PROJECT ON

"TACKLING PLASTIC WASTE IN THE ENVIRONMENT"

(MANGALURU AND THIRUVANANTHAPURAM)

Report: Thiruvananthapuram

Application of Waste Wise Cities Tool: Ground data assessment results

UN-Habitat IND Office

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List of Abbreviations

CKCL	Clean Kerala Company Limited
DPR	Detailed Project Report
HH	Households
HIG	High Income Group
HKS	Haritha Karma Sena (women self-help group)
KEIL	Kerala Enviro Infrastructures Ltd
LIG	Low Income Group
LVP	Low value plastics
MCF/ MRF	Material Collection Facility/ Material Recovery Facility
MIG	Middle Income Group
MLP	Multi Layered Plastic
MSW	Municipal Solid Waste
NGO	Non-governmental organisation
NGT	National Green Tribunal
OECD	Organization for economic cooperation and development
RRC/RRF	Resource Recovery Centre/Facility
SDG	Sustainable Development Goals
SUP	Single Use Plastics
TPD	Tonnes per day
TMC	Thiruvananthapuram Municipal Corporation
UN	United Nations

UN-Habitat	United Nations Human Settlement Program
WACS	Waste amount and composition survey
WaCT	Waste Wise Cities tool
WFD	Waste Flow Diagram
WWC	Waste Wise Cities

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1.0 Introduction

Under the Waste Wise Cities (WWC) programme, United Nations Human Settlement Program (UN-Habitat) has developed the Waste Wise Cities Tool (WaCT), based on SDG indicator 11.6.1 parameters, to support cities and countries in undertaking a comprehensive diagnostic of Municipal Solid Waste (MSW) to aid scientific and evidence-based development of projects and investments. As part of the Waste Wise Cities, UN-Habitat supports cities in establishing better waste and resource management strategies, creating business and livelihood opportunities, and transiting towards a circular economy.

This project is funded by the Alliance to End Plastic Waste INC, a not-for-profit entity and is being implemented by UN-Habitat in Ethiopia, India and Kenya. The project targets six cities across these three countries to assess waste management status and develop city-specific project proposals. In India, the project is being implemented by UN-Habitat India Country Office in two cities, Thiruvananthapuram and Mangaluru. The project aims to help implement solutions towards a circular economy, creating businesses and livelihood opportunities while enhancing resource recovery.

1.1 UN-Habitat – Waste Wise Cities Program

UN-Habitat launched "Waste Wise Cities" in October 2018 to address the increasing global waste management crisis. WWC aims to support cities and local governments in achieving the Sustainable Development Goals related to waste and contribute to implementing the New Urban Agenda. Through the WWC, waste management will be prioritized, higher on the political agenda of participating local governments. This will monitor and improve waste-related Sustainable Development Goals Indicators and apply the generated data in decision-making processes. In addition, UN-Habitat will assist participating cities to become waste wise with activities in the following four key action areas:

- Data & Monitoring: Developing capacity for monitoring of waste-related Sustainable Development Goals indicators and waste data in general.
- Knowledge & Best Practices Sharing: Sharing knowledge and good practices on waste management through the partner network that is being created as part of Waste Wise Cities Campaign and includes cities and municipalities, NGOs, private sector, academia, UN Agencies, etc.;
- Advocacy & Education: Advocating and educating on integrated sustainable waste management systems, including the 5Rs, and developing materials that will support cities and educate their residents.

- Project Finance & Bankability Support: Supporting the development of bankable projects, training on financial aspects of waste management, and building partnerships, especially with potential donors.

1.2 Partners in the project

1.2.1 UN-Habitat India office

UN-Habitat in India is working closely with the Ministry of Housing and Urban Affairs to champion India's New Urban Agenda and has crafted a new strategic partnership with the Government of India on mutually agreed technical cooperation initiatives supporting sustainable urbanisation in India. In India, UN-Habitat is devising an integrated and demand-driven approach that combines refining urban planning and design frameworks, providing infrastructure upgrading policy and technical guidance, implementing pilot projects for learning-by-doing, and mainstreaming innovations through testing technology solutions to transform India's urban landscape.

1.2.2 Alliance to End plastic waste

The Alliance is a not-for-profit organisation with more than fifty members representing global companies and organisations across the plastics value chain. The Alliance is planning to invest in projects to develop, accelerate, and deploy solutions, engage communities and stakeholders, and catalyse capital to help end plastic waste in the environment.

The organisation has programs across four pillars:

- **Infrastructure** to collect and manage plastic waste and increase plastic recycling, especially in developing countries.
- **Innovation** to advance and scale modern technologies and business models that minimise plastic waste, make recycling and recovering plastics easier and create value from post-use plastics.
- **Education** and engagement of stakeholders including governments at all levels, businesses, communities, and consumers to mobilise action; and,
- **Clean up** and prevention of concentrated areas of plastic waste in the environment with a focus to identify and halt the flow of waste at its source

1.2.3 Thiruvananthapuram Municipal Corporation

Thiruvananthapuram is the state capital and southernmost district of Kerala. The total population of Thiruvananthapuram Municipal Corporation (TMC) is 9,69,298, with 2,72,820 households, of which 64% are urban, 12% semi-urban, and 24% rural. The Health Standing Committee & the Health Department are responsible for solid waste management in TMC.

Thiruvananthapuram does not own any landfills for the disposal of their waste. TMC advocates for bio-degradable waste (BDW) management at source and has supplied forthcoming households with aerobic bins at their own cost and biogas plants at subsidized rates. Aerobic bins at the community level are also installed at various locations to manage the household and commercial BDW. TMC has established material recovery facilities and resource recovery centers to manage non-bio-degradable wastes. It has outsourced HH waste collection to mainly service providers, women self-help groups and other agencies and has also impanelled agencies for waste collection from Commercial Establishments.

1.3 Project goals and objectives

The project aims to

- strengthen engagement with various municipal and other key stakeholders for capacity building of cities to assess MSW status and define sustainable interventions.
- map waste flows and plastic leakages to prepare the waste flow diagrams by training on-ground volunteers/ municipal staff/ others to conduct the survey.
- conduct stakeholder meetings to discuss the existing challenges and recommendations for strengthening plastic waste management and develop a SWM Action plan.
- prepare an action plan for effective plastic waste value chain management to ensure a decrease in plastic leakages and subsequently prepare proposals for funds mobilisation.

2.0 Data based decision making in Waste Management

The quantity of waste generated grows with socio-economic development, and as the population in cities becomes more dense, acute public health and environmental problems become more commonplace. Poor waste collection and disposal results in agglomeration of uncollected waste piles, build-up of rodent and insect populations, open waste burning with concomitant impacts on public health and pollution of air and water. Furthermore, the overwhelming evidence is becoming clear that unmanaged and mismanaged waste is the main contributor to plastic pollution of the marine environment.

The 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs), introduced in September 2015, sets out several targets to address waste management, material efficiency and the impacts of waste on the environment. There are four SDG targets related to waste management, namely MSW management (SDG 11.6), chemicals and hazardous waste (12.4); recycling, including e-waste (12.5); and food waste (12.3). In addition, waste data is needed for a further two closely related targets on domestic material consumption and material footprint (8.4 and 12.2) and marine litter (14.1).

Waste SDG indicator monitoring provides essential input data for urban planning and management in cities and the setting of policy frameworks in countries. The waste SDG Indicators enable focus and concentration on tackling the causal factors of the public health, urban environmental and marine pollution crises facing the world. By extension, they also contribute in a meaningful way to creating business, employment and livelihood opportunities and the transition towards a circular economy. However, despite the recent upscaling of global attention to waste management and pollution of the marine environment, basic data on the stocks and flows of waste through urban management systems are seriously lacking. Therefore, a step-change in data quality and accessibility is required to tackle what has become one of the world's greatest challenges.

Delivering on this need's international partnership and collaboration, in addition, the technical, institutional, and financial capacity of city governments needs to be enhanced at all levels of government; there is a need to disseminate data collection methodologies, definitions and concepts, and an upscaling of support to policymakers for evidence-based decision making.

3.0 About Waste Wise Cities Tool

UN-Habitat has finalized the Waste Wise Cities Tool – Step by Step Guide to Assess City MSWM Performance through SDG Indicator 11.6.1 Monitoring (WaCT) in 2020 through the African Clean Cities Platform and Waste Wise Cities initiative. WaCT guides cities and local governments through the steps to assess the environmental performance of an MSW management (MSWM) system, food waste generation and resource recovery systems in cities. By doing so, it provides critical information for cities and countries to establish better waste and resource management strategies.

WaCT consists of seven steps to guide cities on how to collect data on MSW generated, collected, and managed in controlled facilities. The tool provides a household survey guide for estimating total MSW generation, a questionnaire to investigate the MSW recovery chain and criteria to check the environmental control level of waste management facilities in the city. In the last step linkages with other SDG indicators are elaborated and an assessment using a Waste Flow Diagram (WFD) is introduced. The WFD is a separate but complementary methodology to the WaCT. It uses rapid and observation-based assessment for mapping waste flows and quantifying plastic leakage from MSW management systems (GIZ et al., 2020).

In 2021, UN-Habitat under the Alliance to End Plastic Waste project, “Tackling plastic waste in the environment” selected 4 cities, 2 from India, Thiruvananthapuram and Mangaluru, and 2 from Ethiopia, Addis Ababa and Bahir Dar, to participate in the Waste Wise Cities Tool application to identify policy and infrastructure gaps for the improved solid waste.

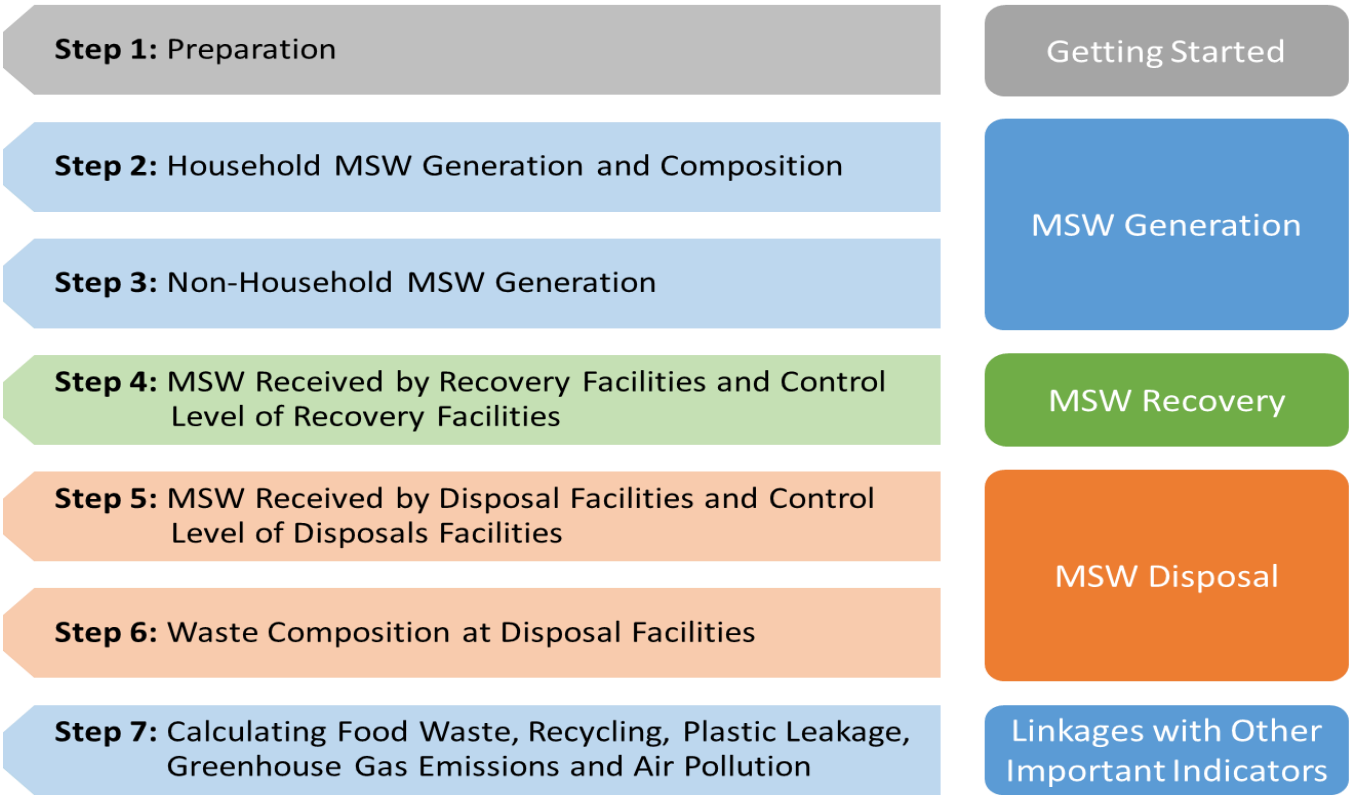


Figure 1 WaCT steps

4.0 Implementing WaCT in Thiruvananthapuram

4.1 Step 1 – Preparation

The aim is to deliver the project with an inclusive and participatory approach, with local partners, including municipal corporations and other important stakeholders such as NGOs, formal and informal service providers, and other stakeholders working in the waste value chain.

An online inception workshop[1] was organised on March 17, 2021. The Inception workshop was aimed at explaining the initiative by UN-Habitat, its relevance, outcomes & the benefits in making informed decisions in Municipal Solid Waste Management. Target audiences were the decision-makers of Thiruvananthapuram Municipal Corporation & other immediate stakeholders.

1 Link to inception workshop: https://www.unhabitat.org.in/post/un-habitat-concluded-the-inception-workshop-with-thiruvananthapuram-municipal-corporation

Following the inception workshop, a detailed background report was prepared on the existing waste management scenario in Thiruvananthapuram in consultation with and inputs from the nodal officer & health department of TMC. The background report gives the current scenario of municipal solid waste generation, institutional set-up, strategies adopted by TMC for decentralised SWM mechanism. From the information gathered a snapshot of the current MSW management status quo was arrived as below;

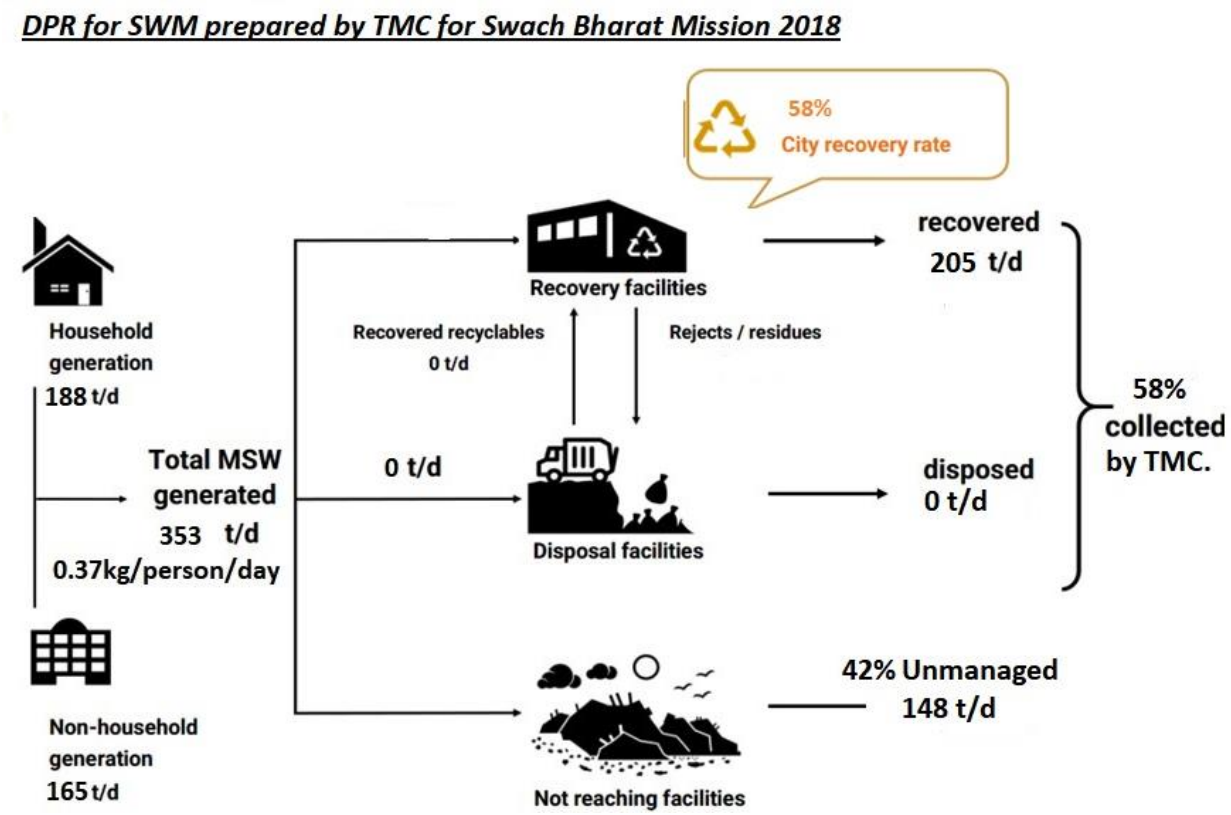


Figure 2. Waste management status quo of Thiruvananthapuram Corporation

The background report helped in understanding the lacunae, focus areas, information & data needed for effectively implementing this project. Section 5.0 'Challenges and assumptions made while applying WaCT' discusses these in detail.

In October 2021, the mission duration was finalised to two weeks (WaCT is a rapid assessment tool to be implemented in four weeks). Hence, the activities were planned and prioritized in advance of the visit. A workflow and budget were also prepared for the primary field assessment survey (Annexure 2).

4.1.1 Procurement of materials

The assessment required waste sampling from 10 households each from 3 survey areas representative of income groups (low, middle, and high) along with their waste composition analysis. Procurement of material was done before the survey for an effective field assessment study.

Table 1 Procurement list for WaCT implementation in Thiruvananthapuram

Items	Duration	Purpose	Actions
Vehicles for transportation	8 days	Waste quantification & sampling (collection of liner bags)	Route mapping was done for using five vehicles (4-wheel cargo autorickshaw). The collection vehicles were arranged on a rental basis
Vehicle trips	10 days	Visiting recovery facilities and other movements of the team	Taxi service opted by UNH
Liner bags, gloves, goggles & masks and shoes	8 days	Waste collection form 90 households	Pre-ordered by UNH
Buckets (40nos), HDPE tarpaulin sheets, thick gloves, masks, shoes, Hanging weighing scale, Pencils, pens, tape and marker	8 days	Waste quantification and composition analysis	Buckets were provided by the Health Department of TMC. Other items were procured by UNH.
Labourers of sorting waste	8 days	Segregation of waste into 12 categories for composition analysis	Sanitary workers of TMC were sourced to help the volunteers in composition analysis
Hardcopy of tabulations/forms/references	8 days	Used for recording data & interviews by the team	The sheets were finalised (Attached in Annex) and printed by UNH

Given the Kerala state guidelines on source segregation and existing municipal bye-laws, two bags were printed for each HH (green for biodegradable waste and blue for non-biodegradable waste).

Figure 3 Collection bag for wet waste

Figure 4 Collection bag for dry waste

4.1.2 Selection of survey wards and households

The sample size determines the statistical significance of the results obtained. This is reflected by the statistical confidence level and margin of error. For example, in a city with a population size of 10,000 – 10,000,000, at least 370 to 384 households need to be sampled to achieve the normally recommended values of a confidence level of 95% with a margin of error of 5%. However, in many situations, it may be unfeasible and costly to collect waste samples from 384 households for seven days for a city, therefore as the WaCT guideline suggests, 90 households were sampled (10 households from 3 survey areas from high-, middle- and low-income groups each), which is still in the same confidence level, but with a margin of error of 10%. in consultation with TMC, see table 2 below. The three wards for each income group were selected after consultation with the nodal officer & the officials of TMC. Households in each ward was also decided on discussion with respective ward elected representative. It was assured that the houses thus selected were distributed across these wards.

Table 2 Criteria for descriptive selection of income groups

Income level	Housing type description
High	Luxury apartments, single-detached houses with gardens in upscale wards.
Middle	Apartments, a single-detached house little land from middle income areas
Low income/informal settlements	Slums, apartments with single rooms & quarters with no compound walls in low-income wards

Reference: Waste Wise Cities Tool, 2021, UN-Habitat

A consent letter was prepared (Annexure 1), and with the support of field volunteers, ten households were selected from each of the nine areas using random sampling and considering the willingness of HHs to participate. In addition, extra precautions were taken to select households that did not have any COVID-19 cases. In total, 90 households, 10 per ward in wards 17,19,24,29,34,47,66,68 and 88, were to be sampled.

Table 3: Wards surveyed in Thiruvananthapuram for WaCT application

HIGH INCOME WARDS [ward no. & name]	MIDDLE INCOME WARDS [ward no. & name])	LOW INCOME WARDS [ward no. & name]
24- Kuravankonam	68- Kamaleshwaram	34- Kachani
17- Pattom	47- Mudavanmugal	19- Kudapanakunnu
29- Vazhuthacaud	88- Vallakadavu	66- Poonthura

Figure 5. Nine wards finalised for collection of household waste for WaCT assessment

4.1.3 Site visit and coordination

Prior to the waste assessment study, a recce visit was done in Thiruvananthapuram by the Waste Management Consultant, UN-Habitat India to understand the existing waste management systems, which included door to door collection, interaction with ward-level officers, decentralised Material Recovery Facilities (MRFs) and Resource Recovery Facilities (RRFs).

To conduct the household waste assessment, the team was allotted a Resource Recovery Facility (RRF) at Manacaud by the Thiruvananthapuram Municipal Corporation (TMC). The site was visited, and it was ensured that the facility was prepared for the detailed household characterization study. A route planning was carried out, and it was concluded that at least 5 collection vehicles will be required for the collection of segregated bags from 9 wards (90 HH).

Figure 6 The RRF at Manacaud by the TMC for conducting detailed household waste characterisation study

4.2 Establishing a working team for WaCT application

4.2.1 Selection of local NGO partner for shortlisting volunteers

Sahridhaya, a local NGO was engaged in conducting the study in Thiruvananthapuram. A team of 20 volunteers was shortlisted through Sahridhaya to assist the UN-Habitat project team in facilitating surveys in 9 wards and providing support in the WaCT application in Thiruvananthapuram city. They had the following major responsibilities:

- Identify/ map districts/ neighbourhoods to survey
- Receive training from the UN-Habitat project team on the application of WaCT in target cities.
- Provide field support as a working team, which includes but is not limited to collecting required data for the survey, carrying waste characterisation at the level of households and disposal facilities, interviewing & assessing the environmental control level of both the formal and informal waste recovery facilities and assessing the plastic leakage situation in the cities system.
- Analyse and process collected data as per the requested format.
- Assist in developing the Waste Flow Diagram – a rapid assessment for mapping waste flows and quantifying plastic leakage.
- Support the workshop to discuss the results of the survey.

4.2.2 Training of Volunteers

The volunteer training workshop was conducted on November 12, 2021, in Thiruvananthapuram to train the 20 volunteers on the application of the Waste Wise Cities tool (WaCT).

Table 4 Programme Schedule for the training of volunteers held on November 12, 2021

Time	
9.00 – 9.10	Registration of participants
9.10 – 9.15	Welcome Address Jogesh Arora, Programme Specialist, UN-Habitat India
9.15 – 9.30	Keynote Address Binu Francis, Secretary, Thiruvananthapuram Municipal Corporation
9.30 – 9.45	Background of the 'Tackling Plastic Waste in the Environment' Project by UN-Habitat Swati Singh Sambyal, Waste Management Specialist, UN-Habitat India
9.45 – 11.00	Household and Non-Household MSW Generation (WaCT Step 2 and 3) Sreekumar S, Waste Management Consultant, UN-Habitat India • How to conduct household and non-household survey • Sorting guidelines • How to enter and report daily waste quantities • Dos & Dont's
11.00 – 11.15	Tea/Coffee Break

11.15 – 12.15	Class Activity: Demo of household collection and sorting (Participants will be divided into 4 working groups to demonstrate household and commercial waste collection and sorting) Kartik Kapoor, Waste Management Consultant, UN-Habitat India
12.15 – 13.15	MSW received at recovery and disposal facilities (Step 4, 5 & 6) Swati Singh Sambyal, Waste Management Specialist, UN-Habitat India • How to survey recovery facilities • How to enter and report data • Dos & Don'ts
13.15 – 14.00	Lunch Break
14.00 – 14.45	Distribution of volunteers into teams for field assessment and ground survey Swati Singh Sambyal and Sreekumar S, UN-Habitat India
14.45 – 15.30	Ensuring COVID-19 safety and hygiene on field Jogesh Arora, Programme Specialist, UN-Habitat India
15.30 – 16.00	Q&A session and Close of session

Jogesh Arora, Programme Specialist, UN-Habitat India gave a brief introduction about UN-Habitat and its work in India, followed by a background of the 'Tackling Plastic Waste in the Environment Project by Swati Singh Sambyal, Waste Management Specialist, UN-Habitat India.

Figure 7. Mr. Binu Francis, Secretary, TMC, Ms. Swati Singh Sambyal, Waste Management Specialist, Mr. Jogesh Arora, Programme Specialist and Mr. Sreekumar S, Waste Management Consultant, UN-Habitat India at the inaugural session of training programme of WaCT application in Thiruvananthapuram, Kerala, November 12, 2021

During the workshop, the UN-Habitat India team briefed the participants about the project ' Waste Wise Cities: Tackling Plastic Waste in the Environment' followed by technical sessions on applying the WaCT. The workshop also had class exercises wherein the volunteers were split into two groups and were involved in a waste segregation exercise along with demonstration of recording the data to understand the real-time scenario and ground-related challenges while conducting the survey. Further, Jogesh Arora took the session on ensuring COVID-19 safety protocols and hygiene on the field, including appropriate behaviour while doing surveys.

Figure 8 Briefing the Waste Wise Cities Tool

Fig 9. Class exercise on sorting wastes into categories

Figure 10 Class exercise on HH waste characterisation data entry

Figure 11 Session on COVID19 safety protocols

The teams were formed for the collection of waste from 90 households in different wards based on 3 income groups. The list of volunteers was split into three groups

1) For waste collection, transportation, sorting & quantification & composition analysis: people who were well versed with the wards and knew the households wherein the wastes need to be collected were used for daily collection. Other members were assigned for sorting, composition analysis and data entry. One member was also assigned a supervisory role to check the process flow.

2) For conducting interviews with commercial establishments, MRF's & RRC's, formal and informal service providers

3) For supporting recovery mapping in the city by interviewing Value Chain waste handlers & traders

The workshop concluded by addressing the questions concerning the WaCT application and volunteer engagement, with instructions on ensuring COVID-19 safety and hygiene on the field, including appropriate behaviour.

Figure 12 Training for volunteers on WaCT assessment held on November 12, 2021, at Hotel Hycinth, Thiruvananthapuram

On November 13, 2021, a meeting with volunteers was organized at the Manacaud RRF for the. disbursement of material for the assessment and demonstrating field protocols and behaviour.

- The members assigned for the collection of wastes from the respective households made their confirmation call informing the members of the households at the beginning of the

survey and ensure the willingness of all the 90 households to provide their wastes for the next 8 days.

- Safety jackets, sanitizers, gloves were handed to the teams.
- The bags (blue and green) were distributed to each team (two bags for each HH to collect segregated wet waste in a green bag and dry waste in a blue bag).
- The sheets for recording the data of the sampling exercise (waste quantities and characterisation) were handed over to the teams.
- The volunteers were instructed to code the bags to be given to households in the format: Day/Income group/Ward No/ Sample House no [e.g., 15Nov/LI/34/HH3]
- These coded bags were distributed by the volunteers on the same day for collection of wastes from the respective households on 14/11/21 *(day 1).*

The volunteers were also trained to conduct interviews with the commercial units that were selected for the survey on the Forms they need to use to fill in data and were given hard copies of the reference they would need to arrive at conclusions concerning the ladder of control and different categories of wastes.

Figure 13. Volunteers coding the bags to be given to HHs for waste collection

4.2.3 Implementation plan for WaCT in Thiruvananthapuram

The implementation of WaCT was undertaken from November 14-21, 2021. A detailed description of the day wise schedule is shown in the table below.

Table 5 Schedule for household survey and characterization study in Thiruvananthapuram

Date	Day	Survey Team	Remarks
Nov 13	**Day 0**	Distribute empty bags with coding and give instructions on segregation to HHs	Provide in sheet the number of people in each household
Nov 14	**Day 1**	Collect the filled bags of previous day, give new bag for next day (coded accordingly)	Use Day 1 to practice on data entry in sheets; reject the recording for this day
Nov 15	**Day 2**	The following actions were repeated for days 2 to 8 of the mission: • Give new bag for next day • Collects the filled bags of previous day • Weigh bags at sorting site • Do the detailed HH waste characterisation study	Nov 15 onwards to collect all data in sheets and handover daily to UN-Habitat India team
Nov 16	**Day 3**		
Nov 17	**Day 4**		
Nov 18	**Day 5**		
Nov 19	**Day 6**		
Nov 20	**Day 7**		
Nov 21	**Day 8**		
Nov 22	**Day 9**	Thank the HHs for participation	

4.3 Estimating household waste generation and characterisation

The collection of samples from households was scheduled by the volunteers engaged for collection between 8:00 am – 11:00 am, and the collected samples were loaded on collection vehicles in each ward and were brought to the RRF at Manacaud.

The collected bags from different wards were organized income group-wise into three sorting stations at the RRF, Manacaud. The sorting teams were to sort, characterize and weigh for each income group to run the sampling for three wards parallelly. One volunteer was also assigned as a supervisor for the complete process. Local sanitary workers of TMC were engaged to help the volunteers in waste segregation for composition analysis.

- Initially all the bags of the ward were weighed and recorded on a sheet, Household wise.
- Later the bags of all ten households from the designated ward were opened and waste segregated into twelve categories in separate buckets (as shown in Table 5).
- Each bucket was weighed recorded on a sheet.
- The data were later entered into an excel sheet for each ward.
- After the sorting exercise is complete, the site was cleaned and disinfected by the workers at the RRF

Household waste collection and distribution of empty bag for next day

Weighing Collected HH waste samples at RRC Manacaud

Collected HH wastes being brought to RRC Manacaud

Sorting site at RRC Manacuad

Figure 14. Volunteer teams collecting samples from assigned households

Table 6 Categories for sorting of the waste as suggested by WaCT

1	Kitchen/ canteen waste	Cooked or uncooked food, organic waste from food preparation
2	Garden/ park waste	Non-food biodegradable materials resulting from landscaping
3	Paper & cardboard	Paper & cardboard packaging, paper & cardboard products
4	Plastics – film	Thin plastic is used in packaging and for other purposes
5	Plastics – dense	Hard plastics are used in packaging and for other purposes
6	Metals	Ferrous and non-ferrous metals packaging and non-packaging
7	Glass	Packaging and non-packaging glass
8	Textiles & shoes	Clothes and other textiles, as well as shoes
9	Wood (processed)	Untreated and treated processed wood
10	Special wastes	Waste electric and electronic equipment (anything with a cable), batteries/accumulators, other hazardous waste. COVID related Masks and PPE's
11	Composite products	Products are made of more than one of the above, such as drink containers ("tetra pack"), plastic, metal and glass products, etc.
12	Other	Anything that cannot be classified in one of the above categories

As required in WaCT analysis, the first day's samples were rejected as there is a tendency for people to give all their accumulated waste on the first day. Weighing, sorting and segregation exercise was carried out on the first day's sample as a demonstration to the volunteers on the sampling procedure and evaluating the checks/improvements needed.

Figure 15. Waste Characterisation study. The data samples of the first day were discarded as households tend to give more waste on the first day of sample collection

4.4 Commercial waste generation

WaCT Analysis suggests three techniques for obtaining the information for non-household waste generation,

1. **Conducting waste sampling from non-household MSW sources** through arbitrary sampling, similar to the household waste survey. Although this approach would yield accurate results, due to the prevailing COVID-19 pandemic and the fact that many institutions were either closed or not functioning at normal capacity, it was decided to not use this approach.
2. **Conduct interviews with non-household MSW sources** and their waste collection service providers to get approximate amounts of generated waste. The methodology was to choose premises representative of the survey area, identify and interview 2 hotels, 2 restaurants, 2 schools, 2 offices, 1 shopping mall/supermarket, 1 market and 1 hospital per survey This approach could not be adopted since reliable business licensing data was not available with TMC to project the total non-Household waste generation.
3. **Proxy method:** Since there was no reliable licensing data and the fact that 1 and 2could not be adopted, it was decided to use a proxy to estimate the MSW generation from non-household sources. UN-Habitat researched the proportion between household and non-household waste generation using the historical data of OECD countries. It is suggested that about 30% of total MSW is generated by non-household sources and 70% by households. WaCT guide recommended the use of a proxy of 30% to estimate MSW generated by non-household sources.

   Also, to validate the proxy used and to get an idea of non-household waste management, 4 volunteers were split into a team of two and each team conducted surveys and interviews of commercial units inwards assigned to them. The questionnaire for interviewing non-household waste generation from the WaCT guideline was used for this purpose.

Figure 16. Commercial Survey team to map and interview non-household units in selected wards

4.5 Mapping Recovery facilities

Thiruvananthapuram Municipal Corporation does not have a landfill for the disposal of non-recyclable wastes or rejects. Hence MSW collection service chain in TMC is a recovery management service. For the WaCT analysis, it was important that detailed mapping of all the recovery facilities both formal and informal was done. It helps in understanding the recovery capacity of the city against the number of recyclables in the MSW stream and how these recyclable materials move through the recovery chain.

Resource Recovery Facilitates (RRFs) that aggregate material from material recovery facilities (MRFs) and major Apex facilities was considered for the survey. Information on quantities of waste going to these facilities is important to generate waste flows. This step also helps local governments and waste management operators to optimize their operations and inclusively plan waste management interventions.

The UN-Habitat India team visited major apex and intermediate facilities in Thiruvananthapuram dealing with paper and cardboard, plastic, metal, and glass.

TMC has formal service providers [Waste Collection Service Chain] in the form of Haritha Karma Sena [HKS], who manages the dry waste generated in the households by bringing them to MRFs. In certain areas, HKS also processes biodegradable waste from households and markets at Community Aerobic Bins provided at the Material Recovery Facilities [MRFs]. TMC has also

empaneled agencies to handle commercial wastes from establishments that do not have their own waste handling mechanism.

Hence a Formal Service Chain mechanism will include services of HKS, commercial waste handlers, all the MRFs which manage both wet and dry waste and larger Resource Recovery Centers (aggregators). The Government agency Clean Kerala Co Ltd (CKCL) which manages dry wastes, majorly low-value plastics, e-waste and hazardous for TMC are also a part of this Formal Service Chain. TMC follows a yearly waste collection calendar to collect different categories of waste.

The questionnaire provided in WaCT was referred to conduct the resource recovery surveys at all these areas and to mark 'level of control' (Table 7) was also assessed.

It was understood from discussion with the health officials of TMC that around 30% of households in TMC are serviced by Informal Service Chain who collect segregated wastes from Households. The flow and fate of these wastes cannot be quantified as there was no immediate data available and cannot be directly surveyed in a Rapid Assessment Survey such as WaCT.

A large portion of dry wastes of monetary value is managed by Formal and Informal Value Chain Service providers. Formal Traders are agencies that have commercial licenses and have a structured retrieval and management mechanism. Informal Traders do not have a structured setup and waste management mechanisms are uncontrolled. All Apex Agencies of Value Chain were interviewed, and their level of control was evaluated.

TMC does not have any End of Chain Recyclers. All the major formal and informal aggregators are Apex Traders. The reason for the same could be the City's proximity to the neighbouring state of Tamil Nadu which has a significantly low cost of labour. It was understood that most of the recovered materials are transported to the end of chain recyclers in Tamil Nadu.

An extensive recovery mapping exercise was conducted to capture the recovery chain and map waste flows. The level of control was assessed using the 'ladder of control' of the WaCT questionnaire. A total of 72 entities were surveyed in 8 days. The primary survey team visited 33 Commercial Establishments to understand the waste generation and management process, 32 MRF facilities were visited obtaining details of 296 Community Bins (of 443 functional bins) managing organic wastes and dry wastes. Information was also collected from 18 Authorised Commercial Waste Handlers.

Primary Survey also covered 8 Formal waste management facilities, which included three Resource Recovery Centers & 11 Informal major Apex Traders during this rapid assessment. Where ever primary survey was not feasible due to distance constraints, information was

gathered telephonically. Data was obtained from TMC on special waste collection drives, materials transferred to end of chain recyclers, CKCL etc.

During the field study, it was observed that almost 50 percent of commercial wet waste is managed as feed to pig farms on the outskirts of the city. The UN-Habitat India team visited one of the pig farms and met the Secretary of the Pig Farmers Association, Thiruvananthapuram to understand its effectiveness in managing wet waste.

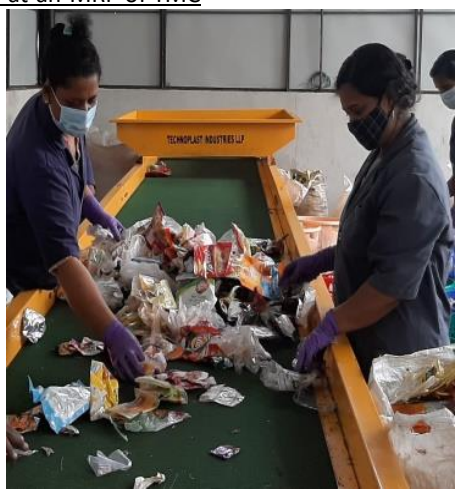
Figure 17 Visit to a pig farm

Updated data of all households managing their Biodegradable wastes at their homes and wastes managed at Community Aerobic Bins were sourced from TMC for quantification.

The WaCT assumes a proxy estimate of 10% for material loss during the recovery process of collection and sorting. A proxy estimate is sufficient for the WaCT assessment because a more detailed and accurate assessment can take considerable time (and budget) and distracts attention away from understanding the quantities and level of control at the point of entry into the recovery system.



A Community waste treatment facility at an MRF of TMC

Resource Recovery Center of TMC at Muttathara

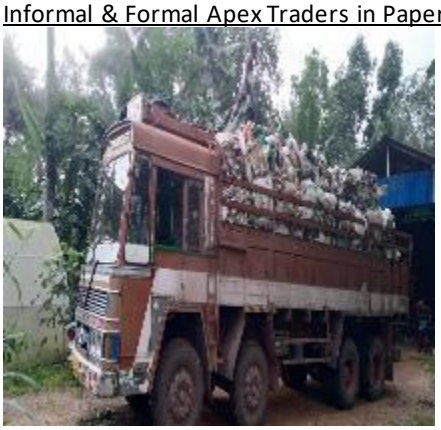


Formal Value Chain Recovery facility of a major Apex Trader

Fig 18. Recovery facilities Surveys

Community bins for BDW, sorting of NBDW, Incinerator at RRC Manacaud

Informal & Formal Apex Traders in Paper and Cardboard



SUP's & rejects being transported to End of Chain Recyclers from MRF

Informal Apex Trader @ Killipalam

Visit to a Major Apex trader in Metals

Fig 19. Recovery facilities Surveys

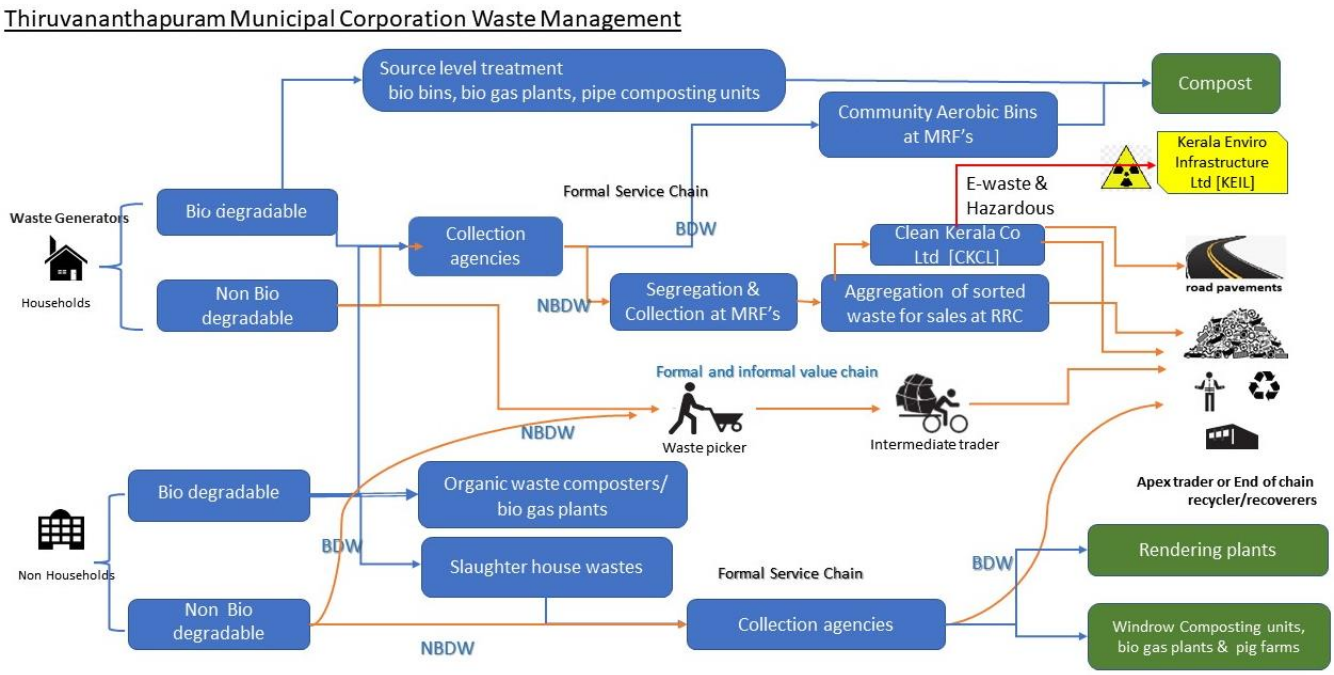


Figure 20 Material recovery flow in Thiruvananthapuram Municipal Corporation

Table 7 Reference for 'Level of Control' in the recovery facilities

Full Control	• Built to and operating in compliance with current national laws and standards • Pollution control compliant to environmental standards • Protection of workers' health and safety • The nutrient value of biologically treated materials utilized for separate organic waste (e.g. in agriculture/horticulture) • Materials are extracted, processed according to market specifications, and sold to recycling markets • Weighing and recording of incoming loads conducted • All outgoing loads registered by weight and type of destination
Improved Control	• Engineered facilities with effective process control • Pollution control compliant to environmental standards • Protection of workers' health and safety • Evidence of materials extracted being delivered into recycling or recovery markets.
Basic Control	• Registered facilities with marked boundaries • Some environmental pollution control • Provisions made for workers' health and safety • Weighing and recording of incoming and outgoing loads conducted

Limited Control	• Unregistered facilities with distinguishable boundaries • No environmental pollution control • No provisions made for workers' health and safety • Weighing and recording conducted
No Control	• Unregistered locations with no distinguishable boundaries • No provisions made for workers' health and safety • No environmental pollution control

4.6 STEP 5 & 6: Landfill for waste generation & characterisation

The city does not own a landfill for the disposal of their wastes and has established a zero-waste model focusing on the management of household wet waste at the source or the MRF facilities managed by TMC. It is reported by TMC that around 60 percent of the households currently manage their wet waste at source using either pipe compost, kitchen (aerobic) bin or biogas waste management methods.

To address wet waste management at places with space constraints like housing clusters/colonies, slums, markets etc., 'Thumburmuzhy' (i.e., Community) Aerobic Bins and biogas plants are installed.

Since there is no landfill in the city, it was not possible to conduct the Disposal Site waste quantification and disposed waste characterisation [Step 5 and 6 of WaCT]. To circumvent this issue, a detailed Resource Recovery mapping and survey was conducted as mentioned in 4.5 above.

5.0 Challenges & Assumptions made while applying WaCT

5.1 Data Collection

Thiruvananthapuram Municipal Corporation is a unique case when it comes to applying WaCT for SWM analysis since TMC advocates BDWM at the source itself. Being a rapid assessment tool, the STEPS in WaCT are designed for any CITY which has a daily waste collection system and a disposal facility in the form of a Landfill. The challenges faced and the assumptions made are described below:

1. Quantification of HH waste management at Source:
    a. It was decided to obtain the number of home-based bio bins, pipe composts & biogas plants units supplied by TMC and obtain their current usage. 4 members were taken per household, based on the average total population Vs the number of households from the records with TMC. This was also cross-checked against the average number of persons for the 90 households selected for the WaCT survey.
    b. The organic fraction of BDW in kg/capita/day which would later be obtained from the WaCT Analysis could be used to approximately arrive at the amount of waste being managed at HH level in TMC
2. Quantification of Commercial waste management: Since source-level management is promoted by TMC, a list of all authorized commercial waste handlers was obtained for recovery analysis. The difference between the total commercial MSW generated by TMC & the quantity managed by Commercial waste handlers was assumed to be managed by the commercial establishments.
3. Quantification of Formal Recovery Mechanism of NBDW by TMC: Since TMC follows a calendar system for collection of various categories of wastes; also supported through special collection drives; data obtained from TMC in all these cases for one year was averaged to arrive at their quantity in TPD for WaCT analysis.

5.2 Population Estimation and Income-wise Distribution

The population of Thiruvananthapuram Corporation is taken as 9,69,298 from the information available in the DPR on SWM[1][pg. 48]. WaCT analysis tool also requires income-wise data input.

Thiruvananthapuram Corporation has not conducted an economic survey for obtaining population income-wise. As per the Detailed Project Report on SWM[1] by TMC, it was seen that the population of the High-Income Group in TMC was 1,55,227. A reliable estimate on the population for Low Income Group in 78 wards was obtained from the State parastatal Kudumbashree Unit in TMC, which was projected for 100 wards, giving the population of LIG as

2,89,097. The remaining population were assigned belonging to the Middle-Income Group i.e., 5,24,974.

6.0 Data entry in WaCT DCA

The data collected in the forms were entered in the WaCT DCA excel tool as per the given instructions. Once the entry is completed, the Survey data can be validated by the user and uploaded from WaCT DCA to a global server (RWM.GlobalSERVER). Data can later be accessed from server [open WaCT DCA from Waste Wise Cities web page or RWM. Global web page]. The data entry tool helps to avoid double-counting errors and includes a proxy for 'rejects' that come out of the recovery system as waste.

As explained in Section 4.2.5, a 30% proxy of Household waste generated was used for quantifying the Commercial Waste. Every collection and recovery mechanism shall have some rejects which need to be disposed of/handled appropriately. WaCT suggests 10% of the total MSW recovered would be rejected. The same was used for TMC's data analysis. Since STEP 5 & 6 of WaCT (see 4.2.7) was omitted. No entries were made in WaCT for information related to Disposal Facilities.

7.0 WaCT Flow Chart of Thiruvananthapuram Corporation

WaCT Analysis estimates the MSW generation of TMC to be 423 TPD. A snapshot of the scenario is shown in Fig 21 below.

The rapid assessment tool provides the following information.

1. TMC generates 423 Tonnes of MSW per day.
2. 267 Tonnes/day of MSW i.e., 57 % of the total MSW generated is collected for recovery.
3. 27 TPD, i.e., 10 % of this recovered material turns up as rejects during the recovery process, should end up for disposal
4. 28 TPD, a portion of the Street sweepings and sanitary wastes should also be ending up for disposal.

[1] Detailed Project Report on Solid Waste Management for Swachh Bharat Mission 2018
[2] Report on the "Status of solid and liquid waste management", Thiruvananthapuram Municipal Corporation, August 2019.

5. It was seen that some MRFs which had adjoining land were managing these rejects by either burying on land or burning them in incinerators.
6. 128 TPD of MSW generated remains unmanaged /uncollected as a portion of which may be managed by the informal service providers [TMC estimates 30% of the waste collection service is also provided by informal service providers]. However, their mode of operation and waste management is UNKNOWN.
7. Sustainability Development Goal indicator 11.6.1, i.e., "Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal solid waste generated, by the city", for which the WaCT was developed; informs that 51% (216 TPD) of the total MSW generated by TMC is managed in facilities with some form of Control.

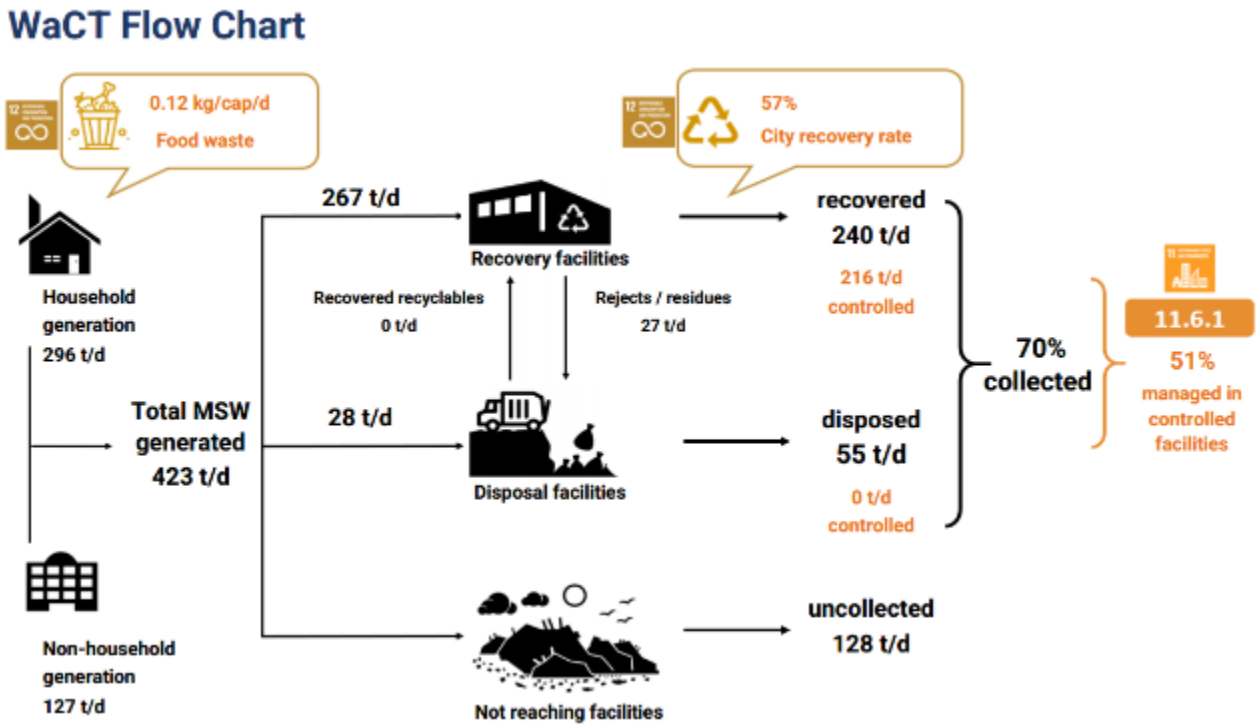


Figure 21 Waste Flow Chart for Thiruvananthapuram city

8.0 WaCT Results for Thiruvananthapuram Municipal Corporation

WaCT application for SDG 11.6.1 gives a clearer picture of MSW generation, collection, recovery, and their flow. The per capita MSW generation of Thiruvananthapuram Corporation is 0.44 Kg/person /day or 440 gm/person/day. Average Household MSW generation is 0.31kg/person/day & the Food waste generation is at 0.12 Kg/person/day.

8.1 Household Waste Generation

From the primary survey as per WaCT, the household MSW waste generation information is provided in Figure 22.

TMC had earlier estimated[1] HH waste generation at 188 TPD of the 353 TPD. As a major deviation, WaCT through its primary household waste collection analysis estimates the amount of HH waste generation as 296 TPD, which is 57% more than earlier estimated.

As expected, there is a 'high to low' gradation of MSW generated across the income level, although there is no significant difference. This could be attributed to the better standards of living and lifestyle of the city dwellers. It is noticed that Kitchen/Canteen fraction generated by the HI (34%) < MI (38%) <LI (39%). This could be due to the varied cooking and food consumption patterns within the upper-income group preferring eating out/ parceled service more. Also, the garden waste generated by the Higher Income (12%) is less compared to Middle (13%) and Low income (18%). The reason for this trend could be that people with larger parcels of land manage their garden waste and don't find it necessary to dispose of garden waste when compared to people with land constraints.

Interestingly it is also seen that the plastic waste generated by the High & Low-income levels are almost the same at 12%, with the Middle-income contributing lesser @ 9%. One of the reasons could be the awareness of the High- & Middle-income groups on the impacts of plastic waste and they are opting for alternate packaging. Another reason for the higher plastic content in LIG households' waste is the availability and use of smaller single-use plastic packaging and sachets catering to their needs, resulting in a larger magnitude of these wastes, especially plastic films.

As expected, special waste, consisting of e-waste, is generated more by the HI compared to MI & LI.

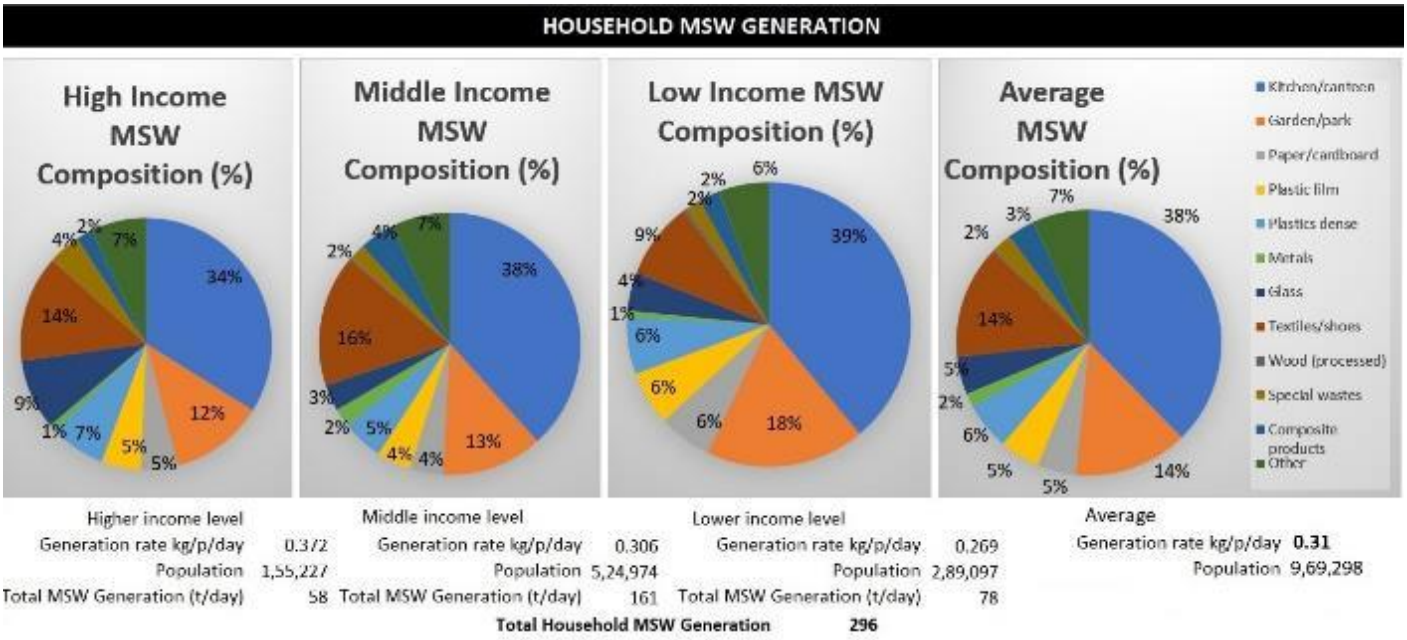


Figure 22 HH MSW generation.

8.2 Commercial waste

Using a 30% proxy to estimate the MSW generation (see section 4.4) from non-household sources, it was estimated that the city generates 127 tons/day of Non-Household Waste. The value is lesser but almost in agreement with the fraction of Commercial Waste 162 TPD reported by TMC in their SWM DPR [1] & their report[2].

However, a detailed survey for commercial waste generation is needed for validating the quantity to use for decision-making purposes.

8.3 Recovery of Waste

Being a city with no landfill, TMC's decentralised collection mechanism is more focused on maximum channelization of resources for processing. TMC promotes recovering resources at source wherever possible and outsourcing collection services to manage collection and recovery wastes in a controlled manner.

Fig 23. shows the quantity and the % composition of the materials recovered by the Collection and Recovery Mechanism in TMC, using WaCT.

RECOVERY SUMMARY

	Recoverable Material	Collected Qty t/d
1	Plastic PET	15.78
2	Plastic HDPE	15.28
3	Plastic PP	15.31
4	Plastic PVC	7.18
5	Plastic LDPE & Films	1.53
6	Plastic EPS/Styrofoam	0.01
7	Other / mixed plastics	5.80
8	Paper or Cardboard	58.36
9	Glass	6.76
10	Metal	18.50
11	Organic waste	118.50
12	Mixed waste	3.75
	TOTAL	**266.75**

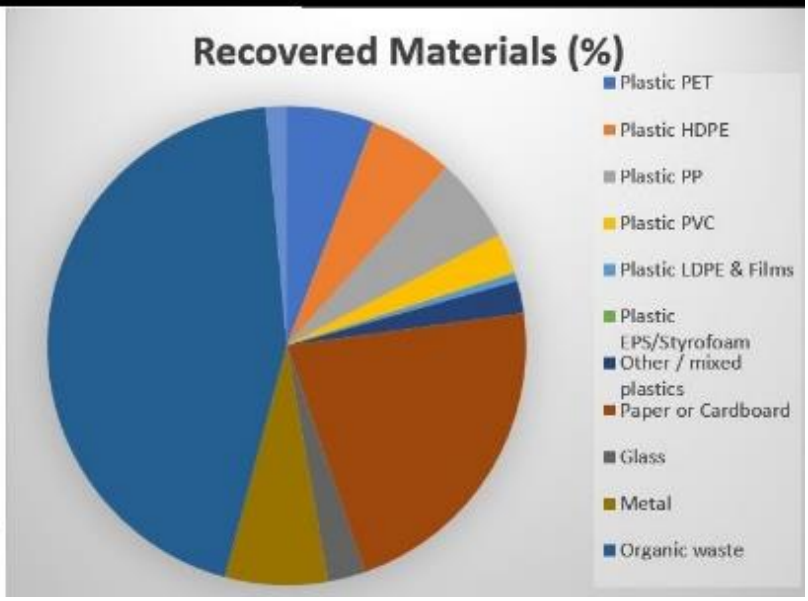


Fig.23 Summary of recovered materials

8.3.1 Deducing Bio Degradable Waste Recovery for WaCT

a) For arriving at BDW waste managed at HHs with source-level composting facility: Four members were taken per household, based on the average of total population Vs the number of households from the records with TMC. This was also cross-checked against the average number of persons for the 90-household selected for the WaCT survey. Per Capita organic waste generation obtained from the primary composition survey was multiplied by 4 & the number of households using the aerobic bins supplied by TMC for managing their organic waste.

i.e., *51.57 % (organic content in HH MSW) x 269 T/d (HH MSW) = 152.65 T/d i.e., 0.16 kgcpd. 4 persons/HH x 46601 HH's (with aerobic bins) X 0.16 = 29.8 ~ 30 T/d*

Although TMC claims 40% HH to be using the composting facility; the same could not be reliably ascertained for efficiency due to lack of data.

b) Through interviews with operators of community bins (443 no's) wastes managed per day was obtained as 12TPD

c) Since TMC advocates for all commercial establishments to manage their organic waste at source through aerobic bins/ biogas plants or through the authorised commercial waste

handlers; quantity of such commercial organic waste was obtained as a difference of total organic waste generated by these establishments and organic waste handled by commercial waste handlers (through interviews with the Authorised agencies).

i.e. 127 T/d is Commercial Waste of the Total 423 T/d generated by TMC of which 65.49 T/d (51.57 %) is organic. 42.3 T/d of organic waste is managed by Commercial Waste handlers. The remaining 23.2 T/d is expected to be managed at the source by the establishments.

It is seen from WaCT that TMC recovers/manages 74 % of the Organic Waste it generates i.e., 118.5 TPD of 160 TPD of BDW.

Table 8 shows the Contribution of the Formal and Informal Sector (both Service and Value Chain) in recovering 267 TPD of MSW generated.

Table 8. Contribution of the Formal and Informal Sector in the Recovery Process

Category	Total Recovered in TPD	Contribution by Formal Sector in TPD	Formal contribution %	Contribution by Informal Sector in TPD	Informal contribution %
Plastic PET	15.8	1.8	12	13.9	**88**
Plastic HDPE	15.3	1.5	10	13.7	**90**
Plastic PP	15.3	1.6	10	13.7	**90**
Plastic PVC	7.2	1.8	25	5.4	**75**
Plastic LDPE & Films	1.5	1.2	**80**	0.3	20
Plastic EPS/Styrofoam	0.0	0.0	**95**	0.0	5
Other / mixed plastics	5.8	5.8	**100**	0.0	0
Paper or Cardboard	58.4	34.5	59	23.9	41
Glass	6.8	0.7	10	6.1	**90**
Metal	18.5	0.5	3	18.0	**97**
Organic waste	118.5	102.5	**86**	16.0	**14**
Mixed waste	0.0	0.0	0	0.0	0
Other waste	3.8	1.2	32	2.6	68
TOTAL (in TPD)	**266.8**	**153.2**		**113.5**	
% share of total recovered			**57**		**43**

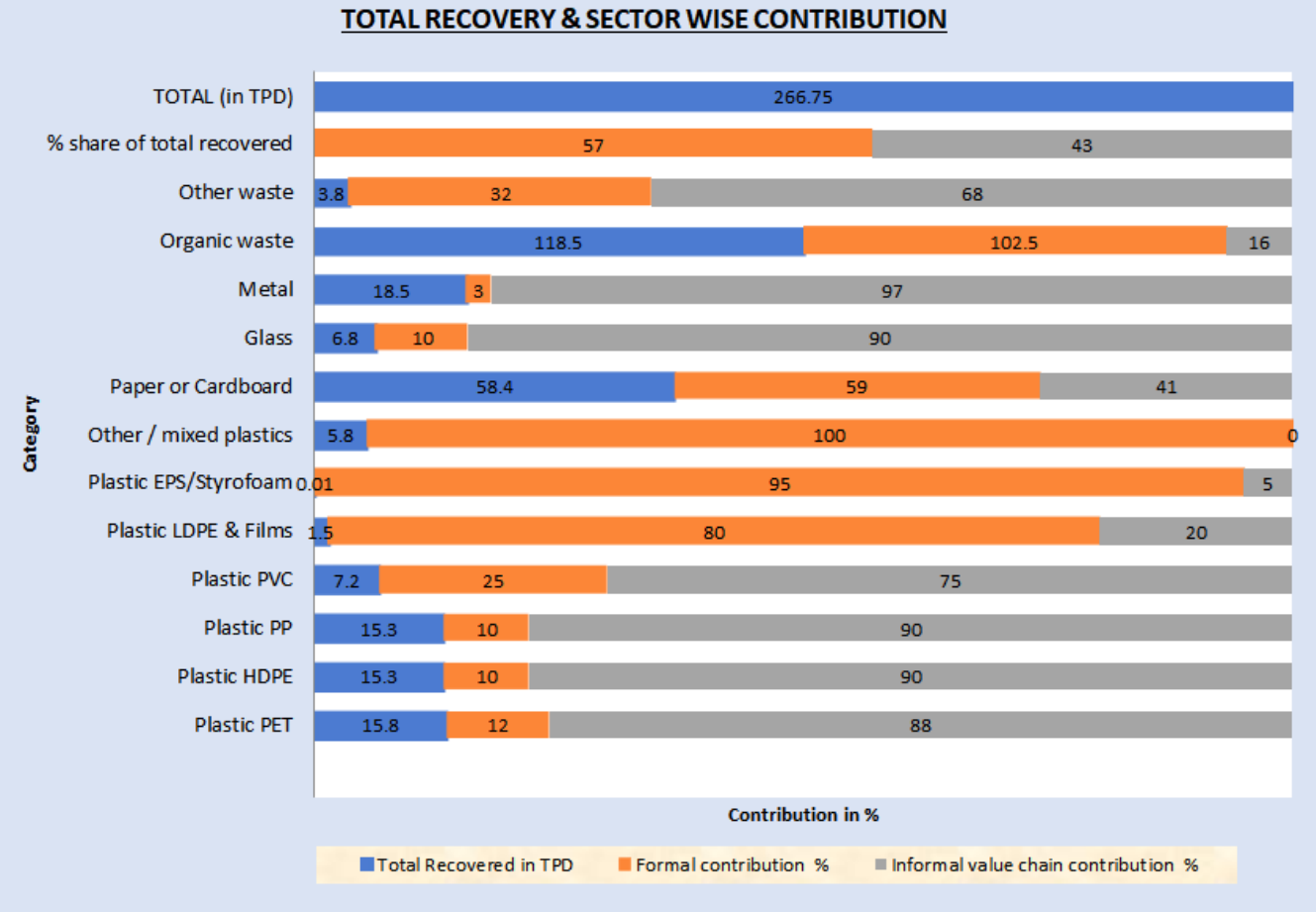


Fig 24. Contribution of sectors in recovery of MSW in TMC

- It is seen that the Formal Sector contributes 57% and Informal Sector 43% in the MSW Collection for Recovery. The Formal Sector here includes the formal service chains of TMC and the agencies working for TMC & the formal value chain which are majorly private traders. The Informal Sector here means the Informal Value Chain.
- As a service provider, TMC directly and through its agencies is managing most of the BDW and materials of low value.
- A major portion of dry wastes of economic value is managed by the Formal & Informal Value Chain Sector.

It may be noted here that items of high economic value are handled by private waste handlers. TMC has a good opportunity to generate revenue by upgrading its waste collection process to recover items of high economic value.

The level of control of these Recovery Facilities was also studied as a part of the survey based on a detailed questionnaire available in WaCT (Table 7), which evaluates the compliance of these

facilities concerning the Legal, Environmental, Health and Safety requirements, record keeping etc. Of the 75 recovery facilities surveyed, none of the 31 MRFs has full control. 20 only had basic, although with health, safety and environment issues. Of the three RRCs, the RRC at Muttathara had Full Control. The other full control systems were the poultry waste collection and management process. The informal value chain services which contribute to 43 % of the waste recovery, it was seen that only 3 had Basic Control and the other 10 had No Control.

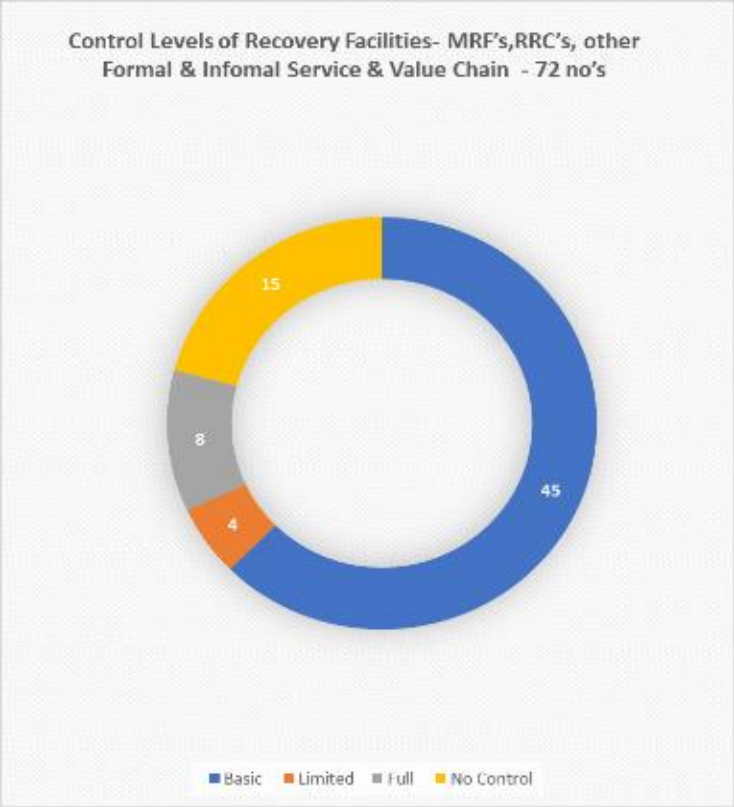


Figure 25 Level of control in the number of Recovery Facilities

9.0 MSW of Thiruvananthapuram City as per WFD

The Waste Flow Diagram (WFD) is a rapid and observation-based assessment TOOL that visualises the MSW flows applying material flow analysis. The WFD was developed in cooperation by GIZ, the University of Leeds, Eawag-Sandec and Wasteaware. It develops on the data used in the WaCT.

The aim of WFD can be summarized into six objectives:

1) To provide a rapid assessment of a cities or municipalities MSW management system and visualise the flows of waste, including informing the SDG11.6.1 sub-indicators
2) To use observational-based assessments to quantify the sources of plastic leakage into the environment from the municipal solid waste management system, and determine the eventual fate of this uncontrolled waste
3) To identify the high-priority sources of plastic pollution to make informed interventions
4) To allow benchmarking and comparison between cities
5) To run scenarios to gain approximate insights into how proposed interventions may impact the solid waste management system and plastic pollution
6) To quantify the effectiveness of applied interventions

Waste Flow Diagram is targeted as a first-level approximation, whereby detail and accuracy of the analysis are traded for a more rapid assessment with fewer data requirements.

The WFD maps the flows of waste according to a process flow systems diagram. The model is presented according to a Material Flow Analysis where each box represents a process (stage or fate) and arrows represent the mass flows in-between. As mentioned in Objective 1 above, WFD has a calculation mechanism that gives the composition of the Total MSW generated, based on the waste quantification done using WaCT. The WFD Tool characterises MSW into **6 categories, which are Organics, Plastics, Paper & Cardboard, Glass, Metal & Others**, whereas WaCT characterizes MSW into 12 categories.

To use the Methodologies in WFD; the quantities of some related waste categorisations of WaCT (e.g., all categories of plastics deduced in WaCT are summed up to get 'plastic' type in WFD) are combined to get the appropriate quantity & results as required in the WFD tool.

The composition of HH MSW was obtained with a characterisation study of HH waste in WaCT. WFD explains that the same cannot be generalised for the whole city as waste composition will vary for commercial spaces. The overall composition of the city is calculated as shown in the table below based on suggestions as in 'Table 5 of the GIZ guideline for WFD'. Here, the composition of MSW recovered is taken from the total obtained from the survey of recovery facilities; to note that rejects (10%) are subtracted from recovered waste as it ends in the city's disposal system and recorded in the disposal facility. Account for the overall waste composition of the city can be referred to in the table below.

Table 9 Calculation of MSW Composition for WFD

No.	in TPD	Paper	Plastic	Glass	Metal	Other	Organic	Total
1	MSW Recovered	58.4	60.9	6.8	18.5	3.8	118.5	**266.8**
2	MSW Disposed	0	0	0	0	28	0	**28**
3	MSW Uncollected	6.1	13.8	5.9	2.1	34.3	66.1	128.2
4	MSW extracted from disposal site	0	0	0	0	0	0	
5	Total MSW (1+2+3+4)	64.4	74.6	12.7	20.6	66.0	184.6	**423.0**
	Total MSW Composition %	**15.24**	**17.65**	**2.99**	**4.87**	**15.6**	**43.65**	**100.0**

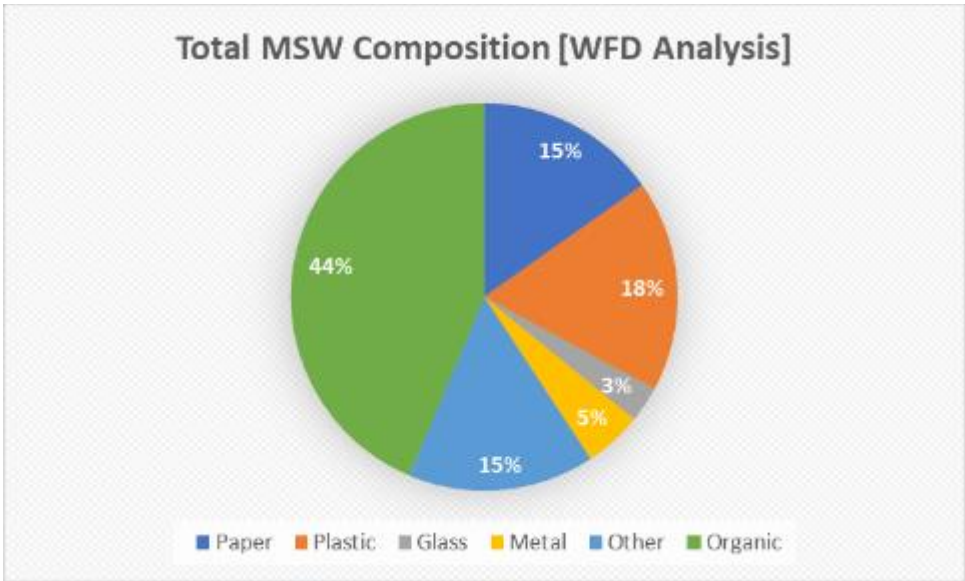


Figure 26 Total MSW Composition of TMC as per WFD

Since TMC does not have a disposal site, values for rows 2 & 3 are empty in Table 21. When it comes to Waste Composition of the Total MSW, WFD predicts a higher Plastics Content @ 18% and Paper @ 15%. Organic Component in the Total MSW is lesser@ 44% as against 52% as per WaCT's HH waste characterisation [Fig. 22].

10.0 Plastic Waste Leakages from WFD

WFD calculates the total potential plastic leakage into the environment from the MSW system and determines the eventual fate of this uncontrolled waste. Results also allow benchmarking and scenario analysis based on various proposed interventions or comparisons between plastic pollution of different cities.

The data collected from WaCT provides direct input for the WFD. The data entry in WFD requires observations to be made as per the guide. For Thiruvananthapuram, three expert observations were made independently. This was later collated based on discussions and majority agreement.

Table 10 Observations made while evaluating plastic leakages & its Fate for Waste Flow Diagram

Plastic leakage potential levels per leakage influencer				**Baseline**
No.	**Item**	**Leakge Influencers**	**Unit**	**Value**
1.1	Plastic waste leakage from collection services	Collection containers	NA	Low
1.2		Loading method	NA	Medium
1.3		Primary transportation	NA	NA
1.4		Multiple handling / waste transfer	NA	NA
2.1	Plastic waste leakage during informal value-chain collection	Recyclables extraction method	NA	Medium
2.2		Transportation method	NA	Medium
3.1	Plastic waste leakage during formal sorting	Formal treatment plastic reject rate	% of formally collected plastic	0.1
3.2		Disposal of rejects	NA	Very high
4.1	Plastic waste leakage during informal service chain sorting	Informal treatment plastic reject rate	% of informally collected plastic	0.1
4.2		Disposal of rejects	NA	Very high
5.1	Plastic waste leakage during transportation to disposal	Capacity vs load	NA	Low
5.2		Waste containment	NA	Low
5.3		Vehicle cover	NA	Low
6.1	Plastic waste leakage from disposal facilities	Environmental hazards	NA	Medium
6.2		Exposure to weather	NA	High
6.3		Waste handling	NA	Medium
6.4		Coverage	NA	High
6.5		Burning	NA	Medium
6.6		Fencing	NA	High
7.1	Plastic waste in storm drains entering waterways	Frequency of rainfall / storm events	NA	Medium
7.2		Drain clean-up	NA	Low

Plastic pollution levels per fate				Baseline
No.	**Item**	**Description**	**Unit**	**Value**
8.1	Fate of uncollected plastic waste	Level of plastic openly burnt	NA	Medium
8.2		Level of direct dumping on land	NA	High
8.3		Level of direct dumping in drains	NA	Medium
8.4		Level of direct dumping in water systems	NA	High
9.1	Fate of plastic waste leaked during collection and transportation	Level of plastic to land	NA	Low
9.2		Level of plastic to drains	NA	Medium
9.3		Level of plastic to water systems	NA	Medium
10.1	Fate of plastic waste leaked from formal sorting	Level of plastic openly burnt	NA	Low
10.2		Level of direct dumping on land	NA	Low
10.3		Level of direct dumping in drains	NA	Very low
10.4		Level of direct dumping to water systems	NA	None
11.1	Fate of plastic waste leaked from informal sorting	Level of plastic openly burnt	NA	Very low
11.2		Level of direct dumping on land	NA	Medium
11.3		Level of direct dumping in drains	NA	Low
11.4		Level of direct dumping to water systems	NA	Low
12.1	Fate of plastic waste leaked from disposal facilities	Level of plastic to land	NA	High
12.2		Level of plastic to drains	NA	Low
12.3		Level of plastic to water systems	NA	High

This Data was input into the WFD excel tool to obtain the Systematic WFD of all the 6 categories of materials & the leakage of plastics into the environment. Figure 27 shows the systematic WFD of all the MSW. Fig 28 specifically shows the flow of the plastic component of the MSW.

Fig 27. Systematic Waste flow diagram of all MSW using WFD analysis *(All leakages are in Tonnes/year).*

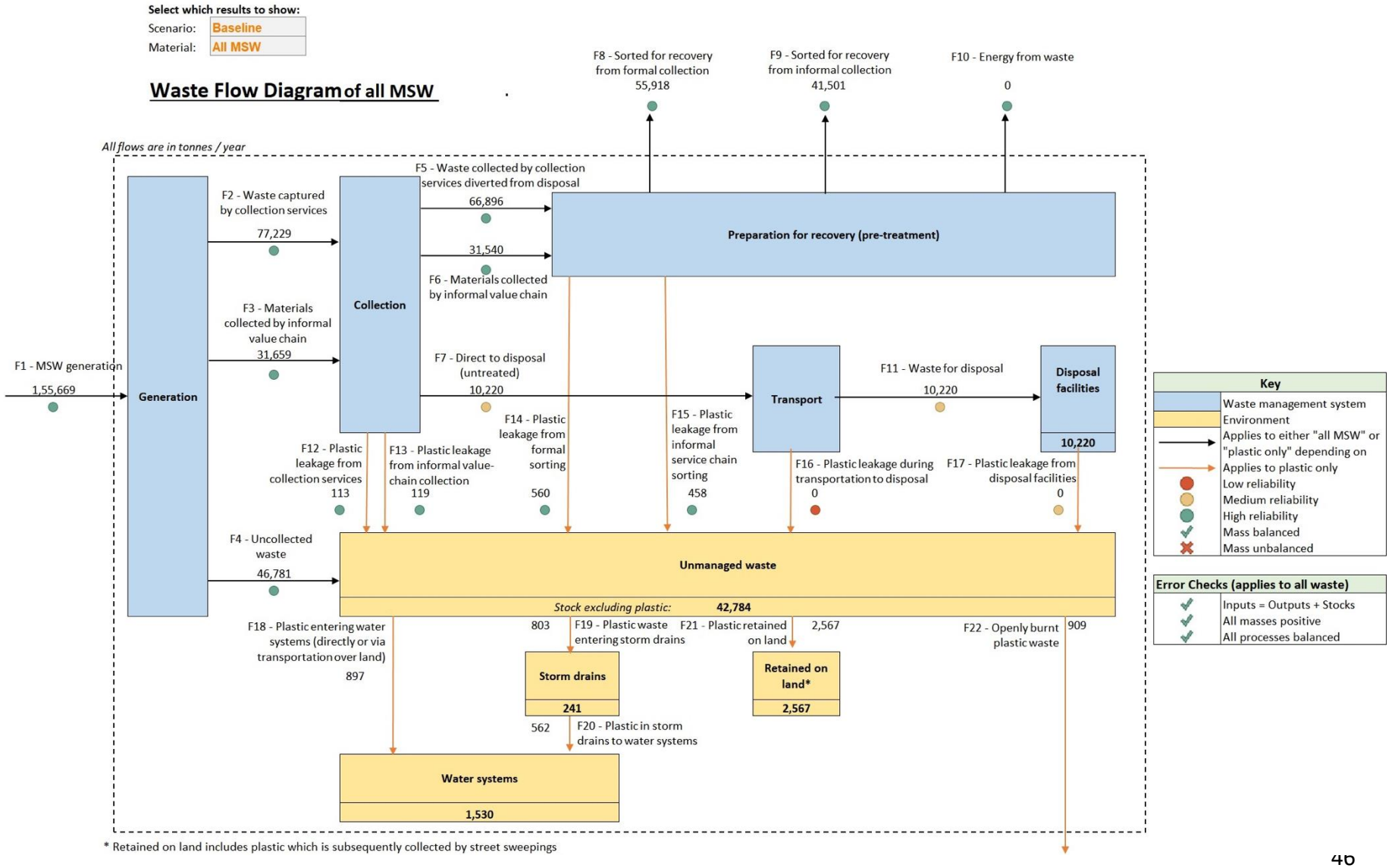


Fig 28. Systematic Plastic Waste flow diagram using WFD analysis *(All leakages are in Tonnes/year).*

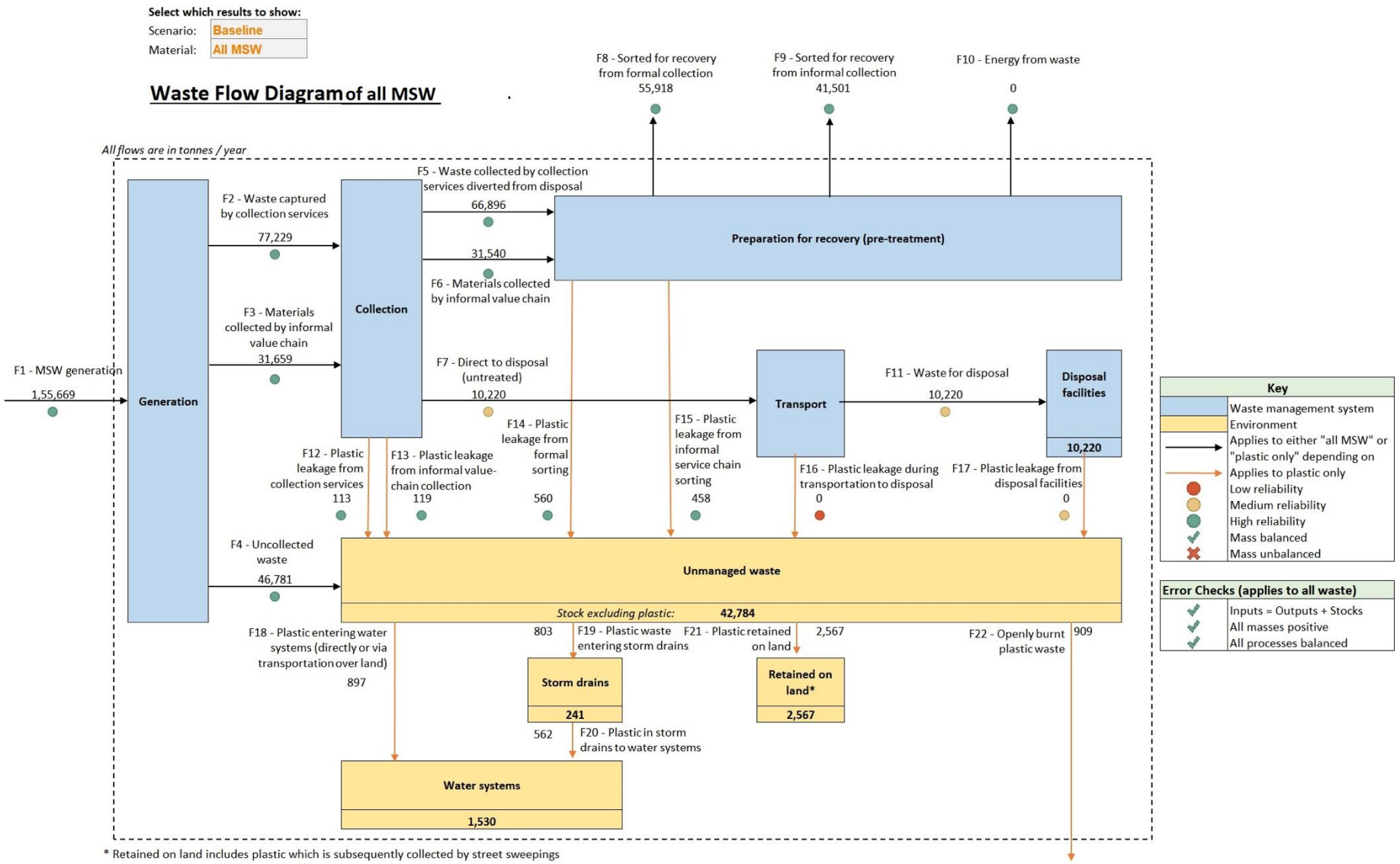


Figure 29 below depicts the Plastic waste Flow, their leakage at various stages of management & their fate in the form of a Sankey Diagram. Table 23 summarises the flow of plastic generated by the city.

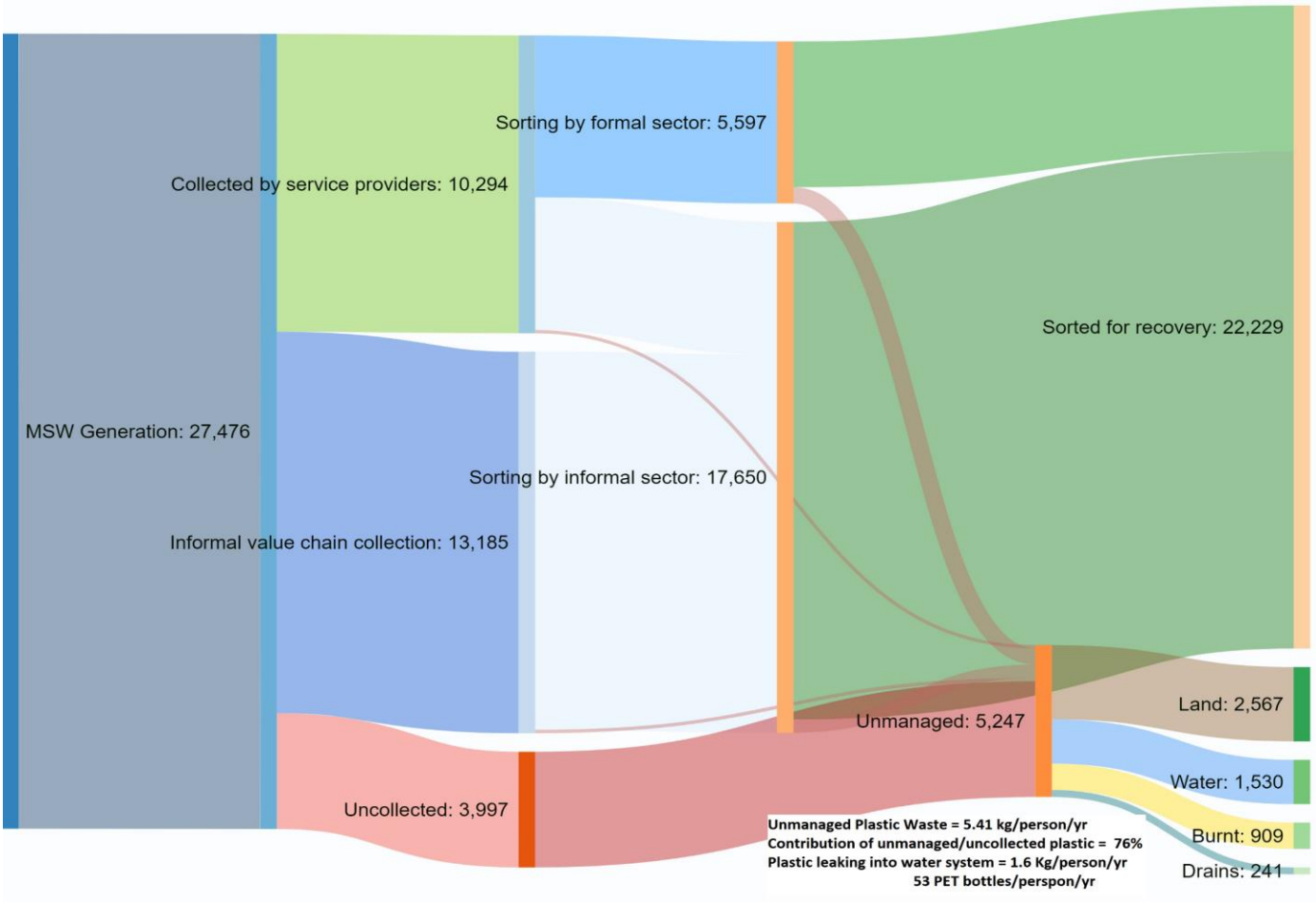


Figure 29 MSW Plastic Leakage & Fate using 'Sankey-Diagram' in TMC (Tonnes/Year)

Table 11 Summary of the flow of plastic waste in the city (in Tonnes/Year)

Plastic Generation	27,476	18% of total MSW
Total Collected	**23,478**	**85%**
Collected by service providers	10,294	44%
Informal value-chain collection	13,184	56%
Uncollected	**3,997**	**15%**
Disposal	none	none
Sorted for recovery	23,247	79%
Sorting by formal sector	5,037	22%

Sorting by informal sector	17,192	78%
Unmanaged (Uncollected + rejects of recovery)	**5,247**	**19%**
Landfill / dumpsite	none	none
Present in Environment	5,247	21%
Retained on land	**2,567**	**49%**
Plastic entering water system from Land	897	17%
Plastic Burnt	**909**	**17%**
Plastic entering Drains	803	15%
Plastic entering water system from Drains	562	11%
Retained on Drains	**241**	**5%**
Retained in Water	**1,459**	**29%**
Contribution of plastic leakage from land to water		*62%*
Contribution of plastic leakage from drain to water		*38%*

We can make the following observation from the WFD for Plastics generated in Thiruvananthapuram City:

- ✓ Of the 1,55,669 TPA of MSW generated, 27,476 TPA are plastics.
- ✓ 85% of the plastic waste generated is collected by formal & informal facilities in TMC
- ✓ 15% of the plastics generated in the MSW remains uncollected; as a portion of this can also be mismanaged, which is 3,997 Tonnes/Year or 11 Tonnes/Day.
- ✓ 22% of sorting of plastics is handled by the Formal Sector and 78% by the Informal Sector
- ✓ 19 % of plastic generated in the MSW is unmanaged, which also includes the rejects during sorting
- ✓ The above 19 % of the unmanaged plastic, i.e. 5,247 Tonnes/year **LEAKS** into the Environment,
    - of which 49% is retained on the LAND
    - 17 % are BURNT
    - 5% are retained in the DRAIN
    - **29 % of the unmanaged plastic enters the WATER system & eventually ends up in the ocean, which amounts to 1,459 Tonnes/Year or 5 Tonnes/day.**
- ✓ The extent of plastic leaking into the water systems can be explained below

Plastic to water systems per person	1.6	kg per person/year
Plastic to water systems per person	53	no. PET bottles per person/year*
Plastic to water systems	2,250	no. of waste trucks/year***

**Mass of 1.5 litre PET bottle: 30 g, ***Volume truck: 20 m3, Density mixed plastic waste: 34 kg/m3*

The pictures below [Fig 30] explain the possible plastic leakage scenarios and their eventual fate into this Environment as a part of the WaCT study at TMC.

	
Illegal dumping of waste on roadside @ Killipalam	Dumped on vacant land at kalladimugham with no SW collection system
	
A Formal HH waste collector's sorting facility with 'no control' @ Maruthamkuzhi	Uncollected MSW dumped on land. Leakage on Land and Marine pollution. Scenario at one of the coastal areas- Valiyathura

	
Uncontrolled disposal at an MRF into land (Jagathy)- leakage on land and water	Plastic leakage into water body near Railway Station
	
e.g. rejects in an uncontrolled informal sorting facility @ KIllipalam	Waste collection carts of TMC – potential for leakage during transportation

Figure 30 Various sources of leakages from collection systems and non-collection/mis management of MSW

11.0 Data validation and comparison

The data obtained from the assessment study was cross-checked with the collected background data and estimations made in Thiruvananthapuram's DPR[1] prepared in 2018. The WaCT results with regards to the waste characterisation was closer to the estimations made in the DPR. The review was carried out with relevant stakeholders other than the UN-Habitat team on the collected data and outputs, the table below lists the major reviewers.

Table 12 Reviewer list for WaCT data

No	Name	Organisation	Significant feedback	Action
1	Mr. Santhosh Kumar & Mr. Ramesh Kumar	TMC	Acceptable estimations on efficiency of material recovery and waste generation	Accepted
2	Mr. David Newby	Waste aware	As seen on ground, it was suggested to reflect the quantity of unrecoverable wastes in the collection system as being disposed (e.g., rejects, sanitary wastes etc.) to better explain the prevailing scenario & avoid negative values in the mass balance. It was advised to create a single disposal record "small uncontrolled dumpsites" in the data entry of WaCT to accommodate for such rejects.	Corrections made

12.0 Value addition of WaCT in Thiruvananthapuram

A comparison of the benefits of applying WaCT is shown as a snapshot in the figure 31 below. Through the application of WaCT, TMC has a better understanding of the waste flow stream & their efficiency in collection for recovery. Unaddressed and mis-managed MSW had come to the fore through WaCT analysis. This has given the city more clarity on the magnitude of all possible environmental leakages & their Fate. There is more clarity on the contributions of Formal and Informal sectors in MSWM, in terms of the quantity handled, coverage, the efficiency of operation and quality of service.

Shri. Binu Francis, Secretary of Thiruvananthapuram Municipal Corporation has noted the value addition of WaCT; thus, *"Thiruvananthapuram Corporation's slogan of 'My Waste My Responsibility' has enabled its citizens to become aware and responsible for the waste they generate. Being a city without a landfill, the Corporation has adopted a decentralised waste management model with a focus on source-level segregation. The city promotes the treatment of bio-degradable waste at the source and has established community-level treatment facilities. Various service providers and women Self-help Groups have been authorised for collection and recovery of municipal solid waste (MSW) at the Material Recovery Facilities and Resource Recovery Centres of the Corporation. Implementation of the Waste Wise Cities Tool developed by UN-Habitat has helped the city in rapidly assessing its existing efficiency on municipal solid waste management as well as in quantifying waste generated, channelised for recycling and leakages into land and water environment. This will help the corporation in making effective evidence-based circular decisions on MSW at both policy and infrastructure level."*

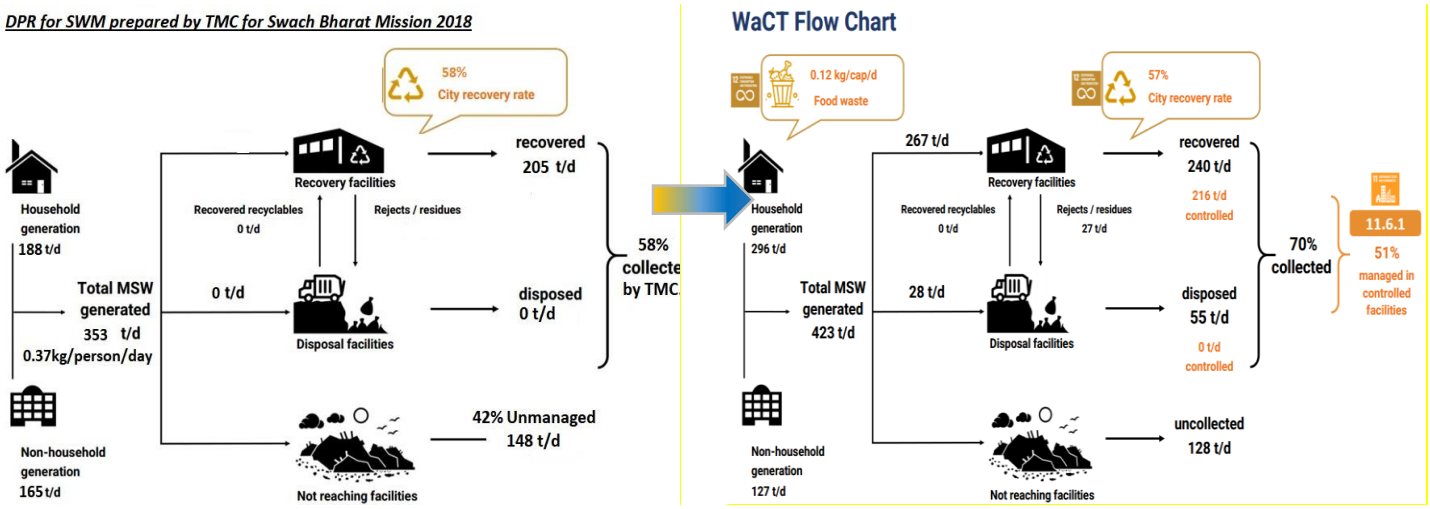


Fig 31. MSW flow chart before & after applying WaCT

13.0 Gaps identified by WaCT

As predicted, there is an overall increase in the quantum of waste generated. WaCT analysis gives a changed perspective on the composition of the MSW. The plastics component in the MSW has creased almost 2-fold and there is a decrease in the Organic fraction, showing a change in the consumption pattern of the population. Further, there is a marked difference in the contribution of HH waste @ 296 TPD compared to TMC's earlier prediction[1] of 188TPD. Figure 32 gives a comparison of the composition of HH MSW.

A better insight comes to the efficiency of the collection & Recovery Mechanism of TMC's Decentralised collection of NBDW and source-level treatment of BDW. WaCT shows that TMC can recover 57% of the wastes it generates. TMC claims that it effectively manages only 58 % of the MSW directly and through outsourced agencies.

WaCT analysis gives a clearer picture by including the contributions of the Formal service & value chain and Informal value chain recoverers (Table 20 & Fig 24). It could be deduced for WaCT, that the Formal Service chain of TMC is recovering 37 % of the Total MSW of 423 TPD & the informal Value Chain is recovering 27%.

WaCT has brought to light the lacuna in managing Rejects. 55 TPD of wastes are being disposed of in informal dumpsites, burnt or buried and which has contributions from rejects (27TPD) during sorting & 28TPD as inserts from street sweeping and sanitary wastes needing proper address.

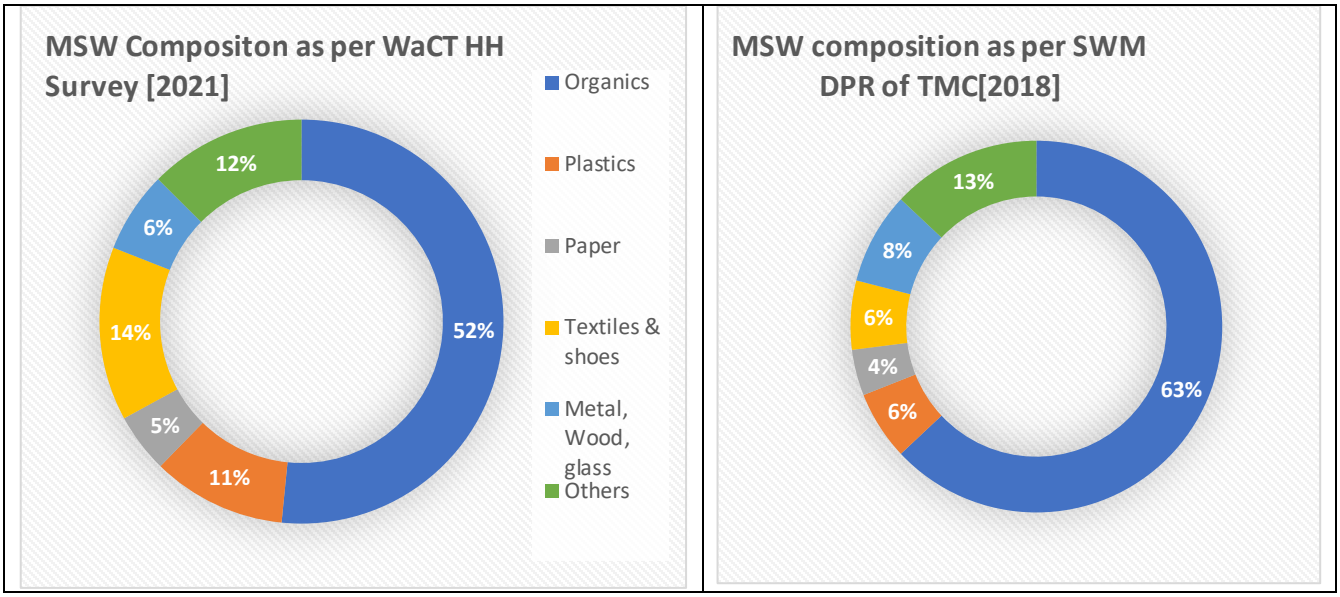


Fig 32. MSW waste composition comparison WaCT 2021 vs TMC data 2018

Another grave issue that needs immediate attention shown through WaCT analysis is addressing the unmanaged /uncollected MSW of 128 TPD. It is estimated by TMC that informal service providers cover 30% of the corporation area addressing a portion of this quantity. However, their mode of operation and waste management mechanism is unknown, contributing to Environmental Leakages as much as uncollected wastes do.

The waste Flow Diagram although depicting the plastic leakage gives a clear picture of the flow of unmanaged waste into the environment. As seen for TMC, the fate of most of the uncollected waste is to end up on land. The second abject fate; is them ending up in the Water system & eventually the oceans affecting marine ecology.
The above situations are an eye-opener for many cities in Kerala which do not have options are the disposal of rejects and do not collect their MSW regularly.

Based on the WaCT assessment, four key intervention areas have been identified to improve Thiruvananthapuram's solid waste management and achieve SDG 11.6.1:

1. Awareness and capacity building with a focus on waste minimisation, segregated collection, and circular systems
2. Strengthening resource recovery by enhancing upcycling interventions and bringing efficiency and coordination in MRF/RRF operations
3. Improvement of management of uncollected waste and disposal of residual waste from MRFs/RRFs to control leakages inland and marine environment.
4. Circular financing in SWM projects

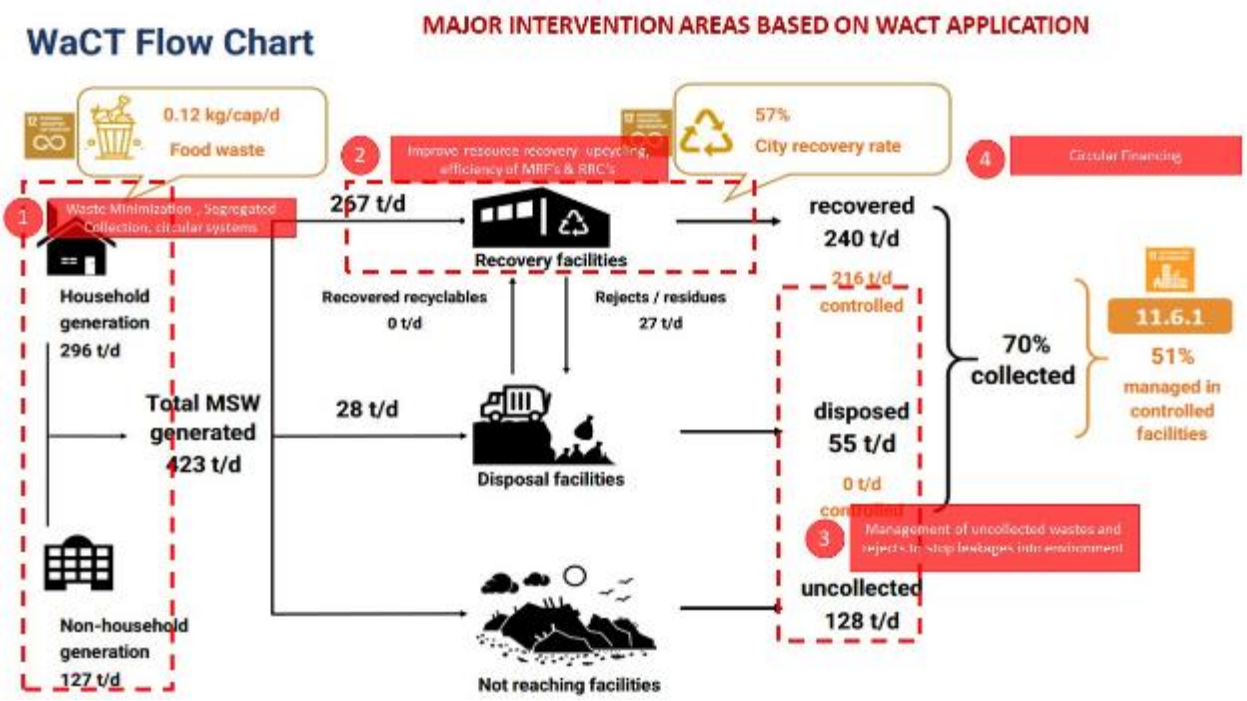


Figure 33 Waste flow with highlighted intervention areas

14.0 Recommendations

WaCT and WFD study through its analysis have systematically helped to understand the solid waste management process quantitatively and qualitatively in TMC. It has helped in visualizing the lacunae and suggesting critical control points needing attention for efficient SWM and Environmental Protection.

TMC needs to include, train, and empanel more waste collection agencies to increase collection coverage at both households and non-household levels. A detailed survey and audit of the current systems of SW collection, management and its efficiency are important to improve coverage and avoid leakages.

Regular performance auditing the waste management facilities of the commercial waste handlers are necessary for ensuring Quality Control during license grant and renewal. The same can be applied to the HH waste management service providers once all of them are brought under the ambit of authorised service providers.

It could enact bylaws to allow only authorised service providers to operate in the city. TMC could enhance the already existing '**Smart Trivandrum'** mobile application for delivering SWM services.

TMC as a service provider was not generating/promoting revenue from the sale of recyclable materials of higher economic value. This can be seen as a deterrent for the authorised HH waste collection agencies and commercial waste handlers to provide the waste to TMC owned MRFs or RRCs. TMC can leverage its position as Service Provider by taking measures to also recover all materials of value, thereby supporting its SW management process. This would require enhancing its MRFs and RRCs to effectively handle different types of wastes or developing RRCs to handle specific types of wastes only and provide competitive remuneration to the waste handlers.

Currently, all the recyclable materials of high value are managed by the Value Chain sector which is mostly Private entities. It was seen that many of these entities operate with NO environmental Control. TMC can regularize the functioning of these Value Chain Traders through a proper audit by ensuring their mandatory Health, Safety and Environmental Norms. Incentive mechanisms for continued compliance can be devised for the same.

WFD shows a large quantity of unmanaged waste and plastics are drastically impacting the environment eventually affecting the health, hygiene, and aesthetics of the city. Addressing this should be the main point of TMC while strategising Efficient SWM mechanisms.

WaCT & WFD analysis has given ample information in the form of quantities. Any improvement /development activities planned can use this data as a baseline. Scenarios are available in WFD for use to visualize how any planned intervention shall affect the outcome before they are physically considered for implementation in the field.

Annexure 1 - Letter of support from TMC for WaCT implementation

THIRUVANANTHAPURAM MUNICIPAL CORPORATION

Palayam, Vikas Bhavan Ph: 0471-2320821,
E-mail: tvpmcorpn@gmail.com

H19/76782/2021 Date: 27/10/2021

Dear Sir/Madam,

We are glad to inform you that UN-Habitat, India office officials and representatives from Sahridaya are surveying to collect data on waste generation and its recovery in Thiruvananthapuram Corporation to support Sustainable Development Goal indicator 11.6.1.

Under the Waste Wise Cities (WWC) programme, UN-Habitat has developed the Waste Wise Cities Tool (WaCT), based on SDG indicator 11.6.1 parameters, to support cities and countries in undertaking a comprehensive diagnostic of Municipal Solid Waste (MSW) to aid scientific and evidence based development of projects and investments. As part of the Waste Wise Cities, UN-Habitat is doing this pilot study in Thiruvananthapuram to help support the city in establishing better waste and resource management strategies, creating business and livelihood opportunities, and transiting towards a circular economy.

The study includes collecting information and waste from households and institutions for a certain period; the data collected will support Thiruvananthapuram Municipal Corporation (TMC) towards developing strategies and plans to improve waste management and achieve a better urban living environment for its residents.

The survey will start on 12th November 2021 and will extend till the last week of November, 2021 in selected wards – ward number 17,19,24,29,34,47,66,68 & 88. Under the survey, the team shall survey twelve households in each ward. The survey shall also cover visits to recovery facilities and processing sites. All the sensitive information on name and address will be confidential and not displayed in any discussions or platform

We would appreciate your collaboration in allowing the UN-Habitat India officials and the team from Sahridaya to collect the information and material necessary for assessing SDG indicator 11.6.1.

TMC would appreciate your support towards the study.

Thanking you,

Yours Sincerely,

(Binu Francis)
Secretary
Corporation of
Thiruvananthapuram

Annexure 2 - Detailed work flow plan for WaCT application

Timeline Thiruvananthapuram Municipal Corporation			Nov-21		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Number of volunteer
Steps	Activities	Estimated days	Notes	Pre-field	Day																					
														1	2	3	4	5	6	7	8	9	10	11	12	
WaCT Step 1	Procurement of equipments	NA	A: Major purchases made @ Delhi & Couriered to local address at TVM. Local Purchases @ TVM	A								A	A													
	Establishing team (Workshop)	NA	A: pre-field-Volunteer selection A1: Volunteer training	A								A			A1											
	Information on number of HH & commercial units	NA	A: Pre-field task with Nodal person	A																						
	Preparing sorting site for characterisation study	1	A: Selection of site for sampling & permission to use A1: Preperation at site									A				A1										
	Prepations of liner bags for sampling	1	A: bags need to procured earlier												A											
	Finalising logistics	NA	Tarpaulin sheets, sorting buckets, balance for wt., preparing area for sorting																							
WaCT Step 2	Selection of HH & notifying them	5	A:Reach out with letter from Municipality A1:Visit and orientatiom after workshop by volunteers	A				A	A	A						A1										
	Sampling and Characterization study	8	A: Collection & Characterisation study at sorting site														A	A	A	A	A	A	A	A		12
WaCT Step 3	Selection of commercial unit	1	A: deciding the action plan & mapping Non Households A1: volunteer assignment & letter of permission to survey	A									A1													
	[option 1] Characterisation study	NA	A: Collection and characterisation study at sorting site (Unit: Hotel, restraurant, Hospital, TBD)																							30% approx
	[option 2] Interaction/Evidence based	4	A: Only visit and get data if waste amounts are not reported, ask the collection companies														A	A	A	A						4, split into 2 groups
WaCT Step 4	Mapping of Waste Recovery facilities	NA	A: To get this information from municipality, health officials of all wards, obtain ctc info & intial contact, location mapping	A			A	A	A		A	A														
	Visits and interviews + Evaluation of level of control	7	A: Visit to TMC managed facility with questionnaires A1: interview with commercial waste handlers & visit to pig farm to study bio waste management														A	A	A	A	A1					3 to 6 dedicated members
			A2: Visit & interview with value chain traders																		A2	A2	A2			
WaCT Step 5	Landfill waste amounts	NA	A: Visit Landfill for Weigh bridge data, Ask for 2 Weeks Data and also need older data for	STEP 5 ommited since no landfill																						TMC has no landfill
	Level of control		A: Experts visit																							
	Interview with Waste Pickers																									
WaCT Step 6	pre-arrangements	NA	A- Evaluate situation and map out the incoming waste channels for selction A1- Field arrangements with appratus and all	STEP 6 ommited since no landfill																						
	Landfill waste characterization		Possibly a Friday and one another day for Mangalore Can select a day when volunteers are free from step 2-3																							
WaCT Step 7	Plastic leakage survey	4	Experts only																	A	A	A	A			
Others	Waste Density	NA	Can be incorporated with characterization Equipment shall be needed																							Not done
	Compling all information	3	A:Make system for on-spot data management A1: Data compilation	A													A	A	A	A	A	A	A	A/A1		2 made responsible for 8 days

Annexure 3 - Work Sheet at sorting site for recording the data

Given the arrangement of team and centralised sorting site for the study, a one pager sheet was used for recording the data to reduce multiple handling of

Survey Area					Day:	Volunteer name:											
						HH			Shop			Restaurant			Office		
Entity	A	B	C	D	Categories	E	F	G	E	F	G	E	F	G	E	F	G
HH1					Kitchen/Food												
HH2					Garden/Park												
HH3					Paper & cardboard												
HH4					Plastic – film												
HH5					Plastic- dense												
HH6					Metals												
HH7					Glass												
HH8					Textile & Shoes												
HH9					Wood												
HH10					Special Waste												
Shop 1					Composite products												
Shop 2					Others												
Rest 1																	
Rest 2																	
Off 1																	
Off 2																	
A: Weight of bag with wet waste						E: Weight of bucket with waste											
B: Weight of bag with dry waste						F: Weight of bucket											
C: Total weight of bag --> Enter this value in main sheet						G = E - F: Weight of Waste --> Enter this value in main sheet											
D = A + B - C: Weight of waste																	

Annexure 4 - Waste generation and characterisation sheet

The sheets below are to record the waste generation data of HH for the entire survey period. Data from daily sheets were collated in below sheets for reporting purpose.

Survey Area:	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10	Total
Number of residents											
Weight of bag	Daily waste generated by HH in Kgs (weight of filled bag - weight of empty bag)										
Day 2											
Day 3											
Day 4											
Day 5											
Day 6											
Day 7											
Day 8											

HH Waste Characterisation										
Survey Area:		* Day total should be the same as day total in HH quantity sheet								
No	Categories	Day 2 (Kg)	Day 3 (Kg)	Day 4(Kg)	Day 5 (Kg)	Day 6 (Kg)	Day 7 (Kg)	Day 8 (Kg)	Sum (kg)	Average (kg)
1	Kitchen/Food									
2	Garden/Park									
3	Paper & cardboard									
4	Plastic – film									
5	Plastic- dense									
6	Metals									
7	Glass									
8	Textile & Shoes									
9	Wood									
10	Special Waste									
11	Composite products									
12	Others									
	Total									

Annexure 5 - Results on waste generation at HH level from WaCT implementation

The table shows the data entry of WaCT application for HH waste generation. 10 Households from 9 wards of 3 different income groups. HH waste was collected for 8 days. First day's waste was discarded since there is a tendency of people to give away larger quantity on the first day & hence wouldn't be representative of the actual waste generated from that HH.

Details of Waste Generation from the 9 Survey Areas

1. HI(W No.24)	**Kuravankonam**				**Daily waste generated by HH in Kgs**					
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	3	7	2	3	2	5	3	4	4	6
Day 1	0.620	2.035	0.885	1.230	1.050	1.235	0.510	1.925	0.855	2.015
Day 2	0.940	2.640	1.250	1.015	0.860	3.360	1.600	2.045	1.365	1.455
Day 3	0.835	2.350	0.775	0.445	0.945	2.455	1.485	1.105	1.215	3.450
Day 4	1.205	2.230	0.530	0.860	1.105	1.895	1.560	1.375	0.995	1.665
Day 5	1.350	1.450	0.410	0.730	0.610	1.457	1.295	1.100	1.470	2.850
Day 6	0.605	1.065	0.525	1.235	0.525	3.635	2.150	1.355	1.645	1.550
Day 7	0.560	1.350	0.375	1.155	0.450	1.835	1.005	1.115	1.550	2.145
wt. per capita /HH	**0.291**	**0.268**	**0.339**	**0.318**	**0.396**	**0.453**	**0.457**	**0.358**	**0.325**	**0.360**
2. HI(W No.17)	**Pattom**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	4	3	3	5	2	6	5	2	2	5
Day 1	1.530	0.725	0.655	2.760	0.855	3.715	2.205	0.505	1.050	1.350
Day 2	0.855	1.885	1.525	1.700	1.075	1.610	4.215	0.595	1.625	1.455
Day 3	1.530	0.800	0.590	1.055	0.910	2.895	1.280	0.470	1.405	2.405
Day 4	1.485	1.000	1.845	2.655	0.430	2.075	1.645	0.625	0.460	1.950
Day 5	1.165	2.055	1.460	1.365	0.745	2.575	1.075	1.215	0.655	1.255
Day 6	1.855	0.840	0.705	1.795	0.955	1.545	1.105	1.720	0.845	2.490
Day 7	1.405	0.200	0.525	1.290	1.035	1.300	2.135	1.050	0.460	2.450

wt. per capita /HH	**0.351**	**0.357**	**0.348**	**0.361**	**0.429**	**0.374**	**0.390**	**0.441**	**0.464**	**0.382**
3. HI(W No.29)	**Vazhuthakadu**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	6	7	6	5	6	5	5	5	5	4
Day 1	1.275	0.92	0.315	1.055	2.365	1.560	0.465	1.68	2.735	3.945
Day 2	1.015	1.18	3.155	0.51	4.400	3.135	0.77	0.535	0.7	2.07
Day 3	2.185	1.44	7.38	0.995	6.795	3.895	0.77	0.52	1.7	2.045
Day 4	0.865	1.105	4.63	1.06	3.310	4.950	0.635	2.895	1.51	1.16
Day 5	1.195	0.67	3.835	1.005	3.945	2.780	2.315	0.795	0.715	1.015
Day 6	1.41	0.845	3.045	1.04	3.335	2.145	2.135	0.305	1.59	0.85
Day 7	1.42	1.39	3.82	0.42	3.340	1.895	7.285	2.415	0.775	2.49
wt. per capita /HH	0.223	0.154	0.623	0.174	0.655	0.582	0.411	0.261	0.278	0.485
4. MI (W No.88)	**Vallakadavu**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	6	5	3	8	8	5	5	4	4	5
Day 1	1.845	2.115	0.385	2.645	2.265	1.715	0.355	1.215	0.729	1.215
Day 2	1.720	0.345	0.770	1.370	3.520	1.135	0.410	0.825	0.645	0.995
Day 3	1.450	0.350	0.505	2.780	4.305	1.785	2.705	0.740	0.840	1.290
Day 4	2.760	1.840	1.590	2.240	2.845	0.690	3.205	0.475	1.104	2.425
Day 5	1.785	1.335	0.240	1.910	0.830	2.210	2.185	0.555	0.705	0.745
Day 6	2.055	1.385	0.645	2.255	1.595	0.855	1.775	1.600	0.790	1.255
Day 7	0.985	2.235	0.360	2.365	2.335	1.960	1.035	0.895	0.555	0.830
wt. per capita /HH	0.300	0.274	0.214	0.278	0.316	0.296	0.333	0.225	0.192	0.250
5. MI (W No.68)	**Kamaleswaram**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	2	4	5	4	3	6	4	4	4	9
Day 1	0.235	1.100	1.145	2.256	1.725	2.320	1.420	1.115	1.275	1.770
Day 2	0.240	1.535	1.400	1.575	0.785	3.300	1.155	0.645	1.140	3.430

Day 3	0.375	1.490	2.100	1.890	0.655	1.895	2.075	0.975	0.980	2.435
Day 4	0.510	1.205	1.520	1.125	2.150	2.480	0.950	1.480	2.350	3.000
Day 5	0.355	1.165	3.105	0.960	1.840	0.960	1.565	1.525	1.105	2.285
Day 6	0.290	1.970	1.395	0.890	0.915	1.140	0.890	1.705	0.710	1.500
Day 7	0.115	0.445	1.425	2.155	0.845	0.595	0.915	0.905	1.255	3.450
wt. per capita /HH	0.151	0.318	0.345	0.388	0.425	0.302	0.320	0.298	0.315	0.284
6. MI (W No.47)	**Mudavanmugal**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	4	3	6	5	3	4	6	3	6	3
Day 1	1.83	0.67	1.725	2.415	1.11	1.630	1.02	0.600	2.45	1.14
Day 2	0.645	0.73	2.24	1.85	1.075	1.605	1.675	0.458	1.565	0.355
Day 3	1.2	0.6	2.545	1.28	0.91	0.510	1.61	0.493	1.875	0.685
Day 4	0.89	0.855	0.975	0.56	0.85	2.550	4.685	0.917	2.67	1.065
Day 5	1.27	0.74	1.415	1.03	1.11	0.595	3.21	0.423	1.96	0.75
Day 6	1.695	1.84	1.78	1.445	0.985	1.080	3.875	0.438	2.105	0.805
Day 7	1.725	1.33	2.055	1.7	0.87	1.245	0.62	0.560	0.895	1.145
wt. per capita /HH	0.331	0.322	0.303	0.294	0.329	0.329	0.398	0.185	0.322	0.283
7. LI (W No.34)	**Kachani**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	4	3	4	3	2	3	4	4	3	3
Day 1	0.055	1.05	1.425	1.64125	1.280	1.085	3.21	0.820	1.54	0.62488
Day 2	0.23	0.8	0.88	0.739375	0.510	0.465	0.48	1.165	0.725	0.4964
Day 3	0.15	0.845	1.365	1.475	0.650	0.655	0.385	1.220	1.12	0.96
Day 4	0.22	0.675	0.545	1.215	0.450	0.58	3.82	1.095	0.605	0.985
Day 5	0.45	0.645	0.72	0.52	0.485	1.56	0.495	1.585	1.035	0.778
Day 6	0.495	1.09	1.69	0.96	0.550	0.515	0.995	1.105	0.635	0.94024
Day 7	1.425	1.265	0.455	0.565	0.495	1.625	0.41	0.745	1.02	0.675
wt. per capita /HH	0.108	0.303	0.253	0.339	0.316	0.309	0.350	0.276	0.318	0.260

8. LI (W No.66)	**Poonthura**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	3	6	7	4	6	9	8	7	6	6
Day 1	0.525	1.245	2.245	1.39	0.88	2.8	2.535	1.295	1.88	3.215
Day 2	0.795	1.830	2.565	1.03	1.015	3.51	4.565	1.655	1.36	1.01
Day 3	0.43	0.890	1.74	0.875	2.99	1.145	1.42	2.695	2.465	1.255
Day 4	1.425	1.620	0.855	0.705	1.17	2.54	1.505	1.105	1.675	0.955
Day 5	0.18	0.995	2.21	0.885	2.115	3.015	1.465	2.375	2.205	0.965
Day 6	0.295	1.855	0.755	0.955	1.25	2.865	2.07	1.875	1.745	1.455
Day 7	0.94	1.850	1.17	0.745	0.56	1.38	1.305	1.97	1.035	1.15
wt. per capita /HH	0.219	0.245	0.236	0.235	0.238	0.274	0.265	0.265	0.294	0.238
LI (W No.66)	**Kudapanakunnu**									
	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	HH9	HH10
No. of Members	4	2	4	4	3	4	5	4	6	4
Day 1	1.385	0.69	0.44	1.225	1.07	0.21	2.485	1.335	1.77	2.01
Day 2	0.65	0.265	0.755	1.16	0.555	1.185	1.315	0.875	2.05	1.01
Day 3	1.280169	0.375	3.665	1.02	0.35	1.825	0.645	0.515	1.275	0.799825
Day 4	1.445	0.415	2.04	1.51	0.325	1.915	2.36	2.15	0.795	1.505
Day 5	1.52	0.255	0.335	1.035	0.31	0.85	1.21	1.57	1.94	0.735
Day 6	0.395	0.615	0.36	0.755	0.14	1.385	1.22	0.865	1.47	1.67
Day 7	1.895	1.245	1.85	0.785	1.51	0.97	0.61	1.385	1.15	1.075
wt. per capita /HH	0.306	0.276	0.337	0.268	0.203	0.298	0.281	0.311	0.249	0.314

Annexure-6 - Team for UN-Habitat's implementation of Waste Wise Cities tool in Thiruvananthapuram city

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