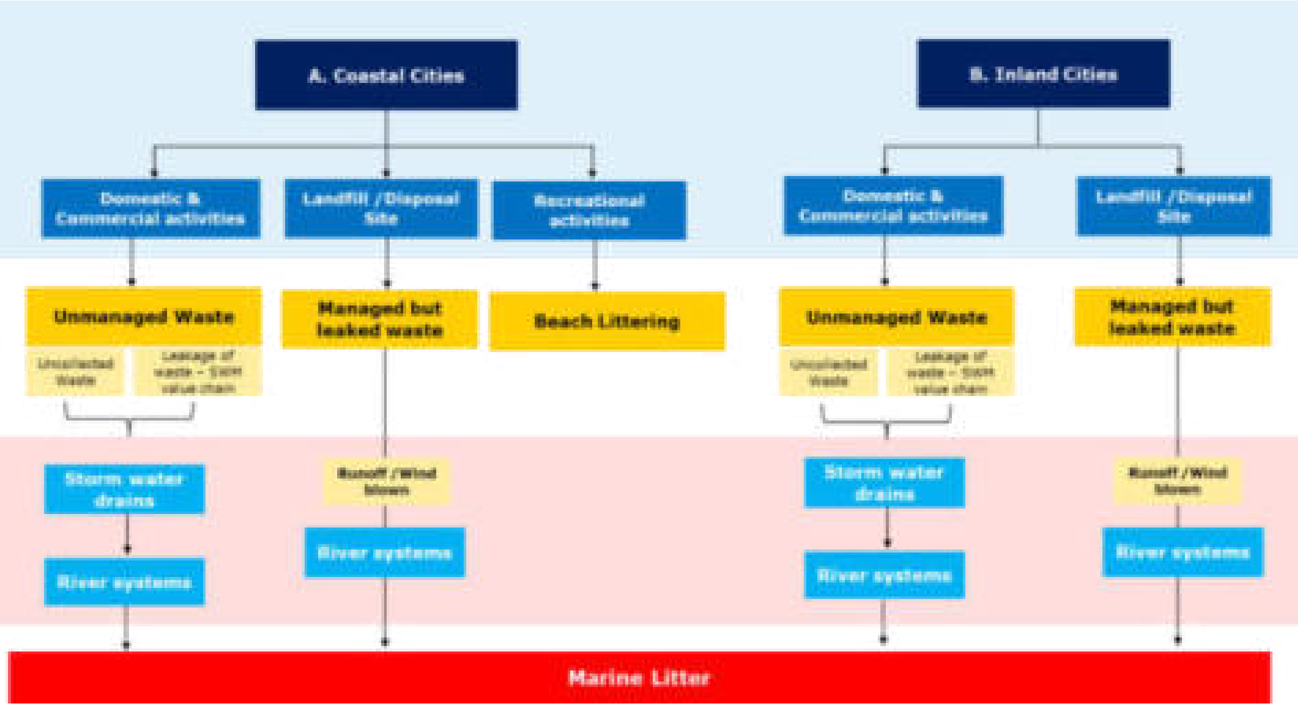


Figure 1: Marine litter in coastal and inland cities

CCP-ME project focuses on preventing plastic waste leakage at source and at identified hotspots through sustainable waste management practices in 3 cities including Port Blair. The CCP-ME project intends to upgrade the infrastructure, strengthen digital monitoring and exchange mechanisms, and support the development of national framework conditions to prevent leakage of plastic waste into the environment. This project aims to support the measures of implementation and capacity development under CCP-ME by providing consulting services and technical assistance to Ministry of Housing and Urban Affairs (MOHUA) at the central level, urban local bodies in Kochi, Kanpur, Port Blair and their respective states in coordination with the main GIZ project office in Delhi and GIZ teams in the states/ cities. The overall objective of the project is **"Enhanced practices**

[2] *Plastic Industry Status Report 2020 by PlastIndia Foundation*

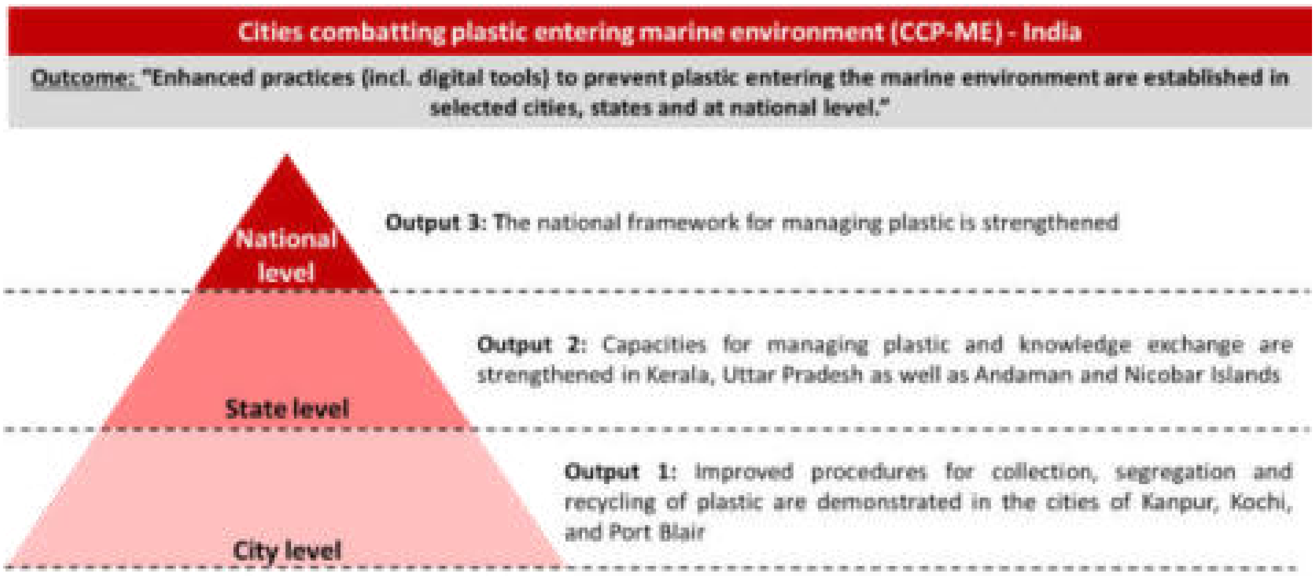
(including digital tools) to prevent plastic entering the marine environment are established in selected cities, states and at national level."

The cities of Kochi, Kanpur and Port Blair, along with their respective states Kerala, Uttar Pradesh and Andaman & Nicobar Islands have been selected considering their different characteristics, making their experiences, learnings and demonstration projects relevant and applicable for other cities and states in India and internationally.

The project is following a multi-stakeholder approach which includes private sector, urban local bodies (ULBs), states (SUDDs and other related agencies) and national level (MoHUA). The project is working towards development of the national guidelines, specifications and standard operating procedures (SOPs), digital and technological tools, a digital platform for secondary raw materials as well as awareness raising and capacity building approaches. This is expected to encourage improvements in segregation, collection, transportation, treatment and disposal of waste in municipalities, thereby establishing an efficient system, which ensures that no waste finds its way into rivers or oceans. In all three cities, pilot projects for material recovery facilities (MRFs) are expected to be implemented on a demonstration basis and tied up with bulk recyclers and producers in order to maximize resource recovery and to support the conversion of non-recyclables to recyclables, thus closing the material loop.

The outputs identified for the project are presented in the following Figure 1.

Figure 2: CCP-ME project objective (outcome) and outputs



Rapid Assessment to identify measures in the city of Port Blair

Understanding the outputs to be met by the larger program, the Consultant team has performed a rapid assessment of the waste sector in Port Blair. The team has undertaken detailed assessment of policy and regulatory framework related to the solid waste management at national, UT and city level in an attempt to identify prevailing gaps and challenges in the enabling framework faced by the city. The team conducted a field visit to the city to understand the systems and processes present in the management of solid and plastic waste. Understanding the challenges in the existing systems and processes, the team has made recommendations and potential action points to be considered at city level to assist improve services and achieve the overall output of the project.

Tasks and Deliverables Covered in the report

The report covers:

1) Rapid assessment of existing situation, in particular:
    a. Review of enabling framework – policy and regulatory framework (city, UT and national level)
    b. Review current practices in waste management including plastic waste and other non-biodegradable waste - practices for segregation, collection, transportation. MRFs, treatment and disposal
    c. Review of relevant existing documents including those prepared by GIZ
2) Identification of gaps and challenges
3) Case studies (more than 3 national and 3 international cases) as a basis to overcome the gaps and provide recommendations (a separate report shall provide full detailed case studies).
4) Recommendations including aspects for improvement of the segregation, collection, transportation, treatment and disposal system, for improvement of functioning of the waste management system in the city, as required.
5) Prioritization of actions

2. Enabling framework

The aim of this section is to provide an overview of the enabling framework within which the waste management sector operates, and which influences the stakeholders operating within the sector, their roles, responsibilities and accountability, and the waste management operator models and infrastructure that collect, store, treat and dispose of solid waste within the city and UT.

2.1 Review of Policy and Regulatory Framework

An overview of the existing policy and regulatory framework influencing the management of solid and plastic waste at national, Union Territory (UT) - Andaman & Nicobar Islands and city level (for Port Blair) is illustrated in Figure 3:

Figure 3: Policy and Regulatory Framework for Solid and Plastic waste management in Port Blair

The principle policies and regulations that establish the framework at all three levels of governance (National, UT, City) that impact the scope of this project have been reviewed and details is presented below:

Table 1: Applicable policy and regulatory framework for solid and plastic waste management at national, UT and city level

Name	Content / Purpose	Relevance &Contextual Observations
National Level		
Municipal Solid Wastes Management Rules 2016	*Developed and administered by the Ministry of Environment, Forest and Climate Change (MoEFCC).* Aims to unify waste management rules throughout the country and between states. Defines the roles and responsibilities for national, state and local administrations, along with other stakeholders in the waste management system and identifies their roles and responsibilities. The rules specify the waste management practices being followed across the solid waste management value chain in the urban local bodies, outgrowths of urban agglomerations and notified areas.	Establishes the roles and responsibilities for sector stakeholders, including – waste generators, MoEFCC, other related ministries, Urban Development Departments of the states/ UTs, CPCB, SPCB/ PCC, ULBs, manufacturers, industries etc. Details monitoring and reporting criteria as well as permitting criteria for all waste management operators and facilities. It provides broad technical guidelines on management and handling of the solid waste management system across the value chain, which are further operationalised in a Manual on Solid Waste Management, 2016 (Annex 1). In addition, the rules also cover aspects of financial sustainability via collection of user fee, recommends PPP across the SWM value chain, inclusion of informal sector, capacity development of involved stakeholders and aspects of IEC. It provides a national level action plan for implementation of the rules. 1. Mandates states to prepare the state SWM policy/ strategy 2. ULBs to prepare SWM Plan etc. Although providing a framework for the sector with defined roles and responsibilities as well as the regulatory oversite and reporting mechanisms, the resources and capacity to implement these rules in each state is limited and often fall well short of the intent. The rules also play particular attention to the large informal sector operating in India by favouring low sized decentralised MRF operations that fall under certain permitting and reporting requirements, rather than promoting any centralised approach.
Plastic Waste Management Rules 2016 (Amended in 2018, 2021)	*Developed and administered by the Ministry of Environment, Forest and Climate Change (MoEFCC).* Aims to regulate and manage the plastic waste throughout the country. The rules identify the materials which are permissible and not possible across uses in India. It also defines the roles and	Establishes the roles and responsibilities of the identified stakeholders - waste generators, CPCB, SPCBs and ULBs (responsible for segregation, collection, storage, transportation, processing and disposal of the plastic) - to establish, operate and monitor waste management systems it also covers gram panchayat, manufacturer, Importers, brand-owner, plastic waste processor (recycler, co-processor, etc.) and producers.

Name	Content / Purpose	Relevance &Contextual Observations
	responsibilities of involved stakeholders including national, state and local level stakeholders, including private and public.	It empowers the ULBs to frame suitable by-laws for user fees (for management of plastic waste) and impose penalties for violations. It provides broad technical guidelines for processing of non-recyclable plastic waste and encourages IEC and inclusion of the informal waste picker community in the overall management of plastic waste. Despite defining roles and responsibilities, the Plastic and Solid Waste Management Rules fall short of preventing overlap of responsibilities or providing guidance on coordination structures to ensure these stakeholders can implement their roles efficiently. This is particularly apparent in monitoring and enforcement and the role of the SPCB and CPCB.
Uniform Framework for Extended Producer Responsibility (under PWM Rules 2016)	*Draft models for implementation of EPR guidelines for plastic waste management, role of different stakeholders in plastic waste management*	MoEFCC issued Guideline Document Uniform Framework for Extended Producers Responsibility (Under Plastic Waste Management Rules, 2016). The guidelines define different models that State can adopt for EPR implementation (plastic waste) – fee based model and PRO based model. It also discusses regarding the concept of plastic credit model where a producer is not required to recycle their own packaging, but to ensure that an equivalent amount of packaging waste has been recovered and recycled to meet their obligation. The guidelines also provide guidelines principles for uniform framework for EPR implementation by the States and ULBs It is to be noted that the guidelines issued in the public domain is for receiving comments and feedback from various stakeholders and is yet to be notified.
National Resource Efficiency Policy 2019	*Policy identifies key resource materials and sectors and provides interventions and targets to ensure resource efficiency*	Identifies plastic as a key resource with the packaging sector being a key sector for ensuring resource efficiency. The policy defines interventions and targets to ensure resource efficiency in the plastic packaging sector. The proposed interventions include: EPR implementation, capacity building, mandating minimum recycled plastics quantity, collection targets for plastic waste management by producers etc. The proposed targets include the very (almost overly) ambitious: 100% recycling and reuse rate of PET plastics by 2025, 100% recycling of PET plastic and 75% recycling and reuse of other plastic packaging materials by 2030, ban on disposal of recyclable waste including plastics into landfill

Name	Content / Purpose	Relevance &Contextual Observations
UT Level		
UT Policy and Strategy on Solid Waste Management for Andaman & Nicobar Islands, 2018	***Developed by Andaman and Nicobar Administration*** *The policy and strategy outline various aspects for solid waste management in the urban and rural areas including - overall objectives, guiding principles, strategic interventions, action plan and expected outcomes* *The policy & strategy is applicable for urban and rural areas of UT*	It ensures participation of all stakeholders involved in SMW in A&N islands The policy and strategy highlight most of the aspects mentioned in the SWM Rules 2016 including – source segregation, scientific management of waste, decentralized management of waste, user charge collection, identifying responsibilities of bulk waste generators (BWGs), integration of informal sector, private sector participation, ban on single use plastic, EPR implementation for plastic (PET bottles), plastic in road construction IEC, capacity building of stakeholders etc. In addition to the aspects highlighted in the SWM Rules 2016, the policy and strategy also focus on - • Adopting twin bin systems at all Government and private commercial establishments • Feasibility and viability of waste to energy and recovery of fuel from waste plastic • Collaborate with regional /national /international research institutes of repute dealing with development off site-specific solid waste management
Notification on ban on plastic carry bags, 2005	***Issued by Department of Science and Technology, Andaman and Nicobar Administration***	Ban on use, carrying and sale of virgin or recycled plastic carry bags below 20 micros thickness and 20*30 cm in size.
Notification on Plastic ban, 2019	***Issued by Pollution Control Committee, Department of Science and Technology, Andaman and Nicobar Administration***	Ban on select plastic items • PET bottle - <2litres • Single use plastic – all size • Plastic straw – all size • Sachets - <15ml • Plastic carry bags – all size • Plastic sheet /pouches – all size Exception has been provided for – plastics manufactured for export purpose, packaging used at manufacturing /processing units, packaging of milk /milk products and compostable carry bags
City Level		
Port Blair Municipal Council SWM Bye laws 2017	***Developed by Port Blair Municipal Council***	The SWM Bye laws define the responsibilities of various stakeholders involved in solid waste management in the city including the Port Blair Municipal Council.

Name	Content / Purpose	Relevance &Contextual Observations
	The bye laws identify the responsibilities of Port Blair Municipal Council and other stakeholders involved in solid waste management. The policy is applicable for the municipal limits (urban area) and provides directions across SWM value chain including segregation, collection, transportation, processing and disposal	In addition to the aspects highlighted in the SWM Rules 2016, the bye laws focus on • Declaring solid waste free /sanitation zones to avoid illegal dumping and littering the open spaces • Segregation of waste into six specified groups by the generators – biodegradable waste, hazardous waste, biomedical waste, C&D waste, bulk garden /horticulture waste an\d non-biodegradable waste • Right to send notices and penalties in case of violation Prohibition of open burning of waste • Constitute committee for grievance redressal at ward and city level • Develop integrated management information system (MIS) for SWM sector • Run processing units on commercial basis and ensure financial viability • Make adequate arrangement for composting and sale of compost

2.2 Compliance status of the city

Understanding the existing policy and regulatory framework applicable for management of solid and plastic waste management in the city, it is important to evaluate the compliance against the identified policy and regulatory framework.

Table 2: Compliance status of city against applicable policy and regulatory framework

Sr No	Aspect	SWM & PWM Rules 2016	UT WM Policy & Strategy	PBMC SWM Bye Laws	Compliance status for the city
1.	Policy and strategy	Preparation of State /UT level policy and strategy for management of solid and plastic waste management	-	-	A&N administration have notified UT level SWM policy and strategy. While the policy includes some aspects of plastic waste management, there is no specific strategy for plastic waste management.
2.	Short &long-term action plans	State /ULBs to prepare short and long-term action plan for	-	-	The UT level policy and strategy provides broad action plan to achieve aim objectives defined for the sector. But PBMC has not prepared any detailed short or long-term action plan for the sector.
3.	Preparation of contingency plans	ULBs to prepare contingency plans for appropriate storage of waste, to tide over			The State Policy and Bye laws do not provide emphasis on contingency planning.

Sr No	Aspect	SWM & PWM Rules 2016	UT WM Policy & Strategy	PBMC SWM Bye Laws	Compliance status for the city
		situations of non-performance of processing /treatment /disposal facilities			Currently, the ULB has not prepared any contingency planning for the sector.
4.	Establishing ward and city level committees	SWM Rules 2016 and SBM Guidelines stipulated formation of Ward Committees to monitor MSWM provision at City Corporation level		Establishing ward and city level groups for grievance redressal	No active ward and city level groups present in the city
5.	Waste minimization	Focus on waste minimization at source	-	-	The per-capita waste generation in the city is higher than that of metro cities. In spite of that, there is no increased focus on waste minimization from the municipal authority.
6.	Segregation at source	Ensure 100% segregation at source Ensure collection and transportation of segregated waste Devise incentive /disincentive mechanism to promote segregation	Ensure segregation after collection	Ensure segregation at source – 6 categories of waste	Segregation at source is nearly 40 to 50%[3]. The second level of segregation takes place at secondary collection /transfer points No incentive /disincentive mechanisms devised to ensure 100% segregation at source
7.	Sanitary and hazardous waste management	Segregation of sanitary waste at source and mandates ULBs to explore mechanisms for disposal of sanitary waste.	Sanitary napkins /diapers incinerators at airports, women hostel and other select places	-	No system presents for management of sanitary waste generated in the city. It is currently being collected as part of non-biodegradable waste and being disposed at the disposal site. There are no incinerators used in the PBMC area for disposal of sanitary waste although there is an incinerator installed in the Cantonment area for Sanitary Waste. Limited hazardous waste management is provided, however, E-Waste is managed by the registered scrap dealers in the city (31 Nos).
8.	Door to door collection	Ensure 100% door to door collection			Door to door collection (DTDC) system present in all 24 wards. The coverage of DTDC for commercial and institutional establishments is not 100% in the city

[3] *The estimate is based on observations made during the field visits and discussion with the municipal authority*

<table>
<tr><th>Sr No</th><th>Aspect</th><th>SWM & PWM Rules 2016</th><th>UT WM Policy & Strategy</th><th>PBMC SWM Bye Laws</th><th>Compliance status for the city</th></tr>
<tr><td></td><td></td><td colspan="3"></td><td>due to lack of monitoring mechanism and contractual gaps.

The following are the major gaps in the contract between the ULB and the SHG
• Contract do not mention specific targets to be achieved by the SHGs (100% collection from the establishments)
• Contract do not define monitoring mechanisms to estimate the efficiency of DTDC by the SHGs
• It does not define incentive and disincentive mechanisms for achieving the target</td></tr>
<tr><td>9.</td><td>User charge collection</td><td colspan="3">Collect user charge from the waste generators</td><td>PBMC has notified schedule for user charge collection from different types of waste generators. The municipal authority is also collecting user charges from the waste generators as applicable. The user charges applicable as per the PBMC Byelaws 2017 is presented below:

<table>
<tr><td>Sr No</td><td>Waste generator type</td><td>User Charges (INR per month)</td></tr>
<tr><td>1.</td><td>Households (segregating waste)</td><td>50</td></tr>
<tr><td>2.</td><td>Households (not segregating waste)</td><td>1000</td></tr>
<tr><td>3.</td><td>Small Commercial establishments</td><td>50 to 150</td></tr>
<tr><td>4.</td><td>Hotels & restaurants</td><td>>500</td></tr>
<tr><td>5.</td><td>Meat shops & other establishments</td><td>300</td></tr>
<tr><td>6.</td><td>Bulk waste generators</td><td>300</td></tr>
</table></td></tr>
<tr><td>10.</td><td>Processing of waste</td><td colspan="3">Scientific processing of biodegradable waste

Decentralized waste management of both biodegradable (wet) and non-biodegradable (dry)

Recycling of dry waste</td><td>Composting units present in the city cannot handle complete biodegradable waste generated in the city. PBMC intends to promote in-situ management of biodegradable waste. PBMC has established 12 SLRM centres for decentralized management of dry waste</td></tr>
</table>

Sr No	Aspect	SWM & PWM Rules 2016	UT WM Policy & Strategy	PBMC SWM Bye Laws	Compliance status for the city
		Use of non-recyclable plastics in road construction, cement kilns etc.			PBMC implemented pilot project on use of plastic waste in road construction. However, the initiative needs to be further upscaled. The segregated dry waste including recyclables and non-recyclables are being sent to the mainland through two major shipping lines. However, most of the segregated dry waste transported to the mainland is recyclable waste as there is limited market for non-recyclable dry waste. The margin of profit is higher in case of recyclable waste. The market value for the non-recyclables is less and since the transportation costs are higher, the profit margin is significantly low. Hence, the SLRMs prefer to collect, segregate and transport recyclables and mon-recyclable waste will either remain stored in the SLRM units or gets disposed at the disposal site.
11.	Disposal of waste	Establish sanitary landfill for scientific disposal	-	Establish sanitary landfill as per SWM Rules 2016 Leachate collection and treatment facility to be established	There is no sanitary landfill in the city. The waste is currently being dumped at the disposal site located within close proximity to the sea. It has no base liner or other environmental controls to isolate waste from the environment (water, soil and air) or treatment systems to ensure leachate and gas emissions are contained and treated in an environmentally appropriate manner.
12.	EPR implementation	EPR implementation for management of plastic waste	EPR implementation for management of pet bottles	-	There are currently no EPR systems established or operating in the city or UT. The UT Strategy does not provide any indication on how the EPR system is envisaged to be implemented

2.3 Inferences on gaps and challenges

While the UT SWM policy and strategy for A&N islands and the PBMC Bye laws are comprehensive, they have some gaps in terms of coverage and enforcement

Coverage

- While the national SWM Rules 2016 highlights the need for establishing a system for segregated collection and management of sanitary waste, the UT SWM policy and PBMC Bye laws do not reflect these requirements.
- The existing policy framework do not provide an action plan or guidelines on establishing an integrated data management system for regular monitoring to inform decision making. The data collection system in the city currently falls short of requirements and is not reliable.
- The existing policy and regulatory framework do not highlight the need for preparation of action plans for implementation of IEC, awareness creation and capacity building related activities.

Enforcement

- While the SWM Rules- 2016 and PBMC SWM municipal Bye laws stipulated complete segregation at source, the city is yet to achieve 100% segregation at source. There are no incentive /disincentive mechanisms devised by the municipal authority to encourage waste generators to segregate waste at source.
- While both the SWM Rules and PBMC SWM Bye laws stipulates establishment of sanitary landfill, the city do not have a functional sanitary landfill facility for scientific disposal of waste.
- While the policy framework for the SWM sector in the city encourages participation of private sector across the SWM value chain, the city has not explored various models and options for private sector participation, especially in collection and transportation.
- As per the applicable policy framework, the bulk waste generators in the city shall be made responsible for management of waste on their own by establishing suitable treatment facilities. However, there are no guidelines or technical support provided to the bulk waste generators to establish treatment facilities to manage their own waste. The shortfall in sector monitoring capacity also affects the enforcement of this waste producer responsibility. The city administration has identified few bulk waste generators. However, there has been limited efforts in improving the capacity of the identified bulk waste generators to manage their own waste.
- The Schedule I of PBMC SWM Byelaws 2017 define suitable fine /penalty for every attempt of violations. For instance, penalty for dumping and littering of waste in drains, footpath etc is INR 500 per instance, penalty for non-segregation of waste is INR 500 for individual and INR 1000 for bulk waste generators, fine for burning of waste – INR 500 per instance, fine for employee mixing the segregated waste while collection is INR 500 etc. However, the resources allocated to monitor and enforce these violations are not sufficient and as a consequence has not been successful.

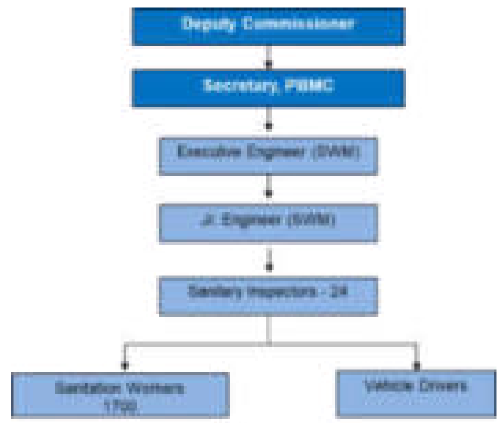
3. Review of Current Practices

The chapter presents the understandings from the rapid assessment of existing SWM systems and processes including the review of infrastructure facilities and stakeholder activities across the SWM value chain for service delivery, policy and regulatory framework, institutional & governance mechanisms and private sector participation. The chapter also highlights the gaps and challenges present in the sector that require immediate attention.

3.1 Institutional and Governance

There is limited delegation of Solid Waste Management responsibilities to technical competence within the PBMC, with senior officials being directly involved in directing services at all stages of the SWM value chain

Considering that Port Blair is a small city, there is no dedicated department for solid waste management (SWM). SWM operations at the city level fall within the purview of the Executive Engineer (SWM) who reports to Secretary, PBMC. The Executive Engineer is supported by Junior Engineer and Sanitary Inspectors. A total of 24 Sanitary Inspectors are appointed across 24 wards (one for each ward). They are responsible for monitoring collection and transportation of waste and grievance redressal in their respective wards.



PBMC is supported by various private and informal sector stakeholders, directly or indirectly, for solid waste management in the city

A summary of the key stakeholders and their involvement in solid waste management in the city is presented below:

Stakeholders /Sectors	Solid Waste Management Value Chain				
	Collection & Transportation	*Secondary Waste Collection & Transportation*	*Processing /recovery*	*Disposal*	*Monitoring*
Public Sector /Government	**PBMC**– DTDC from Households, street sweeping	**PBMC** - secondary waste collection &transportation to processing units and dumpsite, segregation of waste	**PBMC** – Development of infrastructure, monitoring	**PBMC**– Disposal of waste	**Pollution Control Committee –** Overall monitoring, implementation of SWM & PWM rules
Private Sector	**2 Private SHGs** – DTDC and transportation from commercial /institutional waste generators		**Private vendors** – O&M of 12 SLRMs **SHGs** – O&M of compost plants		
Informal Sector	**31 Scrap Dealers** authorized by PBMC **Kabadiwalas**		**21 Waste Dealers** Authorized by PBMC – Sale of recyclables and non-recyclables		

3.2 Overview of system

The schematic below presents our understanding of the waste service chain and waste material flow within the Port Blair city.

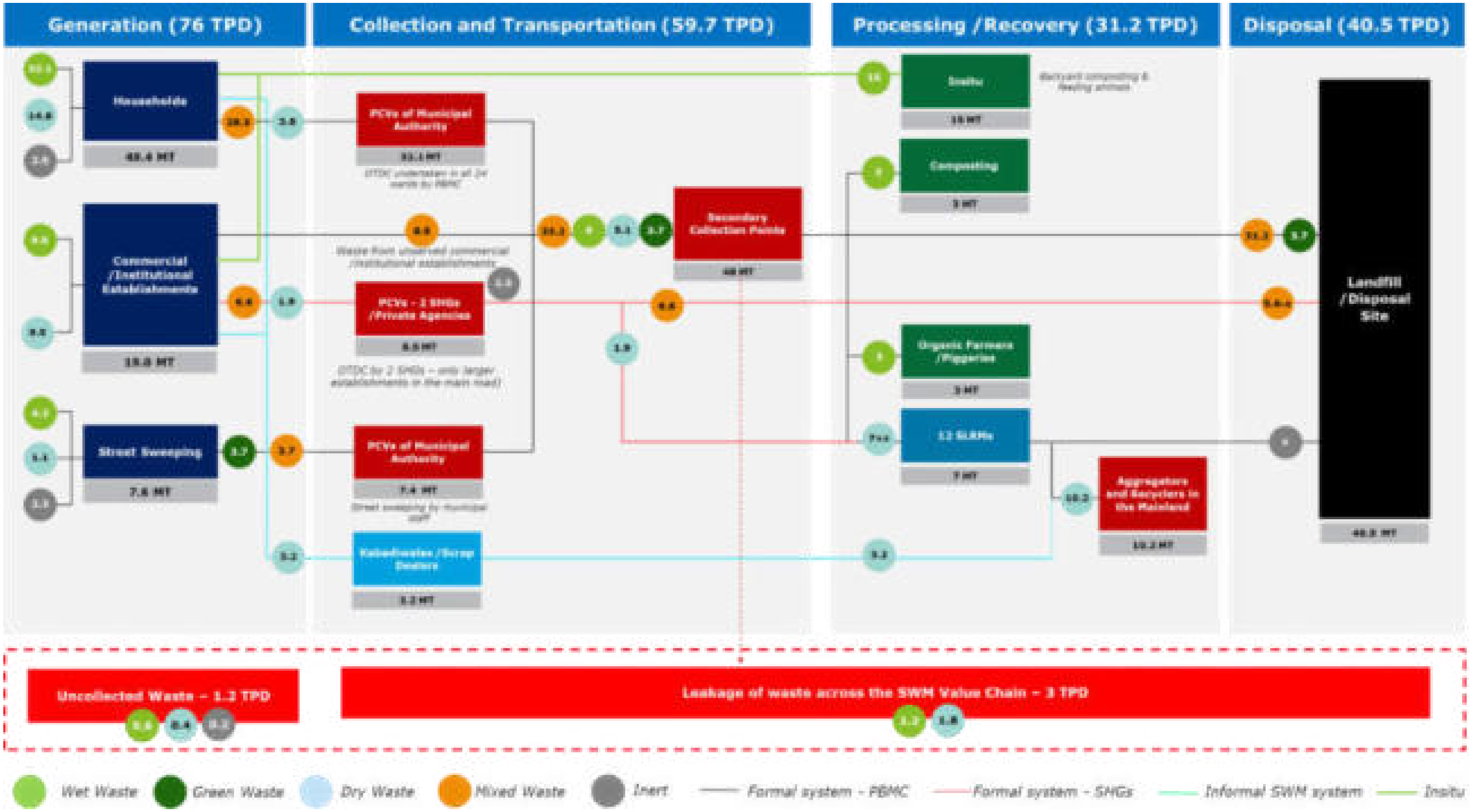


Figure 4: Waste Flow Diagram for Port Blair City

Disclaimer: *waste service chain and waste material flow are based on the information made available by Port Blair Municipal Council (PBMC) as well as personal communications with various stakeholders involved in the SWM value chain. Appropriate assumptions have been made in case of data gaps. The assumptions have been summarized in Annexure 1.*

3.2.1 Waste Generation

A. Assessment of existing systems and processes

Waste generation in the city is estimated at 76 TPD

The total waste generation in the city is estimated at ***76 TPD***[4] representing around ***507 grams*** per capita per day, which is slightly lower than the estimates made in SWM Detailed Project Report (DPR) (590 grams) and annual reports of State Pollution Control Board (515 grams). The share of waste generated by various types of waste generators in the city is presented in the table below:

Sr No	Type of Waste generator	No of generators	Quantity of waste generated (TPD)	% Total
1.	Households	50,000	49.4	65%
2.	Commercial & Institutional Establishments*	8000	19*	25%
3.	Street sweeping	-	7.6	10%
	Total	**-**	**76**	**100%**

**19.0 TPD waste generated form the commercial and institutional establishments include waste generated from the large hotels, restaurants and the Junglighat Fish landing facility which houses around 2000 fishermen. The waste generated form the fish landing facility majorly includes fishing nets used by the fishers. It is locally purported said that typically an average fishing net weighs 3-5 kgs and can last 9-12 months depending on the use.*

Note: There is need for in depth assessment of management of waste generated from the Fish landing facility

The composition of waste generated by various waste generators is presented below:

Sr No	Type of waste generator	Composition of Waste (%)		
		Wet Waste*	Dry Waste**	Inert***
1	Residential waste generator (Household)	65%	30%	5%
2	Commercial & Institutional Waste Generators	50%	50%	-
3	Street Sweeping	55%	15%	30%

**Wet waste includes food waste and other organic waste including garden waste*
***Dry waste includes – plastic, paper & cardboard, glass, metal, cloth etc.*
****Inert includes mud, silt, sand etc.*

Segregation at source has been effectively initiated in all 24 wards. However, it was observed that very few households are segregating waste at source into wet waste (organic, food and garden waste) and dry waste (recyclables and non-recyclables). Some households segregate the garden /horticulture waste, which is also collected as wet waste by PBMC staff. The municipal authority has notified that the bulk waste generators (generating more than 50 kg per day) present in the city need to manage their own waste. However, only a few bulk waste generators (around 9) have been identified across the city and only 2 of them are managing the wet waste on their own.

The list of BWGs registered with the PBMC is as follows:

1. Minnie Bay Defence Wives Welfare Association (Ward No. 16)
2. Hotel Fortune Bay Island Resort (Ward No. – 4)
3. Dr. B.R Ambedkar Institute of technology (Ward No. 17)
4. Mohanpura Modern Fish Market (Ward No. 5)
5. Jungighat Modern Fish Market (Ward No. 13)
6. Gandhi Park (Ward No. 10)
7. Marina Park (Ward No. 5)
8. Joggers Park (Ward No. 12)

[4] *Source: Discussion with officials from Port Blair Municipal Council*

9. Vijay Bagh DWWA (Ward No. 14)

BWGs are segregating the biodegradable and non-biodegradable waste at their premises. The biodegradable waste is supposed to be used to produce compost for self-use while the non-biodegradable waste is collected by the vehicles of the PBMC and taken to the designated SLRM or the dumping site at Brookshabad. However, as mentioned above, most of the BWGs are not doing in-situ composting. Many households in the city carry out in-situ composting of the biodegradable waste and use the compost for their kitchen gardens.

Waste generation is expected to further increase by 2031

The population of Port Blair city has increased from 1.4 lakhs in 2011[5] to around 1.5 lakhs in 2021[6] and is further expected to increase to 1.65 lakhs by 2031. Based on the SWM DPRs prepared for various cities in India, it is estimated that the per capita waste generation will increase by at least 1 to 2 percent every 2 years. Accordingly, the per capita waste generation is expected to increase to 533 grams by 2031 there by increasing the total city waste generation to 88 TPD.

Sr No	Year	Population (lakhs)	Per Capita waste generation (grams)	Total Waste Generation (TPD)	Waste generated by Tourists (TPD)
1.	2021 (current, Sept 2021)	1.50	507	**76**	6 to10#
2.	2031 (Scenario 1) *	1.65	533	**88**	7 to 11##
3.	2031 (Scenario 2) **	1.65	425	**70**	

**Scenario 1 assumes that the per capita waste generation increases by 1 % every 2 years*
***Scenario 2 assumes that PBMC will put successful efforts for waste minimization and the per capita waste generation is reduced to 425 grams (which represents the average per capita waste generation across other cities in India)*
 # As per reports, the tourist population visiting the city was around 4 lakhs in 2017. Hence, assuming 4.5 lakh tourist population the estimated waste generation from the tourists is 6 to 10 TPD (average stay duration –4 days, per capita waste generation in the range of 600 grams to 1 kg)
Assuming 5 lakh tourist population the estimated waste generation from the tourists is 7 to 11 TPD (average stay duration – 4 days, per capita waste generation in the range of 600 grams to 1 kg)

B. Review of applicable policy and regulatory framework

A brief review of compliance of the city against the applicable policy and regulatory framework relevant to waste generation is presented below:

National	State /UT /City Level (Andaman & Nicobar)		Observations
SWM Rules 2016	UT Policy for SWM Strategy 2018	PBMC SWM Byelaws 2017	
• Segregation at source mandatory - biodegradable, non-biodegradable	• Identification of bulk waste generators	• Waste generators responsible for segregated storage of waste into 6	• Segregation of waste at source into 6 categories as per the bye laws was not observed on the ground

[5]Source: Census 2011 (including 6 new wards added in 2015)
[6]Source: Discussion with officials from Port Blair Municipal Council

National	State /UT /City Level (Andaman & Nicobar)		Observations
SWM Rules 2016	**UT Policy for SWM Strategy 2018**	**PBMC SWM Byelaws 2017**	
and domestic hazardous • Sanitary waste to be disposed separately from non-biodegradable waste • Bulk waste generators to segregate waste at source and encouraged to practice in-situ composting for wet waste • Horticulture/ green waste to be stored separately	and their responsibility • Focus on public awareness on SWM strategies	different categories (biodegradable, domestic hazardous, bio-medical, C&D, bulk garden /horticulture waste and all other non-biodegradable waste • Bio-degradable waste to be managed at the source through in-situ composting • Identification of bulk waste generators (generating waste more than 50 kg per day) to set up their own treatment plants (in-situ)	• There is no system for segregated collection and management of sanitary waste • While limited number of bulk waste generators are identified, not all of them meet their defined responsibilities. There is no separate mechanisms adopted in practices for managing waste from BWGs. Only 2-3 hotels are managing the wet waste on their own, but the dry waste is managed by PBMC only. • In-situ management of wet waste is prominent – anecdotal evidence suggests around 15 TPD of wet waste is being in-situ composted or being fed to the animals /cattle. • Limited segregation of green waste (garden /horticulture waste) observed • There is no provision for households to directly deposit waste with agents at pre-determined rates

C. Inferences on gaps and challenges

Policy and institutional aspects

- The UT SWM policy does not highlight the importance of segregation at source. It does not specify segregation options or methods to be adopted by municipal authorities[7]. However, the PBMC bye laws specify that the waste needs to be segregated into 6 defined categories.
- The UT SWM Policy or the PBMC SWM bye laws do not highlight the need for a specific management system for sanitary waste
- While the PBMC SWM bye laws require segregation at source, there are no monitoring mechanisms, incentive-disincentive mechanisms defined to mobilise complete segregation at source
- While the bulk waste generators are expected to develop own treatment facilities and manage their waste, there are no guidelines or financial incentives introduced to support the same. Monitoring systems to enforce this waste generator responsibility is also lacking.

Systems and processes

- Surveys are required to be conducted across different types of waste generator for quantifying actual waste generation and characterization of waste generated
- Survey to be conducted to estimate waste generation from tourists

[7] *Source: Review of policy framework by the Consultants*

3.2.2 Primary Collection & Transportation

A. Assessment of existing systems and processes

Door to door collection (DTDC) has been initiated in all 24 wards and for all types of waste generators

Door to door collection (DTDC) from the households across all 24 wards is carried out by the staff appointed by PBMC. There are around 24 auto tippers procured for DTDC. However, considering the difficult terrain, the DTDC is mostly conducted using smaller hand carts (drums /plastic carts attached with wheels). The waste is later taken to the nearest secondary collection /transfer points (as a bin free city, these are uncontained open sites)[8]. The municipal authority is also responsible for performing street seeping activities in the city. The salary of the sanitary staff involved in DTDC and street sweeping activities and the O&M cost for DTDC from the households is borne by PBMC.

DTDC from the commercial /institutional establishments has been outsourced to private SHGs

DTDC from the commercial and institutional establishments across the 24 wards is contracted out to two (2) private SHGs - Shree Venkateshwara SHG (12 wards) and Friends SHG (12 wards). The SHGs are responsible for collection and transportation of waste generated from the commercial /institutional establishments. They are also authorized to levy user charges predefined by the municipal authority to meet the operational expenses. (Copy of legal authorization for SHGs to levy user charges is presented in Annexure 5). It is observed that the coverage by the SHGs is not 100% and they tend to collect waste only from larger commercial establishments and ignore the smaller establishments located in the internal roads. These smaller establishments dump the waste in the nearest secondary collection points and is further managed by PBMC. On the other hand, the waste collected by SHGs is directly transported to processing facilities /dumpsite.

Collection and Transportation		
 Handcart used for primary collection from HH *Source: Consultant team (field visit)*	 Primary Collection form Households *Source: Consultant team (field visit)*	 C&T of Green waste *Source: Consultant team (field visit)*

B. Review of applicable policy and regulatory framework

A brief review of compliance of the city against the applicable policy and regulatory framework is presented below**:**

[8]*Uncontained open site can be defined as the site with no boundary wall, platform or any other structure to ensure zero contamination of the nearby environment by the waste*

National	State /UT /City Level (Andaman & Nicobar)		Observations
Solid Waste Management Rules, 2016	**UT Policy for SWM Strategy 2018**	**PBMC SWM Byelaws 2017**	
• Door to door collection from all residential and non-residential units • Safe storage of domestic hazardous waste • Separate collection of street sweeping waste • ULBs to frame by-laws incorporating the provisions of rules • Bio-medical, C&D and industrial wastes shall not be mixed with municipal solid waste	• 100% coverage through door to door collection • Ensure 100% segregation of collected waste by engaging SHGs or other private players • Ensure installation of twin bins at all Govt. and commercial establishments	• 100% door to door collection to be achieved • Ensure segregation at source and collection of segregated waste • Bye-laws highlight the management of bio-medical waste and C&D waste so that they do not get mixed with the MSW	• Door to door collection ensured in all 24 wards, however, 100% DTDC is not achieved • PBMC staff are involved in street sweeping and waste is separately taken to nearest secondary collection point • PBMC has formulated SWM bye-laws in line with SWM Rules 2016 • The twin bin system has been partially implemented in the Govt and commercial establishments

C. Inferences on gaps and challenges

Systems and processes

- **Lack of effective monitoring mechanism to ensure better service delivery by PBMC** – It is observed that there are no service delivery targets set and no monitoring framework defined for daily /monthly monitoring of various aspects including coverage, extent of user fee collection, extent of segregation at source etc.
- **Lack of effective monitoring mechanism to ensure better service delivery by SHGs** - There no monitoring mechanisms in place to review and monitor the performance of SHGs appointed for DTDC. SHGs are not collecting waste from the small and medium commercial /institutional establishments located in the internal roads. They are primarily focusing on large establishments located in the main roads.
- **Lack of performance-based contracts** – There are no key performance indicators /targets defined in the contracts to ensure standard service delivery from the SHGs.
- The scope of work of the private SHGs do not include awareness creation among the waste generators regarding waste minimization, segregation at source, waste disposal etc.
- **Limited involvement of private sector** - DTDC collection from the households is completely undertaken by PBMC staff increasing the risk and financial burden on the municipal authority. PBMC is yet to explore the benefits of involving private sector for complete collection and transportation.

Policy and institutional

- While the policy and bye laws highlight the need for involvement of private sector participation, the municipal authority has not been successful in establishing sustainable PPP model for collection and transportation of waste.
- There are no guidelines for establishing successful PPP models across SWM value chain

Infrastructure

- **Low operational efficiency of the vehicles** While there are total 70 vehicles for collection and transportation, only 57 are currently operational[9]. In addition, the quantity of waste transported in each of the vehicle is significantly lower than the capacity that the vehicle can handle[10]. The low operational efficiency is resulting increased operational cost. With improved operational efficiency, the existing fleet is sufficient to manage the waste generated.

3.2.3 Secondary Collection /Transfer Points

A. Assessment of existing systems and processes

Around 48 TPD of waste is being managed at 120 secondary collection /transfer points present across the city

The waste collected from household DTDC (32.1 TPD) and street sweeping activity (7.4 TPD) is transported to more than 120 designated secondary collection /transfer points present across 24 wards. In addition, the waste generated by the commercial /institutional establishments currently not serviced by SHGs (8.5 TPD) is directly received at these secondary collection /transfer points. These points are managed by PBMC. PBMC staff involved in DTDC and street sweeping further segregate the dry received at the secondary points into various fractions including paper, cardboards, metals, plastics - PET, PP (color-wise), MLPs, etc. The segregated fractions of dry waste are then transported to 12 SLRM centers. Around 3 TPD of segregated wet waste is sent to 2 functional composting units. A further 3 TPD of segregated wet waste is taken by organic farmers to feed cattle and pigs. The remaining mixed waste is taken to the dumpsite directly from the secondary collection /transfer points. There are around 8 twin tippers, 24 trucks and 1 compactor owned by PBMC and used to transfer waste from secondary collection /transfer points to designated processing facility or dumpsite.

B. Inferences on gaps and challenges

Systems and processes

- **Unscientific management of waste at secondary collection /transfer points –** There is no infrastructure developed at these secondary collection /transfer points to delineate the site, contain the waste, keep animals and climatic conditions from distributing waste, or to assist undertake segregation of materials. Hence, the waste is being unscientifically managed leading to substantial and continuous leakage of waste generated leachate into local water courses / drains and open environment.

---

[9] *Source: Discussion with officials from Port Blair Municipal Council*
[10] *Source: Discussion with officials from Port Blair Municipal Council and observations made during field visits*

<table>
<tr><th>Secondary Collection /Transfer point near Pheonix Nala, Mohanpura (Ward no 3):

Source: Consultant team (field visit)</th><th>Secondary collection /transfer point in Ward 4:

Source: Consultant team (field visit)</th></tr>
<tr><td colspan="2">There are no precautions taken by the staff and the waste is being managed unscientifically. As a result, lot of waste finds its way into the nalas and open environment.</td></tr>
</table>

Infrastructure

- There are no dedicated constructed or scientific transfer stations /points present in the city
- There are no weigh bridges present at any of the locations to quantify and collect data on waste being handled.

3.2.4 Processing and Recovery

A. Assessment of existing systems and processes

Around 6 to 7 TPD of segregated dry waste is being transported to the mainland from the SLRM centers established by municipal authority

There are purportedly 12 operational Solid Liquid Resource Management (SLRM) centers established across the city under Swachh Bharat Mission. These SLRM units are operated by 7 different vendors. The scope of work for the vendors include - (1) Segregation and baling of dry waste received from secondary collection /transfer points (2) Operate the plant developed by PBMC (3) Sale of recyclables and non-recyclables waste (4) Transportation of segregated waste to mainland (5) Transportation of rejects to authorized disposal site. Around 180 MT of segregated recyclables and non-recyclables was transported to the mainland from these 12 SLRMs in the month of August 2021. Accordingly, it is estimated that the dry waste managed by these SLRMs combined is around 6 to 7TPD. The segregated dry waste is transported mainly to Chennai, Kolkata and Vishakhapatnam through 2 major shipping lines.

SLRM Centres

SLRM Centre at Mohanpura

Source: Consultant team (field visit)

Bailed Milk pouches /tetra pack

Source: Consultant team (field visit)

Bailing Unit at SLRM center

Source: Consultant team (field visit)

Bailing Unit at SLRM center

Source: Consultant team (field visit)

Bailed Plastic

Source: Consultant team (field visit)

Bailed Cardboard

Source: Consultant team (field visit)

Bailed Plastic

Source: Consultant team (field visit)

Shredded Plastic

Source: Consultant team (field visit)

Note: *Further assessment is required to understand the health and safety aspects in the SLRM units and how reject materials are being collected and transported to dumpsite*

Operational efficiency of SLRM units is in the range of 25% to 60%

Considering that the average input capacity of the individual SLRM units is around 1.5 to 2 TPD, the total combined capacity of all 12-current operating SLRM units is estimated to be around 20 TPD. However, the actual quantity of dry waste managed in two (2) SLRM units is around 1.2 TPD with operational efficiency of 60%. The dry waste managed in other 10 SLRMs are in the range of 300 to 400 kg each with operational efficiency of 25%.

No of SLRM centers	Design input Capacity (TPD)	Actual capacity utilized (TPD)	Operational efficiency
2	2	1.2	60%
10	1.5	0.4	27%

The under performance of the units is due to the following reasons:

- Unequal distribution of dry waste collected by PBMC and SHGs to the SLRM units
- Lack of performance-based contracts - there are no key performance indicators (performance standards) defined and monitored by PBMC
- Lack of mechanization of SLRM units

More than 35% of the wet waste generated by households and commercial /institutional establishments is managed through in-situ methods, thereby reducing the burden on the municipal authority

The UT SWM Policy and PBMC bye laws intend to promote in-situ management of organic /wet generated in the city. Accordingly, it is estimated that out of 42 TPD of wet waste is generated by households and commercial /institutional establishments nearly 15 TPD is managed through in-situ methods. In addition, there are two functional composting facilities managed by private vendors handling around 5 TPD of wet waste. The infrastructure for the plant is developed by municipal authority. The salary of employees and other O&M expenses of the plant to be borne by private vendor. The expenditure is expected to be met by sale of segregated recyclables and non-recyclables.

Compost plant at gandhi Park

Compost plant at Gandhi part

Source: Consultant team (field visit)

Compost pit at Gandhi park

Compost plan

Source: Consultant team (field visit)

The details of the compost units are presented below:

Sr No	Name of Unit	Technical details	Design capacity	Operational capacity	Compost generated
1.	*Gandhi park vermicompost unit*	10 to 12 compartments of 12ftx2ftx4ft (4 ft height) – 30 days	*3 TPD*	*2 to 3 TPD*	*50 kg*
2.	*Brookshabad compost unit*	10 to 12 compartments of 12ftx2ftx2ft (2 ft height) – 60 to 90 days	*2 TPD*	*1 to 2 TPD*	-

B. Review of applicable policy and regulatory framework- Waste Processing

A brief review of compliance of the city against the applicable policy and regulatory framework is presented below**:**

National	State /UT /City Level (Andaman & Nicobar)		Observations
SWM Rules, 2016	**UT Policy for SWM Strategy 2018**	**PBMC SWM Byelaws 2017**	
• Bio-degradable waste→ compost plant, bio-methanation plant or any such facility • Non-biodegradable waste→ processing facility or material recovery facilities or secondary storage facility • Combustible fraction of waste → waste to energy plant, power plants, cement kilns	• 100% treatment of waste through state of art technology Insitu management of wet waste • Encouraging 3 R strategy • Explore feasibility and viability to establish waste to energy plant	• Insitu management of wet waste generated in the city • Decentralized management of waste • Formulating mechanisms to market the compost • Promote use of recycled products • Use of plastics in road construction	• Around 15 TPD of the wet waste generated in the city is being insitu composted or fed to cattle /animals, thereby reducing the burden on the municipal authority • The municipal authority is yet to devise mechanisms to encourage reuse and recycling of dry waste • PBMC has piloted the project where plastic waste has been used in road construction. • No mechanisms devised to create market for the by-products

C. Inferences on gaps and challenges

Infrastructure

- **Gap in infrastructure for wet waste management** - The total wet waste generation in the city in 2021 is estimated at 46 TPD. Considering that around 15 TPD is being managed through insitu methods and around 3 TPD is taken by the organic farmers, the city requires infrastructure to manage remaining 28 TPD of wet waste. However, the current capacity of the composting units is only 5 TPD. Hence, there is an infrastructure gap of 25 TPD as on 2021 and 32 TPD as on 2031 to ensure complete processing of wet waste generation.

  Substantial quantities of Biodegradable waste including the garden waste/ tree-fellings etc. are transported directly to the Brookshabad dumping site in view of the inadequate composting facility in the city.

- **Gap in infrastructure for dry waste management** – The total dry waste generated in the city is around 27 TPD. While informal sector is handling around 3.2 TPD of dry waste, the 12 SLRMs have capacity to handle 20 TPD. Assuming SLRMs to operate at 90% efficiency, there is still a need for infrastructure to manage remaining 7 to 10 TPD of dry waste in 2021 and 10 to 15 TPD in 2031 (excluding the dry waste to be generated by tourists).

Considering that the municipal authority has proposed 7 new SLRM units for the city, there could be two options explored by PBMC:

<table>
<tr><th></th><th>Description</th><th>Design Capacity (for 2031 - excluding waste generated by tourists)</th><th>Design Capacity (for 2031 - including waste generated by tourists)</th></tr>
<tr><td>Option 1</td><td>Establishing 7 new SLRM units to manage waste through decentralized approach</td><td rowspan="3">10 to 15 TPD</td><td rowspan="3">18 to 24 TPD</td></tr>
<tr><td>Option 2</td><td>Augmentation of existing SLRM units</td></tr>
<tr><td>Option 3</td><td>Establishing centralized MRF facility</td></tr>
</table>

Considering ease of operations and monitoring aspects, it is important for PBMC to re-evaluate the proposal for additional SLRM units. Instead, feasibility for a centralized MRF facility of capacity 15 to 20 TPD (including dry waste to be generated by tourists) can be explored as an alternative option.

PBMC is evaluating setting up a MRF to handle 30 TPD of dry waste at Brookshabad Dry Resource Centre area where there is appropriate land-availability locate away from the city habitation with good parking facilities.

- **No weigh bridge present** in any of the processing units to estimate the quantity of waste reaching the units and quantity of rejects sent to the disposal site

Systems and processes

- **Low operational efficiency of the SLRMs -** While the total capacity of the SLRM units is estimated to be around 20 TPD, only6 to 7 TPD of segregated dry waste is currently sent to the mainland. This is compounded by the near absence of DTDC of source segregated material, with actual segregation of materials being conducted informally from predominately mixed waste and without any health and safety standards at open secondary collection points. This dramatically impacts the efficiency and effectiveness of the entire material flow and service chain with regard to quality and quantity of materials recovered from the waste stream for recycling. SLRMs being utilized only as material aggregators and baling centres reliant on PBMC waste collectors to deliver segregated materials rather than acting as local Material Recovery Facilities themselves dramatically constrains the efficiency and effectiveness.
- **Unequal distribution of dry waste among the SLRM units -** There are no mechanisms defined to ensure minimum quantity of waste to the individual SLRM units. Currently the dry waste from the secondary collection /transfer points is sent to these SLRMs in an ad hoc manner resulting in unequal distribution of dry waste among the units. While most of the units are getting around 300 to 500 kg, two of the units are receiving 1.2 MT each.
- While PBMC is involved in segregation and handing over of dry waste to the SLRM units, the revenue shared with the municipal authority is very minimal (INR 0.5 to 1 per kg).
- **Lack of market for non-recyclable dry waste** – The value for recyclable waste transported to the mainland is significantly higher than that of the non-recyclable dry waste. The profit margin for non-recyclable dry waste is less as the transportation cost to the mainland is high and the value for the same is low. Hence, the SLRM units are more motivated to segregate and transport recyclable waste to the mainland while the non-recyclable waste either remain stored in the

SLRM units or gets disposed at the disposal site. As SHGs are not incentivized to collect, segregate and transport non-recyclable, the chances of these waste entering the environment is high as they are unlikely to be collected and segregated.

- **Lack of incentive mechanism to create market for by products –** Although the policy and bye laws encourages municipal authority to introduce incentive mechanisms to create market for the by-products, no initiatives have been taken from the municipal authority.

3.2.5 Disposal and legacy waste management

A. Assessment of existing systems and processes

Municipal authority is yet to establish Sanitary Landfill for disposal of waste

The disposal facility in the city does not meets the standards of an engineered sanitary landfill as required by SWM Rules, 2016.It does not have impermeable base liner, leachate collection and management system, efficient drainage system etc. It is estimated that around 40 TPD of waste is dumped in the disposal site on daily basis[11]. This waste consists of rejects from SLRMs and mixed waste from the secondary collection points. Due to lack of processing /sorting facilities around 13 TPD of dry waste and 23 TPD of wet waste including garden waste is being disposed without treatment. Further, the legacy waste accumulated at the dumpsite site is estimated at around 1,00,000 MT.[12]

Disposal Site

Disposal site – View 1
Source: Consultant team (field visit)

Disposal site – View 2
Source: Consultant team (field visit)

B. Review of applicable policy and regulatory framework- waste disposal

A brief review of compliance of the city against the applicable policy and regulatory framework is presented below**:**

National	State /UT /City Level (Andaman & Nicobar)		Observations SWM Rules, 2016
SWM Rules, 2016	**UT Policy for SWM Strategy 2018**	**PBMC SWM Byelaws 2017**	
• Establishing sanitary landfill • Take necessary actions to bio-mine or bio-remediate.	• 100% scientific disposal of waste • Sanitary landfill to be developed • Remediation of legacy waste and recovery of resources		• Disposal site is not a sanitary landfill • 13 TPD of dry waste and 23 TPD of wet waste including garden waste is being disposed without treatment • 1 lakh MT of legacy waste to be remediated

[11] *Source: based on the material flow analysis*
[12] *Source: Discussion with officials from PBMC*

C. Inferences on gaps and challenges

Infrastructure

- **Need for development of sanitary landfill** – Due to the absence of sanitary landfill facility, the disposal of waste in unscientific manner is raising severe environmental concerns. As there is no impermeable base liner present, there is possibility of ground water contamination. Also, considering that the city is an island, there is also high possibility of waste and leachate entering the marine system. There is a need for developing sanitary landfill facility as per SWM Manual (CPHEEO guidelines) for safe and scientific disposal of the waste.

  As per Municipal Solid Waste Management Manual published by CPHEEO[13], the following are the major aspects highlighted for development Sanitary Landfill facility:

  1. Phasing of landfill facility
  2. Base sealing system
  3. Leachate Management – collection system, collection pond, treatment
  4. Storm water management – garland drains, storm water drains
  5. Landfill gas management
  6. Covering of waste – daily, intermediate and temporary covers
  7. Filling and compaction of waste
  8. Slope stability
  9. Closure and post closure plan

- **Need to plan for operational financing of sanitary landfill** – An indicative benchmark cost / MT for operation and maintenance of proper sanitary landfilling of waste in India is in the region of 700 and 1100 INR / MT, versus 200 – 400 INR / MT for dumpsites like this (not including land and site engineering capital cost depreciation). The financial implications of establishing and operating a sanitary landfill must be acknowledged and factored into sector planning. The implications of a high cost per MT of landfilling should also be factored into the cost of alternatives, which can become more viable with greater return on investment and less operational financing required when compared to landfill. This is an important, if not critical, aspect of any integrated waste management enabling environment and a critical aspect for the UT / PBMC to address in order to stimulate and leverage private financing in the waste sector.

- **Need for remediation of legacy waste** – The legacy waste accumulated in the disposal site due to unscientific disposal is adding to the environmental concerns. Hence, there is a need for remediation of legacy waste

- **No weigh bridge** present at the disposal site which is making it difficult to quantify waste being disposed on daily basis and in turn develop data based informed planning and decisions making.

Policy and institutional

- No mandate /guidelines /technical support provided for developing sanitary landfill at State /UT level
- No mandate /guidelines /technical support provided for remediation of legacy waste

3.2.6 Informal Sector

A. Assessment of existing systems and processes

The informal sector is not as significant as found in mainland cities

Port Blair is an island and there are no recycling industries /units present in the city. All the segregated dry waste needs to be transported to the mainland for reuse /recycling/recovery.

[13]*Source: Municipal Solid Waste Management Manual by Central Public Health and Environmental Engineering Organisation (CPHEEO) (http://cpheeo.gov.in/upload/uploadfiles/files/Part2.pdf)*

Hence, there is limited scope for small scale waste pickers to collect waste in the city under the current enabling conditions. However, there are around 31 scrap dealers registered with ULB. It is estimated that around 3.2 TPD of dry waste is being recovered from the informal sector majorly including metals.

B. Review of applicable policy and regulatory framework – Informal recycling sector

A brief review of compliance of the city against the applicable policy and regulatory framework is presented below**:**

National	State /UT /City Level (Andaman & Nicobar)		Observations SWM Rules, 2016
SWM Rules, 2016	**UT Policy for SWM Strategy 2018**	**PBMC SWM Byelaws 2017**	
• Establish a system to recognize/ organize informal waste pickers or collectors and encourage SHGs	• Integration of informal sector for dry waste management		• 31 scrap dealers are registered with the ULB • There are no waste pickers identified and registered in the city • SHGs part of door-to-door collection from commercial /institutional waste generators

4. SWOT analysis of current practices and identification of Gaps

4.1 Strengths, Weaknesses, Opportunities and Threats Analysis of the current SWM system

4.1.1 Strengths

Political

1. National policy and regulatory framework is well established with clearly defined roles and responsibilities for stakeholders involved within the sector and provides a solid framework that enables both public and private sector participation in delivering and improving the waste management operations.
2. National Policy and regulatory framework continue to develop with concepts including Extended Producer Responsibility (EPR) being integrated into the system that offer improved sector financing opportunities.
3. National policy and regulatory framework empower the State to be able to enact locally appropriate by-laws to address local challenges in the sector.
4. Political and regulatory framework provides good guidance and standards without being overly prescriptive which would limit innovation (although this must be maintained carefully)

Institutional

5. Being part of a small UT, Port Blair, the capital, is the major urban centre and there is a certain amount of homogeneity in the Institutional arrangement.
6. The UT's main focus for SWM has been on Port Blair and the institutional arrangements have been made accordingly. The institutional framework focussing on the entire chain of operations including door to door collection & segregation, secondary collection and transportation, dumping of MSW is being handled by PBMC.
7. There is a good Institutional mechanism in place based on PBMC experience in developing PPP operation models for SLRMs, vermin- compost plants and Collection and Transportation of waste from commercial units.
8. The institutional framework is in place to both deliver SWM services directly (from in-house resources) and to contract out services to third party service providers. This framework can facilitate the development and implementation of an efficient integrated waste management system that interlinks primary collection, secondary collection, transportation and processing and disposal operations.
9. The ULB has experience in developing and tendering PPP operator models, especially for SLRM, Vermi-Compost Plants and Collection & transportation of Commercial Wastes, and new PPP models for ISWM in Ward no. 24 and a proposed green field MRF are being planned.
10. The city has been constantly improving its ranking in Swaachha Survekshan over the past 3 years.

Social

11. There is a chain of informal waste aggregators and 31 number of registered scrap dealers in addition to SLRM operators who carry out the segregation (limited) and baling of recyclables and non-biodegradable waste material and shipping it to the mainland centres at Vizag, Chennai and Kolkata.

Technological

12. There is an established and functional system for collection of MSW which has been prevalent over the years.
13. The SLRMs developed by the PBMC, although being very basic in nature and small in size; do provide a good technological innovation for decentralized processing of the recyclable waste. The technological model for standard Vermi-composting being carried out at two plants, supported by PBMC are also indicators of comparative technological strength where the quality of the products is fairly good and meets the minimum standards set for its application, as a compost/fertilizer.
14. The door-to-door collection from the Households, segregation, secondary collection and transportation as well as the final disposal is carried out by PBMC, thus giving the ULB a technological strength to improve its performance constantly.
15. There is a provision to control the input material being supplied to the SLRM and the Vermi compost unit in a segregated manner.
16. The PBMC has also indicated its preference to setup a model MRF closer to the dumping site. PBMC is going ahead with implementation of a 5TPD WtE project based on biomethanation as a pilot project, which could prove to be an innovative project, if successful[14].
17. The ward level audits to be performed in the city will provide additional data /information to make informed decision on SWM systems. The same can be integrated the data management system to be developed in the city.

Environmental

18. ULB initiative to recover approximately 1 Lakh Tonnes of Legacy Waste accumulated at the dumpsite site for a number of years, based on a PPP model.
19. The total legacy waste accumulated at the closed and the existing dumpsite is about 3.5 lakh Tonnes, accumulated over the last 13 years. The recovery of Legacy waste is a major compliance and environment-friendly initiative.

Economic

20. Proven and established market for compost produced, which fetches a premium price of Rs. 50/kg to the SHGs operating the Vermi-compost plants, is a sign of Economic strength of the Informal group engaged in SWM activities.
21. Established and proven recyclable material aggregators and Balers in form of 12 SLRMs across the 24 wards of the city.
22. One SLRM located at Dollyganj is primary working on MLP waste of the city, and supplying the baled material for road construction to the Highway Authorities, PWD etc.

4.1.2 Weaknesses

Political

1. PWM and SWM Rules do not provide clear guidance on how institutions assigned roles and responsibilities within the sector should coordinate amongst each other.
2. The ULB has not prepared or implemented an effective SWM plan as required under the SWM Rules and lack established conditions and by-laws (some have been drafted but not enacted) to assist enforce requirements of SWM and PWM Rules.
3. The Manual on Municipal Solid Waste Management, 2016, is an extensive document with valuable content, however it does not appear to be well known or have been read, understood or utilised by the ULB in their current system planning, design, tendering or otherwise.

[14] *Source: Discussion with officials from PBMC*

4. The collection of waste from the commercial areas has been contracted to two SHGs which are expected to cover all the 24 wards of the city. However, the collection system is not upto the mark and PBMC has to collect from many commercial areas using its own vehicles, thus resulting in a parallel operating system and multiplicity of agencies undertaking the same task.
5. The compliance with the SWM Rules 2016 requiring establishment of a Sanitary Landfill is lacking and an action plan in this regard, needs to be worked out by PBMC on an urgent basis.

Institutional

6. Lack of an established sector training or continued professional development training to develop the capacity of public sector staff, particularly for the ULB to design, implement, operate and monitor various projects.
7. Lack of a Committee with representation from all major departments involved in SWM operations is a major weakness.
8. Lack of established vigorous training and capacity building of ULB workers and other operators
9. No health and safety policy or enforcement
10. Lack of capacity at city, state and national level to conduct sufficient monitoring and enforcement (M&E) of existing rules, either through lack of skilled staff, lack of training or simply overburden of tasks allocated, prevents the comprehensive monitoring required to regulate the complex service and value chains. This is required beyond the “end-of-pipe" waste management sector and includes, manufacturing standards, product standards, EPR measures, PROs, collection services, recycling standards, sector health and safety standards, site and operator permitting, etc. The allocation of resources to monitor and enforce the PWM and SWM Rules needs improvement.
11. Waste collection and other Service Agreement Contract terms of engagement between private collection and waste facility operators are for a period of one year, generally. This is insufficient time to secure loans or incentivise investment by private operators in equipment and /or systems to optimise service delivery standards. PPP contract periods require to be appropriate to incentivise investment and improve the overall efficacy of the system.
12. The PBMC Sanitation staff works in multiple roles in collection, segregation, transportation of the wastes at SLRMs, Vermi-Compost Plants and the Dumping site.
13. There is also duplication of effort with multiple vehicles collecting the waste from the secondary points transporting either to SLRM, Vermi- compost plant or the dumping site. Although a strong PBMC workforce is involved in the SWM operations, there are only two technical personnel to monitor the entire process.
14. For the contract given to the SHGs of collection of the commercial waste in the city, there is virtually no monitoring for PBMC in terms of the effectiveness and extent of coverage. Also, the SHGs who collect the User-fees from the commercial units do not report to the PBMC on the revenue collected. These revenues are also not shared with the PBMC, resulting in complete lack of control on the secondary collection of commercial waste in the city.

Social

15. Poor understanding of health and safety and lack of training and physical conditions result in poor working environment throughout the waste management system from collection to SLRM operation

Technological

16. Missing source segregated containers or ineffective collection of waste fractions as mandated in the national policy and regulatory framework.
17. Lack of effective containers or site delineation / containment at community disposal points to ensure waste is contained and protected from the weather, waste pickers, animals etc that distribute the waste facilitating it's leakage to the marine systems. In fact, the city has been designated 'Bin-Free' and there are no bins installed at the Secondary Collection points in the city which represents a significant challenge to developing a robust system.
18. The secondary collection /transfer points are mostly uncontained open site as the site has no boundary wall, platform or any other structure to ensure zero contamination of the nearby environment by the waste
19. Not all waste transportation vehicles are covered, resulting in scattering of waste during transportation.
20. No sanitary landfill established resulting in residual waste being dumped in a temporary storage area and becoming what is being termed "legacy waste" which, despite some efforts, is continuously increasing and depriving the ULB of land that can be used for other purposes as well as presenting a significant liability in terms of non-compliance and as an environmental hazard
21. Although the segregation is actively carried out at different levels such as the households, by the door to door collectors, and the secondary collection points, the proper procedures and are not followed resulting in some waste getting mixed again while being transported to the SLRMs and the dumping site.

Environmental

22. No established system for domestic Hazardous waste observed to be accessible to all in city
23. The absence of the Sanitary landfill site has led to dumping of the MSW which is done in a haphazard manner. There was visible smoke emerging from the dumping site and probably some of the MSW is being burnt to reduce the quantity, which is non-compliant with the regulatory framework and a serious environmental hazard.
24. Due to heavy rains in the city, the leachate at the dumping site also presents a major environmental hazard, posing grave contamination risk to local sea, impacting the marine life.
25. The disposal site lacks basic infrastructure facilities like approach road, drainage systems etc. resulting increased environmental concerns

Economic

26. No mandated and enforced waste collection fee to recover cost of full-service delivery. No provision for User fees for DTDC by PBMC is also a major weakness in the system.
27. The lack of Financial viability for the PPP Projects e.g. Door to Door collection (DTDC), SLRMs, Vermi-Composting, Legacy Waste Management etc. may result in inefficient and unviable operations, if not properly planned, implemented and monitored.
28. Poor quality (both cleanliness and homogeneity) of recovered recyclables impacts market price attainable for materials being recovered at all stages of the chain.
29. Insufficient financial resources and capacity available within UT to effectively comply with the regulations and reporting mechanisms, as required by the National and UT Rules related to SWM.
30. The absence of a sanitary landfill or indeed operation and maintenance of the waste disposal site in a manner that would be reflected in a sanitary landfill results in the cost of disposing a MT of waste is far below what it will be if a sanitary landfill were in place. This distorts the economics of the sector in that few waste management systems can compete financially with a "free" or low-cost disposal option.

4.1.3 Opportunities

Political

1. Port Blair is a strategically important town in the Andaman & Nicobar Islands in the Bay of Bengal and presents good opportunities for implementation of the CCP-ME project.
2. Plastic product bans present an opportunity to introduce alternative products that are easier to capture and recover through the waste management system.
3. There appears to be strong political will to improve the system and services throughout the economy
4. The Service Level Benchmarks (SLBs) framework includes Benchmarks for water supply, wastewater management, storm water drainage and solid waste management which can be expanded to include additional sub-performance indicator benchmarks within the waste sector to incentivise improvement.

Institutional

5. Port Blair is also having many key strategic institutions such as Indian Navy, Port Trust Authority etc.
6. Establishing Performance Level Indicators for waste service provision including segregation and material recovery targets could incentivise improved performance.
7. The homogeneity at Institutional level for Andaman & Nicobar, UT and Port Blair city presents a great opportunity in the implementing innovative mechanism for PWM including EPR framework and buy back mechanisms.

Social

8. Framework for engaging community in segregation, stopping of littering, regular payment of user charges etc. is established and public appear to be willing to engage in initiatives.
9. There exists an opportunity to develop livelihoods for the informal sector engaged in SWM activities, albeit at a smaller level.
10. There is a virtual absence of the informal sector at the secondary collection points, unlike other cities, as there is little value associated with the recyclable material which has no local market and has to be transported to the mainland centres for recycling and reuse in a baled form. This is regarded as an opportunity to develop an effective and efficient recovery system without impacting an existing informal sector.

Technological

11. Innovations are continuously being made in the waste management sector, Port Blair can benefit from innovations and lessons learnt in implementing new technologies in other cities, states and internationally.
12. Existing Infrastructure such as SLRMs, Vermi compost Units etc. could be developed further through technology interventions to upgrade the SWM system specially the PWM in the city. It is also important to capture the data on quantity of waste fractions managed at these centres to ensure effective monitoring (triangulating) and informed decision making.

Environmental

13. Global acknowledgement of the waste crisis and its impact on the environment is assisting put the need for changing consumer behaviour and waste management practices.
14. A great opportunity exists in developing a SLF Site for MSW, thus improving the environmental aspects of SWM and also for achieving the compliance with the regulations.

Economic

15. Port Blair, the largest town in the A&N island and well connected with all other islands in the UT, is the Economic hub and any development there would have a great impact on the overall economy. Also being a major tourist attraction, there is an opportunity to increase tourism through effective measures for a better management of MSW, specially the Recyclable & Non-biodegradable wastes.
16. With the digital platform to be introduced in due course of time, recyclers located in Port Blair and nearby areas could benefit a lot from this initiative which would help them to become economically viable through a better capacity utilization & more efficient operation
17. Employment opportunities within the waste sector are increasingly being realised and assisting move waste management work up the professional acceptance ladder.
18. Allocating appropriate capital and operational finances for development and scientific closure of sanitary landfill will increase the price per tonne of disposal and thereby make alternatives to disposal more attractive from a cost comparison perspective. With proper enforcement and charging mechanisms this can represent a critical component of the enabling environment for improved integrated waste management and leveraging / attracting additional private and public financing.

4.1.4 Threats

Political

1. Political and regulatory framework, including national rules, guidance and standards could easily become overly prescriptive which would limit innovation.
2. Uncoordinated programmes, or financing waste management initiatives through short term programmes, can result in ULBs applying for any and all project financing being offered based on funds availability rather than from a local integrated and strategic planning focus, impacting sector cohesion and viability.
3. Lack of an elected body of representatives presently, could be perceived as threat and a bottleneck for effectively implementing the policy measures and the plans for SWM.

Institutional

4. No User Fees for DTDC by PBMC and no monitoring of the User Fee collected by the SHGs for collecting & transporting waste from Commercial areas, could be a long-term financial threat to compliant SWM System
5. The strategic Institutions/facilities such as Indian Navy, Defence, Port Authority etc have their own SWM system which is not integrated with that of PBMC
6. The waste from about 70 odd village Panchayats located in the nearby islands is also transported to Port Blair from where it is transhipped to the mainland.

Social

7. Lack of public participation or acceptance of changes to the current waste management service may impede development.

Technological

8. There is a risk that technology maturity and markets may not be fully developed for innovative Investments being made by the ULB, such as the 5 TPD Plant for biomethanation the risk of investing in these directly and loosing financially and reputationally is large, rather than contracting a BOOT or other PPP approach that outsources or spreads the risk.
9. Developments in packaging material and compostable polymers entering the consumer goods market may result in greater investment being required in polymer identification technology to efficiently detect and segregate compostable polymers from recyclables.

10. Reliance on markets for low grade polymers such as plastics waste to roads that are not yet fully accepted (e.g. they may cause greater microplastic pollution in waterways than is reasonably acceptable) could impact long-term viability.

Environmental

11. Under current operational practices some waste from the wards is released into the drains which ultimately reaches the marine environment, especially during the rainy season.
12. The hotspots such as major drains in the city, pose a great threat to the MSW management in the city, especially the plastic and other non-biodegradable wastes, which end up as major pollutants in the Bay of Bengal.
13. The disposal of MSW haphazardly at the Dumping site is a great environmental and health and safety threat. Burning of the waste is also prevalent, as observed during the field visits which releases carcinogenic uPOPs and short-term climate pollutants into the local environment in contravention of several UN conventions.

Economic

14. Fluctuations in material markets are inherently challenging for maintaining financially viable recycling initiatives.
15. The potential economic fall out as a consequence of the COVID-19 pandemic or any other local, national or international economic impact will adversely affect the ability to secure sufficient investment in the system.

Operational

16. Multiple handling and segregation of waste collected by the PBMC at the Household level, presents a threat operationally for smooth functioning of the SWM system.
17. The quantities of Segregated Recyclable & other non-biodegradable wastes being presently delivered to SLRMs are small resulting in a low capacity utilization for these facilities. Now more SLRMs are proposed to be added by PBMC as well as a Greenfield MRF at Brookshabad which may result in further non-viable operations of these facilities and is thus a major threat.

4.2 Identification of Gaps

4.2.1 UT Level Assessment

Aspects	Responsible Agency	National	UT/ ULB	Policy and Regulatory Gap
Coverage	Not Applicable	• Applicable to ULBs along with the outgrowth of urban agglomerations and notified areas.	• Applicable to territorial limits of the ULB only	The policy does not cover outgrowth of urban agglomerations and notified areas.
Policy & Strategy Focus	State/UT (policy/ Strategy) and ULBs (SWM Plan)	• UT to Prepare SWMPolicy/ Strategy • ULBs to prepare SWM Plan	• Andaman & Nicobar Island has framed a SWM Policy, 2018 • ULB required to prepare SWM Plan	Policy recommendations not implemented The SWM Rules 2016 requires ULBs to prepare a SWM Plan. Port Blair has prepared the By- Laws on SWM 2017 and a DPR on SWM Collection & Transportation but no robust ISWM implementation plan exists with a focus upon waste processing and disposal exists..
Solid Waste Management value chain				
Waste Generation	Residential and non-residential units	• Segregation into three categories mandatory - biodegradable, non-biodegradable and domestic hazardous • Sanitary waste and horticulture waste to be stored separately	In addition to the National level framework, • Prohibit litter in storm water drains • Non-biodegradables to be cleaned, dried and handed over to local body for recycling • In-situ Composting at the HH Level	Enforcement mechanism for SWM Rules 2016 and Port Blair By-Laws on SWM is weak.
Bulk Waste Generators		• In-situ composting for wet waste	• 5 BWGs notified by PBMC, all hotels	Weak enforcement mechanism for in-situ management of waste for bulk waste generators.

Aspects	Responsible Agency	National	UT/ ULB	Policy and Regulatory Gap
Waste Collection	ULB	• Door-to-door collection from all units • Separate collection of street sweeping waste • ULBs required to frame by-laws for SWM. • ULB to consolidate augmentation of equipment and infrastructure required for waste segregation at source and its transportation in segregated manner. • Every day dedicated collection of sanitary waste wrapped in a cover/pouch, which may be mandatorily provided by sanitary product suppliers.	• Door-to-door collection from all units • Point to point collection of waste permitted • Separate systems for waste collection from commercial units.	100% door to door collection – however this is not segregated. Segregation carried out in multiple stages at DTDC level as well as at the Secondary collection points. Being a Bin-less city, there are no litter or community bins. A network of community storage bins as per SWM Rules 2016 may be established.
Secondary storage	ULB	• Secondary storage facilities to be set up along with MRFs • Separate storage facility for street sweeping waste. • Establishing citizen drop off centers for storage of domestic hazardous waste.	• Separate storage of waste - biodegradable, non-biodegradable and domestic hazardous • MRF to be set-up →involve informal sector waste pickers	12 SLRMs in operation in the city, operated by 7 agencies but the quantity of segregated recyclable & non-biodegradable waste delivered by PBMC is small.
Transportation	ULB	• Biodegradable and non-biodegradable waste to be collected separately, with biodegradable and sanitary waste to be collected on daily basis.	• Vehicles to be covered and store segregated waste • Mechanized handling of waste	Partial compliance as vehicles is not all covered and have space to store segregated waste.
				One informal Transfer Station at Mohanpura (ward no. 4) where compactor is used to collect mixed waste & deliver to dumpsite.

Aspects	Responsible Agency	National	UT/ ULB	Policy and Regulatory Gap
Processing	ULB	• Bio-degradable waste →compost plant, bio-methanation plant etc. • Non-biodegradable waste →MRF • Combustible fraction of waste →waste to energy plant, power plants, cement kilns	• In addition to the National level framework, • Decentralized processing facilities for biodegradable waste	Implementation framework for the SWM Rules 2016 and PBMC By-Laws 2017 have weak implementation, No SLF in operation, only haphazard dumping.
Disposal	ULB	• Prohibit dumping of mixed waste • Disposal of residual waste only	• Prohibit dumping of mixed waste • Disposal of residual waste only	No SLF, only dumping of the MSW.
Legacy waste	ULB	• Take necessary actions to bio-remediate the existing legacy waste with provisions for establishing leachate treatment plant along with an engineered sanitary landfill.	• Take necessary actions to bio-mine or bio-remediate	**Bio-remediation** process initiated; tendering process is underway.
Other Aspects				
User fee	ULB	User fee and spot fines set by the ULB by-laws		No- User- Fees for HHs
PPP	ULB	Private sector participation permitted across the SWM value chain		Private sector participation is observed in multiple stages of the SWM value chain but these are not conventional PPP contracts and therefore lack that private and public sector collaboration and associated efficiency and effectiveness gains.
Training and capacity building	ULB	Focus on training and capacity building of the ULB staff and the informal sector engages in the SWM value chain.		There is a need to conduct training and capacity building at the UT and ULB level across various aspects of SWM value chain
Inclusion	ULB	Organise / register the informal sector engaged in the SWM value chain of the city and integrate them in the SWM system		Very little participation from Informal Sector except for 31 Kabbadiwalahs who deal mainly in the metallic and E-Waste
Community engagement	ULB	Promote home composting, bio-gas generation, decentralized processing of waste at community level		Home Composting prevalent as well as 2 small Vermi-Composting plants in operation, but no plant to convert the biodegradable waste delivered to the dumping site.
IEC	ULB	Emphasises on awareness generation on issues and practices on SWM	Preparation of IEC plan required for the ULBs	Data requested

4.2.2 City Level Assessment

Aspects	Responsible Agency	National	UT/ULB	Policy, Institutional, Infrastructure
Coverage	PBMC	• Applicable to ULBs along with the outgrowth of urban agglomerations and notified areas.	• Applicable to territorial limits of the ULB only	PBMC to incorporate changes.
Policy & Strategy Focus	UTs (policy/ Strategy) and ULBs (SWM Plan)	• UTs to Prepare SWM Policy/ Strategy • ULBs to prepare SWM Plan	• PBMC has framed SWM Bye Laws in2017 • ULB required to prepare SWM Plan, as per the DPR already prepared. • UT Policy and Strategy on SWM for Andaman & Nicobar Islands, 2018	**Policy/ Regulation:** SWM Plan for Port Blair prepared but not fully implemented. **Institutional:** Big gap observed in the collection System for Commercial waste, which has been entrusted to the 2 SHGs but virtually no monitoring on contract by PBMC.
Solid Waste Management value chain				
Waste Generation	Residential and non-residential units	• Segregation into three categories mandatory - biodegradable, non-biodegradable and domestic hazardous • Sanitary waste and horticulture waste to be stored separately	In addition to the National level framework, • Prohibit litter in storm water drains • Non-biodegradables to be cleaned, dried and handed over to local body for recycling	**Policy/ Regulation:** segregation levels in the city are high but Sanitary waste not collected separate as per the regulation **Infrastructure:** the infrastructure in the city is adequate to handle segregated waste from the households, with multiple operations undertaken for segregation of wastes at Secondary collection points. However, the Implementation is not up to the mark. **Policy/ Regulation:** Lack of Sanitary Landfill and domestic/ commercial hazardous waste management system **Policy/ Regulation:** Tree cuttings are collected separately.

Aspects	Responsible Agency	National	UT/ULB	Policy, Institutional, Infrastructure
				Institutional: Limited Lack of robust data on waste composition and generation rates impacts ability to conduct sector monitoring and planning.
Bulk Waste Generators		• In-situ composting for wet waste	• Own systems for sorting of waste • PBMC collects the non-biodegradable & Recyclable waste from the BWGs	**Policy/ Regulation:** In-situ composting and for bulk waste generator promoted. – However, only 5 bulk waste generators have identified till date 12 SLRMs in operation but unviable due to low quantities.

Waste Collection	ULB	• Door-to-door collection from all units • Separate collection of street sweeping waste • ULBs required to frame by-laws for SWM	• Door-to-door collection from all units • Point to point collection of waste permitted • Separate systems for bulk, bulky, poultry, fish and slaughterhouse waste. • **ULB staff free to segregate valuable waste at the household level and sell to aggregators**	**Policy/ Regulation:** Lack of SWM systems for bulk-waste generators **Institutional:** Secondary Points near of waste into the environment and creation of hotspots across the city **Institutional:** Data generated from various technological and managerial interventions is not being integrated and utilized for decision making **Institutional:** Lack of performance-based contracts for collection and transport of Commercial waste as well as for SLRMs and Vermi-Compost units. **Institutional:** Fragmented, standalone service agreements with contractors for different aspects in the waste management chain are impacting the integration of services.

Aspects	Responsible Agency	National	UT/ULB	Policy, Institutional, Infrastructure
Secondary storage	ULB	• Secondary storage facilities to be set up along with MRFs • Separate storage facility for street sweeping waste	• Separate storage of waste - biodegradable, non-biodegradable and domestic hazardous waste • Decentralised Composting and Recycling options.	**Infrastructure:** No Bins for separate storage of waste - biodegradable, non-biodegradable and domestic hazardous at Secondary Collection points. **Infrastructure:** Uncontained waste community storage / secondary collection points results in waste being scattered and lost from formal collection system.
Transportation	ULB	• Biodegradable and non-biodegradable waste to be collected separately	• Vehicles to be covered and store segregated waste • Mechanised handling of waste • Mobile Transfer Station (MTS) or Fixed Compactor Transfer Station (FCTS)	**Infrastructure:** One Transfer station is basic and inefficient and conduct little to no formal segregation and compound challenges at the Dumping Site.
Processing	ULB	• Bio-degradable waste →compost plant, bio-methanation plant etc. • Non-biodegradable waste →MRF • Combustible fraction of waste →waste to energy plant, power plants, cement kilns	In addition to the National level framework, • Decentralized processing facilities for biodegradable waste (Vermi-Compost) • Decentralized SLRMs for Recyclables & Non-biodegradable Waste.	**Institutional:** Need for market linkage for the by-products for both Compost and the Baled Non-Biodegradable material from SLRMs.
Disposal	ULB	• Prohibit dumping of mixed waste • Disposal of residual waste only	• Prohibit dumping of mixed waste • Disposal of residual waste only	**Infrastructure:** Lack of Sanitary Landfill, Dumping site not maintained properly, burning of waste observed.
Legacy waste	ULB	• Take necessary actions to bio-mine or bio-remediate	• Take necessary actions to bio- mine or bio-remediate	**Institutional:** Accumulated legacy waste leading to environmental concerns, Tendering process underway for bioremediation of 1 Lakh tonnes of Legacy waste.
		Other Aspects		

User fee	ULB	User fee and spot fines set by the ULB by-law		No User Fees being collected by PBMC at HH level. Provision for spot fines laid out clearly.
PPP	ULB	Private sector participation permitted across the SWM value chain		**Institutional:** Limited success for private sector participation as the agreements and contracts are not comprehensive and do not include performance-based parameters (e.g. SLRMs, Vermi-Composting, Commercial Waste Collection & Transportations)
Training and capacity building	ULB	Focus on training and capacity building of the ULB staff and the informal sector engages in the SWM value chain.		**Institutional:** Lack of capacity of SWM staff and other stakeholders across aspects of SWM management – institutional, technical, financial, administrative, HR etc.
Inclusion	ULB	Organise/ register the informal sector engaged in the SWM value chain of the city and integrate them in the SWM system		**Policy:** Lack of integration of informal sector into the formal system
Community engagement	ULB	Promote home composting, bio-gas generation, decentralized processing of waste at community level		**Institutional:** IEC plan not prepared focusing on waste minimization, segregation at source, home composting, bio-gas generation, decentralized processing of waste at community level etc. PBMC to prepare this plan.
IEC	ULB	Embassies on awareness generation on issues and practices on SWM	Preparation of IEC plan required for the ULBs	

4.2.3 Plastic Waste Management

Aspects	National	UT/ULB	Compliance Status	
	Plastic Waste Management (Amendment) Rules,2021		UT	Port Blair
Policy & strategy focus	ULBs to frame bye-laws incorporating the provisions of these rules	-	Plastic Waste Amendment Rule 2021 framed	By-laws prepared but not fully implemented.
Plastics and Multilayer packaging material use permissible	Carry bags and plastic packaging →without any added pigment of with acceptable standards Carry bag made of virgin or recycled plastic→not be less than 70 microns in thickness from 30 September 2021 Carry bag made of virgin or recycled plastic→not be less than 100 microns in thickness from 31 December 2022 Non-woven plastic carry bag shall not be less than 60 Gram Per Square Meter (GSM) with effect from the 30 September, 2021	Notification for ban of single Use plastic & MLP (5/9/2019)	Notification for exemption of freight charges for transportation of plastic, glass & E-waste (28/6/2018) .	
Plastics and Multilayer packaging material use not permissible	Carry bags made from recycled plastic →not to be used for ready to eat/ drink food stuff Single use plastic, including polystyrene and expanded polystyrene, commodities shall be prohibited with effect from the 1 July, 2022: (a) Ear buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice-cream sticks, polystyrene [Thermocol] for decoration (b) Plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packing	Use of plastic carry bags <50 microns Use of disposable carry bag >50 microns not having registration number of manufacturers with effect from 15 July 2018 Cups, glasses, plates, spoon tumblers etc made from plastic or thermocol disposable after one time use after 15 August 2018 Prohibit all kinds of disposable plastic carry bags with effect from 2 October 2018		Prohibition on Sale of 1 liter packaged water bottles (only 2 L bottles permitted)

Aspects	National	UT/ULB	Compliance Status	
	Plastic Waste Management (Amendment) Rules,2021		UT	Port Blair
Generation	(a) Waste generators shall minimize waste generation as per SWM 2016Rules (b) Waste generators shall not liter plastic waste (c) Waste generators shall segregate and store the plastic waste at source and handover to ULB Bulk/ institutional generators: (a) Segregate and store waste as per SWM Rules, 2016 (b) Handover the waste at authorizes processing facilities/ disposal facilities/ deposition centers on their own or authorize collection agency	Prohibition on throwing non-biodegradable waste in public place, drain, gully, pit, ventilation shaft, pipe and fittings Gazette notification of PBMC dated 5/9/2019 prohibiting the use of Single use Plastics	The UT SWM rules are based on the principles of waste minimization, prohibit litter and encourage segregation.	No Bins or depots provided for temporary deposit or collection of the non- biodegradable garbage by the local authority
User fee/ Fines	Pay user fee or charge as may be specified in the bye-laws of the local bodies for plastic waste management	Penalty/ fines provided for violation of the PBMC rules ATR on penalties levied for non-compliance with the regulation prohibiting use of single use plastics.	Fines imposed → Partially Complied[7]	Fine on Sanitary Inspector for non-collection of segregated waste from the ward.
Retailer and Street Vendors	(a) Shall not sell or provide commodities to consumer in carry bags or plastic sheet or multilayered packaging, which are not manufactured and labelled or marked as per PWM Rules,2016 (b) Violation to attract fines as specified under the bye-laws of the local bodies (c) Shopkeepers and street vendors willing to provide plastic carry bags for dispensing any commodity to register with ULB by paying a plastic waste management fee →min INR 48,000 per year	Not Covered	-	Covered partly in Bye-Laws for SWM, PBMC
Segregation, collection, storage, transportation, processing and disposal of the plastic	ULB is responsible for: (a) Segregation, collection, storage, transportation, processing and disposal of the plastic (b) Channeling recyclable waste fraction to recyclers (c) Ensuring that open burning of plastic waste does not take place. (d) Ensure no damage is caused to the environment in the process	No Provision for placement of receptacles and places for deposit of non-biodegradable garbage in the bin-less system implemented in the city.	Specified under DPR on SWM and By- Laws on SWM for Port Blair City.	Good level segregation of waste observed 16 Water ATMs installed to reduce PET consumption site for Demonstration Project of MRF at Brookshabad, identified by PBMC.

Aspects	National	UT/ULB	Compliance Status	
	Plastic Waste Management (Amendment) Rules,2021		*UT*	*Port Blair*
Non recyclable plastic waste	Non-recyclable plastic waste to be channelized to, (a) Road construction (b) Energy recovery (c) Waste to Oil Thermo set plastic to be recycled as per CPCB guidelines	Not Covered	A Pilot project in Ward no. 24 planned on a PPP basis for ISWM A pilot project on MRF planned at Brookshabad	16 Tons of Plastic used for Road construction Regulations on Informal waste pickers & waste dealers to collect processed plastic waste & unprocessed plastic for road construction 21 authorized waste dealers
Inert from recycling and processing facilities	As per Solid Waste Management Rules, 2016	Not Covered	No data	No data
Inclusion	ULBs responsible for engaging civil societies or groups working with waste pickers;	Part of the SWM Policy.	No data	No data
Compostable plastic	The standard to conform to the Indian Standard: IS 17088:2008 titled as Specifications for Compostable Plastics →CPCB certificate needed for marketing and selling	Notification on ban of plastic bags and use of compostable bags.	Policy in place	Policy in place.
Information, Education, Communication (IEC)	ULB is responsible for creating awareness among all stakeholders about their responsibilities	Covered under the bye-laws but IEC budget is more need-based than a specified amount, as required under the regulations.	No data	No data

5. Recommendations and prioritised actions

Proposed Recommendations:

Understanding the prevailing gaps and challenges faced by the city in solid waste management, the following recommendations have been proposed:

Table 3: Gaps and proposed recommendations

Sr No	Aspect and Relevant Gap /Challenge /Need	Recommendations	Reference Case Study
A	**Strategy and Governance**		
1	**Strategy and action plan for ISWM** • Relevant and cross cutting all identified gaps / challenges is the absence of a robust integrated solid waste management implementation plan for the ULB / City • No dedicated department /cell for SWM	**1. Develop Integrated SWM strategy and action plan** a. PBMC to develop strategy with time-bound action plan for integrated solid waste management implementing the UT Policy and Strategy on Solid Waste Management for Andaman & Nicobar Islands, 2018 and other relevant local Bye Laws, Policies, Rules, and Guidelines, representing a detailed SWM Plan (detailed short or long-term action plan, sector contingency plans, etc) as required by the SWM Rules. This would involve identifying the interconnected requirements, engaging all stakeholders and covering all factors including technical, environmental, financial/economic, socio-cultural, institutional, and policy/legal/political, for all links in the waste service and value chains. In particular, a focus must be on developing robust interconnected performance-based service agreements / contracts with each service provider that ensures all aspects of the services are compatible with one another enabling the efficient and effective flow of resources through the system. Ensuring facilities are developed through options assessment to ensure compatibility is also essential. The implementation plan should also detail procedures for promotion of waste minimisation and for forming Ward Committees to monitor MSWM provision at City Corporation level.	

Sr No	Aspect and Relevant Gap /Challenge /Need	Recommendations	Reference Case Study
		b. Augmentation of waste disposal facility should be among the priority for PBMC, so as to comply with SWM Rules, 2016. c. Capacity development related to developing such plans, and the development of the plans themselves are the key foundation stone – to be developed based needs assessment for capacity building d. Review of institutional system focusing on need for dedicated department /cell for SWM	
2	**Data collection and management system** • There is no reliable estimate for waste being managed at various stages of SWM value chain as there are no weigh bridge present in any transfer points, processing and disposal sites • No integrated MIS	**2. Development of integrated data collection and management system** a. Weigh bridge to be installed at important transfer points (Mohanpura – Ward no. 4), processing and disposal units / facilities to enable accurate quantification of waste flows that enable proper data driven informed planning and decision making b. Develop integrated MIS for SWM sector c. Development of daily MIS system with IoT interface equipped with vehicle maintenance system and material traceability.	**Refer Case Study 6.10&6.11**- Technological intervention and data management in Vishakhapatnam and Nasik
B	**Waste Generation and Segregation**		
3	**Segregation at source** • Source segregation level is low in the city • Segregation happening at multiple locations (at source and secondary collection points) increasing burden on PBMC staff • The scope of work of SHGs involved DTDC do not include IEC and awareness activities focusing on segregation at source	**3. Improve segregation levels at source** a. Prepare comprehensive IEC and citizen engagement plan for the city focusing on source segregation b. PBMC to conduct citizen engagement initiatives to promote segregation at source (jathas, awareness drives, participative and educative events etc.) c. Introduce city level incentive and disincentive mechanisms to promote segregation at source (rebate on user fees, penalty on providing mixed waste etc.) d. Include IEC and capacity building activities under scope of work of SHGs or any other private operators performing DTDC -	**Refer case study 6.2:** Role of NGOs in improving segregation at source in Udupi

Sr No	Aspect and Relevant Gap /Challenge /Need	Recommendations	Reference Case Study
		Identify and plan the implementation of an efficient and effective operator model and means of source segregation for all required waste fractions	
4	**Waste minimization** • Despite having one of the highest per capita waste generation in the country, there are limited efforts undertaken for waste minimization at source • No incentive /disincentive mechanism introduced by PBMC to encourage waste minimization techniques	**4. Ensure waste minimization** a. Policy and regulatory framework to mandate waste minimization at source – A&N Administration to provide suitable guidelines for PBMC to achieve waste minimization at source. b. PBMC to prepare comprehensive IEC and citizen engagement plan for the city focusing on waste minimization at source c. PBMC to conduct citizen engagement initiatives to promote waste minimization (jathas, awareness drives, participative and educative events etc.)	**Refer Case Study 6.12–** IEC and Citizen engagement
5	**Sanitary waste management** • There is no system present for segregated collection and management of sanitary waste	**5. Scientific management of sanitary waste generated** a. PBMC to develop system for segregated collection and management of sanitary waste as per SWM Rules 2016	
C	**Collection and Transportation**		
6	**100% door to door collection and transportation** • Lack of monitoring mechanisms to ensure 100% DTDC - It is observed that the SHGs involved in DTDC from the commercial /institutional establishments are no covering 100% of the commercial /institutional establishments • Lack of performance-based contracts – the payments are linked to the key performance parameters • Lack of technological intervention to monitor DTDC • Increased burden to PBMC as it is responsible for DTDC from the households	**6. Introduce /strengthen monitoring systems to ensure 100% door to door collection** a. Undertake integrated waste management planning exercise and feasibility study to identify most appropriate means to rationalise existing collection contracts to ensure compatibility of services provided and optimise material flows through system b. Develop vehicle movement plan (required capacity, trips, no of waste generators to be covered - households, commercial establishments, route, timings etc.) and monitor the same through technological interventions including RFID tagging and GPS tracking to ensure effective monitoring of vehicles (collection and transportation) c. Introduction of performance-based contracts for door-to-door collection and transportation and link payments /LDs /incentives to the defined key performance indicators (coverage, timings, route, source segregation and linkages to processing and disposal units).	

Sr No	Aspect and Relevant Gap /Challenge /Need	Recommendations	Reference Case Study
		d. Provide additional infrastructure to ensure 100% door to door collection in the city based on need assessment	
7	**Secondary collection /transfer points** • Creation of hotspots - unscientific management of waste at secondary collection /transfer points leading to leakage of waste into open environment and water systems • Lack of transfer stations in the city	**7. Scientific management of waste at the secondary collection /transfer points** a. Transfer stations – Feasibility study to assess and confirm the requirement of transfer station (Pilot at ward 4) b. Rehabilitation of existing secondary collection /transfer points to ensure scientific management of waste (fencing, creation of platform, reducing leakage etc.) c. Removal of exiting hotspots – preparation of hotspot management plan d. In-dept assessment to ensure sustainable management of waste generated at the fish landing facility	
8	**Bulk waste generators** • Only 4-5 bulk waste generators are identified out of which 2 bulk waste generators are managing wet waste generated on their own	**8. Provide support to bulk waste generators to manage waste on their own** a. Provide technical and financial support to the bulk waste generators to establish and operate treatment facilities to manage the waste on their own b. Devise incentive /disincentive mechanisms for the bulk waste generators encouraging them to manage the waste on their own	**Refer case Study 6.1 -** System for bulk waste generators in Bengaluru
D	**Processing and Recovery**		
9	**Wet waste management** • There is gap of 25 TPD in the city to ensure complete processing of wet waste	**9. Ensure 100% processing of wet waste generated in the city** a. Feasibility study to be undertaken to evaluate need for creation of additional infrastructure to meet the gap b. Creation of market for compost c. Devise incentive mechanism to promote insitu composting of wet waste d. Exploring decentralized models for management for organic waste generated form the markets and green waste collected	**Refer case study 6.3**– Community composting model in Dhaka **Refer Case Study 6.4**– Marketing of city compost in Maharashtra

Sr No	Aspect and Relevant Gap /Challenge /Need	Recommendations	Reference Case Study
10	**Dry waste management** • Low operational efficiency of the SLRMs • Unequal distribution of dry waste among the SLRM units - There are no mechanisms defined to ensure minimum quantity of waste to the individual SLRM units. • Absence of performance-based contract – There are no key performance indicators /targets defined in the contracts to ensure standard service delivery from the operators • Lack of incentive mechanism to create market for by products • Need for infrastructure to manage remaining 7 to 10 TPD of dry waste • Lack of market value for non-recyclables leading to storage or disposal of non-recyclable waste at SLRM centres	**10. Improving operational efficiency of the existing SLRM units** a. Develop financially viable model for operation of SLRM units (win-win for PBMC and operator) (including, where required, appropriate subsidy from public sector)– Business planning and analysis to develop profitable operating model for SLRM units. b. Introduction of performance-based contracts and linking payments /LDs /incentives to the defined key performance parameters c. Ensure equal distribution of dry waste across units - Contracts to ensure minimum quantity of waste to be supplied to individual units or allocating wards to respective SLRM units. Also, the vehicle movement plan prepared by the municipal authority will ensure that the vehicles from the specific wards reaches respective SLRM unit as defined in the contract. d. Creation of market for recyclables and non-recyclables – incentive mechanisms including EPR, market subsidization etc. More importantly, the market value for the non-recyclables needs to be devised to ensure collection, segregation and disposal of non-recyclable waste which includes providing support for transportation cost for the non-recyclables etc, e. Feasibility study to be undertaken to evaluate need for creation of additional infrastructure to manage 15 to 20 TPD of dry waste – MRF (including dry waste generated by tourists)	**Refer Case Study 6.5**– Automated MRF at Indore
E	**Disposal**		
11	**Sanitary landfill** Unscientific disposal of waste in the dumpsite due to absence of sanitary landfill	**11. Scientific disposal of waste** b. **Prioritise allocating resources to operating existing disposal site as will be required at future sanitary landfill -** (human resources, equipment, working practices) to enable incremental operational finances to progress and contribute to the enabling environment of applying full cost of landfill in the system, elevating financial viability of alternatives. c. **Development of sanitary landfill** for scientific disposal of waste including leachate collection and management facility based on comprehensive cost modelling to maximise benefits	

Sr No	Aspect and Relevant Gap /Challenge /Need	Recommendations	Reference Case Study
12	**Legacy waste management** Around 1 lakh MT of legacy waste to be remediated	12. **Remediation of legacy waste –** bioremediation, biomining	**Refer case Study 6.7, 6.8. 6.9** – Bioremediation of legacy waste management

Prioritization of the proposed recommendations

Each of the proposed action points under the recommendations have been prioritized into High Priority, Medium Priority and Low Priority based on following two parameters -

A. **Ease of implementation** – The ease of implementation of the recommendation has been classified into High, Medium and Low based on the following aspects -
   - Simplicity of the recommendation
   - Resource requirement and availability
   - Need for expertise of consultants
   - Extent of coordination required between the stakeholders
   - Acceptability by citizens
B. **Level of Impact** - The level of impact of the recommendation has been classified into High, Medium and Low based on the following aspects –
   - Impact of the recommendation on improving the SWM systems /services
   - Impact on governance of the sector to strengthen accountability / transparency
   - Environmental impact
   - Financial Impact

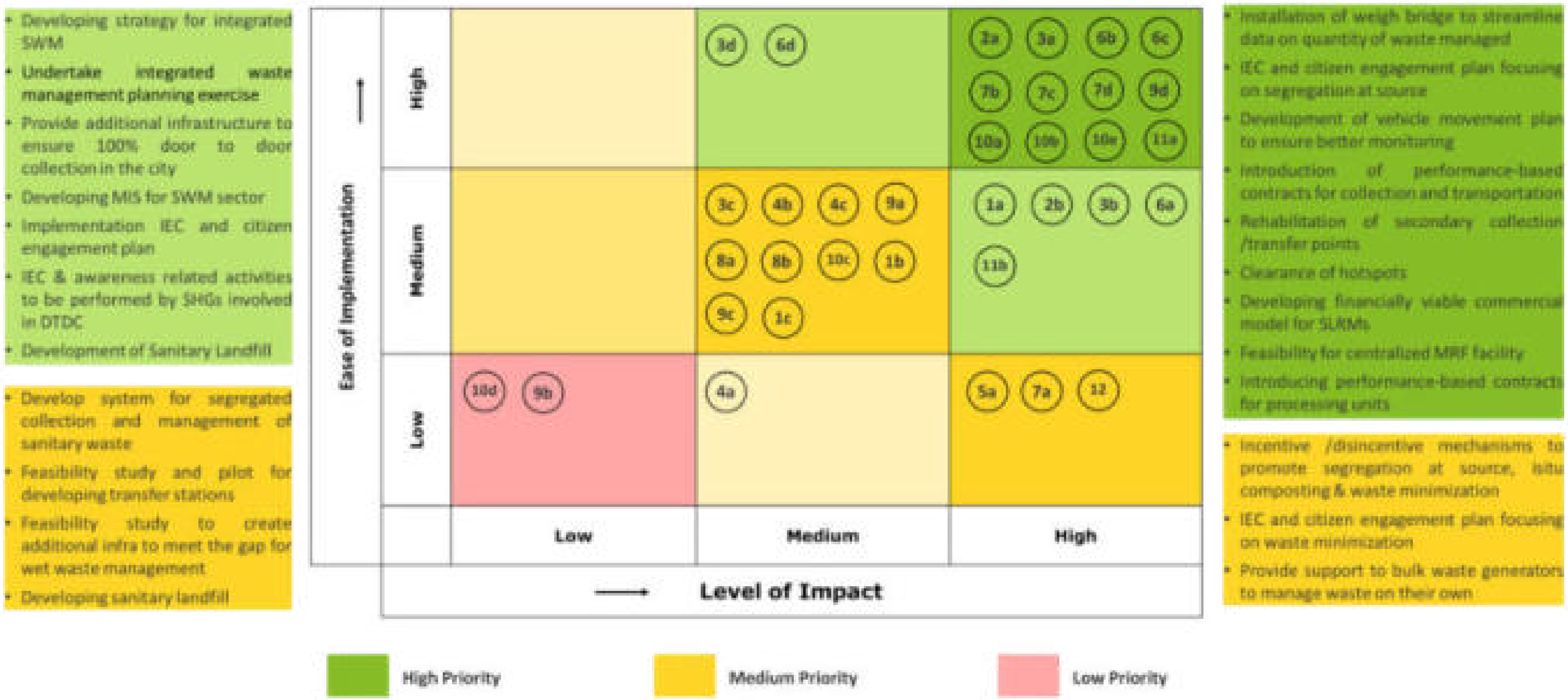


Figure 5: Prioritization of proposed recommendations

Detailed evaluation of the recommendations across the two parameters is presented below:

Table 4: Detailed evaluation of the recommendations across the two parameters

Sr No	Recommendations	Ease of Implementation	Level of Impact	Priority	Timeline
1	**Develop Integrated SWM strategy and action plan**				
a	PBMC to develop strategy and action plan for integrated solid waste management	Medium	High	High	Short-term (less than 1 year)
b	Capacity development related to developing such plans, and the development of the plans themselves are the key foundation stone – to be developed based needs assessment for capacity building	Medium	Medium	Medium	Medium-term (2 to 3 years)
c	Review of institutional system focusing on need for dedicated department /cell for SWM	Medium	medium	Medium	Medium-term (2 to 3 years)
2	**Development of integrated data collection and management system**				
a	Weigh bridge to be installed at important transfer points, processing and disposal units to get the exact estimate of quantity of waste and streamline data collection (or as minimum, conduct waste quantification exercise using portable axel scales to obtain week long data at each site twice per year to obtain immediate data needs for planning purposes)	High	High	High	Short-term (less than 1 year)
b	Develop integrated MIS for SWM sector	Medium	Medium		
3	**Improve segregation levels at source**				
a	Prepare comprehensive IEC and citizen engagement plan for the city focusing on source segregation	High	High	High	Short-term (less than 1 year)
b	PBMC to conduct citizen engagement initiatives to promote segregation at source (jathas, awareness drives, participative and educative events etc.)	Medium	High	High	Medium-term (2 to 3 years)
c	Introduce city level incentive and disincentive mechanisms to promote segregation at source (rebate on user fees, penalty on providing mixed waste etc.)	Medium	Medium	Medium	Short-term (less than 1 year)
d	Include IEC and capacity building activities under scope of work of SHGs or any other private operators performing DTDC	High	Medium	High	Short-term (less than 1 year)
4	**Ensure waste minimization at source**				

Sr No	Recommendations	Ease of Implementation	Level of Impact	Priority	Timeline
a	Policy and regulatory framework to mandate waste minimization at source – A&N Administration to provide suitable guidelines for PBMC to achieve waste minimization at source.	Low	Medium	Medium	Medium-term (2 to 3 years)
b	PBMC to prepare comprehensive IEC and citizen engagement plan for the city focusing on waste minimization at source	Medium	Medium	Medium	
c	PBMC to conduct citizen engagement initiatives to promote waste minimization (jathas, awareness drives, participative and educative events etc.)	Medium	Medium	Medium	Short-term (less than 1 year)
5	**Scientific management of sanitary waste generated**				
a	PBMC to develop system for segregated collection and management of sanitary waste as per SWM Rules 2016	Low	High	Medium	Medium-term (2 to 3 years)
6	**Introduce /strengthen monitoring systems to ensure 100% door to door collection**				
a	Undertake integrated waste management planning exercise and feasibility study to identify most appropriate means to rationalise existing collection contracts to ensure compatibility of services provided and optimise material flows through system	Medium	High	High	Short-term (less than 1 year
b	Develop vehicle movement plan and monitor the same through technological interventions including RFID tagging and GPS tracking to ensure effective monitoring of vehicles (collection and transportation).	High	High	High	Short-term (less than 1 year
c	Introduction of performance-based contracts for door to door collection and transportation and link payments /LDs /incentives to the defined key performance indicators (coverage, timings, route, segregation).	High	High	High	Short-term (less than 1 year
d	Provide additional infrastructure to ensure 100% door to door collection in the city	High	Medium	High	Medium-term (2 to 3 years)
7	**Scientific management of waste at the secondary collection /transfer points**				
a	Transfer stations – Feasibility study to assess and confirm the requirement of transfer station (Pilot at ward 4)	Low	High	Medium	Short-term (less than 1 year

Sr No	Recommendations	Ease of Implementation	Level of Impact	Priority	Timeline
b	Rapid enhancement / rehabilitation of existing secondary collection /transfer points to ensure scientific management of waste (fencing, creation of platform, reducing leakage etc.)	High	High	High	Short-term (less than 1 year
c	Removal of exiting hotspots – preparation of hotspot management plan	High	High	High	Short-term (less than 1 year
d	In-dept assessment to ensure sustainable management of waste generated at the fish landing facility	High	Medium	High	Short-term (less than 1 year
8	**Provide support to bulk waste generators to manage waste on their own**				
a	Provide technical and financial support to the bulk waste generators to establish and operate treatment facilities to manage the waste on their own	Medium	Medium	Medium	Short-term (less than 1 year
b	Devise incentive /disincentive mechanisms for the bulk waste generators encouraging them to manage the waste on their own	Medium	Medium	Medium	Short-term (less than 1 year
9	**Ensure 100% processing of wet waste generated in the city**				
a	Feasibility study to be undertaken to evaluate need for creation of additional infrastructure to meet the gap	Medium	Medium	Medium	Short-term (less than 1 year
b	Create market for compost	Low	Low	Low	Medium-term (2 to 3 years)
c	Incentive mechanism to promote insitu composting of wet waste	Medium	Medium	Medium	Short-term (less than 1 year
d	Exploring decentralized models for management for organic waste generated form the markets and green waste collected	High	Medium	High	Short-term (less than 1 year
10	**Improving operational efficiency of the existing SLRM units**				
a	Develop and assess viable operator model options for enhancing the efficiency and effectiveness of SLRM units (to be conducted in conjunction with assessing and modelling source segregated collection options).	High	High	High	Short-term (less than 1 year)
b	Introduction of performance-based contracts and linking payments /LDs /incentives to the defined key performance parameters	High	High	High	Short-term (less than 1 year)

Sr No	Recommendations	Ease of Implementation	Level of Impact	Priority	Timeline
c	Ensure equal distribution of dry waste across units - Contracts to ensure minimum quantity of waste to be supplied to individual units or allocating wards to respective SLRM units	Medium	Medium	Medium	Short-term (less than 1 year)
d	Creation of market for recyclables and non-recyclables	Low	Low	Low	Medium-term (2 to 3 years)
e	Feasibility study to be undertaken to evaluate need for creation of additional infrastructure to manage 15 to 20 TPD of dry waste – MRF (including dry waste generated by tourists)	High	High	High	Short-term (less than 1 year)
11	**Scientific disposal of waste**				
a	Immediately establish landfill unit with resources and capacity to operate existing dumpsite to standard required of waste placement operations at a sanitary landfill as part of incremental progression of standards and budget allocation for SLF operation	High	High	High	Medium-term (2-3 years)
b	Sanitary landfill – Feasibility study, design and construction planning	Medium	High	Medium	
12	**Remediation of legacy waste**	Low	High	Medium	

Annexures

Annexure 1: Assumptions made for the waste service chain and waste material flow diagram

1. The total waste generated in the city is estimated at 76 TPD (Due to assessment being conducted during the Covid-19 pandemic restrictions, the estimate does not include waste generated by tourists which is not anticipated to be around 10% of that presented).

2. Share of waste generated by various waste generators
   - Households is around 65% of the total waste generated
   - Commercial and institutional establishments is around 25% of the total waste generated
   - Street sweeping activity is around 10% of the total waste generation

3. Composition of waste considered for various waste generators

Sr No	Type of waste generator	Composition of Waste (%)		
		Wet Waste*	Dry Waste**	Inert***
1	Residential waste generator (Household)	65%	30%	5%
2	Commercial & Institutional Waste Generators	50%	50%	-
3	Street Sweeping	55%	15%	30%

**Wet waste includes food waste and other organic waste including garden waste*
***Dry waste includes – plastic, paper & cardboard, glass, metal, cloth etc.*
****Inert includes mud, silt, sand etc.*

4. It is assumed that the SHGs responsible for DTDC from the commercial /institutional establishments collect 50% of the total waste generated by the commercial establishments and the remaining 50% of the waste generated by the commercial /institutional establishments that are unserved, dump their waste in the secondary collection /transfer points.

5. The wet waste managed through insitu methods is 15 TPD

6. Segregated dry waste transported to mainland in a day is considered as 6 to 7 TPD (180 MT per month)

7. The operational capacity of the composting units is estimated at 3 TPD

Annexure 2: Manual/ Advisories/ Guidelines/ SOPs related to Dry Waste and other Non-Biodegradable Waste

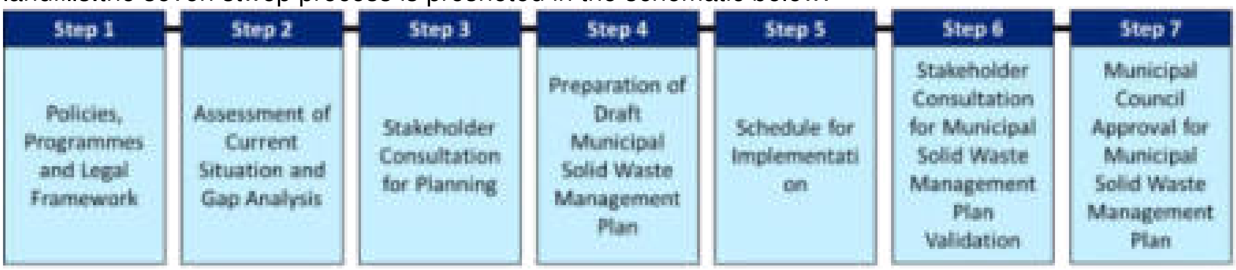
In addition to the above-mentioned national, state and city policy framework, various manuals, advisories, guidelines and SOPs have been developed at the national and state level to support most importantly the states and the urban local bodies, along with other stakeholders such as decision makers, elected office bearers and senior bureaucrats. These are detailed in the section below.

1.1 Manual on Municipal solid Waste Management, 2016

Title	Manual on Municipal Solid Waste Management, 2016
Published by	Central Public Health and Environmental Engineering Organisation (CPHEEO), which is a technical wing of Ministry of Housing and Urban Poverty Alleviation (MoHUA) under the Swachh Bharat Mission
Objective	The manual is a guideline on implementation of the Solid Waste Management Rules 2016 and provides an overview on key issues of MSWM and promotes understanding of challenges and opportunities in the urban SWM sector. It provides detailed description of technologies for treatment and processing of waste, applicability of evolving technologies, and planning frameworks to undertake concrete measures toward institutional strengthening and financial management leading to sustainable MSWM.

Coverage:

1. **A step by step approach towards preparation of a Municipal Solid Waste Management Plan** based on principles of integrated solid waste management, extended producer responsibility, decentralised waste management systems and integrating of informal sector. As per the principles, reduction & reuse at source is the most preferred under the ISWM hierarch, followed by recycling, composting, waste to energy and landfills.the seven stwep process is presneted in the schematic below:



2. **Technical advisory on – segregation, collection and transportation**, which include recommendations on SWM system components starting from waste minimisation strategies (including EPR Tools, ULB interventions) followed by segregation at source (wet, dry, domestic hazardous), storage of waste at source (three bin system), collection (primary, secondary, street sweeping etc.), secondary storage (secondary storage points, transfer stations) and transportation (segregated waste collection with minimum exposure) and street cleaning. Recommendations include technical specifications on planning, design of facilities, specification, type of equipment and use of information technology etc. These are mainly backed by the national and state level Solid Waste Management Rules, national/ state level policies and ULB level notifications and by-laws. The section also includes advisory on community involvement, involvement of informal waste collectors and IEC.
3. **Technical advisory on – processing and treatment of municipal solid waste**, which technical document on available processing and treatment technologies for MSW, such as recycling (advisory on potential recycling of materials) & recovery (MRFs – mixed stream, source separated, dry waste), composting, waste to energy, bio methanation, refused derived fuel etc. and presents a hierarchy of processing and treatment options. The manual also outlines the unit processes along with process flows, standard designs, equipment & manpower requirements and market linkages.
4. **Technical advisory on municipal sanitary landfills,** includes guidelines on minimization of environmental impact, identification of waste characterization to be accepted, components, planning and

design of landfill and related IEC activities. It also includes advisory of closure of existing dumpsites and bio-remediation.

5. **Technical Advisory on Solid Waste Management Plan Implementation**, includes guidance on preparation action plans, detailed project reports-DPR (content of the DPR), contracting of MSW service (project structures), tendering -contract management-supervision (draft EOT/ RFP, contract, contract monitoring framework etc), financial planning and IEC for implementation.
6. **Technical Advisory on Monitoring the Municipal Solid Waste Management Service Provision,** includes advisory on monitoring of service provisions/ SLBs, use of information systems, preventive maintenance interventions, complaint redressal system, EHS related aspects, environmental monitoring, training and capacity building requirements and required IEC activities.
7. **Technical advisory on – special waste,** includes advisory on management of special waste – domestic hazardous waste, plastic waste, bio-medical waste, slaughterhouse waste, electric & electronic waste, waste tyres, lead battery waste etc.

1.2 Guidelines for Co-processing of Plastic Waste in Cement Kilns, 2016

Title	Guidelines for Co-processing of Plastic Waste in Cement Kilns, 2016
Published by	Central Pollution Control Board technical wing of Ministry of Environment, Forest and Climate Change (MoEFCC)
Objective	This Guideline provides the protocol to be followed by different stakeholders in co-processing of plastic waste in cement kilns and gives a layout of business Model for Success of Co-processing.
Coverage:	
1. **Responsibility of Local Bodies:** responsible for setting up, operationalization and co-ordination of the waste management system by ensuring segregation, collection, storage, transportation, processing and disposal of plastic waste, channelization of recyclable plastic waste fraction to recyclers and finally processing and disposal on non-recyclable fraction of plastic waste. The local body can seek assistance of producers for setting up of system for plastic waste management. 2. **Roles and responsibilities of different stakeholders:** Responsibilities of the stakeholders for use of plastic waste in co processing in cement kiln are described which covers Municipal staff, Municipal authority, Staff of Cement plant, Producer, Brand owner and Importer, Concerned SPCP/PCC. 3. **Technical Details:** Description of Co-processing, Infrastructure requirement, feeding method and operating condition along with its performance evaluation have been described. 4. **Business Model:** A viable business model for demands that income should be higher than expenditure incurred by the respective entity along with typical case situation has been explained.	

1.3 Consolidated Guidelines for Segregation, Collection and Disposal of Plastic Waste, 2017

Title	Consolidated Guidelines for Segregation, Collection and Disposal of Plastic Waste, 2017
Published by	Central Pollution Control Board (CPCB), technical wing of Ministry of Environment, Forest and Climate Change (MoEFCC)
Objective	The guidelines provide a detailed description of plastic waste generation and its management in India. It also briefed the roles and responsibilities of different stakeholders in efficient PW management.
Coverage:	
1. **Roles and Responsibility of stakeholders** identifies the role and responsibilities of CPCB and prescribed authorities, NGOs, etc.	

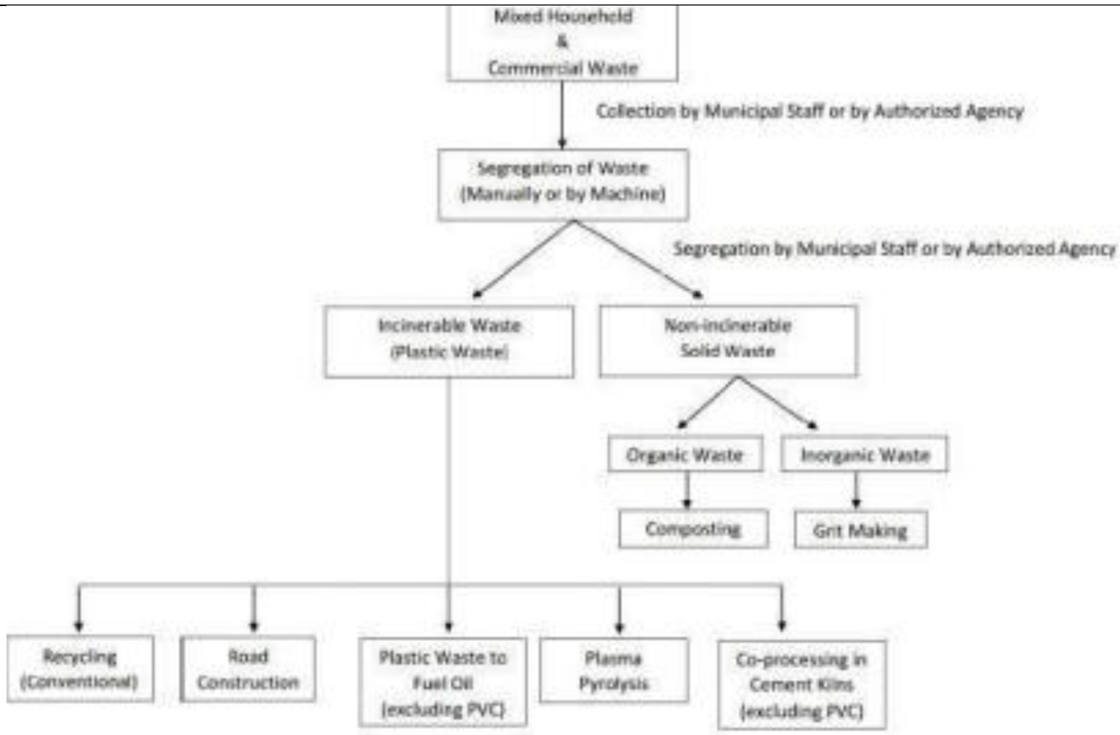


Diagram for Plastic waste Management

2. **Technologies for Disposal of Plastic Waste:** The major technologies include Utilization of Plastic waste in road construction, Co-processing of Plastic Waste in Cement Kilns, Conversion of Plastic Waste into Fuel-oil: Refused-derived Fuel (RDF) and Disposal of plastic waste through Plasma Pyrolysis Technology (PPT) have been described.
3. **Constraints and Recommendation:** Problems of the proposed technologies and alternative production of Petro-based plastic carry bags/films have been defined. Do's and Don'ts' s also have been briefed with feasible recommendation.

1.4 Guidelines for the Disposal of Non-recyclable Fraction(Multi-layered) Plastic Waste, 2018

Title	**Guidelines for the Disposal of Non-recyclable Fraction (Multi-layered) Plastic Waste, 2018**
Published by	Central Pollution Control Board (CPCB), technical wing of Ministry of Environment, Forest and Climate Change (MoEFCC)
Objective	The guidelines provide advisory on management of non-recyclable plastic waste which comprises of multi-layered structure, which may be made from thermoset or thermoplastic material. However, due to complex structure, it cannot be separated, and hence cannot be recycled.
Coverage:	
1. **Collection segregation and transportation of plastic waste** identifies Urban local bodies are responsible for segregation, collection, storage, transportation, processing and disposal of plastic waste either on their own/ engaging agencies/ producers. 2. **Extended Producer Responsibility:** Promotes producers to work out the modalities for waste collection system based on EPR by involving State Urban Development Departments, either individually or collectively, through their own distribution channel or through local body concern. 3. **Advisory on hierarchy of management and disposal options:** Established a hierarchy of waste management and disposal options from most preferred to least preferred include co-processing in cement kilns, electrical and electronic goods, and disposal in secured landfills. The guidelines include technology overview, details of the process components/ stages, pre-requisites for use of the options, technical specifications and cost aspects.	

1.5 Guidelines on usage of Refuse Derived Fuel in various industries, 2018

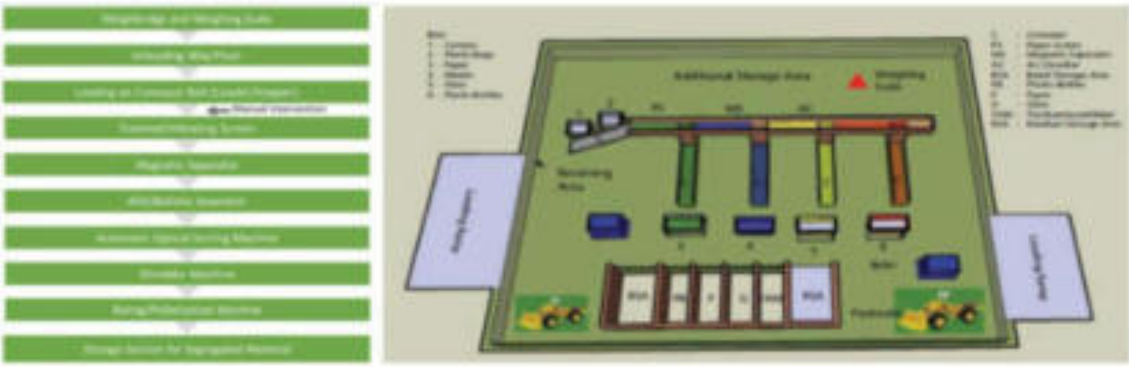
Title	Guidelines on usage of Refuse Derived Fuel in various industries, 2018
Published by	Central Public Health and Environmental Engineering Organisation (CPHEEO), which is a technical wing of Ministry of Housing and Urban Poverty Alleviation (MoHUA) under the Swachh Bharat Mission
Objective	The guidelines provide advisory on usage of Refuse Derived Fuel in various industries, including the existing policy framework, directive on use of RDF across industries, standards for RDF, measures for operation of standards and recommendations on incentives.
Coverage:	
1. **Advisory on suitability of RDF across industries,** such as cement plants, thermal power, iron &steel and brick kilns considering suitability parameters such as RDF size specifications, impact on final output, feeding mechanism adopted, environmental impact, residue disposal etc. 2. **Recommendations on RDF Standards:** Over the standards prescribed by CPHEEO and CPCB, recommends a comprehensive list of parameters for various uses – SCF, RDF (Grade III), RDF (Grade II) or RDF (Grade I) as standard parameters for RDF. 3. **Guidelines of RDF preparation and quality check mechanism:** This includes details on steps for RDF preparation, steps to check RDF at co-processing facilities, concerned standards for RDF and testing infrastructure requirements etc. 4. **Recommendations on funding support and incentives:** The guidelines presents a broad financial analysis and provides recommendations indicative costs for setting up RDF plants, incentives for promoting RDF, available financing instruments and leveraging of funding from various government sources – central, state and ULB. 5. **Recommendations on business models:** The guideline recommend operation models for RDF plant – standalone RDF plant by ULB, RDF for a cluster of cities and towns and cement industry take-off model.	

1.6 Advisory on Material Recovery Facility (MRF) for Municipal Solid Waste, 2020

Title	Advisory on Material Recovery Facility (MRF) for Municipal Solid Waste, 2020
Published by	Central Public Health and Environmental Engineering Organisation (CPHEEO), which is a technical wing of Ministry of Housing and Urban Poverty Alleviation (MoHUA) under the Swachh Bharat Mission
Objective	The objective of the document is to provide advisory on MRF – defining what is a MRF, types of MRF (by ownership and operations), advantages of MRF and propose scalable MRF models for urban areas.
Coverage:	
1. **Advisory on MRF Facility and its components:** The document defines an MRF, described various types of MRF – by ownership (publicly owned and publicly operated, publicly owned and privately operated, privately owned and privately operated, jointly owned and jointly operated) and based on operations (mixed MRF or Dry/ Clean and manual, semiautomatic, automatic). The advisory outlines the process flow for various MRF types, identifies the criteria for selecting a MRF type, criteria for locating MRF and identifies authorizations and permissions required. 2. **Advisory on scale of MRF based on population – design and process flow:** Proposed MRF for urban areas of population range <50000, 50000-100000, 100001-500000, 500000-1000000 and >1000000. The systems proposed across the urban areas are presented below:	

Population Range	Waste Generation (TPD)	Indicative% of Dry Fraction (incl. plastic waste)	Capacity of MRF	Area Required	Proposed Infrastructure/ Type of MRF	Per Facility Indicative capital Investment (excluding cost of land) in INR
Up to 50,000	15-20 TPD	<50%	1-5 TPD each capacity as per requirement of ULB	1500-2500 Sqm	Manual MRF	15-30 lakhs
50,001- 1,00,000	Up to 40 TPD	<50%	2-10 TPD each capacity as per requirement of ULB	1500- 3000 Sqm	Manual MRF	15-45 lakhs
1,00,001 - 5,00,000	Up to 200 TPD	50 - 55%	50, 75, 100 TPD Each	6000- 8000sqm (1.5-2.0 acres)	MRF – Semiautomatic	4.0- 6.0 Cr
5,00,001- 10,00,000	Up to 400 TPD	50- 55%	100+	8000- 10000 (2.0-2.5 acres)	MRF – Semiautomatic	5.0-6.0 crores
10,00,001 – 20,00,000	Up to 1000 TPD	55-60%	100+	10000-12000 sqm (2.5- 3.0acres)	Semiautomatic / Automated MRF	6.0 Crs / 18- 20 Crs
20,00,001 Plus	More than 1000 TPD	55-60%	100/200/300	10000-20000 sqm (2.5- 5.0acres)	Automated MRF	Rs. 18-20, 24-26 and 29-31 (for 100,200,300 TPD respectively)

Design of MRF for urban areas with population > 10 lakhs is presented below:



3. **Advisory on equipment used in MRF:** The advisory proposed a list of equipment at semi-automated or Automated MRF. The list of the equipment is presented below:

No	Equipment	Intended Use
1	Weighbridge	Weighing of large quantities of incoming waste
2	Weighing scales	Weighing of incoming waste and sorted recyclables
3	Sorting tables	Manual sorting and segregation of recyclables
4	Loaders	Loading of incoming waste into conveyor system, sorting tables; Loading of baled recyclables into outgoing vehicles; Moving of residual or rejected waste out of the facility to the processing/ disposal site
5	Conveyor with hopper	Receiving waste from loader and movement of waste for segregation in to select recyclables
6	Conveyor system	Mechanized and regulated movement of waste for segregation
7	Trommel	Segregation of dry waste or recyclables based on particle size
8	Magnetic separator	Separation of ferrous-bearing metals
9	Air classifier	Separation of materials such as paper and plastic based on size, shape, and density
10	Bottle perforator	Perforation of plastic bottles prior to compaction to optimize baling
11	Baler	Compaction and binding of recyclables
12	Forklift	Movement of baled waste within MRF

In Manual MRF certain equipment like weighing scale, sorting table, air classifier, baler could be present.

4. **Advisory on Do's and Don'ts and best practices:** The advisory further details best practices, sound as well as prohibited practices in MRF, safety practices to be adopted (hygiene, first aid and other facilities),

Annexure 3: Institutional functions

The seven core Institutional functions in wastes and resources management governance

Function	Description
Policy maker	Policy can be defined as a plan or course of action intended to influence and determine decisions, actions, and other matters. Policy shapes the legal, institutional framework, the financial framework, the planning framework and the market for delivery of services. In resource and waste management, there are many options, and the role of the policy maker is to establish goals, set legislation, and shape the economic climate for the sector. Typically, part of the policy function is to ensure the balanced development of infrastructure and services across all territorial areas of a country, and to put in place mechanisms to deliver good practice, including financing and other economic instruments and incentives.
Regulator	The regulator controls or directs according to rule, principle, or law. In the resource and waste management sector there are two-three main roles, financial, technical and environmental regulation. The financial regulator allocates municipal revenue and audits expenditures. The technical regulator approves technology selection and design standards. The environmental regulator determines, and issue permits and licenses, and to follow-up and enforce the provisions contained within them – through the issuance of penalties and fines, and for prosecuting malpractice.
Planner	Planning can be defined as the process of setting goals, developing strategies, and outlining tasks and schedules to accomplish these goals. It is a multi-level process in which there is a diversity of stakeholder groups involved. In the resource and waste management sector, it is important to secure the participation of different interest groups in the formulation of the overall goals and specific investments and measures.
Client (or employer)	The Client (or employer) 'ensures' that services are delivered to the required standard, coverage and environmental performance. This does not mean that they actually provide the services – rather that they make sure that the services are properly provided (by the operator, see below). The Client sets the performance standards, supervises performance and manages contracts (where they exist). This function becomes more prominent once services have been contracted-out. However, the Client function can also exist in public-run services, although less explicitly. There may be different Clients for different materials streams, and different links in the waste management service chain.
Operator	The operator is responsible for the day-to-day delivery of services. These may include street sweeping, collection, transfer, treatment and disposal of waste, and extraction of resources throughout the waste management chain. There are many different types of operator, including municipal departments, private sector (international/national), NGO/CBO, and informal. Operators exist regardless of whether their contribution is formalised into a service contract.
Revenue collector	The role of the revenue collector is to ensure that sufficient money is collected from customers and Government transfers or borrowing to support the desired level of activity and performance of the resource and waste management sector. Revenue from customers rarely covers the full costs of resource/waste management, however, in some places it does. The need to bridge the financing gap creates a close (and sensitive) inter-dependency between the revenue collector and financial policy maker functions.
Change Agent	Institutions, people and their networks capable and responsible for making change happen. Change agents can come in many different forms, as government departments/agencies, NGO's and limited companies. A key role is being the information and education coordinator, ensuring that the correct information is disseminated to the correct people at the correct time to ensure sector success.

Annexure 4: Roles and Responsibilities of sector stakeholders as defined in 2016 SWM Rules.

Stakeholder	Role and Responsibility
Manufacturers or brand owners of disposable products	Provide necessary financial assistance to local authorities for establishment of SWM systems
	For non-biodegradable packaging, establish system to collect back the packaging
Waste Producers:	Segregate and store their waste in three separate fractions: Bio-degradable, non-bio-degradable, domestic hazardous
	separate construction and demolition waste and manage as per Construction and Demolition waste rules 2016
	Forbidden to throw, burn or dump waste
	All waste generators to pay a fee for service as specified in Bye-laws
	Engage either authorised waste pickers or authorised recyclers to take recyclable wastes
	Ensure waste collector or agency designated by local body removed residual waste.
Waste Management Facility Operators	shall design and set up the facility and take responsibility for safe and environmentally sound operations per the technical guidelines issued by the CPCB and the MoUD Manual on SWM.
	Obtain approval from State PCB/PCC
	Submit annual report in Form III to the State PCB/PCC and concerned local body
Waste to Energy	Non-recyclable waste >1500K/cal/kg calorific value will not be landfilled but used for energy recovery.
Local Authorities	Prepare solid waste management plan
	Arrange for door to door collection of segregated solid waste from all households
	Establish a system to recognise of waste pickers or informal waste collectors (in effect authorising these collectors) and self help groups and their participation in waste management services
	Frame bye-laws incorporating the provision of the MSWM Rules
	Prescribe user fees and collect fees directly or through authorised agency
	Communicate rules to waste generators and ensure generators only use waste pickers and collectors authorised by the local body
	Setup MRFs or Secondary Storage Facilities to enable informal or authorised waste pickers and waste collectors to separate recyclables.
	Bin Colours: Bio-degradable waste - Green Recyclables - white Residual - Black
	Establish waste deposition centres for domestic hazardous waste (one per 20km2)
	Educate generators to deposit their hazardous waste at centres

Stakeholder	Role and Responsibility
	Provide training on SWM to waste pickers and waste collectors
	setting up decentralised composting / bio-methanation plants for market waste
	Transport segregated non-bio-degradable wastes and C&D waste to respective processing facilities
	Involve communities in waste management
	Facilitate construction, operation and maintenance of solid waste processing facilities directly or though PSP or other agency adopting suitable tech that adheres to the MoUD guidelines and standards prescribed by the CPCB.
	Preference is given to DECENTRALISED processing to minimise transportation cost and impacts.
	Construct, operate and maintain a sanitary landfill (as per schedule 1) directly or outsourcing.
	Provide adequate funds for capital investments as well as Operation and Maintenance of SWM services in annual budget
	Apply (by Form I) to SPCB/PCC for grant of authorisation to set up waste processing, treatment and disposal facilities that exceed 5 tonnes/day.
	Local body Prepare annual report (on form IV) annually and submit to Commissioner or Director, Municipal Admin. and subsequently to State Urban Development Dept. and State PCB/PCC
	provide education training to workers and contract workers and supervisors for door-to-door segregated waste and transportation of unmixed waste to processing/disposal facility.
	ensure all facility operators provide PPE to workers
	Frame byelaws and prescribe criteria for levying spot fines for persons who litter or file to comply with MSWM rules, delegate powers to officers or local bodies to levy fines as per byelaw.
	Create public awareness through information, education and communication campaigns and educate waste generators.
Dept. in charge for allocating land assignment	Shall provide suitable land for setting up SW processing and treatment facilities
District Magistrate / Collector/Deputy Commissioner	Facilitate identification and allocation of suitable land (as per above, in coordination with Secretary in charge of UD) for setting up SW processing and disposal facilities to local authorities.
	Each quarter, review performance of local bodies on waste segregation, processing, treatment and disposal and take corrective measures where required in consultation with other stakeholders.
Secretary-in-charge, Urban Development in the States and UTs	Through the commissioner or Director of Municipal of Municipal Administration or Director of local bodies
	Prepare a state policy and SWM strategy (consistent with SWM Rules, national policy and MUD strategy (to include guidelines regarding integration of waste pickers or informal waste collectors in SWM system)
	Ensure implementation of these rules by all local authorities
	Town Planning Dept of the State to city master plans have provisions for setting up SWM processing facilities.
	Identify and allocate suitable land to local bodies for setting up SW processing and disposal facilities (and incorporate them into State, city, etc. land use plans)

Stakeholder	Role and Responsibility
	Direct developers of Special Economic Zones, Industrial and Industrial Parks to allocate 5% of total area for recovery and recycling facilities.
	Facilitate establishment of regional sanitary landfill on a cost sharing basis and ensure professional management of landfill
	Arrange for capacity building of local bodies in managing solid waste, segregation and transportation of processing of such waste at source.
	Start a scheme on registration of waste pickers and waste dealers.
State Pollution Control Board / Pollution Control Committee	Enforce the MSWM rules in the state through local bodies, review rule implementation twice per year in close coordination with Directorate of Municipal Admin or State Urban Development Dept.
	Issue authorisation to the local body or other operator of waste management facilities (as Form II), stipulate Schedule I and II compliance standards - review permit renewal applications every 5 years
	Ensure applications for facilities using new technologies have appropriate standards specified by the PCB/PCC, request standards from CPCB if none.
	Monitor compliance with Schedule I and II, tech and env. standards once per year for facilities over 5 tonnes/year
	Regulate inter-state movement of waste
	Prepare and submit a consolidated annual report (from the Local Bodies) in Form V to CPCB and MoUD on implementation of rules and action taken against non-compliance by local body.
State Level Advisory Body	A State Level Advisory Board is to be established with specified stakeholders to meet every 6 months to review matters related to implementation of the rules, state policy and strategy on SWM and give advice to state gov. on implementation.
	Produce review reports and submit to State PCB/PCC
Central Pollution control Board	Co-ordinate with State Pollution Control Boards and the Pollution Control Committees for implementation of the MSWM Rules and adherence to the prescribed standards by local authorities.
	Review and keep updated environment standards and norms for solid waste processing facilities or treatment technologies.
	Annually review through State PCB/PCC the implementation of prescribed standards for SW processing facilities or treatment technologies and compile data monitored by them.
	Review proposals of State PCB/PCC on use of new technologies for processing, recycling and treatment of solid waste and prescribe performance standards for them.
	Monitor, through State PCB/PCC the implementation of the MSWM Rules by local bodies and prepare an annual report for submission to the Ministry of Environment, F and CC and publication for public access.
	Publish guidelines on buffer zones applicable to waste processing facilities handling over 5 tonnes per day.
	Publish guidelines on environmental aspects of processing and disposal of solid waste to enable local bodies to comply with provision of these rules
	Provide guidance on inter-state movement of waste

Stakeholder	Role and Responsibility
Ministry of Environment, Forest and Climate Change	Overall national monitoring of the implementation of the MSWM Rules through a Central Monitoring Committee.
	Central Monitoring committee to meet annually to monitor and review implementation of rules.
Ministry of Urban Development	Coordinate with state Govs and UT Administrations to:
	Annually review measures taken by states and local bodies for improving SWM practices and execution of SWM projects funded by the Ministry and external agencies and advise corrective measures.
	Formulate national policy and strategy on SWM
	Support States and UTs to formulate state policy and strategy on SWM based on national strategy and policy
	Conduct R&D in SWM and disseminate information to states and local bodies
	Conduct training and capacity development to local bodies and other stakeholders
	Provide technical guidelines and project finance to states, UTs and local bodies to meet SWM rules and standards

Annexure 5: Provisional order for SHGs to perform DTDC:

Provisional order for SHGs to perform DTDC:

No.: 113/EE-III/SWM/MC/2020-21/126

नगरपालिकापरिषद् कार्यालय

OFFICE OF THE MUNICIPAL COUNCIL

पोर्टब्लेयर

PORT BLAIR

Port Blair, dated 13.02.2021

Provisional Order to execute the work of collection & transportation of solid waste from shops & establishments from area covering PBMC entire 24 wards.

In order to address the solid waste collection & transportation of commercial areas, PBMC have conducted series of meeting with bulk waste generators/ commercial establishments and PBMC's registered SHGs (Vulnerable occupation group).

In view of the meeting conducted with Hotels/ Restaurants & Bars on dated 13.11.2020, with Industrial estates i.e., Dollygunj & Garacharama on dated 23.11.2020, and with Grains/ Grocers Association Shops on dated 04.12.2020 and it was decided to engage the Self Help Groups in the waste collection & transportation works from the commercial establishments at their source on user charges basis.

Accordingly, this office has obtained of SHGs registered with PBMC from Project Officer, PBMC vide No.: 2-37/PO/UPA/PBMC/2020-21/229, dated 05.02.2021, and found both the SHGs are registered with PBMC under DAY-NULM, MoHUA under vulnerable occupation group (Sanitary workers).

Since the SHGs are registered under Sanitation occupational groups, therefore they have started the commercial collection from 1st December, 2020, the details are as follows:

S.No.	Name of SHGs	Area of waste collection
1.	Shree Venkateshwara Self Help Group	Ward No. 01 to 17 & Dollygunj Industrial Estate
2.	Friends Self Help Group	Ward No.: 18 to 24 & Garacharama Industrial Estate

Therefore the PBMC issues this provisional order to the said Self Help Groups subject to fulfilment of the following terms & conditions:

1. The SHG need to contact & tie-up with the Sr. Sanitary Inspector & Sanitary Inspector of concerned Wards of PBMC.
2. The SHG need to coordinate with Shops & Establishments of given listed shops by PBMC.
3. The SHG need to hire their own vehicle & engage their own manpower for the work.
4. The SHG need to levy or charge the monthly user fees on the 1st day of every work completion month as per the prescribed rates/ notified charges of PBMC.
5. The SHG shall ensure the dry wastes collected are completely segregated into different streams including wet waste.
6. The SHG need to transport the collected segregated to nearest SLRM Centre & handover the same to In-charge of same, for onward processing.
7. In case of violation by the members of SHG or Shops & establishment will be considered as breach of PBMC-Solid Waste (Handling & Management) Bye-Laws, 2017 and necessary penalties as applicable will be imposed.
8. The work is awarded for 01 month initially, based on the experience and management further 01 month will be extended and based on the performance necessary support will be given by PBMC.
9. The SHG members need will collect the waste from the commercial establishments in a close coordination schedule & ensure no waste is left unattended.

Executive Engineer-III (Works & SWM)
Municipal Council

Annexure 6: Case Studies

6.1 Bengaluru: System for bulk waste generators through empanelment of private service providers

There are more than 100 private service providers empaneled with BBMP for managing the waste generated by the bulk waste generators. The private service providers are responsible for collection, transportation, processing, and disposal of waste generated by the bulk waste generators. With collection efficiency of around 95%, nearly 1,120 TPD out of 1,179 TPD of wet waste generated and 343 TPD out of 361 TPD of dry waste generated by the bulk waste generators is being collected by these private service providers.

Type of Waste	Waste Generated	Waste Collected	Waste Processed	Unaccounted	Leakage	Uncollected
Wet Waste	1179	1120 (95%)*	1038 #	59	22	59
Dry Waste	361	343 (95%)*	298 ##	38	7	38

**As per KSPCB Annual Reports*
#Piggeries - 425 TPD, private biomethanation plants – 50 TPD, Compost plants – 217 TPD, insitu composting – 347 TPD
Waste picker entrepreneur - 284 TPD, MRF – 14 TPD

It is estimated that the service providers collect nearly 6 TPD of sanitary waste from the residential bulk waste generators. The wet waste collected is either in-situ composted or taken to the bio-methanation plant for processing. The dry waste collected from the bulk waste generators is either sorted at the MRF facilities or sorted by the informal sector – waste picker entrepreneurs.

6.2 Udupi CMC: Role of NGOs in improving the segregation levels and in-situ waste management, Case of Udupi CMC

The City Municipal Council of Udupi has signed a MoU with Saahas NGO to provide IEC and technical support for a period of three years. The role of Saahas NGO will include –

- Support CMC in IEC related activities - Developing IEC content, creating awareness programs on segregation at source, training of households and commercial establishments on insitu composting, organizing public /community participation events
- Monitoring and supervising SWM services – collection, transportation, processing and disposal
- Training and capacity building of CMC staff and SHGs
- Marketing of recyclables and non-recyclables sorted

With combined efforts of CMC and Saahas NGO, the segregation levels in the city has significantly improved in the past few years. While the collection of segregated dry waste has increased from 336 TPD in November 2020 to 414 TPD in January 2021, the collection of segregated wet waste has increased from 604 TPD in November 2020 to 772 TPD in January 2021. In addition, the share of home composting /insitu composting is also increasing over the years. At present, 206 households have adopted pipe /pot composting and around 3,135 households have adopted other home composting methods.

6.3 Dhaka: Community Composting Model in Dhaka, Bangladesh

A private firm Western Concern (WC), in partnership with the Dhaka City Corporation (DCC), initiated Dhaka's Community-based Decentralized Composting (DCDC). The model adopts partnerships with multiple stakeholders to ensure effective decentralized management of wet waste. The key features of the model include:

- Integration of informal sector in door to door collection and composting

- Partnership with public sector: Dhaka City Corporation (DCC) and Public Works Department (PWD) permitted to use their land for the establishment of composting units and also by waiving water and electricity charges
- Partnership with donor agencies: Model was promoted under UNDP funding
- Partnership with farmers /end users for marketing of the compost: WC had signed a partnership agreement with Map Agro Ltd. on marketing of compost generated in waste composting plants of WC

6.4 Maharashtra: Creating market for city compost in Maharashtra through HARIT scheme

Through the scheme "HARIT: New Civic way of life", the Maharashtra government intended to promote wet waste composting in the state. The scheme initiated in May 2017 and out of 256 ULBs in Maharashtra, 44 are HARIT certified till date. The key features of the project are as mentioned below:

- The state intends to support the marketing of compost through its registered brand, HaritMaha City Compost.
- The ULB sends periodic samples of the compost for testing in agri lab whose report along with the process flow chart is then sent to state for Harit authorization.
- Through HARIT Ticker, the compost producing ULBs are connected with buyers interested in using organic compost.
- It also facilitates and promotes the purchase and sale of organic compost through government subsidies.

6.5Indore: Automated Centralized Material Recovering Facility in Indore

Indore is a city Madhya Pradesh with a population of 19.64 lakhs. The total waste generation in the city is estimated at 1,113 Tons per day. The combined utilization of 2 MRFs in the city is around 606 TPD and one of the MRF facility has been established in PPP mode. The key features of the project are as mentioned below:

- Centralized MRF facility established on PPP mode with private sector investment of INR 30 cr
- Capex – INR 25 cr and Opex – INR 70 to 80 lakhs per month
- Land requirement – 4.5 acres
- The facility is fully automated and mechanized
- Integration of 700+ waste pickers and kabadiwalas post training

6.6Indore: Efficient legacy waste management in Deoguradia, Indore[15]:

Indore is a city Madhya Pradesh with a population of 19.64 lakhs. The total waste generation in the city is estimated at 1,113 Tons per day. While Indore has taken considerable steps to tackle waste management, it could not manage Deoguradia, a 100-acre dumpsite. Despite the city being dubbed the cleanest in India in 2017 in Swachh Survekshan survey, the dumping yard remained a concern for officials and citizens alike. The City Corporation took initiative to remediate the legacy waste and closure of open dumpsites through bio-mining. The project initially started in a PPP mode, however, was later completed by the Indore Municipal Corporation on its own. The key features of the project are as mentioned below:

- 100 acres of land reclaimed through bio-mining
- Worth of land reclaimed was over 300 crores
- 13 Lakh MT solid waste bio-mined within 6 months, with a cost less than INR 10 crores against a projected cost of 65 crores

[15] *https://www.niua.org/csc/assets/pdf/waste/full-case.pdf*

To ensure remediation of the legacy waste of this dumpsite, Indore adopted an integrated approach as indicated below:

- Quantity of the waste to be Bio-remedied was determined on the basis of contouring of area to be treated
- Bioremediation treatment was done by dividing the site into suitable blocks
- Raking of garbage layer through long spike harrow operating in cross directions was done regularly to pull out rags, plastic, rubber, textiles etc.
- Coarse material and garbage were screened through rotary/ horizontal screens. The recovered earth was spread in the dedicated area. No extra charge was paid to the contractor for lead or lift of the material
- The stone, bricks, ceramics which were removed while screening and raking was sent for land filing or for filling up of low-lying area, while the recyclables like plastic, glass, metal, rugs cloth recovered from the waste was bundled and sold
- The soil recovered was used for refilling the ground on the same site where greenery is developed
- The recovered construction and demolition waste were recovered and sent to C&D processing facility to produce building materials and the left-over of the waste was sent to a secured landfill
- Daily monitoring of the progress of work was done by a team headed by Indore Smart city
- While 100 acres of the land was reclaimed, the project also resulted in considerable decline in diseases arising out of the trenching ground, Elimination of dump fires and leachate generation.

6.7Nagpur: Legacy waste management in Bhandewadi, Nagpur

The Bhandewadi dumpsite has been in operation since the year 1966 and has been earmarked as a compost yard in all the development plans for the city since then. It is estimated that more than 18 lakh MT of waste has been dumped on the dumpsite since its inception. In the January of 2017, Nagpur Municipal Corporation (NMC) started processing legacy waste along with some fresh waste using bioremediation/ bio-mining technology at the existing dumpsite. From approximately 6 lakh MT of garbage, a total of 311 windrows of five to six feet in height were created. This process involved bio-mining of waste, followed by segregation and harrowing of waste and spraying of bio-cultures to accelerate degradation. According to the NMC officials, the process has been successful in reducing the height of the existing dumpsite. However, a lack of market for compost and soil derived from the process has affected the project to a certain extent for which the NMC has taken initiatives presently. Source:
https://www.unescap.org/sites/default/files/Report_IN_Nagpur_SolidWasteManagement_ArcadisGermanyGmbH_2017.pdf

6.8Delhi: Bio-mining of legacy waste at Delhi Landfill

The Bhalswa landfill situated in north-west Delhi, operational since 1994, handled around 2400 tonnes per day of waste and the dumpsite reached a height of 62 metres by 2019. Biomining operations were started to recover 70 acres of land from the legacy waste. The key features of the project are as mentioned below:

- In around 10 months, more than 6 lakh tonnes of legacy waste were bio-mined
- Around 4200 MT of legacy waste is being processed every day
- More than 58,800 sq. m area has been cleared from the dump site

6.9Hyderabad: Bio-capping of legacy waste at Hyderabad

The Greater Hyderabad Municipal Corporation (GHMC) has a population of 6.8 million as per 2011 census and generates 5,300 tonnes of waste daily. The projected, executed in a PPP mode, aimed to cover the 135-acre dumpsite that had reached a height of 60m. The key features of the project are as mentioned below:

- The dumpsite was divided into several cells and a layer of impermeable soil cover was spread over the entire area.
- Leachate collection ponds were constructed to collect and process leachate
- A geotextile layer was spread, and vegetation was grown over it to prevent soil erosion
- It is estimated that the total project cost would be around INR 141 crore and the dumpsite would emit landfill gases and leachate for next 15 years

6.10 Vishakhapatnam: Technological intervention and data management in Vishakhapatnam[16]

The Greater Visakhapatnam Municipal Corporation (GVMC) created a technology based solution to eliminate Garbage Vulnerable Points (GVP).The GVMC started with provision of 100% door to door waste collection service to avoid creation of new GVPs and the city the corporation created a special application, called as the 'Black spot app', for the citizens to update any GVP in their vicinity. The Residents could upload pictures of any black spot which they come across, on the application. The local ward officer is then required to survey the spot for at least 2 days and ascertain the reason. After converting the Black spot into a Green spot, the local team monitor the area along with the spot for 6 months, where the ward office uploads photographs of the spot on the Black spot application on alternate days for regular Monitoring and Evaluation. Even after converting a black spot into green, GVMC officials do not stop monitoring the point to ensure sustainability of the initiatives.

6.11 Nashik: Technological intervention and data management in Nashik[17]

In 2011, Nashik Municipal Corporation (NMC) was successful in effectively monitoring Collection and Transportation of Municipal Waste through its Centralized monitoring Unit. With the start of the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) project, NMC received central funds for strengthening the existing system resulting in the procurement of 124 ghantagadis and GPS systems under the project. GPS machines were fitted on each vehicle to improve the collection and transportation efficiency of the vehicles. An agency was appointed by NMC for installation of the GPS system (machines and software) and its operation and maintenance (O&M).A cell (centralized monitoring unit) was formed at the NMC office to manage and supervise the overall system: monitoring and tracking of vehicle movement on a regular basis, tracking of complaints and inefficiencies, and generating daily and weekly reports. The redressal of complaints was done with the support of the sanitary inspectors at ward level. This led to the following outcomes:

- Effective and timely redressal of complaints was generated through the GPS monitoring system by the ward level sanitary staff.
- Generation of daily and weekly reports by vehicles to ensure adherence to the timing and collection of waste at the respective collection points.
- Information, transparency and data availability on the public domain for citizens and public representatives with respect to the routing and timings of the vehicles increased confidence in the system.

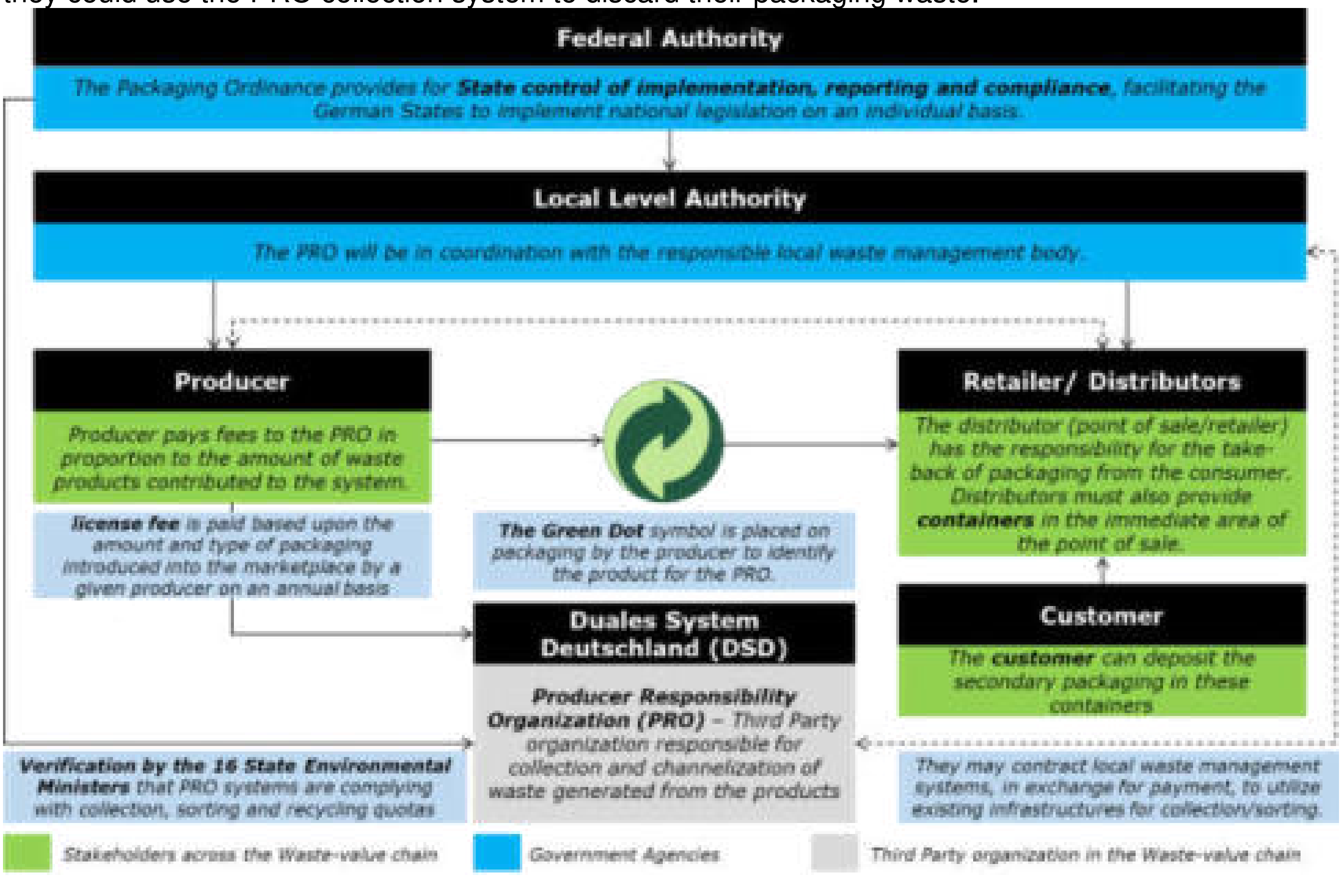
6.12 Indore: IEC and Citizen Engagement, Indore[18]

[16] *Transforming urban landscapes of India; Success Stories in Solid Waste Management; NIUA; 2019*
[17] *CPHEEO Manual (Part II) for MSWM*
[18] *Transforming urban landscapes of India; Success Stories in Solid Waste Management; NIUA; 2019*

After securing 25th position in Swachh Survekshan 2016, Indore was declared the cleanest city in 2017. This was possible due to Indore Municipal Corporations (IMC) successful behavioral campaign which covered over 5 Lakh households in 19 zones and 85 wards of the city. For mass reach, IMC availed the services of NGOs in the State. Before launching the drive for segregation, it was important for the IMC to impart awareness and knowledge on segregation of waste at source to all residents. This was done through the support of NGOs. This door to door awareness generation initiative started at an individual level, but slowly became a public movement; wherein every household was covered individually along with commercial areas and establishments. Before the start of the campaign, the volunteers were tutored on the different methods of communications. For the awareness drive, the NGOs used flip charts, pamphlets, banners, nukkadnataks, live demonstration of waste segregation using green and blue coloured dustbins, etc. The process of behavioural change took IMC two years. Moreover, the IMC hasn't stopped the campaign and is aiming for sustainability of the result. It is also important to note than IMC had built the necessary infrastructure before starting the campaign.

6.13Germany: Implementation of EPR Framework for plastic packaging in Germany

The first large-scale EPR Program in Germany was initiated through "Avoidance of Packaging Ordinance (1991)" known as the Green Dot Programme. An annual license fee needs to be paid by the producers to the DSD to use the green dot label. Wherein, the green dot informed consumers that they could use the PRO collection system to discard their packaging waste.



The fee paid by the producers is based on the material type and weight. This differentiated fees system, with low fees for highly recyclable material like tin or paper, directly influences the producer's choice of material for packaging. The incentive promotes reduction in resource use and innovation in packaging design, one of the key objectives of the EPR system.
The 'green dot' system resulted in significant waste reduction. Wherein, Germany achieved a 3 percent annual reduction in packaging between 1991 and 1997, as compared with a 2 percent – 4 percent annual increase, before the implementation of the ordinance.

6.14 France: Support for using recycled plastic in plastic manufacturing industries in France

In France, the Environment Agency (ADEME) supports the reincorporation of recycled plastics by providing manufacturers with the grant to fill the gap between the price of fossil plastics and the price of recycled ones. The project is also helping the manufacturers to study and invest in order to use recycled material.

In addition to the above initiative, the French authority, because of the poor recyclability of opaque PET and of the practical problems posed to the recycling industry, decided to impose a “malus”, i.e. a higher fee paid by producers using opaque PET to their EPR Scheme(s), in line with the principle of eco-modulation of fees, as long as no solution is found to recycle this new material. Although the bottles are eco-designed for other aspects - they use 25% less plastics and allow to get rid of the aluminium strip covering the aperture. But these bottles are not recyclable.

giz

Universität Rostock

Management of Organic Waste for Andaman and Nicobar Islands

Situational Analysis and Strategy

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Global Project
“Export Initiative Environmental Protection GreenTech „Made in Germany” (BMUV)
Köthener Str. 2
10963 Berlin / Germany
T +49 30 338 424 646

Management of Organic Waste in India (MOWI)
3rd Floor, B-5/5, Safdarjung Enclave
New Delhi 110029
T + 91 4949 5353
F + 91 4949 5391

E info@giz.de
I www.giz.de

Responsibles:
Mr Markus Luecke
Project Head, Export Initiative Environmental Protection, GIZ

Mrs Vaishali Nandan
Project Head, Management of Organic Waste in India (MOWI), GIZ

Submitted by:
Department of Waste and Resource Management,
University of Rostock, Germany.

Authors:
PD Dr Satyanarayana Narra, University Rostock, Germany
Mr Vicky Shettigondahalli Ekanthalu, University Rostock, Germany
Dr Haniyeh Jalaipour, University Rostock, Germany
Dr Edward Antwi, University Rostock, Germany
Ms Vidhi Singh, University Rostock, Germany

Editors:
Dr Bharat B. Nagar, GIZ
Dr Supreet Kaur, GIZ
Ms Carla Rossitto, GIZ
Mr Aviral Saxena, GIZ
Ms Soma Biswas, GIZ

On behalf of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

GIZ and University of Rostock are responsible for the content of this publication.

New Delhi, India
October 2022

Contents

Abbreviation

Abbreviation	Standard form
ANPCC	Andaman & Nicobar Pollution Control Committee
ANI UT	Andaman & Nicobar Union Territory
BWG	Bulk Waste Generator
CDM	Clean Development Mechanism
EC	conductivity
NSIC	National Small Industries Corporation
CSR	Corporate Social Responsibility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ESDP	Entrepreneurship and Skill Development
FCO	Fertilizer Control Order
GVPs	Garbage Vulnerable Points
GIS	Geographic Information System
GPS	Global Positioning System
GoI	Government of India
GP	Gram Panchayat
ICT	Information and Communication Technology
INDC	Intended Nationally Determined Contributions
KVIC	Khadi and Village Industries Commission
MGIRI	Mahatma Gandhi Institute for Rural Industrialization
MOWI	Management of Organic Waste in India
MCF	Material Collection Facilities
MoHUA	Ministry of Housing and Urban Affairs
MNRE	Ministry of New and Renewable Energy
MSW	Municipal Solid Waste
NICRA	National Initiative on Climate Resilient Agriculture
NIMSME	National Institute for Micro, Small and Medium Enterprises
NPBD	National Project on Biogas Development
NGO	Non-Governmental Organisation
OWM	Organic Waste Management
PBMC	Port Blair Municipal Corporation
PMEGP	Prime Ministers Employment Generation
SHG	Self Help Groups
SLRM	Solid & Liquid Resources Management
SWM	Solid Waste Management
SDG	Sustainable Development Goal
SBM	Swachh Bharat Mission
TPD	Tonnes per day
m	Meters
MSME	Micro, Small, and Medium Enterprises
MoEFCC	Ministry of Environment, Forest and Climate Change
UNFCCC	United Nations Framework Convention on Climate Change
ULB	Urban Local Body
WtE	Waste to Energy

List of Figures

List of Tables

1. Introduction

The expansion of the Indian population and swelling growth in the GHG emissions on account of human activities have risen to damaging levels against the civil population of India[1]. Solid waste management in this scenario becomes an integral and vital link to ecological and human health pillars of society. India generates approximately 1.52 lakh tonnes of waste every single day. Of all the waste generated and collected, a contributing 27% is noted to be processed, and at least 73% of this waste is mostly dumped in nearby landfill locations[2]. An estimation suggests an increase to 735 million tonnes/ year of waste generation by 2051 from 164 million in the year 2001. Thus, the estimated level of waste generation increases by ~5% every year[3].

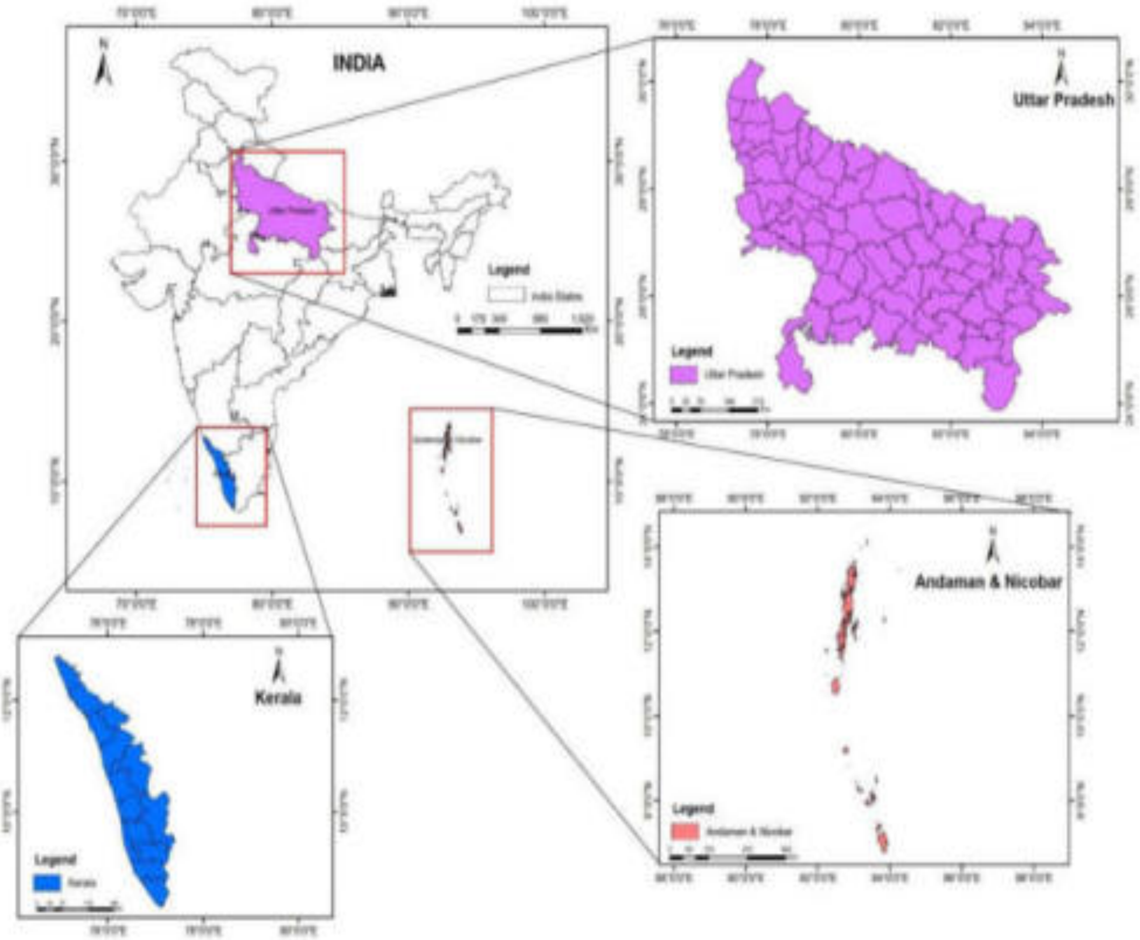


Figure 1. Geographical representation of the studied locations of India.

Organic waste management is an effective way to deal with this issue. Lack of attentiveness and impactful behaviour when it comes to waste generation and management is creating a massive issue with the MSW situation. This results in mixed-type of waste collection which ultimately ends up being dumped in an informal and unstandardized manner in the dumpsites. These dumpsites generate a high amount of GHGs and subsidize leachate polluting the groundwater.

[1] Joshi, R., & Ahmed, S. (2016). Status and challenges of municipal solid waste management in India: A review. Http://Www.Editorialmanager.Com/Cogentenv, 2(1). https://doi.org/10.1080/23311843.2016.1139434
[2] Mohanty, S., Saha, S., Santra, G. H., & Kumari, A. (2021). Future Perspective of Solid Waste Management Strategy in India. Handbook of Solid Waste Management, 1–36. https://doi.org/10.1007/978-981-15-7525-9_10-1
[3] Planning Commission, Government of India, Report of the task Force on waste to energy (Volume I) in the context of integrated municipal solid waste management, (2014)

Ministry of Housing and Urban Affairs, GoI (MoHUA) in the year 2014 also launched “Swachh Bharat Mission” or “Clean India Mission” for the urban and rural population for the solitary goal of solid and sanitation waste management in India. Later in the year 2016, The Ministry of Environment, Forest and Climate Change (MoEFCC) also revised the Solid Waste Management Rules for solidification and up-gradation of solid waste management policies and strategies in India. The SWM rules of 2016 have obligated stakeholders to segregate waste at the source, creating centralised or decentralised waste treatment facilities at the household and as well as at the community level. It also prohibits stakeholders from processing organic waste in landfills. These stakeholders involve diverse levels of hierarchical bodies like waste collectors and water processing facilities, Urban Local Bodies (ULBs), and Gram Panchayats (GPs), which cover a large area in terms of authority in implementing such practices.

Notwithstanding, numerous initiatives being taken at the city, state, or national level for organic waste management unmovingly appears to be challenging. These challenges begin with poor waste segregation at the source, low coordination between collection and transport points, and short of treatment facilities and awareness.

The Government of India launched its flagship program Swachh Bharat Mission1.0 in 2014 envisaging measures to improve conditions of solid waste management both in rural and urban areas. The first phase of the program was focused on stopping open defecation and solid waste management including source segregation and promotion of city compost. The present second phase of the program is focused on setting up de-centralized systems for management of organic waste, onsite management of waste by bulk waste generators, bio-methanation of organic waste and remediation of legacy waste. In addition, the notification of Solid Waste Management Rules, 2016 strengthened this vision, by creating obligations on stakeholders including ULBs, GPs, waste generators and waste processing facilities among others to regulate the waste management system in the country. The SWM Rules have imposed several obligations on different stakeholders regarding the management of organic waste such as source segregation, management of organic waste at household and community levels, transportation of segregation organic waste, setting up of decentralized and centralized organic waste processing facilities and a prohibition on disposal of organic waste in landfills.

For further improvements and recommendations, and as part of the Indo-German cooperation, GIZ jointly with MoHUA initiated “MOWI – Management of Organic Waste in India”. The project is funded by the German Federal Ministry of Environment (BMUV) under the global project Export Initiative (ExI). The project aims to develop and review the existing state strategy, provide overall recommendations, and create a roadmap to embark on the successful implementation of organic waste management sustainably. It is planned as a complementary measure to the project “Cities Combating Plastic entering Marine Environment (CCP-ME)” with the intended goal to improve plastic waste management.

1.1 Selection of sample locations

India is a diverse country in terms of geographical terrains, climatic conditions, soil composition, and in terms of tourism and religious interests. The demographics of Indian society change at every course of distance based on income, family size, the rate of literacy, and lifestyles from urban to suburban to rural areas quickly. To attain the objective of the project the sample locations were chosen based on the following criteria;

Selection of an Island Area

Andaman and Nicobar Union Territory (ANI UT) as a collection of islands are distinctive in terms of their geographical location. It is a consolidation about 836 Islands/ Islets/ Rocky Outcrops in the territory, 38 are inhabited permanently[4,5]. Not all islands of ANI UT are open to the public as they are controlled by Indian defense establishments. Furthermore, because of the presence of the endemic species and its ecological importance, ANI UT is protected by several environmental regulations. It has 10 national parks and marine national parks. It has a combined number of small islands, which challenges the transportation and collection of waste. ANI UT reported generating up to 165 MT[6] of solid waste per day, out of which 121 TPD[7] of the waste is sourced from the city of Port Blair which is also the capital of the Andaman and Nicobar Islands. The development of organic waste management strategies for ANI UT would serve as a baseline that could be replicated with higher efficiency on any island within India.

1.2 Methodology

As soon as the project was launched, in-depth desk research was initiated. An online off-the-field study is important in this scenario to grasp the current status of management of waste in the three vastly distanced states. Further, as the University of Rostock is located in Germany, it was important for the waste experts to prepare data prior to their field visits. As a part of desk-based secondary research, the survey team reviewed existing external data that is publicly-available, including government reports, studies, laws, policies, and guidelines applicable at both the national and local levels, and reports or scoping conducted by credible agencies among others including the data available with GIZ. The primary data gathered during the secondary research were discussed with GIZ India on a monthly basis to extract the most out of the available information and to understand the authenticity of the gathered data. The desk based secondary data collection included following aspects.

Understanding of political hierarchies: The hierarchy of waste management regulating bodies for a location differs from each other. Depending on the governing body and complexity of the location a prior assumption for the waste management situation can be done.

Preparation of Factsheets: Factsheets for each ULB were prepared prior to the field visits. These factsheets were imported with the information on every ULB's demographic status i.e. current population, population density, soil & climatic conditions, governing body, and a map location of ULB in the state territory. Additionally, these factsheets were added with survey questions. The answers to the survey question would help the waste experts in collecting data with regards to capacity, volume, transport chain and fleet of the ULB's waste management system.

[4] https://www.andaman.gov.in/about

[5] District Census Handbook Andaman & Nicobar Islands, 2011 (According to 2011 Census of India, Andaman & Nicobar Island consists of 572 islands, out of which only 31 islands were inhabited, in which Nicobar Islands, North & Middle Andaman, and South Andaman consists of 10, 14, and 7 inhabited islands respectively. This data of inhabited islands is contradicting with the data from the state portal of U.T Administration, A & N Islands)

[6] Data submitted to NGT in affidavit dated April 2019 filed by the Union Territory of Andamans and Nicobar Islands, p.57.

[7] Andaman & Nicobar Administration, Pollution Control Committee (ANPCC)

Current by-laws: Similar to factsheets, the existing by-laws were thoroughly studied for a better understanding of the applied regulation on waste management. With regards to OWM by-laws define their own waste generators, waste categories, waste treatment methods, and waste disposal techniques. ULBs are independent of their own by-laws thus with the change in location the change in regulation was also observed.

Local Initiatives / NGOs / Start-ups:

Within the last decade in India, the rise of start-ups has become part of the culture. The recent start-ups have not only contributed to the economy but also to the demand side solution of the waste management scenario in India. Thus, a list of existing movements, schemes, and local initiatives was laid down with the list of start-ups. This recollection was later used in strategies as prospective ideas for implementation as suggestions for collaboration.

Field Visit:

Field visits were the crucial part of the study as they involved cross-relating the digital data with the existing system. The visits were planned for the duration of 30 days in three states. The selection of sample states and ULBs was done by the Government of India in cooperation with GIZ, India. The schedule was planned in such a way that experts get to meet the state and ULB officials at the end of the visit to every state and understand the various aspects of organic waste management. These meetings were planned to collect existing challenges faced by the administration in implementing technical ideas. ANI UT was visited between 27.01.2022 to 02.02.2022. With special attention to organic waste, the waste management system in Swaraj Dweep and Shaheed Dweep was surveyed to understand the situation in the rural area of ANI UT and similarly survey was carried out in Port Blair to understand the situation in the only municipal corporation of ANI UT. The report uses data from all these areas to analyse and prepare strategy for the state.

1.3 Limitations

During the course of the project, there were a few times when the study had to be restricted within a boundary. These boundaries have created lesser reach towards efficacy in understanding the system. In this study, ANI UT had the greater challenges in terms of the availability of digital data. The data availability from the Government department was scarce due to staggered and unstructured data. In the field, a similar gap was observed regarding the accessibility of the non-digital data. The hardcopy data manuals, booklets of standards procedures and scientific maintenance data were either absent or not updated well. These limitations have impacted several stages of the investigation in this project on and off the field. Accordingly, there are suggestions developed and mentioned in the state-wise recommendations.

1.4 Objective

This study seeks to strengthen the entire capacity of organic waste management in ANI UT. The detailed strategies presented in this report has been developed after the comprehensive desk research (review of the current policies, laws, existing technologies and management options, and programs related to organic waste management), field visits to the selected ULBs, and meetings with officials and experts in waste management at ULB and state levels. The developed strategies include the recommendations to guide ANI UT's organic waste management system, such as.

- Strategies for the utilization of appropriate organic waste treatment technologies and types of facilities, including a recommendation on setting and replication of the facilities.
- Strategies for organic waste diversion. Recommendations for separate collection and transportation of organic waste, and recommendations on collection fleet.
- Extended approaches for the development of organic waste management system in ANI UT through the developed strategies on a) strategy for treating special organic waste streams, b) strategy for supporting small scale industries in the field of organic waste management, c) strategy for enhancing the funding mechanisms, d) establishing a recommendation for capacity building and communication among different stakeholders, e) strategy for effectively treating sanitary waste, etc.

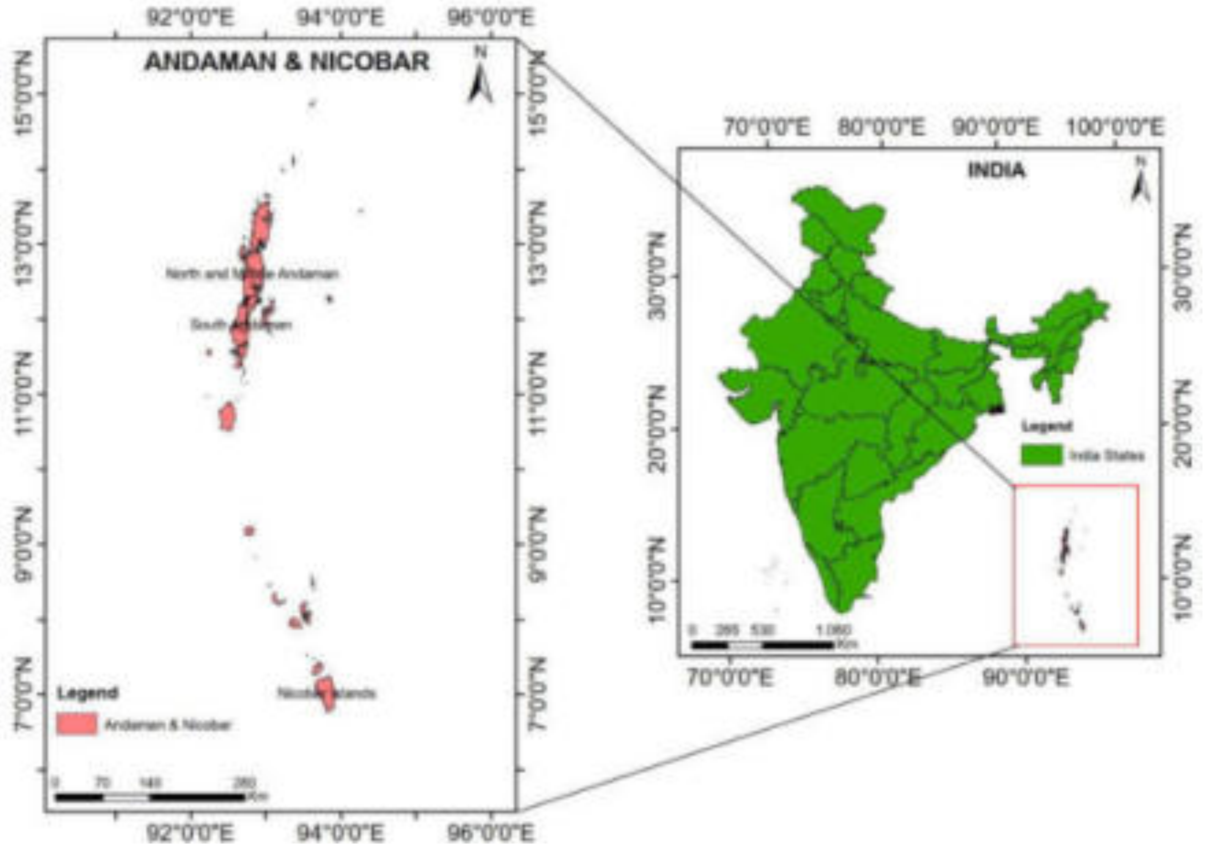
The developed strategies foster the ANI UT's efforts for managing organic waste sustainably. The successful implementation of the developed strategies has greater potential for improving the overall organic waste management infrastructure in ANI UT.

2.General Information on the ANI UT

2.1 Introduction

Andaman and Nicobar Islands is a union territory of India. The Andaman and Nicobar Island comprise 3 districts (North and Middle Andaman, South Andaman, and the Nicobar Islands), with 9 tehsils, each district having 3 tehsils (see Figure 2). Out of 836 Islands/ Islets/ Rocky Outcrops in the territory, 38 are inhabited permanently[8][9].

Most of the islands (around 550) are in the Andaman group of islands, out of which 28 islands are inhabited[10]. The Nicobar Islands consist of 22 main islands, 10 of which are inhabited. There is a channel that is approximately 150km wide (the ten-degree channel) that divides the Andaman Islands from the Nicobar Islands. A total of 8,249 km^2 of the land area is found in the territory, which includes 6,408 km^2 in the Andaman Islands and 1,841 km^2 in the Nicobar Islands. There are two official languages in the islands: Hindi and English. Bengali is the dominant and most spoken language and is spoken by 26% of the population. According to the 2001 Census of India, Hindi (18,23%), Tamil (17,68), Telugu (12,81%), Malayalam (8,11%), and Nicobarese (8,05%) are also spoken on ANI UT island[11].



---

[8]https://www.andaman.gov.in/about

[9]District Census Handbook Andaman & Nicobar Islands, 2011 (According to 2011 Census of India, Andaman & Nicobar Island consists of 572 islands, out of which only 31 islands were inhabited, in which Nicobar Islands, North & Middle Andaman, and South Andaman consists of 10, 14, and 7 inhabited islands respectively. This data of inhabited islands is contradicting with the data from the state portal of U.T Administration, A & N Islands)

[10] https://www.andamantourism.gov.in/about.php

[11] Census of India, 2001

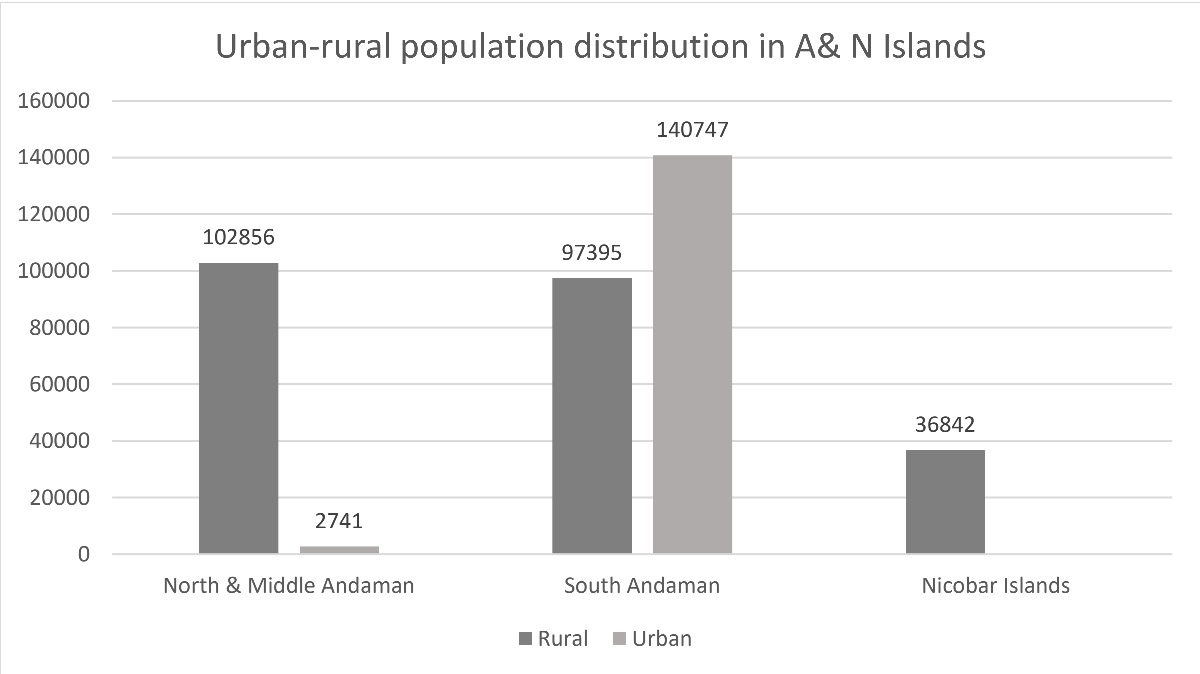
Figure 2: Andaman & Nicobar Islands Location map with Administrative Districts

Andaman & Nicobar Islands are surrounded by a beautiful emerald sea, dense green forests, mountains, pristine coral reefs, white sandy beaches, and a national park that helps make these islands one of the most acclaimed tourist destinations in the world. The Andamanese town, Port Blair is the capital town of the union territory, where all trade, commerce, and administrative activities are managed. Port Blair not only acts as a gateway to the Andaman & Nicobar Islands, but it also contributes to the freedom struggle of the country. Port Blair is 1200 km away from Chennai or Kolkata.

Around 121 TPD Municipal solid waste[12] has been generated in the only urban local body (ULB) namely Port Blair Municipal Council of Andaman and Nicobar Islands.

2.2 Population

According to the 2011 Census of India, the population in the Andaman & Nicobar Islands was 380581, of which 202871 were males and 177710 were females[13]. The distribution of rural and urban population is 62,3% (237102) and 37,7% (143480) respectively. The population distribution of the three districts, North & Middle Andaman, South Andaman, and the Nicobar Islands are 105597 persons (27,7%), 238142 persons (62,6%), and 36842 persons (9,7%) respectively[14]. In the North and Middle Andaman districts, the rural-urban split is 102856 persons and 2741 persons respectively. Whereas in the South Andaman district, it is 97395 persons and 140747 persons. Nicobar Island is entirely rural (Figure 3).



[12] Andaman & Nicobar Administration, Pollution Control Committee (ANPCC)
[13] District Census Handbook Andaman & Nicobar Islands, 2011
[14] District Census Handbook Andaman & Nicobar Islands, 2011

Figure 3: Urban-rural population distribution in A& N Islands, source[15]

The graph below (Figure 4) depicts the decadal growth of population in total, rural, and urban areas of the ANI UT. According to Census 2011, the urban area of ANI UTs has registered a growth rate of 23,5%. Whilst the rural area of ANI UTs has a growth rate of -1,2%. The decreasing trend in population is more evident in rural areas of Andaman & Nicobar Islands from 1961 to 1971.

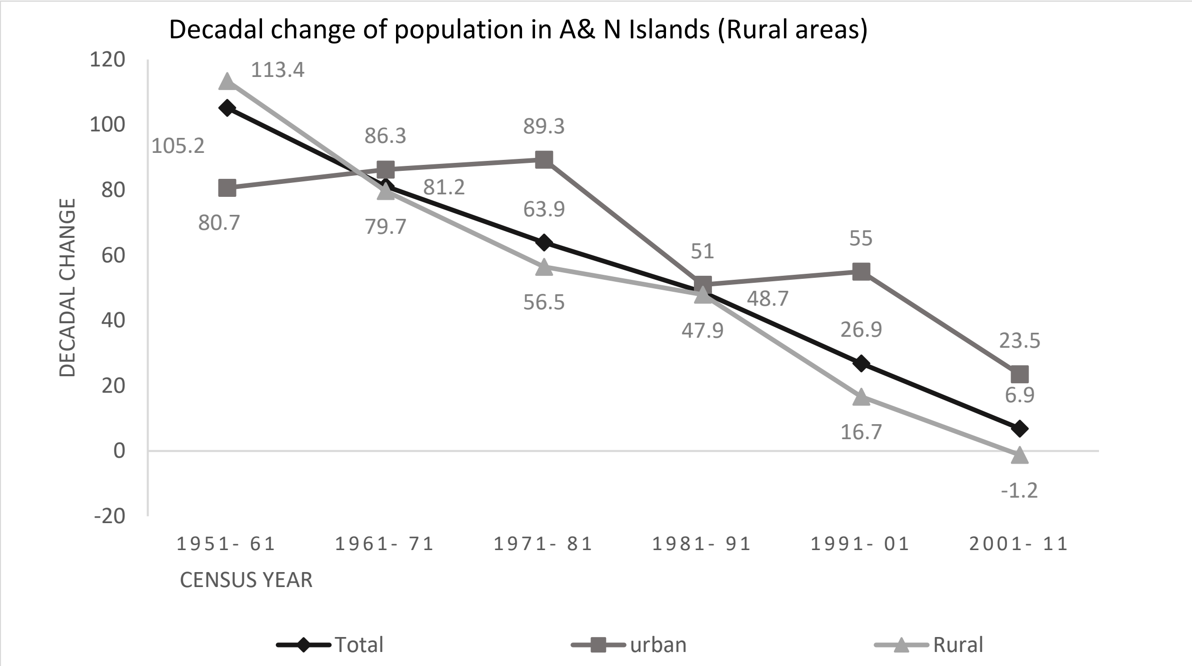


Figure 4: Decadal change of population in Andaman & Nicobar Islands (Rural area), 1951- 2011, source[16]

2.3 Geographical condition

There are two island groups- the Andaman Islands and the Nicobar Islands that separate the Andaman Sea from the Indian Ocean to the east. The Andaman Islands are to the north of this latitude, and the Nicobar Islands are to the south, separated by the 10° North parallel. Geographically, the Andaman & Nicobar Islands are located at the longitude of 92° to 94° East and between 60° and 140° North.

In the Andaman Islands, rugged hills divide wide elongated valleys separated by north-south trending ridges. There are five basic types of terrain: mountain ranges, isolated hills, slopes, plains, and swamps. These islands have ridges with high relief and also higher peaks that range from 200m to 300m above mean sea level located predominantly in the eastern part, the highest point in these islands is at 732m above mean sea level on saddle peak in the North Andaman[17]. Hill slopes are moderately steep and rugged and prone to soil erosion. It is relatively rare to find flat areas.

[15] District Census Handbook Andaman & Nicobar Islands, 2011
[16] District Census Handbook Andaman & Nicobar Islands, 2011
[17] District Census Handbook Andaman & Nicobar Islands, 2011

2.4 Economy

Agriculture, forestry, and fishing

Most Andaman Islanders are engaged in agriculture. Rice, coconuts, betel nuts, fruits, and spices (such as turmeric) are the main crops grown. Rubber, oil palms, and cashews are also important. Besides farming, the islands have a small forestry sector, which produces sawn wood for domestic use; surpluses are exported to India's Mainland. Fisheries on the islands are primarily for domestic consumption.

Manufacturing

Both the Andaman and Nicobar island groups are not highly industrialized. However, many manufacturing activities are conducted on both islands. In addition to furniture and wood products, Andaman islands produce processed foods and textiles.

Tourism

With plenty of hotels scattered throughout the territory, tourism is a fast-growing industry in the Andaman and Nicobar Islands. Most of the tourists are from the Indian mainland. There are many parks, gardens, and sanctuaries in the territory, which attract ecotourists and trekkers.

Transportation

South Andaman has the most paved roads. Port Blair and Digilpur are the main harbors for North Andaman and South Andaman respectively. There is a boat service between Port Blair and North, Middle, South, and Little Andaman. Air mode of transportation services is available to the northern and southern Indian mainland from Port Blair.

2.5 Legal Framework, Responsibilities, and Organizational Structures

The "Port Blair Municipal Council of Solid Waste (Handling and Management) Rules, 2017"[18] and the "Rural areas (Panchayati Raj Institutions & Tribal Councils) of entire Andaman and Nicobar Islands' Solid Waste (Handling and Management) Bye Law, 2019" defines sources of waste, the responsibility of stakeholders, collection and transportation of waste with their disposal and treatment options. The highlights of the laws declared in waste management rules of urban and rural ANI UT are mentioned below:

[18] http://db.and.nic.in/pbmcwebsite/gazette/SolidWasteManagement.pdf. Accessed on 20.03.2022

Source segregation

- The segregation of waste should be done into at least 6 different categories;
  - Bio-degradable waste or wet waste
  - Hazardous waste generated from households/ hotels/ resorts/ shops
  - Non-biodegradable or recyclable waste
  - Bio-medical or hospital waste
  - Construction or demolition waste
  - Garden and horticulture waste including tree trimmings
- To enable the easy collection, hotels and commercial establishments to segregate their recyclable waste further into metal, recyclable and non-recyclable plastic, paper/cardboard, glass, tetra pack and any other category decided by the collection agency or the panchayats.
- Bins with easy to operate design
  - Green – Bio-degradable waste
  - Blue – recyclable
  - Black – storage of other wastes

Collection

- The generator should deliver the waste in the unmixed form by following the categories mentioned above.
- Delivery of waste in a mixed form is a breach of the law and the penalties have to be introduced to all generators who are mixing the waste.
- Bio-waste generated shall be considered for composting by the generator, if not it should be kept in closed containers for door-to-door collection.

Treatment

- Hotels, restaurants, units of catering, bulk food producers, wedding venues, hospitals, and meat markets shall set up their own facilities for managing organic waste. It is also followed as a condition during issuing licenses for any commercial units. In the situation of any space constraints, bulk generators shall coordinate with the designated biowaste storage centers.
- Disposal of waste by burning on the streets or dumping on illegal grounds, either in a private or public space is prohibited and attracts penalties.
- Selecting landfill or composting site 500m away from human settlement, touristic spots, and eco-spaces.
- The processing units should be state-of-the-art facilities approved by the Andaman & Nicobar Pollution Control Committees.

Monitoring, standards, and system improvement

- It is a must for the Municipalities/Panchayats to create provisions or complaint systems for feedback on the waste collectors/ collecting agencies.
- The compulsion to resolve the complaints within a week and keep records.
- Waste collectors must also be able to register complaints against generators, and bulk generators for dumping waste and delivering unsegregated waste.
- Rural agencies require to review Solid Waste Management Plans for the panchayats every 5 years.
- Ensure the SWM efficiency in keeping up with the standards of sustainability, viability, and upgradation with the international developments.
- ULBs are responsible for marketing the compost or suitable methods for waste treatment at the source.

Financial framework

- 30% subsidy shall be given to commercial spaces like hotels and restaurants for taking care of their waste via compost, biogas plant, or vermicompost. (Conversely, as discussed with officials at PBMC there are no such schemes. In the rural area (Swaraj Dweep), however, was providing the reduction in user-fee collection for the commercial generators treating organic waste at source)
- User-fee may be charged by the Municipalities/Gram Panchayats for the collection of the segregated waste.
- Fines for illegal dumping, delivering mixed waste, and disposing of irregular may rise fine and be noticed within 3 days of a complaint.
- Any person who disposes of, dumps, releases, or spills the waste on public or private space in regard to an environmentally valued space is liable for an offense and receives penalties. (see Table 1 for the overview of penalties according to Schedule (1) for urban and rural SWM systems)

Table 1: Imposing penalties according to Schedule (1) for urban and rural SWM systems

Mentioned Section	Subject to Violation	Fine per violation in ₹ (rural)[19]	Fine per violation (urban)[20]
5. (1)	Disposal of waste outside the storage containers	₹ 500	₹ 500
6. (3)	Delivery of waste that is not segregated and stored in separate bins as specified a. Individual b. Bulk generator	a) ₹ 500 b) ₹ 5,000 to 15,000	a) ₹ 500 b) ₹ 1000
6. (26)	Mixed delivery of biodegradable waste	₹ 500	₹ 1000 /m^3
6. (30)	Mixing of the waste at the collection point by the waste collector	₹ 500	₹ 500
7. (1)	Littering in the public place	₹ 500	₹ 500
9. (1-6)	Violation of notices and penalties	Up to ₹ 5,000	Max ₹ 10,000

[19] Solid Waste Management in the rural regions of Andaman and Nicobar Islands Bye-law, 2019
[20] Port Blair Municipal Council of Solid Waste (Handling and Management) Rules, 2017

3. Status quo of the organic waste management in PBMC

3.1 Key Stakeholders for SWM in PBMC

Diverse stakeholders participate in the Port Blair organic waste management process, each focusing on a different segment of the waste value chain. Although the city's solid waste management is the responsibility of PBMC, some of its responsibilities have been delegated to other stakeholders. Following is a list of the stakeholders and the activities they are currently involved in concerning the organic waste management of PBMC (Table 2)[21].

Table 2: Key Stakeholders for SWM in Port Blair

Sl.no	Stakeholder	Activity
Collection and transportation of organic waste		
1	PBMC	Door-to-door collection from Households and public places such as markets using crates and auto-tippers
2	Friends SHG	Door-to-door from commercial establishments in Wards 17-24
3	Venkateshwara SHG	Door-to-door from commercial establishments in Wards 1-16
Processing of organic waste		
1.	PBMC	Onsite composting in sanitary offices
2	Stree Hausala SHG	In charge of the composting facility at Gandhi Park
3.	Friends SHG	In charge of composting unit at Brookshabad
4.	Private Piggeries	Private parties that operate piggeries within and outside PBMC jurisdiction

3.2 Overview of organic waste management in the PBMC

Site visits have been carried out by the survey team to understand the level of segregation, collection, and efficiency of transport systems. Including processing and final organic waste disposal, linkages of the market for final products, and financial feasibility of OWM system. In this concern PBMC, the only urban area in ANI UT, Swaraj Dweep, and Shaheed Dweep were visited to understand the urban and rural perspectives of organic waste management in ANI UT. Figure 5 shows the visited locations during the field trip in the order of Swaraj Dweep, Shaheed Dweep, and Port Blair.

[21] As per the field visit in January 2022 and interviews with PBMC officials.

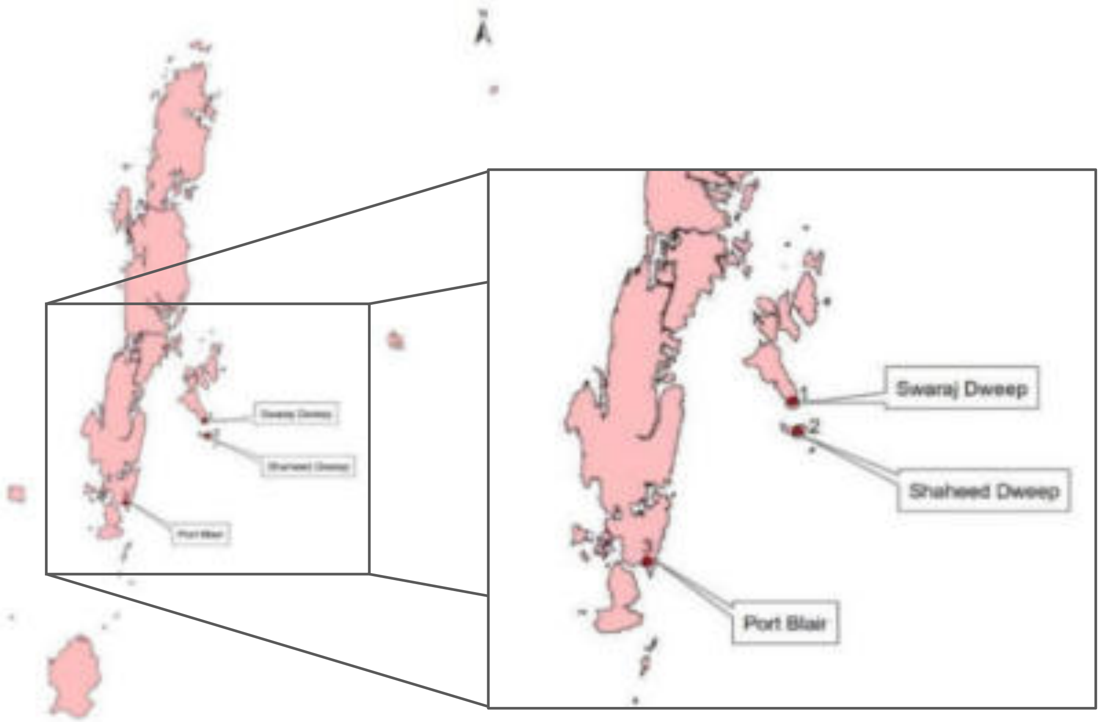


Figure 5 Surveyed areas

Port Blair is the only urban town of ANI UT, Port Blair Municipal Corporation (PBMC) has 24 notified wards with a population of 1,43,488[22] and spread over an area of 41.22 sq. km. However, as per the estimation by the Department of Tourism, Andaman and Nicobar Island has about 5 lakh tourists visited in the year 2017-2018 which puts greater pressure on waste management by generating a significantly high amount of solid waste.

The general overview of organic waste management practice in PBMC is depicted in Figure 6. Door-to-door collection from the household is carried out by PBMC staff and the door-to-door collection from commercial generators is carried out by two Self-Help-Groups (SHGs) namely, Shree Venkateshwara and Friends. A marginal, ~2% amount of the organic waste generated in the household is managed at the source. According to information shared by PBMC officials, no commercial generators are currently managing their organic waste at the source, and consequently, all of them rely on the waste collection service provided by the PBMC.

Despite having six organic waste treatment facilities in PBMC, a very minimal amount of generated organic waste is being handled by these facilities and five of the existing facilities are in non-operation condition and one facility at Gandhi Park only handles horticulture waste. Nevertheless, there are few additional initiatives from PBMC for processing organic waste which has been started in December 2021 through decentralized composting; one pit composting unit in ward number 5 (Near stadium), and bin composting in ward number 7 (Junglighat) and ward number 20 (Naya Pahad Gaav) has been initiated. However, the amount of waste managed is less and the technique used is rather rudimentary. Further, currently there are three identified piggeries collecting organic waste directly from the vegetable shops, meat shops, and hotels using it as animal feed.

[22] Census of India, 2011. Link: https://censusindia.gov.in/2011census/censusinfodashboard/stock/profiles/en/IND035_Andaman%20&%20Nicobar%20Islands.pdf

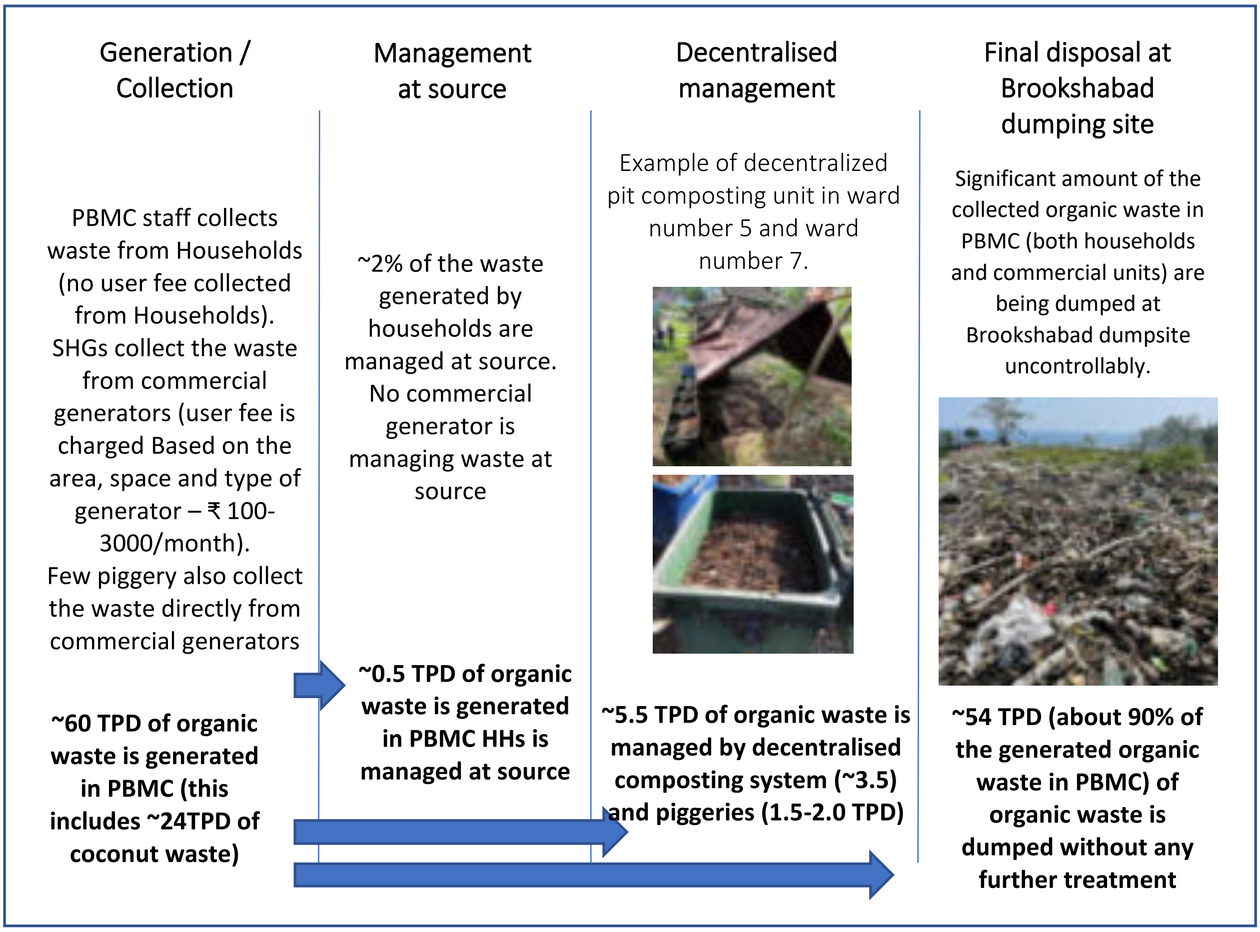


Figure 6 General overview of organic waste management practice in PBMC[23]

The majority of the organic waste is collected by the PBMC (from Households) and the two SHGs Friends, and Shree Venkateshwara (from commercial generators). The waste generated from these facilities is currently being transferred to the central dumpsite at Brookshabad and a fraction of this organic waste collected from commercial generators goes to the piggery located next to Brookshabad.

3.3 Waste generation and composition in PBMC

Port Blair is the only urban town of ANI UT, Port Blair Municipal Corporation (PBMC) has 24 notified wards with a population of 1,43,488[24] and spread over an area of 41.22 sq. km, which produces about 100 TPD[25] of municipal solid waste of which about ~60 TPD[26] is organic waste (this includes ~24TPD of coconut waste). PBMC and SHGs are collecting the waste daily from household and commercial units in all 24 wards. In PBMC per capita waste generation is about 590-680 grams/day which varies depending on the climatic condition and the tourist season. Table 3 provides the data on population, area, household number, and other institutions

[23] Calculated considering the waste characterization results from the report "U.T. Policy and Strategy on Solid Waste Management for Andaman and Nicobar Island, 2018"
[24] Census of India, 2011. Link: https://censusindia.gov.in/2011census/censusinfodashboard/stock/profiles/en/IND035_Andaman%20&%20Nicobar%20Islands.pdf
[25] Information provided by PBMC official
[26] Calculated considering the waste characterization results from the report "U.T. Policy and Strategy on Solid Waste Management for Andaman and Nicobar Island, 2018"

numbers in the 24 wards of PBMC[27]. Ward number 5, with an area of 1.07 sq. km has a comparatively higher number of institutions (1190). In contrast, ward 22 with an area of 7.89 sq. km has only 56 institutions and 667 Households. The diversity of the population density and commercial and touristic activities has a direct influence on the composition and quantity of the waste generated in PBMC.

Table 3: Ward wise data on waste generation

Ward number	Population	Area in sq. km	Households	Institutions
1	7384	0.59	2085	143
2	6745	0.65	2316	283
3	7356	0.75	2267	314
4	5635	0.64	3142	942
5	7939	1.07	3216	1190
6	7590	0.72	2571	657
7	6816	0.37	2263	252
8	3917	1.21	1210	78
9	6195	0.75	2839	727
10	4905	1.31	2071	226
11	6175	0.53	2017	63
12	6467	2.27	2365	206
13	5891	0.72	2240	413
14	6247	0.2	2093	210
15	6688	0.65	1972	170
16	5544	1.33	1902	403
17	9198	4.11	3557	502
18	8023	3.53	3957	315
19	7763	1.79	3289	930
20	7857	1.59	2230	161
21	5410	3.14	1504	146
22	2762	7.98	667	56
23	8359	3.97	2696	265

[27] U.T. Policy and Stratergy on Solid Waste Management for Andaman and Nicobar Island, 2018

24	8400	1.37	2967	240

An overview of the composition of waste in the urban area of ANI UT[28] is shown in Figure 7. Among the generated waste, 59.34% comprised organic waste among which 35.16% is compostable organic material such as Leaves (9.89%), Hay and Straw (2.47%), vegetable & fruit waste (4.89%), and fine organic waste (17.91%). Coconut waste makes up for the highest generated organic waste fraction at the composition of 23.35% and poses greater concern as the generated coconut waste in PBMC is currently being dumped in Brookshabad dumpsite without any treatment method. Additionally, Figure 7 does not show the composition of the sanitary waste generated. In PBMC currently, there is no mechanism for the collection and treatment of sanitary waste. The significantly high amount of sanitary waste generated is currently being either dumped or burnt by households uncontrollably.

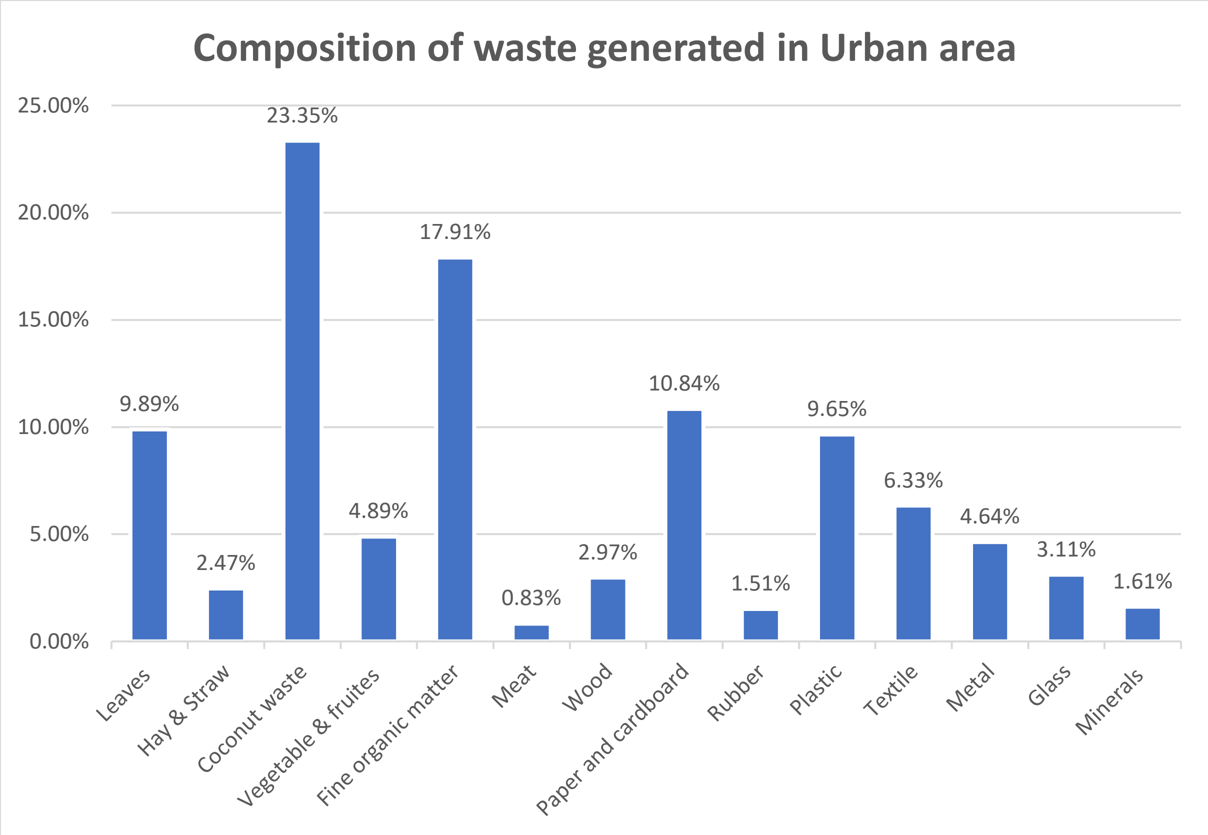


Figure 7: composition of waste generated in the urban area (PBMC) of ANI UT

3.4 Organic waste collection and transport in PBMC

As per the information by PBMC officials, the overall status of Door to door collection is 100%. It was noted, however, that several open dumps of mixed waste were visible in the city during the field visit, which suggests that leakages are occurring in the primary collection of waste from all generators. Despite PBMC Solid Waste (Handling and Management) Bye-Laws, 2017[29] specifying the user fee of ₹ 50/household, there is no user-fee is collected from households. Based on interviews conducted with PBMC staff and observations made during

[28] U.T. Policy and Strategy on Solid Waste Management for Andaman and Nicobar Island, 2018
[29] PBMC Solid Waste (Handling and Management) Bye-Laws, 2017. Link: http://db.and.nic.in/pbmcwebsite/gazette/SolidWasteManagement.pdf

field visits, waste collection from the household is entirely handled by PBMC staff, and the primary waste collection from households in Port Blair has a two-step procedure.

In the first step, PBMC sanitation workers collect household waste (door-to-door) using hand-pulled plastic crates and/or High-density polyethylene bags. The organic waste collected during the door-to-door collection process is collected near the roadside in open spots. In step two, all organic waste collected near the roadside is further collected by PBMC vehicles, typically light commercial vehicles, like auto tippers and twin compartment trucks. An overview of segregation and collection mechanism in household PBMC is shown in Table 4.

Table 4: Overview of segregation and collection mechanism in household PBMC

Segregation	Coverage	Collection vehicle	Staffs	User charge/month
	Frequency	GPS		
2 Way	100%	Wheelbarrows -268 Cargo autos-24, HMV-24	Total Sanitary workers - 894	No user-fee
	Daily	no		

3.4.1 Commercial Waste Generators[30]

Two SHGs, Shree Venkateshwara and Friends, have been designated as door-to-door waste collectors as part of an initiative by PBMC to create self-sustaining models for waste management. The PBMC interviewed stakeholder representatives and representatives of both SHGs. They stated that waste needs to be collected and transported by both SHGs.

From communications with Friends SHG and from reviewing their list of establishments, it was concluded that they are currently serving 307 commercial establishments, including hotels, restaurants, and bars. Organic waste generated by commercial establishments and bulk waste generators is frequently stored in garbage bags outside premises for collection. Collection occurs between 1700 hrs and midnight. According to representatives of Friends SHG, at the moment they are using three light vehicles (two Tata 709 vehicles and one Mahindra Bolero pickup truck) to collect organic waste. In Brookshabad, organic waste collected by the SHG is directly taken to the city dump without any secondary transfer.

On 12.11.21, a meeting was held by superintending Engineer, PBMC together with representatives of all association members to decide and finalize the revised user charge for commercial waste generators as per the provision of PBMC- Solid Waste Handling and Management Bye-Laws, 2017.

Regarding this, at the meeting, the proposed rates based on the size of the establishments were decided and finalized for the collection of commercial waste by the SHGs. The rate was accepted by the Chamber of Commerce & Industries, Hotelier Association, Grains & Grocers Association, and Bar Association, along with the Andaman Tourist Association. Table 5 provides the user charges rates for establishments according to the PBMC- Solid Waste Handling & Management Bye-Laws, 2017.

[30] Saahas field visit in December 2021.

Table 5: The user charges rates for different establishments as per the PBMC-Solid Waste Handling & Management Bye-Laws, 2017

Sl.No.	Agencies	User Charges Per unit/ Per month in ₹
1.	Others (commercials like Pan shops, flower shops, another small unit not greater than 4 m^2 area) including Street vendors	100
2.	Grocery, departmental and other Shops medium unit not greater than 10 m^2 area	150
3.	Private / Government establishments medium unit not greater than 15 m^2 area	300
4.	Wholesalers and big establishments like textile, footwear, etc., and Pharmacy	500
5.	Vegetable and meat shops	500
6.	Vehicle showrooms	1000
7.	Bakery & Restaurants, Dabha, Hotels, Homestay	1000
8.	Hotels attached with bars/ Restaurants	3000

Gaps:

- **No user fee collection from the households**: The economic viability of the collection system depends on user fees. However, PBMC is currently not collecting the user fee from the households, making the financial aspect of waste management unsustainable
- **Absence of collection/treatment option for sanitary waste:** Waste collectors in PBMC do not collect the sanitary waste from the Households. The sanitary waste is highly mismanaged by either burning it uncontrollably or dumped in the Brookshabad dumping site. The waste sourced from sanitation and hospitals falls under the category of sanitation and biomedical waste. Considering the possibility that the mismanaged sanitary waste can enter the organic waste stream; proper handling of sanitary waste is crucial not only in terms of hygiene and disease control but also has a greater effect on the quality of compost production at centralised and decentralised composting units.
- **Lack of infrastructure to store segregated waste:** Several BWGs do not have proper bins or storage containers to separate organic waste, according to information received from SHGs. Most hotels store their waste in garbage bags, which can be difficult to handle and also tear easily, causing the waste to leak out. Port Blair's PBMC has also removed bins from several markets and commercial areas as part of its bin-free city strategy.
- **Coconut waste management:** Coconut waste makes up for the highest generated organic waste fraction in PBMC at the composition of 23.35% and poses greater concern as the generated coconut waste in PBMC is currently being dumped in Brookshabad dumpsite without any treatment method

3.5 Organic waste treatment and disposal in PBMC

3.5.1 Organic waste management at the source

According to the data provided by PBMC, ~2% of households are currently managing the organic at source. Currently, there is no incentive/support provided by either PBMC or ANI UT governmental authorities to encourage organic waste management at the source in PBMC.

3.5.2 ULBs initiative towards OWM at centralized and community level decentralized methods

S. no	Name/ Location	Capacity (TPD)	Method used	Present status	Remarks
1	Gandhi Park	0.7	Vermi Compost Facility	Operational	The facility handles only horticulture waste. The woman SHG "Stree Hausala" with ten employees is currently managing this facility. SHGs do not receive any financial assistance from PBMC. However, required resources viz. equipment and other inputs for composting process are provided by PBMC. The facility is producing 60 kg/day of finished compost which is sold 1-2 times a week near the Junglighat area. Compost is usually bagged in a 2kg plastic bag and sold at ₹ 50/kg. For bulk purchases costs varies between ₹ 35-45, where the SHG retains the revenue obtained by the sales of compost.
					
2	Brookshabad Compost Facility	5.0		Non-operational	Despite having the capacity to treat 5TPD of organic waste none of the pits had fresh organic waste or compost in them. Expired food items such as wheat, potatoes, and packaged food were

					dumped at the site. The organic waste that was supposed to be treated at this facility is currently diverted to the dumping site next to the facility. The facility has about 25 pits of size (3.5X1X1 m).
					
3	Anarkali Compost Facility	0.25	Pit composting (dug into the ground)	Operational	Only cow dung is been used as input material. A pit of size approximately 2.5X1.5X1.5 is dug into the ground and the cow dung is being dumped into the pit. After partial composting is over the partially composed input material will be sent to Gandi park for co-composting.
4	Junglighat	0.25	Electric Composting Unit	Non-operational	The unit is placed within the fish market building but has not been used due to odor concerns and malfunctioning of the unit.
5	Sanitary office, Junglighat	0.7 (1 TPD on Mondays[31])	Bin composting	Operational	Organic waste from ward no. 7 is composted at this facility. The facility has large waste collection bins which have been converted to composting bins. Nearly 500kg/month of compost is being produced and sold at ₹ 50/kg. however, during the survey team visit compost was sent for testing and the officials were waiting for the results. The facility was using rotten vegetables, fruits, and spoiled jaggery as inoculum in the composting process. Nevertheless, the composting technique did not have a proper mechanism for leachate

[31] Due to the weekly market

					collection. The produced leachate was directly drained to the ground.
					
5	Mohanpura Electric Composting unit	0.25		Non-operational	The unit is placed within the fish market building but has not been used due to odor concerns and malfunctioning of the unit.
6	Dollygunj SLRM	Not available		Non-operational	Composting pits in the SLRM centers are being used for storing dry waste
7	Mukthidhan	0.2	Open composting	Operation	The composting unit has a simple and ineffective method of composting. Street sweeping used tea powder, eggshells, and dried leaves collected from ward 7 and ward 4 are mixed and directly dumped on the ground in an open area and waited till the waste gets composted. There are also plans for converting this composting unit into a composting process demonstration unit that will be used for capacity-building activities.
					
7	Near stadium	0.5	Pit composting (dug	Operational	The facility claims to have a total treating capacity of 500kg/day. However, the facility is very small to handle 500kg/day

			into ground)		of waste. During the survey team's visit there were two pits dug in the ground and one pit was under the digging process. The method used for compost was rudimentary without any aeration mechanism making the final quality of compost highly questionable. Further, the facility has not processed any compost so far (30.01.2022). the composting facility only receives the waste from vegetable/market waste from wards 4 & 5. Currently, one municipality staff is managing the complete facility. The facility also has plans to start a nursery and currently has received seeds from the agriculture department in collaboration with PBMC.
					
8	Naya Paahad Gav	0.25	Bin compost ing	Operatio nal	Organic waste (including horticulture waste) from ward no. 20 is composted at this facility. The facility has large waste collection bins which have been converted to composting bins.

In addition to the efforts of PBMC for managing organic waste, BARC has installed a biogas plant of 500Kg /day capacity at Dr. B.R. Ambedkar Institute of Technology, Port Blair. However, the biogas plant is currently in non-operational condition due to technical issues. Further, PBMC is planning to install a biogas plant of 5 TPD to manage the organic waste generated in PBMC.

Gaps:

- **A significantly low quantity of organic waste is treated:** The treatment and processing of biodegradable waste at the household and the community level are significantly low. According to our estimation, among the 60 TPD of generated organic waste in PBMC, only ~6TPD is being treated and ~54 TPD (about 90% of the generated organic waste in PBMC) is dumped without any further treatment. There are very minimal efforts from PBMC to support organic waste management at the source. A negligible number of households opt for composting at the source. Decentralized composting is practiced in different wards of PBMC. However, apart from the vermicompost unit in Gandhi Nagar (the facility handles only horticulture waste) most of the other composting units either do not produce any compost or produce compost in an unscientific way.

- **Organic composting facilities are poorly designed:** The method used for composting is rudimentary without any aeration mechanism, leachate collection system makes the final quality of compost highly questionable. A major reason is poor system design. The composting system is not designed in a way that ensures moisture control, air circulation, and heating of the pile. In this regard, the construction of a roof, drainage system, airflow inlet, and turning is neglected in many cases.

  The capacity of each composting unit is not estimated based on receiving materials. This leads to a non-homogenous mixture and hinders effective process control. Further, throughout the decomposition process, temperature measurement, squeeze test for moisture control, and frequent turning is not frequently implemented. For almost all systems, a leachate collection system is not considered to allow to collect the extra moisture, especially in the rainy season. Additionally, most of the existing composting facilities do not consider the local weather challenges such as high humidity. The composting process is more susceptible to high air humidity.

  In most of the existing composting units, organic waste is currently being dumped unscientifically. The improper ventilation and lack of proper mixing leads to an anaerobic condition in the pit immobilising the composting mechanism that in turn causes odour nuisance and methane emission. In the case of the Brookshabad composting facility despite having a well-constructed composting unit with a capacity to treat 5TPD of organic waste, the composting facility is non-functional and currently being used as a warehouse to store expired agriculture products.

- **No incentives for OWM at the source:** there are no proper efforts and programs by PBMC to support the generator who is managing organic waste at the source.
- **The quality of compost produced is questionable:** most of the facilities treating organic waste and producing compost do not have an FCO compliance certificate for the sale of compost.
- **No brand for the sold compost:** marketing of the produced compost is a problem as there is no branding of the compost produced in PBMC

3.5.3 Privately Owned Animal Feed Systems[32]

Animal feed systems are traditional systems of consuming organic waste, especially food waste in India. During field visits, 3 (three) private piggeries were identified which are currently taking organic waste from Port Blair city; 2 (two) of these are operating in rural areas outside the jurisdiction of PBMC and 1 (one) is located at the Brookshabad dumpsite. A summary of these piggeries is given below:

[32] Complete information in this section was provided by Saahas Zero Waste which was obtained during their field visit in December 2022.

Sl.no	Location	No: of pigs	Quantity of waste processed	Source and type of waste
1	Lal Mitti	Approximately 80 adult pigs	1.5 TPD[33]	Vegetable and meat waste from individual shops in Port Blair
2	Manglutan	66 adult pigs	330 Kgs per day	Meat waste from 16 individual shops in Port Blair
3	Brookshabad	500-700 adult pigs	No data available[34]	During field visits, the pigs were observed feeding on mixed waste at the dumpsite. In addition, some amount of organic waste collected by Shree Venkateshwara SHG is being diverted to this piggery.

Table 6 Piggeries in Port Blair

3.5.4 Final Disposal of Organic Waste at Brookshabad Dumping Site[35]

Considering the waste characterization and generation results from the report "U.T. Policy and Strategy on Solid Waste Management for Andaman and Nicobar Island, 2018", PBMC generates approximately 60TPD of organic waste. At presently approximately 2% (~0.5 TPD) of the generated waste at households are treated at source and nearly 3.5 TPD of organic waste is managed by functioning decentralised composting systems. The two privately owned piggeries located at Lal Mitti and Manglutan are respectively handling about 330 kgs and 1 Tonne of organic waste generated within Port Blair every day. As per information gathered during field visits and through discussions with PBMC representatives (by Saahas Zero Waste), nearly all organic waste produced from markets[36] is being sent to Brookshabad dumping site. Majority of the organic waste collected by the two SHGs Friends and Shree Venkateshwara is also currently being routed to the central dumpsite with the exception of unquantifiable amount going to the piggery at Brookshabad. Therefore, currently, about 54 TPD of organic waste generated within Port Blair city remains unprocessed.

As per affidavits[37] submitted to the National Green Tribunal (set up for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources) by ANPCC, the central dumping site at Port Blair is classified as a landfill. The affidavits further states that this landfill has been closed and only about 16% of reject waste goes to the site. However, during field visits in December 2021, it was observed that the dumping site was operational and mixed waste is still being dumped at the site. In addition, large patches of the dumpsite were on fire during the field visit and it was not clear if it was

33 According to the owner, each adult pig consumes at approximately 20kgs of organic waste per day. This quantity has been arrived on that basis.
34 PBMC and SHGs have both been requested to share logs of organic waste being diverted to Brookshabad Piggery, however as per discussions conducted with both agencies, this data is not presently not maintained by them.
35 Complete information (expect first paragraph) in this section was provided by Saahas Zero Waste which was obtained during their field visit in December 2022.
36 Unquantifiable quantities of meat waste from markets and households are fed to stray animals and some quantity of organic waste is also used by households for their plants.
37 NGT affidavit submitted by ANPCC dated January 2020

intentional or because of a methane flare up. There are discussions with respect to carrying out bio-remediation of legacy waste at the dumpsite and a private party has been selected by PBMC for this[38].

In terms of monitoring the quantity of waste that is being sent to the dumpsite on a daily basis, a check post has been set up by the PBMC. All vehicles carrying waste to the dumpsite are required make an entry at the checkpoint. Therefore, the checkpoint has a record of number of vehicles going to the dumpsite each day along with the number trips. However, there is no weighbridge at the dumpsite and therefore, there is no data available on the amount of waste going into the dumpsite.

Current dump site on fire

Pigs from the piggery feeding at the dumpsite

Figure 8 Brookshabad Dumping Site

Gaps

- **No weighbridge at check point**: Given the dumpsite does not have a weighbridge, PBMC is unable to determine the quantities of organic waste going to the dumpsite despite keeping records of the number of vehicles that come to the site every day.
- **Lack of data**: The checkpoint register does not capture details about the type of vehicle entering the dumpsite. Therefore, estimation of waste through volume (linked to the capacity of the collection vehicle) and density of waste is also not possible.
- **Requirements of sanitary landfill are not complied with:** A major ecological feature of the ANI UT is its corals and marine life and the central dumpsite at Brookshabad is located less than 150 meters from the coast. The SWM Rules set out the requirements of sanitary landfills and have given ULBs (having population less than 5,00,000 persons) time until 2019 to set up sanitary landfills. The Brookshabad dumpsite does not comply with the requirements of a sanitary landfill and at present there is no structure installed at the dumpsite to prevent the leachate and other potential hazardous run-offs from entering the ocean, especially during monsoons. Therefore, there can be adverse environmental

[38] As per information provided by GIZ city representative.

impact[39] from the continued operations of the Brookshabad dumpsite and non-compliance of requirements of sanitary landfill.

4. Status quo of the organic waste management in rural ANI UT

4.1 Key stakeholders for SWM in rural ANI UT

Considering the rural structure and the small population of rural areas there are very limited stakeholders in the organic waste management in the rural part of ANI UT. In Shaheed Dweep complete waste management is handled by GP. However, in Swaraj Dweep, GP is handling the entire waste management with the help of one SHG in waste collection. The stakeholders and their activities currently involve the organic waste management of rural areas (Swaraj Dweep and Shaheed Dweep) of ANI UT are shown in Table 7[40].

Table 7: Key Stakeholders for SWM in rural (Swaraj Dweep and Shaheed Dweep) ANI UT

Sl. no	Stakeholder	Activity
	Swaraj Dweep	
1	SHG (no information on the name)	Door-to-door collection from Households and commercial units.
2	GP sanitary staff	Management of the collected waste by SHG
	Shaheed Dweep	
1.	GP sanitary staff	Entire collection and management of waste stream

4.2 Overview of organic waste management in rural ANI UT

Site visits have been carried out by the survey team to understand the level of segregation, collection, and efficiency of transport systems. Including processing and final organic waste disposal, linkages of the market for final products, and financial feasibility of OWM system. In this concern PBMC, the only urban area in ANI UT, and Swaraj Dweep and Shaheed Dweep were visited to understand the urban and rural perspectives of organic waste management in ANI UT. Figure 5 shows the visited locations during the field trip in the order of Swaraj Dweep, Shaheed Dweep, and Port Blair. For the purpose of understanding the organic waste management practice in the rural part of ANI UT, Swaraj Dweep and Neil Island was visited by the survey team. The general overview of organic waste management practice in Swaraj and Shaheed Dweep is depicted in Figure 9.

[39] The adverse environmental impact can include ingestion of hazardous substances by marine life, depletion of oxygen in water and resultant hypoxic zones among others.
[40] As per the field visit in January 2022 and interviews with GP officials.

The waste collection in the visited GPs (Swaraj Dweep and Shaheed Dweep) is carried out mainly from the primary door-to-door collection system. Organic waste is only collected from commercial generators and for households it is promoted to treat at the source. Usually, households treat the organic waste using composting technique or it is fed to animals. Concerning commercial generators, no commercial generators are currently managing their organic waste at the source, and consequently, all of them rely on the waste collection service provided by the GPs. One exception for the commercial generator is Taj Hotel, located on Swaraj Dweep Island. Taj Hotel has a vermicomposting unit and a biogas plant which cumulatively has the capacity to treat 120-130 kg of organic waste per day.

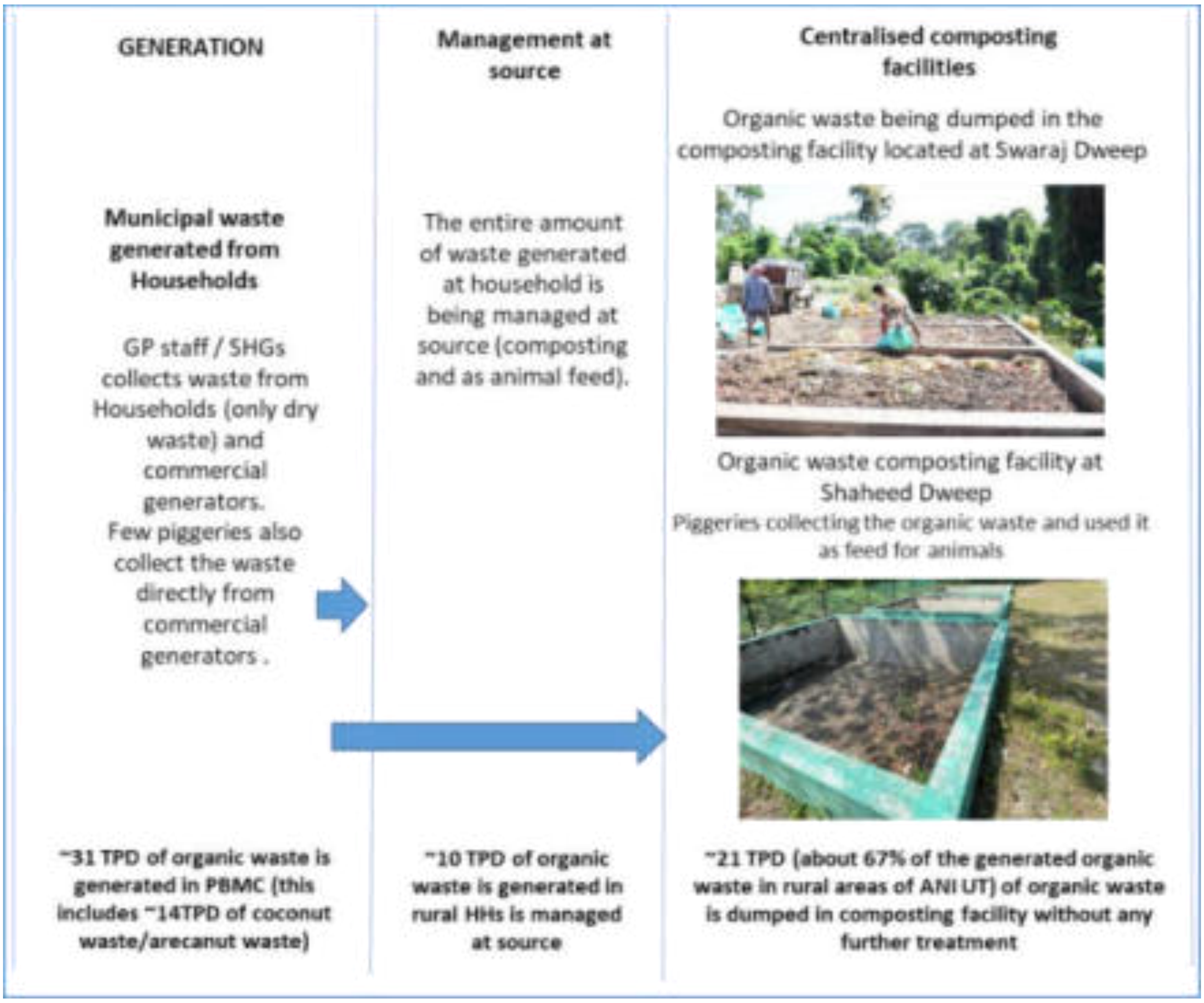


Figure 9 General overview of organic waste management practice in rural ANI UT[41]

The majority of the organic waste collected is currently being transferred to the central composting unit at the respective GP (Swaraj Dweep receives waste from Shyamnagar and Govindnagar GP). Despite having a centralized composting pit, organic waste is currently being dumped in the composting pit leading to the anaerobic condition in the pit and odour nuisance. Currently, there is no compost being produced among both visited GPs.

[41] According to U.T. Policy and Strategy on Solid Waste Management for Andaman and Nicobar Island, 2018, total waste generated in rural areas of ANI UT is 20-50 TPD and consist 62% of organic waste (34% of compostable organic waste and rest is coconut and Arecanut waste. All the calculation are done considering waste generation of rural areas as 50TPD.

4.3 Waste generation and composition in rural ANI UT

Except for Port Blair, all other areas in ANI UT are rural areas, covering about 8207.75 sq. km. There are more than 500 islands in the rural area of ANI UT, of which only 28 islands are inhabited in which Bambooflat, Car Nicobar & Campbell Bay, Choudhri, Diglipur, Ferrargunj, Swaraj Dweep, Little Andaman, Mayabunder, Neil, Rangat, Wimberleygunj are the major hubs of commercial and touristic activities in rural areas aside from Port Bair city. Geographically isolated, rural areas of ANI UT have a much lower population density and generate around 20-50 TPD of waste. The composition of waste generated in the rural area of ANI UT is given in Figure 10. Among the generated waste 62% comprised of organic waste among which 34% is compostable organic material such as food and garden waste. Coconut/Arecanut waste makes up for the highest generated organic waste fraction at the composition of 28% and poses greater concern as the generated coconut/Arecanut waste in rural ANI UT is not collected or dumped uncontrollably without any proper treatment method. Additionally, Figure 7 does not show the composition of the sanitary waste generated. Similar to PBMC, there is no mechanism for the collection and treatment of sanitary waste in rural parts of ANI UT, and the generated sanitary waste is currently being either dumped or burnt by households uncontrollably.

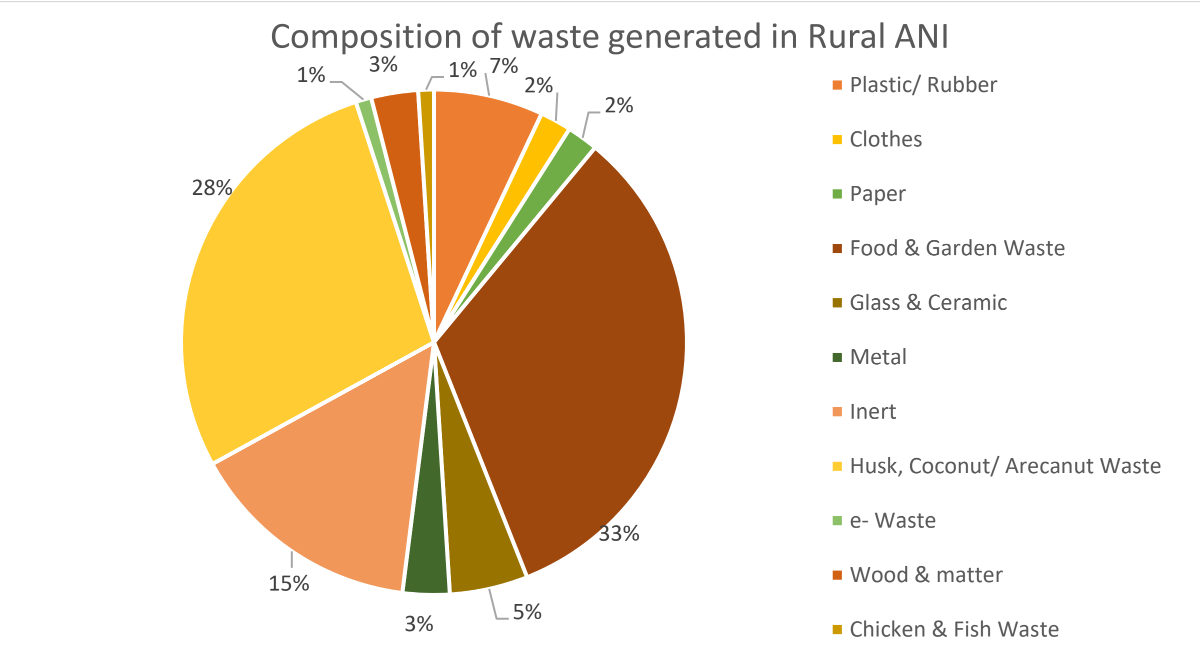


Figure 10: Composition of waste generated in Rural ANI UT

Waste generated in the visited locations is depicted in Table 8.

Table 8: Waste generated in Swaraj Dweep and Shaheed Dweep

Location	Population	Per capita waste generation (Kg/day)	Total waste generated in TPD	
			Organic waste	Dry waste
Swaraj Dweep	6315	0.25 – 0.3	0.25	0.7 – 0.8
Shaheed Dweep	5000	0.18-0.2	0.4/month	2.4/month

4.4 Organic waste collection and transport in rural ANI UT

The waste collection in the visited GPs (Swaraj Dweep and Neil) includes mainly primary door-to-door collection. In Shaheed Dweep, GP staffs are completely responsible for the collection of waste both from households and commercial generators. However, in Swaraj Dweep SHG is involved in the door-to-door collection and GP pays ₹ 75,000 / month for SHG for its service.

No organic waste is collected from the households and the organic waste generated in the household is composted at the source or fed to animals. As far as commercial generators are concerned, no commercial generators are currently managing their organic waste at the source, and consequently, all of them rely on the waste collection service provided by GP. As mentioned earlier, only exception for the commercial generator is Taj Hotel, located on Swaraj Dweep Island has a vermicomposting unit and a biogas plant with a cumulative capacity to treat 120-130 kg of organic waste per day.

The dry waste from the household is collected twice a week and waste from commercial generators is collected daily. If the waste is not segregated the waste collector opposes collecting the waste by giving a warning, if the situation continues the sanitary worker will impose a penalty. The waste collector collects the user fee of ₹ 50/month from the households and for commercial generators, the cost varies depending on the size and type of establishment. For hotels not providing complimentary water bottles ₹ 10/room/day, hotels providing complimentary water bottles ₹ 15/room/day, restaurants ₹ 5/table/day, and for small vendors ₹ 50-100/week. However, due to covid situation hotels and restaurants are not running at full capacity. In this concern, GPs are taking written declarations from hotels and restaurants on their actual operation size, and the user fee is collected accordingly.

Currently, GP in Swaraj Dweep has started an initiative to promote source-level treatment for waste. GP is providing 30% off on user fees for the BWGs having a composting facility. Some BWGs give their organic waste to the piggery. In addition to GP's efforts on organic waste management, some piggeries also collect the organic waste directly from the commercial generators.

The majority of the organic waste collected is currently being transferred to the central composting unit at the respective GP (Swaraj Dweep is receiving the waste from Shyamnagar and Govindnagar GP). Despite having a centralized composting pit, organic waste is currently being dumped in the composting pit without any production of compost.

The overview of segregation and collection mechanism in rural ANI UT (Shaheed Dweep and Swaraj Dweep) is shown in Table 9.

Table 9: Overview of segregation and collection mechanism in Shaheed Dweep and Swaraj Dweep

Place	Segregation	Coverage	Collection vehicle	Staffs	Number of commercial generators
		Frequency	GPS		
Swaraj Dweep	1 way – households 2 way – commercial generators	60-70 %	Pull cart- 10-15 Electric cart- 1 LMV - 1, HMV - 1	SHG – 15-20 Daily major – 45	Approx. 100

		Weekly twice– households Daily – commercial generators	no	GP official - 1	
Shaheed Dweep	1 way – households 2 way – commercial generators	100%	Cycles – mostly all collection workers have one Electric cart- 1 (not-functioning) LMV - 1	Sanitary staff – 29 Supervisor - 1	50 – hotels + resorts 15-20 – Restaurant 100 – small vendors 1 - market
		Weekly twice– households Daily – commercial generators	no		

Gaps

- **There is no proper collection/treatment option for sanitary waste:** waste collectors are not collecting the sanitary waste from the House. The significantly high amount of sanitary waste generated is currently being either dumped or burnt by households uncontrollably. The waste sourced from sanitation and hospitals falls under the category of sanitation and biomedical waste. Considering the possibility that the mismanaged sanitary waste can enter the organic waste stream; proper handling of sanitary waste is crucial not only in terms of hygiene and disease control but also has a greater effect on the quality of compost production at centralised and decentralised composting units.
- **There is no proper collection/treatment option for coconutons/annumrecanut**: waste Coconut/Arecanut waste makes up for the highest generated organic waste fraction at the composition of 28% and poses greater concern as the generated coconut/Arecanut waste in rural ANI UT is not collected or dumped uncontrollably without any proper treatment method

4.5 Organic waste treatment and disposal in rural areas of ANI UT

4.5.1 Organic waste management at the source

According to the data provided by GP officials[42], the entire organic waste generated by households are currently managed at source. Currently, the generated organic waste by households are either composted or used to feed animals.

4.5.2 OWM at centralized and community level decentralized methods

Sl. no	Name/ Location	Capacity (TPD)	Method used	Present status	Remarks

[42] As per the field visit in January 2022 and interviews with GP officials.

1	Solid waste management center. Cluster GP Govind Nagar & GP Shyam Nagar. (Swaraj Dweep)	0.5	Open-pit composting	Non-Operation	The facility has ten composting pits of size 10X10X8 feet and receives about 2-2.5 Tonne of organic waste per month. The composting technique used is highly ineffective. Composting pits are designed without a proper aeration system, no roofing, no efficient facility for the collection of leachate, and no inoculum is used during the composting process. To date (February 2022) no compost has been produced from this facility however organic waste collected from commercial generators is being dumped every day.
					
2	Hotel Taj, Swaraj Dweep	Biogas (100 kg-size of digestor) Vermi-composting (20-30kg/day)	Vermicomposting unit and a biogas plant	Biogas (non-operational) Vermi-composting (operatiional)	This commercial generator has a vermicomposting unit and a biogas plant which cumulatively can treat 120-130 kg of organic waste per day. However, the biogas plant is currently in non-operational condition due to less amount of organic waste produced at the facility (because of the covid situation less number of tourists are visiting the hotel)
					

3	Solid waste management centre. Cluster GP Ram Nagar, Shaheed Dweep (Neil Kendra)	0.5	Open Pit composting	Non-Operational	The facility has seven composting pits of size 15X15X6 feet. The composting technique used is highly ineffective. Composting pits are designed without a proper aeration system, no roofing, and no efficient facility for the collection of leachate. To date (February 2022) Currently no organic waste is received in the facility and all of the pits were empty.
					

Gaps

- **No amount of collected organic waste is converted into compost:** Despite having a larger facility to treat and manage organic waste, currently, no compost is produced. Both Swaraj Dweep and Shaheed Dweep have compost units of size 0.5 TPD each. However, in Swaraj Dweep organic waste from commercial generators is collected and dumped uncontrollably into the composting pit (no compost is produced so far) and in Shaheed Dweep despite having a composting unit no organic waste is brought into the facility
- **All of the organic composting facilities are poorly designed:** The method used for compost is rudimentary without proper roofing, aeration mechanism and/or leachate collection system making the final quality of compost highly questionable. A major reason is poor system design. The composting system is not designed in a way that ensures moisture control, air circulation, and heating of the pile. In both cases, a leachate collection system is considered but designed poorly and has a high tendency to collect extra moisture, especially in the rainy season. Additionally, all the existing composting facilities do not consider the local weather challenges such as high humidity and heavy rainfall. The composting process is more susceptible to high air humidity. In the existing composting units, organic waste is currently being dumped unscientifically. The improper ventilation and lack of proper mixing leads to an anaerobic condition in the pit immobilising the composting mechanism that in turn causes odour nuisance and methane emission.

5. Technical concept, strategies and approach for organic waste management

5.1 Upgrading existing composting methods and the suggestion of creating a centralised post-composting facility in ANI UT

Despite having several composting facilities in PBMC and Rural parts ANI UT, the method used for composting is rudimentary in most cases without any roofing system, no aeration mechanism, and no leachate collection system. The lack of technical knowledge will not only make the composting process highly inefficient but, also makes the final quality of compost highly questionable. Additionally, most of the generated compost is currently being sold without proper testing, certification, and/or branding. The following section provides a strategy for improving the current composting facility and an approach to creating a centralized post composting unit.

5.1.1 Troubleshooting the functional & non-functional composting plants in PBMC and Rural area:

Composing is a microbiological process affected by temperature, moisture, and oxygen concentration. These parameters are fundamental in the design of all composting systems. The successful operation of a composting plant is dependent on several factors; namely, the quality of received material, sorting, mixing, piling, turning, temperature, moisture control, maturation, screening of the waste, and bagging of the final product. The know-how on the physical and chemical properties of incoming materials is the key to sorting and mixing an appropriate ratio of the raw feedstock. The plant manager should run some trials to find out the best mixture under local conditions. The process is adjusted by the addition of cow dung, dry leaves, wood chips, sawdust, etc.

Table 10 Criteria for selection of the composting technology[43]

Constraining Criteria	Windrow Composting	Box Composting	Explanation
Space is limited		×	Box composting requires less space than windrows.
Long-term availability of land is not ensured	×		Windrow composting requires less investment in stationary infrastructure.
Financial constraints for initial investments	×		Windrow composting is less expensive due to lower infrastructural requirements.
Labour is hard to find		×	Box composting requires less manpower than windrow.

The composing system should be designed in a way that ensures moisture control, air circulation, and heating of the pile is at the required levels. In this regard, the construction of a

[43] Rothenberger, S., Zurbrügg, C., Enayetullah, I., Sinha, A.H.M. (2006). Decentralised Composting For Cities Of Low-And Middle-Income Countries - A Users' Manual

roof, drainage system, airflow inlet, and turning is important. For effective process control, the capacity of each composting unit should be estimated based on receiving materials. The optimum homogenous mixture can be up to three days old material. Accordingly, each composting box or bin can be designed with such capacity. Throughout the decomposition process, temperature measurement, squeeze test for moisture control, and frequent turning should be implemented. For all systems, a leachate collection system should be considered to allow to collect the extra moisture, especially in the rainy season.

5.1.1.1 Composting at Household-level

Home composting is a simple method to treat biowaste at the household level. Practising the household composting method contributes to the diversion of biowaste from landfills/dumpsites and reduces the cost of SWM. The final product can return to the soil as mulch or as a soil conditioner. Home composting is an effective solution in ANI UT to the SWM dilemma. Several composting models have been adapted to the local conditions of households in India and a wide variety of available containers are used in different provinces. In PBMC, limited households are practising composting at source and the main home-composting methods are pit composting, bin composting and crate composting. However, to promote the organic waste treatment at the household level, in the first phase, another suitable home-composting method should be identified to be adapted locally. The benefits and drawbacks of each system are the major drivers in adapting a composting technique to the local context of ULBs.

The capacity building comes in the second phase. the trainers should get training at the ward level on the requirement of each composting method and optimum operating conditions. These technical know-hows should be transported to the citizen for successful management of organic waste in homes. To achieve the latter a key factor is that in all types of home composters, proper segregation of biowaste[44]. Kitchen and garden waste can be used as raw input materials. However, meats, bones, oil, and dairy products should not be added to the system. The small volume containers are ideal to treat fruits, vegetables, food, and garden leaves. To control the moisture in the container, fruits like watermelon should be squeezed before addition and if possible, the leachate should be collected. Additionally, the smaller the particle size the faster the decomposition process. In containers where air circulation is restricted, materials should be mixed regularly and bulky agents such as sawdust or dry leaves should be added. To accelerate the composting, soil or cow dung can be added between layers. Another way to fix the available inoculum is to add the sawdust and add materials to it. This would help to control moisture, reduce odour, increase porosity and speed up the process. few recommendations on the most adopted composting models in India are further mentioned in Table 11.

Further, other parameters also have to be considered for producing a good quality compost. For example, placing a composter container is a factor that affects the proper implementation of the process. Locating the composter container indoors or under a shelter is crucial to avoid direct sunlight and rainwater penetration. If the containers allow leachate collection, the excessive moisture can be collected over the period of the composting process. the collected leachate can be applied to the soil after diluting with a 1:10 ratio (leachate: water). The composted material can be removed from the container after 4-6 weeks according to the

[44] Kawai, Kosuke; Liu, Chen; Gamaralalage, Premakumara Jagath Dickella (Hg.) (2020): CCET guideline series on intermediate municipal solid waste treatment technologies: Composting.

composting method. At the last stage as an indicator, the composting materials turn dark and smell like fresh earth. To purify the composted material the final product can be sieved and the coarse material can be returned to the container for composting again. The produced compost should be placed on the ground at least for two weeks before application to the ground.

Nevertheless, the trainer must frequently monitor the organic waste management in households to control and improve the system. one suggestion here is that every municipality should have a proper working model of all different types of the composting process. installing such a working model will help the citizen to have firsthand information about the process.

Table 11: Composting techniques at a household level. Their benefits, drawbacks, and recommendations

TYPE	Benefits & drawbacks	Recommendation	Model
Plastic Bucket	Benefits: low-priced, suitable for small households, shorter decomposition time Drawbacks: needs daily monitoring, generates odor or attracts pest	Chopping the waste, regular mixing using a fork, addition of sawdust, soil, or spraying inoculum to speed up the process.	 source:[45]
Crate composting	Benefits: low-priced, suitable for small households, shorter decomposition time Drawbacks: temperature control, needs daily monitoring, generates odor or attracts pest	Using cardboard to line the inside of the crate can assist to maintain a consistent moisture level.	
Pot	Benefits: low-priced, leachate collection outlet Drawbacks: low air circulation	Drilling holes in the pots for air circulation, the addition of saw dust, soil, or cow dung between layers.	
Three bins	Benefits: light weight and easy to handle, inexpensive, able to start the process for fresh materials Drawbacks: no moisture and temperature control	Lining the bottom of buckets with newspaper, the addition of sawdust, soil, or cow dung between layers.	

[45] Atin, Biswas; Shailshree, Tewari; Subhasish, Parida (Hg.) (2021): decentralized-management-of-segregated-organic-waste. New Delhi: Centre for Science and Environment.

Khamba	Benefits: able to start the process for fresh materials, treating higher volume of biowaste Drawbacks: no moisture control	Lining the bottom of pots with newspaper, Drilling holes in the pots for air circulation, chopping the input material, addition of soil or cow dung to pots.	

5.1.1.2 Decentralised composting facilities

Treatment of biowaste in a decentralized manner is widespread in India. Following this approach prevents the additional expenses of collecting and transporting waste over long distances. The decentralized facility has lower operating expenses and less operational complexity which promotes community-based waste management and creates jobs for the locals. A community-scale composting facility eliminates the demand for additional disposal facilities, promotes organic waste recycling locally, and creates small-scale businesses and enterprises[46]. In this regard, first of all the existing systems should be optimized by troubleshooting the functional and nonfunctional decentralized composting facilities. To this end, capacity building through training of trainers & integration of awareness-raising directly on storage bins and decentralized composting plants are crucial.

In order to obtain a high-quality final product, effective design and management of the process is the key element. The frequency of waste collection should be considered according to the generation rate and weather conditions. Biowaste decomposition in the storage containers results in odour and leachate generation. It is also crucial to collect waste in separate fractions for avoiding impurities and contamination. The waste collector removes the unwanted material from the biowaste fraction. A manual sorting can be conducted on received feedstocks in the decentralized facility. Figure 11 provides an overview of parameters that has to be considered in a community based composting approach.

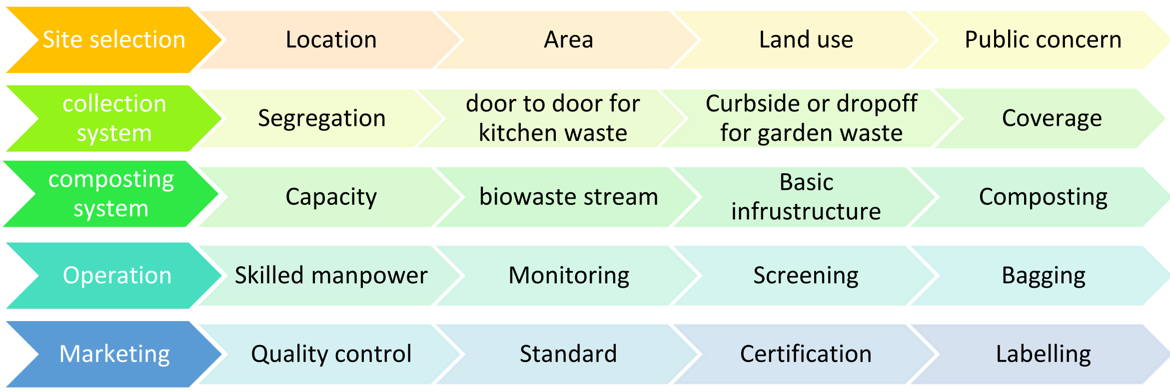


Figure 11: Flow chart of the community-based composting approach

Site selection is a common condition that has a considerable impact on the development of a community-scale composting facility. The available site should be evaluated based on collection distance, accessible area, land use, community interest, existing organic waste stream, and estimation of future biowaste generation trends. The capacity of the system has to be assessed based on the obtainable biowaste streams.

[46] Bruni, Cecilia; Akyol, Çağrı; Cipolletta, Giulia; Eusebi, Anna Laura; Caniani, Donatella; Masi, Salvatore et al. (2020): Decentralized Community Composting: Past, Present and Future Aspects of Italy.

Concerning collection systems, there are several adapted methods for primary collection of bio-waste namely: door to door, block, Curbside, and communal collection. The door-to-door method is the most effective method for source segregation of Bio-waste. However, it requires a higher labour force, time, and investment as well as the presence of a household member during collection time. This is the most effective method to raise awareness and promote source segregation. In communities where people have better cooperation, a block or Curbside collection scheme is implemented. Block collection is implemented in less populated areas, where households can be easily informed by ringing a bell and are willing to carry waste bins. In the case of higher population areas, the curbside method is more effective. It has to be also ensured to have maximum collection coverage. Once the location and capacity of the decentralized facility within each ward are selected and the collection system is ensured, the choice of composting technology is the next step[47].

Several composting methods can be implemented on-site for communities, institutions, and bulk generators of the waste. Viable techniques can be chosen upon economic resources, available materials, climatic conditions, technical infrastructures, vacant or available land space, waste volume and composition, physical and chemical properties of the waste, environmental consideration, and marketing requirements. Additionally, some basic features should be considered in the development of every decentralized composting facility including freshwater supply for the composting process, skilled workers, construction of a roof to control moisture in dry and rainy seasons, allocation of a sorting area with a concrete surface, considering a table for sorting, setting up a manual sieve for screening and establishment of a storage area for the packaging of the finished products[48]. Finally, the marketability and sales of the produced compost decides the sustainability of the composting unit. To this concern, quality control, certification, and having proper brand ensures the sales of the produced compost.

[47] Atin, Biswas; Shailshree, Tewari; Subhasish, Parida (Hg.) (2021): decentralized-management-of-segregated-organic-waste. New Delhi: Centre for Science and Environment.
[48] Zurbrügg et al. 20 Zurbrügg, Christian; Drescher, Silke; Rytz, Isabelle; Sinha, A.H.Md. Maqsood; Enayetullah, Iftekhar (2005): Decentralised composting in Bangladesh, a win-win situation for all stakeholders.

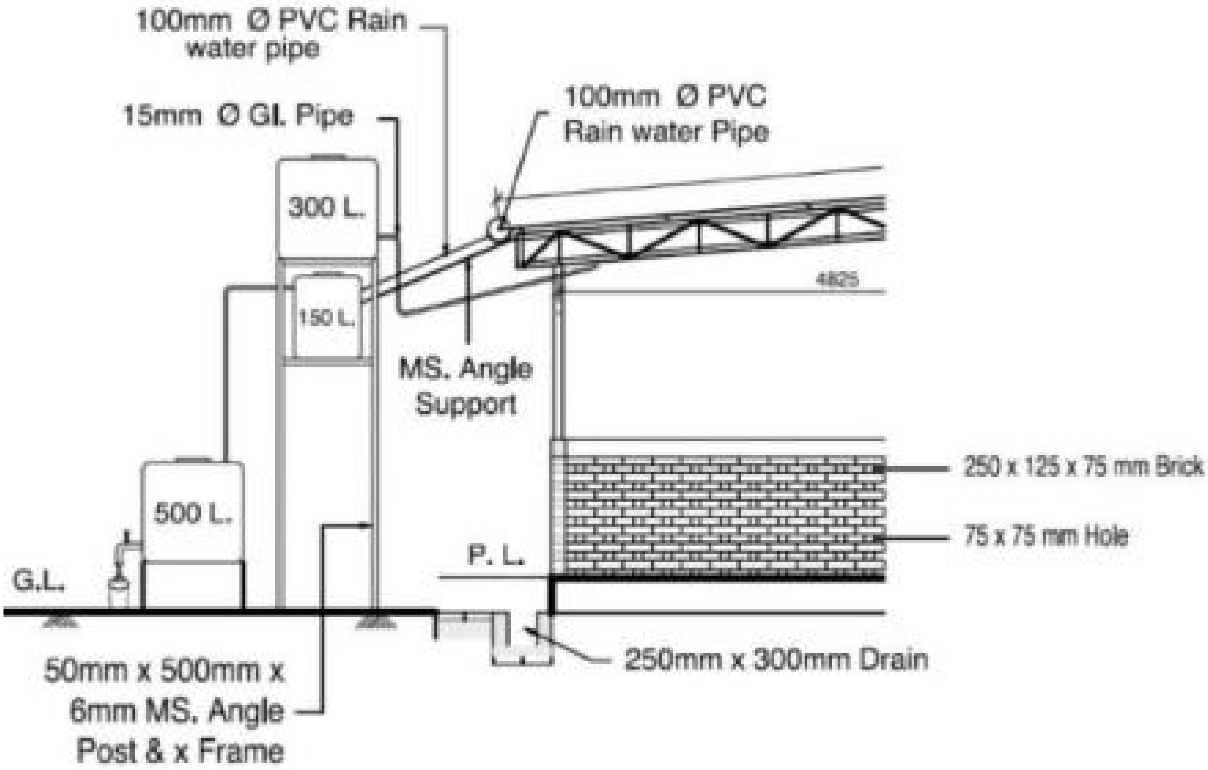


Figure 12: A simple structure for collecting rainwater from the top roof [49]

The rainwater can be collected during the wet season by designing a rooftop construction system. With a simple structured design, using a PVC pipe at the edge of the top of the roof the rainwater can be collected in the storage tank, which can be later used during the dry season (see Figure 12). Furthermore, composting material can attract animals and make a nuisance for the citizens; therefore, it is highly recommended to fence the system set up.

The common composting methods practised in small to medium size decentralized facilities in ANI UT are pit composting, bin composting, and vermicomposting. This section provides information on the second phase of strategy and promotes the construction, operation, and maintenance of these systems. Table 12 provides an overview of different composting models.

Pit composting is the most widespread community levels composting technique in ANI UT. The pits should be constructed in a well-elevated area under the roof. Typically the pit composting in ANI UT is generally done in two ways (see Table 12). 1) By digging a pit into the soil and directly feeding the pit with organic material. 2) Construction of pits with a brick wall that is partially immersed into the soil and partially above ground level. The first method of composting used the rudimentary composting approach without any aeration mechanism, no proper structure and roofing mechanism making it highly susceptible to weathering action in turn producing a questionable compost. The second method has a slightly improved

[49] Rothenberger und Zurbrü Rothenberger, Silke; Zurbrügg, Christian (2006): Decentralised Composting for Cities of Low- and Middle-Income Countries. A Users' Manual. Duebendorf, Switzerland: Waste Concern. gg 2006.[49]

construction technique but the outcome of the compost is highly questionable as there is no proper aeration mechanism, no leachate collection mechanism, and no roofing.

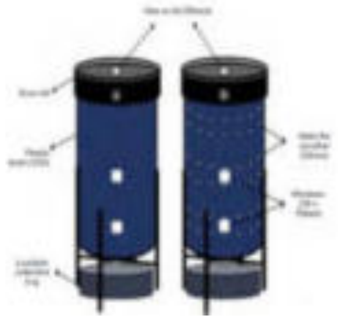
Following are the recommendations that as to be considered for the pit composting technique. Each pit can be maintained for up to 6 months. Higher priority has to be given in concern to the quality of input material. Further, having a proper design structure also plays an important factor in producing quality compost. As explained earlier using a simple structure design rooftop for the composting unit can be constructed which can also collect rainwater during the rainy season. Considering the fact that the construction raw material in ANI UT is imported from the mainland, the construction of even such a simple structure can be cost-intensive. One possible cost-effective alternative option concerning scares of construction raw materials is to use locally available materials such as coconut tree branches for the construction of proper roofing. Additionally, to prevent foul odour generation and pest attraction, the green and brown material should be mixed thoroughly (to ensure proper Carbon: Nitrogen ratio). The moisture level should be maintained at 50% and composting material should be turned regularly. The addition of inoculum (e.g. cow dung slurry) and chopping of the green materials help to speed up the composting process.

Installation of a perforated web, PVC pipes, or creating a drainage layer out of coarse material (gravel, branches, etc.) at the bottom of the structure allows controlling the excess moisture. Considering slope in the design layout of composting area ease the leachate collection. The addition of the green biowaste in thin layers between brown waste or thorough mixing before spreading is a must for an effective decomposition process. Fresh materials are mixed with the previous layer using a fork or a shovel to increase the feed to the system. The temperature should be maintained up to 65 °C for at least one week to ensure a hygienic final product.

Once the pit gets full, it can be covered with soil or cow dung and the same process could be used in the second pit. Usually, the final product is finished in 2 to 3 months when the material reaches ambient temperature, smells like soil, and has a medium to dark brown colour.

Table 12: Type of composting technique model, their benefits, and drawback.

TYPE	Benefits & drawbacks	Recommendation	Model
Pit composting (dug into the ground)	**Benefits:** low-priced, the pit size is adjustable to feedstock **Drawbacks**: the complete process is unscientific	2m×1m area per each pit, spreading cow dung slurry at the bottom, chopping the biowaste and covering with soil or brown material, in-situ monitoring	

High-density polyethylene (HDPE) container	**Benefits:** improved air circulation, fit for any area **Drawbacks:** temperature control, generating odour or attracting pest	Materials should be cut and mixed with dry leaves or sawdust. Should not contain any oily or liquid items. Water should be sprayed to maintain 50% moisture content.	 source :[50]
Bin composting	**Benefits:** Inexpansive, fit for any area **Drawbacks**: air circulation, leachate control, generate odours.	Materials should be cut and mixed with dry leaves or sawdust. The material should not contain any oily or liquid items. Frequent turning is required. The mechanism for collecting leachate from the bottom of the bin has to be adapted.	
Pit composting: (constructed partially above and partially below ground)	**Benefits:** low-priced, potential to treat larger quantity of compost **Drawbacks:** require skilled manpower	Mix the brown and green feedstock with a 3:1 ratio before filling the system. it is very important to have proper roofing, leachate collection system and aeration system through walls. For facilitating proper leachate flow it is important to provide sloping in the floor. Further leachate collection can be enabled by constructing small pit next to composting units and connecting them with properly sloped pipes.	

50 Atin, Biswas; Shailshree, Tewari; Subhasish, Parida (Hg.) (2021): decentralized-management-of-segregated-organic-waste. New Delhi: Centre for Science and Environment.

Vermicomposting	**Benefits**: high-quality final product **Drawbacks:** require adequate area and skilled manpower, the higher final price	proper for the ward level, pre-composting and chopping the biowaste ease the process, cover the piles to keep the moisture	

The vessel composting systems needs a slightly higher initial investment. Proper implementation of the design concept plays a pivotal role in this approach[51]. Simple methods such as the **High-density polyethyene** container and **Bin composting** can be utilized at both household and community levels. In these systems, attention should be paid to air circulation by regular turning, the addition of bulky agents and moisture control. Some other practical solutions include placing a mixture of cow dung, compost and dry leaves at the bottom, chopping the green waste, spraying inoculum and daily covering with brown materials. The composting process takes at least 45 days in an HDPE container and 30-45 days in a ring. Once the material is cool down, the container can be unloaded. The finish materials should be air-dried in the shadow and screened. The coarse materials can be added to a running system. Further concerning the bin composting a mechanism for collecting leachate from the bottom of the bin has to be adapted. The leachate collection can be facilitated by making holes in the composting bins and creating a layer of coarse gravel. The leachate produced during the composting process can be collected by keeping the collection tray below the bin composting unit.

Another effective biowaste treatment method in the context of ANI UT is **Vermicomposting**. It is a cost-effective technology that benefits from the activity of earthworms. The interaction between microorganisms and earthworms in the digestion system results in the decomposition and stabilization of the biowaste. The preferred temperature range for the degradation process is 25°C to 37°C and it doesn't go through the thermophilic phase. The substrate is the major contributor to the vermicomposting process[52]. Cow dung is the most suitable bedding to promote the efficiency of the process, whereas another type of biowaste e.g. kitchen waste can be handled as co-substrate. Ideally, at least 30% of the total substrate should include cow dung[53].

Vermicomposting can be conducted using windrow piles, pit method, and in-vessel e.g. bins, cement ring, etc. Among different earthworm species, *Eisenia fetida* and *Eudrilus eugeniae* are most widely used. These species have a higher growth rate and adaptation to a wider range of biowaste. The vermicomposting process includes the reproduction of the worms which gets affected by several parameters. The substrate with a C: N ratio of about 25, pH in the range of 4.2 to 8, and a moisture content of 65 to 70% is among them. Furthermore, under

[51] Harshitha, Jampala; Krupanidhi, Sreerama; Kumar, Sunil; Wong, Jonathan (2016): Design and development of indoor device for recycling of domestic vegetable scrap. In: *Environmental technology* 37 (3), S. 326–334. DOI: 10.1080/09593330.2015.1069896

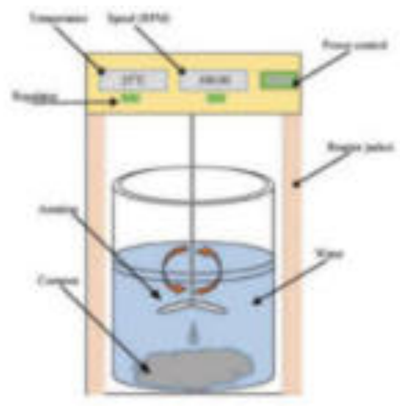
[52] Manaf, Latifah Abd; Jusoh, Mohd Lokman Che; Yusoff, Mohd Kamil; Tengku Ismail, Tengku Hanidza; Harun, Rosta; Juahir, Hafizan; Jusoff, Kamaruzaman (2009): Influences of Bedding Material in Vermicomposting Process. In: *IJB* 1 (1). DOI: 10.5539/ijb.v1n1p81. Manaf et al. 2009.

[53] Ali, Usman; Sajid, Nida; Khalid, Azeem; Riaz, Luqman; Rabbani, Muhammad Muaz; Syed, Jabir Hussain; Malik, Riffat Naseem (2015): A review on vermicomposting of organic wastes. In: *Environ. Prog. Sustainable Energy* 34 (4), S. 1050–1062. DOI: 10.1002/ep.12100.

the optimum condition, the worms require 1.25 kg feed/kg worm/day for a density of 27–53 worms per kg[54]. These requirements are met only by sufficient O&M and skilled manpower. Overall, the vermicomposting process takes longer and requires more know-how.

The final product of vermicomposting is a fine material rich in nutrients such as nitrogen(N), potassium (K), and phosphorous(P). Therefore, usually, it can be used to produce tea compost and has a higher final price. It is a quality organic soil amendment with a high agronomic value resulting from the good enzymes of earthworms. Besides, the absorption of heavy metals by the digestion system results in lower toxicity of vermicompost.

<table>
<tr>
<td>What is tea compost?

The liquid extract of compost under an/aerobically controlled condition is called tea compost. It is rich in nutrients and contains beneficial microbes[55] It is a positive effect on:
• seed germination
• seedling growth
• Plant growth
• Crop development
• stop the plant diseases
• soil fertility</td>
<td>
Figure 13: A schematic diagram of tea compost[56]</td>
</tr>
<tr>
<td colspan="2">How to prepare tea compost aerobically?

High-quality compost (e.g. vermicompost) is diluted in a 1:10 compost to water ratio in a tank. The mixture is aerated using a stirring agitator (as shown in Figure 13) at room temperature. After at least 3 days, the liquid phase can be filtered and extracted as compost tea[57].</td>
</tr>
</table>

The last phase of ensuring the successful implementation of decentralized composting facilities is maintenance and monitoring of the system. To this end, monitoring tours for community and decentralized composting plants using a traffic lights system to identify the hotspot of contamination should be planned. The community bins should allocate precisely to the property owner or bulk waste generator to give a warning in case of violating the rules and raising awareness. After several warnings and training penalties should be introduced.

5.1.2 Quality control for achieving FCO complaint compost

Quality of the organic waste: Final quality of the produced compost significantly depends on the quality of collected organic waste. The collection and transportation of source-separated organic waste can ensure the higher quality of the final compost produced. In this concern, the segregation of the waste at the source and the collection of segregated waste in its pure form has to be given attention.

[54] Ali et al. 2015.
[55] Ingham, Elaine R. (2005): The Compost Tea Brewing Manual. 5. Aufl. Corvallis, Oregon: Soil Foodweb Inc.
[56] Waqas, Muhammad; Korres, Nicholas Emmanuel; Khan, Muhammad Daud; Nizami, Abdul-Sattar; Deeba, Farah; Ali, Iftikhar; Hussain, Haziq (2019): Advances in the Concept and Methods of Seed Priming, S. 11–41. DOI: 10.1007/978-981-13-8625-1_2
[57] Waqas et al. 2019.

Pre-sorting: Despite taking greater care in some cases some impurities make their way into the composting facility together with the organic waste. This problem could be addressed by giving special attention to pre-sort the received material for any impurities. Special attention has to be given to plastic and hazardous waste material such as metals, hospital waste, sanitary waste, batteries etc. Presence of these impurities during the thermophilic process of composting results in the release of toxic substances e.g. heavy metals.

Carbon: Nitrogen ration: During composting, the microorganisms responsible for decomposing organic wastes use carbon as a source of energy and nitrogen as the source of proteins. The feedstock C:N ratio of 30:1 is considered ideal for the composting process. The composting process will be slowed down by too much carbon or very large particles. In contrast, the presence of higher nitrogen content makes the compost system too hot and kills the organisms responsible for composting. To adjust C:N ratio, bulky agents such as wood chips or sawdust should be added which prevents nitrogen lost in form of leachate or ammonia.

Aeration: The turning schedule is set upon the decomposition rate, temperature, and moisture content of the waste. A higher turning rate is required at the beginning of the process; first and second weeks to allow air circulation, to cut the materials into small pieces, and to balance the temperature in the composting system. A high turning frequency contributes to a faster decomposition rate. However, it also leads to higher moisture and temperature loss as well as higher operational cost. A balanced turning schedule plays a key role in heating up the pile and destroying the pathogens.

Temperature control: High temperatures are necessary to destroy pathogenic organisms/undesirable weed seeds and to aid the decomposition of organic matter. The decomposition process is accelerated in the thermophilic temperature range (55°-65°C). The drop in temperature in the compost system before the stabilization of material can mean that the composting system is becoming anaerobic and should be aerated. Further, the high temperatures do not continue when the composting system is properly aerated.

Moisture content: Moisture control is another crucial element in the composting process. With the squeeze test, the moisture content of the composting system can be estimated. Dry material breaks down easily in the hand ensuring the need for irrigation. It is highly recommended to irrigate the composting system during the aeration process to distribute moisture evenly. An inadequate amount of moisture deprives organisms of water necessary for metabolism, inhibiting their activity and halting the entire composting process.

Maturation*:* During the maturation phase, turning and frequent water addition are not required. When possible, the material should be loaded in a pile of about 1.5 m in height to maintain moisture content until it reaches an ambient temperature. A clear indication of the finish material is that even after the addition of water there will be no temperature rise in the pile. The matured compost has a dark brown colour and earthy smell. The appearance of white mould in the compost, temperature fluctuation, and foul odours indicate the need for a longer curing phase. In an area with heavy rainy seasons, the pile should be kept under the roof during the curing phase to prevent the washing of the nutrients.

Screening*:* A mature compost still contains coarse materials. The particle size of the finished materials depends on the physical properties of the feedstock. Accordingly, the mature compost must be screened to get rid of impurities. If the feedstock contains a higher ratio of foreign materials then additional screening before maturing phase may be required. There are two common types of screens available; 1. flat frame and 2. rotating drum sieve. Based on the final application and local conditions various mesh sizes are also used. A medium-size sieve with 4mm could be used for source-segregated feedstock, whereas a 1mm fine sieve or less may be required to purify the mixed waste input materials.

Storage: The final product is sold either in bulk or in the bags. Preferably, the final product should have a moisture content of lower than 40% before packing, to avoid water transportation with the compost. Packing the materials should be done before it is out on the market. The proper packing choice is waterproof, porous bags made of woven polypropylene. The bags should contain information about raw feedstock, weight, estimated nutrient content, data of packing, and the ratio of application for different plants.

Quality control of the final compost: The final product should be detected frequently. Analysis of chemical properties defines stability (C:N<20), the potential toxicity of the compost (e.g. heavy metals, organic pollutants), agronomical value (nutrients, pH, EC) and maturity (toxicity to plant root) of the final compost. Cooperation with a certified laboratory to conduct sampling and analysis of the compost produced is therefore necessary. A stable and mature final product should meet the criteria set by the national standards. Compost quality standards as per solid waste management rules are mentioned in Table 13. The nutrient balance of the compost is an important feature for the final application of the product. Therefore, frequent measurement gives an outlook to the customers and potential buyers of the compost.

Table 13: National standards for the final products to meet the stable end product criteria

Parameter	Organic compost FCO 2009	Phosphate-rich organic manure FCO (PROM) 2013	Vermicompost
Arsenic (mg/kg)	10	10	-
Cadmium (mg/kg)	5	5	5
Chromium (mg/kg)	50	50	50
Copper (mg/kg)	300	300	-
Lead (mg/kg)	100	100	100
Mercury (mg/kg)	0.15	0.15	-
Nickel (mg/kg)	50	50	50
Zinc (mg/kg)	1000	1000	-
C/N ratio	<20	Less than 20:1	
pH	6.5-7.5	≤6.7 in 1:5 solution	
Moisture, % by weight	Max 15-25	Max 25	15-25
Bulk density (g/cm3)	<1.0	≤ 1.6	0.7-0.9
Total organic carbon, % by weight	Min 12	Min 7.9	18
Total nitrogen (N), % by weight	Min 0.8	Min 0.4	1
total phosphate (P2O5), % by weight	Min 0.4	Min 10.4	0.8
Total potassium (K2O), % by weight	Min 0.4	-	0.8
Colour	Dark brown to black	-	Dark brown to black
Odor	Absence of foul odor	-	Absence of foul odor
Particle size	Minimum 90% material should pass through a 4.0 mm IS sieve	Minimum 90% of material should pass through a 4.0 mm IS sieve	Minimum 90% of material should pass through a 4.0 mm IS sieve

Conductivity (as dSm-1)	≤ 4.0	≤ 8.2	

Marketability: When compost production is part of the waste management system and gets subsidized by the local government the marketing strategy is mainly based on the demand and the potential application. However, in some cases, the composting facility has low or no external support which makes several parameters difficult to achieve and understand (viz., identification of a potential customer, understanding existing markets, and deciding the price according to the willingness to pay). In the first scenario, through awareness-raising, the compost can be sold or distributed free of charge to the citizens for an application in their homes. The compost with lower quality can be used for land shaping, making roads, or landfilling. In the second scenario, the quality of the final product and possible application must be clearly defined. Labelling and certification of the product is a crucial strategy to reach better marketability. The existing markets for fertilizers and potential competitors should be examined carefully. This would ease the market evaluation for potential customers and the pricing of the product. In the beginning, only cost recovery of the process may be viable. Deciding the distribution channel is another decisive factor based on the market examination. Direct delivery or selling through a local retailer with good networks of customers are possible choices. Lastly, the promotion of the product through marketing strategies enhances customer trust. Advertising, free delivery, and application instruction manuals are some additional examples. Additionally, stakeholders like agriculture department can be used for marketing of compost in the PBMC and rural area.

Nevertheless, the creation of a centralised post composting facility solves several problems associated with fine quality compost production and marketability in ANI UT. Section 5.1.3 provides a detailed strategy to showcase the importance of creating a centralized post composting plant and linking the decentralised units to treat all the organic waste produces in ANI UT.

5.1.2.1 Links to the Indian Fertilizer Control Order

The Indian Fertilizer Control Order[58] has described the quality control (QC) procedure for the production and marketing of composts produced from municipal organic waste. Different raw input organic materials can be subjected to the composting process, ranging from yard and green space waste to kitchen waste and manure. MSW can also be used as raw organic input in the composting process but the quality of the final product is a matter of concern in case of poor source separation. The foreign materials in compost produced from mixed waste can harm soil texture in the long term and probable chemical and biological contamination emitted from hazardous waste during the composting process can pose risks to soil, water and the food chain. Thus, high attention has been paid to compost parameters that are highly linked with agronomic value (nutrient content) and hygiene factors (heavy metals)[59]. The quality of produced compost is decisive in the final application.

class	Fertilizing Index	Clean Indicator	Application
A	>3.5	>4.0	It can be used in the cultivation of all kinds of plants.
B	3.1–3.5	>4.0	Medium fertilizing potential and low heavy metal content

[58] https://agriodisha.nic.in/content/pdf/Fertiliser_Control_Order_1985.pdf
[59] heavy metal content of compost defines by different standards can be found in the annex.

C	>3.5	3.1–4.0	High fertilizing potential and medium-heavy metal content
D	3.1–3.5	3.1–4.0	Road construction concerning the fulfilment of national standards on all heavy metals. Application for Landfill reshaping and covering
RU-1	< 3.1	-	Should not be allowed to market due to low fertilizing potential. However, these can be used as a soil conditioners
RU-2	>3.5	>4.0	Should not be allowed to market. Restricted use. Can be used for growing non-food crops. Requires periodic monitoring of soil quality if used repeatedly.
RU-3	>3.5	-	Restricted use. Should not be allowed to market. Can be used only for developing lawns/gardens (with a single application), rehabilitation of degraded land

Classification of municipal compost application in India was studied by Saha et al. (2010) according to the Fertilizing Index (FI) and Clean Index (CI). FI defines the quality of compost based on total C, N, P and K contents as well as C: N ratio and respiration activity, whereas CI illustrate the heavy metal contents[60]. Accordingly, municipal compost marketability and application are distinguished in different compost classes[61]. Below provided information can give insight to different stakeholders in the process of municipal organic waste composting namely the national government, local government, compost producer and farmers.

Grading the municipal compost considering CI ensures the public department in terms of environmental protection and public health. Defining several application possibilities contributes to the diversion of organic waste from landfills which is a matter of concern to local governments and ULBs. Various marketable final products enable the operator of the composting facility to generate revenue from selling different quality of compost and considering the FI in final product classification promotes the application of high-quality compost in agriculture by farmers. Overall, using the grading system enables the restriction of pollution, recycling of organic waste, improving soil quality and increasing the profit.

Compost graded under classes A, B, C and D is allowed to market. These types of compost are completely in compliance with the Indian fertilizer standard in terms of heavy metals. Classes A and C have the highest agronomic value, while classes A and B have the minimum pollution potential. The compost classes of RU have a restricted application range. RU-1 has a low fertilizer value but is suitable as a soil conditioner. Compost graded under RU-2 can be used for agricultural purposes (non–food crops). However, monitoring soil quality in terms of heavy metals content is a must. The RU-3 class may be allowed for one-time application under restricted conditions like developing lawns/gardens, afforestation, rehabilitation of degraded land etc. Compost samples, which do not belong to any of the above classes, may be diverted to landfills.

5.1.3 Creation of a centralized post-composting plant and linking it to decentralised composting units in PBMC

As explained earlier both in urban and rural areas of ANI UT the composting technique used is rudimentary. Most composting pits are designed without a proper aeration system, no roofing, and no efficient facility for the collection of leachate. In the rural area of ANI UT (Swaraj

[60] Calculation for Fertilizing Index and Clean Index is provided in Annex
[61] "J.K. Saha et al. 2010

Dweep and Shaheed Dweep) despite having composting facility (the composting technique used is highly fundamental) no compost is produced so far and most of the compost generated in PBMC is currently being sold without proper testing, certification, and/or branding. A significantly high amount of organic waste in PBMC is being dumped at the brookshabad dumping site without any treatment.

The rate of biowaste utilization in PBMC can be increased considerably by post-processing the compost produced at the decentralized composting units at central composting facilities. Considering the inefficient method of composting process, inferior quality of final compost produced, lack of trust among the end-users, and poor sales of produced compost; having a centralized post composting facility could create overall value addition. Quality control of the produced compost is a crucial factor in the application of the final product. Evaluating the physical and chemical properties of the final product in the de-centralized approach is challenging. Not all the facilities have access to a certified lab to meet the required standards. The centralised organic waste management can also act as a facility for compost testing facility for compost coming from smaller decentralised units and also a facility to enrich them to the FCO compliance. The testing of the compost can be facilitated within the post composting facility by setting up a lab or by the utilization of compost texting kit. This scheme would ease the branding of the final product. One main brand for the complete PBMC could be created for better advertising and acceptance by people as a standard product. Better marketing results in generating higher revenue from the selling of the final product. The centralized post composting facility acts as a composting unit where the entire compost produced in ULB will be conditioned, tested, branded and marketed. Having a centralized composting unit will benefit in the following ways.

- Reduction in the volume of waste to be transported to the central composting facility (as the volume reduction of the organic waste is already being done at the decentralised unit)
- Interconnection of the existing decentralised system with the centralised system for support and technical assistance.
- Easy and organised handling of the organic waste
- Production of higher quality compost - Second composting step in the centralised post composting plant for having higher quality compost
- The centralised organic waste management can also act as a facility for compost testing facility for compost coming from smaller decentralised units
- Easy monitoring of the final compost
- Easy branding of the compost and improved revenue generation
- Enhanced value addition through collaboration with nursery

Table 14 provides an overview on the size requirement of the post-composting facility that has to be considered for PBMC. The estimation has been made considering the amount of compost that will be received into the post-composting facility with the projected population till 2051. The assumption includes the estimation of the organic waste that is generated only in PBMC and considering the projected population till the year 2051. The organic waste treated in the decentralised facility in 2051 is estimated by projecting the population of PBMC to 2051 and multiplying it by the per capita compostable organic waste generation and considering 80% of compostable organic waste that is generated is treated at decentralised composting facilities. The approximate size of the post-composting facility in PBMC is estimated by considering 50-

60% biomass weight reduction after composting[62] and 90% transfer efficiency from decentralised composting facilities to centralised post-composting facilities.

Table 14 Overview of the size of the district-wise post-composting facility in PBMC

ULB	Population in 2011[63]	Estimated population in 2051	Estimated organic waste treated in decentralised facilities in 2051 (TPD)[64]	Approximate size of post composting facility (TPD)[65]
PBMC	143488	213634	26.92	**14.54**

Capex and Opex costs for the development of a post composting facility of size 5000 Tonne/annum

Details of the construction and operation of a windrow composting plant with 5000 Tonne of receiving waste per year are shown in Table 15. In the construction year, a total amount of ₹ 9.3 million should be invested in the purchase of the materials and equipment. Considering 310 working days in a year, at least 1 manager and 3 workers are required on a daily basis. The facility operation cost adds up to about ₹ 4.3 million per year. The construction of a windrow composting plant can be invested through a government grant, loan or equity investment. The alternative way is to convert the composting unit Brookshabad into a post composting facility. Selling compost and receiving gate fees are the main sources of generating revenue. Considering the current situation of PBMC about 90% of the generated organic waste is dumped in dumpsite without any further treatment. Installing a centralised post-compost facility can be financially viable considering the higher quality of the end compost, higher sales of compost and receiving gate fees.

Table 15 Cost estimation for constructing a post-composting facility of 5000 Tonne/annum capacity

Account group	Unit	Price ($) (per 5000 Tonne/annum)	Price (₹) (per 5000 Tonne/annum)
Facility Operations			
Electricity Demand (kWh/tonne)[66]	4	2090	164800
Fuel Demand (litres/tonne)[67]	7.5	44370	3505125
Personnel			
Manager/ Engineer	1	7,600	602608
Composting workers (full-time)	3	4500	351000

[62] Nojosa, Ellen & Barbosa, Rodrigo & Marques, Georgiana & Vasconcelos, Osmar. (2021). BIOMASS REDUCTION OF ORGANIC MATERIALS IN A DOMESTIC COMPOSTING SYSTEM REDUÇÃO DE BIOMASSA DE MATERIAIS ORGÂNICOS EM SISTEMA DE COMPOSTAGEM DOMÉSTICA. BIOFIX Scientific Journal. 6. 98-102. 10.5380/biofix.v6i2.79902.

[63] Census of India, 2011. Link: https://censusindia.gov.in/2011census/censusinfodashboard/stock/profiles/en/IND035_Andaman%20&%20Nicobar%20Islands.pdf

[64] Estimated organic waste treated in decentralised facilities of PBMC in 2051 is calculated by multiplying population X percapita waste generation (0.6 kg) X composition of compostable organic waste (35%) X 60% of generated organic waste being treated in decentralised and centralised composting facility.

[65] Size of post composting unit considering after 50% biomass weight reduction after composting at decentralised and centralised composting facilities, and transfer efficiency from decentralised composting facilities to centralised post composting facility as 90%.

[66] electricity price of ₹ 8.24/kWh (business). https://www.globalpetrolprices.com/India/electricity_prices/

[67] Diesel price as ₹ 93.47/liter. https://www.globalpetrolprices.com/India/diesel_prices/

Composting System Capex			
Backhoe loader	1	59,000	4678110
Rotary drum screen	1	30,000	2378700
Small tools (temperature measuring lance, chainsaw etc.)	1	2,500	198225
Infrastructure & Site Development (ha/tonne)	0.0002	15830	1255160
Capital Cost Contingency (% of Capex)	10%	10733	851020
All Systems O&M			
Maintenance Cost (% of Capex)	2.00%	21466	1508845
Insurance (% of total Capex excl. VAT and grants)	1.00%	-	
Outside Services and Supplies (% of O&M before contingency)	2.00%	2147	150885
O&M Cost Contingency (% of O&M)	10.00%	10733	754423

Following are the action plans and approaches for creating a centralised post composting plant and linking the decentralised composting units in PBMC.

Stage 1: Existing situation analysis and optimization, and identification of location

As a short time goal (up to 1 year) importance has to be given to analysing and optimization of existing decentralised composting units, and the Identification of location for setting up a central composting facility. For analysing the existing mechanism of composting in the decentralised units various parameters such as the design of the composting units, existing technical specifications for the production of the compost, amount of waste coming into the facility, quality and quantity of the compost that is being produced has to be taken into consideration. Upon the comprehensive examination of the existing situation, every composting process has to be optimised concerning the design of the composting units (as explained in section 4.1.1) and the mechanism of the composting process (as explained in section 4.1.2). Such optimization in composting unit design and the composting process could ensure the production of fine quality FCO complaint compost.

Further as explained in section 4.1.3, the creation of a centralised post composting unit in PBMC would significantly increase the bio-waste utilization and provides an organised system for post conditioning, testing, branding and marketing of the compost produced in various decentralised composting units of PBMC. In this concern, as a short term goal it is important for identifying the location for setting up a centralised post composting facility. The site selection for the construction of a post composting unit can be one of the most crucial steps. The course for determining an appropriate location is particularly complex because the site selection hinges on many different factors and has an impact on the demographic, economic, public acceptance and environmental aspects. Following are the prime factors that are essential in deciding the location for centralised composting: (1) transporting distance, (2) restrictions concerning location (legal and environmental), (3) available land area, (5) site access, (6) public acceptance, (7) acquisition and development costs. Considering the above factors in deciding the location which ensures smooth functioning and longevity of the composting facility. According to our estimation entire process of analysing/optimising the existing situation of decentralised composting units and identification of the location for setting up a post composting unit could generate about 2-5 full-time jobs in PBMC.

Stage 2: Centralized secondary composting facility

In the medium-term goal (2nd – 3rd year), Central composting units with integration to decentralised composting systems have to be initiated in the identified location of PBMC. The post composting units have to be constructed giving prime importance to the technicality of the composting system and considering the future waste generation for at least 40 years ahead. During this phase together with the construction of post composting units importance also has to be given to the optimization of the collection route, capturing maximum organic waste generated in PBMC, and introducing digitalization aspects whenever possible (Detailed strategy concerning digitalization has been provided in section 4.8). When possible production of the co-products such as inoculum using the leachate also has to be initiated. The production of co-products has the potential for increasing the value and enabling the financial sustainability of the system. According to our estimation, the construction of a centralised post composting facility in the identified location of PBMC could generate about 10-15 full-time jobs in PBMC.

Stage 3: Operation, maintenance and beyond

Stage 3 is considered to be a primary factor that ensures stable operation, financial sustainability, and longevity of the composting facility. Soon after successful and smooth operation of the centralised composting unit, further aspects such as appointing a quality inspector for continuous inspection of the compost produced, upgrading the operation and maintenance aspects of the composting unit, creation of composting brands, marketing of compost, and upcycling the value of compost through nursery have to be initiated as a long term goal (after 3 years) with the proper mechanism. Appointing a quality control inspector could be a crucial step in stage 3. The quality inspector should have proper scientific knowledge of entire organic waste management (specifically composting process) and should be capable of training the employees in the composting facility whenever required. The centralised post composting units should also act as compost testing facilities for compost coming from smaller decentralised units and also a facility to enrich the compost to FCO compliance. As explained earlier one main brand for the complete PBMC for better advertising and acceptance by people as a standard product. According to our estimation Stage 3 has the potential to generate about 15-18 full-time jobs in PBMC.

The creation of a centralised post composting facility solves several problems associated with fine quality compost production and marketability, and enables easy and organised handling of organic waste in PBMC. Additionally, the successful implementation of a centralized post compost unit will have additional benefits viz. significantly decrease the amount of organic waste entering dumpsites/garbage vulnerable points, increase revenue generation as a result of sales of higher quality compost, creates more jobs, and aids in the reduction in GHG emissions. The approach for having a centralised composting facility in PBMC with a realistic timeline is depicted in Figure 14.

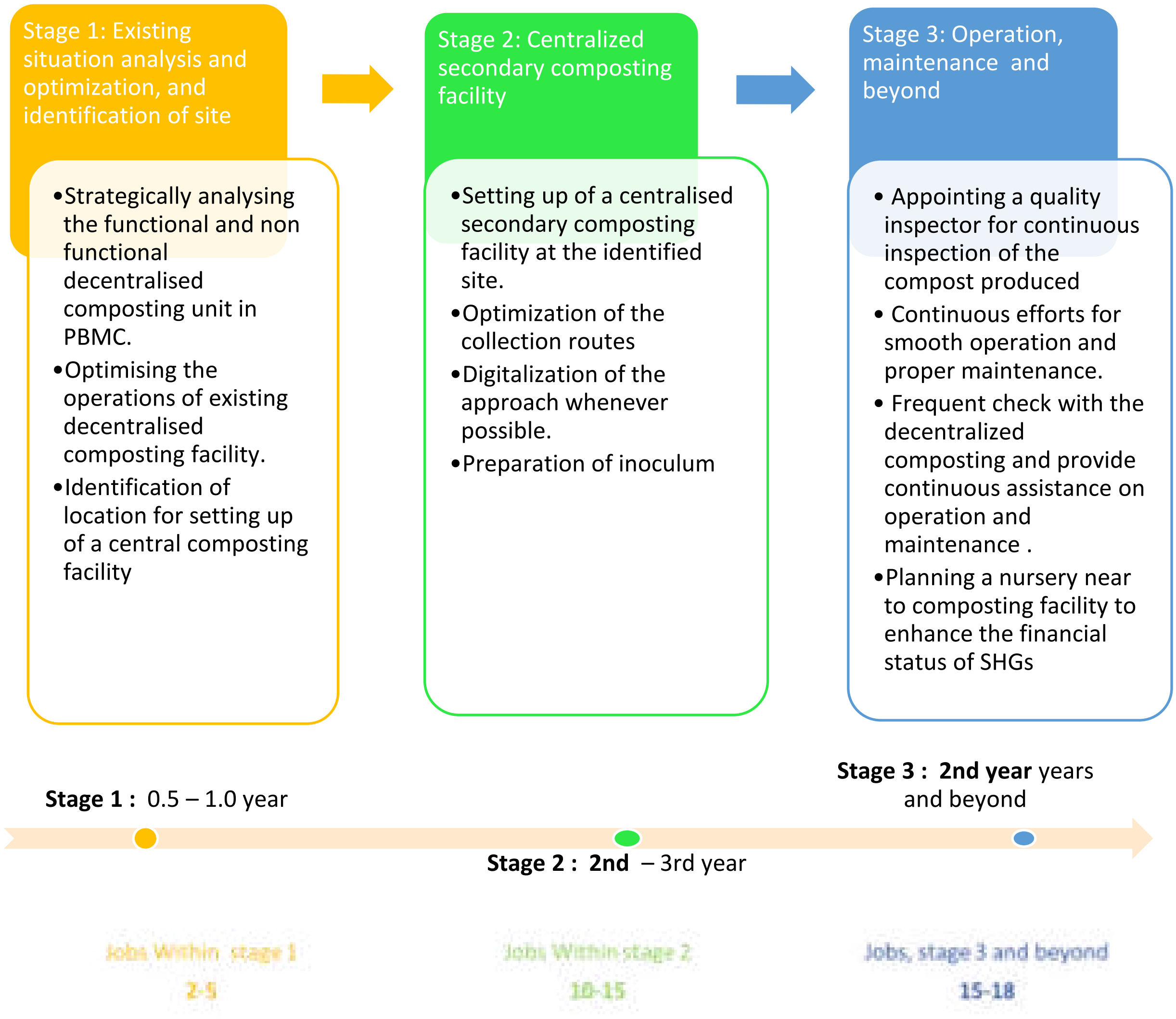


Figure 14: Approach for having a centralized post composting plant in ANI UT

The above strategy has its specific designated benefits to enhance the organic waste system of PBMC. Nevertheless, the implementation of this strategy will also have an interlinking effect between the strategies that enable the management of organic waste in ANI in the broader context. For instance, as mentioned above a direct effect of having a centralized post-composting unit can be seen through the increased quality and quantity of the compost produced in PBMC. In a broader aspect, the successful implementation of a centralized post compost unit will have additional benefits viz. 1) decrease the organic waste dumped at garbage vulnerable points, 2) increase the sales of compost, 3) increase revenue generation, 4) creation of more jobs, 5) reduction in GHG emissions etc. The interlinking effects could be hard to quantify and the successful implementation of all the strategies will have a significantly increased interlinking benefit that could be seen in a shorter and longer period.

5.2 Promoting technologies for managing organic waste produced by BWGs at the source

The U.T policies and By-Laws in ANI UT strongly suggest the management of organic waste at the source. However, in PBMC the percentage of households and commercial generators who are practising organic waste management at the source is significantly low (~5%). Similarly, in the rural area of ANI UT, expect a few expectations, no commercial generators are managing organic waste at the source. As per the information from GP officials, currently, organic waste produced in the household in the rural area is been either composted at the source or fed to animals. However, there is no proper mechanism to monitor how the composting is carried out. There is a lack of a proper system for supporting the waste generator to treat the organic waste at the source by the municipality and GP. In most cases, waste generators do not have exposure to different technology other than compost for valorising the generated organic waste.

In this concern additional, there should be an intensive promotion of different organic waste valorising technologies for households and commercial units for the management of organic waste at the source. In addition to composting, another technology such as biogas units[68] could be promising considering the situation of ANI UT.

<u>Biogas potential in PBMC</u> Currently, about 40TPD[69] of organic waste (excluding coconut waste) is being generated in 24 wards of PBMC. Considering the possibility of treating 25% of the generated organic waste stream with a centralised biogas plant, PBMC can produce 2.6 lakh m^3 CH_4/annum with the possibility to install a CHP plant of size 112 kW[70]. Under the stable operation condition of the biogas plant, PBMC alone has the potential to produce about 800 MWh of electricity and 770 MWh of heat per annum. However there is a need of experts to design and develop such a plant. The overview on developing a anaerobic digestion system in India can be found in the following Annexure 4.

5.2.1 Promotion of biogas technology in ANI UT (especially in the rural areas)

In ANI UT, utilization of anaerobic digestion as a biowaste treatment technology at HHs and the commercial establishment is significantly low. In this background, the utilization of biogas for cooking has to be given primary importance considering the technology is low-tech, low-maintenance and easily operational. Promotions for producing electricity using anaerobic digestion in ANI UT could cause increased failure rates in biogas units, as the electricity production from biogas is comparatively more high-tech with high-maintenance, more moving parts and requires higher capital costs.

An anaerobic digestion system at the household level can not only aid in the management of organic waste but, significantly influence the social-economical and environmental aspects of ANI UT, especially in the rural areas. The increasing prices of fossil fuels and taxes on energy sources have increased the need for finding alternative, clean and economical sources of energy. Increasing energy demand and its associated cost is a critical reason for extensive climate change, resource exploitation, and also restricts the living standards of humans, particularly in rural areas with low economical backgrounds. The costs of LPG in India have increased more than 60% since 2020 and the cost of a domestic LPG cylinder (14.2 Kgs) in

[68] Detailed overview of biogas technologies adabtable in india and their technical specifiacation is been provided in annexure
[69] Information provided by PBMC offical
[70] The methane generation and power plant size was calculated by assuming 8000 hours of operating per year, 0.36 electricity efficiency and 0.42 thermal efficiency

ANI UT stands at ₹ 1075.50 as of June 2022[71] - this could be more than 11% of the monthly expenses of many people living in the rural areas[72]. The challenges concerning increasing LPG costs and the fact the ANI UT is geographical isolation and dependent on the mainland can drive people to find alternative resources. Many of the rural communities in ANI UT could be forced to rely on traditional energy sources such as firewood, crop residues, etc if the situation persists. The conventional energy source often poses environmental and health impacts.

Anaerobic digestion systems are beneficial in developing countries because they are low-tech, low-maintenance and safe. It not only can effectively manage organic waste generated in households but provide reliable fuel, improved public health and sanitation, and produces digestate that can be used for amending the soil as well. Also, they save people the labour of collecting large amounts of firewood, freeing them up to do other activities. Thus, biowaste-based energy systems can help in overall rural development. Biogas for rural areas also has environmental benefits. It reduces the need to burn wood fires, which helps to slow deforestation and eliminates the emissions those fires would have produced.

Similar to the benefits a household biogas plant could bring to the rural communities of ANI UT, the promotion and installation of biogas plants at the commercial establishments also have greater advantages. Installation of biogas plants at the commercial establishments could not only reduces the workload of PBMC and GP for the management of organic waste and reduces the load on the existing dumpsites but, also can provide benefits to commercial generators (especially hotels and restaurant) as a cheap fuel alternative.

Low-income families in developing countries, particularly in rural areas, often find it difficult to afford anaerobic digestion systems, regardless of their lower cost than some other technologies. In many cases there is a crucial need for financial and technical assistance to promote the technology. Educating people on the technicality of biogas plants and governmental subsidy plans could assure the success of the biogas systems in ANI UT.

Together with the subsidies providing an alternative benefits in the form of organic vouchers (that could be redeemed in certain shops) or returning 2 months' user fee/year as a performance bonus for commercial units who are managing their waste by themselves effectively. Alternative incentives such as waiving-off or reduction of waste collection user-fee from commercial units/households managing waste at source could be provided as a promotion for organic waste management at source. For the commercial units producing less amount of organic waste, there could be a scheme for collaboration between the commercial units to ensure proper supply of the organic waste and smooth running of the installed small treatment unit. For an instance, Taj Hotel, Swaraj Dweep has a commercial scale biogas plant (100 kg/day capacity). However, the plant is currently not in operation because of the under-capacity of food waste. In such a situation having a proper collaboration between other commercial generators could ensure the continuous supply of organic waste. The digestate produced by the biogas plants of commercial generators has to be linked to the nearby composting plants for the stabilization, sterilization, ease of utilization, and proper management of the digestate including branding of the consequently produced compost. The introduction of such schemes, incentives, and collaboration efforts could create confidence and motivates the waste generators to scientifically manage their waste at the source.

[71] https://www.goodreturns.in/lpg-price-in-andaman-nicobar-s1.html. Accessed on 09.06.2022
[72] https://www.bbc.com/news/world-asia-india-61410449. Accessed on 09.06.2022

Nevertheless, monitoring, operation and maintenance aspects of the technology used (biogas/composting) will be a crucial deciding aspect for the sustainability of any such management options. In this concern municipality/GPs has to provide supporting hands for frequent training through capacity building.

Considering the cost of a household biogas plant (size 0.5-1.0 m^3) at ₹ 20,000.00; providing 75% subsides on biogas plant for 50% of existing households (4647 Households[73]) in the rural areas of ANI UT, would cost ~₹ 70 million. However, considering the benefits the successful implementation of biogas technology could bring to the social, economical, and environmental aspects of rural ANI UT, the spent money could be easily justifiable.

The below section provides an overview of anaerobic digestion and the various available technology in India that are suitable for ANI UT.

5.2.2 Overview of anaerobic digestion (AD) in India

The anaerobic digestion (AD) process has turned out to be promising in India as the moisture content in the municipal solid waste (MSW) is high[74]. Anaerobic digestion (AD, also known as the biogas process) is one of the WtE technologies widely used in India. Waste-to-energy (WtE) technologies play a vital role in mitigating energy deficiency and also in improving municipal solid waste management (MSW) in India. This process is used to produce biogas by using microbes to degrade organic matter significantly. This organic matter is called 'biomass'. The biomass or feedstock comes from a few major sources:

- Origin from farm feedstock (includes manure, crop residue, harvest waste, and energy crops),
- Separately collected domestic wastes from households by municipalities,
- Wastes from the livestock such as cow dung, and
- Wastewater sludge or greywater

[73] https://www.ceicdata.com/en/india/census-number-of-households-by-size-andaman-and-nicobar-islands/census-number-of-households-andaman-and-nicobar-islands-rural-by-size-6-to-8-members. Accessed on 11.06.2022

[74] Thomas P, Soren N, Rumjit NP, James JG, Saravanakumar MP (2017) Biomass resources and potential of anaerobic digestion in Indian scenario. Renew Sustain Energy Rev 77:718–730

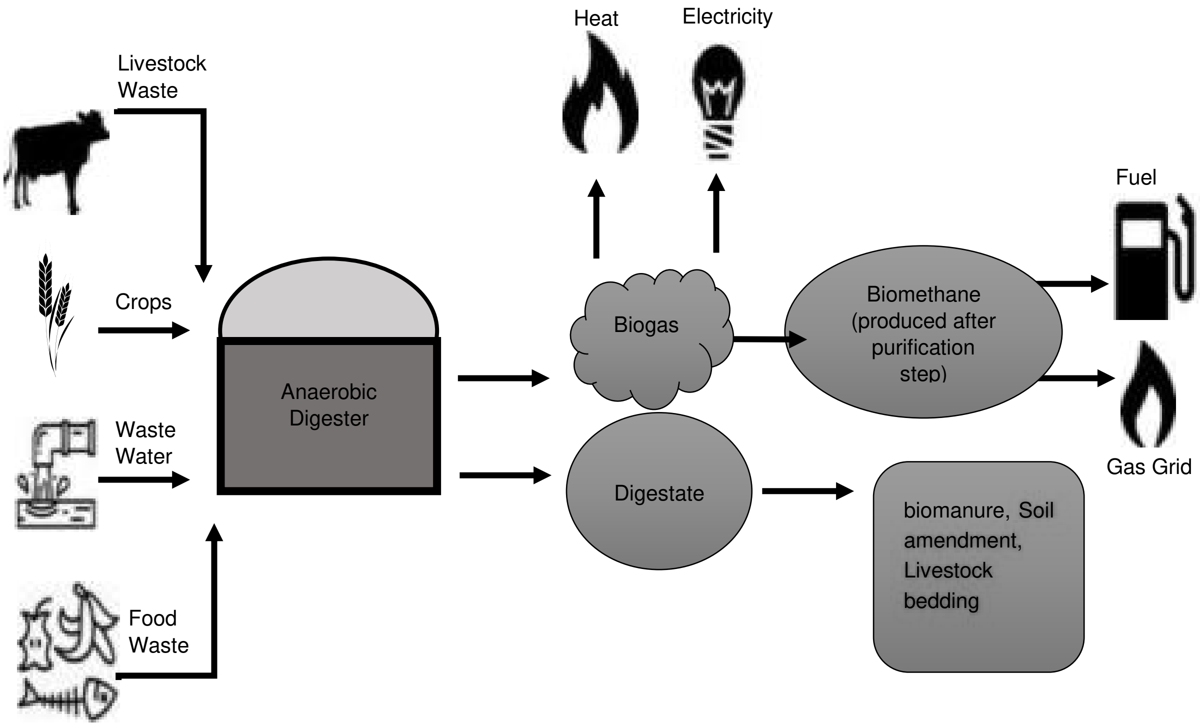


Figure 15: A general flow process of feedstock to anaerobic digestion process.

Anaerobic digestion is a microbial degradation process through which organic substances are decomposed in the absence of oxygen while producing biogas and nutrient-rich digestate. It is a process that already occurs naturally in the environment such as in landfill sites, and some livestock manure management systems. However, the process can be controlled, optimized, and contained using an anaerobic digester, which mitigates climate emissions.

Biogas is mainly methane (CH_4), depending on the quality of the feedstock the concentration varies between 50% to 70%. Other than (CH_4) the second major component is carbon dioxide (CO_2) with a variable concentration between 25% - 50%. Other miscellaneous traces of components present in biogas are water (H_2O), oxygen (O_2), traces of sulfur (S_2), and hydrogen sulfide (H_2S). Biogas post-purification and upgradation (bio-methanation) would result in 98% methane and possess similar properties to that of natural gas. The liquid and solid material produced after the production of biogas is called digestate and is generally used as solid manure[75]. A generic flow of feedstocks through the anaerobic digestion to produce biogas with their end products consumption pathways is represented in Figure 15. Biogas can be used like natural gas to provide heat, generate electricity, etc. It can also be purified, compressed, and used as vehicle fuel or to generate other energy products after further processing. The residual matter which is left after the anaerobic digestion is called digestate. Both the liquid and solid portions of digestate can be further used as fertilizers, as soil manure, or even as livestock bedding, etc.

Biogas is usually generated from the animal slurry, sewage sludge produced/settled in wastewater, or at landfill sites containing the organic substance. However, biogas can also be produced from almost any organic waste which has the ability to produce biogas: human excreta, slurry, animal slurry, organic fraction from MSW, fruit and vegetable waste, slaughterhouse waste, meat packing waste, dairy factory waste, brewery, and distillery waste, etc. Nevertheless, some fibre-rich organic wastes like wood, leaves, etc. are more difficult to

[75] Wellinger, A., Murphy, J., & Baxter, D. (2013). The Biogas Handbook: Science, Production and Applications. *The Biogas Handbook: Science, Production and Applications*, 1–476. https://doi.org/10.1533/978085709741

break down in a digester and make poor feedstock for the production of biogas. Mixing up the multiple waste streams in the same digester, also referred to as co-digester can also aid in increasing the biogas yield.

5.2.2.1 Promotion of various biogas models in India

During the oil crisis of the 1970s, it became apparent that commercial energy was outside the economic reach of the Indian rural population. Consequently, one of the first biogas technology programs began in India in the 70s. The global energy crisis, the high-end expensive oil import, and local energy shortages brought the alarming situation and awareness of the need for raising domestic fuels[76]. The upsurge in India's population growth and economic development has raised countless challenges such as energy scarcity, rise in water demand, sanitation management, solid waste management complexities, etc. To withstand economic growth and improve the quality of life, the New National Energy Policy of 2017 prioritizes energy services[77]. Because of the growing energy demand, it has been calculated that by 2030 India will import more than 50% of its energy supply[78]. To mitigate the energy deficiency in India, the Indian government has assured an investment of 350 million USD in renewable energy programs and projects[79,80].

MNRE launched substantial use of biogas as energy and promoted the installation of biogas plants in the early 1980s under the scheme National Project on Biogas Development (NPBD)[81]. The installation of small-size Biogas plants for 2- 4 livestock got popularized due to this Program and most of the expenditures for the installations were covered by the MNES[82]. The NPBD motivated households to accept the biogas technology by incentivizing the households who would opt for it. Additionally, it also suggested to help with the construction workers and connecting with the agencies in the dissemination of biogas technology. This initiative became a key idea in promoting biogas as a fuel since the availability of oil-based fuels was not readily available in the rural parts of India[83]. The initiative excelled in promoting two major types of biogas plants: 1) floating type biogas plants and 2) fixed dome type biogas plants

In the year 2006, the NPBD program was renamed to National Biogas and Manure Management Programme (NBMMP) 2006 under the Ministry of New & Renewable Energy (MNRE). A new off-grid biogas power generation program was launched for rural areas with 3kW to 250kW decentralized power availability. Provision to private and public sectors with financial incentives was also provided to stimulate the production of bio-CNG using bio-methanation technology. With the up-gradation of management and handling of solid waste management rules in 2000, the Ministry of Environment and Forestry came up with –

---

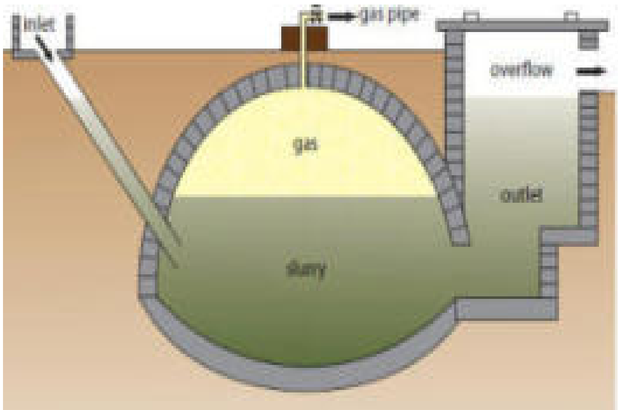
[76] P. Deo S. Modak P.R. Shukla 1991.*Decentralized energy planning,* New Delhi, India, Oxford and IBH Publishing Co. Pvt. Ltd.
[77] Lena Breitenmoser, Thomas Gross et al, Anaerobic digestion of biowastes in India: Opportunities, challenges and research needs, Journal of Environmental Management
[78] Mohan, S.V., Chiranjeevi, P., Dahiya, S., Kumar, A.N., 2016. Waste derived bioeconomy in India: a perspective. N. Biotech
[79] Lena Breitenmoser, Thomas Gross et al, Anaerobic digestion of biowastes in India: Opportunities, challenges and research needs, Journal of Environmental Management
[80] Ministry of Statistics and Programme Implementation, Government of India. Energy Statistics 2017.
[81] Prachi Pandey, Aditya Pandey, Dairy Waste and Potential of Small-Scale Biogas Digester for Rural Energy in India, MDPI, 2021
[82] Tomar, S.S. Status of biogas plant in India. Renew. Energy 1994.
[83] Azeem Hafiz, P.A.; Rashid, A.R.; Muhamed, S.A.; Sharukh, M. Study of Biogas as a Sustainable Energy Source in India. Int. J. Res. Mech. Eng. 2016, 4,

DISCOMS (electric distribution companies to procure 100% electricity generation from waste to energy plants. Generic tariffs and subsidies were also announced later[84]. The rate of circulation of biogas is small, thus, the share and consumption of biogas are also insignificant. Approximately, 5 million family/individual biogas plants have been installed under the biogas development program, which is 40% of the total potential of the Biogas Development program aimed at up to 12 million by MNRE[85]. Additionally, 400+ biogas off-grid power plants with a total power generation capacity of 5.5 MW have been set up. A few years back, India produced 10 billion M3 of biogas with 4.75 million farms in 2014. This installed capacity gradually rose to 179MW in 2015, and then to 157MW in the year 2016.

Despite the efforts by policymakers the production, circulation, and motivation to adapt biogas as a continuous fuel has not reached new benchmarks. Multiple barriers exist to the low dispersion of biogas technology in India. One of the key financial barriers in rural areas is the upfront installation cost of the biogas plant, the high level of bureaucracy, and delays in processing financial subsidies[86]. Whereas, few other barriers are; inadequate supply of livestock, aggregated waste (when supply is adequate), lack of technical infrastructure and knowledge, and access to skilled workers for maintenance and upscaling for revenue generation.

Fixed dome digester

Fixed-dome biogas plant comprises a closed immovable dome-shaped digester with a gas holder, a fixed feedstock inlet chamber, and a displacement pit as an outlet to collect the digestate. These digesters are shaped like a dome and are usually built underground as seen in Figure 16[87]. The waste slurry is fed from a mixing tank through an inlet pipe connected to a digester. After fermentation of the waste slurry, biogas is collected in the space under the dome and the digested slurry is displaced into the outlet by the pressure of the produced biogas as a picture in Figure 16.



[84] Mittal, S., Ahlgren, E. O., & Shukla, P. R. (2018). Barriers to biogas dissemination in India: A review. *Energy Policy*, *112*, 361–370. https://doi.org/10.1016/J.ENPOL.2017.10.027

[85] Energy Statistics, C.S. Office (Ed.), Ministry of Statistics and Programme Implementation, New Delhi (2014)

[86] D. Raha, P. Mahanta, M.L. Clarke. The implementation of decentralised biogas plants in Assam, NE India: the impact and effectiveness of the National Biogas and Manure Management Programme Energy Policy, 68 (2014), pp. 80-91

[87] www.kingdombio.com/develop.htm

Figure 16: (L) A standard diagram of a fixed-dome biogas reactor (R) Underground dome (Deenbandhu) plant being built in South India (courtesy: Kingdombio)

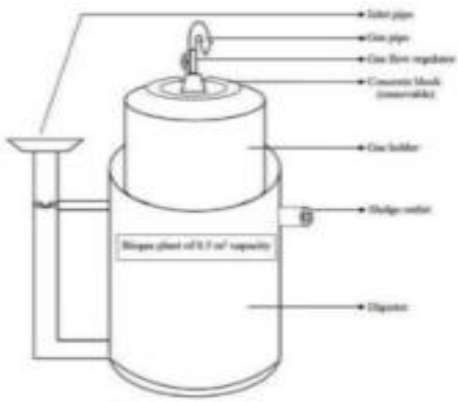
In India, as different private companies and NGOs manufacture these designs currently several designs of fixed dome plants were developed, viz., the Janata Model, Deenabandu Model, and VINCAP Model. Fixed dome digesters may be constructed of either concrete, bricks, mortar, or a combination of both. They are the most commonly used digesters for household biogas plants in India. It is estimated that around 80 % of the 5 million digesters in India are fixed domes digesters[88].

Advantages and disadvantages of fixed dome digestor

Advantage	Disadvantage
• Highly cost-effective – relatively low construction cost. • Comparatively expanded lifespan when constructed by a skilled worker. • Due to the absence of moving and metal parts, less maintenance is needed. • Less temperature fluctuation and saves space - as the dome is constructed underground. • Capacity building and employment for skilled local workers	• Skilled technical work is required to ensure the air-tight construction of the dome • The major concern of gas leaks when constructed by inexperienced masons • Inconsistent gas pressure depends on the volume of collected gas. • In the event of problems occurring after construction, it is highly difficult to repair as the structure is located underground.

The light-weight Portable Bio Gas

This lightweight Portable Bio Gas Plant consists of a fermenter tank and on the top is a reserve tank (floating dome) called a gas holder to collect the produced biogas as shown in Figure 17[89]. Most of the portable biogas plants are floating dome types however fixed dome type biogas digesters can also be available depending on the requirement.



[88] Global Methane Initative 2020

[89] Mohammed Shejir, R., George, S., Anil, K. S., Abeena, B., Sherin, K. G., & Sunanda, C. (2017). Comparative Study of the Quantity and Composition of Biogas Production Using Cattle, Buffalo and Goat Excreta. *International Journal of Livestock Research*, *36*(12), 2277–1964. https://doi.org/10.5455/ijlr.20170718035457

Figure 17: (Left) Floating drum biogas plants in India. (Right) Schematic sketch of a portable floating drum biogas plant (Mohammed Shejir et al., 2017)

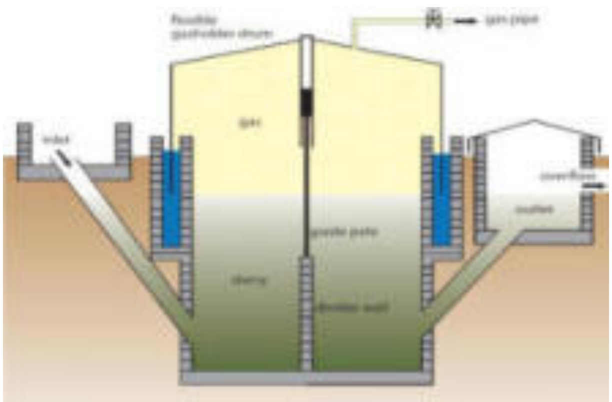
This lightweight Portable Biogas plant varies from a size of 0.5 m^3 to 6 m^3. Usually, the smaller units (0.5m^3 - 2m^3) are equipped with or without a water jacket, however, the bigger ones (>2m^3) are designed with a water jacket. In this technology, the gasholder does not float directly on the effluent but in a filled water compartment which is designed to minimize gas loss and improve the cleanliness of the biogas unit[90].

Advantages and disadvantages of a light-weight portable biogas unit

Advantage	Disadvantage
• Significantly less time is required for the complete installation of the plant. • Easy to relocate whenever required • No special skills are required for the installation of the plant • Excavation of the earth is not required. • Suitable for Households with a confined land area (as there is also a possibility to install on the rooftop) • These plants have better resistance to salty water and are suitable for places close to sea-level[91].	• Susceptible to weather conditions during colder seasons - As the plant is installed above ground. • Comparatively less biogas yield as plastic retains less heat compared to conventional plants constructed with concrete or metal[92]

Floating Drum Biogas plant

The floating drum biogas plant consists of a cylindrical digestor and a movable, floating gas-holder, with a digester size typically ranging up to 50 m^3. The digestor section of the reactor is usually constructed underground with concrete, bricks, or quarry stone and then plastered as seen in Figure 18. The floating gasholder is generally made of metal and is painted to create a protective barrier against corrosion. The gasholder either floats directly above the fermenting feedstock or floats on a specifically constructed water jacket which aids in reducing the leakage of the produced biogas.



[90] Decentralised anaerobic digestion of market waste – Case study in Thiruvananthapuram, India - Eawag, aquatic research
[91] Evaluation of small-scale biogas systems for the treatment of faeces and kitchen waste – Eawag, aquatic research
[92] Menkiti Nnamdi I, Ndirika Victor - Comparative Evaluation of Fiber-glass Reinforced Plastic and Metal Biogas Digesters

Figure 18: (L) Schematic diagram of a floating drum biogas digester. (R) A still from India of an FDB plant

The waste slurry is fed from a mixing tank through an inlet pipe connected to a digester as shown in Figure 18. After fermentation, the digested slurry is displaced into an outlet. The produced biogas after fermentation is collected in the floating gas-holder which rises and falls depending on the amount of biogas generated, thus providing a visual indication of the available/generated biogas. The biogas plant with a floating drum design provides relatively constant pressure output and depends on the weight of the floating drum. Additional gas pressure can also be created by adding extra weight to the floating drum.

Advantages and disadvantages of floating drum biogas plant

Advantage	Disadvantage
• Operation and design are simple • The floating drum directly visualizes the volume of the stored biogas • Possibility to regulate the gas pressure output using the additional weight. • Relatively easy for construction and there is less possibility of problems concerning the construction error.	• The utilization of steel drums makes the construction cost high • Shorter lifespan. A floating drum is susceptible to corrosion when not maintained properly. • Relatively high maintenance cost (de-rusting and regular painting of metal-drum is essential to ensure longer lifespan)

Continuous stirring tank reactor (CSTR)

The Continuous Stirred Tank Reactors (CSTR) is a biogas plant designed with a vertical cylinder tank constructed using steel or concrete and covered with an impermeable cover to collect the produced biogas also known as a complete Mixed Digester. It is a popular and widespread option for large-scale anaerobic digestion applications. The continuous stirring mechanism inside the digestor aids in keeping the heterogeneous feedstock in a homogenous form, in turn providing an adequate contact of the feedstock with micro-organisms enabling increased biogas yield as seen in Figure 19[93]. This particular digestor has the potential to process all types of biomass (including co-digestion of different biomass) and produce biogas with higher efficiency.

[93] Market Opportunities for Anaerobic Digestion of Livestock and Agro-Industrial Waste in India The Global Methane Initiative Section 4 Technology Options (2020).

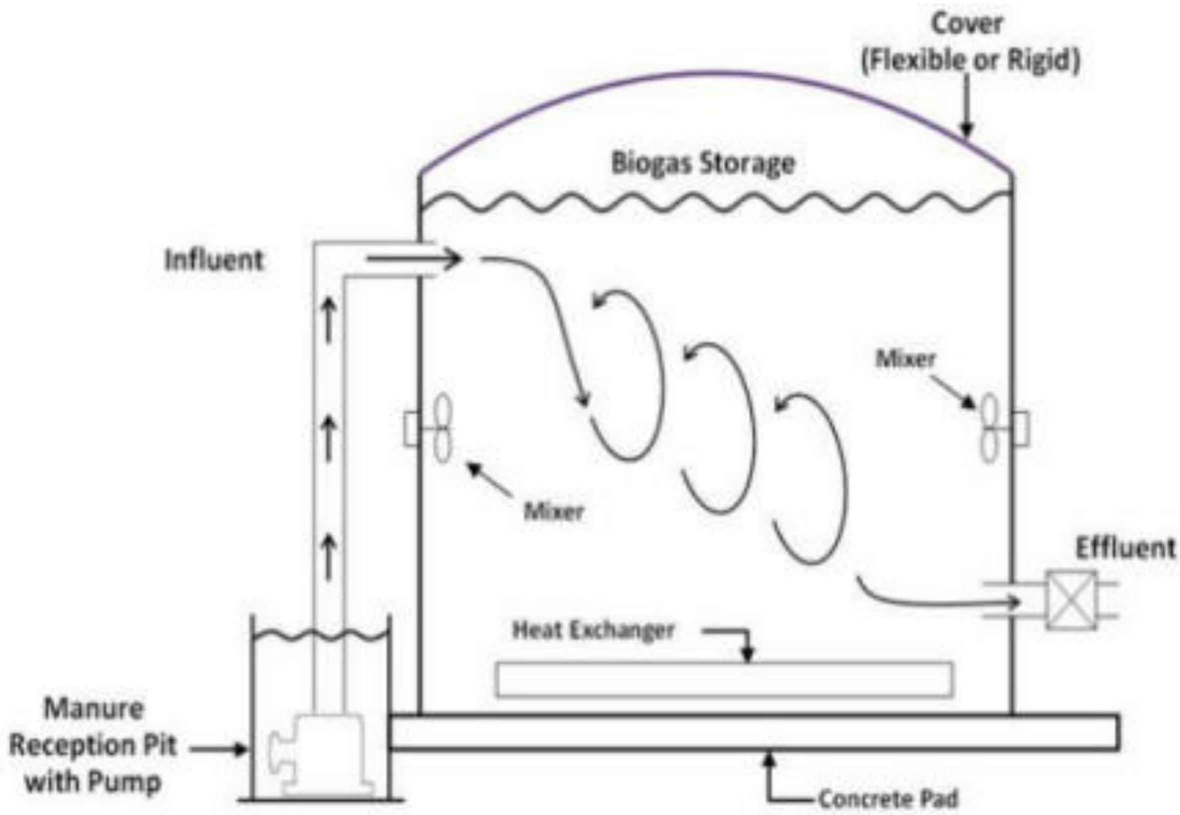


Figure 19: Diagram of a completely mixed digester (Global Methane Initiative)

Typically, CSTRs are built above ground with the reactor volume > 130 m^3 digestor and could be operated as a mesophilic or thermophilic reactor. Depending on the reaction temperature, the retention time of AD can be as low as 15 days[93]. Further, this system can operate in extreme climate conditions as regulating the temperature of digestor content is economically viable due to high efficiencies.

Advantages and disadvantages of CSTR

Advantage	Disadvantage
• Greater flexibility over the feedstock choice and better control over the complete process • Also suitable for high protein content waste • Low operation cost and higher efficiency • Optimum heat and feedstock distribution inside the digestor	• High investment costs • Frequent maintenance is required • Technically skilled personnel are required for the smooth operation of the plant • Comparatively less biogas yield as plastic retains less heat compared to conventional plants constructed with concrete or metal[94]

The technical requirements for smooth functioning of biogas plants and the general set of problems recognized in low-tech anaerobic digesters which can be faced on a day-to-day basis and their troubleshooting techniques are provided in Annexure 4.

[94] Menkiti Nnamdi I, Ndirika Victor - Comparative Evaluation of Fiber-glass Reinforced Plastic and Metal Biogas Digesters

5.2.3 Waste minimization through animal feeding

In an integrated waste management approach waste prevention and minimization are at the top of the hierarchy (see Figure 20). The concept of waste minimization is ideally to prevent food waste generation by management of food surplus at all levels of the value chain from the farm (producer) to the consumer. Once the food surplus is generated, it aims to handle it through food donation, animal food, production of new products, energy, and nutrient recovery. At the lower management level, the food waste is collected and directly disposed of safely.

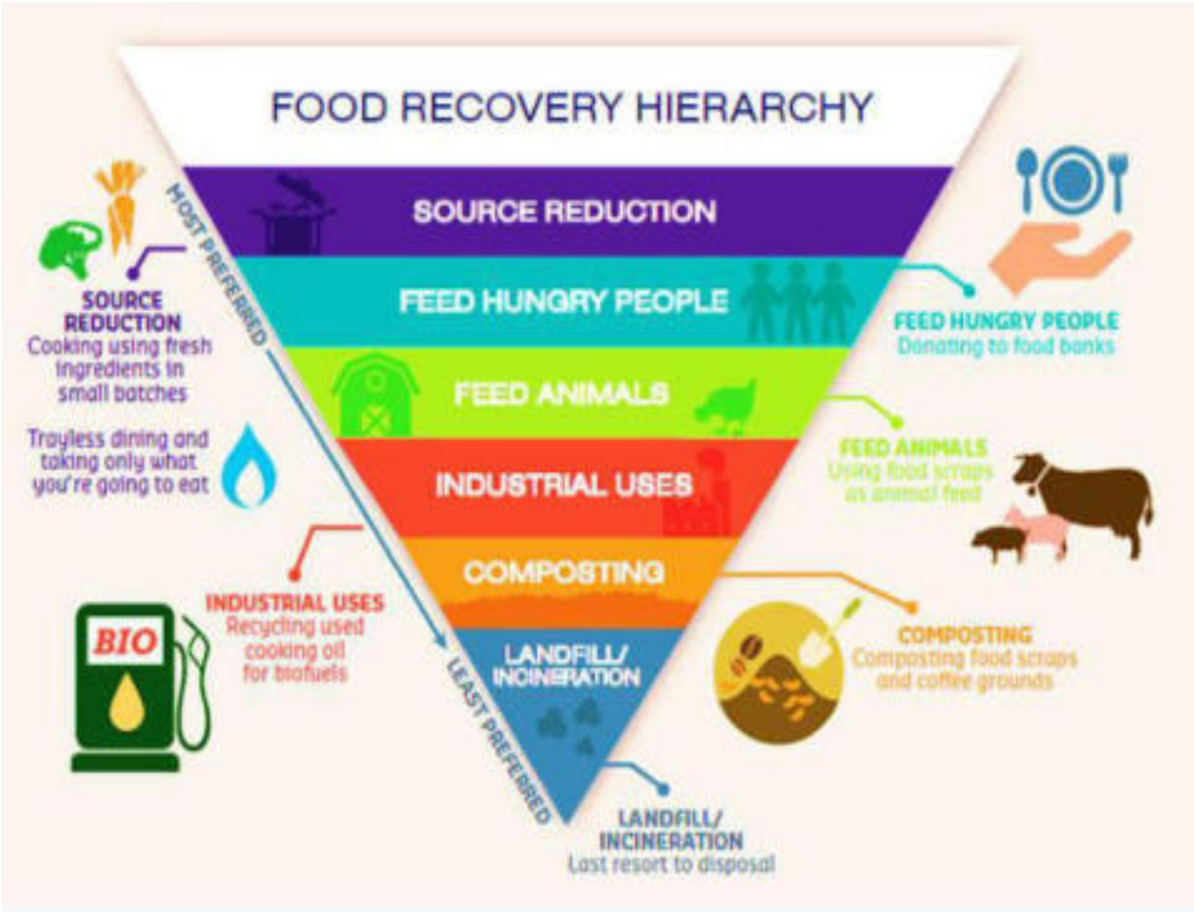


Figure 20: Food Recovery Hierarchy (Environmental protection agency)

Effective implementation of biowaste minimization strategies involves policy interventions at different political levels. For example, promoting compostable packaging products throughout ANI UT, behavioural change for food donations at the local level, and direct collaboration between the commercial organic waste generators with the business units performing animal husbandry. The primary focus has to be given to reducing the amount of organic waste generated.

Figure 21 can be used to describe different waste management and prevention options for food business and markets[95]. Food businesses like grocery stores, restaurants, cafeterias, and markets have a major role to play in finding the solution and reducing costs at the same time.

- [95] Mattias Eriksson, 2015. Doctral Thesis: Supermarket food waste - Prevention and management with the focus on reduced waste for reduced carbon footprint. DOI: [10.13140/RG.2.1.2502.3447](10.13140/RG.2.1.2502.3447)

Conducting an organic waste assessment is the first step in reducing the amount of organic waste generated. Such assessment will help in understanding the exact organic waste stream that is being thrown away. Being aware of what exactly is being discarded, there is a higher chance to reduce disposal costs, reduce over-purchasing and labour costs, reduce the amount of water and energy used for production, and reducing greenhouse gas emissions.

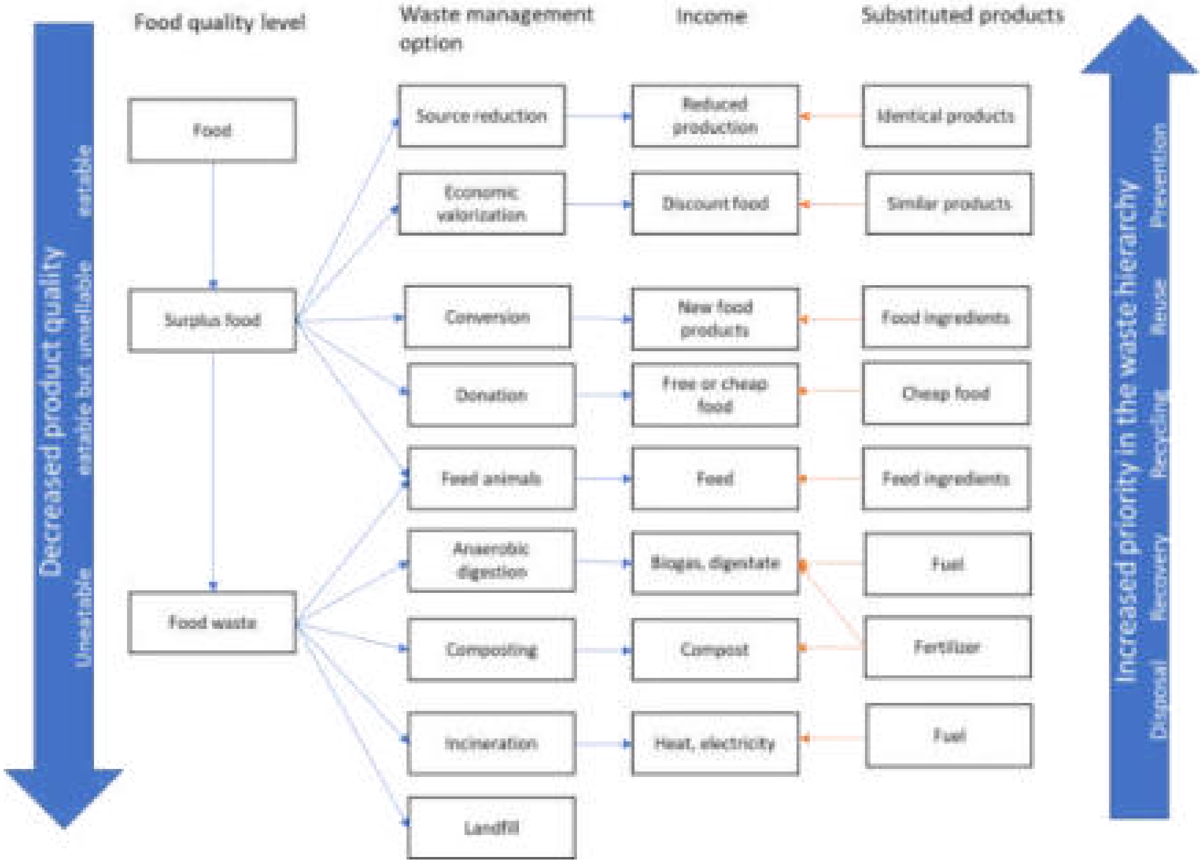


Figure 21 Food waste management and prevention options for food business and markets.

After reducing the avoidable sources of organic waste, a second focus has to be given to enhancing the reuse mechanism of generated organic waste. In India, animal feed systems are traditional methods of consuming organic waste including food waste. In PBMC currently, there are three private piggeries taking organic waste from Port Blair city. Among the existing three piggeries two are operating in rural areas outside the jurisdiction of PBMC[96] and one piggery is located at the Brookshabad dumpsite. To promote the waste recycling scheme in PBMC, the focus has to be given to enhancing the efficiency of the existing system. PBMC can cooperate with piggeries to ensure the effective collection of available food. Piggeries can also support the collection system financially. For example, piggeries could contribute to the purchase of a collection fleet for separate food waste collection or provide financial support for the collection and delivery of the organic waste.

An alternative option for ANI UT would be to support the existing system and officially link the piggeries with the commercial generators that could provide a mechanism for the collection of the organic waste from different hotspots. Having such a strategy is not only a sustainable long time solution for managing the organic waste generated by commercial generators but also reduces the burden on PBMC. In the longer phase, the system can be improved when organic

[96] Saahas field visit in December 2021.

waste reusing schemes are well-defined. This could be achieved by considering practical and efficient collection and recycling systems and backing them up with the necessary bylaws to assure their implementation. A clear mechanism for interaction between ULB and relevant stakeholders should be developed. In addition, the ULB should inspect environmental and hygiene-related matters of animal feeding in close cooperation with the Pollution Control Board committees. For example, creating a guide to make it clear which foods can be reused and training health inspectors on safe food reuse.

Nevertheless, it is also equally important to encourage active public awareness campaigns by publicizing the goals, programs, and ways in which stakeholders may participate. Attention should be paid to strengthening institutional arrangements, reviewing stakeholder duties, and monitoring the goals and achievements annually. The alternative approaches to promote organic waste management are explained in the below section.

5.2.4 Approach for promoting alternative organic waste management techniques in ANI UT

Following is the approach for promoting alternative organic waste management techniques in ANI UT that have to be divided into short, medium, and long term goals.

Short term goals (up to 1 year):

The primary approach for promoting alternative organic waste management techniques in ANI UT has to do with updating the policy guidelines and by-laws. By-laws have to be updated favouring the BWGs who are attempting to manage organic waste at the source. For example schemes such as a reduction in the user fee for the BWG who are managing organic waste at source or waiving of two months' user fee (annually) for BWG who are managing organic waste at source could have a positive impact on promoting of organic waste at source. Additionally, there could be a subsidies scheme for promoting successful organic waste management techniques such as composting or biogas. As a prerequisite for obtaining subsidies, there should be a mandatory introductory course on the operation and maintenance of biogas/composting units (the cost for such an introductory course could be borne by the beneficiary). Having such mandatory courses will significantly decrease the number of parties who do not have a real interest in owning a source-level organic waste management system. Additionally, such a subsidies scheme has to be backed up with an additional clause that “If the subsidized biogas/composting unit becomes non-functional within one year of the installed time, either the subsidies will be revoked on such plants with penalties and/or the biogas/composting units will be taken back and re-distributed to another potential beneficiary”.

Promotion and advertisement of the new scheme and technologies also play an important role in attracting more users into the system. In this concern, one effective mechanism would be to pass the information directly through the waste collected workers (for example SHGs). Together with the manual promotion through waste collection workers, utilization of online/offline platforms such as official websites, newspapers, and social networking would significantly aid in reaching more waste generators.

Medium-term goals (2nd – 3rd year):

In the medium-term goals, introductory training for interested parties has to be conducted to provide information on technical, operational and maintenance details on the treatment technology (Biogas/composting). Additionally, importance also has to be given to appointing and training sanitary inspectors as a part of the medium-term goal. Appointing a sanitary inspector could be a crucial step in the medium-term goal. The sanitary inspector should have a proper scientific knowledge of entire organic waste management (if necessary training has to be provided to sanitary inspector specifically on composting/biogas process) and should be capable of training the employees and public with the technical, operation, and maintenance aspects of composting and biogas units whenever required. Nevertheless, ULB should also have functional biogas and composting units that are specifically designated for demonstration and education purposes.

Long term goals (2nd year onwards):

Long term goals should mainly focus on the sustainability of newly adapted policy and by-laws concerning organic waste management at source. In this concern, monitoring the installed composting/biogas unit and providing frequent training on operation and maintenance aspects would be a key factor that decides the success rate of the adopted organic waste management technology. The long term goals should also focus on the collaboration between BWGs to ensure continuous availability of feedstock for smooth functioning of installed composting/biogas units. For the commercial units producing less amount of organic waste, there could be a scheme for collaboration between the commercial units to ensure proper supply of the organic waste and smooth running of the installed treatment unit. As explained earlier, Taj Hotel, Swaraj Dweep has a commercial scale biogas plant of 100 kg/day capacity. However, the plant is currently not in operation because of the under-capacity of food waste. In such a situation having a proper collaboration between other commercial generators could ensure the continuous supply of organic waste.

For an instance, in Port Blair, many gastronomic businesses do not have enough area for the installation of biogas plants. Whenever the possibility is raised to have biogas within the premises of the commercial establishment, the opportunity can be used to collaborate with other gastronomic businesses to ensure the proper supply of organic waste. Such collaborations will ensure the free supply of biomass to the parties having biogas plants and the parties not having source-level organic waste management units can benefit by discarding the waste free of cost. Another alternative approach would be to share the construction, operation and maintenance costs between the parties having and utilization of the produced biogas depending on the agreed terms. This approach could be possible when the commercial generators are in close proximity. Figure 22 depicts the overview of the approach and timeline for promoting alternative organic waste management techniques in ANI UT.

Additionally, the successful promotion of alternative organic waste management techniques in ANI UT will have additional benefits viz. significantly decreasing the amount of organic waste entering dumpsites/garbage vulnerable points, increasing the value of organic waste, increasing revenue generation, creating more jobs, and aids in the reduction in GHG emissions.

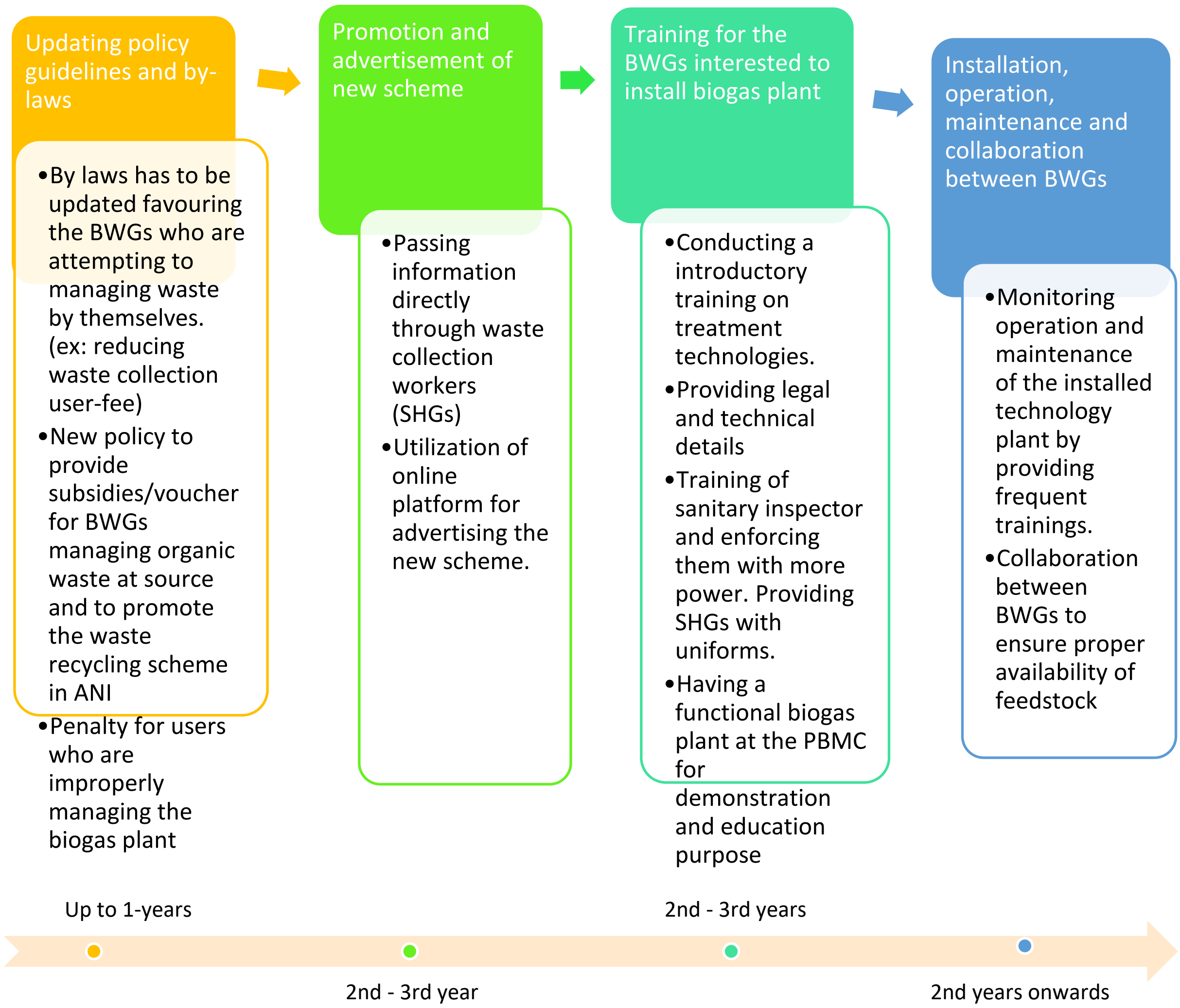


Figure 22: Approach for promoting alternative organic waste management techniques in ANI UT

The above strategy has its specific designated benefits to enhance the organic waste system of ANI UT. Nevertheless, the implementation of this strategy will also have an interlinking effect between the strategies that enable the management of organic waste in ANI UT in the broader context. For instance, as mentioned above direct effects of promoting of biogas technology in ANI UT can not only aid in the management of organic waste but, significantly influence the social-economical and environmental aspects of ANI UT, especially in the rural areas. In a broader aspect, the successful implementation of the above strategy will have additional benefits viz. 1) decrease the organic waste dumped at garbage vulnerable points, 2) decrease the load on the composting system in ANI UT 3) increase revenue generation, 4) creation of more jobs, 5) reduction in GHG emissions etc. The interlinking effects could be hard to quantify and the successful implementation of all the strategies will have a significantly increased interlinking benefit that could be seen in a shorter and longer period.

5.3 Strategy on optimization of waste collection and transportation of waste – PBMC and rural areas

5.3.1 Adapt the proper waste collection system

As per the information by PBMC officials, the overall status of Door to door collection is 100%. It was noted, however, that several open dumps of mixed waste were visible in the city during the field visit, which suggests that leakages are occurring in the primary collection of waste from all generators. On the other hand in the rural part of ANI UT (Shaheed Dweep and Swaraj Dweep), no organic waste is collected from the households. As per the information from GP officials currently, organic waste produced in the household is been either composted at the source or fed to animals. However, there is no proper mechanism to monitor what is happening with the generated organic waste.

There are several methods that could be adapted for the primary collection of biowaste namely: door-to-door, block, Kerbside, and communal collection. Considering the size of ANI UT and the geographical terrain door-to-door method is the most effective option for the collection of source segregated biowaste. The door-to-door collection is especially useful in the wards having narrow streets where a collection truck cannot reach the individual house.

In the door-to-door collection system, households can either place the filled containers outside their doors or hand them over to the waste collector upon their arrival. The waste received from the households will be directly emptied into the waste collection vehicle. The door-to-door waste collected can either be stored in a secondary collection point or directly transferred to secondary collection vehicles. The choice between secondary storage or direct transfer to secondary collection vehicles will depend on the availability of secondary collection vehicles, the area of collection, and the timing of collection. The requirement for secondary collection vehicles would be much higher if waste from all residential areas were collected during the mornings and transferred directly from primary to secondary collection vehicles in comparison to staggered timings of waste collection. The solution here would be to have a staggered timing of waste collection or have a secondary collection point where door-to-door waste collected can be stored before transferring to a secondary vehicle. Nevertheless, wet, dry and domestic hazardous waste must be transported in a segregated manner.

The door-to-door collection option is also the most effective method to raise awareness and promote segregation at the source. Despite having great advantages, door-to-door collection requires a higher labour force, time, and investment as well as the presence of a household member during collection time.

In the wards with wider streets, where the collection trucks can pass through conveniently a block or Kerbside collection scheme is implemented. Block collection can be implemented in the less populated wards, where households can be easily informed by ringing a bell that the collection vehicle is arrived and is willing to collect the waste. The collection vehicles arrive at a specific location at a given time and date to collect household waste. Households bring their waste containers and empty them directly into the vehicle. In the case of higher population areas with wider streets, the kerbside method is more effective. The house owners leave the waste containers at the edge of the road. A waste collector removes the waste from the curbside or empties the containers into the vehicle as it passes through the street at a scheduled time, and the containers are returned to their original place. In the kerbside method, fixing the schedule plays a key role in the proper collection of biowaste. Waste collection during the daytime e.g. 10 am to 2 pm is proved to be the most appropriate time for handling biowaste.

In PBMC, considering the area of the ward and their distance to the waste treatment centres, a secondary collection point is not required in the wards where a block or Kerbside collection scheme is implemented. In the wards implemented with a block or Kerbside, collection scheme, it is economically feasible to transport the waste directly to the waste treatment centre considering the short-haul distance. The frequency of primary collection services depends on population density, level of cooperation, climate condition, income level, etc. In hot seasons, a daily waste collection is necessary. However, high collection frequency is labour-intensive and costly. Promoting biowaste management at the household level is a determinative factor in this regard.

Particularly in the wards with significantly narrow roads, utilization of communal bins could be highly cost-effective. As shown in Figure 23 in the communal bin method of waste collection, depending on the waste generation rate a container is placed in a particular ward. In this method, the waste generators bring the waste to the designated container and discard their waste. The content of the container is emptied daily into the collection vehicle and then the empty container is returned to its original place. The communal bin system provides greater advantages by reducing the number of labour required for the collection of the waste from the wards with narrow roads that larger waste collection vehicles cannot reach. Nevertheless, one disadvantage of the communal bin system is that if the waste is pressed into the huge bins and stored for a long time may cause leachate and odour nuisances. This problem could be overcome by appointing a person to monitor the community bins constantly.

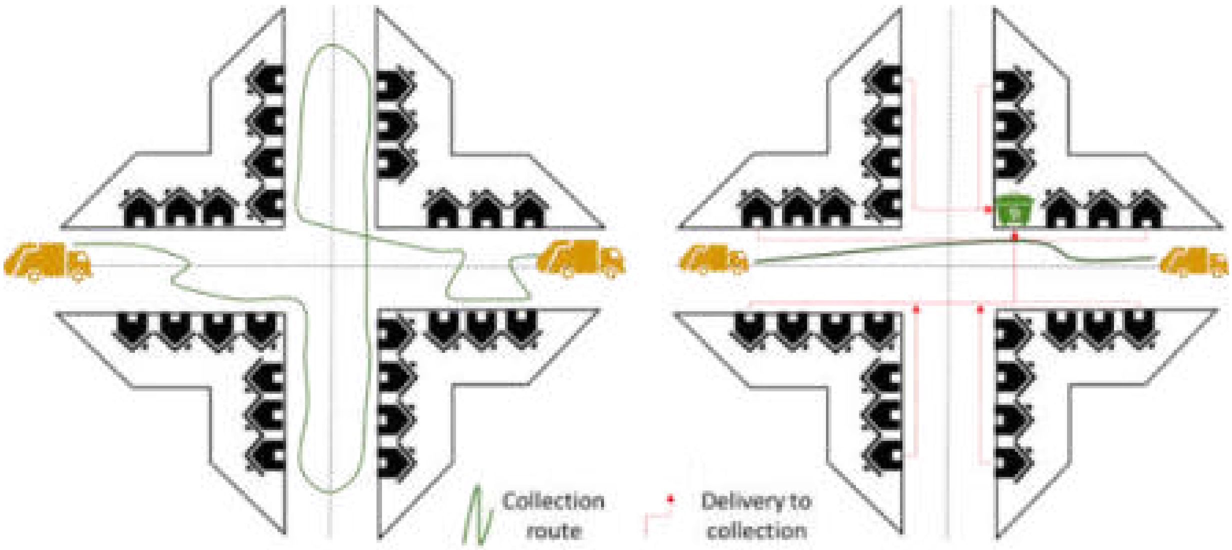


Figure 23 Comparison between the door-to-door and community bin collection system

5.3.2 Select the appropriate type and number of waste collection vehicles:

Selection of a proper waste vehicle type and waste collector teams is another important aspect of collection service. The type of collection vehicle is dependent on various aspects which include population density, road size, financial liability, and waste volume. Currently in PBMC door-to-door collection is mostly carried with the help of a makeshift crate. The design of the makeshift crate is very rudimentary with just a rope being tied to a plastic crate and the waste collector manually pulls the crate through the narrow passage. Additionally, the crates do not have any wheels on the bottom which makes the collection process significantly difficult considering the steep terrain of ANI UT. The door-to-door collected waste from the Households is further loaded to a tipper truck and gets transferred to a secondary transfer truck which does not have any infrastructure to transport the waste in a segregated manner and therefore, the waste gets mixed during the transportation. To overcome the mixing up of waste and to increase the value of organic waste there is a crucial need for choosing the appropriate waste collection and transportation fleet.

During the selection of the transportation fleet, prime importance has to be given to the separate storage containers in these vehicles. These containers should be used for separately transporting food waste and other organic waste. This would increase the value of organic waste for reuse (feeding to the animals). The waste workers should get trained on these requirements and they can be integrated into the collection vehicles. The same concept should be applied to the other waste stream; separate collection containers should be used for distinguishing the sanitary and hazardous waste from the rest of the recyclable waste.

Handcarts/tricycle vehicles require low investment and they are appropriate for door-to-door biowaste collection on narrow streets of different wards of PBMC. Auto Rickshaws and tipper trucks require medium to high investment costs, whereas compactor trucks need the highest cost. The tipper trucks and compactor trucks need wider space for collection service. All collection vehicles must consist of separate storage containers and must be purchased from reputed manufacturers to increase the lifespan and lower the maintenance costs. The overview of the waste collection fleet is given in Table 16.

Table 16: Overview of waste collection fleet

Parameter	**Handcart** 	**Tricycles** 	**Auto Rickshaw** 	**Tipper Truck** 	**Compactor Truck** 
Range	< 2km	< 5km	< 10 km	Unlimited	Unlimited
Road size suitability	Narrow	Narrow	Narrow	Medium	Wide
Volume	0.5 m^3	2 m^3	3-4 m^3	10 m^3	12 m^3
Labor Requirements	1 collector	1 driver 1 collector	1 driver 1 collector	1 driver 2 collectors	1 driver 2 collectors
Cost	Very low	Low	Medium	High	Very high
Service life	5 years	5 years	10 years	5 years	5 years
Trips/day	2	2	3	3	3

Once the type of the collection vehicles is chosen the number of collection fleets is estimated considering the density and number of households, waste generation rate, collection model (door to door, block, Kerbside), frequency, number of staff, the required time for each trip, and distance to the treatment facility. These factors are crucial for offering 100% coverage of biowaste collection services. Additionally integrating digitalization into the waste collection system can significantly optimize the complete collection mechanism (Geo-tagging households and other waste generators, digitalization of money collection from households and commercial generators, and Tracking, monitoring, planning, and management of vehicles/resource).

5.3.2.1 Estimation of collection vehicle and labour required for waste collection

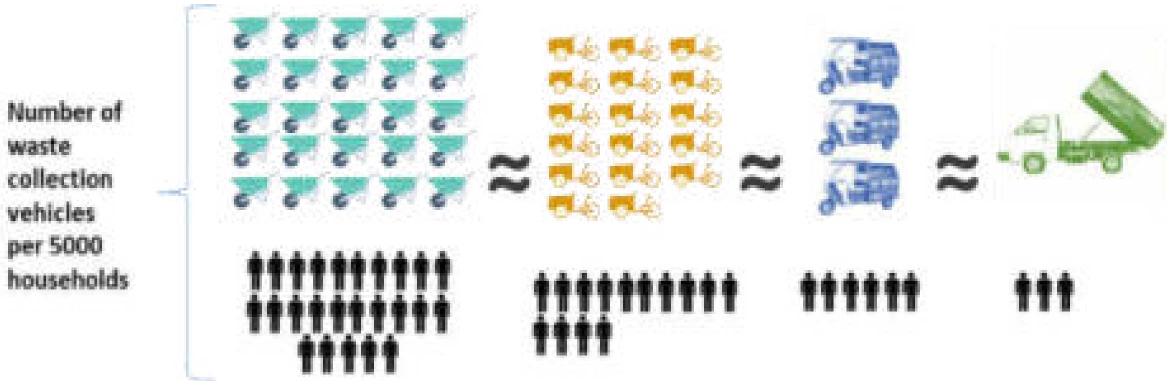
Handcarts, tricycles and auto rickshaw can be used for the collection of waste in the wards having narrow streets. Handcarts and tricycles are particularly adaptable in the wards with alleyways of width < 2m. Considering the capacity of a handcart as 0.5 m^3, the average waste generation per household at 2kg, and the waste density at 350 kg/m^3; in a single trip waste collector having a handcart can visit ~90 households. With a maximum of two trips per day, a single waste collector with a handcart can visit about 180-200 households. With this calculation, about 5-6 handcarts with accompanying labour are required for the collection of waste from 1000 households. Considering the utilization of a tricycle with a $1m^3$ loading volume; a single trip could cover ~180 households. With a maximum of two trips per day, a tricycle with one rider/collector can visit about ~360 households. With the utilization of handcarts and tricycles, there is a greater need for a secondary collection point where the waste collected from households can be temporarily stored till the compactor trucks collect and transfer it to the respective treatment facility. A single trip of compactor truck of $12m^3$ loading volume is enough to collect the waste generated by ~2000 households.

Auto rickshaws can be used in the wards with alleyways of width between 2-3 m. Considering the utilization of an auto-rickshaw with a $3\text{-}4m^3$ loading volume; a single trip with one driver and one collector could cover ~700 households. With a maximum of three trips per day, an auto-rickshaw with one driver and one collector can visit about ~2000 households. Considering the short-haul distance to treatment centres in PBMC; auto-rickshaws can directly transport the collected waste to treatment centres without the requirement of additional secondary collection points and vehicles.

Tripper trucks are greatly suitable for a block or Kerbside collection in the wards with wider streets. Auto-rikshaw can also be used in the block and kerbside collection with less populated wards. Considering the utilization of a tipper truck with a $10m^3$ loading volume; a single trip with one driver and two collectors could cover ~1800 households. With a maximum of three trips per day, a tipper truck with one driver and two collectors could cover ~5400 households. Similar to auto-rickshaw, tipper trucks can directly transport the collected waste to treatment centres without the requirement of additional secondary collection points and vehicles.

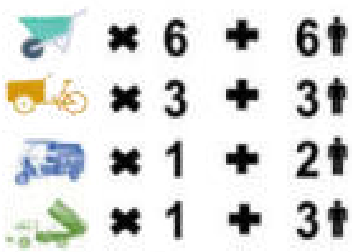
Figure 24compares the number of different collection vehicles and their respective capex and opex required to collect the waste from 5000 households in a day assuming the average waste generation per household at 2kg and the waste density at 350 kg/m^3. Further, Figure 24 attempts to estimate and combination collection fleet required for 10000 households with scenario 1 as 50% households having narrow road connection and 50 % households having wide road connection, and scenario 2 as 25% households having narrow road connection and

75 % households having wide road connection. The comparison in Figure 24 makes it clear that the utilization of handcarts and tricycle has significantly lower capex costs in comparison with auto-rickshaws and tipper trucks. However, opex cost for handcart and tricycle is considerably higher considering higher labour requirement.



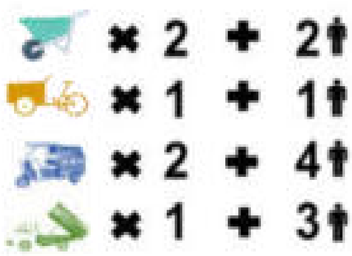
Parameter	Handcart	Tricycles	Auto rickshaw	Tipper truck
Collection frequency & model	Daily, Door to door	Daily, Door to door	Daily, door-to-door or block/kerbside collection	Block/Kerbside collection
Labour / vehicle	1 person	1 rider and 1 collector	1 driver and 1 collector	1 driver and 2 collector
Coverage per trip	~90 HHs	~180 HHs	~700 HHs	~1800 HHs
Collection time per vehicle trip	2.0 - 3.0 hours	3.5 hours	2.0 hours	2.0 hours
Max. trips per day/vehicle and total coverage	2 trips and ~180 households	2 trips and ~360 households	3 trips and ~2000 households	3 trips and ~5400 households
Capex* for attending 5000 HHs.	Rs.1.25 lac	Rs.2.10 lac	Rs.4.5 lac	15 lac
Opex/year** for attending 5000 HHs.	Rs.28.9 lac	Rs.16.8 lac	Rs.8.1 lac	Rs.6.6 lac

Combination of collection fleet required for 10000 households with 50% household having narrow road connection and 50 % having wide road connection



Capex*	Rs.20.25 lac
Opex/year**	Rs.19.80 lac

Combination of collection fleet required for 10000 households with 25% household having narrow road connection and 75% having wide road connection



Capex*	Rs.18.75 lac
Opex/year**	Rs.18.20 lac

*Capex is calculated by considering costs of handcart as Rs.5000/unit, tricycle at Rs.15000/unit, auto rickshaw at Rs.1.5 lac/unit, and tipper truck at Rs.15 lac/unit.

**Opex is calculated considering common labour cost at Rs.10,000/month and 10% of capex maintenance cost for handcart and tricycle, and 20% of capex maintenance cost for auto rickshaw and tipper truck

Figure 24 Overview of collection vehicles and their respective capex and opex costs

The comparison of per year opex costs of different collection fleets is depicted in Figure 25. For attending a lesser number of households, utilization of handcart and tricycle seems financially feasible, however, as the coverage area increases the opex costs of handcart and tricycle considerably increases in comparison with auto-rickshaws and tipper trucks. An increase in the opex cost for handcarts and tricycles is directly linked to the increasing number of labour requirements. For higher cost-effectiveness in waste collection and transportation, proper planning in the selection of the collection fleet is crucial. The utilization of handcarts and tricycle should be strictly limited to wards and areas with narrow roads. Whenever the possibility raises it is advisable to change the collection fleet from handcarts and tricycles to auto-rickshaw.

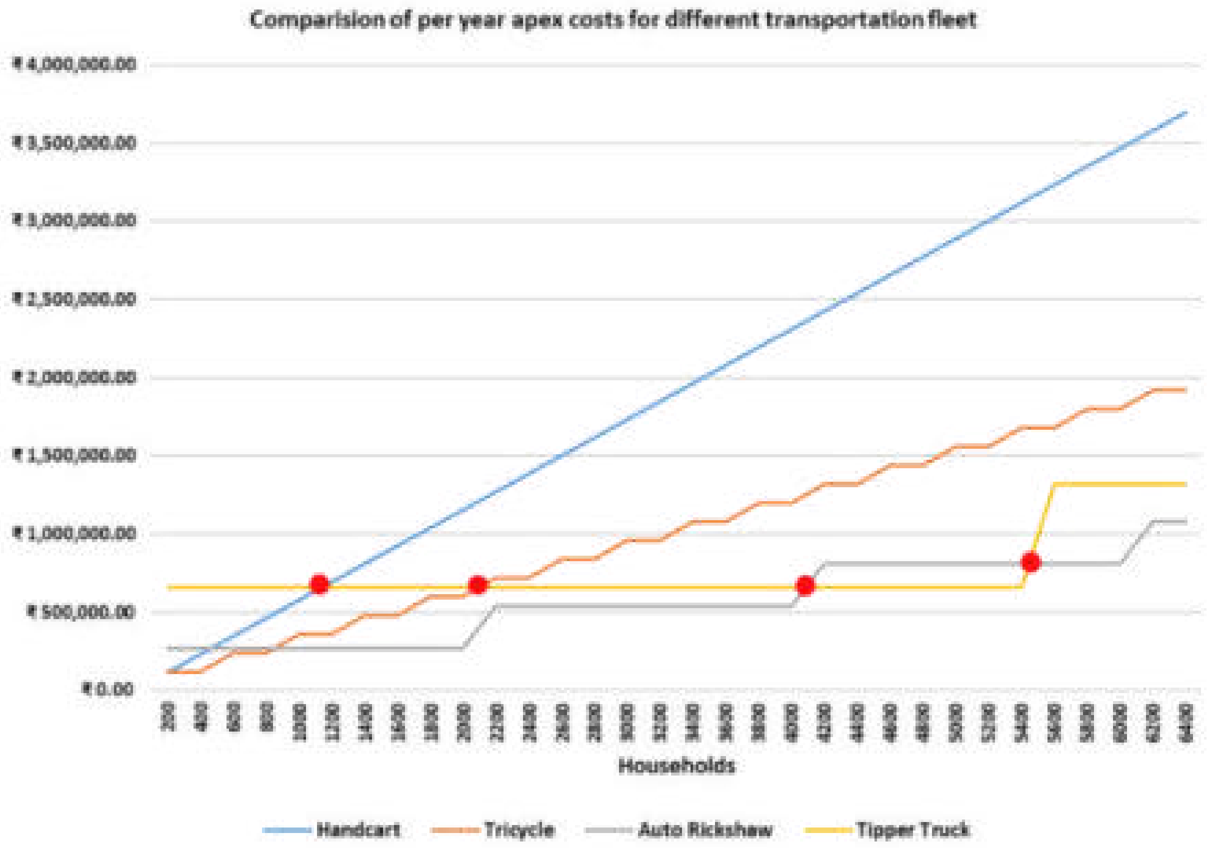


Figure 25 Comparison of per year opex costs for different transportation fleet

5.3.3 Waste collection user fee

The economic viability of the collection system depends on user fees. However, PBMC is currently not collecting the user fee from the households, making the financial aspect of waste management unsustainable. Different schemes can be adapted to collect the fee from households based on social conditions.

PBMC should commence collection of user fees from at least 50% of the households in Port Blair with a high acceptance rate. In communities with a low level of acceptance, awareness has to be created on the importance of waste management and the frequency of the waste fee collection and user-fee charge could be reduced. Alternatively, integrating waste collection fees as tax together with the property tax could also generate revenue for the municipality.

The user fees must be collected by an official person and the waste collector should hand out receipts for each received fee. Further, information on the financial system (received fees, operation and maintenance costs, etc.) should be reported annually in form of an information campaign to ensure the system's liability and transparency. One option to enable greater transparency would be to Implement double entry accounting. As the name suggests, double-entry bookkeeping relies on a two-sided accounting entry in order to maintain financial information. There are two equal and corresponding sides of the double-entry bookkeeping system: debits and credits. Double-entry bookkeeping is characterized by transactions affecting at least two accounts, which always contain one debit and one credit, and which have equal total debits and credits. The purpose of double-entry bookkeeping is to detect financial irregularities and fraud. Such a mechanism will not only builds trust in the citizen but also increases the acceptance level. A detailed explanation of enhancing the funding mechanism is provided in section 5.6.

5.3.4 Promote community participation in source segregation and biowaste collection

Public participation in the community is crucial for a successful collection and treatment program. The citizens should be contacted through several channels such as community meetings with religious leaders, face-to-face interaction with the sanitary inspector, awareness campaigns, advertising tools, and integration of infographics directly into the waste collection vehicle. When possible, the collection fleet can use loudspeakers for creating regular awareness of complete waste management. The importance of source separation should be highlighted during introducing the new collection scheme and the composting facility. Explaining how the community can benefit from waste management as a source of income, keep a clean neighbourhood, and protect the public health would encourage the users to pay the user fee. In this regard, the responsibility of both service providers and citizens should be clearly defined in ANI UT.

With an effective community mobilization, problems such as illegal dumping could be solved This requires a stepwise program to first identify the vulnerable points, clean the area, and allocate community storage bins to these points. Second, raise people's awareness and introduce a traffic light system (red, yellow, green) for controlling the waste disposal in the community bins. The target group should be informed regularly and in case of a deteriorating situation, citizens should get an alarm (yellow notification for moderate and red for significant problems) for monetary penalties (Figure 26).

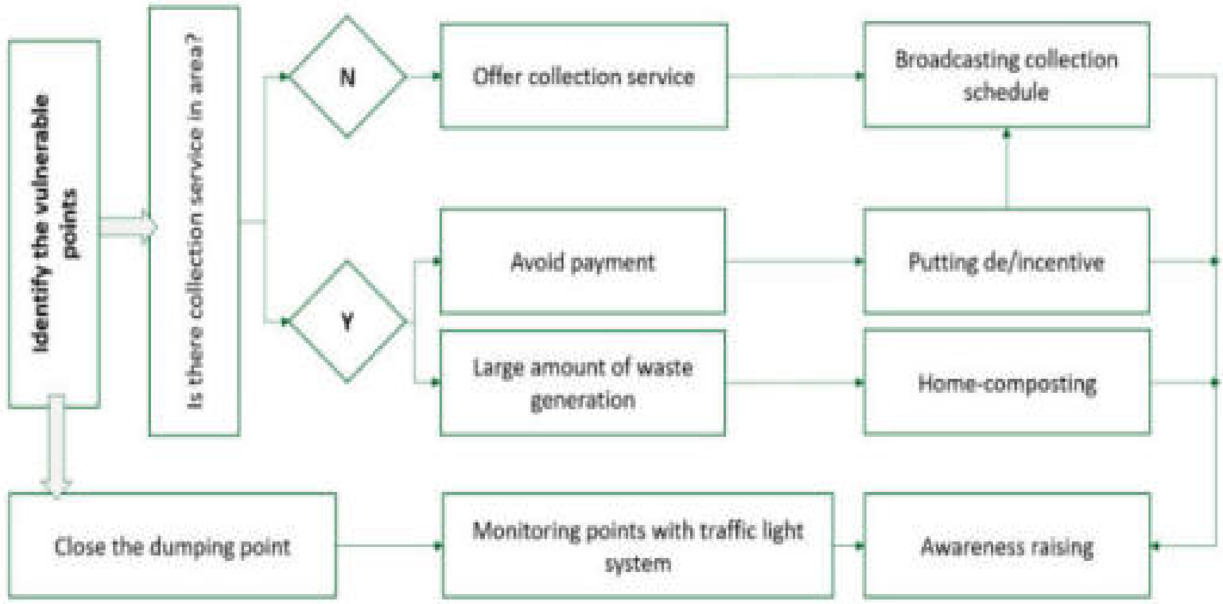


Figure 26: Approach to managing the Garbage vulnerable points

The above strategy has its specific designated benefits to enhance the organic waste system of ANI UT. Nevertheless, the implementation of this strategy will also have an interlinking effect between the strategies that enable the management of organic waste in ANI UT in the broader context. For an instance, by an optimised collection and transportation system there is a possibility to achieve 100% segregated waste collection in ANI UT. In the broader aspect, achieving 100 % collection efficiency will benefit in several ways viz. 1) a significant decrease in the number of garbage vulnerable points, 2) increases the value of organic waste (reuse of organic waste stream as animal feed) and enables the creation of MSMEs to treat the specific organic waste stream (for example coconut waste), 3) increases the quality of compost as the segregated waste stream has fewer impurities, 4) increase the revenue for the ULB, 5) creation of more sustainable jobs in every aspect of the movement of the waste, 6) reduction of GHG emissions, etc. The interlinking effects could be hard to quantify and the successful implementation of all the strategies will have a significantly increased interlinking benefit that could be seen in a shorter and longer period.

5.4 Strategy for managing coconut waste in ANI UT

According to PBMC and U.T policy strategy on SWM for ANI UT 2018, 23.35% of the waste generated in the urban area consists of coconut waste which significantly contributed to the organic waste generated. Coconut waste is classified as dry organic waste. In PBMC, a significantly high amount of coconut waste is being dumped at the Brookshabad dumping site without proper waste management technology and disposal option for coconut waste. Figure 27 shows the coconut waste dumped in Brookshabad dumpsite along with other waste streams. Nevertheless, during the field visit, it was also noticed that PBMC has a high demand for compost and PBMC imports fine quality compost from the mainland. By adopting proper management technology, coconut waste can be converted to fine quality peat looking material (compost) and several other value-added products. Valorization of coconut waste in ANI UT not only aids in the management of the waste which is currently being dumped in dumpsites but also can produce revenue and meet the need for compost in PBMC.

Figure 27: Coconut waste dumped together with other waste in Brookshabad dumpsite in PBMC

Coconut waste comprises coconut husk, coir pith/cocopeat, and coconut shells. Coconut fruit consists of 40 % husks comprising 30 % fiber, with Coir pith/coco peat making up the rest of the mass. Chemically coconut husks contain cellulose, lignin, pyroligneous acid, tar, tannin, and potassium. Coir pith/coco peat has high lignin and cellulose. Additionally, coconut shells are an attractive biomass fuel and are some of the best materials for manufacturing activated carbon. Coconut waste biomass is an attractive product to create a value-added product because as a material it has a large number of advantages. 1) The residual material from coconut is sustainable and CO_2 neutral and can be used entirely, 2) Coconut is a Perennial crop that is available constantly throughout the year. 3) Management of coconut waste can be a promising source of additional income. Below is the information on the valorisation pathway for different components of coconut waste.

Coconut husk

The husk of a coconut comprises 30 % coconut fibres and 70 % Coir pith. Coconut fibres and coir pith can be separated from the coconut waste by shredding the coconut waste and processing it through roller mesh. After the separation, fibres can be used for the preparation of products such as brushes, floor mats, rugs, cushions, rope, fibreboard, construction material etc. Nevertheless, importance has to be given to understand the market potential of the products before implementing

Coconut shell

The coconut shell is very dense, covered with microspores and has a heating value of 20.8MJ/kg making it a good fuel substitute and also material for the preparation of activated carbon. Usually, when the coconut shell is discarded in the dumpsite it takes more than a year to get decomposed and can emit CO_2 and methane when subjected to open burning. Proximate analysis of coconut shell contains high volatile solids content and low ash content making it highly suitable for the pyrolysis process. Further, coconut shells also contain higher fixed carbon content with microscopic pores making them a proper material for the preparation of fixed carbon.

Coir pith

Coir pith contains a substantial amount of lignin, a constituent that is found in ligneous cell walls that has the potential to be used as an adhesive for the coconut fibres. Properly conditioned coir pith and crushed husks are biodegradable soil substrates that significantly enrich the soil texture and improve moisture retention, thus enhancing yield efficiency for horticultural and greenhouse settings. The utilization of coir pith also offers an environmentally sustainable and cost-effective alternative to peat moss, a common soil amender that is extracted from peatland and used to foster the growth of the plant.

With the proper technology and conversion pathway, coconut waste produced in PBMC has the potential to meet the needs of compost in PBMC which is currently being imported from the mainland.

5.4.1 Approach and timelines for setting up of small scale industries for processing coconut waste

The action plan presents the achievable goals, approach and timeline to reach the set goals in a set timeframe. These targets and action plans will guide UT's efforts in the creation of small scale industries for processing coconut waste. As per our estimation, the creation of small scale industries for processing coconut waste could create about 50 jobs within three years. Following are the action plans and approach timeline for the creation of small scale industries for processing coconut waste in ANI UT.

Planning – stage 1 (up to 6 months)

During the first stage, detailed planning of the coconut waste processing plant and training of a small group on practical aspects of coconut waste processing has to be carried out simultaneously. Planning of the coconut waste processing plant should include a detailed analysis of the amount and the location of the coconut waste generation, location identification, preliminary collection route planning, and research on various valorisation pathways and marketability of the products (that are planned to produce). Simultaneously, a small workgroup has to be selected and training has to be provided on the practical aspects of coconut waste processing, and an employability training module focused on basic employability skills and occupational health. It is estimated that the entire process of identification of site, planning of coconut waste processing plant, research on various valorisation pathways, marketing the product, and training of a small group could generate about 5-10 full-time jobs in PBMC.

Pilot stage – stage 2 (0.5 – 2nd year)

After the identification of the site and providing training to the small group; the next step is to construct and operate the first pilot plant at the identified location. The installed pilot plant will be operated by the trained group under supervision. During this stage, there will be continuous efforts to optimise the quality and efficiency of the entire system and the experience will be gained that could help in the replication of similar plants. Additionally, introducing digitalization could also help in increasing the overall efficiency of the process. In the beginning stages digitalization can be introduced in paper-based processes such as billing, accounting, and documentation. Later whenever the possibility is raised it could be expanded in different streams (Viz., collection route planning) which improves the overall efficiency of the system and reduces the chances of errors. It is estimated that by the end of stage 2, PBMC alone has the potential to generate about 15-20 sustainable jobs focusing on the management of coconut waste.

Finalized model development - stage 3 (2^{nd} – 3^{rd} year)

With the experience gained by running the pilot plant, stage 3 mainly focuses on the development of the final plant model that could be easily replicated within ANI UT. Simultaneously importance also has to be given to the identification of the locations in the rural part of ANI UT and to improve the capacity building programs. Keeping the experience gained by the pilot plant as a baseline, plant models of various sizes (small, medium and large) to suit the requirement of different locations has to be created. Having such mechanisms will ensure the effective replication of the coconut waste processing plants throughout ANI UT. The successful implementation of the plans so far would ensure about 20-30 sustainable jobs focusing on the management of coconut waste in ANI UT.

Replication stage – stage 4 (3^{rd} year onwards)

After the identification of the potential location in the rural part of ANI UT; the next step focuses on the replication of the coconut waste processing plants at the identified locations. The main goal here is to capture the entire coconut waste stream in ANI UT and creation of a financially sustainable model that could create jobs. As a part of this stage, there will also be a continuous effort to optimise the quality and efficiency of the entire system. Further importance also has to be given to exploring new valorisation pathways and the marketability of the new products. The successful replication of the coconut waste processing plant throughout ANI UT not only helps in the manage the entire coconut waste in ANI UT but, has the potential to increase the value of waste and create 50+ Jobs within the period of 3years. Figure 28 gives an overview of action plans and approach timeline for the creation of small scale industries for processing coconut waste and shows different stages of coconut waste valorization. Coconut waste management in ANI UT has a significantly high potential to reduce the GHG emission by diverting the huge amount of organic waste entering the dumpsites (Waste generated in the urban and rural areas of ANI UT consists of 23.35% and 28% coconut waste, respectively)

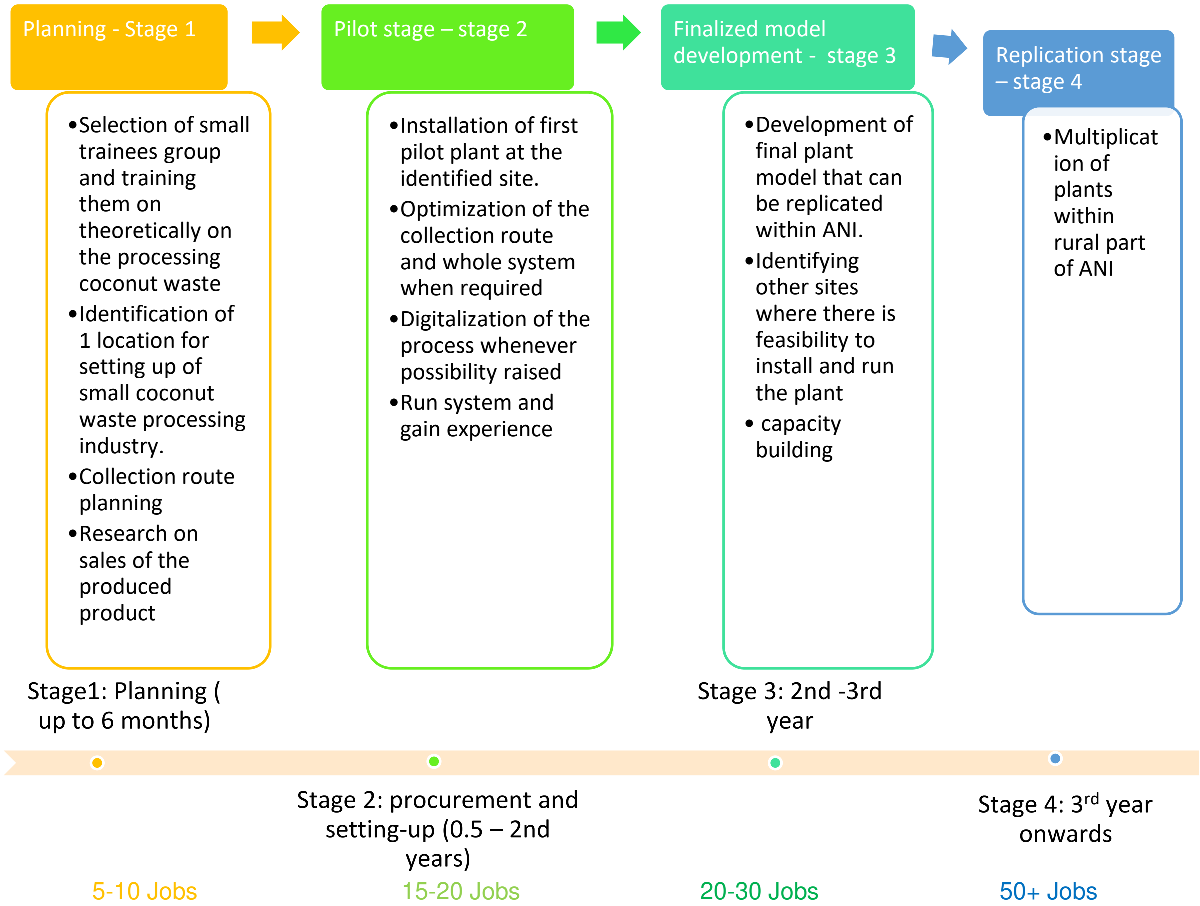


Figure 28: Action plan for setting up of small scale industries for processing coconut waste

Figure 29 Coconut waste valorization pathway

5.5 Supporting micro, small, and medium-scale industries and start-ups to enhance organic waste management in ANI UT

Due to its demographic and topographic conditions, especially the sea being in the middle between the mainland and the islands, the pace of the industrialization process remains rather slow. Various parameters such as lack of infrastructure facilities, transportation bottlenecks, lack of skilled manpower, low population density, scattering of the population in various islands, lack of market, and lack of raw materials contribute to the slow pace of Industrialisation. In ANI UT, 2433 Micro and Small Industries have been listed up to 31.3.2015 with a collective investment of ₹ 657 million and employing over 12K persons[97].

GoI has a plethora of incentive schemes to support micro and small-scale industries. The Micro, Small, and Medium Enterprises (MSME) sector of the Indian economy has evolved as a dynamic and active industry. MSMEs serve a critical role in creating jobs at a lesser cost than major industries, contributing to the country's socio-economic growth. The Ministry of Micro, Small & Medium Enterprises has the responsibility to empower this sector by supervising relevant institutes namely the Khadi and Village Industries Commission (KVIC), the Coir Board and National Small Industries Corporation (NSIC), National Institute for Micro, Small and Medium Enterprises (NIMSME), and Mahatma Gandhi Institute for Rural Industrialization (MGIRI)[98].

Empowering the MSMEs in the solid waste management sector would promote the utilization of biowaste as a valuable resource, create jobs and revenue, decrease the burden on the MSW system, a clean neighbourhood, and improve the public mentality towards biowaste management. To this end, MSMEs should be supported in terms of legal frameworks, capital investment, credits, technical infrastructure, know-how, technology, capacity building, training, branding, and the linkage of the final product to the market.

ANI UT government in cooperation with the Ministry of Micro, Small & Medium Enterprises should investigate the existing MSMEs in the MSW sector. ANI UT government should also facilitate the adaptability of these MSMEs by speeding up the bureaucracy and creating a clear and transparent legal framework for standardization and quality control of the final product. Further, it should establish a link between the national government, and MSMEs to promote financial support. Several financial schemes are offered by the Ministry of Micro, Small & Medium Enterprises, which could be allocated to MSMEs in the waste management sector. The overview direct benefit transfer (DBT) schemes of the Ministry with the benefit type, number of beneficiaries and total funds transferred/expenditure incurred[99] is shown in Table 17.

[97] http://dcmsme.gov.in/old/dips/state_wise_dips/State%20Industries%20Profile%20of%20A&N%20Islands.pdf
[98] Das 2017.
[99] Government of India. Ministry of Micro, Small and Medium Enterprises, Annual report 2020-21. Link: https://msme.gov.in/sites/default/files/MSME-ANNUAL-REPORT-ENGLISH%202020-21.pdf

Table 17: Overview of DBT schemes of the Ministry

Name of the Scheme	Funding	No. of funded projects (2020-2021, upto 31.12.20)	Total Expenditure (₹ X 10 million) 2020-2021, upto 31.12.20)
Assistance to Training Institutes (Training Component)	In-Kind	1279	0.86
Marketing Development Assistance Scheme Grant to Khadi Institutions	Cash	200827	54.52
Coir Vikas Yojana	Cash	89	0.035
Scheme of Fund for Regeneration of Traditional Industries	In-Kind	7523	0
Prime Ministers Employment Generation Program (PMEGP)	Cash	22977	707.16
National Awards	Cash	45	0.45
Entrepreneurship and Skill Development Program (ESDP)	In-Kind	14357	0
International Co-operation (IC) Schemes	Cash	68	1.25

Additionally, ANI UT could introduce financial tools e.g. tax breaks and low-interest loans to support the existing MSMEs and legislate the formation of a waste management fund. The inflows that come from taxes on the waste management value chain can be allocated directly to MSMEs or through a senior officer or setting up a private body to manage funds (Figure 30).

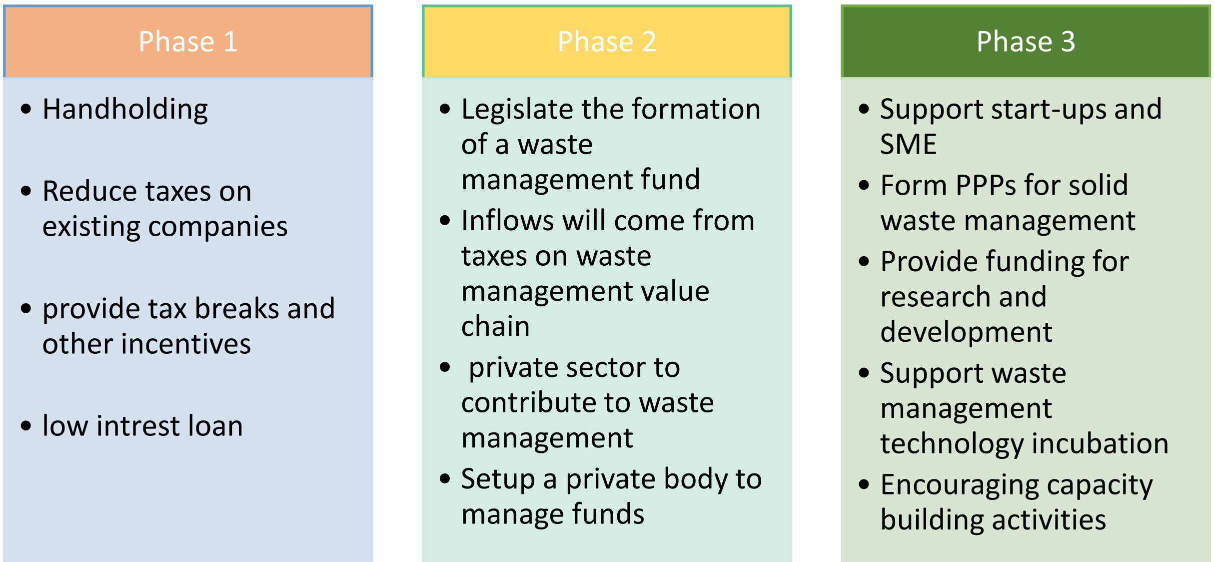


Figure 30: Approach for supporting MSMEs in the solid waste management sector

5.5.1 Supporting MSMEs in the solid waste management sector

Capacity building, incubation, and support for better access to technical know-how and technology is another key aspect of developing MSMEs in the solid waste management sector. Here, the interlink between educational institutes, universities, and vocational training plays a key role. Technical training and knowledge exchange also create opportunities for further research and development.

On the ground level, the start-ups, and MSMEs need support for planning and provision of the technical infrastructure. The reliable information regarding estimated generated waste, quality of feedstock, collection service, etc. is crucial in this stage. The MSMEs should get an overview of the existing competitors and market for the target product. This would help them to establish an effective marketing strategy. Figure 31 shows the steps to be considered in developing a business from a waste stream.

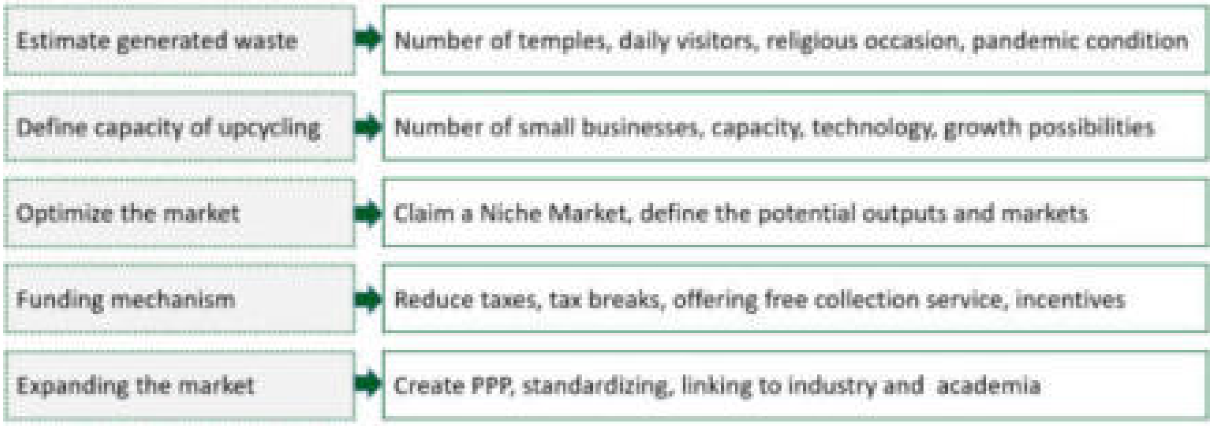


Figure 31: Key considerations in developing a small business from a waste stream

As a short term goal (up to 1 year) importance has to be given to market study and choosing a niche market to ensure the financial viability of the business. Soon after selecting the waste stream and niche market, the next step is to identify the locations for the construction of the plant/setting up of the business. Nevertheless, short term goals should also ensure the continuous availability of input waste stream and the systematic planning of the collection route.

After the identification of the location, studying the market and selecting the niche market; the **medium-term goal** (2nd to 3rd year) should focus on constructing and operating the first pilot plant at the identified location. The installed pilot plant has to be operated by the trained group under supervision. During this stage, there will be continuous efforts to optimise the quality and efficiency of the entire system and the experience will be gained that could help in the replication of similar plants in later stages. Additionally, introducing digitalization could also help in increasing the overall efficiency of the process and the marketability of the products.

As a long term goal (3rd year and beyond) Importance has to be given to enhancing the product by creating the standards for treatment techniques. Standardization of valorisation techniques for the particular waste streams will ensure the quality and marketability of the product produced. Standardization of the products could be done by linking to industry and academia. The collaboration between industry and academia would also aid in exploring other remaining potential of raw feedstock and capturing other niche markets. Long term goal should also focus on the replication of the standard treatment facility. In this concern, funding schemes have to be developed and handholding has to be provided for private parties to enable the sustainable growth of the sector. Figure 32 provides an overview of approaches for developing a small business from a waste stream.

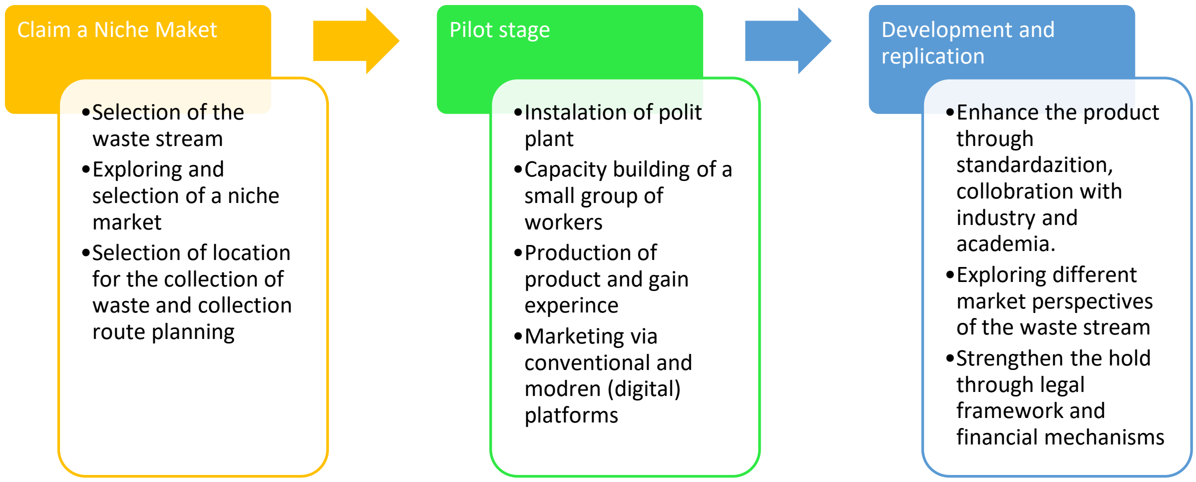


Figure 32: Approach to developing a small business from a waste stream

5.6 Strategies for the enhancement of the funding mechanism

5.6.1 Financial sources

The development of the waste management system should be based on precise financial calculations that account for all relevant expenditures, including hidden costs and profits. This critical role in the planning phase is to assure the waste management system's financial feasibility and long-term sustainability. In this concern, detailed and comprehensive data on the actual costs of municipal solid waste management activities should be examined including hidden and neglected expenditures. This enables decision-makers to correctly compare current and planned services, anticipate future costs with accuracy, and completely assess outsourcing possibilities. Nevertheless, it is crucial to have particularly designated fund allocation for waste management and segregated financial accounting will provide a flexibility and control over the available funds.

Solid waste management activities should be planned to fulfil the legal framework. The system complexity may vary based on the local authority's financial capabilities. It is essential to ensure that all schemes are designed and implemented sustainably. Accordingly, the cost recovery of projects should be guaranteed through available internal and external sources. Usually, property taxes are the most reliable source of funding for ULBs. However, to make solid waste management financially viable, ULBs should levy user fees on all eligible households. For the poor urban area, subsidies are given so that lower user fees are levied. This should be set, agreed and enforced by the steering committee comprising all stakeholders. The ULB should charge the services offered with appropriate tipping fees e.g. collect fees from the dumping trucks.

The sale of the final product from the recycling of biowaste is another source of funding. The quality of input material, process control, branding, and marketing play important role in making revenues. Other internal resources for funding solid waste management projects are penalties.

People should inform about the offered services, followed by monitoring tours. The introduction of a traffic light system to warn the people in a stepwise manner and raise their awareness is essential to prevent social issues.

5.6.2 Define goals for cost recovery of MSW services

To make MSW profitable, full cost recovery is essential. All costs for the management of biowaste should be analyzed to define realistic goals. Collection & transportation, Processing & disposal, operation & maintenance costs per kg of biowaste generated from households, commercial sectors, and institutional establishments should be estimated. The waste generator should be evaluated based on the amount of generated waste and other appropriate indicators. For example, households based on income level, commercial and institutional sectors based on the capacity and size of the premises.

The lowest timeframe is considered for the full O&M cost recovery of the commercial and institutional sectors. For up to 3 years, the collected user fees from bulk waste generators should cover 100% of the O&M cost of collection services. Similar measures could be considered for high-income level households. For middle-income level households, a longer time frame of up to 5 years is considered and for low-income level, poor and slum areas, a 50 % cost recovery is 5 years could be set.

5.6.3 Cost recovery schemes:

The most challenging step in the financial viability of the waste management system is the mechanism of cost recovery. Following are the most common cost recovery schemes that could be used.

5.6.3.1 Financing from user-fee

Operational and maintenance expenditures generally require a reliable cost-recovery system for long-term sustainability. The standard approach for many ULBs for cost recovery is through standard user fee collection which is usually charged to users for services provided. As a general rule, those who generated the waste and benefited from waste management should be liable for the costs associated with its management („polluter pays principle“). Therefore, a charge should be levied specifically for the services made available to and used by the general public. Ideally would be to charge the entire waste service in the form of user fees to each user. It would result in a true fair distribution of the burden of collecting, treating, disposing of, and following up on waste along with the prevention or restoration of the environmental damage that the waste generator could cause.

The most effective method of user fee collection is to match the willingness and the ability of users to pay the fee. In addition to willingness-to-pay, affordability-to-pay is an important marketing component for solid waste services. A failure to estimate the affordability of payments implies the danger of not being able to claim the full cost of solid waste management. Thus, the use of intelligent charging mechanisms or models is essential. Based on the expenses of providing and performing a service, this fee must be charged to the waste generator. User-fee should include a fixed/base fee, variable fee, and EPR fee to promote a reduction in the waste generation or to make waste disposal more affordable for low-income households.

Generally speaking, the fixed costs associated with waste management are defined as those expenditures incurred depending on base waste generation and the extent to which waste disposal services are actually used. In other words, the costs are incurred primarily by providing the necessary conditions for providing the respective service. The variable costs shall be those incurred in connection with actual service provision, and in particular, in relation to waste volume and the range and intensity of disposal activities. In addition to base and variable fees, user-fee should also incorporate certain charges that are designated as EPR fees. EPR fee will act as an extension of the base fee and variable fee as the consumer is also responsible for the consumption of any product produced by a manufacturer.

Fixed/base fee has to be integrated to the property or asset related. Deciding the base/fixed fee has to consider various parameters viz. size of the property, type of property, i.e. private, commercial or mixed utilisation, quantity of waste generated based on the size of the property etc. Variable costs come into play whenever the generator is producing a larger amount of waste than that the fixed/base fee is covering. In general, fixed costs generally account for 60 to 80% of total costs, whereas variable costs rarely exceed 20 to 40%.

To increase the efficiency of user fee collection, user fees may be collected directly from the customer via independent waste service bills or in conjunction with property or other utility taxes. A most practical approach for greater user-fee collection would be to introduce a digital house-tag system (similar to fasttag for highways toll collection). In the house-tag system, the owner of the any residential or commercial will pay a yearly user fee in advance (depending on the designated combination of base, variable and EPR fee) and the difference in the paid fee and the utilised services will be corrected every year and the difference will be settled accordingly. The introduction of such a system in ANI UT will ensure higher transperancy and budget in advance for the smooth functioning of the waste management system.

5.6.3.2 Financing from general tax revenues

The user-fee collection efficiency could be improved if user fees are collected along with utility charges and property taxes. However, this would require significant coordination and so an increasingly mature waste management system to join the waste collection user fee with the property or utility taxes. The financial sustainability of complete management of organic waste services (collection, transportation, treatment and disposal) cannot be possible only by depending on user fees. Especially in the regional context of ANI UT, together with user-fee; funds and transfers received from state and central governments play a major role in the sustainable management of organic waste.

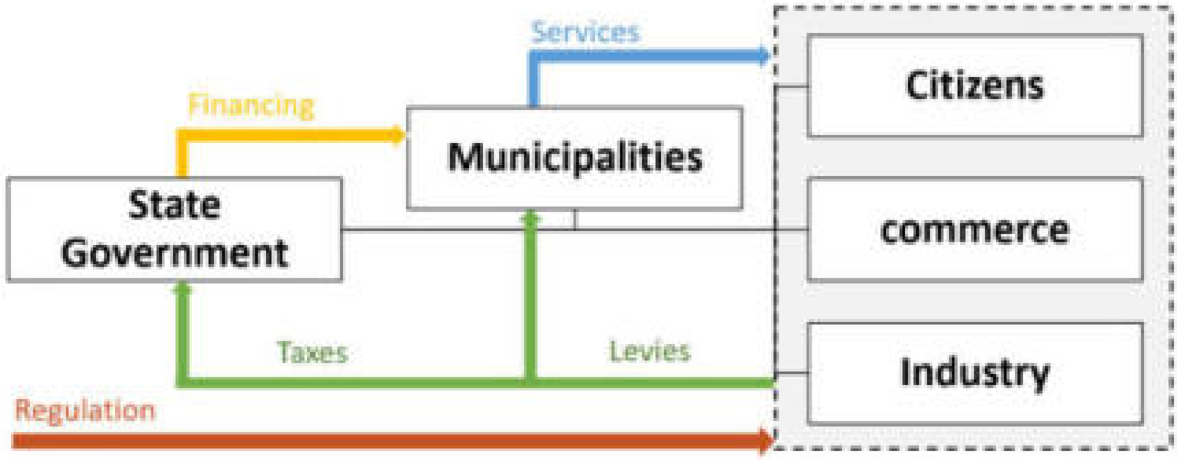


Figure 33: Financing schemes form general tax revenues

In addition to government transfer and external budget support, partnership with the private sectors can also ensure the greater financial investment and sustainability of the waste management system. The private partnership could be incorporated at all stages of the waste management value chain viz., waste collection, transportation, construction and operation of waste management sites, and disposal site. The private sector participating in the waste management can recover their cost through the service provided directly by the user and/or with the stable opportunities provided by municipalities to earn revenue from tipping fees and sales of recovered materials.

5.6.3.3 Financing from environmental funds, taxes & duties

Environmental funds or environmental taxes and duties could be an advanced mode of funding mechanism that could complement the conventional funding mechanisms. The primary purpose of environmental taxes is to include the costs of pollutants released and the costs that are associated with the consumption of ecosystem services for the products manufactured for an economy. In general, environmental pollution costs include "externalities" acquired as a result of economic activity, and are not included in the direct costs incurred by producers or consumers. The collection of funds can be facilitated by charging the duties for environmental protection, penalties for environmental polluters, and additional charges for environmental authorisations of any new projects.

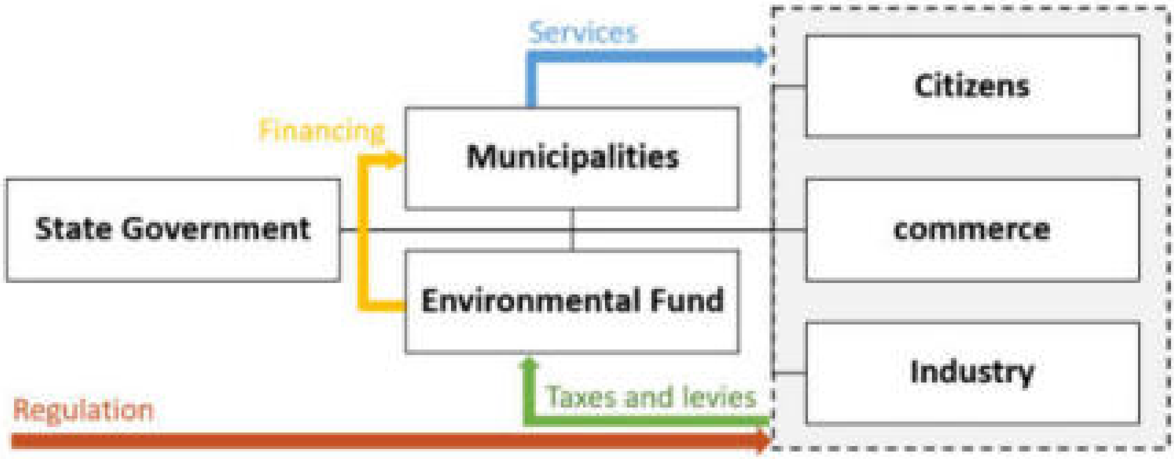


Figure 34 Financial schemes from environmental funds.

5.6.3.4 Earmarked taxes and levies

Similar to environmental taxes and duties, earmarked taxes and levies could be an advanced mode of funding mechanism that could complimentary the conventional funding mechanisms. Waste generation is significantly increasing because of the increasing number of tourists in ANI UT. The concern on problems associated with increasing waste generated by tourists can be tackled by strategically implementing a tourist tax. The collection of the funds/taxes can be facilitated directly by imposing the fees directly at the arrival of airports or could be collected by the hotels together with the stay charges.

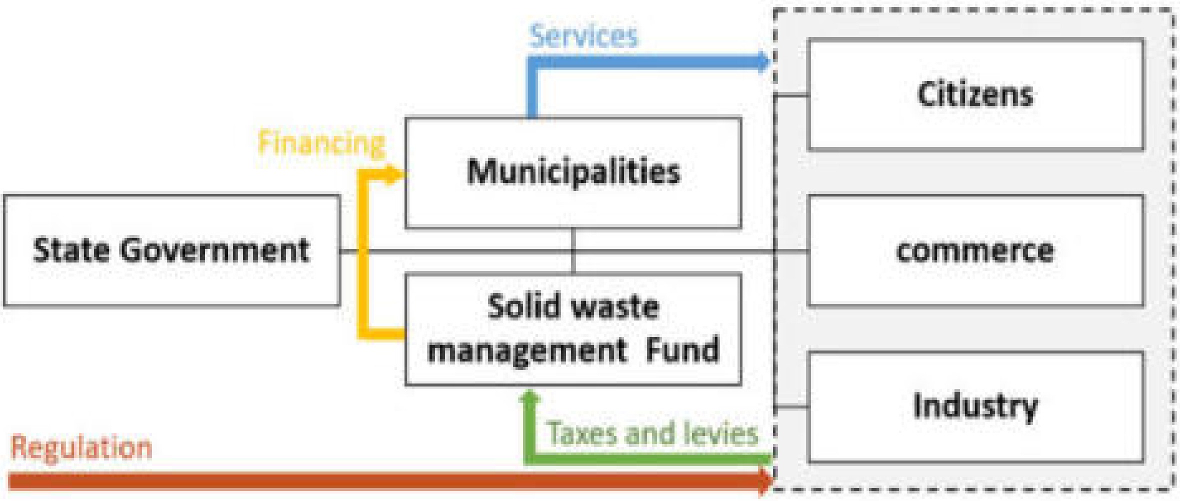


Figure 35 Financial schemes from earmarked taxes and levies

5.6.4 Cost recovery schemes

The most challenging step in the financial viability of the MSW system is the mechanism of cost recovery. Three common cost recovery schemes are 1) the collection of user fees regularly e.g. monthly, 2) levy collection fees annually with property tax, 3) and levy charges with utility (water and electricity). The social context is an important aspect of defining the cost recovery scheme. The most effective method of user fee collection is to match the willingness and the ability of users to pay.

The standard approach for many ULBs with cooperating people for cost recovery is through periodically user fee collection e.g. monthly. Fees may be fixed or variable in order to promote the reduction in waste generation or to make waste disposal more affordable for low-income households. For an instance, within a single city, poor communities may be charged minimal or no fees whereas the wealthier communities, commercial operators, non-governmental organizations, and institutions may be required to pay the regular user fee.

In places where people are not willing to pay for solid waste management services, the other schemes are practical. Enforcement of the user fees should be done gradually and the ULBs have to introduce the MSW fees as a fraction of property tax or utility charges and increase it annually. However, the full cost recovery of the collection system in these schemes is challenging and ULB should try to raise the awareness of the society about the importance of a clean environment and convince them to pay the user fee periodically. Figure 36 depicts the different sources for funding a solid waste management system.

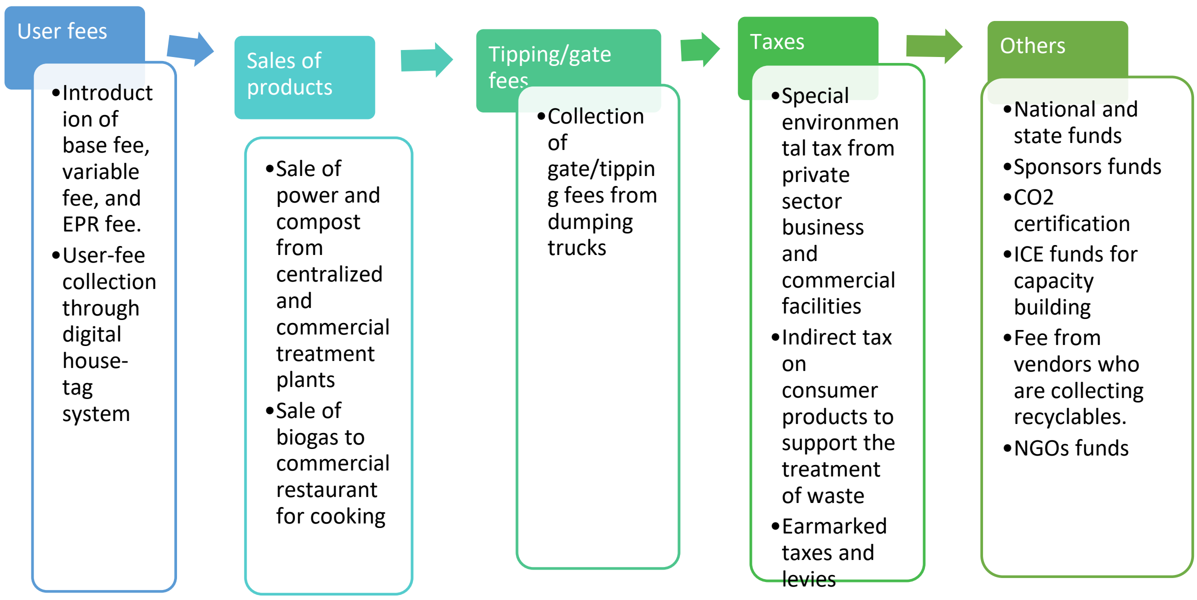


Figure 36 Different sources of funding for the solid waste management system

5.7 Enhancing stakeholder's engagement, awareness-raising, and capacity building in PBMC and rural area

Participation of the community is essential for any waste management program to be successful. Communications campaigns determine the behavioural patterns of communities and provide them with the means to cooperate actively. Telephone calls and digital applications (Swachata App, limited to PBMC) are the public grievance method used in ANI UT. In PBMC, Swachata Awareness Team is currently conducting IEC training for streamlining complete waste management aspects for the public, PBMC sanitary workers, and SHGs. However, the existing mechanism of overall organic waste management is far away from satisfactory and to improve the existing situation effective capacity building and regular awareness-raising programs are necessary for behavioural change in the long term.

A major component of ensuring the sustainability of waste management systems is the integration of environmental and economic approaches, behavioural change, and capacity-building activities. Behaviour change requires sustained effort over time, which is why these activities need to be considered as a continuous process. It is noted in Swachh Bharat Mission-Urban guidelines that, an effective solid waste management system requires the cooperation and input of many stakeholders, including groups like community-based organizations, NGOs, and other agencies responsible for waste management, as well as students. Such stakeholders are encouraged to be involved in the development of interventions that support IEC and change in behaviour.

5.7.1 Awareness-raising campaign and communication channels

The ULBs can adopt a gradual approach to raise awareness, increase public interest in SMW issues, evaluate the community participation, make a trial of different approaches, adapt the best and maintain the approved communication schemes (see Figure 37). In a modern waste management system, people are trained to be aware of methods to handle the waste generated (Awareness). To invite people to the voluntary programs e.g. home-composting, the major focus is marketing, whereas, in the case of obligatory programs e.g. illegal waste dumping, it is explained beforehand exactly what is expected. Participation could be increased when program criteria are clear and simple to follow by creating interest in people (Interest). Initial participation of the people could be usually fair, even in the well-publicized initiatives (Evaluation). People may decide not to participate if they are experiencing trouble (Trial). Additional guidance and information should be available through well-publicized helplines. The level of participation should continue to rise (Adoption). Ongoing education programs encourage constructive comments and where appropriate it has to be facilitated with updated materials. High participation rates are maintained through encouragement and effective instructions (Maintenance).

Figure 37 The process of raising awareness through educational programs

To raise the awareness of the community, education methods are chosen considering social conditions and budget. People must be informed through several approaches such face to face training, communication via digital apps and social media, and regular event at public places for national and international environmental occasions such as earth day, public cleaning campaigns, street plays, billboards, etc. Training of the young generation at school, educational institutes etc. is more effective for the future solid waste management system.

The communication chosen in the ANI UT should be suitable for all the target audiences. In a print medium, attention should be paid to the infographic to convey messages noticeably. The icon representing reuse, recycling, and disposal can be promoted by artefacts, billboards, wall writing and printing on all products used by the community. Audio-visual communication has a broad reach and a long-term influence, and it is effective in changing attitudes and encouraging behaviour change. Through collaborations with local radio and television stations, a long-term campaign on sanitation and hygiene concerns is achievable. When compared to traditional commercials, catchy advertisement tends to capture the audience's attention and have a stronger recall.

Internet websites and social media could also have a similar reach to an audience in ANI UT. However, The most successful communication strategy in this aspect is face to face communication, which includes persuasive conversations and talks with individual members of the household. Door-to-door collection staff have shown to be the most crucial connection in maintaining source segregation initiatives. Through the IEC campaign, all residences, business entities, and other institutional establishments must be contacted. The overview of different communication channels that could be used for creating awareness is provided in Figure 38.

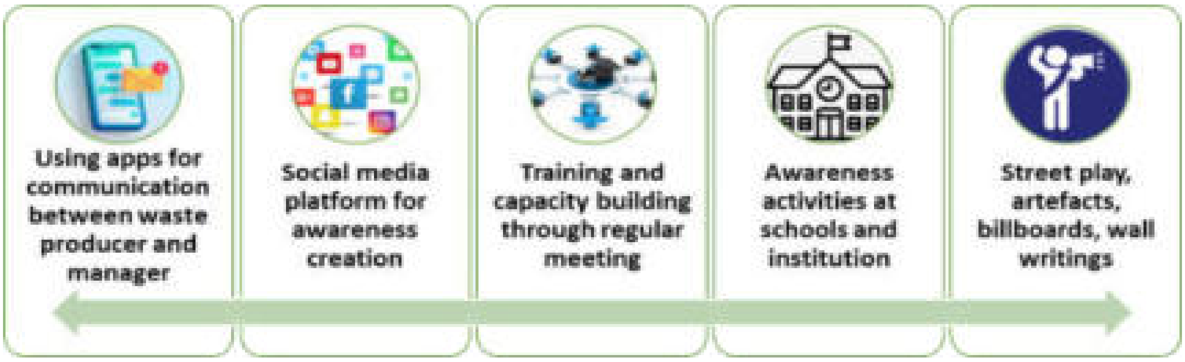


Figure 38: Communication channels for the creation of awareness

5.7.2 Capacity building campaign and stakeholder involvement

There is a direct relationship between lack of skilled manpower and system malfunction. In many cases, the responsibility is assigned to the waste management staff and personnel without capacity building. The capacity building programs should include all levels of the waste management hierarchy. In this regard, a guideline for training different groups should be developed at the national level. At the UT level, a successful ULB (among rural and urban ANI UT) can be chosen annually as the role model to advocate best practices and discuss effective approaches during visiting tours of ULB authorities and different stakeholders.

Figure 39 gives an overview of phase wise action plan and the timeline for successful capacity building with stakeholder involvement.

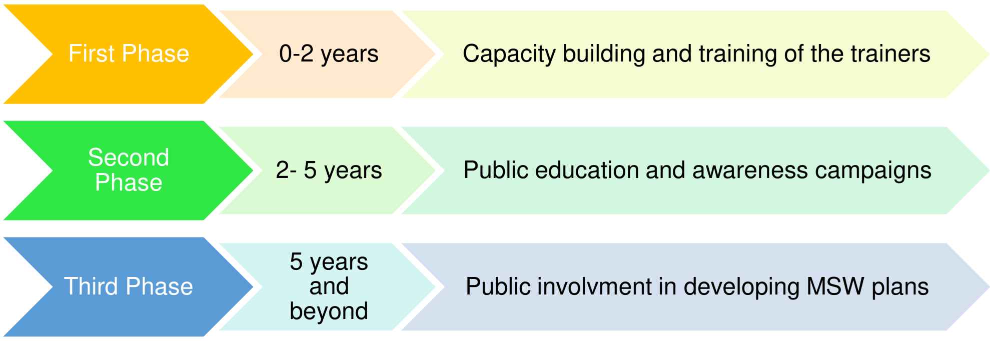


Figure 39 Overview of phase-wise action plan and the timeline for successful capacity building with stakeholder involvement

As a short term goal (0-1 year), the creation of training guidelines for different stakeholders group and training different stakeholder groups concerning waste management has to be prioritised. The chief training areas for different stakeholders should include the following aspects

- Collection Staff: Time and frequency of door to door collection, segregation of waste into fractions at source, interaction with citizens, and occupational health.
- Transportation staff: time and frequency of transporting the waste, segregation of waste into fractions at secondary point/transfer station, interaction with collection staff, and occupational health.
- Staff at Processing Plant: Assessing the waste received at the treatment facility including weighting and characterization, handling of fine and coarse fractions after processing, O&M of plant machinery, using personal protective equipment, Health, Safety and Environment cautious
- Senior officers including sanitary inspector: Monitoring and supervising all field activities, capacity building and welfare of staff, documentation and reporting of all activities

At the higher hierarchy, refresher courses should be conducted for officers and supervisors at least once every 5 years. As explained earlier, a successful ULB (among rural and urban ANI UT) can be chosen annually as the role model to advocate best practices and discuss effective approaches that a particular ULB has chosen to obtain the success. This could be facilated by organising a field visit to model ULB by the authorities/sanitary inspectors and key stakeholders for other ULBs.

In the midterm (2-5 years), the trained staff and workers can enormously contribute to public education and awareness-raising. To this end, waste generators has to be educated on the importance of management of waste, need for user-fee collection, proper handling and segregation of the generated waste at source, management of organic waste at source (as animal feed, composting and biogas production) As explained in Section 4.7.2, ULBs can adopt a gradual approach to raise awareness, increase public interest in SMW issues, evaluate the community participation, make trials of different approaches, adapt the best options and maintain the approved communication schemes.

As a long term goal (5th year and beyond) community involvement plays a key role in improving solid waste management systems. The citizen should participate actively in the development of waste management schemes (Figure 40). To this end, the issue of new waste management methods should be brought to the public's attention (Concern) and the target neighbourhood should be invited to a community workshop (Involvement). Leaders from a variety of interest groups (regulatory authorities, residents from nearby areas, local waste management specialists, and environmental/corporate representatives) should be argued to attend the workshop. During the workshop, the interest groups communicate their points of agreement and disagreement to one another as well as to program designers (Issue Resolution). Groups should establish a list of options, which should include "no action" (Alternatives). Each alternative has to be explored in terms of its economic and environmental implications (Consequences) and the widely accepted option with more overall weightage has to be chosen (Choice). The measures required to carry out the program are detailed, and any potential negative consequences are minimized to the extent feasible (Implementation). The program should be evaluated based on the community feedback regularly (Evaluation).

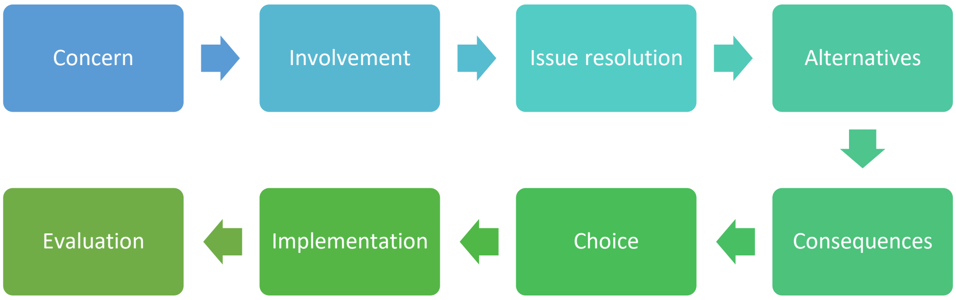


Figure 40: Approach for communication campaign and public participation during any major development of the waste management system

Overall, in ANI UT effective capacity building and active awareness-raising should bring into focus and put on the UT and ULB agenda. Accordingly, a specific budget should be allocated for the respective activities and monitored of such activities has to be done to evaluate their effectiveness.

Capacity building can be additionally enhanced by collaborating with vocational training institutes such as National Skill Council Development Co-operation (NSDC). NSDC aims to encourage skill development by creation of large, quality and for-profit vocational institutions. Furthermore, NSDC provides funding for the development of profitable and scalable vocational training programs. The organization also provides support systems such as quality assurance, information systems and training the trainer academies, either directly or indirectly through partnerships. By providing funding to companies, organizations, and enterprises that offer skill training, NSDC serves as a catalyst in skill development. Collaboration with such training institutes will foster the capacity building initiatives.

5.8 Digitalizing the waste management sector - PBMC and Rural area

5.8.1 Introduction

Digital technologies are crucial in an effective waste management sector for safer, transparent, economically feasible and highly resource-efficient waste management. Various digital technologies in the waste management sector have been introduced, even though the digital field is quite diverse. Highly competitive private companies and bigger public players tend to accept and adopt modernized digital technologies faster. Comparatively, the smaller companies and public enterprises appear to be slower, and lack necessary investments as well[100,101].

Figure 41: Challenges in SWM without ICT

For well-organized monitoring and assessment of waste management, proper Information and Communications Technology (ICT) is required. Figure 41 depicts the challenges faced in municipal solid waste management systems without the introduction of ICT. With the help of ICT, complaints of people can be analyzed with actual information and solutions can be made accordingly. Garbage bins and collecting vehicles can be tracked easily with the help of ICT and the route can be optimized accordingly for more efficient and transparent collection and transportation of waste. Difficulties and complications in calculating the amount of waste generated can be handled well with the help of ICT. Through ICT response to emergencies and proper management of manpower can be achieved easily. User fee collection directly using a digital platform helps in a competent waste management system (Paytm, Bhim, and G-Pay could be integrated into the user fee collection system). Digitalized waste management helps public authorities in providing better services to the people and society and thereby upscaling them one step closer to the concept of a circular economy. Figure 42 gives an overview of digitalization and its applications in different sectors of waste management.

---
[100] ISWA, 2019
[101] Eionet Report- ETC/WMGE 2020/4: Digital waste management

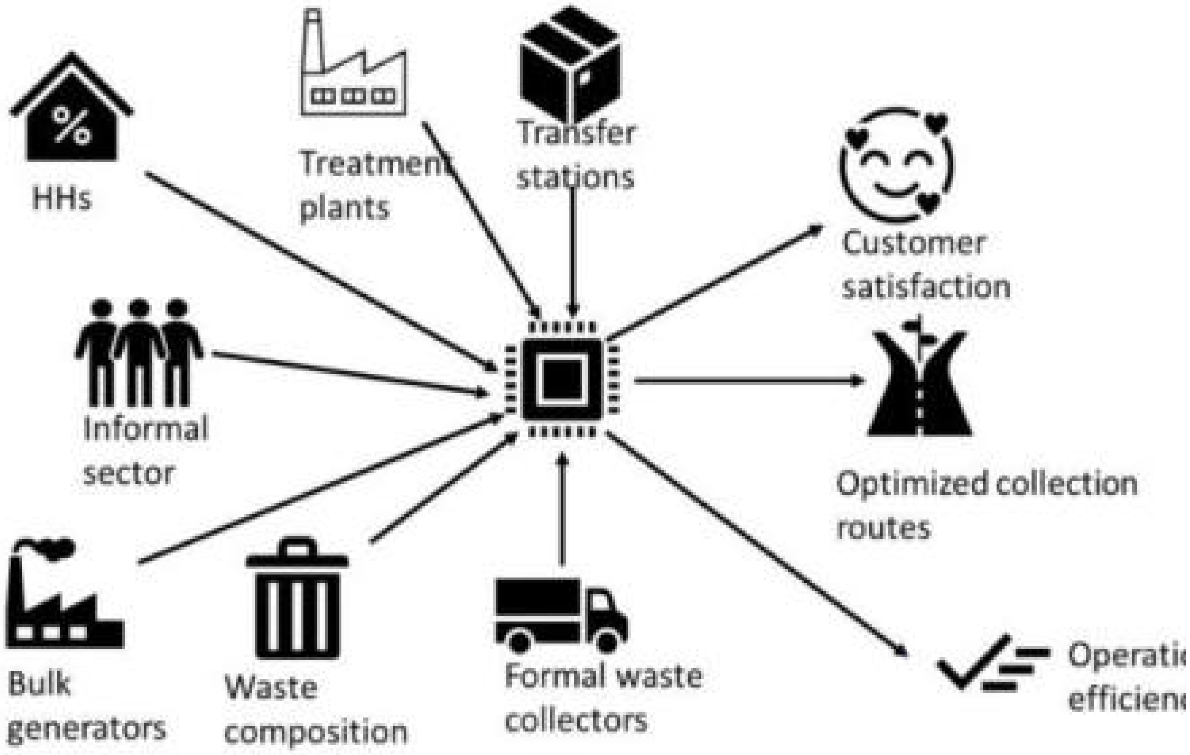


Figure 42: Overview of Digitalization in the waste management sector

There are a few factors that delay the use of digital tools in the waste management system. Factors such as digital literacy to implement and monitor digital tools, higher costs for digital solutions, security of IT systems and requirement of digital ecosystems are considered as the inhibition factors in the digitization of the waste management sector. As a result, digitalization in the waste management sector of India and ANI UT has to be adopted gradually.

5.8.2 Communication

Communication has an imperative role in digital waste management systems, especially in tasks such as billing and documentation. Communication between waste collectors and people (customers) about the information on pick-up dates, information on waste separation, bills, and disposed waste reports are needed to schedule pick-ups, ongoing waste contracts data change, and to enquire on prices and services.

Several digital solutions to enhance communication are subdivided into the following categories:

- Website: General information on services, prices, fees etc. will be displayed on websites. Information on waste separation, collection timings, data on collection stations, transfer stations, information on hazardous waste and how to deal with it etc. will be mentioned on the websites. It is easy for citizens to report on illegal littering, uncollected or lagged waste collection, and other issues through websites as a medium of communication.
- Mobile App: Mobile apps are user-friendly these days as they are handy for customers to track real-time data on their waste given away, notifications and messages of important news and events can be received immediately as well.

- Integration in already existing apps or websites: if there is already an application or website available for communication purposes, waste-related information can be added to this. This can help in minimizing the number of different information access points and thereby increase customer satisfaction and convenience.
- Usage of third-party apps: Third-party apps such as WhatsApp, Facebook, Twitter, Instagram etc. can be used to communicate with customers as these apps have better reach among people.

5.8.3 Waste collection

The collection of waste is a vital part of waste management, and it can be digitized using sensors in collection vehicles with weighing balances to check the weight of the collected waste and route planning to optimize the routes. Thus, this can save operation time, inventory tracking and resource planning. Even a minor improvement in routing can have a faster return on investments due to the higher costs for running the collection vehicle.

The main challenges in waste collection, segregation and treatment are:

- Sanitation workers are often inconsistent with their jobs, as they skip collecting waste from households and there is no way for the authorities to track this.
- Separating biodegradable waste from other waste is often difficult for the authorities.

One possible way to solve these problems is by using QR Codes.

Tracking waste collection by QR Codes

To track the waste collection, authorities can assign a QR Code to each household. This QR Code will be encoded with a unique identifier or a unique URL. QR Code will make an entry to the online database when scanned by the waste collectors. This can include many details such as time of waste collection, date, household number, amount of waste, information regarding segregation etc. This data can be further processed and analyzed by the authorities. This will ensure that the sanitary workers do not miss collecting waste.

Digitalization of user-fee collection system, subsidies schemes and alternative benefits

Digitalization plays significantly greater role in the success of user fee collection. As explained in the section 5.6.3.1, the efficiency of user fee collection can be improved by introducing a digital house-tag system (similar to fastag for highways toll collection). In the house-tag system, the owner of the any residential or commercial will pay a yearly user fee in advance (depending on the designated combination of base, variable and EPR fee) and the difference in the paid fee and the utilised services will be corrected every year and the difference will be settled accordingly. The introduction of such a system in ANI UT will ensure higher transparency and budget in advance for the smooth functioning of the waste management system. Nevertheless, as explained in section 5.2.1 subsidies schemes on source level organic waste management technologies and the alternative benefits in the form of organic vouchers or user fee concession for commercial units who are managing their waste by themselves effectively should also be linked using a digital platform.

5.8.4 Internal processes

All the paper-based processes such as billing, accounting, controlling, processing of orders, documentation, and management of sub-contractors could be digitalised. The main advantages of digitalization in reducing paper works have cost reduction, more storage of data, easiness to find data, and reduction in chances for errors. Table 18 gives an overview of digital solutions which can be applied in the waste management sector.

Table 18: Examples of digital technology applications in waste management

Communication	Waste Collection	Internal processes
Websites	QR Codes	Billing
Mobile apps	Sensor-equipped vehicles	Accounting
Integration in other services	Route planning	Controlling
Third-party social media apps	Resource planning	Processing of orders
Third-party social media apps	Inventory tracking	Documentation
	Documentation	

The digitalization approach and timeline in the waste management sector are shown in Figure 43. The approach to digitalization is subdivided into 3 stages;

Stage 1 should focus on digitalizing the collection system, transfer system, and capturing the dumpsite information. Digitalization at stage 1 will significantly improve the efficient route planning, resource planning, tracking of the vehicles and the movement of waste, and enables the systematic collection, monitoring and maintenance of all the data. Stage 1 it is expected to take up to 8 months to complete.

Stage 2 should focus on digitalizing waste generation such as households, bulk generators, temples, etc. As explained earlier, a QR code has to be assigned to a different type of waste generator using which details such as time and date of waste collection, house number, amount of waste, user fee collection, and information regarding segregation could be captured. As a part of stage 2, even the piggeries and animal husbandry also have to be digitalised to have information about the quantity of waste being reused by such a system. This stage is estimated to take a time of 1 year to 2 years to complete the digitalization.

Stage 3 should involve the digitalization of treatment plants, landfills, and the SLRM centre that could enable optimization and data accuracy of the entire waste management system. It is expected to take up to 3 years to complete the digitalization of stage 3.

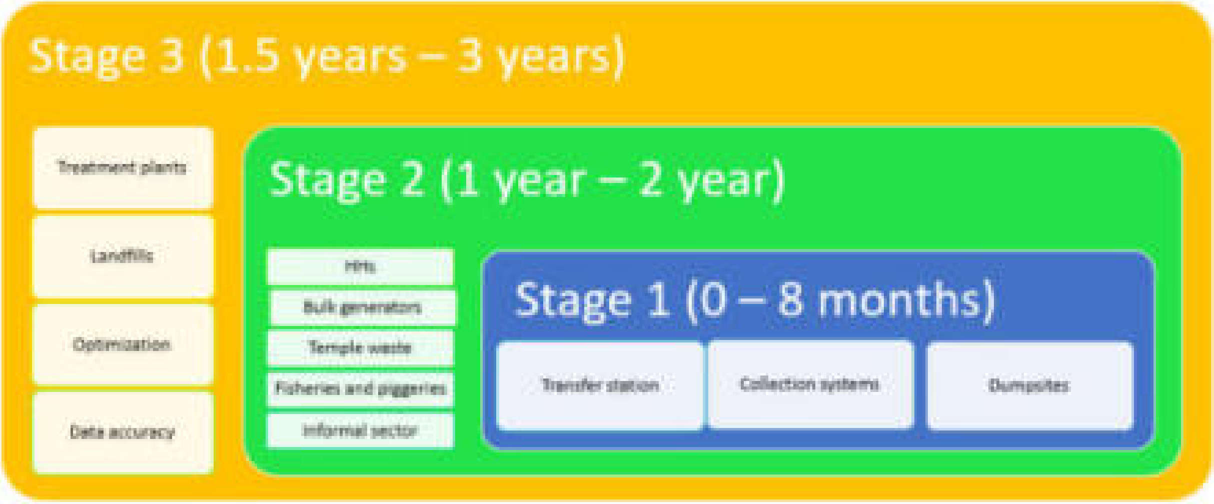


Figure 43: Digitalization approach

5.9 Additional strategies for the overall development of waste management in ANI UT

5.9.1 Strategy to effectively treat sanitary waste from households and institutions with hospital waste

Despite the by-laws in ANI UT making it mandatory for the institution to own incinerators for the proper disposal of sanitary waste, there is no facility to treat the sanitary waste at the source. Currently, in ANI UT, the sanitary waste is highly miss- managed by either burning it uncontrollably or dumped in the Brookshabad dumping site (waste generated in PBMC). The waste sourced from sanitation and hospitals falls under the category of sanitation and biomedical waste. The handling of bio-medical waste is crucial in terms of contaminating other humans and spreading diseases. The bio-medical waste is highly infectious and full of contaminants, chemicals and drugs with a higher potential to cause disease outbreaks.

In this regard collecting the sanitary waste from Households and redirecting it to existing incineration plants (GP Pant Hospital, PBMC has an incinerator of capacity 150 kg/hr) for scientifically managing it could be one option for scientifically treating the sanitary waste. Another possibility would be to construct the additional treatment plant according to the requirements.

Following is the approach for effectively treating the sanitary waste and hospital waste generated in ANI UT.

Stage 1 - Use existing the existing treatment centres and plan additional facilities (up to 1 year)

During the first phase, priority has to be given to the effective utilization of the existing incineration facility to treat the sanitary waste generated at Households in PBMC. One possibility in PBMC could be to collect the sanitary waste for a particular ward and redirect it to co-incinerated with medical waste at the existing incineration plant in GP Pant Hospital. However, this approach will not be able to capture the entire waste generated in PBMC. To overcome this limitation it is required to analyse the actual quantity of sanitary waste generated in PBMC and depending on which the size and location of the new incineration plants have to be planned. Instead of promoting the decentralised incinerators at the institutional level, finding a site for setting up a centralised incineration plant could help in the combined management of the hospital and sanitary waste in a more systematic way.

Stage 2 - Construction of new incineration plant (2nd – 3rd year)

After the identification of the site and deciding the size of the incineration plant; the next step is to construct and operate the first incineration plant at the identified location. Here the importance has to be given to capturing the entire sanitary and hospital waste generated in PBMC. There should also be a continuous effort to optimise the efficiency of the entire system and the experience gained could be helpful development of the final plant model that could be easily replicated within ANI UT (especially in rural areas)

Stage 3 - Treat all sanitary and hospital waste in ANI UT (3rd year and beyond)

The final incineration plant model that is created based on the experience during stage 2 can be replicated depending on the requirement in the rural part of ANI UT. The successful replication of the incineration plant in ANI UT has higher potential in effectively managing the entire sanitary and hospital waste generated in ANI UT. Figure 44 depicts the overview of the approach and relavent timeline for effectively treating the sanitary waste and hospital waste generated in ANI UT.

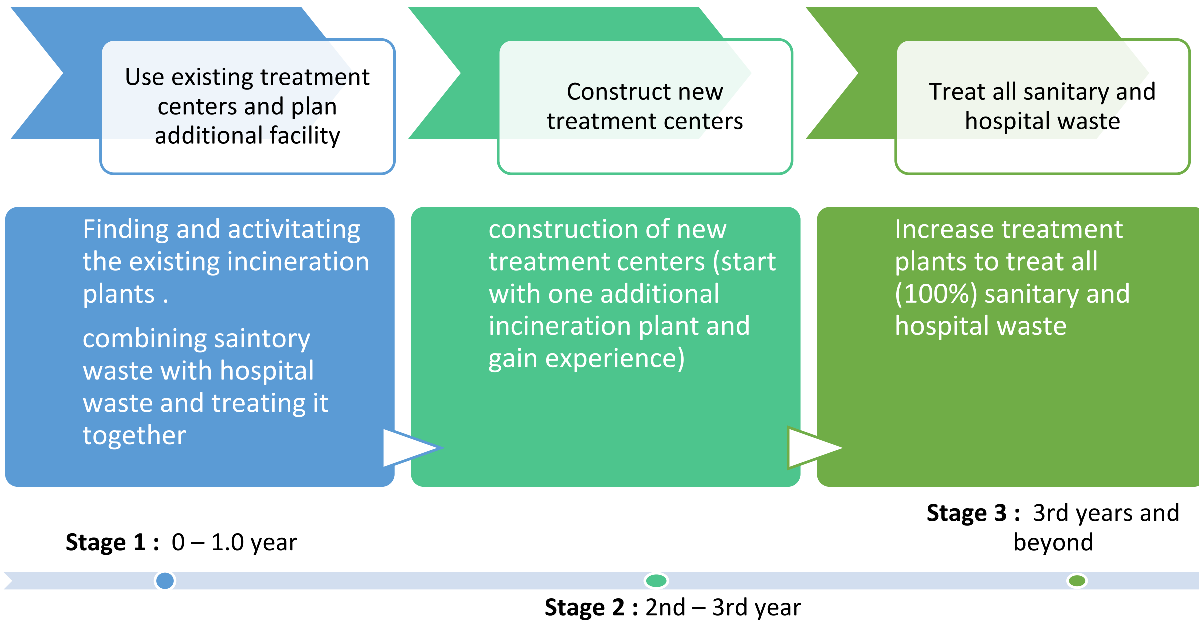


Figure 44: Approach for treating all sanitary waste

5.9.2 Job creation

Job creation is crucial to achieve fundamental development goals to manage waste and resources sustainably. Manpower is an essential prerequisite for urban development to be sustainable and well managed in terms of waste management. Even low skilled workers can find employment in the waste management sector. As part of sanitation, prevention of health problems, environmental protection, greenhouse gas mitigation, and resource efficiency waste management is vital. It is estimated that effective waste management and recycling can reduce greenhouse gas emissions by 10- 15%. Therefore, the development of sustainable waste management systems holds great promise for economic, ecological, and social advancement. But establishing sustainable waste management systems is a time consuming and challenging process. Sustainable waste management is crucial for the development of a green economy. Recycling in particular and waste management in general have the greater potential to create a lot of employment opportunities even for unskilled labour. Waste collection and sorting can be done by even illiterate people. This opens employment and income opportunities for disadvantaged groups of the population, contributing to the achievement of SDG 17, Goal 1: No Poverty.

Industries in industrialized countries developed collection and logistics systems to make the collection as efficient as possible and to save labour costs. Capital and machines are used to replace manual labour whenever possible. A high employment impact is desirable from a policy perspective of development in developing and populous countries such as India, where labour is available at a reasonable cost. Therefore, the collection systems used in industrialized countries do not fit the living conditions of people in developing countries. Rather, simple systems with a high level of service and based on the principle of the home collection which uses simple collection and transport techniques are more appropriate. They attain more collection rates and also have higher employment potential.

The scheme below (Figure 45) shows the job creation potential using the linear waste management practice, linear waste management practice with partial digitalization, and circular waste management practice with complete digitalization[102].

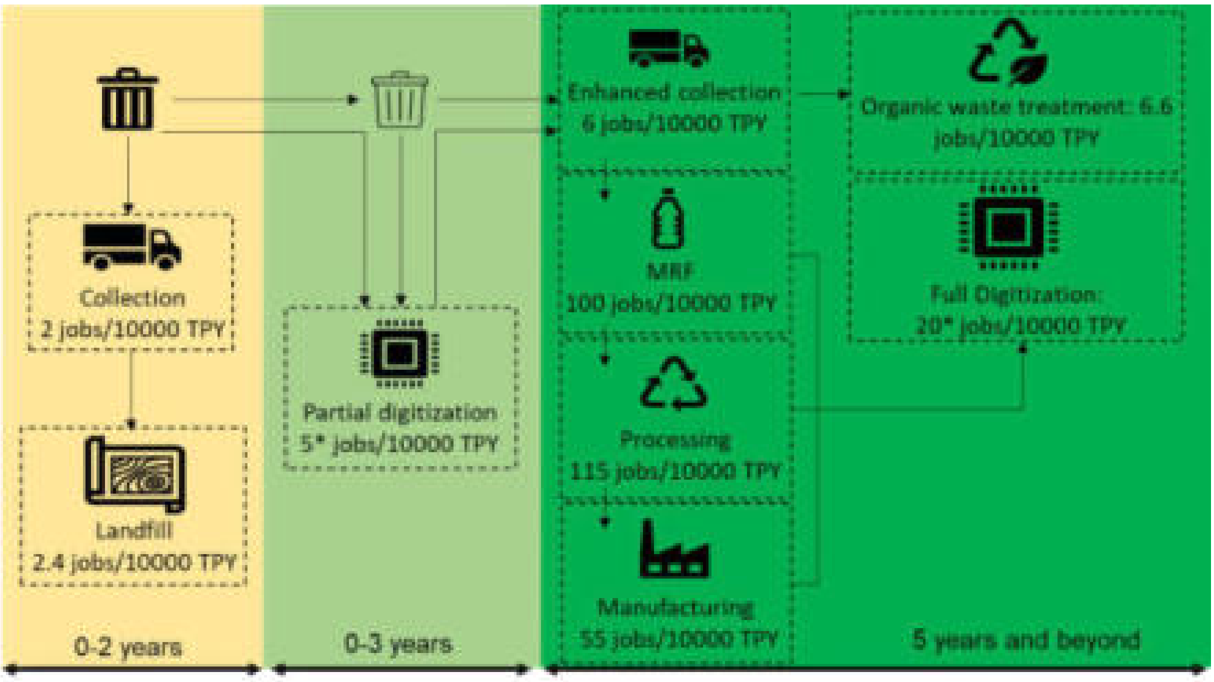


Figure 45: Job creation potential of the waste management sector[103]

As per the information provided by PBMC officials, PBMC is currently generating about 100 TPD of MSW and has 100% waste collection efficiency. On other hand, Swaraj Dweep is generating ~1 TPD and has 70% collection efficiency, and Shaheed Dweep is generating about

[102] https://zerowasteworld.org/wp-content/uploads/Jobs-Report-ENGLISH-2.pdf.%20. Accessed on: 20.12.2022
[103] https://zerowasteworld.org/wp-content/uploads/Jobs-Report-ENGLISH-2.pdf.%20. Accessed on: 20.12.2022

2.8 T/Month and has 100% collection efficiency. Considering already an established collection efficiency there is very minimal room to create the job in the waste collection system of ANI UT. However, the amount of organic waste treated in PBMC is very minimal, and the rural area (Swaraj Dweep and Shaheed Dweep) despite having a facility to treat and manage organic waste, no compost is produced so far. In this concern, according to our estimation setting up of a post composting facility to treat the entire organic waste generated in PBMC has the potential to generate ~18 jobs in ANI UT (refer to section 4.1.3). Additionally, in ANI UT there is a possibility to create more jobs by managing the generated coconut waste. According to PBMC and U.T policy strategy on SWM for ANI UT 2018, 23.35% of the waste generated in the urban area consists of coconut waste which significantly contributed to the organic waste generated. As per our estimation, the creation of small scale industries for processing coconut waste could create about 50 jobs within three years in ANI UT (refer to section 4.4.1). Nevertheless, partial digitalization of waste management in ANI UT has the potential to create 27 Jobs (considering 5 jobs /10000 TPY) and the complete digitalization of waste management has the potential to create 110 jobs (considering 20 jobs /10000 TPY).

Figure 46 depicts the approach and timeline that will guide the state's efforts for enhancing employment opportunities. In an improved solid waste management system there is a higher potential for job creation. In this regard, digitalization plays an important role by increasing system efficiency based on reliable data. In the early stages (up to 2 years) of improving the MSW management, collection service integration informal sector into the system, and partial digitalization of waste management sector could create job opportunities. In the medium term (2-4 years), the development and growth of the recycling industry, semi-mechanized treatment facility, and complete digitalization of waste management sector will create substantially high number of jobs. Finally in long term (4-7 years), under an improved system, SMEs in waste management companies and start-ups in the waste recycling sector would create the highest economic activity.

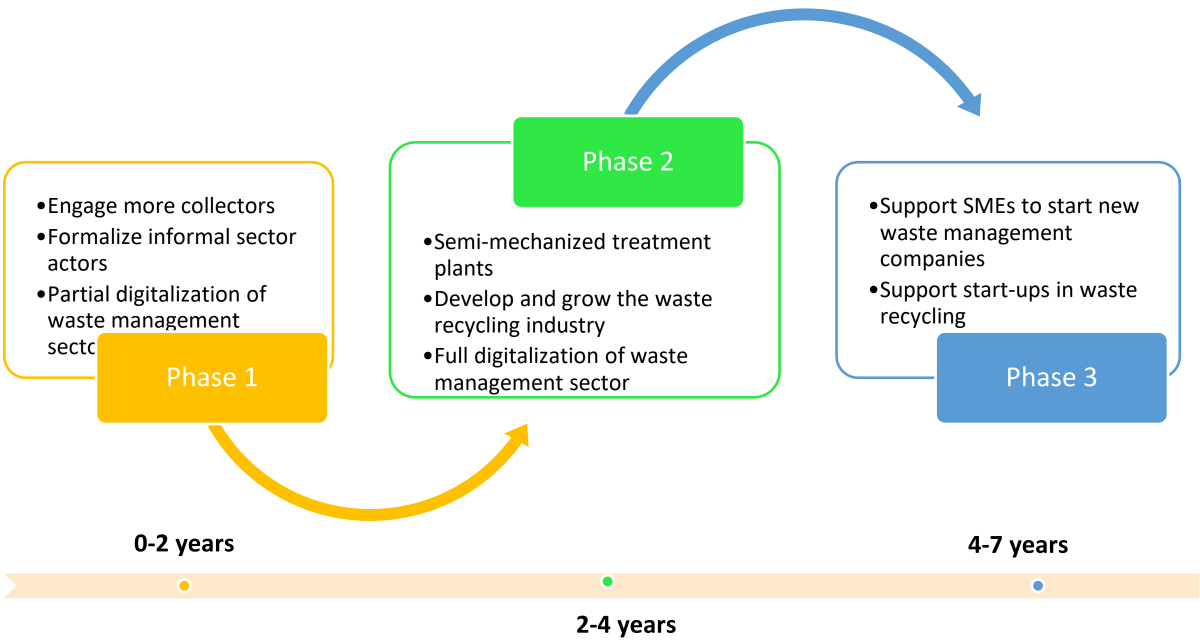


Figure 46: Approach for enhancing employment opportunities through waste management

5.9.3 Combating climate change and achieving SDG goals

India has attempted to adopt more environmentally friendly policies by committing to the United Nations Framework Convention on Climate Change (UNFCCC). Goals have been set for different sectors to reduce the emissions intensity of GDP by 33-35% by 2030 compared to 2005 levels. This would be equal to avoiding 359 billion tonnes of CO_2 equivalent. To achieve these goals, promotion of clean energy, enhancing energy efficiency in industries, developing of climate-resilient urban centres, promoting waste management, safe-smart and sustainable green transportation networks, planned afforestation, abatement of pollution, and citizens and private sector contribution to combating climate change are considered the main action areas. Accordingly, the country granted initiatives to the cities such as[104]:

- Swachh Bharat Mission (Clean India Mission) with objective to make the country clean and litter-free with scientific solid waste management in about 4041 towns covering a population of 306 million.
- Swachh Bharat Missions-Urban 2.0 designed to make to make Indian cities 'Garbage Free'
- Investment in Solid Waste Management (SWM) projects over the years and providing ₹ 25 billion (USD 397 million) as a grant in aid to states and Urban Local Bodies specifically for SWM through public-private partnerships.
- Amendment of Municipal Solid Waste Management (Management and Handling) Rules to emphasize proper segregation of waste at source.
- Enhancing the Waste to Energy capacity and encouraging conversion of waste to compost by linking it with the sale of fertilizers and providing market development assistance.
- Increase the forest/tree cover to enhance carbon sequestration by about 100 million tonnes of CO_2 equivalent annually.
- Adopting a megaproject called the National Initiative on Climate Resilient Agriculture (NICRA) and investing to enhance soil health.

[104] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf

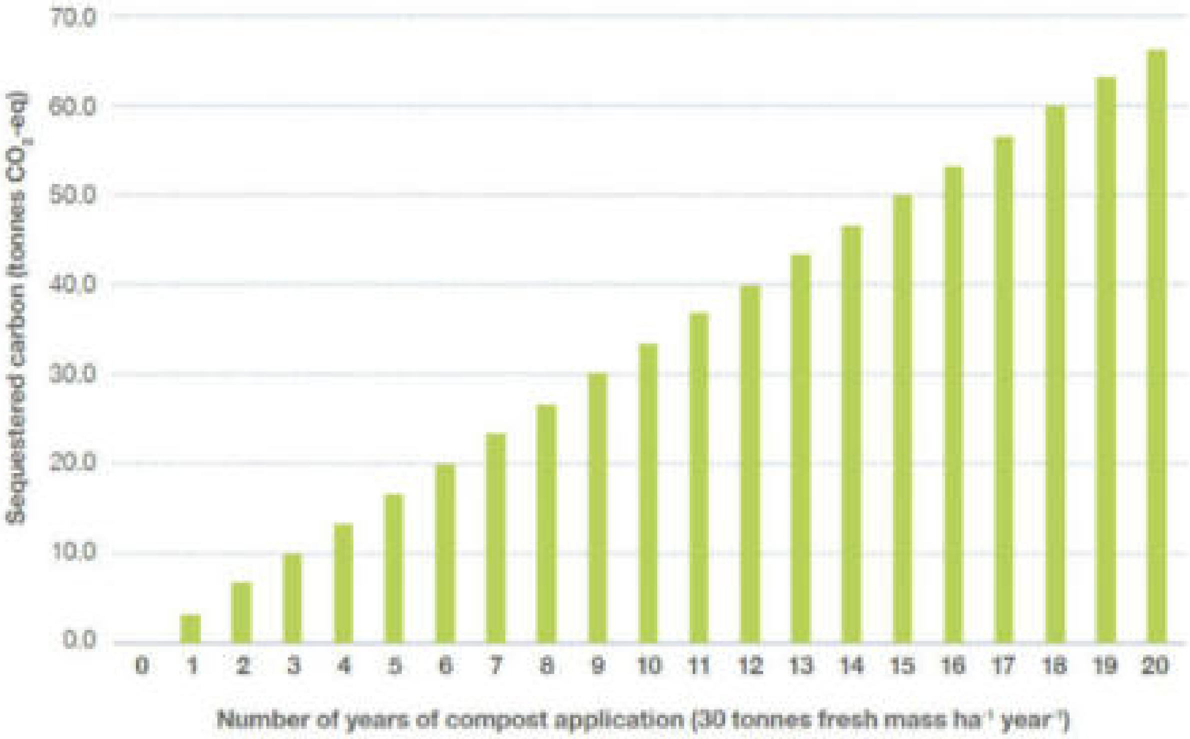


Figure 47: sequestered carbon over a 20-year period following 30 TPY of compost (fresh mass) applied to 1 hectare of land at the medium sequestration rate [105]

Management of dumpsites and increasing the organic waste management in ANI UT have the potential to contribute to achieving several goals of the adapted national strategy. According to our estimation ~90 of the generated organic waste in ANI UT is entering the dumpsites. Considering the fact that the dumpsite in ANI UT is unsanitary and without any mechanism for treating the landfill gas, there is a significantly huge amount of GHG is emitted into the atmosphere. More worrisome is the fact that the waste entering the dumpsites in ANI UT contains a huge amount of organic fraction in it. With the proper mechanism of waste collection and treatment, there is a possibility of diverting all organic waste from entering the dumpsite. Further, treatment of diverted organic waste from dumpsites has the potential to produce ~3 TPD of dry compost. Assuming a medium rate of increasing soil organic matter (50 kg SOC ha-1 yr-1 t-1 dry mass) and initial organic matter of about 1%, application of 30 tonnes fresh mass ha-1 year-1 would result in 33 and 66.1 (tonnes hectare-1) sequestered carbon in carbon dioxide equivalents over 10 and 20 years, respectively (Figure 47). This would also influence preventing soil erosion, which is in agreement with sustainable development goal target 15.3, i.e., combat desertification and restore degraded land and soil by 2030.

[105] https://www.iswa.org/biological-treatment-of-waste/?v=3a52f3c22ed6

According to our estimation about 90% (54 TPD) of the generated organic waste in PBMC is dumped uncontrollably in dumpsite without any further treatment. Every tonne of organic waste in the dumpsites emits 80.3 kg of methane into the atmosphere[106]. Utilization of biogas technology to valorise just 50% of the organic waste that is currently being dumped in PBMC could avoid 66 million tonnes of CO_2 equivalent/year entering atmosphere. Such initiative fosters India’s actions towards climate change mitigation.

5.10 Interlinking effects of adapting the suggested strategies

All the suggested strategies have their particularly designated benefits to increase the organic waste system of PBMC and rural ANI UT. Generation, collection, treatment and financing of the waste management system is well defined in this regard. Source segregation and separate collection is the key factor in improving the system and managing the dumpsites. Providing a proper collection system, digitalization and route optimization will increase material recovery and efficiency. Higher benefits for organic waste in PBMC will be guaranteed through the creating of centralized post composing facility. In the rural ANI UT, animal feeding, decentralized facilities and upcycling are better treatment approaches.

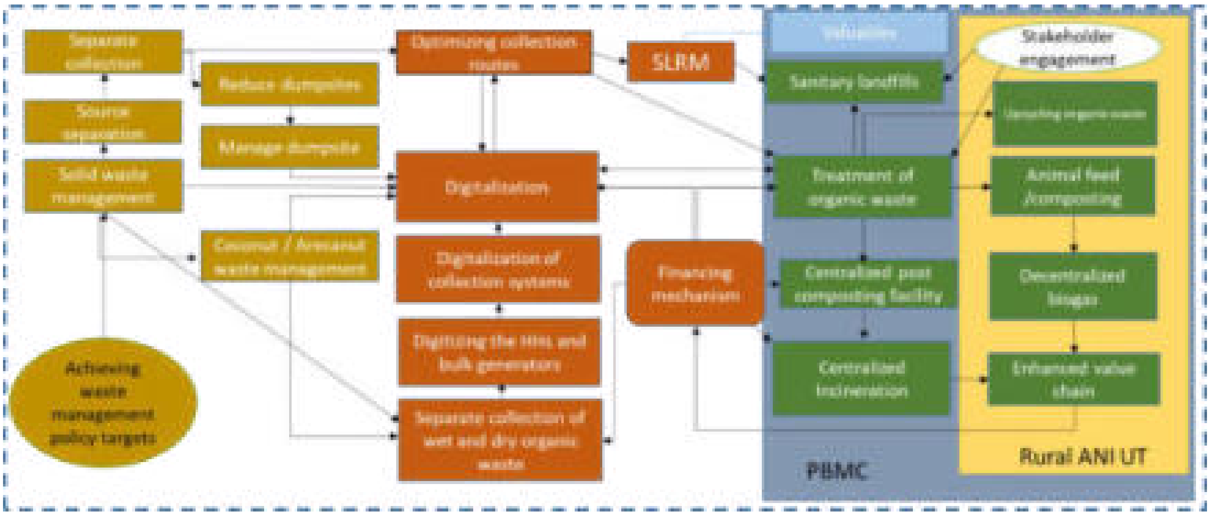


Figure 48 overview of the suggested strategies to improve OWM in ANI UT

All the explained strategies above have their particularly designated benefits to increase the organic waste system of ANI UT. Nevertheless, the implementation of these strategies will also have an interlinking effect between the strategies that enables the management of organic waste in ANI UT in the broader context. For an instance, by an optimised collection and transportation system there is a possibility to achieve 100% segregated waste collection in ANI UT. In the broader aspect, achieving 100 % collection efficiency will benefit in several ways viz. 1) a significant decrease in the number of garbage vulnerable points, 2) increases the value of organic waste (reuse of organic waste stream as animal feed) and enables the creation of MSMEs to treat the specific organic waste stream (for example coconut waste), 3) increases the quality of compost as the segregated waste stream has fewer impurities, 4) increase the revenue for the ULB, 5) creation of more sustainable jobs in every aspect of the

[106] https://extrafood.org/the-need/food-waste/ accessed on 18.06.2022

movement of the waste, 6) reduction of GHG emissions, etc. Similarly, as mentioned in section 4.1.3 a direct effect of having a centralized post composting unit can be seen through the increased quality and quantity of the compost produced in ANI UT. In a broader aspect, the successful implementation of a centralized post compost unit will have additional benefits viz. 1) decrease the organic waste dumped at garbage vulnerable points, 2) significantly decrease the amount of organic waste entering dumpsites 3) increase the quality of compost produced in ANI UT, 4) increase the sales of compost, 5) increase revenue generation, 6) creation of more jobs, 7) reduction in GHG emissions etc.

Similarly, as mentioned in section 5.2, direct effects of promoting of biogas technology in ANI UT can not only aid in the management of organic waste but, significantly influence the social-economical and environmental aspects of ANI UT, especially in the rural areas. In a broader aspect, the successful implementation of the above strategy will have additional benefits viz. 1) decrease the organic waste dumped at garbage vulnerable points, 2) decrease the load on the composting system in ANI UT 3) increase revenue generation, 4) creation of more jobs, 5) reduction in GHG emissions etc. The interlinking effects could be hard to quantify and the successful implementation of all the strategies will have a significantly increased interlinking benefit that could be seen in a shorter and longer period.

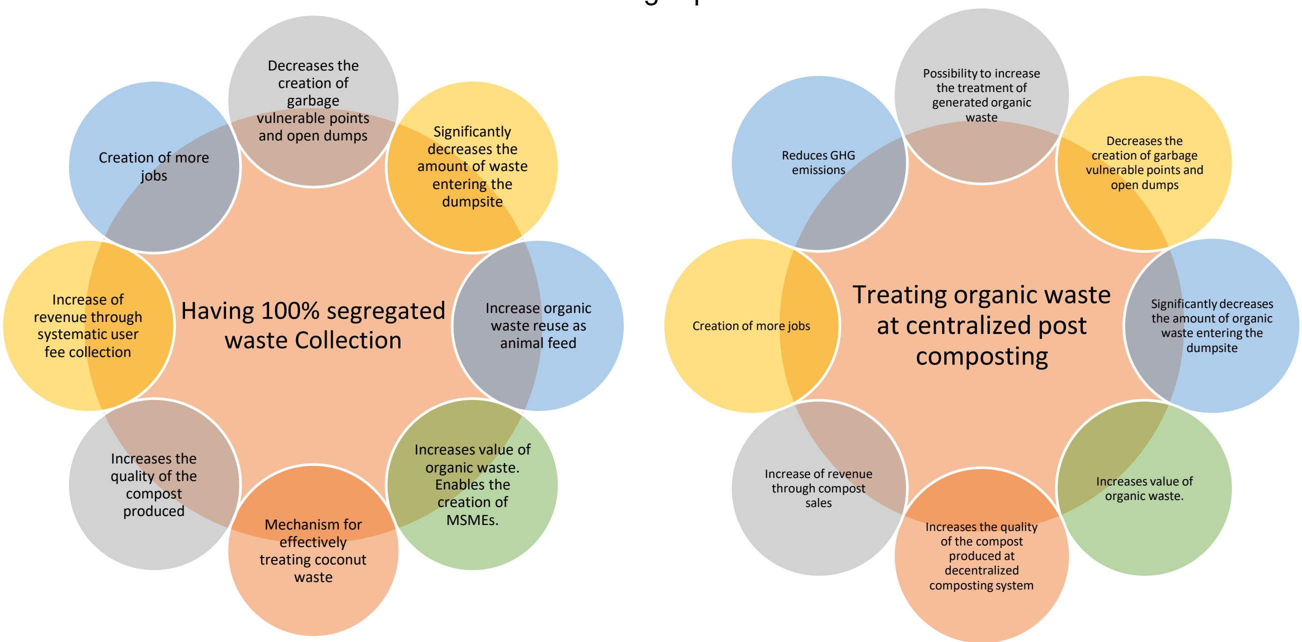


Figure 49 Interlinking effects of adapting the suggested strategies

5.10.1 Relevant international policies

The largest part of municipal waste is bio-waste, which primarily consists of food and garden waste. In European nations, different waste management policies are in place for this significant waste component, and they vary according to the circumstances and resources available there. Some European nations have already begun collecting bio-waste separately, but some are still looking for solutions. Yet, in 2018, significant revisions were made to European the Waste Framework Directive (WFD)[107] that in the next years, national, regional, and local authorities and stakeholders will need to make crucial decisions about the sustainable management of biowaste. The revised WDF mandates:

[107] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

- all EU Member States to collect biodegradable waste separately or assure source recycling from the end of 2023 forward.
- new objectives for the recycling of bio waste to achieve landfill reduction targets for municipal waste[108]
- the European Commission to propose a binding food waste reduction objective by the end of 2023, together with an aspirational aim to minimize food waste in accordance with Sustainable Development Goal 12.3 of halving food waste by 2030.
- the adoption of particular food waste prevention programs as well as assessing and reporting food waste generation on a yearly basis starting in 2020.

More than 34% of the municipal solid waste produced in the EU-28 in 2017—86 million tons in total—is made up of bio-waste (28 EU Member States for the period 2013-2020). Therefore, recycling bio-waste is essential for achieving the EU goal of recycling 65% of municipal wastes by 2035. The process of putting in place a separate bio-waste collecting system can be time-consuming and difficult. The integration of a bio-waste plan into larger waste and circular economy goals requires a comprehensive and coordinated policy framework. Pay-as-you-throw policies are the most often used form of policy since they clearly incentivize the separation of bio-waste from residual wastes. Other essential considerations include promoting awareness, giving customers accurate information, and matching treatment capacity to the volume of separately collected bio-waste.

Nearly two-thirds (60%) of all bio-waste from households and similar sources is food waste. Preventing food waste is seen as society's moral obligation more so than other sorts of waste. It is connected to the waste of financial resources and the unfavorable environmental externalities that arise. Food waste is often a top issue in waste prevention policies in the majority of European nations. Awareness-raising and informational initiatives are the most popular types of policy measures to combat food waste. Platforms for food redistribution and increased advertising of second-class food sales by shops are two more prevalent strategies.

Furthermore, the two most often used biowaste treatment methods at the moment are anaerobic digestion and composting. The compost and digestate must be of excellent quality to be used as a soil enhancer and/or fertilizer in order to complete the bio-waste cycle. Management of the process and end products' quality is crucial for developing a market for compost and digestate since it may foster consumer confidence in the results. A fundamental need for producing high-quality outputs is the separation of bio-waste at the source. National compost quality standards are being developed or already exist in at least 24 countries. Out of them, 12 countries have created compost quality certification and management programs, opening up access to markets with greater added values like potting compost.

Adopt the policy on collection of organic waste separately or assure source recycling

The EU Waste Framework Directive requires Member States to implement policies to encourage high-quality recycling through the separate collection of biowaste. This is a requirement for high-quality recycling and preparation for reuse. It also avoids the contamination of other waste streams with foreign materials. Advanced separate collection strategies including door-to-door collection and Pay-As-You-Throw (PAYT) models are legitimately offered plans that maintain the system's cost-efficiency, produce the best environmental and social outcomes, and meet the objectives. Once participants get training, it often results in greater environmental awareness on their part.

[108] https://www.eea.europa.eu/data-and-maps/indicators/diversion-from-landfill

A number of Member States have applied the revised Waste Framework Directive to the collection of biodegradable packaging and compostable food waste, which can be converted into energy through anaerobic digestion and industrial composting. The target placed by WFD in this scenario is that “all EU Member States to collect biodegradable waste separately or assure source recycling from the end of 2023 forward". In addition to helping to collect more bio-waste, biodegradable plastics will ultimately contribute to the new recycling targets. The revised version of the amended standard may be based on relevant European standards, including the harmonized standard EN 13432 for industrially compostable plastic packaging. The Packaging and Packaging Waste Directive recognizes that bio-based plastics can aid in reducing European dependence on imported raw materials and minimize plastic packaging's environmental impact. Packaging can be made more sustainable by using bio-based and recycled materials. However, European legislators fail to introduce concrete legislative measures that would encourage the use of bio-based recyclable and compostable packaging, despite the fact that Member States are encouraged to do so.

Implementation of such a policy and target in India can significantly increase the value of organic waste and enables in creating the higher quality of compost that can easily pass FCO compliance. Further in the long run it will also aid in the management of organic waste at the source level. In order to decide which distinct collection model to use, a set of standardized minimum requirements must be established. Not imposing a single model with a top-down approach, nevertheless, since local authorities require flexibility to choose their preferred option and that each solution should be tailored to the local circumstances.

Harmonization should be used in conjunction with other strategies that improve the treatment capabilities of underperforming regions, such as separate collection and recycling and reuse preparation. Harmonization shouldn't support any waste hierarchy-bottom solutions. In contrast, such harmonization should make it possible for waste management to prioritize waste avoidance efforts above reuse planning and high-quality recycling. In case of the ANI UT for example setting goals for diverting food waste to animal husbandries, raising public awareness and home composting is prioritized in the policy-making.

Adopt the policy on diversion of waste from landfill

Based on the waste hierarchy, the EU prioritizes waste avoidance before planning for reuse, recycling, other forms of recovery, and disposal, including putting in landfills. The least preferable approach, this one should only be utilized in extreme cases. The EU's long-term objective is to move toward a circular economy, which minimizes waste production and utilises waste that cannot be avoided as a resource wherever feasible. According to the EU Landfill Directive, by 2035, Member States must reduce the quantity of municipal waste delivered to landfills to 10% or less of the total amount generated. Accordingly, member states opt for other treatment methods including biological treatment of biowaste (composting and anaerobic digestion), material recovery and combustion.

Despite the fact that overall waste generation has continued to rise, the amount of waste going to landfills has reduced (7.6% less in 2018 than in 2010). The landfill rate, which is the amount of waste delivered to landfills as a percentage of total waste generated, dropped from 23% to 20% within the same time frame. There has been some good progress achieved in keeping waste out of landfills for some waste streams, such (mixed) domestic waste and comparable waste. The rate for combustion waste grew by 16% (8.5 million tons), while the rate for sorting residues increased by 111% (mostly secondary wastes from waste treatment plants) (19.5 million tons). Due to the expansion of the EU's combustion capacity, stricter requirements for the material utilisation of combustion residues, and the growth of the waste sorting industry, a shift from landfill to the material recovery of waste was made possible, resulting in these increases for combustion waste and sorting residues.

Bans and levies on landfills, as well as incentives for recycling, are policies that have been shown to reduce landfilling in European member states. The same policies on landfill charges and prohibition cannot be adopted in case of India since in many cases final disposal is performed by the public sector, thus recycling incentive works better, especially in case of biowaste. the major fraction of municipal waste in all studied provinces is organic waste and encouraging the source separation and treatment of biowaste in decentralized composting facilities should be linked to the policies for diversion of waste from landfill. In ANI UT, the policy should define goals for decreasing landfilling of the organic waste and address the home composting and community/decentralized plants.

5.10.2 Key performance indicators of the suggested strategies

This section provides a quantifiable measure of performance over time for a specific objective of the selected strategy. In this concern indicators such as 1. Promotion of biogas technology, 2. Upgradation of existing composting units and creation of post composting facility, 3. Optimization of waste collection and transportation system, and 4. Digitalization in waste management have been analysed and their micro indicators have been developed. The developed micro indicators help to understand results over a period of time enabling the municipalities for making better decisions. Additionally, micro indicators aid in predicting what might happen based on data, allowing the concerned authorities to make adjustments to improve outcomes.

The gradient of the colour shows the dependence between the micro indicators over the period. Achieving the initial micro indicators (indicated with the red colour of time duration) significantly influences the outcome of the micro indicators in the later stage. For an instance in the promotion of biogas technology, the actual benefits of achieving the micro indicators can only be seen between the time periods 12-18 months, when the micro indicator levels make the transition from yellow to green. However in upgrading existing composting units and creation of post composting facility, the gradient colour transition starts in 6th month and so does the visibility of the actual benefits.

The strategy of upgrading existing composting units and creation of post composting facility beginning 24 months are very crucial. Within the first six months, achievements have to be made on having a detailed reporting of the existing decentralised composting units and finalising the location for the construction of a centralised post composting facility. From 6-24 months micro indicators such as 1. Upgraded decentralised composting units, 2. Commencement of centralised post-composting unit construction, 3. Smooth functioning of all decentralised composting units, and 4. Production of good quality compost in the decentralised composting facility has to be achieved. During the first 24 months, the transition of colour is from red to yellow indicating low actual benefits. From 24 to 36 months the transition in the colour from yellow to green indicates the medium benefits which could be seen by the achievement of micro indicators such as 1. Fully functional centralised post composting unit, 2. 50% of the decentralised composting units linked to centralised post composting facility, 3. ~50% of generated organic waste being converted to FCO compliant compost. In the later 4th year of implementing the strategy, the transition in the colour is getting more green depicting the commencement of higher actual benefits. The success of this stage can be validated by my monitoring the micro indicators such as 1. ~100% of the decentralised composting units linked to centralised post composting facility, 2. ~50% of generated organic waste being converted to FCO compliant compost, 3. Increased revenue generation through sales of compost, 4. Zero organic waste entering the dump site.

For the strategy on optimization of collection and transportation, the beginning of 6 months is very crucial. Within the first six months plan has to be made on 1. Collection route and collection fleet, 2. Structure of user fee collection, and 3. Plan for implementing digital technology in the user-fee collection (house tag) and waste collection fleet. During the first six months as shown in the image, the transition of colour is from red to yellow indicating low to no actual benefits. From 6-18 months micro indicators such as 1. >70% of the collection fleet should be in operation, 2. ~50% of the collection fleet has to be connected to digital technology, and 3. 50% user fee collection via online house tag system has to be achieved. Later 3rd year of implementing the strategy the transition in the colour is getting more green depicting the commencement of higher actual benefits. The success of this stage can be validated by my monitoring the micro indicators such as 1. 100% of collection fleet connected to digital technology, 2. 100% User fee collection via online house tag system, and 3. Significantly increased quality of compost produced.

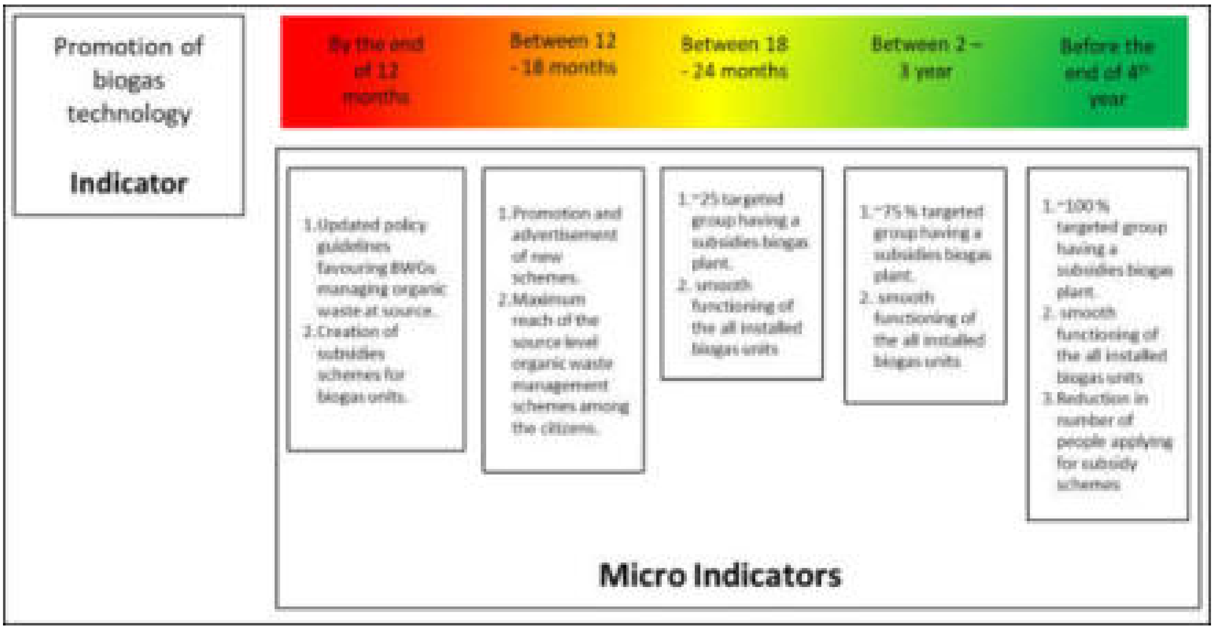


Figure 50 KPIs for promoting biogas technologies in ANI UT

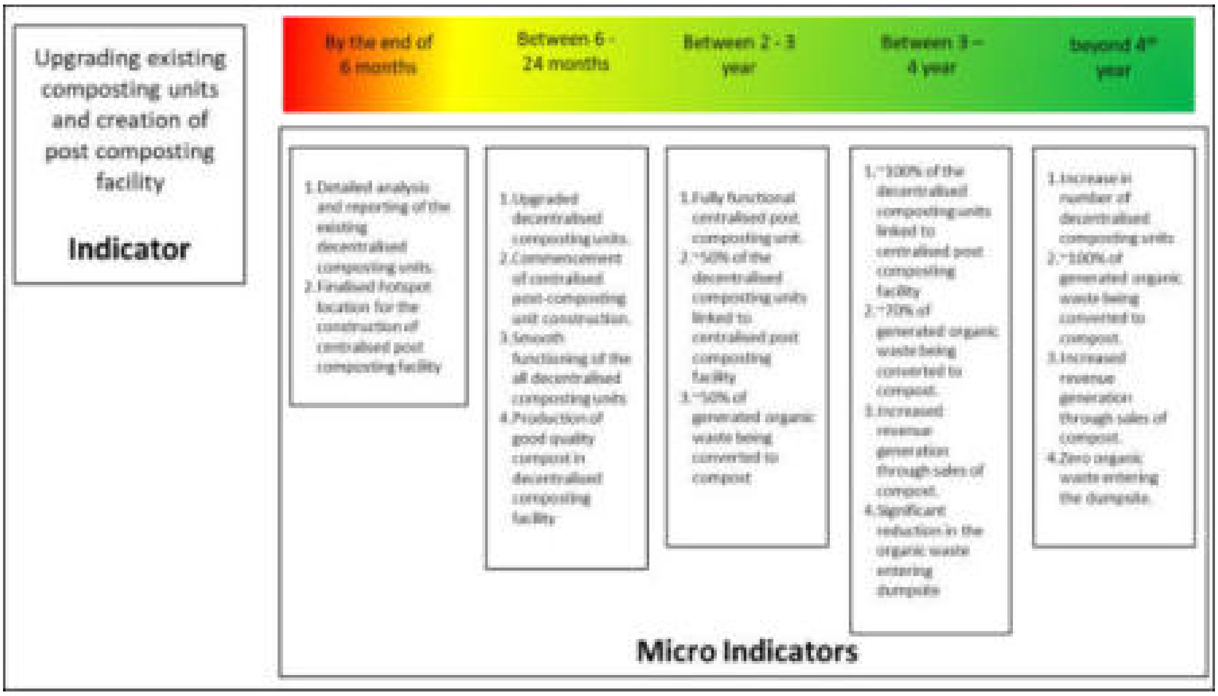


Figure 51 KPIs for upgrading existing composting units and creation of post-composting facility

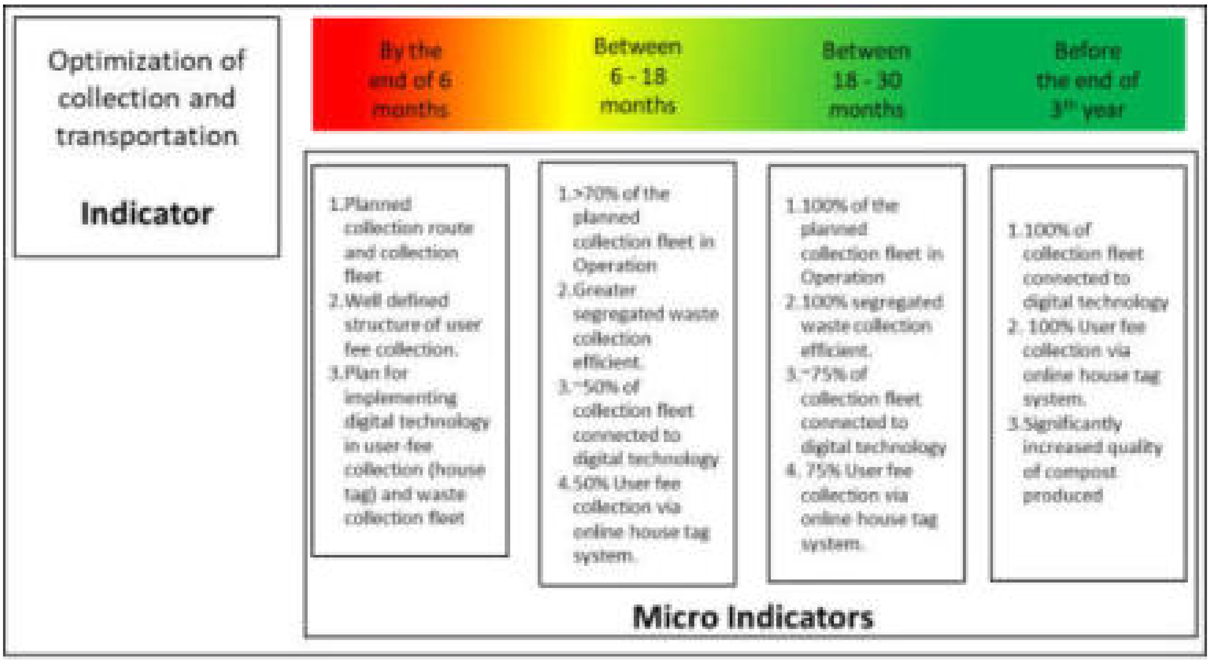


Figure 52 KPIs in optimizing collection and transportation system

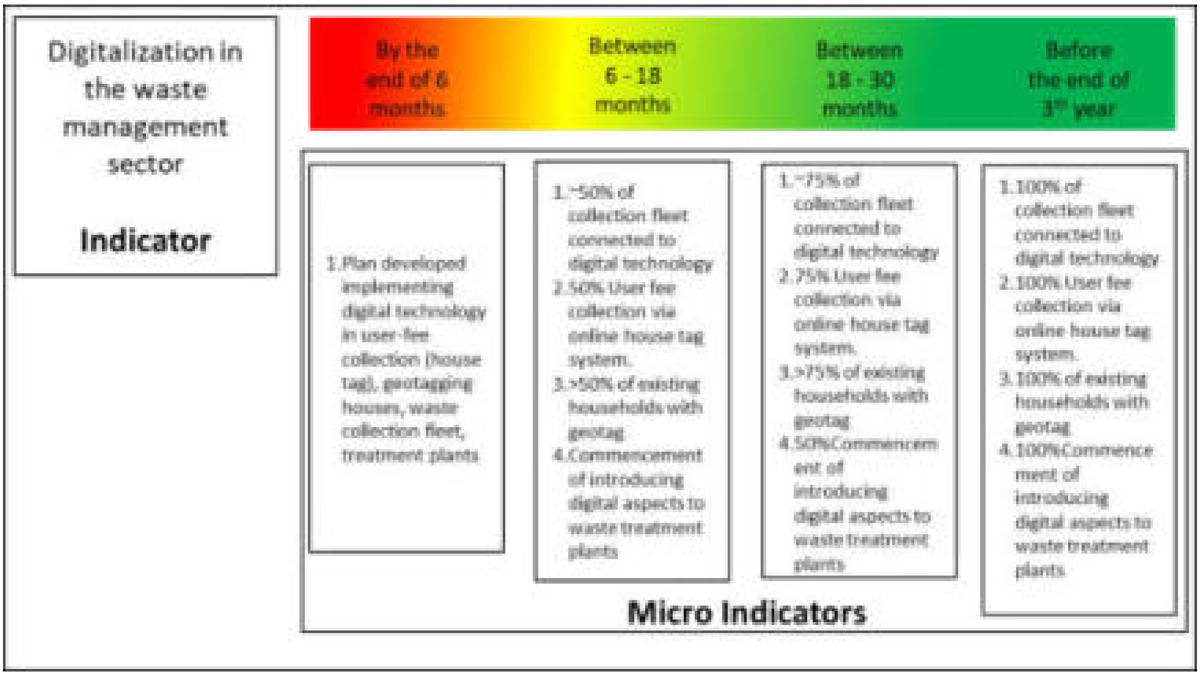


Figure 53 KPIs in the achievement of digitalization in waste management

6. Conclusion and timeline for implementation of strategies

Andaman and Nicobar Islands (ANI UT) as a collection of islands are distinctive in terms of their geographical location. With the presence of the endemic species and its ecological importance, ANI UT is protected by several environmental regulations. In this concern, mismanagement of waste in ANI UT has greater potential to threaten the delicate and vulnerable ecosystem of ANI UT. ANI UT reported generating up to 165 MT of solid waste per day, out of which at least 65% of the waste is sourced from the city of Port Blair which is also the capital of the Andaman and Nicobar Islands[109]. The current system of organic waste management in ANI UT is rudimentary and the fact a significantly high amount of organic waste is directly dumped in the dumpsites without any treatment is making the situation more worrisome. Therefore, this study investigated the organic waste management system through field visits in PBMC, Swaraj Dweep, and Shaheed Dweep to assess the gaps and suggest strategies to improve the existing situations.

Despite having several composting facilities in PBMC and Rural parts of ANI UT, the method used for composting is rudimentary in most cases without any roofing system, no aeration mechanism, and no leachate collection system. The lack of technical knowledge will not only make the composting process highly inefficient but, also makes the final quality of compost highly questionable. The U.T policies and By-Laws in ANI UT strongly suggest the management of organic waste at the source. In PBMC the percentage of households and commercial generators who are practising organic waste management at the source is significantly low (~5%). Similarly, in the rural area of ANI UT, expect a few expectations, no commercial generators are managing organic waste at the source. In this concern, there is a greater need for improvement of the overall system through awareness-raising programs for the creation of behavioural change. Nevertheless, equal importance has to be given for the troubleshooting and upgrading of the existing composting system for the production of good quality composting and to capture the entire organic waste stream of ANI UT.

As per the information by PBMC officials, the overall status of Door to door collection is 100%. Several open dumps of mixed waste were visible in the city during the field visit, which suggests that leakages are occurring in the primary collection of waste from all generators. Currently in PBMC door-to-door collection is mostly carried with the help of a makeshift crate. The design of the makeshift crate is very rudimentary with just a rope being tied to a plastic crate and the waste collector manually pulls the crate through the narrow passage. Most of the time separately collected waste in PBMC gets mixed during transportation due to the improper infrastructure for transportation of the segregated waste, There is no proper mechanism to monitor what is happening with the generated organic waste. Overcoming these challenges needs a systematic approach for selection of proper collection to flee, capacity building activities through various stakeholder groups.

Treatment of coconut waste is also a major concern in treating the organic waste streams of ANI UT. According to PBMC and U.T policy strategy on SWM for ANI UT 2018, 23.35% of the waste generated in the urban area consists of coconut waste. In PBMC, a significantly high amount of coconut waste is being dumped at the Brookshabad dumping site without proper

[109] Data submitted to NGT in affidavit dated April 2019 filed by the Union Territory of Andamans and Nicobar Islands, p.57.

waste management technology and disposal option for coconut waste. The successful adaption of the presented strategy in this not only aids in managing the entire coconut waste in ANI UT but, has the potential to increase the value of waste and create 50+ Jobs within the period of 3years. Nevertheless, the successful implementation of the presented strategies in the report provides several other benefits Viz. increasing the number of start-ups and small scale industries working in organic waste management, improving the funding mechanism, digitalization in the waste management system of ANI UT, job creation and cutting down the GHG emission in ANI UT.

Time-plan								
Year	*1st year*		*2nd year*		*3rd year*		*4th year*	
semi-annual	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*
Strategy: Approach for having a centralized post composting plant in A&N (Urban and Rural)								
Stage 1: Existing situation analysis and optimization								
Stage 2: Centralized secondary composting facility								
Stage 3: Operation, maintenance and beyond								
Strategy: Promoting various technologies for managing organic waste produced by BWGs at source (Urban and Rural)								
Updating policy guidelines and by-laws								
Promotion and advertisement of the new scheme								
Training for the BWGs interested to install a biogas plant								
Installation, operation, maintenance and collaboration between BWG								
Strategies: Optimization of collection and transportation								
Planning phase of collecton route, fleet and user-fee								
Collection fleet expansion								
Digitilization aspect implementation								
Strategy: Setting up of small scale industries for processing coconut waste (Starting with urban areas and extending it to rural areas)								
Planning								
Stage 1: Pilot stage								
Stage 2: Finalized model development								
Stage 3: Replication stage								
Strategy: Digitalizing the waste management sector								
Planning								
Pilot stage - Stage 1								
Partial implementation – Stage 2								
Full operations – stage 3								

The below table provides the summary of the developed strategies and their timeline that has been comprehensively discussed in the previous chapter of the report. These targets and action plans will guide the state's efforts to improve the existing organic waste management situation in ANI UT.

Annexure 1

The questionnaire used during the field visits

(Urban Area/City/District Name)- Management of Organic Waste in India Project

1.BACKGROUND

2. DEMOGRAPHY

3. URBAN ADMINISTRATION

4. SOLID WASTE MANAGEMENT

Waste Generation		
1	What are the sources of waste generated?	
	What are the types of waste generated?	
	What is the average municipal waste generation rate per person per day? (in Kg/Capita/d)	
2	What is the average total municipal waste generated? (TPD)	
3	What is the quantity of MSW generated (wet, dry , and HH hazardous waste) ? (avg TPD)	
4	What is the average MSW composition of waste generated from ULB areas (composition of various organics, inorganics etc.) (in %)	
5	Is city tracking waste generation and composition fluctuations in various seasons? Describe briefly.	
6	What is the average quantity of municipal waste that is generated individually from Residential, Commercial, Industrial and Public areas? (TPD)	
7	How many bulk waste generators are there in city and what is the quantity of waste generated by them? (TPD)	
8	Is there a fee associated with processing BWG's waste?	
Waste Segregation		
1	What is the status of source segregation in the city?	
2	Level of segregation practiced in the city? (2 way / 3 way)	
3	Is there a penalty for not giving segregated waste? (for HH)	
4	Is there a penalty for disposing waste at dhalaos/municipal bins after a time slot of the day? (How much)	
5	How much percentage of Households(Households) of the total Households in MC hand over source segregated waste for collection? (%)	
6	What motivates Households to handover segregated waste?	

7	Does the city have schemes like shop with your waste or buy back to develop a feeling of wealth in waste?	
8	What is the mechanism of source segregation? Is it carried out via domestic help who brings the waste to collection point or waste collectors who provide door to door collection ? Do citizens segregate waste from source?	
9	How does the ULB ensure that its staff is well aware of segregated collection and that the appropriate infrastructure is in place for streamlining segregated collection?	
10	What IECs/community level engagements are done by ULB to keep citizens engaged on waste management? (including engagement with NGOs/ other agencies)	
11	What is total number of registered ragpickers in the urban area/city/district? (if available ward wise also)	
Waste Collection		
1	What is the system for waste collection? (Primary and secondary - from dhalaos, dustbins, Households, etc.)	
2	Which are the waste collection facilities that are provided? (e.g.: door-to-door collection, bins placed at a close distance from or within a society, 3 bin system)	
3	What is coverage areas of bins in ULB? (#of bins/km^2) (Note: range to be provided for different type of areas: slum, residential, commercial etc).	
4	What is the status of door-to-door collection? (% Households or total Households getting d2d services)	
5	How is door-to-door collection service effective? Will the collector provide service to each and every household, even when the apartment is on 3rd floor or only till front gate of the apartments?	
6	What are the frequencies of waste collection? (wet, dry, HH hazardous). **In case** the system for waste collection from street bins (litter bins) is different, please inform about the frequency of collection.	
7	Is there any monitoring mechanism for households that provides segregated waste? (for waste collection)	
8	Is there a GPS system to track door-to-door collection? (for primary waste collection vehicles)	
9	What is the level of penetration of informal waste collectors? How much percentage of Households do they cover?	
10	What is the user charge for door to door collection? How is user charge collected ? What is the rate of user charge collection (₹)?	
11	What are the benefits extended to all Sanitary workers including Informal Waste Pickers, Informal sewer/septic tank cleaners – 'Safaimitras' i.e. workforce engaged under/through Jaagirdari system, SHG, NGO, private agency, etc.	

112	Is there any PPE/safety kits made available to informal sector workers ? Has ULB given trainings to informal waste collectors in past? (please elaborate topics of such trainings and number of such trainings)	
13	How is the waste collection mechanism for BWGs including marriage homes? (For both organic and inorganic waste)	
14	Are there any on-call collection services available for dry waste and organic waste management?	
15	Is there any agency providing services for dry waste collection based on app or webportal or via association with RWA or others?	
16	Is waste collection infrastructure available with ULB for primary collection (such as carts, tricycle, LMV and colour coded bins, dhalao,etc.)?	
17	In case of waste collection by ULB, is there a contractor to provide d2d collection service or is it carried out by th ULB itself?	
18	Please provide the total number of staff and collection workers.	
19	Who is responsible for the collection of HH waste, e-waste, and C&D waste that is generated within MSW? (If there is any).	
20	How does the city ensure integration of informal sector?	
21	Is there a buy back system/incentive for e-waste in city coming to e- waste collection centre established by ULB?	
22	Is there a mechanism to collect waste from open plots/ open drains (non designated waste collection spot)? Please elaborate mechanism and frequency of waste collection from such areas	
23	Is there a formal mechanism to collect waste from hotspots (undesignated collection spots) ?	
24	What is the total number of dhalaos/waste dumping sites in the urban area/city/district?	
25	What is the total number of sorting centres in the urban area/city/district?	
26	What is the total number of garbage vulnerable points (GVPs) in the urban area/city/district?	
27	How many GVPs in the urban area/city/district, have been transformed?	
Waste Transportation System		
1	What are the types (and numbers) of waste transportation vehicles available throughout urban area/city/district? (eg, autotipper, trolley, rickshaw, wheelbarrow)	
2	Among point 1 above, how many are compartmentalized with/without ICT systems enabled?	
3	Is tipping fees collected? If yes, from how many areas in the urban area/city/district?	

4	What is the number of trips per day by waste collection vehicle?	
Waste Processing		
1	What is the total number of processing sites in urban area/city/district? (installed, functional and under construction)	
2	What is the installed capacity of treatment plants? (Non-biodegradable and biodegradable waste with name of plants and location)	
3	Technology adopted for each treatment plant (both for biodegradable and non-biodegradable).	
4	What is the amount of rejects we get from organic waste processing plants? (Rejects in TPD from each, if possible)	
5	What is the amount of waste processed by RWA/home composting?	
6	How much compost is generated and provided to fertilizer companies/farmers/horticulture department/sold at other places?	
7	Is city compost FCO compliant?	
8	What is the off- take quantity for city compost? And what is the selling price for market?	
9	Are there any compost testing labs available nearby?	
10	How many biogas/bio methanation plants are in the city? (for MSW)	
11	How is biogas utilized in the urban area/city/district, along with the amount utilized for each use?	
12	What is the amount of mixed waste compacted?	
13	What is the total number of compactors installed?	
13	What is amount of waste reaching the landfill site? (composition in wet, dry and mixed)	
14	Amount of Leachate generated and its fate	
15	Is the landfill a sanitary landfill? If there is none, are there any under construction?	
	Remediation measure level for old dumpsites if any? (In percentage)	
16	How many RWAs/institutions/bulk waste generators (BWGs) are involved in the waste processing at source, and what are the processes used by them?	
17	Any innovative scheme related to waste processing and management (around 3 R's) available in the urban area/city/district? If yes, details please.	
Digital Innovations and Capacity Building		
1	Any digital app based services available? If yes, details please.	
2	Whether the digital app has any bottlenecks? If yes, what are these bottlenecks as per the observations?	
3	Is ICT based system being used for monitoring the staff involved in waste management? If yes, how many such staffs enrolled via this system?	

4	For the staffs not enrolled, how are they being monitored?	
5	Does a public grievance monitoring system exist for the urban area/city/district related to waste management? If yes, what are modes? (online/offline)	
6	What is the percentage of such grievances resolved? (monthly/annually)	
7	What are the modes utilized for social media outreach and how often? (twitter/facebook/awareness/community engagement)	
8	Are there any training sessions being conducted? If yes, the regularity period of these trainings and for whom are these sessions conducted?	
9	Are there any training partners involved?	
10	Are there any initiatives taken at local level for reducing the waste generated at HH/RWA/Bulk waste generator level in the urban area/city/district?	
11	What schemes/ competitions are there at urban area/city/district level for waste management? (reducing/reusing/recycles the waste)	
Citizen Engagement		
1	How many NGOs/SHGs/Private sector/CSR, or others involved in waste management, along with the nature of engagement?	
2	How many street vendors/hawkers are associated with PM SVANidhi Scheme followed by 'Swachhata Oath' signed?	
3	Whether Market associations and Government offices associated with any specific citizen engagement initiatives? (Name of such organizations and the initiatives)	
4	How many art works around SBM and Swachh Sarvekshan been done or under progress? (artefacts, billboards, hoardings, wall writings, mascots)	

5. *FINANCE*

Grants for SWM	
Expenditure on SWM	
Property tax	

6. LOCAL CONTACT PERSONS

Annexure 2

Compost quality assessment system

Heavy metal content of compost defines by different standards

Country	Type of standard	Heavy metal limit (mg/Kg)							
		As	Cd	Cu	Cr	Pb	Zn	Ni	Hg
Germany	Class I	-	1	70	-	100	300	35	0.7
	Class II	-	1.5	100	-	150	400	50	1
Austria	Class A+	-	0.7	70	70	45	200	25	0.4
	Class A	-	1.0	150	70	120	500	60	0.7
	Class B	-	3.0	500	250	200	1800	100	3.0
Belgium		-	1.5	90	70	120	300	20	1
Denmark		25	0.8	100	-	120	4000	30	0.8
France		-	3	-	-	800	-	200	8
Portugal	Class I	-	0.7	100	100	100	200	50	0.7
	Class II	-	1.5	200	150	150	500	100	1.5
	Class II A	-	3.0	400	300	300	1000	200	3.0
	Class III	-	5.0	600	400	500	1500	200	5.0
Spain	Class A	-	0.7	70	70	45	200	25	0.4
	Class B	-	2.0	300	250	150	500	90	1.5
	Class C	-	3.0	400	300	200	1000	100	2.5
Canada	Category A	13	3.0	400	210	150	700	62	0.8
	Category B	75	4.0	-	-	500	1850	180	5
EU eco-label to growing media	-	-	1.0	100	100	100	300	50	1
EU - Council Regulation No 2092/91	-	-	0.7	70	70	45	200	25	0.4
Iran		10	10	650	150	200	1300	120	5
India		-	5	300	50	100	1000	50	-
Malesia		-	5	-	200	300	-	150	2
Tunes		-	3	300	-	180	600	60	2
China		30	3	-	300	100	-	-	5

Annexure 3

Fertilizer Index and Clean Index

Fertilizing Index (FI)

Fertilizing Index (FI) is defined by Saha et al. (2010) according to the following formula:

$$FI = \frac{\sum_{i=1}^{n} S_i W_i}{\sum_{i=1}^{n} W_i}$$

Where S_i is score value assign to analytical data and W_i is the weighing factor of each parameter. Criteria for assigning 'weighing factor' to fertility parameters and 'score value' to analytical data is as followed:

FI	Score value (Sj)					Weighting factor
	5	4	3	2	1	
Total organic C (%dm)	>20.0	15.1-20.0	12.1-15.0	9.1-12.0	<9.1	5
Total N (%dm)	>1.25	1.01-1.25	0.81-1.00	0.51-0.80	<0.51	3
Total P (%dm)	>0.60	0.41-0.60	0.21-0.40	0.11-0.20	<0.11	3
Total K (%dm)	>1.00	0.76-1.00	0.51-0.75	0.26-0.50	<0.26	1
C/N ratio	<10.1	10.1-15	15.1-20	20.1-25	>25	3
Respiration activity (mg CO2-C/g VS d)	<2.1	2.1-6.0	6.1-10.0	10.1-15	>15	2

Clean Indicator (CI)

Clean Indicator (CI) is defined by Saha et al. (2010) with following formula:

$$CI = \frac{\sum_{i=1}^{n} S_j W_j}{\sum_{i=1}^{n} W_j}$$

Where S_j is the score value assigned for analytical data and Wj is the associated weighting factor for each specific heavy metal. Criteria for assigning 'weighing factor' to heavy metal parameters and 'score value' to analytical data is as followed:

CI	Score value (Sj)						Weighting factor
	5	4	3	2	1	0	
Zn (mg/kg dm)	<151	151–300	301–500	501–700	701–900	>900	1
Cu (mg/kg dm)	<51	51–100	101–200	201–400	401–600	>600	2
Cd (mg/kg dm)	<0.3	0.3–0.6	0.7–1.0	1.1–2.0	2.0–4.0	>4.0	5
Pb (mg/kg dm)	<51	51–100	101–150	151–250	251–400	>400	3
Ni (mg/kg dm)	<21	21–40	41–80	81–120	121–160	>160	1
Cr (mg/kg dm)	<51	51–100	101–150	151–250	251–350	>350	3

Annexure 4

Technical aspects for smooth operation of biogas plant

The rapid multiplication of organisms is the key to an effective digestion. The operational parameters of anaerobic digestion are focused on uplifting the growth and density of these organisms, which ultimately enhances the overall efficacy of the digester. The integration and interdependence of these parameters are shown in the Figure 54, and later explained in this section below. The technical, biological, and chemical factors play a vital role in the monitoring and maintenance of any biogas plant. The parameters such as High Retention Time (HRT), Carbon and Nitrogen ratio, pH of the substrate, and Organic Loading Rate (OLR) are crucial while planning a biogas plant.

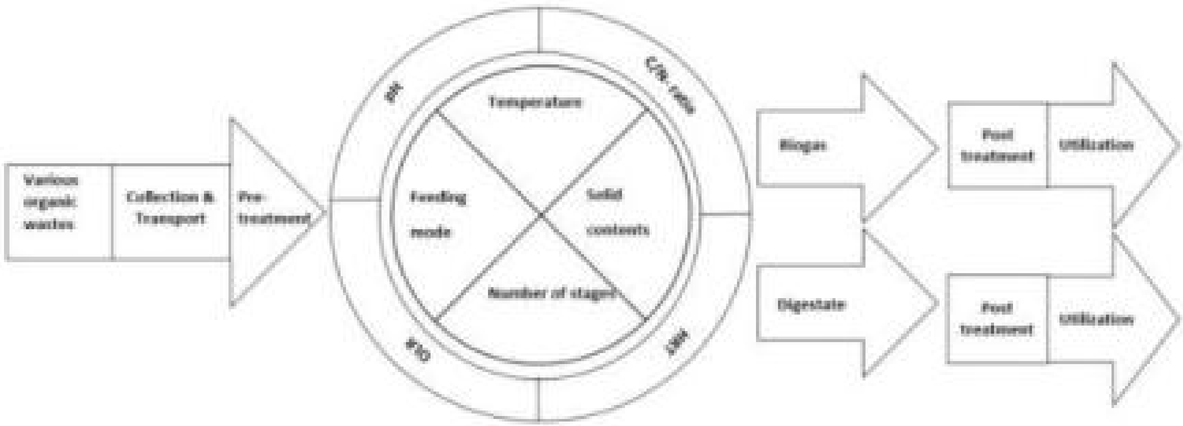


Figure 54: The systemic supply chain of the anaerobic digestion process and parameters (Vögeli, Y., et al., 2017)

Operational temperature: Anaerobic Digestion operates at two optimum ranges of the temperature; 1) 30-40 °C, for the mesophilic microorganism's growth at an average of 37°C. 2) 45-60°C, for the growth of thermophilic microorganisms at an average temperature of 55°C. The mesophilic range of microbes are more adapted to the anaerobic digestion process. They are stable, and adapt to external changes of temperature and other environmental conditions well. Moreover, they consume less energy resulting in more energy products at the end. Contrastingly, for a maximum yield, mesophilic organisms need longer retention as their digestion process is slower than the thermophilic microbes. For this reason, since thermophilic microbes consume more energy they also operate at 50% increased efficiency by digesting fat-rich materials, and producing enzymes rich in yielding maximum biogas production[110]. As the thermophilic microbes function better at the higher temperatures, it results in a fractioned increase in CO (carbon monoxide content) because of lower solubility of carbon at high temperatures. Thus, thermophilic digesters are recommended less for the large-scale biogas plants.

[110] Deublein D. and Steinhauser A. (2011). Biogas from waste and renewable resources: an introduction, Wiley -VCH Verlag GmbH & Co. KGaA

pH: An ideal range of pH for an anaerobic digester to produce biogas in its maximum capacity is between pH 6.5 – 7.5.[111,112] Different phases of the digestion process occur at different pH levels. For example, methanogenic phase occurs at the alkaline range of pH 6.5 – 8.2, whereas acidogenesis and hydrolysis phases occur in the range of pH 5.5 – 6.5 which are comparatively acidic stages. The overall anaerobic digestion is alkaline in nature, thus the upkeep of alkaline level upto 3,000 mg/L is necessary in the whole process.[113] A digester containing a high volatile acid concentration needs normally a higher-than-normal pH value due to the buffer effect of Carbon dioxide/bicarbonate (CO_2^-/HCO_3^-) and ammonia/ammonium (NH^{3-}/NH_4^+). As methanogenic bacteria are very sensitive to pH, they cannot survive below a pH of 6.5[114]. Addition of lime to the substrate can be done to neutralize acidity. Another option is the addition of sodium bicarbonate and sodium hydroxide, they are not a cost-effective option but they also do not form a precipitate at the end unlike lime. In an unfavourable circumstance of unavailability of funds and time, sodium salts can also be directly added for neutralization.

Carbon to Nitrogen Ratio: C:N is the proportion of the Carbon to Nitrogen. A balance of amount of carbon to nitrogen is crucial in degradation of organic content of the digester. The consumption of carbon is 25 to 30 times higher that of nitrogen in the digestion process. Since, amount of carbon reduces rapidly, addition of external carbon content is needed in the form of dry feedstocks which are rich in carbon. With the increase in C:N ratio, a significant increase in the protein by consuming nitrogen can be observed. In the conditions of lower carbon content, the nitrogen gets concentrated within substrate resulting in the formation of ammonia. The formation of ammonia is a warning sign for the failure of the digestion process, as it can significantly increase pH to the toxic levels in the digestion process.

Organic Loading Rate (OLR): The amount of raw materials fed per day per unit volume of digester capacity is termed as organic loading rate and measures the biological conversion capacity of the anaerobic digestion process. Overfeeding or underfeeding of raw materials results in the accumulation of acidic or alkaline solutions which are not favourable conditions for anaerobic bacteria[115]. A mathematical model has been developed by Srivastava and Chynoweth[116] to explain the biogas yield as a function of organic loading rate by using a continuously stirred tank and a non-mixed vertical flow reactorOn an industrial scale, organic loading ranges from 4 to 8 VS/m° for the reactor in a day. This range can result in an efficient removal of volatile solids upto 70%[117]. Although, it works for stirred reactors, for non-stirred reactors the optimum organic loading can stay for upto 2 kg VS/m° per reactor in a day.

Hydraulic retention time (HRT): HRT is the average period that a given quantity of input material remains in the digester to be acted upon by the methanogens. The retention time can be calculated accurately in batch type facilities. For continuous facilities, retention time is generally calculated by

---

[111]Khalid A., Arshad M., Anjum M., Mahmood T., Dawson L. (2011). The anaerobic digestion of solid organic waste-Review. Waste Management Aug; 31(8): 1737–44.

[112] Mata-Alvarez J. (2003). Biomethanization of the organic fraction of municipal solid wastes. IWA publishing. London.

[113] Igoni A. H., Ayotamuno M. J., Eze C. L., Ogaji S. O. T., Probert S. D. (2007). Designs of anaerobic digesters for producing biogas from municipal solid waste. Applied Energy 85, p.430 – 438.

[114] P. Mahanta, *Biogas Digester: A Discussion on Factors Affecting Biogas Production and* Field Investigation of a Novel Duplex Digester *.* Journal of the Solar Energy Society of India, 2005

[115] TERI, 1987, Fixed Dome Biogas Plants: A Design, Construction and Operation Manual, New Delhi.

[116] Srivastava, V.J. and Chynoweth, D.P., 1987, Kinetic Analysis of Biogasification of Biomas, Waste Blend and Its Engineering, Significant Energy from Biomass and Wastes, Elsevier

[117] Vandevivere P., L. De Baere, W. Verstraete (2003). Types of anaerobic digesters for solid wastes, in Biomethanization of the Organic Fraction of Municipal Solid Wastes, J. Mata-Alvarez, Editor. IWA Publishing: Barcelona. p. 111–140.

dividing the total volume of the digester by the daily influent rate[118]. Depending upon various factors like the design and operating temperature of the digester, HRT varies between 20 and 120 days. HRT for the digesters is usually 40- 60 days in tropical regions such as India[119]. A lower retention time for upto a few days is required to operate digestors at a thermophilic temperature range.

Inhibitors: The inhibitors have to be considered when planning and operating a biogas plant. Depending on the concentration some compounds can be toxic in the anaerobic digestion process which affects the biogas yield. High concentrations of some inhibitors can be toxic to the anaerobic process. The typical inhibitors of an anaerobic process are oxygen, hydrogen sulfide (H_2S), organic acids, free ammonia, heavy metals, tannins/saponins/mimosine, and other hazardous substances like disinfectants from hospitals or industries, herbicides, insecticides from agriculture, markets, gardens, households, and antibiotics (Bacitracin, Flavomycin, Lasalocid, Monensin, etc.)[120].

One of the most common inhibitors of anaerobic digestion is ammonia nitrogen[121]. Inhibition through ammonia can be done in a variable range of concentrations. Ammonia inhibition can be attained by inorganic nitrogen concentration of 1400 to 7000 mg N/L. This clearly indicates that ammonia inhibition takes place at a large concentration range[122]. Inorganic nitrogen concentration in an anaerobic reactor contains mainly ammonia (NH_3) and the protonated ammonium (NH_4^+). Most of the inorganic nitrogen is in the form of ammonium at normal pH ranges. The concentration of ammonia also increases with an increasing pH and temperature. The increase in ammonia starts to diffuse through the membrane cells and hinders the functioning of the cell through the disruption of proton and potassium balance inside the cell membrane[123]. This inhibition can result in acidification of the anaerobic digester due to the imbalance and gathering of intermediate digestion products such as volatile fatty acids (VFA). To reduce higher concentrations of ammonium, a longer adaptation time can be given to the anaerobic microorganisms. However, providing a longer adaptation time can result in less methane production.

Classification of anaerobic digestion technology

Abundant Anaerobic Digestion technologies for the treatment of biowaste have been developed worldwide. This makes the selection of a suitable technology difficult to choose from an extensive number of technical options. Digesters range in complexity from simple cylindrical cans with no moving parts to fully automated industrial facilities. Biogas systems can be classified according to their critical operating parameters and elements of reactor design. The following sections discuss the distinguishing features of the selected anaerobic digestive systems.

Temperature: From being critical parameter in the operation of anaerobic digestion units, the temperature is also used as a classification category for the anaerobic digestion systems. This category is divided into mesophilic (30-40°C) and thermophilic (45-60°C) systems. Anaerobic digestion is not suitable for psychrophilic temperatures as the reaction rate is very slow and below 20°C. Thermophilic digestion systems consume more energy and are thought to be less stable than mesophilic digestion systems. However, in thermophilic digestion higher temperatures facilitate

---

[118] Biogas Digest, Volume 1, Information and Advisory Service on Appropriate Technology
[119] UN Guidebook on Biogas Development, 1980, United Nations, New York.
[120] Deublein D. and Steinhauser A. (2011). Biogas from waste and renewable resources: an introduction, Wiley -VCH Verlag GmbH & Co. KGaA
[121] Biogas Digest, Volume 1, Information and Advisory Service on Appropriate Technology
[122] Chen Y., Cheng J. J., Creamer K. S. (2008): Inhibition of anaerobic digestion process: A Review, Bioresource Technology
[123] Kayhanian M. (1999). Ammonia inhibition in high solids biogasification: An overview and practical solutions. Environmental Technology 20

faster gas production and faster reaction rates. A higher temperature also facilitates the hyalinization of the digestate. The developing countries with tropical climates typically do not have heated systems and therefore typically operate in the mesophilic range.

Total Solid content (wet/dry system)/Solid content: Biogas digesters are designed as either wet or dry systems depending on the Total Solid (TS) content of the substrate fed into the anaerobic digester system. Wet biogas reactors have a total solid content of 16%, semidry and dry biogas reactors have a total solid content of between 22 and 40%[124]. Dry biogas reactors are considered to be better compared to wet biogas reactors as the dry digestors usually require smaller reactor volume, lower requirements of energy, and minimal effort in material handling[125]. Further, dry digested material can be directly used as a fertilizer or can be made into pellets to use as biomass fuel as it has less moisture content after the digestion process.

Despite these numerous advantages of dry anaerobic digestion and the continuous progress in system design, a number of practical barriers still hinder the commercialization of this technology in a developing country context. One barrier is the typical batch-wise process (described in more detail below) and another is the filling and emptying process which requires a large enough opening which regularly needs to be sealed in a gastight manner.

Feeding mode (continuous/batch): Feeding of anaerobic digesters can be done either in continuous feed or batch-wise feed. Generally, biogas plants in developing countries are operated in a continuous feeding mode. In continuous feeding mode, the feedstock is added at regular intervals which provides a continuous digestion process.

In batch-fed digesters, first the feedstocks are filled in reactors, closed and left for digestion (retention time), later the digester is opened and emptied[126]. Due to their simple design and lower investment costs, batch systems are recommended to use in developing countries. However, batch systems show serious limitations as once if a batch is shutdown, it undergoes through the methanogenic process as a consequence. This shows that there is high possibility of fluctuations in the production of the gas until the whole system starts to operate stably. This affects the produced gas quality as well. Also, the reactor height is limited in order to ensure the right infiltration of the percolate. Additionally, gastight sealing of the inlet/outlet gets difficult when the doors of the reactors must be opened and closed after each batch sequence. This may lead to biogas losses and an increase in the explosion risk, when emptying as the rest of the methane in the reactor mixes with the air[127].

Number of stages: Generally, biogas plants are either single-stage systems or multi-stage systems. In both the systems hydrolysis / acidogenesis and acetogenesis / methanogenesis steps occur in either the same or in separate digesters. Single-stage systems are simple and easy to design, build and operate. These are less expensive in comparison to multi-stage systems. Single-stage systems are mainly for small, decentralized waste management units and multi-stage digestion systems are used for plants with a capacity of more than 50,000 Tonne / year[128].

---

124 Ward A. J., Hobbs P. J., Holliman P. J., Jones D. L. (2008). Optimization of the anaerobic digestion of agricultural resources. Bioresource Technology 99.

125 Li Y. B., Park S. Y., Zhu J. Y. (2011). Solid-state anaerobic digestion for methane production from organic waste. Renewable & Sustainable Energy Reviews.

126 Khalid A., Arshad M., Anjum M., Mahmood T., Dawson L. (2011). The anaerobic digestion of solid organic waste - Review. Waste Management

127 Vandevivere P., L. De Baere, W. Verstraete (2003). Types of anaerobic digesters for solid wastes, in Biomethanization of the Organic Fraction of Municipal Solid Wastes, IWA Publishing: Barcelona.

128 Anaerobic Digestion of Biowaste in Developing Countries Practical Information and Case Studies, Eawag, 2014

Economical Aspect

Anaerobic digestion is one of the methods to deal with the organic fraction of MSW[129]. The responsible institutions are always seeking the economically best option to treat MSW. Without considering Socio-economic aspects, open dumps are still the best way to dispose of waste. Consideration of socio-economic aspects makes anaerobic digestion and composting economically more interesting. A few advantages of Anaerobic digestion are as follows:

- Fossil fuel replacement:
  Biogas produced from anaerobic digestion can be used for cooking or to produce electricity and heat. The numerous applications of Biogas make it more economically feasible compared to imported energy sources in the long run.
- CDM funding:
  Greenhouse gas emissions can be reduced by producing biogas through anaerobic digestion. These projects are known as CDM Projects and as part of the carbon trading system, CDM projects get financial support.
- Nutrient-rich fertilizer production:
  Organic waste is rich in nutrients and the digested material from anaerobic digestion makes a nutrient-rich fertilizer to use for agricultural purposes. Revenue can be generated through markets for these types of fertilizers as well.
- Generation of employment:
  The operation and maintenance of biogas plants require manpower. This includes skilled and unskilled but trained labor.
- Landfill lifespan extension:
  Reduction in MSW leads to a reduction in landfills which will in turn save space and thereby the lifespan of landfills can be extended. New landfill site constructions could be postponed by reducing landfills through anaerobic digestion.
- External costs reduction:
  Production of organic acids in an unsanitary landfill body creates several environmental burdens by leaking out and polluting groundwater aquifers. It is hard to quantify the impacts created by air and water pollution in monetary terms. Even though, the management of organic waste by anaerobic digestion reduces the external costs significantly.

Except for the replacement of fossil fuel, all the other benefits apply to composting as well.

Social Aspects

Due to the successful application of Anaerobic digestion all over the world, it has a decent social acceptance for the treatment of biodegradable waste. Anaerobic digestion has wide acceptance in the rural areas of developing countries as it provides various benefits;

- Biogas can be produced at household levels.
- Mitigates deforestation by combating firewood.
- Farmers can use the digested materials as fertilizers/ manures it is rich in nutrients.
- Biogas improves the living conditions of people who live in rural areas, and reduces air pollution.

[129] Christian Müller, Anaerobic Digestion of Biodegradable Solid Waste in Low- and Middle-Income Countries, Eawag

It is important to raise awareness to make people consider biodegradable waste as a nutrient resource and this in turn gives the motivation to segregate or separate MSW. For proper feedstock quality, segregation of MSW is a prerequisite.

As more renewable energy programs have been initiated in India in the recent past, anaerobic digestion is welcomed in rural areas. It needs inadequate planning and proper management to develop further.

Environmental Aspect

Anaerobic digestion is an eco-friendly technique that focuses on the reduction of firewood for cooking, soil protection against erosion, reduction in GHGs, and helps in methane capture.

Biogas plants help in reducing CO_2 emissions from burning fossil fuels in two ways. Firstly, Biogas is a substitute for natural gas or coal for cooking and fossil fuels for electricity, heating, etc. Secondly, using the effluent from Biogas digester as fertilizer can reduce the CO_2 emission from the fertilizer industries by replacing it. Also, by providing an alternative fuel resource instead of firewood, deforestation and degradation of ecosystems can be reduced as well.

Conversion of Methane (CH_4) into CO_2 (and water) by complete combustion helps in reducing the greenhouse effect. It is valid only where the treated organic materials would otherwise undergo Anaerobic digestion by releasing methane into the atmosphere. The generation of CO2 has lately been tackled by plantations and green belts.

It is important to capture biogas from all escape pathways from the compensation tanks. The chances of loss of biogas get is higher with a high feeding rate, consumption is low and storage capacity is limited. This risk of biogas overproduction and losses must be mitigated through the installation of biogas lamps. Clear operating instruction manuals must be provided for the households. Also, in order to analyse the amount of biogas availability at the end of the day, a pressure meter can be installed.

There must be a safe distance between Biogas installations to the nearest water resource as there are chances for leakages which may result in the seeping of slurry into the subsurface[130].

Final Operation and Maintenance

In order to achieve high efficiency and maintain stable biogas production, there is some set of rules to be followed. To provide efficient and long-term performance, proper operation and maintenance (O&M) of the various components of the Biogas plant is required. A biogas technician who maintains the plant units must be aware of the operation of the various components of biogas plants. The technician must have taken prior training before the practical implementation.

It is recommended to create a maintenance strategy to keep track of responsibilities, tasks, and mechanisms controlling to check if the responsibilities have been done properly. There are inexpensive biogas flow meters available in the markets, which reduces the manpower requirement in monitoring the biogas flow daily. In Table 19, the general set of problems recognized in low-tech anaerobic digesters is mentioned which can be faced on a day-to-day basis. To understand the problem further, the possible cause is mentioned with a probable solution[131].

---

[131] Anaerobic Digestion of Biowaste in Developing Countries Practical Information and Case Studies, Eawag, 2014

Table 19: Troubleshooting in Anaerobic Digestion systems (adapted from Werner et al., 1989)

Observation of Problem	Possible cause	Solution
Gas production is low	• Insufficient feeding of substrate	• Add more substrate is related to the size of the reactor
Gas pressure is low or continuously decreasing even if gas is not used.	• Blockage of gas pipe by slurry • Gas pipe or valve is leaking • Leakage due to a crack in the dome (worst-case scenario)	• Disconnect the gas pipe from the digester. Compress air through the pipe to unclog what may cause blockage • Conduct pressure test and use soap water (liquid detergent) to check for leakages of valves and joints. Also, check that the water trap and/or valve of the outlet pipe is tightly closed • The reactor must be emptied and the cracks repaired
Gas pressure is as usual but gas supply runs out quickly	• Scum on the surface of digester chamber	• Use a stick to stir (through inlet or outlet) until scum is dissolved • Remove digestate from the outlet and recirculate through the inlet pipe to achieve a mixing effect
Gas pressure is not consistent	• Condensed water has accumulated in the gas pipe	• Open water trap valve to empty condensed water in the pipe • Make sure the water trap is at the lowest point of the whole gas piping system
Gas has a bad smell and is non-flammable	• If pH is acidic (< pH 6), this indicates too much acid in the system and an imbalance of microbial communities • Hazardous antiseptic or other toxic material which were mixed in the feedstock have inactivated some of the bacteria	• Stop adding substrate for 2 – 3 days and check if the gas becomes flammable • Add digestate mixed with lime through the inlet pipe to increase pH and control pH with an acid-base indicator strip
Gas is odourless and non-flammable	• Too much air supply in the burner	• Adjust the air adjustment ring at the nozzle of the burner
Uneven flame	• Water is trapped in gas pipe	• Open the water trap valve to empty the water and then close the valve tightly
Low flame	• Low gas pressure due to leakage • Low gas pressure if most of the stored gas has been consumed (in fixed-dome systems) • Nozzle hole of the burner is too small or flame	• Check biogas plant and gas pipes and valves for leakage • Stop using gas for a day and see if the gas pressure builds up again • Enlarge nozzle hole diameter or clean flame ports of burner

	ports of the burner are blocked	
High flame	• Nozzle hole is too big	• Reduce nozzle hole diameter
Yellow flame instead pale blue flame	• Nozzle hole is too wide	• Regulate air injection until the flame is pale blue
Flame returns in the gas pipe instead of going up through burning holes	• Flame ports are blocked	• Clean/unclog flame ports with a nail or clean them by using a wire brush to scrub and remove sediment and dirt from the burner cap

Annexure 5

Additional strategies for the overall development of waste management in ANI UT

Strategy for creating a centralized SLRM centre in PBMC for proper organisation and management of waste

Most of the visited Solid-liquid Resource Management centres (SLRM) in ANI UT were overwhelmed with the amount of incoming waste without any proper storage facility. Especially, the collected waste which has a low monitorial value was transported to the SLRM centres and dumped uncontrollably. Figure 55 shows the disorganised SLRM centre at Brookshabad. Brookshabad SLRM centre was completely disorganised with different recyclable waste streams dumped in the centre similar to the dumpsite. In the visited rural areas, glass waste is a huge problem (seeFigure 56). A significantly high amount of glass waste is being piled up in the solid waste management centre. There is a possibility to convert the available glass waste to silica for its use as construction material which has to be explored to harness the value of the glass waste. Considering the fact that currently the construction material is generally imported from the mainland to ANI UT, conversion of glass waste to silica would be an excellent resource recovery option.

Figure 55: Disorganized SLRM centre at Brookshabad

Figure 56: Uncontrolled dumping of glass waste near solid waste management facility of Swaraj Dweep

The best approach to manage the SLRM centres in PBMC is by converting all the small SLRM centres into Material Collection Facilities (MCF) and expanding the Brookshabad SLRM centre into a centralised facility or by creating/constructing a new centralised SLRM facility. The small MCF acts as a collection facility where the waste collected from the representative wards could be stored, segregated, and transported to the centralised system where the segregated waste is further processed, bailed, and transported to the mainland for recycling purposes. Nevertheless, after the commencement of the centralised SLRM centre, further aspects such as appointing a quality inspector for continuous inspection have to be initiated as a long term goal. Together with a continuous inspection for the smooth operation of the SLRM centres, the sanitary inspector should also examine and capture the exact data on the waste that is being processed and transported to the mainland. Having such a system not only facilitates organised waste management but enables highly accurate data capture and appropriate information on the revenue that is generated by the waste. Figure 57provides an overview of the approach for creating a centralised SLRM centre in PBMC.

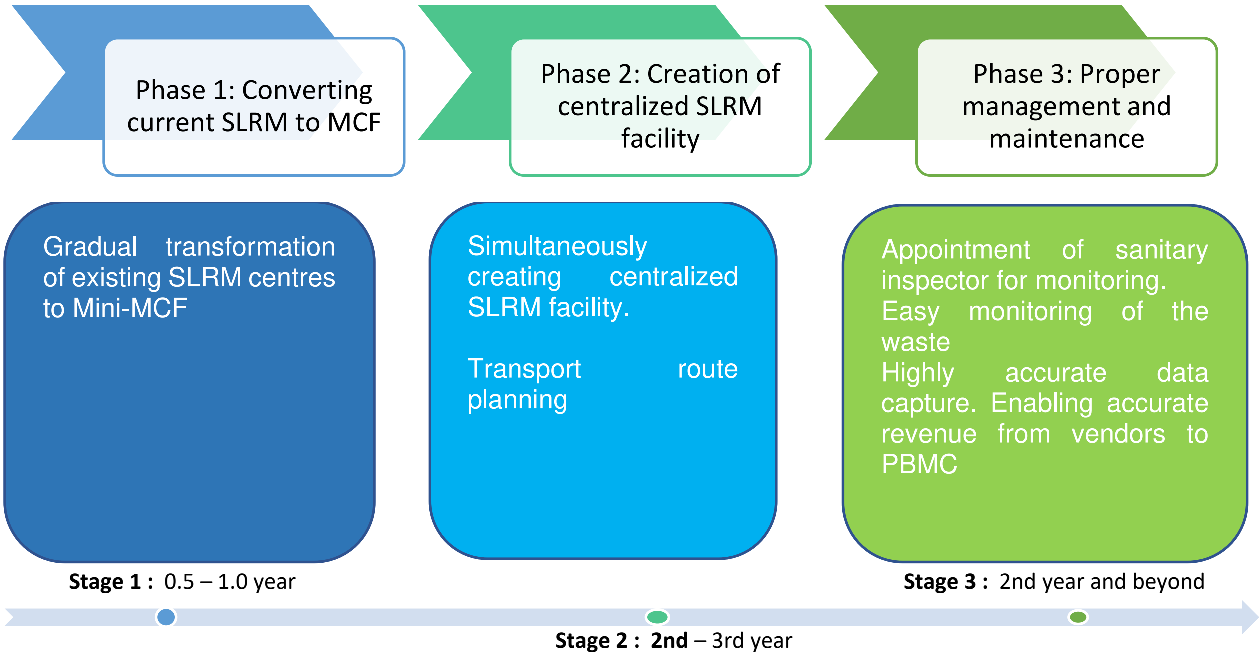


Figure 57: Approach for centralized SLRM center in PBMC

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Management of Organic Waste in India (MOWI) Project

Third Floor, B-5/5 Safdarjung Enclave
New Delhi 110029, India

T + 91 4949 5353
F + 91 4949 5391
E giz-indien@giz.de I www.giz.de

No.: 71/EE-III/SWM/MC/2018-19/142
नगरपालिका परिषद् का कार्यालय
OFFICE OF THE MUNICIPAL COUNCIL
पोर्ट ब्लेयर
PORT BLAIR

Port Blair, dated 26.10.2022

<u>Circular</u>

Regarding: Green Marriage Concept and Zero Waste Events/Weddings/Social or Religious Functions

This is to inform you that Under Swachh Bharat Mission, to achieve the objective of Garbage Free Cities, one of major points is the reduction of waste in the city during events like, Marriage Functions, Religious Events, Birthdays and other Social etc. Port Blair Municipal Council announced the Green Marriage Concept on 09th June 2022.

- Green Marriage concept is focusing on reduce the waste generation in the marriages, eliminating the Single Use Plastic in the events and promote to use the recyclable items like utensils, banana leaves to serve the food.
- All banquet halls/tent houses/catering service providers registered with the ULB have adopted 3R Principles – Reusable cutlery used, and 200 ml water bottled stopped in all functions where catering services are provided by them.
- Zero Waste Events/Weddings/Social or Religious Functions: City/citizen is/are expected to manage at least one Zero Waste Functions in each month between October 2022-December 2022 with zero waste coming out of the Venue.

In this regards, Port Blair Municipal Council in consultation with GIZ developed some important points to use the Green Marriage Concept for further event in your institutions and Standard Operating Procedure for Zero Waste Event developed by MoUHA are attached herewith for your kind reference.

I would like to request you kindly adopt the above suggestions and recommendations in your institutions for Green Marriage and Zero Waste Event & make the city more cleaner and garbage free.

This is for your kind information & necessary action please.

Encl: As above

Yours sincerely,

Secretary
Municipal Council

Scanned with CamSc

Copy to:

1. PA to Chairperson, PBMC for kind information of Chairperson, PBMC.
2. Superintending Engineer, PBMC
3. All Councilors, PBMC
4. All Committee Hall, Marriage, and Functions Hall of Port Blair City.
5. All Hotels and restaurants of Port Blair.
6. Revenue Officer, Port Blair Municipal Council to mandate both guidelines in all community halls of PBMC with immediate effect.
7. Mr. Aviral Saxena, Technical Expert, GIZ, Port Blair

Secretary
Municipal Council

Scanned with CamS

Green Marriage

Green Marriage concept is focus on reducing the waste generation in the marriages, eliminating the Single Use Plastic in the events and promote to use the recyclable items like utensils, banana leaves to serve the food. In fact, it's been said that the average wedding produces 200 Kg of garbage and 63 tons of carbon dioxide. Factor in the thousands of weddings that happen per year, and that's a lot of waste. If you're eco-conscious and interested in reducing your carbon footprint, you might be considering how to have a zero-waste wedding. The focus should be on reducing* the amount of
waste which is �nally transported to the processing/disposal site or processed through on-site composting. Here are some ideas to keep your celebration as sustainable as possible. The following things may be considered for green marriage concept.

- The '3R' (reduce, reuse and recycle) cleanliness formula may be used and plastic, thermocol and styrofoam products are not used at such events.
- Besides decor, the food and catering of your wedding makes for the most waste. Think about the amount of food, drinks, plates, napkins, and utensils that end up in the trash after a party and you'll see why.
- To help eliminate waste from this essential part of your wedding reception, work with your caterer to ensure you're using reusable or compostable plates, utensils, and glassware.
- When it comes to the meal, locally sourced food will reduce your carbon footprint as well as help local farmers. It might also be a good idea to look for where you might be able to donate any leftover food.
- While old-fashioned wedding invitations sent via the postal service are timeless, they also create a lot of waste. In an age when many have access to social media and can host their own websites, it's easy to send out paperless, beautiful wedding e-invites to your guests. If you would still like to send out paper wedding invitations, choose those that are printed on natural or recycled paper.

Conditions for Green Marriage

- Send out paper wedding invitations, choose those that are printed on natural or recycled paper or paperless invitation like e-invitation
- Not to use "Single Use Plastic" or any type of plastic (Glass, spoon, containers, bowl etc.)
- Ensure to use reusable plates, utensils, and glassware or green leaves to serve the food.
- Donate your any leftover food.
- Decoration of event may be through Banana leaves etc. not use the Styrofoam and plastic items or use reusable items for the decoration.
- all banquet halls/tent houses/catering service providers registered with the ULB have adopted 3R Principles – Reusable cutlery used, and 200 ml water bottled stopped in all functions where
  catering services are provided by them

After achieving all above conditions, the couple may be felicitated with a **"Green Marriage Certificate"** .

SOP for zero-waste events Events (Official functions/ Weddings/ Social or religious functions)

The vision of SBM-U 2.0 is to make all cities “Garbage Free”. A key requirement for this would be to adopt 3R principles and principles of circular economy for reducing, reusing and recycling of waste to ensure maximum resource recovery. Parallely, in alignment with Government of India’s focus, SBM-U 2.0 also aims at phased elimination of single-use plastics.

Given that public events pose a challenge for cities in terms of generating substantial quantities of waste and their subsequent disposal, there is a need to ensure that going forward, all public events be conducted on “zero-waste” principles, to minimize the amount of waste generation and need for their safe disposal. This would be possible through use of environment friendly products/ items, easy access to toilets and waste disposal facilities by all attendees at such events, with all COVID appropriate measures as mandated by Government of India in place.

To this end, an indicative SOP with suitable **Do’s/ Don’ts** is being proposed as per suggestive guidelines given below, for ULBs to ensure that any public event in their jurisdiction is a “zero-waste” or Swachh event.

1. Entrance

- No plastic/ flex posters/ signages to be used for displaying information regarding the event. All posters/ signages to be printed on eco-friendly materials such as cloth, jute, paper etc.
- The welcome board at the gate should clearly mention that this is a Swachh or “zero-waste” event.
- No flowers/ decorations made of plastic to be used.
- Foot operated sanitizer machines to be placed at the entrance. A cut-out of the city’s Swachhata mascot, if relevant, may be placed next to the machine.
- Clear signages are put directing participants to the various areas of the event.
- Access to the venue to be *Divyang*-friendly.

2. Registration area (if applicable, for official events)

- Appropriate physical distancing to be maintained at the registration point
- Registration of guests to be carried out by organisers using handheld tablets
- Name tags to be printed on cardboards, with jute/ cloth lanyards
- Participant kit (if provided) may consist of the following items:
  - Cloth/ jute bag made by SHGs from waste cloth

    - Notepad made of recycled paper
    - Eco-friendly plantable pens
    - Mementos, if any, may be made out of recycled materials. Use of *papier mache* boxes, steel lapel pins, stainless steel water bottle, etc may be encouraged.
- Participants to scan a QR code to receive the agenda/ papers/ publications related to the event

3. Inside the venue

- No plastic water bottles of any size, plastic cups/ glasses to be used anywhere in the venue. Only bio-degradable environment friendly drinking cups to be used.
- Drinking water tap dispensing machines/ 20 litre potable water dispensers with paper cups/ steel cups/ glasses to be placed at accessible distances throughout the venue.
- In case of official functions and workshops, for panel discussions, etc, glass water bottles and drinking glasses to be placed on the dais for use by panelists.
- Hand sanitisers to be placed at accessible distances throughout the venue.
- Use of multi-layered wrapping paper, ribbons etc. to be kept to a minimum.
- Presentations made during the event (if applicable) to be posted on a website or emailed to all participants post event instead of providing printed, physical handouts.
- No outside food/ beverages to be allowed inside the venue
- Green, Blue litter bins with prominent signages printed on them to be placed at easily accessible locations throughout the venue, for disposal of bio-degradable (e.g. food, kitchen, floral wastes, bio-degradable cutlery, etc.) and non-bio degradable wastes (e.g wrapping paper, paper cups, ribbons, etc.).
- All litter bins to be emptied frequently (depending on duration of event) and the waste transported out in segregated collection vans of ULB.

4. Dinning- area

- Use of only bio-degradable cutlery/ reusable plates and cutlery (e.g. steel, bone-china etc.) to be used.
- To ensure that no food is wasted, organisers may tie up with local NGOs for distribution of leftovers at shelters OR have in-situ mobile composting at site.
- All litter bins to display key messages such as '*humara kachara humari zimadari'*, '*har din do bin'* etc.
- Signage for saving water to be prominently displayed above wash basins.

5. Washrooms

- Toilets/ washrooms for all gender groups to be available within the premises, fulfilling the following minimum conditions:
    a. *All **toilet seats** and **urinals** clean and usable at all times*
    b. ***Wash basin(s)** clean and usable at all times*
    c. *Availability of **water at all times***
    d. *Adequate **ventilation** facility (vents, slanted glass slats and/or exhaust fan), are **well lit** at all times, both **within and outside**, with each seat having its own light point, and all light points functional*
    e. *Functional **bolting arrangements** on all doors of all toilet seats*

    f. *Proper disposal facility for the toilet effluents*
- All washrooms to be cleaned multiple times in a day, to maintain the above conditions
- All wash basins to have suitable signages (e.g. “Dhoya Kya”) for handwashing, water saving etc.
- Ramps to be in place for *Divyang* attendees
- Ladies’ toilets to have:
    g. *sanitary pad vending machines*
    h. *Wastepaper for wrapping sanitary pads*
    i. *Separate bins to be in place for disposing sanitary pads*
- Soap dispenser machines in each toilet
- SHE toilets (mobile toilets for women), and mobile toilets for men, transgenders, etc. (if required), with all the functionalities of point (1) to be placed at accessible locations around the venue.

GUIDE FOR THE TOURISM SECTOR TO COMBAT MARINE LITTER

in Marine and Coastal Areas of Andaman & Nicobar Islands

Published by:

Part of an Indo-German Cooperation project Cities Combatting Plastic Entering Marine Environment (CCP-ME),

On behalf of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)

Cities Combatting Plastic Entering Marine Environment (CCP-ME)
3rd Floor, B-5/5, Safdarjung Enclave
New Delhi 110029
T + 91 4949 5353
F + 91 4949 5391
E info@giz.de
I www.giz.de

Vaishali Nandan
Project Head, Cities Combatting Plastic Entering Marine Environment, (CCP-ME), GIZ

Authors
Aviral Saxena
Theresa Aigner

Editors:
Carla Rossitto

Responsibility for the content of external websites linked in this publication always lies with their respective publishers. GIZ expressly dissociates itself from such content

Port Blair Municipal Council and GIZ are responsible for the content of this publication

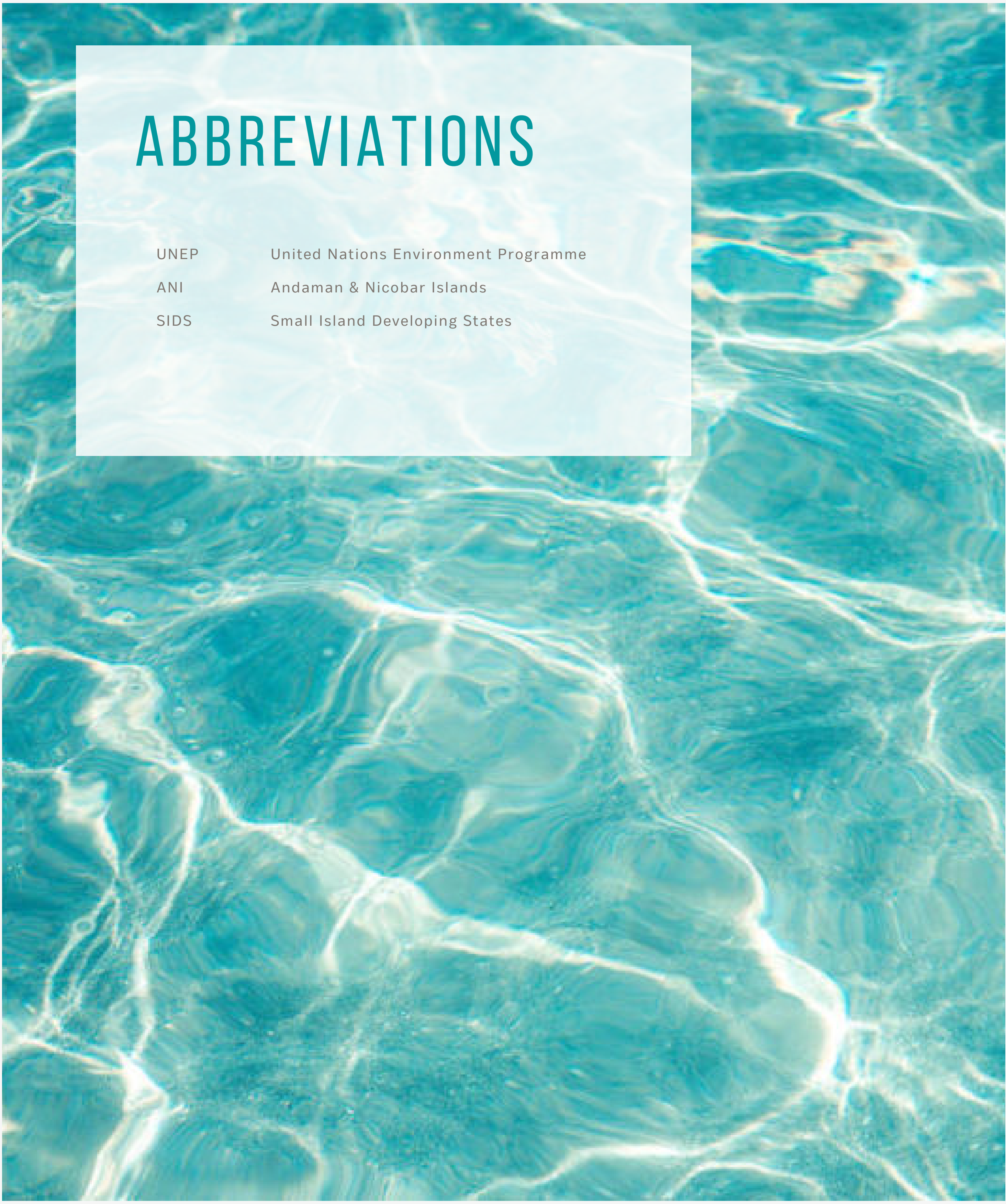
Port Blair, India
November 2022

CONTENTS

Figure 1: Single use plastic bottle polluting a beach

ABBREVIATIONS

UNEP	United Nations Environment Programme
ANI	Andaman & Nicobar Islands
SIDS	Small Island Developing States



LIST OF FIGURES

1. INTRODUCTION

MARINE LITTER

A GLOBAL CHALLENGE REQUIRING INDIVIDUAL ACTION

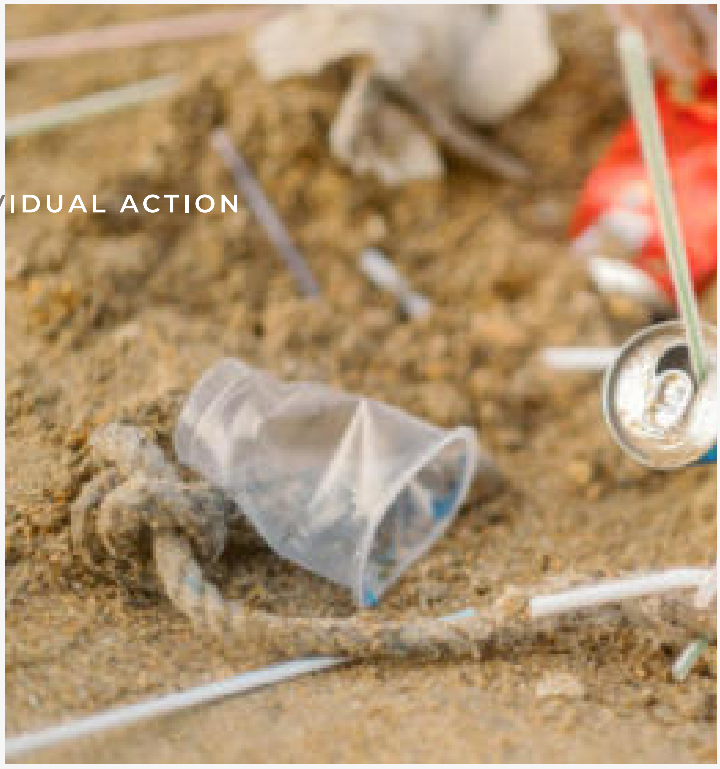


Figure 2: Single use packaging ending up on the beach

Marine litter is defined by UNEP as “any persistent, manufactured or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment”. It threatens ecosystems and affects fishery and tourism industries adversely around the globe. In addition to negative economic and environmental impacts, public health is compromised with a growing concern about micro-plastic and the increased risk of particles entering food webs. In recent times, the level of plastic waste that has accumulated in our oceans and marine ecosystems through the increasing production and use of durable synthetic materials has alarmed the public and policy makers alike.

On a global scale, the problem of marine litter is rooted in the currently dominant linear take-make-dispose production and consumption patterns and unsustainable waste management practices. Marine litter is largely associated with human activities and mainly originates from land-based, riverine and ocean-based sources. It can be foundin different forms on beaches and shorelines, in the water column, on the water surface, and on the seabed. As opposed to natural substances such as food waste, marine litter consisting of synthetic materials including plastics has a longerlifetime and remainsin the environment unless removed.

Current estimates of global marine littering are based on a limited number of modelling studies. Yet, their findings suggest that some 11 million tonnes of plastics enter the oceans annually to become marine litter (UNEP 2022). Moreover, it is estimated that 15-20% of all plastics are entering oceans via riverine ecosystems of which 88-95% are contributed by 10 of the world’s most polluting rivers only. Two of these rivers are located in India, namely Ganga and Indus (Schmidt et al. 2017).

Typically, litter prevalent on beaches and coastlines consist of cigarettebutts, food wrappers and containers, caps, tableware (e.g., disposable forks and spoons), and beverage bottles. Such marine litter originates from the daily consumption practices of people. Since the outbreak of the Covid-19 pandemic, personal protective equipment such as masks and plastic gloves constitute an additional category of waste polluting marine environments. To reduce marine litter around the world, individual action is pivotal. Beyond that, collective efforts are required to minimize waste generation and its leakage to oceans.

TOURISM IN ANDAMAN AND NICOBAR ISLANDS

A MAIN CONTRIBUTOR TO MARINE LITTER AND LIKEWISE BENEFICIARY OF CLEAN ENVIRONMENTS

Tourism is the largest and fastest growing sector in the world economy and main revenue generator for Andaman and Nicobar Administration. Prior to Covid-19 disruptions in 2018, Andaman & Nicobar Islands hosted approximately 5 lakh domestic and foreign tourists every year (Ministry of Tourism, 2019). Therefore, a significant share of the revenue earned by the Andaman and Nicobar Administration is derived from the tourism industry. Recently, the industry of tourism in Andaman and Nicobar Islands has boomed and prospered into a completely new and advanced level. The varied tourist spots in the tranquil islands of Andaman and Nicobar are so spectacular that people from all over the globe gather to witness its charm and grandeur.

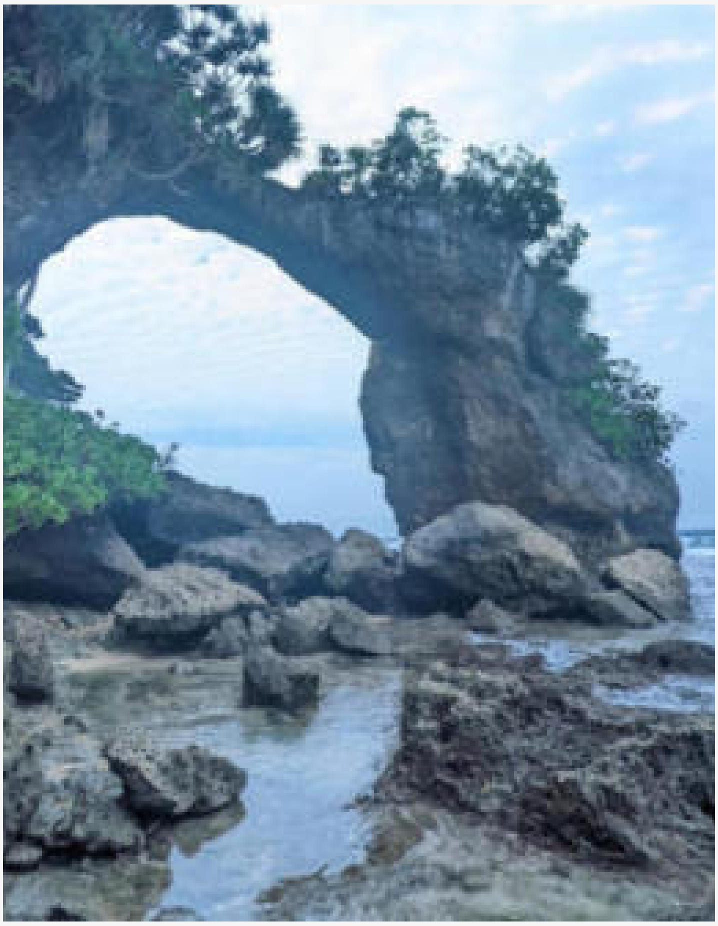


Figure 3: Natural Bridge on Neil Island – Lakshmanpur in Andaman and Nicobar Islands

While ample coastal recreation and beach tourism creates valuable incomes, it has become one of the sources of marine litter on the Islands. Touristic activities increase waste generation by up to one-third during the peak season in Andaman & Nicobar Islands (ANI), resulting in local waste management facilities often being overwhelmed while capacities are exceeded. Many tourist destinations, particularly those in Small Island Developing States (SIDS), are ill equipped to deal with the considerable load of plastic products associated with tourist activities.

Typically, the tourism activities are associated with a variety of plastic products, including toiletry and personal care products, food and beverage packaging, single-use plastic items, such as cups, straws, cutlery, as well as hotel amenities, plastics associated with recreational activities such as diving, camping and catering, as well as fishing gear.

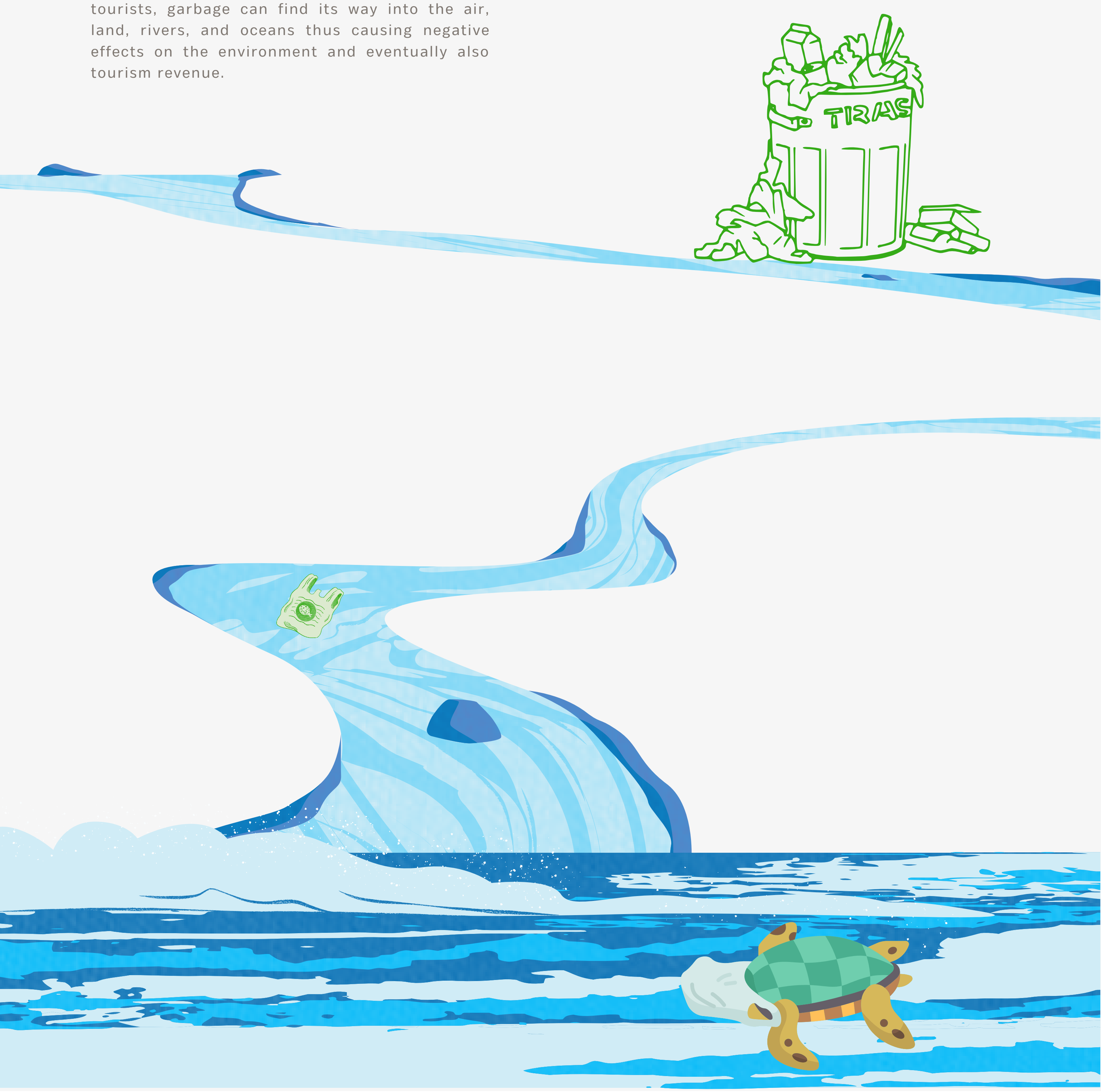
Although the tourism sector is one of the main contributors to the increasing problem of marine litter, it is also in a crucial position to support the conservation of oceans and the blue economy. The external costs of plastic pollution to the tourism sector are becoming increasingly visible. When quantifying the costs attributable to littering, it is undeniable, that lost revenues are considerably high. For instance, regional economic losses associated with plastic pollution in the Mediterranean's are estimated at €641 million per year, with tourism constituting the most affected sector (Dalberg Advisers and WWF Mediterranean Marine Initiative 2019). Thus, the tourism sector has a considerable vested interest in maintaining the appeal of the environment, including the marine environment. It remains undisputed, that tourists want to visit unpolluted, beautiful natural landscapes. However, careless actions including indiscriminate littering may deteriorate the natural environment. Eventually, waste disposed on beaches and coastlines can be carried by wind or water surges into the ocean.

Besides coastal areas, also upstream tributaries to rivers and rivers themselves can become significant sources of marine litter, as the waterflow can carry pollution until final discharge into marine environments. Without appropriate waste treatment in the inland areas garbage from overflowing rubbish bins is carried into the rivers by the wind and rain to finally reach the ocean.

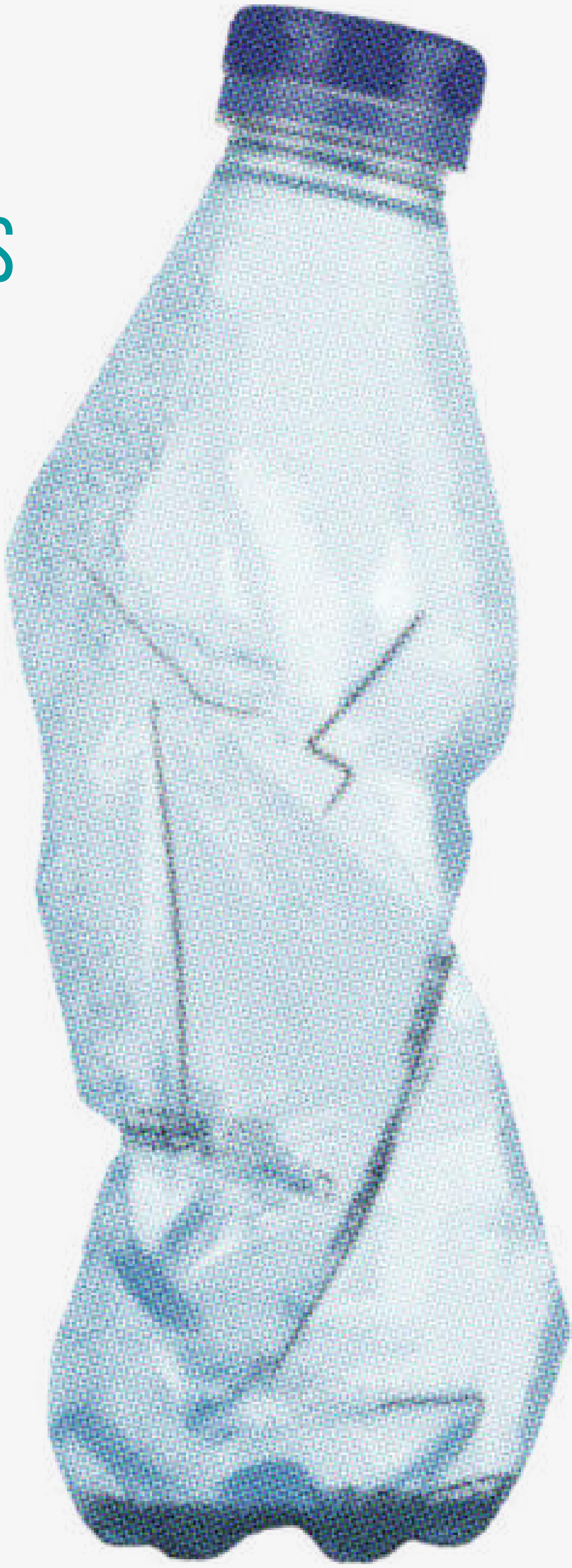
Consequently, this type of garbage increases the amount of marine litter. Unless rubbish bins are sufficiently provided in the beautiful, scenic areas that usually attract a large number of tourists, garbage can find its way into the air, land, rivers, and oceans thus causing negative effects on the environment and eventually also tourism revenue.

Therefore, one of the main challenges the local tourism sector is facing constitutes protecting and preserving the natural environment from littering.

To address the issue, the tourism department of Andaman and Nicobar Islands has developed these guidelines for the tourism sector to combat marine litter in marine and coastal areas of Andaman & Nicobar Islands to reduce the negative impact of tourism related waste.



2. LITTER TYPES POLLUTING MARINE AND COASTAL AREAS



Typically, marine and coastal areas exhibit many types of marine litter. Such litter commonly comprises materials that degrade very slowly, such as plastic products, polystyrene foam, metal, and glass fragments, which commonly originate from food wrappings, beverage cans and bottles, cigarettefilters, plastic bags, and fishing lines. These types of litter do not necessarily remain in the local area where they were discarded. However, they can be transported to distant locations via wind, ocean currents, and waves to subsequently pollute other beaches and shorelines. Moreover, litter travels and accumulates in the water column and on the seafloor.

In 2022, several clean up drives were conducted in Port Blair. Findings revealed that tins, plastic and glass bottles, clothes and other single use plastic items were among the most frequently round items. In recent years, single use plastic bottles were ubiquitously applied for beverages all over the world because of their convenient properties – they are light-weight, durable, and portable. Even though the collection and recycling of plastic bottles is widely encouraged, large amounts of waste plastic bottles remain unrecycled.

Plastic bottles frequently break down into small pieces, making collection and cleanup a difficult task. However, the material is resistant to many natural degradation processes and thus remains in the environment as a pollutant. Its durability is considered valuable for plastic application, but simultaneously causes long-term legacies in nature. In addition, these small pieces are often mistakenly ingested by marine organisms. Subsequently the litter accumulates in the stomach since plastics cannot be digested. Ultimately, humans are adversely affected since plastics enter the food chain. Especially in coastal areas, where fishery constitutes a main contributor to the local food supply and sea food is typically consumed as a local specialty, effects of bioaccumulation may cause harm.

Because of the light weight and durability, plastic bottles can be transported long distances and reach beaches far from their original locations — sometimes thousands of kilometers away. Therefore, discarded plastic bottles are prone to becoming marine litter. As a result of their vulnerability to transportation by natural vectors, international plastic bottles with foreign labels are often found in Andaman and Nicobar Islands. Plastic litter found on the beaches of the island is mostly observed to be of non-Indian origin. The discarded material is likely to be transported by the water currents from South-East Asian countries through the Malacca Straits (which is a major shipping route). Observations revealed that 11 countries including India contributed to the plastic litter on the island namely, Malaysia, Indonesia, Thailand, Singapore, Philippines, Vietnam, Bangladesh, Myanmar, China, Maldives, and Japan.

3. IMPACT OF MARINE LITTER

ECOLOGICAL, ECONOMIC AND SOCIAL CONSEQUENCES

Although locals, unlike tourists, typically do not perceive marine litter as a visual problem, they are the ones most affected by its consequences. However, tourists prefer clean destinations over polluted areas where waste accumulates. Thus, adequate waste management is a cornerstone of coastal economic development. When considering negative externalities associated with littering, both, the economic impact and environmental and health impacts should be considered. Littering can result in a decline in tourist numbers, due to the diminishing vividness and beauty of beaches, but also adversely affect human health and the environment
.

Several consequences listed here are associated with insufficient waste management causing marine litter:

ECOLOGICAL IMPACT OF MARINE LITTER

- **Entanglement** in plastic items such as fishing nets can cause injuries, strangulation, reduction of feeding efficiency and drowning.
- **Ingestion** of plastics is observed in many migratory aquatic life, birds, freshwater fish and terrestrial animals. Turtles and toothed whales are frequently observed to exhibit large quantities of plastics in their guts compartment (UNEP 2016). Plastic ingestion is expected to have both adverse physical and chemical impacts on the species. Additive chemicals applied in plastics such as heavy metals, but also persistent organic pollutants and persistent, bio-accumulative and toxic substances absorbed by plastics from surrounding water can pose significant threats to marine species when ingested (Takada et al. 2022).
- **Habitat** of marine species can be damage by marine litter. In particular, coral reefs can suffer severe damage by the movement of nets and ropes. Moreover, material can easily accumulate in mangroves which can thus become plastic sinks.
- **Rafting** describes the introduction of alien species which are attached to floating material. Marine plastics pollution, which exhibits much greater longevity than most natural materials, extends the range of rafting significantly.

ECONOMIC AND SOCIAL IMPACT OF MARINE LITTER

Impact on Fisheries

- **Entanglement of fishery gear and damage of fishing vessels** through macro-plastic debris or other litter obstructs fishing activities. Consequently, this causes extra work and cost to remove the litter from fishing nets.
- **Ghost fishing** describes the continuation of marine species being 'caught' by abandoned, lost or discarded fishing gear such as nets and traps in the ocean. As a result, significant levels of mortality are caused to commercial stock and thus impact fishers' yields (UNEP 2016).
- **Contamination or damage of the catch** through plastics additionally leads to a loss of income for fisheries.

Impact on Tourism

- Insufficient waste management can cause a **decreased aesthetic value** of tourism sites owing to visible pollution. As a result of reduced visitor numbers, valuable income is lost.
- **High cost for cleanup**, collection and disposal of marine litter result from mismanagement of waste.

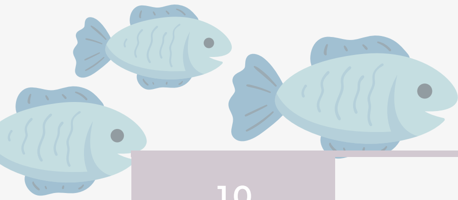
Impact on Marine Transportation

- **Entanglement in screws** (propellers) and clogging of water intakes poses a threat to shipping.

Figure 4: Single use containers accumulating in coastal areas

Impact on Human Health

- Waste dispersed on beached can cause **injuries** such as cuts and transmit other diseases.
- **Medical waste** is generally considered as hazardous as it can be highly infectious. Disposal or washing up of medical waste on beaches thus puts safety of beaches at risk.
- **Plastic related compounds** including flame retardants and other additives, which are particularly frequent in electrical and electronic equipment, construction material and automotive waste, are associated with (eco)toxic effects. Therefore, when littered, these plastics represent a significant threat to human health (UNEP 2016).
- **Breeding grounds for mosquitos** are enhanced if water is stagnant in plastic debris. Consequently, conditions for the spreading of diseases like malaria are enhanced through littering



4. WHAT THE TOURISM SECTOR CAN DO TO REDUCE MARINE LITTER

Tourism in marine and coastal areas is a major contributor to marine litter. Its impact is even expected to grow with tourism recovering as Covid-19 restrictions ease (UNWTO 2022). However, tourists should continue to experience the unique nature the Andaman and Nicobar Islands offer. With joint efforts, the magnificent beauty of the Islands can be upheld.

Firstly, to combat both land-based and sea-based sources of marine litter, sound waste management is pivotal. It contributes indispensably to conservation of nature, to human health and to the lived experiences by tourists. Generally, the **3Rs principle** shall serve as a guideline for sustainable waste management:

1. As a first priority, waste should be **Reduced** by preventing its generation. In other terms, waste generation can be prevented by refraining from single-use items such as disposable tableware.
2. Subsequently, to prolong the lifetime of products, commodities should be **Reused** as long as they are intact or can be repaired to continue fulfilling their purpose.
3. Finally, materials should be **Recycled** to exploit their inherent value. This includes reprocessing of used plastic waste destined for application as a secondary material. To allow for efficient recycling, segregation of waste at source is a prerequisite.

In practical terms, it is advisable to install checkpoints for plastic collection at each tourist site to make tourist destinations on the island plastic-free. In order to conserve the capital of the local tourism sector – its splendid beaches, stunning snorkeling and diving spots and kayaking routes – wastewater similarly requires adequate management. Furthermore, to prevent littering and ensure participation in waste management across all stakeholders, it is of utmost importance to raise awareness on the adverse impacts of marine litter. Beyond that, constant monitoring and assessment of marine litter helps to track successes and identify gaps within the waste management system.

Concludingly, engagement and active participation of all stakeholders is pivotal to preserve the unique beauty of Andaman and Nicobar Islands!

In order to support collective action towards combatting marine litter in the tourism sector, the following section provides **checklists for different tourism stakeholders** to become part of the solution:

- **CHECKLIST FOR HOTELS**
- **CHECKLIST FOR RESTAURANTS AND FOOD STALLS**
- **CHECKLIST FOR STREET VENDORS AND SERVICE PROVIDERS**
- **CHECKLIST FOR OPERATORS OF INLAND ACTIVITIES**
- **CHECKLIST FOR OPERATORS OF MARINE AND COASTAL ACTIVITIES**
- **CHECKLIST FOR THE TRANSPORTATION SECTOR**

CHECKLIST FOR **HOTELS**

to Combat Marine Litter

1/4

- [ ] **Ban single-use items from guest rooms** including disposable cups, water bottles and hotel amenities such as toothbrushes, slippers and single-use containers for shampoo, shower gel and body lotion. Additionally, avoid providing items packed in single use plastics such as individually packed tea bags.

- [ ] Instead, **opt for reusable alternatives**. Invest in reusable tableware including straws e.g. made from stainless steel, as well as bulk bathroom amenity dispensers and hand sanitizer dispensers. Moreover, provide toothbrushes (ideally made of bamboo or wood) and slippers (ideally unwrapped) only upon request.

- [ ] Opt for **reusable or biodegradeable tableware** when providing room service. Additionally, provide washable napkins instead of paper alternatives destined for single use.

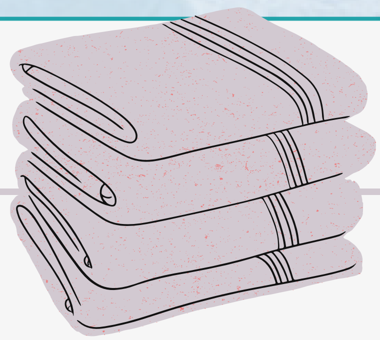
- [ ] Serve guests with **filtered water** in rooms and provide **water dispensers** and water fountains. Additionally, promote the use of water dispensers by selling or gifting **refillable water bottles** to guests.

- [ ] Laundry service provided by your hotel should refrain from packing cleaned clothes in single-use plastic bags. Instead **return the laundry in reusable** garment covers or baskets.

- [ ] To obtain better control of hygiene and reduce food waste, **favour a-la-carte** options over buffets.

- [ ] **Avoid distributing unnecessary flyers** and promotional gifts which may become waste immediately. Consider conveying messages via posters, screens, stickers, etc. which generate less/no waste. Provide sustainable gifts which encourage reuse such as refillable water bottles, reusable food containers, washable cotton bags or beeswax food wraps.

- [ ] Beyond solid waste, prevent wastewater generation by letting your guests decide about the **frequency of cleaning** of sheets. Ask your guests how often bed linens should be replaced and washed. Incentivize your guests to reuse the towels provided. Place signs informing customers about the environmental benefit of reusing of towels and indicate e.g. that hanging towels will be considered clean enough for reuse.



CHECKLIST FOR **HOTELS**

to Combat Marine Litter

- [ ] Consider replacing tissues for drying of hands within your facility (in guest rooms, toilets, etc.) with **washable hand towels or hand dryers**.

- [ ] In times of pandemics, refrain from providing single-use masks. Instead, supply washable, **reusable masks** to prevent the personal protective equipment from washing up on beaches and harming the environment.

- [ ] Place waste bins wisely within and around your premises at highly frequented sites. Provide **4 type of bins** for segregated collection of wet, dry, sanitary & domestic hazardous waste. Moreover, provide bin liners only where necessary and only replace them when dirty.

- [ ] As laid down in the Solid Waste Management Rules 2016 and PBMC SWM municipal Bye, **bulk waste generators** (generating more than 50 kg/day) are responsible for **management of waste on their own**. Consequently, it is required to either implement waste treatment facilities such as composting plants for wet waste or hand over waste to authorized processing or disposal facilities on your own or by contracting collection agencies. Ensure that collection or in-situ processing is frequently conducted to avoid overflowing bins.

- [ ] Display **instructions** for tourists on waste segregation and proper disposal. It is recommended to give instructions on locally applicable regulations for waste segregation for example in the form of stickers, posters or other means of information dissemination. Place them directly at the waste disposal site/where the rubbish bin is located. Suitable stickers were developed by PBMC with support of GIZ which are available for your use!

CHECKLIST FOR **HOTELS**

to Combat Marine Litter

3/4

- [ ] Provide smoking customers with ash trays and empty them frequently to prevent cigarette buds from ending up in the environment. Additionally, consider selling or giving away **portable ash trays** for tourists to carry during their visit and beyond.

- [ ] Set up a **(news)paper recycling program** within your facility. Collect all paper and cardboard separately prior to collection to allow for more efficient recycling if unpolluted and uncontaminated wastepaper.

- [ ] Incentivize your guests to get broken items and clothes **repaired**. Cooperate with local sewers and repairers to provide easy access of their services to customers.

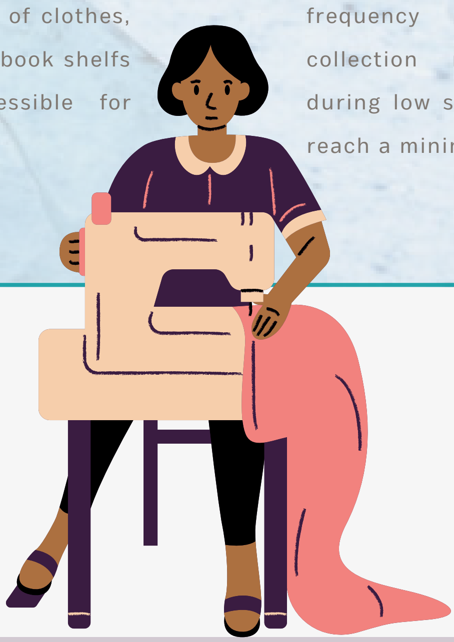
- [ ] Encourage Reuse by creating spots for **redistribution and donation** of clothes, toys and books such as open book shelfs within your premises accessible for tourists.

- [ ] To prevent plastic bags from becoming marine litter, provide **reusable cotton bags** to your guests and encourage its use when out for shopping.

- [ ] **Reduce paper consumption** in your office by switching to digital tools. Additionally, opt for wooden or bamboo pencils to prevent plastic waste from pens. Alternatively, favour pens made from recycled plastics.

- [ ] **Monitor** waste generation within your premises to keep track of achievements. Successes can be communicated and exploited to increase reputation among tourists.

- [ ] **Plan ahead**, to adjust capacity for waste storage and frequency of waste collection according to expected tourist arrivals. While during peak season frequency and capacity of waste collection might require upscaling, during low season waste generation will reach a minimum.



CHECKLIST FOR **HOTELS**

to Combat Marine Litter

4/4

- [ ] Become an advocate for change by accompanying your efforts with **awareness raising activities**. Consider, organizing **clean-up** activities to remove existing litter. Consult the ‘Standard Operating Procedure for Clean up Drives in Port Blair’ developed by GIZ which is accessible via the QR code. Such mobilizing activities can be conducted in **cooperation** with other tour operators or local tourism businesses such as restaurants or tour operators.

- [ ] Inform your guests about **eco-friendly tourist activities** available on the Islands. Therefore, cooperate with tour operators which follow a strict environmental policy.

- [ ] Become a **certified eco-tourism hotel**. Set an example by improving your service with regards to sustainability in a holistic way.

- [ ] Last but not least, to ensure your set measures and goals are sustainably implemented, organize an **internal meeting** with all staff. Transmit your ideas and ensure everyone is aware of new tasks and duties. In order to allow for a smooth implementation of new measures, distribute responsibilities among your staff.

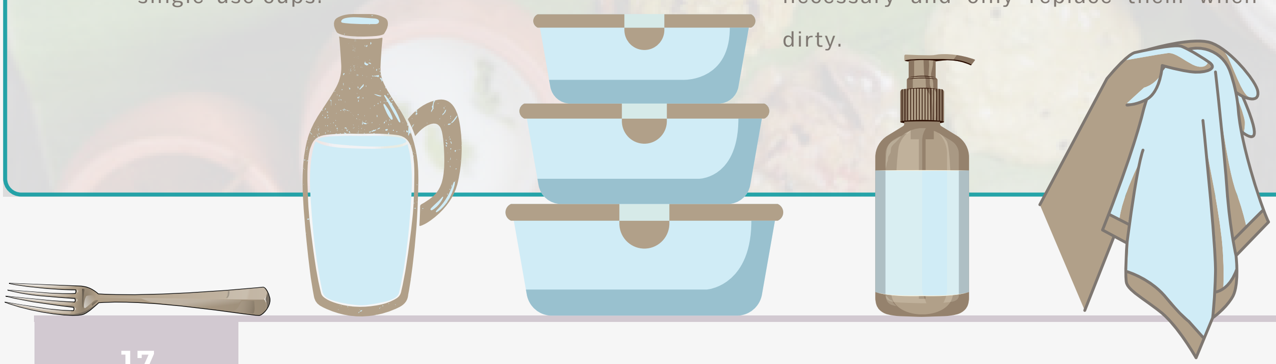
Figure 5: SOP on Clean up Drives in Port Blair

CHECKLIST FOR **RESTAURANTS AND FOOD STALLS**

to Combat Marine Litter

1/2

- [ ] **Ban single-use items** from your restaurant including single-use straws, stirrers, water bottles, cutlery, plates and cups.
- [ ] Instead, opt for **tableware made of durable materials** such as stainless steel, copper or plastic destined for reuse. Consider branding your reusables with your logo which provides an easy opportunity for advertisement. Another sustainable and appealing option is to serve your food in banana leaves or other natural materials which biodegrade easily.
- [ ] Serve take-away food in **biodegradable packaging** such as banana leaves. Otherwise, consider implementing a **deposit return scheme** for take-away food or drinks served in reusable containers and cups or sell the reusable containers directly to customers. The lending scheme can be implemented in cooperation with other similar businesses in your area. Beyond that, encourage customers to bring along their own reusable containers for take-away by offering a discount or charging on single-use cups.
- [ ] Serve customers with **filtered water** by providing refilled glass bottles or jars as well as cups.
- [ ] Favour **refillable sauce dispensers** instead of single use packaging in sachets or disposable containers. Alternatively, provide sauces in bowls or bottles.
- [ ] Similarly, provide **spices**, sugar, salt and other additional flavouring options in **refillable containers** to reduce single use packaging waste.
- [ ] Consider **replacing paper tissues** for drying of hands in your washing room with washable hand towels or hand dryers.
- [ ] Install **refillable soap and hand sanitizer dispensers** in your washrooms.
- [ ] Place waste bins wisely within and around your premises at highly frequented sites. Provide **4 type of bins** for segregated collection of wet, dry, sanitary & domestic hazardous waste. Moreover, provide bin liners only where necessary and only replace them when dirty.



CHECKLIST FOR **RESTAURANTS AND FOOD STALLS**

to Combat Marine Litter

2/2

- [ ] As laid down in the Solid Waste Management Rules 2016 and PBMC SWM municipal Bye, **bulk waste generators** (generating more than 50 kg/day) are responsible for management of waste on their own. Consequently, it is required to either implement **waste treatment** facilities such as composting plants for wet waste or hand over waste to authorized processing or disposal facilities on your own or by contracting collection agencies. Ensure that collection or in-situ processing is frequently conducted to avoid overflowing bins.

- [ ] Additionally, display **instructions on waste segregation** and proper disposal. It is recommended to give instructions on locally applicable regulations for waste segregation for example in the form of stickers, posters or other means of information dissemination. Place them directly at the waste disposal site. Suitable stickers were developed by PBMC with GIZ support which are available for your use!

- [ ] Provide smoking customers with **ash trays** and empty them frequently to prevent cigarette buds from ending up in the environment.

- [ ] **Reduce food waste**, by proper storage, by salvaging leftovers and donating excessive food to the ones in need.

- [ ] **Approach your suppliers** and encourage them to reduce plastic packaging in their deliveries where possible without comprising the quality of the products.

- [ ] **Monitor waste generation** related to your activities to keep track of achievements. Successes can be communicated for promotional purposes.

- [ ] Become an advocate for change by accompanying your efforts with **awareness raising activities,** organized in cooperation with other local tourism businesses such as tour operators or hotels.

- [ ] Organize an **internal meeting** with all staff to transmit your ideas and ensure everyone is aware of new tasks and duties. In order to allow for a smooth implementation of new measures, distribute responsibilities among your staff.

- [ ] Install **eco-friendly dustbins**, benches etc. for your customers' use.

CHECKLIST FOR **STREET VENDORS AND SERVICE PROVIDERS** AT PROMENADES AND TOURIST ATTRACTIONS

to Combat Marine Litter

1/1

- [ ] Public spaces which are highly frequented by tourists should be equipped with **adequate infrastructure** for waste disposal. Separate waste collection for wet, dry, sanitary and domestic hazardous waste should be easily accessible and accompanied by IEC material such as stickers and signs. To ensure tourists can easily understand locally applicable waste segregation, make use of illustrations. Suitable stickers were developed by PBMC with support from GIZ which are available for your use!

- [ ] As laid down in the Solid Waste Management Rules 2016 and PBMC SWM municipal Bye, **bulk waste generators** (generating more than 50 kg/day) are **responsible for management of waste on their own**. Consequently, it is required to either implement waste treatment facilities such as composting plants for wet waste or hand over waste to authorized processing or disposal facilities on your own or by contracting collection agencies.

- [ ] In case rubbish bins are insufficiently available or frequently overflowing, approach your municipal government / gram panchayat or local waste service providers to schedule for **more frequent collection** and/or **greater capacity** of provided bins.

- [ ] Install **eco-friendly dustbins,** benches etc. for your customers' use.

- [ ] Avoid giving away unnecessary plastic bags. Encourage customers to bring along their own **reusable bags** by offering a discount or charging small levies for single-use bags.

- [ ] **Monitor waste generation** related to your activities to keep track of achievements. Efforts and successes of waste reduction can be used to promote your services and create a USP.

- [ ] Become an advocate for change by accompanying your efforts with **awareness raising activities**. Consider, organizing clean-up activities to remove existing litter. Such activities can be conducted in cooperation with other tour operators or local tourism businesses such as restaurants or hotels.

CleanUp Port Blair

CHECKLIST FOR **OPERATORS OF INLAND ACTIVITIES**

such as Sightseeing, Climbing, Trekking, etc. to Combat Marine Litter

1/1

- [ ] Provide your visitors with **carry-along garbage bags** and ask them to refrain from littering in order to reduce waste leakage into nature. At the end of your tour, collect all waste that has been generated and dispose of it at waste collection sites.

- [ ] In case of an organized trip within any means of transport, **collect** the waste from tourists directly **inside the vehicle** and dispose correctly afterwards.

- [ ] Should you generate **more than 50kg** of waste on a daily basis, you are **responsible for waste management** on your own as prescribed by the Solid Waste Management Rules 2016 and PBMC SWM municipal Bye. Consequently, ensure processing of waste on site – such as composting or biomenthanation of wet waste – or hand over waste to authorized processing or disposal facilities directly or by contracting collection agencies.

- [ ] Display **information and educational communication material** on impacts of waste littering and heedless disposal inside your facility or vehicle and direct their attention towards it. Include information on local waste management rules as well as penalties in case of violation. Suitable stickers were developed by PBMC with support from GIZ which are available for your use.

- [ ] **Avoid** distributing **unnecessary flyers and promotional gifts** which may become waste immediately. There are many ways in which messages can be conveyed to guests (posters, screens, stickers, etc.) which generate less/no waste.

CHECKLIST FOR **OPERATORS OF MARINE AND COASTAL ACTIVITIES**

such as Camping, Boat Tours, Fishing, Diving, etc. to Combat Marine Litter

1/2

- [ ] Charge **admission fees** for beaches to finance management and clean-up of the area in cooperation with local authorities.
- [ ] **Ban smoking** on beaches and tourist spots in cooperation with local authorities. Alternatively, hand out portable ashtrays to smoking customers on beaches to ensure cigarette buds are disposed of wisely. Empty the ash trays regularly.
- [ ] **Appoint Life Support Guards** / Safaimitras to collect discarded items on the respective beaches they are responsible for.
- [ ] Raise awareness among beach-tourists by appointing **Lifeguards to announce instructions** for correct deposition of litter in dustbins on a regular basis.
- [ ] Provide your visitors with **carry-along garbage bags** and ask them to refrain from throwing waste overboard. At the end of your tour, collect all waste and dispose of it correctly.
- [ ] In case of an organized trip within any means of transport, **collect** the waste from tourists directly **inside the vehicle** and dispose correctly afterwards.
- [ ] Should you generate **more than 50kg** of waste per day, you are **responsible for waste management on your own**. Consequently, ensure processing of waste or hand over waste to authorized processing or disposal facilities directly or by contracting collection agencies.
- [ ] When providing **food on board**, refrain from any single use plastic packaging which can easily be carried away.

Figure 6: Amount of plastic collected within 15 days on Ramnagar Beach by life support guards appointed to collect discarded items

CHECKLIST FOR **OPERATORS OF MARINE AND COASTAL ACTIVITIES**

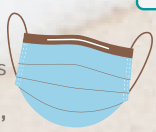
such as Camping, Boat Tours, Fishing, Diving, etc. to Combat Marine Litter

2/2

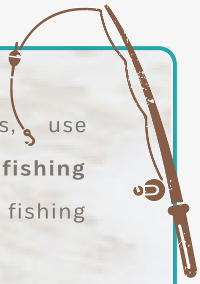
- [ ] Display **information and educational communication material** on impacts of waste littering and heedless disposal inside your facility or boat and direct their attention towards it. Suitable stickers were developed by PBMC with support from GIZ which are available for your use!

- [ ] Avoid distributing **unnecessary flyers and promotional gifts** which may become waste immediately. There are many ways in which messages can be conveyed to guests (posters, screens, stickers, etc.) which generate less/no waste.

- [ ] Refrain from providing single-use masks to tourists. Instead provide a **washable, reusable mask** to prevent the personal protective equipment from washing up on beaches and harming the environment.



- [ ] Install **eco-friendly dustbins**, benches etc. for your customers' use.



- [ ] In case of fishing activities, use **environmentally friendly fishing** products such as biodegradable fishing lines.

- [ ] Become an advocate for change by accompanying your efforts with **awareness raising activities.** Consider, organizing beach clean-up activities to remove existing litter. Such activities can be conducted in cooperation with other tour operators or local tourism businesses such as other restaurants or hotels.

- [ ] Last but not least, to ensure your set measures and goals are sustainably implemented, organize an **internal meeting** with all staff. Transmit your ideas and ensure everyone is aware of new tasks and duties. In order to allow for a smooth implementation of new measures, distribute responsibilities among your staff.

CHECKLIST FOR THE **TRANSPORTATION SECTOR**

to Combat Marine Litter

1/1

- [ ] In Andaman & Nicobar Islands, Port Blair Airport is the main entry point for tourists. Therefore, **IEC material** shall be placed wisely at the **airport** to receive attention by as many tourists as possible.

- [ ] Local means of transportation tourists depend on include public buses, autos, rickshaws and boats. Consider **placing information material outside or inside** of such means of transportation which are frequently used by visitors. Suitable stickers were developed by PBMC with support from GIZ which are available for your use!

Figure 7: A rickshaw, means of transport commonly chosen by tourists

REFERENCES

Bonanomi, G., Maisto, G., De Marco, A., Cesarano, G., Zotti, M., Mazzei, P., Libralato, G., Staropoli, A., Siciliano, A., De Filippis, F., La Storia, A., Piccolo, A., Vinale, F., Crasto, A., Guida, M., Ercolini, D., and Incerti, G. (2020) The fate of cigarette butts in different environments: Decay rate, chemical changes and ecotoxicity revealed by a 5-years decomposition experiment. Environmental Pollution, Volume 261, 114108, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2020.114108

Dalberg Advisers and WWF Mediterranean Marine Initiative (2019) WWF Call to Action: Mediterranean Countries to Step Up Regional and National Policy Ambition Towards No Plastic in Nature by 2030. https://www.wwf.fr/sites/default/files/doc-2019-06/20190607_Rapport_Stoppons_le_torrent_de_plastique_WWF-min.pdf

Ministry of Tourism of the Government of India (2019) India Tourism Statistics 2019. https://tourism.gov.in/sites/default/files/2020-04/India%20Tourism%20Statistics%202019.pdf

Norad, IUCN and Searious Business (2022a) Toolkit for plastic waste-free hospitality. https://www.oneplanetnetwork.org/sites/default/files/from-crm/Toolkit_Plastic_Waste_Free_Hospitality-compressed.pdf

Norad, IUCN and Searious Business (2022b) Toolkit for plastic waste-free tours. https://www.oneplanetnetwork.org/sites/default/files/from-crm/Toolkit_Plastic_Waste_Free_Tours-compressed.pdf

Schmidt, C., Krauth, T. and Wagner, S. (2017) Export of Plastic Debris by Rivers into the Sea. Environ. Sci. Technol. DOI: 10.1021/acs.est.7b02368. http://dx.doi.org/10.1021/acs.est.7b02368

Takada, H., Koro, M. and Kwan, C. (2022) Marine Plastic Pollution: Chemical Aspects and Possible Solutions. In: Nakajima, T., Nakamura, K., Nohara, K., Kondoh, A. (eds) Overcoming Environmental Risks to Achieve Sustainable Development Goals. Current Topics in Environmental Health and Preventive Medicine. Springer, Singapore. https://doi.org/10.1007/978-981-16-6249-2_10

United Nations Environment Programme (UNEP) (2016) Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change. United Nations Environment Programme, Nairobi. https://wedocs.unep.org/20.500.11822/7720

United Nations World Tourism Organization (UNWTO) (2022) Tourism Recovery Gains Momentum as Restrictions Ease and Confidence Returns. https://www.unwto.org/news/tourism-recovery-gains-momentum-as-restrictions-ease-and-confidence-returns

LEGAL INFORMATION

Disclaimer

All indications, data and results of this publication have been compiled and carefully reviewed by the authors. Nevertheless, errors may occur with regard to the content. Therefore, neither GIZ nor the authors will be liable for any claims, losses or damages, direct or indirect, arising from the use of or reliance on the information contained in this publication.

The reproduction or duplication of the publication (including transfer of data to multimedia storage systems) and distribution for non-commercial purposes is permitted, provided that GIZ and Port Blair Municipal Council are acknowledged as the source of the information. For other commercial use, including duplication, reproduction or distribution of all or part of this publication, written permission from GIZ is required.

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Cities Combatting Plastic entering Marine Environment

Third Floor, B 5/5
Safdarjung Enclave
New Delhi, 110029
India

T + 91 4949 5353
F + 91 4949 5391
E giz-indien@giz.de
I www.giz.de

Standard Operating Procedure

Clean-up Drives : Port Blair

Cities Combatting Plastic Entering Marine Environment (CCPME)

PROJECT PARTNERS

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India

Ministry of Housing and Urban Affairs (MoHUA), Government of India, is a federal ministry with executive authority over the formulation and administration of the rules and regulations and laws relating to the housing and urban development in India.

---

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of: Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of the Federal Republic of Germany

---

On behalf of:
Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

The Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, abbreviated BMUV, is a cabinet-level ministry of the Federal Republic of Germany. It has branches in Bonn and Berlin.

---

giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, often shortened to simply GIZ, is a German development agency founded in 2011 headquartered in Bonn and Eschborn that provides services in the field of international development cooperation and international education work.

---

teri The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

The Energy and Resources Institute (TERI) is a research institute established in 1974 in New Delhi that specializes in the fields of energy, environment, and sustainable development. The scope of the organization's activities includes climate change, energy efficiency, renewable energy, biotechnology, and social transformation.

---

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of: Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of the Federal Republic of Germany

In order to solve the global problem of plastic entering marine environment, , the Ministry of Housing and Urban Affairs under Indo-German international cooperation has initiated the 'Cities Combatting Plastic entering Marine Environment' Project. It is funded by the German Federal Ministry for Environment, Nature Conservation, Nuclear Safety and Consumer Protection. The project was planned by the Government of India and Federal Republic of Germany as part of a Joint Declaration of Intent in 2019.

Standard Operating Procedure

Clean-up Drives :Port Blair

Cities Combatting Plastic Entering Marine Environment (CCPME)

Published by:

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices

Bonn and Eschborn, Germany

Cities Combatting Plastic Entering Marine Environment

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
B-5/5, Safdarjung Enclave
New Delhi 110 029, India
T + 91 4949 5353
F + 91 4949 5391

Responsible:

Ms Vaishali Nandan
Email: vaishali.nandan@giz.de

Authors:

Dr Neha
Ms Amarpreet Kaur
Ms Muskan Mascharak
Ms Theresa Aigner

Contributors:

Ms Carla Rossitto
Mr Aviral Saxena
Dr Suneel Pandey

Editor:

Ms Soma Biswas

Design and Editorial:

Mr Santosh Gautam
Mr Vijay Nipane
Ms Anupama Jauhry
Mr Abhas Mukherjee

GIZ is responsible for the content of this publication.
New Delhi, India, 2022

Contents

1. Introduction: About the Project – CCPME

The project Cities Combatting Plastic entering Marine Environment (CCP-ME) is an initiative of the Ministry of Housing and Urban Affairs (MoHUA), in partnership with the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) with technical support from German development cooperation, through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The project is being implemented in the cities of Kochi, Kanpur, and Port Blair and their respective States/Union Territories (UTs) of Uttar Pradesh, Kerala, and Andaman & Nicobar Islands.

The overall project will work on interventions to enable selected cities to improve collection, segregation, and marketing of plastic waste, prevent plastic disposal to water bodies, and improve the handling of port and marine litter. The project will be combined with new tracking, data management, and reporting systems, civil society involvement, and increased cooperation with the recycling industry. This is in line with the Municipal Solid Waste Management Rules, 2016, which stipulate the segregation of waste at source to enable its recovery, reuse, and recycling. The project activities also align with Plastic Waste Management Rules, 2016 and its subsequent amendment in 2018. At the National level, the project is housed with MoHUA and will develop and introduce a national digital platform together with MoHUA to establish links between states/UTs, cities, and the recycling industry. It will also be used to monitor the recycling and reuse of plastic and non-biodegradable waste. In addition, standardized reporting mechanisms for cities and states/UTs to the national level related to quantities of different fractions of recycled dry waste (in particular plastics) will be developed.

CCPME and SBM-U 2.0

Swachh Bharat Mission-Urban (SBM-U) 2.0 is in continuation of the first phase of Swachh Bharat Mission launched by the Prime Minister of India, Shri Narendra Modi, in 2014. Over the last seven years, the Mission has reached all corners of the country and has changed the lives of citizens with its 'people first' focus. Waste processing in India has gone up over four times from 18% in 2014 to 70% in 2021. This has been aided through 100% door-to-door waste collection in 97% wards and source segregation of waste being practiced by citizens across 85% wards[1]. The focus of SBM-U 2.0 till 2025–26 will be on sustaining the sanitation and solid

1 https://pib.gov.in/PressReleasePage.aspx?PRID=1763354

waste management outcomes achieved and accelerate the momentum generated, thus taking Urban India to the next level of 'Swachhata'. Under the Sustainable Solid Waste Management, greater emphasis will be on **source segregation. Material Recovery Facilities (MRFs),** and waste up processing facilities will be set, with a focus on **phasing out single-use plastic. Remediation** of all **legacy dumpsites** will be another key component of the Mission. **SBM-U 2.0 envisions making all cities 'Garbage Free'.** It is expected that all cities will achieve at least 3-star Garbage Free certification under SBM-U 2.0. Under this phase, focus is given on the **well-being on sanitation and informal waste workers,** through provision of personal protective equipment and safety kits, linkages with government welfare schemes along with their **capacity building. Swachh Survekshan,** the world's largest urban cleanliness survey covering over 4,000 Urban Local Bodies (ULBs) was initiated under SBM-Urban in 2016. The Survekshan framework has evolved with the years and has today become a unique monitoring tool that accelerates ground level implementation to achieve sanitation outcomes. Over the years, the survey has received over 7 crore citizen feedback cumulatively. Continuous capacity building of state and city-level officials was undertaken, with over 10 lakh municipal officials and staff trained on various mission components.

To support the target set under SBM 2.0 and Swachh Survekshan, various waste management campaigns focusing on segregation, 3Rs, littering and capacity building of MRFs and waste collectors have been planned under the project **'Cities Combatting Plastic Entering the Marine Environment (CCPME)'.** The aim is to prevent plastic waste at source through sustainable waste management practices at the national, state, and city-level. The communication strategy is one of the measures for achieving improved collection, not the whole approach of the project.

2. Clean-up Drives

Environmental Sustainability helps prevent global warming and climate change. One example of environmental sustainability is through cleaning.

A clean-up is a volunteer activity wherein people pitch in to collect trash to make the place more pleasant and safer for everyone. Coastal/riverine/canal clean-up drives improve the coastal/riverine and ocean ecosystem by ensuring that none of the trash kills marine life or is toxic enough to disrupt the aquatic life cycle. Clean-up drives at tourist spots, religious places like temples, ghats and community settings like monuments sites are the need of the day, which can aid in sensitizing, spreading awareness, and mobilizing people towards garbage-free cities.

A clean-up drive is an opportunity to gather new data about the state and the types of trash that pollutes them. Clean-up drives can serve as catalyst for permanent change in behaviour and attitude as well as encourage communities to adopt good practices such as reuse and recycling, which have a profound effect on waste management in a community.

Port Blair Problem Statement with details about Hotspot areas for the clean-up drive

Port Blair, Andaman and Nicobar Islands

The Central Pollution Control Board (CPCB) estimates that Port Blair, the capital of Andaman and Nicobar Islands, generates 76 tonnes of waste per day, of which 10% is estimated to be a plastic waste. There are no rag pickers in Port Blair, and the city is without bins. Fines have been imposed in Port Blair for littering, and SUP has been banned since 2019. There is a ban on SUP in Andaman and Nicobar Islands that came into effect on September 5, 2019. There is a ban on PET water bottle (less than 2 litres), polystyrene, styrofoam, plastic straws, plastic-bodied cigarette lighters, sachets, SUP use, use-and-throw stationery items, carry bags (made of polypropylene, polythene, plastic, plastic sheets), pouches, ear buds with plastic sticks items. Andaman and Nicobar Islands have faced a significant problem concerning the discarded fishing nets and gear. There is no glass waste or textile waste recycling facilities in Port Blair as it is far away from the mainland. Measures should be taken soon to put up a facility for the recycling of the waste.

3. WHY are We Implementing? – About the Clean-up Drive Strategy

The support provided by the project at the national, state, and local levels for the plastic and non-biodegradable waste needs to be communicated to diverse stakeholders and communities to involve them in the process, resulting in the long-term sustainability of the actions taken. Communication in general seeks to inform the stakeholders with knowledge regarding the project action, its results, and impacts. Each target group and/or stakeholder needs to be addressed through appropriate, adequate, and accessible tools, instruments, and products. This is required to ensure the visibility of the project itself, its activities, and the project partners. Since, the project works with various partners, there is a need to develop a common understanding about project's communication objectives, its target audience, and channels where project information needs to be showcased. Further, the project intends to conduct various events, demonstrations and will be participating in national and international events organized by ministries, institutions, etc. During the tenure of the project, it is envisaged to develop various knowledge products based on the learnings.

Objectives:

- To encourage communities to take collective responsibility to clean the surroundings by removing trash and debris from coastal areas like beaches and other water bodies, tourist spots, religious places, and monuments sites.
- To sensitize communities about the sources, harmful effects of littering and SUP waste with respect to the marine environment and garbage-free cities.
- To change behaviour patterns that cause pollution and to raise awareness on the extent of the marine debris problem.
- To aware people about the need for and importance of waste segregation and waste recycling.

4. WHAT is the Clean-up Drive? – Concept

The CCPME project proposes the following under the clean-up drives:

Organizing clean-up campaigns (planning, implementation, and documentation) in identified hotspots for each city.

Based on the local strategy developed, the clean-up activity's objective must include waste collection, segregation, and adequate disposal. The waste collected will be characterized as quantified and further linked with recyclers at the local level. An important aspect of the activity is to document the quantities of different type of waste collected and ensure the segregated waste from Clean-Up drive is deposited at MRFs or other recycling units

Organize awareness campaigns to prevent littering. The awareness campaign must engage with the target audience and stakeholders of the hotspot area. The awareness campaign/activities need to engage with schools/communities/NGOs/SHGs/RWAs and local residents for wider reach and awareness generation.

Analysis of results/recommendations for hotspot mitigation action. The characterization and documentation of the collected waste can provide information about the source of littering/what type of waste is most common in the area/type of waste generated. A proper understanding/analysis of this information will help in formulating an action plan for the sustainable impact of the clean-up drive.

The concept of the clean-up drive can be characterized as:

- Identify hotspots in the city that may be directly or indirectly (riverine system) linked with the marine or river ecosystem.
- Organize clean-up of the identified water bodies – it can be a combination of clean-up of waste by JCB (supported by municipal corporation/council) and plogging of dry waste around the dirty water body by citizens as volunteers.
- Mobilize and engage/include local stakeholders and the target audience to be part of the clean-up drive through meetings, creatives, publicity and promotional activities.
- Collect and characterize the waste from the clean-up drive, forming linkages with local MRFs so that the waste collected can be recycled.
- Develop IEC engagement/activities for the target audience to increase participation in clean-up drives (plogging, waste identification, etc.).
- Through the clean-up drive incite responsibility amongst the public and demonstrate through the waste collected that conscious effort could

reduce plastic/non-biodegradable waste entering the marine systems.

- Probability of reduction in waste collected in the subsequent clean-up drives of the same hotspot. Thus, justifying sustainable impact of clean-up drive activity.

The project acknowledges that clean up drives are not sustainable, we are only suggesting it to spread awareness on how waste segregation at source can help in reducing marine litter

5. WHERE will the Clean-up Drive Happen? – Selection for Clean-up Drive

Partner City	Area Identified	Clean-up Site	Target Audience	Purpose
Port Blair, Andaman & Nicobar	• Junglighat area • Ramakrishna Mission • Carbyn Cove	• Junglighat fish landing area (will be divided into 3 zones) • Drain connecting with the ocean • Part of the drain flowing through the market	• Fishermen community • Fishermen business • Urban residents in • the area • Girl's hostel • Cafes and restaurants • Street vendors • Shops and shopkeepers • Street vendors • Local markets • Local residents	• Clean fish landing area • To clean drain collecting waste from the city and depositing it in the Indian Ocean • Clean the drain carrying the waste from the market area and surrounding commercial area.

6. HOW will the Clean-up Drive be Implemented? Strategy for Clean-up Drive

6.1 Identification of the problem

- The project CCPME conducted a preliminary study (gap analysis/ secondary data).
- The project carried out discussions with the ULB and various stakeholders.
- Based on the needs of the ULB and the discussions, hotspots in the city were identified.
- The hotspots were identified based on amount of littering, waste generated, type of activity, and the target audience.

6.2 Selection of sites

The sites selected for the clean-up drive are mentioned in the table provided earlier.

The above-identified hotspots are located close to riverine/drain/backwaters that eventually meet the oceans and the marine ecosystem.

In **Port Blair**, the hotspots in the city cover areas of local markets, commercial areas, urban areas and the fishermen community. Especially, the Carbyn Cove area, is the last point before which the canal drains into the water body.

In all the selected hotspots there is observed littering. Through the clean-up drives, the residents around the hotspots will be engaged with to generate awareness and understand the connection between littering and pollution of marine ecosystems.

6.3 Target audience bifurcation

- The target audience for the clean-up drives is identified based on how close the target audience resides to the clean-up site and how much is their contribution in littering.
- In certain hotspots based on observed littering, low/mid income households are identified as the target audience.
- At least one identified hotspot in the city is located in a densely populated commercial area with marketplaces/ vendors/shops/institutions, etc.
- The identified hotspots take into consideration other stakeholders in the administration such as Port/Navy authorities.

6.4 Engagement plan with target audience

The engagement plan with target audience is made taking into consideration the most effective form of engagement specific to various identified target audiences.

- Households are engaged through RWA discussions and demonstrations.
- IEC tools such as Nukkad Nataks are employed to increase awareness about littering.
- Plogging as an activity helps engage with floating populations in the hotspots.
- Community meetings to engage with stakeholders.
- Youth/student mobilization events.
- Workshops/capacity building activities for Port/Navy authorities.
- Awareness drives/campaigns for street vendors/shopkeepers.
- Awareness generation and engagement activities for eco-tourist population.
- Events to mobilize local/state level media.

6.5 IEC and promotion plan

Information, Education and Communication, abbreviated as IEC, will be used as a strategy to spread awareness through communication channels to a target audience to achieve a desired positive result. The strategy is of sharing information through the various communication channels like broadcast or the print media, interpersonal communication in a manner, appropriate to the target group's culture and values. It is intended to instill positive knowledge for appropriate behaviour in the community, which will promote effective waste management, preventive health measures, and development. These channels of communication or IEC materials are either printed or broadcasted media such as posters, flyers, leaflets, brochures, booklets, radio broadcast or TV spots.

The **IEC** material that will be used has been divided into 3 periods:

- Pre-clean-up Drive: Informational flyer, social media – Facebook/Instagram, mass media like TV/newspaper/posters.
- Implementation Period: Public announcements, social media, local newspapers/media agencies.
- Post-Clean-up Drive Period: Banners/ Posters, mass media like TV/newspaper/ posters, social media, local newspapers/ columns.

The template for IEC is provided in the Annexure 5.

6.6 Activity plan (clean-up drives and events)

Carry out 6 mega events – clean-up drives in identified clean-up sites. Each event should be accompanied with pre- and post-clean-up activities.

Pre-event activities can be aligned with outreach/stakeholder consultations/ social media traction/crowd sourcing for clean-up mega event

Post-event activities – social media dissemination of event impact/waste collected/linkages for MRFs/type of waste collected.

A. Pre- and during- event activities

Considering each mega event as a clean-up drive:

Each clean-up drive is required to have pre-event activities. Various media platforms, especially social media is to be leveraged to gain traction for the upcoming event.

Extensive social media documentation of these pre-event categories can enable more participation for the mega event (through influencers, post, quotes, teasers, etc).

The primary purpose of the pre-event activities is to generate/create a 'buzz' for the upcoming mega event. Additionally, the activities are aligned with the objective of the CCPME project.

Substantial social media coverage for all pre-event activities will benefit the extent of public participation and volunteering for the clean-up drive.

Objectives of pre-event activities:

- Mobilizing community/youth/media for the clean-up event.
- Stakeholder discussions and demonstrations (MRF staff/port authorities/ULB staff) for capacity building.
- IEC activities to engage schools/institutions and communities to increase awareness and participation.
- Activities like "Plastic Lao Uphaar Pao" and "Selfie with a Garbie", to create traction through social media.
- Activities to engage influencers/activists to increase reach and participation for clean-up drives.
- Plogging activity to mobilize local residents/target audience for clean-up drives.

Pre-event activities is a tool through which the target audience, stakeholders, residents and communities can be engaged with and help create awareness. The pre-event activities are also to leverage participation and support for the upcoming clean-up drive.

i. Communication/outreach for the cleanup drive (mega event) –

- Media mobilization and sensitization events leading up to and during the clean-up drives.
- Engaging local media: Engage local media reporters/news agencies through ads, editorial columns and talks by the city administration in the clean-up drive/campaign. Media should be included in the event not just called for coverage.
- The clean-up drive may be covered by local social media agency and influencers.
- In the subsequent clean-up drives, based on preliminary impact, include/involve state personnel/celebrities.

ii. Preparing the location (Nets on drains)

- Install a large net/barrier in the drain/canal that will collect the floating waste. The net/barrier needs to be in place for duration of 1/3/5 days depending on approval from local administration and the quality/quantity of waste in the specific drain/canal.
- On the day of the clean-up drive, the net will be taken out of the drain to reveal the amount of collected waste.
- A sample of this waste will be placed in front of the audience to display which articles constitute the most amount of waste. This sample will be displayed in a cordoned-off area, marked with caution/

banners/posters, etc.

iii. Engaging the audience

- Forms which are designed to help characterize certain kinds of non-biodegradable waste will be distributed to the audience seeing the displayed waste.
- The audience will be expected to observe and mark the types and kinds of waste visible. This will help engage the audience while also generating awareness and sensitizing the public.

B. Post-Event Activities

The activities following the clean-up drive is considered as post-event activities.

The post-event activities are primarily based on the following:

1. Characterization and specifications of collected waste from clean-up drive. Detailed recycling and disposal plan.
2. Utilizing social media/local media to disseminate the impact of clean-up drive.

Step-wise procedure for post-event activities:

- The waste collected from the clean-up drive is deposited in trucks.
- The trucks transport the collected waste to a local MRF.
- The MRF is responsible for characterizing/segregating the waste.
- The waste collected from plogging, which is segregated is also brought to the MRF.
- All the segregated waste is quantified and documented by the MRF.
- The quantified waste is then distributed for recycling.
- The quantity of waste collected/material recycled will be conveyed to the media through impact stories.
- These stories will help in creating awareness and consciousness about the connection of littering, waste mismanagement, and recycling.
- Based on this, an article may be published in local newspapers/media outlets.

Each city will strategize and develop a plan to disperse and publicize the amount/type of waste collected in the clean-up drive and the subsequent impact.

The post-event activities can benefit from extensive social media coverage and campaigning—this will help disseminate the impact of the clean-up drive and the subsequent value chain linkages at the city level.

Each clean-up site must be surveyed post event—encouraging the public to share experiences, stories, and pictures from the event. This may facilitate larger participation in subsequent events.

i. Transportation and processing of waste

- Once collected and displayed, the waste will be transported to a local MRF in municipal corporation trucks.
- Once in the MRF, the waste will be weighed, processed, segregated, and further linked to the value chain.
- In the MRF, the staff will be responsible to fill out a detailed form
- The collected and characterized waste can be a part of the post-event activities.

ii. Reclaiming back the clean-up sites

- Through the 6 mega events in the form of clean-up drives, the intent is to demonstrate that the impact of the drives is sustainable. The clean-up drive sites can be reclaimed and utilized as per the local administration's approval.

6.7 Development of activity calendar

The activity calendar is essential for future activity planning because it specifies details such as venue, target group, workdays, and time. This tool is primarily used to organize time for task completion. Furthermore, it aids in the transparency of the entire process and makes it easier to plan for future activities and analyse the work plan.

The activity calendar for the entire duration of the project must be developed, including details of the areas where the clean-up drive will be planned, a list of target communities such as high/low income households and commercial spaces; low/medium income households, shops, and cattle/pet owners; and local/state stakeholder engagement.

This will be followed by the type of activity planned for that month, which may include major event activities such as clean-up drives and waste quantification, as well as pre/post event activities such as community engagement, workshops, capacity building activities and events, and market linkages and demonstrations for local stakeholders.

The following template can be used to create an activity calendar:

CCPME Events Calendar 2022-2023					
Area	**Community**	**Activity**	**Month 1**	**Month 2**	**Month 3**
	High/low income households and commercial spaces	Major event activities - Clean-up drives & Waste quantification			
	Low / medium income households, shops and cattle/ pets owners	Pre/post event activities - community engagement, workshops, capacity building activities and events			
	Local/state level stakeholder engagement	Market linkages and demonstrations for local stakeholders			

6.8 Monitoring and evaluation

The Monitoring and Evaluation (M&E) framework will support the implementation of clean-up drive strategy. The framework also helps in making any mid-course corrections and measure the impact of the communications interventions. The implementing agency will need to identify a set of supportive supervisors and monitors who would monitor and fill the monitoring checklists at all levels. Effective monitoring and evaluation will help:

- Know whether your communications have achieved or exceeded your aim and objectives.
- Identify which activities worked well and which didn't; how they might be improved or whether they should be substituted for other activities.
- Develop better communications in the future by refining and improving activities, focusing spending more effectively and achieving better results.

Monitoring

Monitoring the outcomes of your communications work will allow you to detect whether any changes are happening as a direct result of your inputs. Even if these changes are not your ultimate goal (i.e., the desired impact); they are a step on the way and are therefore a useful indication of change that you can measure.

Monitoring of impacts is essential if you are to determine how effective communications have been in achieving their objectives and thus the ultimate aim. Knowing what impact, you have had will help you to evaluate how effectively the communication activities have been delivered and how good they were at achieving changes you required.

Key Performance Indicators (KPIs) are essential as they are the yardsticks by which you can measure your performance against an objective, and thereby assess how successful you have been.

Monitoring and evaluation will take place both qualitatively and quantitatively during:

Pre-campaign Period – measuring baseline data/inputs

Post-campaign Period – measuring impacts.

6.8.1 Pre-campaign period

1. Measuring baseline data: Undertake pre-campaign research where current hotspot situation can be assessed in terms of waste littered. Later, it could be repeated to form part of post-campaign evaluation. The baseline data will also include the inputs in clean-up drive. Indicators which should be monitored are:

- Monitor the amount of waste littered on the site before clean-up
- The number of communication products used on site
- Monitoring that the products are reused like banners, posters, equipment like hand gloves to another clean-up sites
- Monitoring that the waste is collected and stored in a segregated manner
- The waste should not be littered while storing and during transportation to

the recycling centres. Monitoring the amount and type of recycled waste and its disposal.
- Number of check-in-table set-ups
- Number of resources used: both human and non-human (like, coordinators, number of equipment, etc.
- Number of social and print media impressions

6.8.2 Post Campaign Period

A clean-up drive report for each drive needs to be submitted by the implementing agency which should include details about:

Qualitative Evaluation

Review impact of campaign activities/ Impact Fact Sheet – Attached in Annexure 4

Quantitative Evaluation of the event

a. Number of media releases
b. Number of Selfie with Garbies – post on the social media post
c. Number of communication products disseminated (number of posters, leaflets, etc.)
d. Number of received registrations
e. Number of volunteers participated
f. Ratio of male and female participation
g. Amount of waste collected (waste categorization)
h. Amount of waste recycled
i. Amount of waste sent to landfill

6.9. Expected Output

The envisioned output of the clean-up drives:

- Generating awareness and sensitizing the target audience regarding littering, non-biodegradable waste management, and the marine ecosystem.
- Repeated clean-up drives in the same identified sites – leading to visibly reduced waste and littering in that area.
- Information and knowledge about the source and composition of the waste from the clean-up drive area—resulting in a better understanding and management of waste.
- Capacity development and building for ULBs staff related to the SWM services and local MRFs with further linkages to the value chain.
- Integration of the local administration and the municipal corporation staff in the clean-up drives ensuring regular collection and uptake of waste from the sites. This will help the process of reclaiming the site for public utility in the future.
- Quantification of waste collected from the clean-up drives, actively reducing the amount of non-biodegradable waste entering the marine ecosystem.
- Quantification of waste collected, processed, and segregated by local MRF and further linked with recyclers.
- In the process of carrying out the clean-up drives – large-scale social media outreach and awareness generation leading to behaviour change in the identified target audience and general public.
- Generate public interest and participation to keep the clean-up drive sites clean and maintained, to ensure the campaign is sustainable.

6.10 Interpretation and making use of your clean-up campaign results

After a successful clean-up drive has been conducted, a set of data will have been generated on the site-specific conditions and collected litter. Based on the analysis of the gathered information, conclusions can be drawn on the sources and flows of waste. Therefore, the interpretation of this data will generate valuable results, which subsequently facilitate the determination of best suitable next steps.

By analyzing the data generated during the clean-up event, it becomes clear which types of waste are mainly being littered at the site in question.

1. Household waste

In case the clean-up site was significantly polluted with organic, residual or other waste from households, measures to be considered include:

- Awareness raising campaigns on the importance of waste segregation and the benefits of individual composting.
- Conduction of training on home composting for neighbourhoods/ schools/associations.
- Promote community composting and urban gardening in public areas.
- Research on the collection rate within the municipality to identify gaps in the system. Potentially enhance the collection system.
- Reduce food waste generation via an awareness raising campaign on proper storage of food and recipes for left overs.
- Reduce the distance to waste collection points for households by calculating the optimal location or by increasing the number of collection points, if needed.
- Reduce waste generation by incentivizing packaging-free trade/markets via reduced service fees, subsidies, tax benefits or vouchers.
- Endorse local businesses to opt for minimal packaged products and to incentivize consumers to favour reusable packaging. For example, by charging for single-use items.
- Penalize illegal deposition of household waste.
- In order to circumvent the deposition of waste electric and electronic appliances in uncontrolled environment, raise awareness on its hazardous effects.
- To prevent electric and electronic appliances from becoming waste in the first place, encourage citizens to repair damaged items via awareness raising campaigns, transfer of know-how on repair throughout an event, the promotion of repair shops and/or a (temporary) repair bonus system.
- Promote the use of rechargeable batteries.
- Facilitate the access to MRF followed by an information campaign.
- To reduce discarding and promote reuse and repair of clothes, toys, furniture, books and other commodities, create spots for redistribution/donation such as

open book shelves.

2. Commercial and industrial waste

Furthermore, it can be the case that commercial businesses and industrial companies dispose of end-of-items on public grounds. If this is the case at the clean-up site in question, the following actions are suggested:

- To prevent dumping of waste tyres, awareness needs to be raised on the high thermal recovery potential in energy intensive industrial processes such as cement kilns or for road constructions.
- To leverage the co-processing and co-incineration potential of waste tyres, the introduction of a buy-back centre can significantly increase its collection and recycling rate.
- Reduce food waste from local (super) markets by promoting reduced prices for mature and unsold products, by endorsing cooperation with restaurants/ other businesses/farmers to make use of the products (sauces, animal feed, etc.)
- Promote the redistribution of food left over from food markets/restaurants/ hotels to vulnerable groups.
- Organize a local collection point/system for used cooking oil and cooperate with a business to further process and recycle the oil for further use.

3. Recreational and tourist activities waste

Often, recreational areas and touristic places are prone to accumulation of single-use plastic items. Depending on their purpose and source, the following should be considered:

- **Plastic bags** – sourcing from markets/ supermarkets/commercial centres
  - Introduce a mandatory fee for plastic bags in supermarkets or on markets.
  - Implement a ban of single-use polythene bags.
  - Promote reusable bags via awareness raising campaigns for customers.
  - Incentivize customers to repurpose used plastic bags via an awareness raising campaign.
  - Provide access for market vendors to paper bags and reusable bags for selling.
- **Food and drinks-related single-use plastic items** - sourcing from gastronomy
  - Ban single-use plastic cutlery/plates/ cups/straws/containers.
  - Endorse restaurants/catering businesses/festival organizers to phase out single- use plastic tableware via voluntary agreements or certification schemes.
  - Opt for reusable alternatives during public events.
  - Promote the provision and/or install refillable water dispensers.
  - Implement a deposit-refund scheme for beverage containers such as PET bottles, glass bottles or tetra packs.
- **Single-use plastic amenities** – sourcing from the accommodation sector
  - Incentivize hotels to phase out single-use plastic amenities via voluntary

certification schemes.

- Promote the installment of refillable soap and shampoo dispensers.
- Furthermore, particularly close to touristic sites and monuments well placed, visible signs should instruct tourists on where to and how to dispose of their waste.

Additionally, open discourse and exchange with the respective stakeholders helps to identify specific challenges impeding a transition. This can be undertaken in the framework of a discussion forum of any format.

4. Construction waste

Illegal deposition of waste originating from the construction sector can be countered by:

- Incentivizing construction companies to reuse and recycle second-hand materials, e.g., by organizing a competition on ecological design and construction of buildings.
- Raising awareness on the benefits of closed material loops particularly among manufacturers and contractors.
- Fining illegal deposition of construction waste. Additionally, target augmented enforcement in case of hotspot sites.
- Launching a buy-back centre for recyclable materials.

5. Other waste

Further items of local concern which are concluded from the clean-up reporting need to receive special attention.

- Fishing equipment on polluting marine environment by:
  - » Promoting the repair of damaged equipment, e.g., via repair bonus system, promotion of repair shops, training on repair.
  - » Fining illegal dumping of fishing equipment including nets.
  - » Ensuring availability and sufficient capacity of collection centre for ghost gear/old fishing nets at fishers' most frequented areas.
- COVID-19 related/sanitary waste: masks, gloves,
  - » Educate people about the health risks of littering these wastes.
  - » Ensure dedicated and segregated collection and disposal.
- Prevent cigarette buds from ending up in the environment by installing covered public ash trays impenetrable by the wind.
  - » Campaigning for and promoting the use of portable pocket ashtrays.
- Religious rituals-related waste – be culturally sensitive, provide alternatives for people to express their beliefs in an environmentally sound way.

In sum, you should study strategies applicable to your context to target the 5 major items of concern that appear during your clean-up campaigns.

Other sources of waste leakage can be extracted from the interpretation of your clean-up form results, such as:

1. Insufficient availability of trash cans in public spaces

Based on the submitted 'waste collection survey form' it can be identified whether trash cans and rubbish bins are sufficiently supplied and used by the public. The placement and capacity of trash cans in public areas is highly relevant as it is decisive for the collection efficiency. Hereby the following should be considered:

- Avoid trash thrown away intentionally on site by placing bins at the most frequented sites.
- Avoid washing away of waste by relocating trash cans away from sites, unreasonably close to waterways, particularly in regions of heavy rainfall.
- Avoid overflowing waste bins by increasing the volume of containers and/or number of containers and/or periodicity of collection if the capacity is insufficient.
- Stock up the capacity of trash cans provided during religious festivals or other well attended events.

2. Litter carried/transported via vectors/ wind

In case litter was observed to be scattered across the site, it may have been transported with the wind from various sources. Potential sources of the respective litter include unswept streets, insufficiently covered transport vehicles of collected waste, open trash cans, insufficiently managed landfills or even open dumpsites. Therefore, the following measures should be envisaged:

- Close illegal dumpsites.
- Introduce fines on illegal dumping.
- Penalize the insufficient management of landfills.
- Approach waste collection businesses to ensure transportation vehicles store the collected waste securely.
- Replace uncovered waste bins in windy areas with closed designs/alternatives.
- Increase frequency of street sweeping activities.

Annexure

1. Things to Remember for Each Event

- Requisite safety measures are of utmost importance. All precautions/safety measures must be in place for the clean-up drives.
- No plogging to be done in the canals/drains.
- All waste collected from every clean-up drive/plogging activity must be measured, monitored, and documented.
- The disposal of collected waste must be in a planned and proper manner.
- The clean-up drive and activities surrounding it should result is sustainable impact.

2. Partnerships

Partnerships are required at two stages: pre-clean-up drive and post-clean-up drive.

Pre-clean-up drive

- **Partnerships** can be sought to mobilize volunteers. For instance, Schools/Colleges/NGOs/Waste collectors can be contacted to engage maximum participation in the clean-up drive.
- Contact merchants/local businesses and other potential donors who can supply drinks, food for the volunteers or whatever else you might need during the clean-up drive. Donations of this type also encourage participation.
- **Contact** local authorities for the placement of eco-toilets (moving toilets) if they are not available on the site.
- **Media** partners – targeting local community media (radio/print) to assist in communicating on the event and drive support.

Post-clean-up drive period

- Layout a proper plan detailing waste disposal and recycling plan by consulting with the local authorities.
- Tie-up with major stakeholders like waste collectors who can aid in transportation of waste, waste disposal, and waste recycling.
- **Contact** recyclers in your area who will accept aluminium, glass and plastic bottles and make appropriate arrangements. Recycling should be the major emphasis of clean-up.

3. Key Messages for Stakeholders Slogans

1. Gandagi hum uthaenge, Koora nahi failaenge

2. Koora karna hai Zero, Humein Banna hai Environment Hero

The following listed messages will be disseminated to the audience through different communication channels:

Message 1- Say NO to littering

Sub-Message 1: Do not throw waste like plastic packets into rivers, nallas, and drains.

Sub-Message 2: Littering in water bodies can cause harm to marine environment and animals

Sub-Message 3: Dispose of waste at the appropriate waste deposition centres (Inform masses about waste management system in the city)

Sub-Message 4: Stop littering as it results in reduction in daily capture for livelihood

Sub-Message 5: Safe disposal of old plastic fishing nets

Message 2- Segregation at source is critical for its recycling and disposal (how and what)

Message 3- Segregation at source is critical for human and environmental health

Sub message 1: Sorting your waste makes it easier to understand how to reduce your general waste

Sub message 2: Segregate and then dispose of fishing nets at the appropriate waste deposition centres

Sub message 3: Daily collection of waste can reduce land and water pollution

Message 4- Observe safety measures while handling waste

Sub message 1: Take safety measures like wearing hand gloves, etc., while collecting hazardous material such as glass and metal and its importance for health

Message 5- Inform or educate people about the proper disposal of domestic hazardous waste.

4. Qualitative Evaluation

Review impact of campaign activities/Impact Fact Sheet

Evaluate the impact of your communications by answering the following questions:

Did you achieve your overall aims and objectives?	Refer to the overall aims and objectives you set and check the corresponding monitoring and evaluation Information you have gathered.
What was the overall impact of your communications?	Identify the overall or 'headline' achievement of your communications, e.g., increased tonnage collected, Increased participation etc.
Investigate any other issues (positive ornegative), which you identify or relate to your communications objectives	The review process may uncover some unexpected results (good and/ or bad) that require investigation as well. You should look at all the issues your monitoring and evaluation reveals in order to conduct a thorough review and build on your successes and avoid repeating any mistakes

5. Information, Education, and Communication

The Information, Education, and Communication material that will be used has been divided into 3 periods:

- Pre-clean-up Drive
- Implementation Period
- Post-Clean-up Drive Period

Period	Modes to Engage
Pre-clean-updrive	• Informational flyer • Social media like on Facebook, Instagram pages of the city tocreate the buzz • Mass media like TV, newspaper • Posters
Implementation Period	• Announcements during clean-up drive • Mass media like TV, newspaper • “Selfie with Garbie” – social media post of the volunteers
Post-Clean-up Drive Period	• Banners • Posters • Mass media like TV, newspaper

6. Safety Guidelines for Volunteers

- Wear all the protective equipment provided to you at the site.
- Wear protective gloves during clean-up and avoid touching your face while waste collection, whether COVID-19 is a threat in the community or not.
- Volunteers should wear closed-toe shoes (no flip-flops or bare feet) at all times
- Do not disturb the wildlife.
- Don't touch or pick up dead animals or attempt to move injured animals. Instead, notify the coordinators to make them aware of the animals and their location.
- Never pick up any trash items that you do not feel comfortable touching.
- Be careful while collecting hazardous items, such as sharp objects like needles, syringes etc.
- Don't attempt to move large, heavy objects.
- Don't overstuff your trash bags. If required, take new bags from check-in station
- Avoid over-exertion, sunburn, heat exhaustion, and dehydration. When in doubt, return to the site's check-in station before the end of the scheduled clean-up time.
- Wash hands with soap after the clean-up
- Report any injury to the site coordinators immediately.
- For any assistance, report to site coordinators immediately at …
  (add contact details) …

7. Media Engagement

The local media must be engaged during pre-, implementation and post-clean-up activities.

- Local/regional media agencies must be engaged with and included in pre-event activities to ensure participation and outreach for the clean-up drive.
- Media engagement and involvement can constitute pre-event activities. Activities and events to mobilize and sensitize the media to the objective of the clean-up drive.
- Local influencers/media activists must be engaged for the event.
- In the subsequent clean-up drives, based on preliminary impact, include/involve state personnel/celebrities.
- Engage local reporters/news agencies in the clean-up drive/campaign.
- A local social media agency should track the story and campaign.

7.1 Social Media Management

- For the purpose of social media engagement:
- The contracted agency will be responsible for the creation of the social media campaign handle.
- The contracted agency will be responsible for dissemination of campaign related content through the social media handles.
- All content disseminated must be in accordance with GIZ guidelines.
- Photographs and videos will help to tell the story of the clean-up event after it is over. Send photographs to local Municipal Corporation with a thank you, send a photograph along with a story to a newsletter or newspaper, and share the results with public on social media handles.

Take before photographs of the littered areas.
Photograph volunteers working, volunteers interacting with media representatives, invited dignitaries and sponsors, if any, layout of the event, posters or banners, etc.
Photograph the results – the cleaned area, the piles of collected trash, group photos of the volunteers, etc.

- The social media handles require to be regularly updated with posts from ongoing/upcoming/impact of events.

8. Waste Collection Survey Form

General Information on Collection Site	
Name of Institution undertaking Clean-up:	
Name and Contact of Lead Supervisor:	
Number of Team Members and Volunteers involved:	
State, City, Ward:	
Name of Site:	
Landmark:	
Address of Clean-up Site:	
Length/area under consideration for Clean-up:	
Date/Time of Clean-up Activity	Date: Start Time: End Time:
Type of Environment	☐ Salt Water/Coastal (Beach, Ocean, Bay, Estuary) ☐ Fresh Water (Waterfall, River, Stream, Lake) ☐ Wastewater (Drains, Nallah) ☐ Absence of Water: Trails, Streets, Landparcel ☐ Terrestrial (Beach, Seashore, River Banks/Ghats) ☐ Submarine ☐ On the water surface (Boat, Canoe, Sailboat, Screen, Floating Boom, and Barrier)

Trash Cans or Rubbish Bins present at or along site under study?	☐ yes ☐ no
Are trash cans appropriately placed and used by public?	☐ yes ☐ no
Cleanliness at first Glance?	☐ No debris visible ☐ Scattered debris visible ☐ Lots of debris visible ☐ Large amount on dumped waste
Fill out after clean-up: Evidence of Dumping? Tick one or more	☐ None ☐ Construction waste ☐ Household waste ☐ Commercial and Industrial waste ☐ Recreation/tourist activities waste ☐ Others ___________
Fill out after clean-up: What shall be the destination of the waste collected?	☐ Handed over to urban local body/other department ☐ Send for recycling to others (partner institution, SHGs, company, etc.) ☐ Donated to Informal Collectors ☐ Unknown
Fill out after clean-up: List 5 Items of Local Concern:	1. ______________________________ 2.______________________________ 3.______________________________ 4.______________________________ 5.______________________________
Waste Quantity Summary:	Number of collected Items: ____________ Total Quantity of Waste in kg: _____________ Total Quantity of Waste segregated and diverted for Recycling in kg: _____________

9. Forms for Plogging

Plogging Form	
Date:	
Location:	
Name of event:	
Waste Collected	
Material	**Items Collected**
1. Paper products	
2. Plastic bags	
3. Plastic – Cups/Plates/Straws/Items	
4. Clothes/Fabric	
5. Food Waste	
6. Rubber Products	
7. Wood or Metal Items	
Fishnets (only for Kochi and Port Blair)	

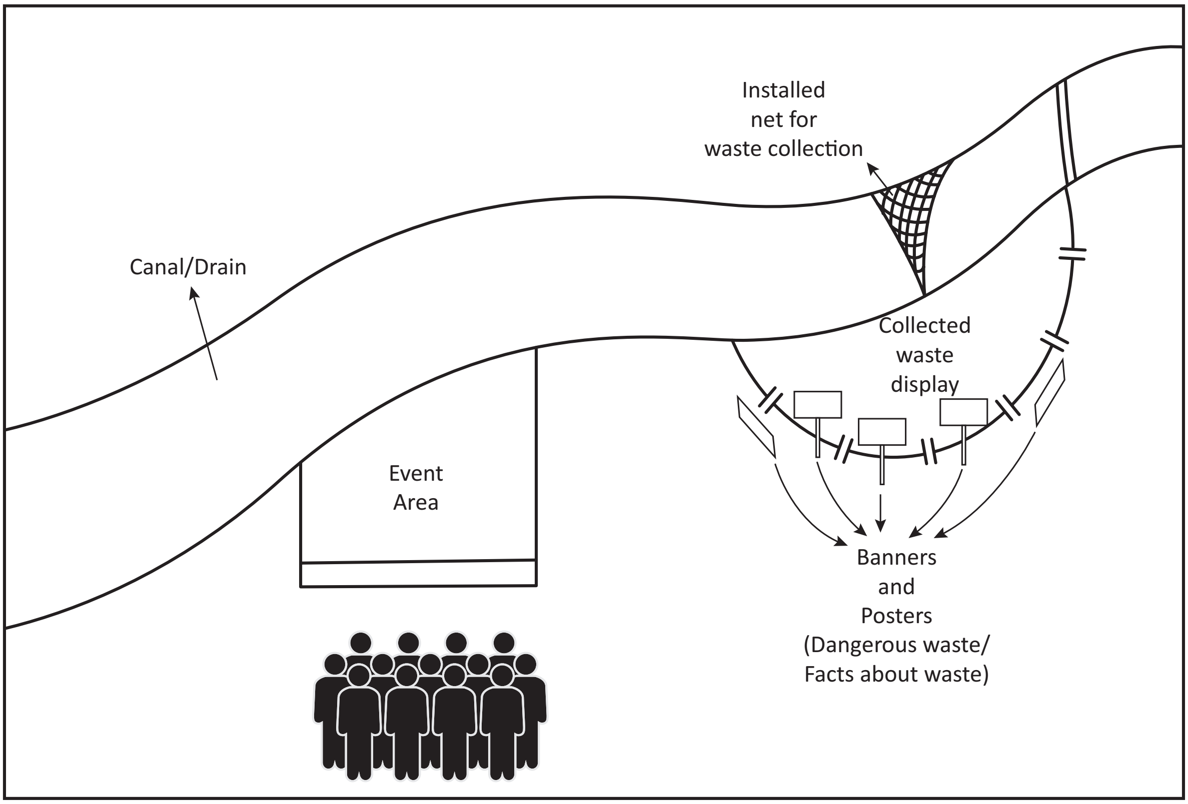
10. Reporting Template

Reporting Template – Clean-up Drive CCPME		
General Information		
1. Name of clean-up site	City	
	Area	
	Date	
2. Is this the first time that this area is being cleaned?	Yes	No
• If no, when did the previous clean-up drive in the area happen?		
3. Organized by		
4. Target Audience		
5. No. of participants		
6. No. of volunteers for plogging		
7. Chief guests, Dignitaries/Delegates present – (Name and Designation)		
Stakeholder Participation		
8. No. of media agencies (name them)		
9. No. of institutions/Organizations (name them)		
10. No. of Residence		
11. No. of schools/colleges (name them)		
Event Details (clean-up drive)		
12. Agenda of the event		
21. Activities that took place as part of the event	Name of activity	Details of the activity
22. Photographs	Put photographs in a separate folder with caption please	
23. Video/Byte	Put videos and bytes in a separate folder with caption please	
24. No. of plogging forms/consent form for photographs collected		
26. Safety precautions used		
Media Coverage		
28. How was the event reported?	Through press release	☐
	Through media reporting and coverage	☐

29. Who released the press release?	Municipal Corporation ☐	
	GIZ ☐	
	External Agency ☐	
31. Copy of the Press Release	Attach as annexure	
32. Total no. of social media posts for the event		
33. Social Media posts made by	Municipal Corporation ☐	
	GIZ ☐	
	External Agency ☐	
34. Handles used for Social Media posts		
35. Tags/Hashtags used for Social Media posts		
36. Copy of the Social Media posts	Attach as annexure	
37. Were Social Media influencers engaged for the event?	Yes ☐	No ☐
38. How were Social Media influencers engaged? (Mode of engagement)		
39. No. of influencers who posted our posts		
40. Copy of the press clippings/posts	Attach as annexure	
Post-media Campaign		
41. What is the strategy for post-media campaign?		
42. What will be posted on social media and which handles will be used?		
43. When will the posts be made?		
45. Copy of social media post	Attach as annexure	
46. What will be published in media?		
47. When will it be published?		
48. When will it be published?		

49. Who will publish it?	Municipal Corporation ☐ GIZ ☐ External Agency ☐
50. Copy of the published material	Attach as annexure
Report on Waste Characterization from the Clean-up drive	
51. Weight of waste collected from clean-up drive	
52. What was the weight of waste collected in the previous clean-up drive?	
53. Quantity of segregated waste collected from plogging activity and what was done with it?	
54. Quantity of waste segregated at MRF	
55. Name of MRF	
56. Copy of Waste Characterization Form (Filled)	Attach as annexure
57. Photographs from MRF	Put photographs in a separate folder with caption please
58. Processed waste sold/handed to (if applicable) whom?	
59. Name of waste recycler	
60. What is the recycle plan for the collected waste?	

11. Visualization of Event



The visualization attached below is only a preferable way of implementation of the whole event and therefore is subject to change as per the needs and ease of the implementing agency.

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Cities Combatting Plastic entering Marine Environment
Third Floor, B 5/5
Safdarjung Enclave
New Delhi, 110029, India

T + 91 4949 5353
F + 91 4949 5391
E giz-indien@giz.de I www.giz.de

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

Clean Up Port Blair

We Segregate our waste at home

Segregation of waste at source helps reduce litter

#Preventlitter

#Cleanupportblair

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

I DO NOT PROMOTE SINGLE-USE PLASTICS

Clean Up Port Blair

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

BE A RESPONSIBLE TOURIST

Carry your reusable cloth bags, bottles and cutlery

#Saynotoplastic

Clean Up Port Blair

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

Clean Up Port Blair

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

USE DUSTBINS TO THROW WASTE

Clean Up
Port Blair

Clean Up
Port Blair
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
On behalf of:
Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection
of the Federal Republic of Germany
DOMESTIC HAZARDOUS WASTE
WET WASTE
DRY WASTE
WE DO NOT THROW WASTE IN THE DRAIN
Segregate your waste
#Preventlitter
#Cleanupportblair

Clean Up Port Blair

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

BIN IT RIGHT

Segregate your waste at source

#Preventlitter
#Cleanupportblair

Clean Up Port Blair

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
of the Federal Republic of Germany

OUR ROADS ARE NOT FOR THROWING LITTER, PUT YOUR WASTE IN DUSTBINS TO MAKE EARTH CLEAN AND BETTER

#Preventlitter
#Cleanupportblair

Clean Up Port Blair

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

of the Federal Republic of Germany

DON'T DUMP FISHING GEAR/PLASTIC INTO SEA

Save marine life,
Save your livelihoods

#Preventlitter
#Cleanupportblair