CLEAN CITIES, BLUE OCEAN

WASTE AUDIT AND CHARACTERIZATION STUDY (WACS) GALLE MUNICIPLE COUNCIL

PHOTO: HELP-O

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DISCLAIMER

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Chathura Walivitiya

CEO HELP-O / Project Manager CACG Project

TABLE OF CONTENT

LIST OF FIGURES

LIST OF MAPS

LIST OF TABLES

ABBREVIATIONS

HELP-O	Human and Environment Links Progressive Organization
GMC	Galle Municipal Council
CACG	Collaborative Action for Clean City of Galle
CCBO	Clean Cities, Blue Ocean
MSW	Municipal Solid Waste
SWM	Solid Waste Management
ISWMAP	Integrated Solid Waste Management Action Plan
PET	Polyethylene terephthalate
HDPE	High-density polyethylene
PP	Polypropylene
LDPE	Low-density polyethylene
PVC	Polyvinyl chloride
PS	Polystyrene
WACS	Waste Audit and Characterization Study
USAID	United States Agency for International Development
HH	Household

EXECUTIVE SUMMARY

"Collaborative Action for Clean City of Galle" is a project implemented in the City of Galle by HELP-O (Human and Environment Links Progressive Organization) in collaboration with the Galle Municipal Council (GMC) for an efficient Solid Waste Management (SWM) system in the city via reducing the generation of plastic waste and promoting a city-wide waste management system. USAID (United States Agency for International Development), Clean Cities, Blue Ocean (CCBO) flagship programme implemented by Tetra Tech, provides the financial and technical support for the said project.

The Waste Audit and Characterization Study (WACS) is a key step towards the development of the Integrated Solid Waste Management Action Plan (ISWMAP), one of the key deliverables under the project. Under the WACS, waste generation and collection pattern of the GMC area was analyzed. This study covered entire GMC area, including Mahamodara Zone, Richmond Hill Zone, Karapitiya Zone, Moragoda Zone, and Galle Bazar Zone. The key objectives of this study were to identify the composition of different types of municipal solid waste by sector, particularly focusing on the plastic waste, create a database of different types of municipal solid waste for the use of the GMC and other stakeholders for future SWM-related decision making and gather SWM data required for the preparation of the ISWMAP for the GMC.

The ASTM Standard Test Method and Rothenberg method were used as the key guides to develop the methodology of the Galle WACS. In addition, several other WACS toolkits and literature were used in finetuning the methodology. Sample selection was done in a scientific manner by paying attention to both population size and geographical distribution of units of the key sectors considered under the WACS. Accordingly, 101 households, 70 commercial units, 50 industries and 30 service units were selected for the WACS from all five Municipal Solid Waste Management Zones in the GMC area.

A comprehensive training sessions and awareness programs were conducted prior to the commencement of the WACS. Appropriate Health and Safety Protocols to be followed during the WACS were included in these training and awareness sessions. The first stage of the WACS was started on 23rd January 2023 and continued until 31st January over a period of eight days. During the first stage, waste generation quantities, composition of the generated waste, volume and density of the waste were measured. 05 GMC supervisors, 10 University Students and 09 laborers were engaged in the first stage. The second stage of the WACS continued from 1st March to 7th March for eight days. Weighing of the GMC waste collection vehicle fleet was carried out during the second stage by a reputed third-party contractor. 02 University Students and 02 GMC supervisors were engaged in the second stage. The findings of both stages of the WACS helped the CACG project team to calculate daily wet and dry waste generation and collection with a more emphasis on the plastic waste and come to important conclusions regarding municipal solid waste generation and collection that will be helpful in developing the ISWMAP in the next stage of the project.

CHAPTER 1

PHOTO: HELP-O

INTRODUCTION

The Waste Audit and Characterization Study (WACS) is a required deliverable milestone under the "Collaborative Action for Clean City of Galle" project (CACG), which is undertaken by the HELP-O (Human and Environment Links Progressive Organization) in collaboration with the Galle Municipal Council (GMC) under a grant from the USAID Program Clean Cities, Blue Ocean (CCBO) managed by TetraTech. The Waste Audit was conducted to understand the composition (wet and dry portions) of Municipal Solid Waste (MSW) collection of the GMC as well as the quantity of daily MSW being collected by the GMC. Thus, the audit consists of two main components as (1) Waste Characterization Study and (2) Waste Quantification Study.

The Waste Characterization Study measured and recorded the compositional data of city-wide MSW generated and collected by GMC in residential, commercial, industrial, and institutional sectors. The Waste Quantification Study is the survey to measure and record the quantity (by weight) of the city-wide MSW collection by the GMC vehicle fleet for each waste collection route in each of the five (05) MSW management zones of the GMC. The planned overall time span of the WACS was sixteen (16) days, which was divided in to two parts as first eight (08) days for the Compositional Analysis of the GMC waste collection and next eight (08) days for the Waste Quantification Study of GMC waste collection.

The WACS was planned with the CCBO technical guidance and was designed within the framework of, the internationally recognized standards and methodologies.

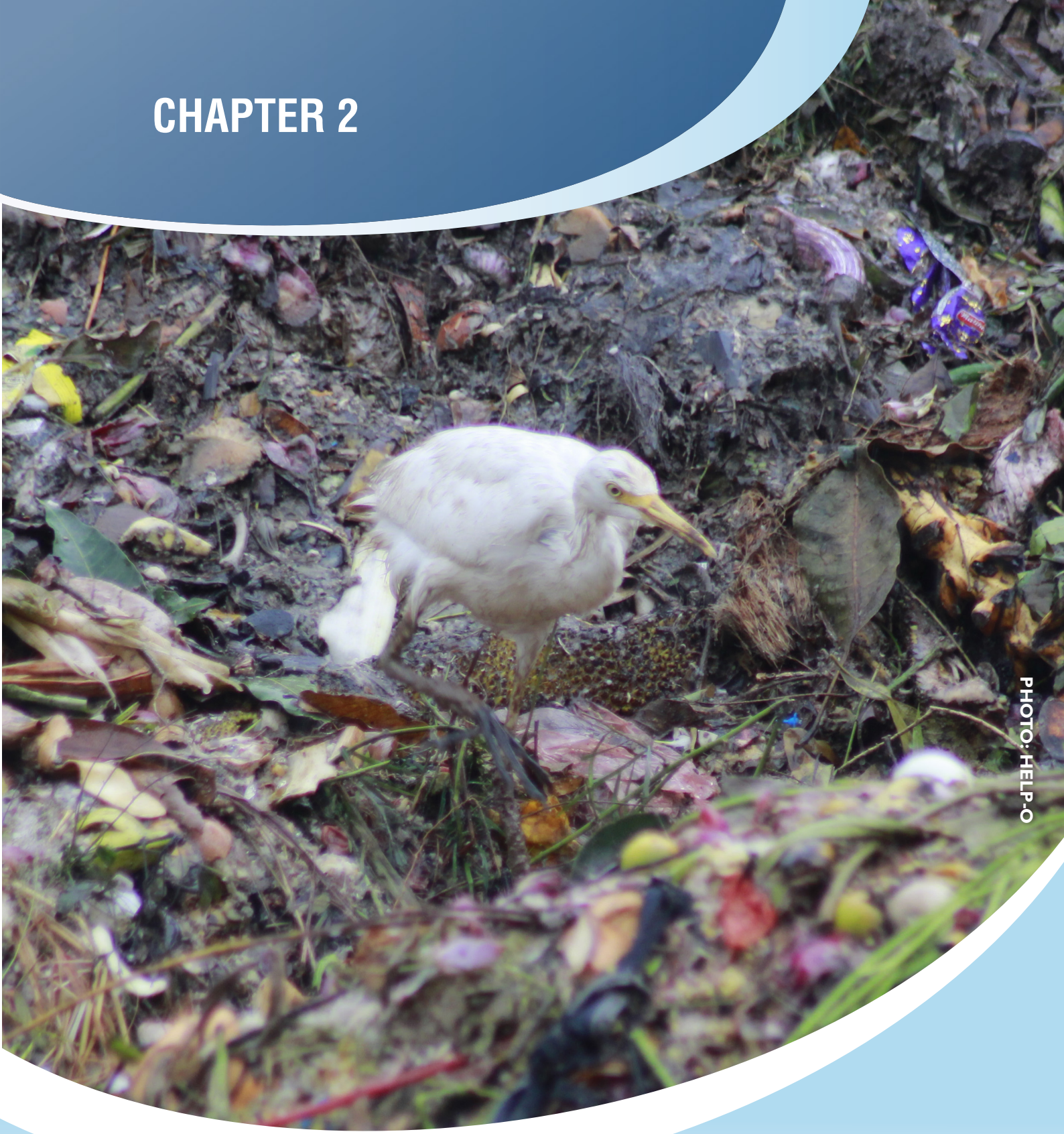
The audit was commenced with a comprehensive training session conducted by the Solid Waste Specialist, followed by a detail planning process to understand the methodology and then to train the waste audit team. The audit team consisted of the CACG Project team, selected GMC staff and HELP-O staff and select 10 University graduates. Simultaneously, a comprehensive coordination effort was established with the key Solid Waste Management (SWM) staff of the GMC. In addition, a comprehensive awareness campaign with a site identification scheme was undertaken for the selected city-wide MSW generators representing all key sectors (residential and commercial) as part of the planning process in advance of commissioning the audit.

A reputed third-party agency (LIYOCHE Weighing Machines Pvt. Ltd) was selected as the sub-contractor for measuring and recording the weight of selected GMC waste collection vehicles under the part two of the audit. They provided the portable weigh bridge at Heenpandala waste yard, and their staff did all the weighing in the presence of the CACG project team.

The entire audit consists of a well-planned data collection, recording, validation, and continuous monitoring mechanism with the participation of CACG project team, including consultants, as well as the guidance and physical participation of the CCBO experts. Further details of the methodology adopted in the waste audit are elaborated below.

The audit findings in this report are important in decision making in relation to enhance the efficiency of current MSW management scheme in the GMC as well as for developing and sustainably implementing an Integrated Solid Waste Management Action Plan (ISWMAP) in the GMC as part of the CACG project with this ongoing CCBO-USAID intervention.

CHAPTER 2



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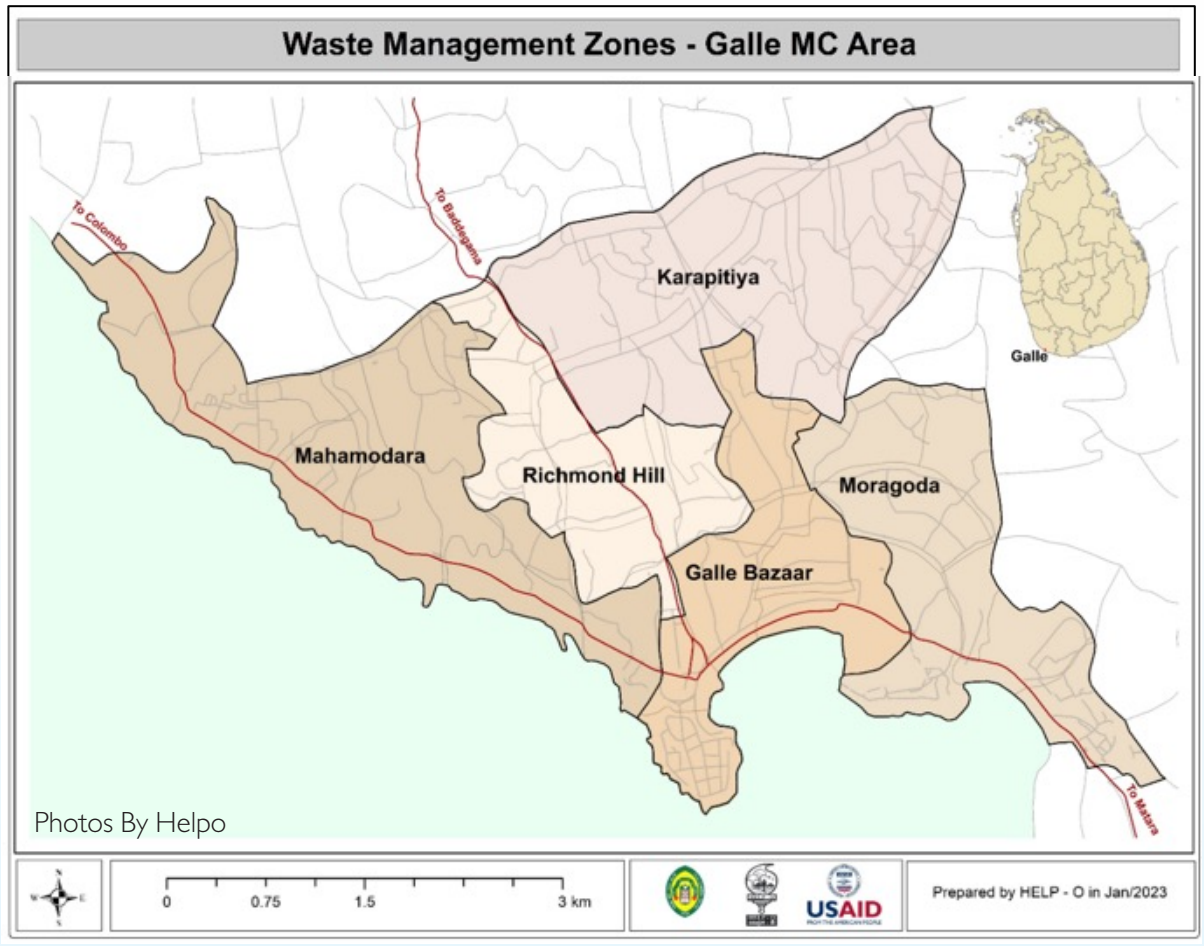
SCOPE AND OBJECTIVES OF THE WASTE AUDIT

2.1. Scope of the Waste Audit

The Waste Audit was conducted covering the entire GMC area, including Karapitiya, Mahamodara, Moragoda, Galle Bazaar, and Richmond Hill Municipal Waste Management Zones. These zones have been identified internally by the GMC for the convenience of administering the SWM process. The map below illustrates the locations of these Waste Management Zones.



Map 1: The focused area of the audit with five internally defined MSW management zones

In addition to other types of solid waste and recyclables generated, the Waste Audit focused on assessing the quantity of plastic waste generated in the city to improve the recycling rate and reduce plastic entering water bodies and eventually the ocean.

All residential, commercial, industrial, and service sectors were covered in the proposed Waste Audit. A fair representative samples were taken so that the Waste Audit could be based on a statistically representative sample of the existing number of establishments under each sector. In addition to the usual non-degradable waste generators under the above sectors, such as residences, small businesses, supermarkets, daily marketplaces, small industries, and so forth, specific attention was given to generators from the Waste Hotspots identified under the assessment survey such as low-income high-density settlements, tourist areas, communities where specific industries are being carried out, such as China Garden residential area, for the Waste Audit by making sure that a reasonable number of establishments from these hotspots were included in the samples.

2.2. Objectives

The objectives of conducting the Waste Audit include the following.

1. To identify the composition of the different types of municipal solid waste by sector in GMC area, particularly focusing on the plastic waste generation and collection
2. To create a database of different types of municipal solid waste for the use of the GMC and other stakeholders for future SWM-related decision making
3. To gather waste data required for the preparation of the ISWMAP for GMC under the CACG project.

CHAPTER 3

PHOTO: HELP-O

METHODOLOGY

3.1. Conceptualizing the Waste Audit Process

As part of the Waste Audit process and before planning the ground activities, a literature review was undertaken to understand the current methods and practices related to the waste categorization and quantification. Accordingly, two of the key methods studied and modified for the Waste Audit were the ASTM Standard Method and the Rothenberger Methods. In addition, a few more related studies, handbooks, and toolkits were reviewed to further strengthen the methodology adopted in this Waste Audit conducted in Galle (BOMA, n.a.; Danielle Ralph, n.a.; Prif Coordination Office, n. a.; ASTM International, n. a.)

As per the literature, a Waste Audit is "collecting, sorting and categorizing waste in order to obtain a statistical picture of the quantities of waste generated at a particular site along with their methods of disposal" (BOMA, n.a., p4). The main requirement in a waste audit is "one-week survey of a sufficient number of households randomly selected in the community" (Rothenberge et al, 2006).

Based on the literature review and conceptualization, the following flow chart (Figure 1) was developed to illustrates the step-by-step process that was followed in planning and conducting the Waste Audit in GMC area. This was developed by taking not only the Standard and Rotenberg methods but also other related studies, into consideration.

Figure 1: Step by step process developed for the Waste Audit in GMC Area

3.2. Preparation for the Waste Audit

The Waste Audit being an activity involving multiple stakeholders covering waste generators, the GMC waste collectors, CACG project team, externally contacted manpower (e.g. University graduates), and subcontracted agencies, well-planned preparation was the key to the success of the program. Therefore, the following key preparatory steps were adopted well in advance of the Waste Audit in Galle with consistent guidance of the CCBO.

- **Development of the Inspectional Waste Audit Plan**

The Inspectional Waste Audit Plan with a road map of key events was developed by the CACG team on 09th January 2023 and shared it with the CCBO technical advisors for comments. The plan was reviewed through a virtual session and finalized the road map. Annex 1 shows the timeline of activities planned to be implemented under the WACS.

- **Selection of the Samples for the Waste Audit**

Due to the limited resources and time constraints, CACG team decided to go for a manageable sample size for the purpose of the Waste Audit. However, the selection of the sample size and distribution of the sample was decided per statistical procedures.

As per the 'Central Limit Theorem' which has been widely used in statistical studies, the distribution of a sample variable approximates a normal distribution as the sample size becomes larger, assuming that all samples are identical in size, and regardless of the population's actual distribution shape. The same theory

suggests that a sample size of thirty (30) often increases the confidence interval of a population data set enough to warrant assertions against findings. Therefore, the sample size of thirty (30) is considered a large sample size and it is widely used as a rule of thumb amongst many researchers (Karunarathna, 2012; Turney, 2022).

Taking the above Central Limit Theorem as the basis and considering the size of the total sector-wise population, CACG team decided to go with the following sample sizes for the Waste Audit.

Table 1: Samples selected from key sectors for the Waste Audit

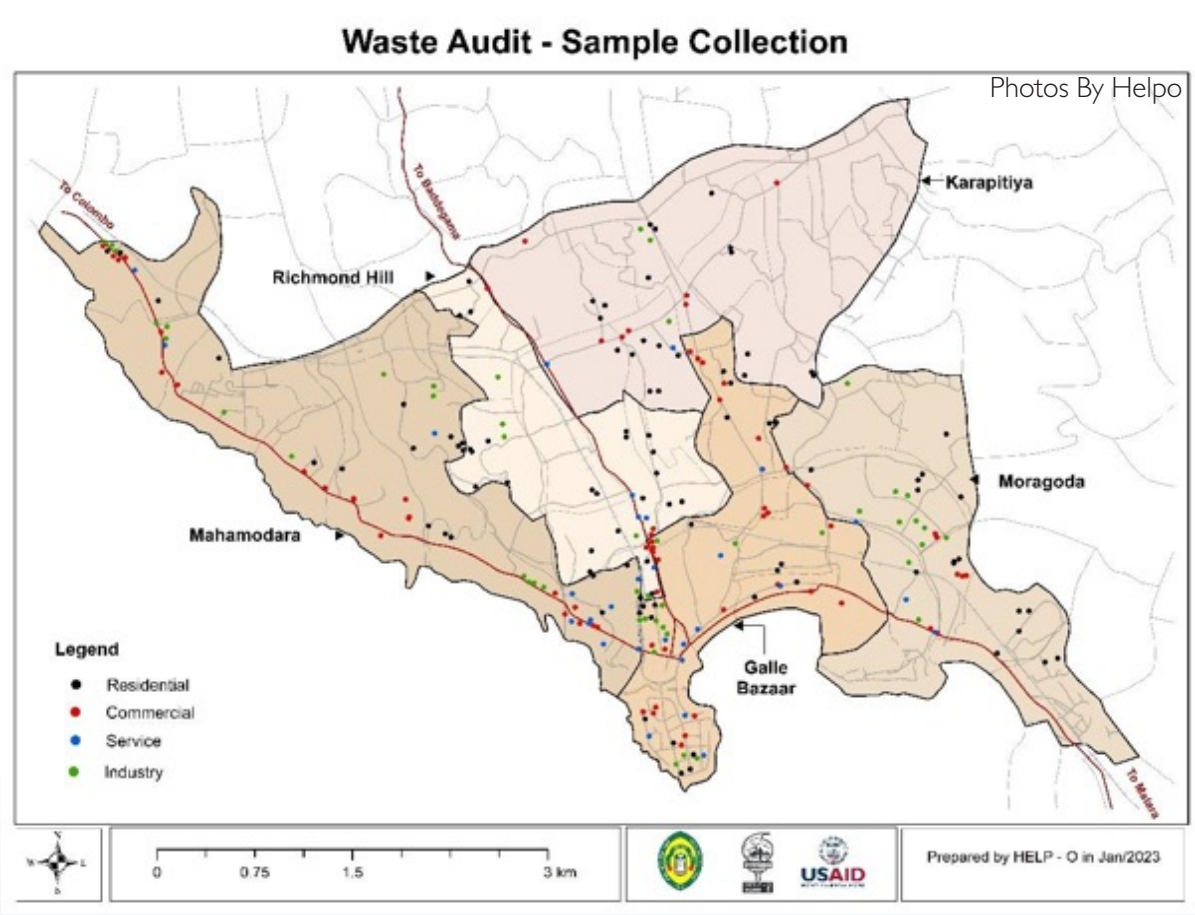
Sector	Total Population	Sample Size selected for the Waste Audit
Residential (Households)	21,291	101
Commercial (Small, medium, and large)	3,440	70
Industrial (Small, medium, and large)	942	50
Service	646	30
Total sample size		251

A total of 251 establishments under each residential, commercial, industrial, and service sector were identified from the locations distributed over the GMC area, representing the five MSW management zones as shown in Table 3 and Map 2 below.

Table 2: Samples selected from each Waste Management Zone

Zone	Residential	Commercial	Industrial	Service
Mahamodara Zone	20	19	10	8
Galle Bazar	20	21	20	12
Moragoda	20	14	12	5
Karapitiya	21	6	5	2
Richmond Hill	20	10	4	3
Total	101	70	50	30

The map below shows the distribution of the samples selected under each sector from all five (05) MSW management zones. A fair spatial distribution was ensured when identifying the samples.



Map 2: Distribution of the identified samples in the GMC area

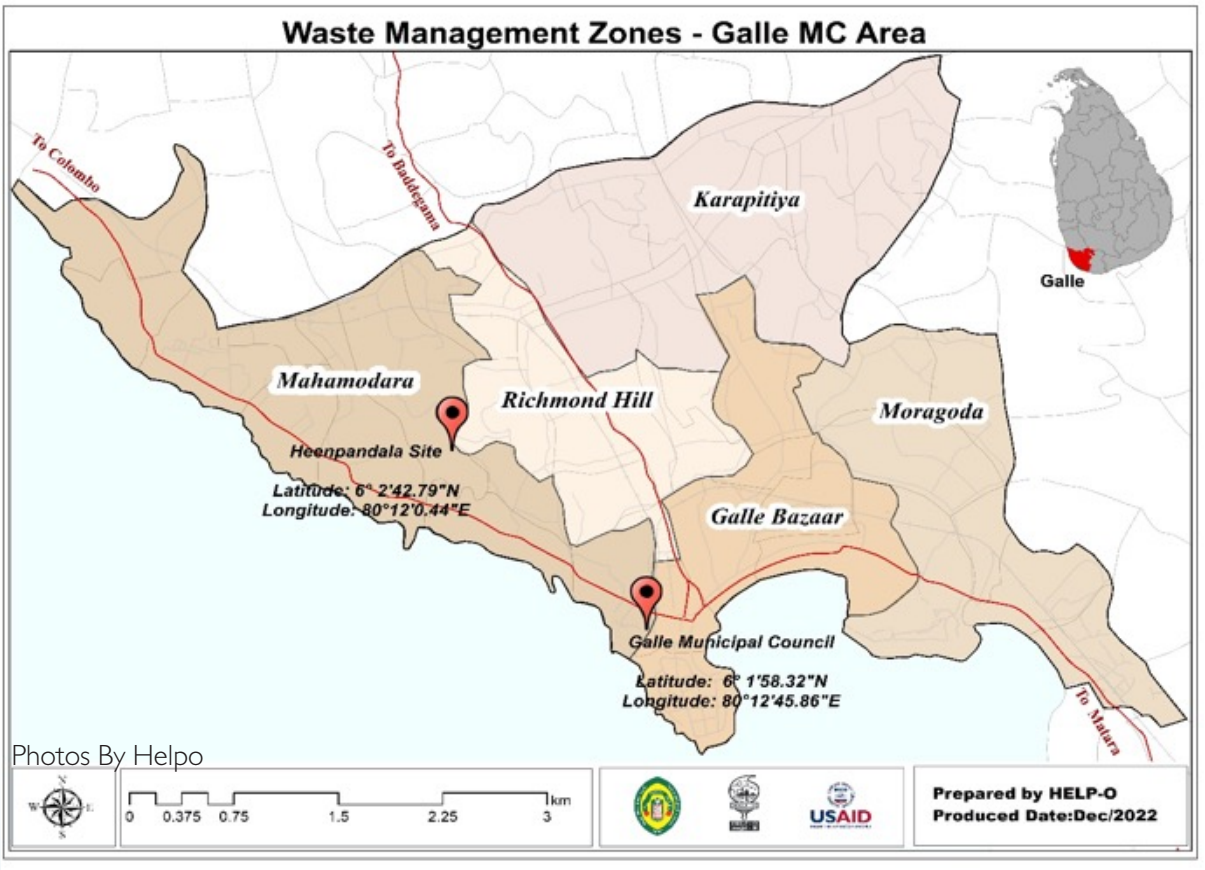
• Selection of the Site for the Waste Audit

In consultation with the GMC, an adequate space at the Heenpendala Waste Transfer and Disposal Site (Heenpandala) owned by the GMC was selected as the waste sorting and weighing area under the Waste Audit.

This location was selected by considering the following key factors;

- Availability of adequate and suitable space for the activities of waste audit including vehicle maneuvering, waste stacking, segregation and ensuring the standard final disposal,
- Convenience of access by the MSW collection vehicle fleet of the GMC.

Heenpandala, which is in Mahamodara zone is shown in the Map 3 below.



Map 3: Heenpandala Waste Transition and Disposal Site

As it was clear that the available CACG project team and GMC-SWM staff alone would not be able to carry out the activities of the audit, it was therefore planned to recruit manpower of suitable capacity externally. With several university graduates, it was decided to engage several staff from the GMC, who were also familiar with the GMC area, to conduct the waste audit. Accordingly, an interview was conducted and a team of Ten (10) university students were selected. Similarly, a team of five (05) Supervisors, including the Supervisor in-charge of the Heenpendala Site and four supervisors in-charge of Waste Management Zones with nine (09) SWM Laborers from the GMC were selected for the Waste Audit as supportive staff.

Special attention was paid for the segregation of plastic waste in the dry component of MSW collection into the standard seven (07) of recyclable plastics fall under the categories of HDPE, PET, PP, LDPE, PVC, PS and Other during the waste characterization. Therefore, the need to provide training to the team members for accurate segregation of plastic waste was recognized from the start. Accordingly, a Solid Waste Management expert (P. L. Loyd, Plastic Waste Specialist) having practical experience in doing the proper segregation and training as well over decades was also hired at the beginning to train the Waste Audit team.

Weight information is key to tracking the amount of waste collected. Monitoring inputs and outputs during materials recovery, extracting energy and disposing of waste is all equally important. Weight data plays a crucial role in all waste management or recycling industries. From tracking the amount of waste collected, to monitoring inputs and outputs during materials recovery, through to extracting energy and disposing of waste, weight information is key to legislative compliance and operational efficiency. Therefore, it was also noticed that the inputs of a competent agency is essential to properly carry out the Weighing of GMC-MSW transporting vehicle fleet. Through a rigorous process, LIYOCHE Weighing Machine (Pvt) Ltd was selected as the sub-contracting party for this task. The weighing bridge was fixed at the Heenpendala site

the entire duration and had the ability to transfer weighing measurements directly to the computer data sheet used by the company.

- Training the Waste Audit team
- Preliminary Awareness and Training for the Waste Audit Team

The need of providing an intensive training program was recognized since the waste audit was a new activity to both the planning and implementing personnel, including the CACG team. Thus, a training program was organized by HELP-O with the technical support of CCBO Solid Waste Specialist. The program was conducted on 4th January 2023 at a local venue, with participation of GMC, CACG and the externally recruited team as a one-day training session. The training covered management (planning, preparation, staffing, resource supply and inter institutional coordination etc.) and technical (means of theoretical applications to conduct waste audit to internationally accepted standards) aspects essential to be incorporated in the planning and implementation of the audit. The CCBO Solid Waste Specialist, U.G. Ekanayaka, and the Capacity Development and Governance, Shan Rajah were the key resource personnel for the session.

Followed by the training workshop, the "Waste Audit Plan" of the CACG was duly updated to comprehensively indicate overall process including resource, funding, manpower and time management aspects, enabling to organize the rest of the activities based on the plan.

Figure 2: Training session on waste audit at Hotel Hasara, Galle on 04.01.2023

• Special training on plastic waste segregation

A special training was conducted for the waste audit team (consisting of University and GMC personnel) on 23rd January 2023 at the Heenpendala waste audit site by a nationally reputed subject expert (P. L. Loyd) based in Sri Lanka. The training, which was a demonstration and the trainer supervised actual

segregation event was focused on practical approach of onsite plastic waste segregation to seven plastic types.

Figure 3: Demonstration by the resource person on Waste Segregation

• Supply of Supplementary Material for the Waste Audit

Following material were identified as essential to conduct the waste audit accurately, effectively and efficiently.

- Waste collection source identification signs (stickers with category name and number),
- Waste collection bags (of suitable material and dimensions),
- Data recording formats (to accurately & easily keep on time records at the site),
- Data/ process monitoring and verification system, waste collection and segregation equipment.
- Vehicle for waste collection and Personal protection equipment for the waste audit team.

Figure 4: The Waste Audit team is preparing the material for the Waste Audit at HELP-O office

• Awareness Program for the Selected Waste Collection Sources

Figure 5: Awareness program for the waste collection sources

A comprehensive awareness program was conducted to educate the sources of selected sample units under the waste audit. They were educated on why and how the audit was planned to be conducted with their role in correct filling of designated bag in house with value of their role, during the planned eight (08) consecutive days. The awareness was undertaken over two (02) days with the participation of nine (09) GMC staff members (Community Development Officers engaging in SWM work), Ten (10) university personnel and CACG project staff.

Specifically prepared Leaflets (see Annex 1) together with coded poly-sack bags for large scale waste generators and generic waste bags small scale generators (putting segregated Dry and Wet waste) were given to the owners of the selected sources.

The selection sample location was coded with numbered stickers to identify it easily within the waste collection process for both the waste audit team and GMC waste collector. A systematic coding method was followed for coding waste bags and stickers to easily identify the correct sample units in the waste audit process.

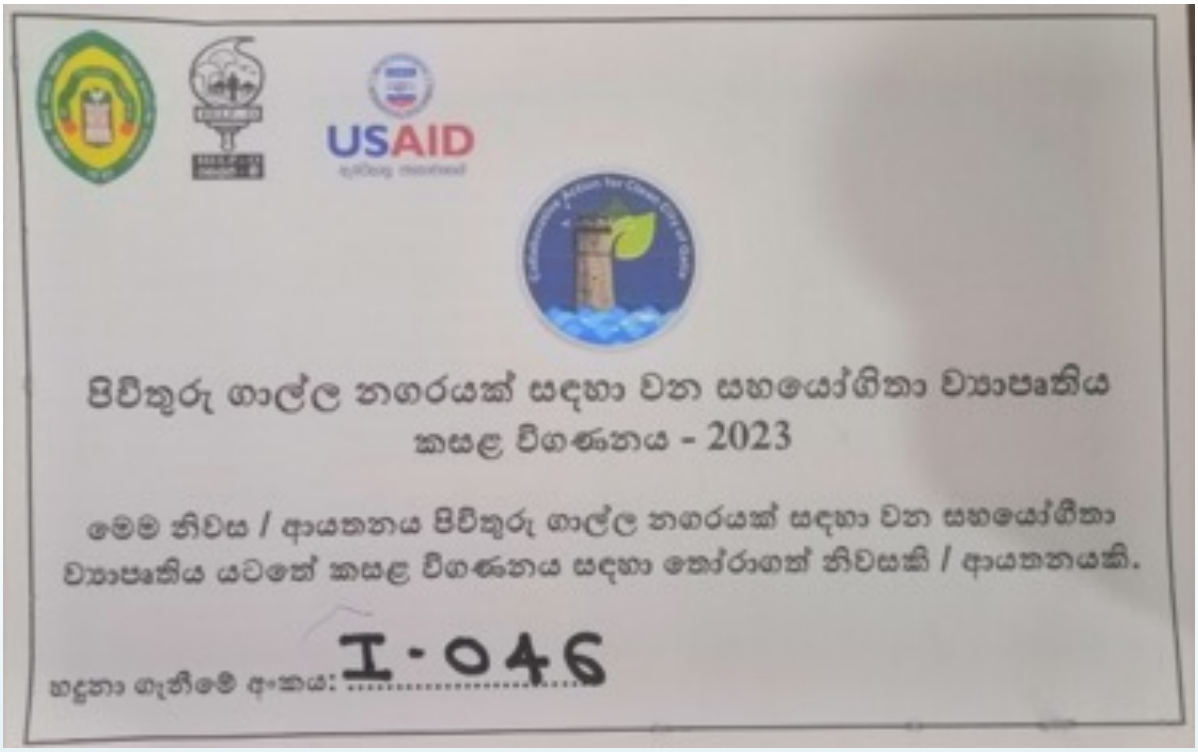


Figure 6:Picture of coded sticker

The numbers of the stickers were designed in selecting and distributing the samples as follows.

- Residential (Household) sector – H01 to H101
- Commercial sector – C01 to C70
- Industrial sector – I01 to I50
- Service sector – S01 to S30

Although theoretically, waste segregation is not encouraged in an audit, it was decided to collect wastes in to two (02) categories as "Wet" and "Dry" as this has been the standard practice by the residents and business in GMC over last three years. The findings of City-Wide Waste Assessment conducted from November 2022 to February 2023 also indicates that this source segregation is well followed by waste generators across all the sectors. The "Wet" component consists of degradable wastes covering, kitchen waste, food waste, and garden waste while the "Dray" component consist of all others like plastic, polythene, PET bottles, PVC, Metal, Glass, Paper, Cardboard, and others such as diapers, shoes, electronics, etc.

3.3. Implementation of the Waste Audit

The two key components of the waste audit are the "Waste Characterization Study" and the "Waste Quantification Study". The process involved in implementing these two components is described below.

3.3.1. Waste Characterization Study

This task being the first stage of the waste audit was to measure the waste generation of GMC. This was conducted over a period of consecutive eight (08) days from the date of commissioning the program on 23rd January 2023. The details of the sequential steps followed are as follows.

• Waste Collection and Transportation up to the Heenpandala

Four vehicles were deployed to collect waste bags from the sample locations and four university students, four laborers, and drivers were engaged for the process. The initially planned route covering five waste management zones (Galle bazaar, Richmond Hill, Mahamodara, Moragoda, and Karapitiya), of each waste collection vehicle was reviewed at the end of Day 1 to optimize the collection efficiency and continued for the following seven (07) days with minor changes to further improve collection efficiency as and when required. After optimizing, three (03) vehicles were deployed to collect waste from five (05) zones from residential, industrial, and service sectors while one vehicle was deployed to collect waste from the commercial sector (which were noticed to be accessible after 9.00 A.M in general).

The coded two waste collecting bags were delivered to the sources during the awareness session of sources for Dry and Wet Waste. Each day, after collected two samples, empty numbered two bags were given to the sources.

The team led by the University graduates, visited each waste collection source, and handed over the designated bags for the following day, very briefly discuss to inform or understand any concerns in process, mark the data sheet which used to record the waste bags (seen annexure 02) and collect the filled bag (with the support of GMC worker) and deliver to Heenpandala site for follow up actions. The waste collection process took about six hours (from 6.00 A. M. to 12.00 Noon) each day. Measuring and sorting process was started afterwards.

Figure 7: Waste Collection and Transportation by Waste Audit Team

• Waste Unloading from the Vehicle and Stacking at Heenpendala

After transported the collected dry and wet waste bags from each source safely unloaded by the GMC worker assign to the Vehicle under the supervision of university graduates. Simultaneously, two (02) University personnel on the site observed and marked on the data sheet the due receipt of unloaded bags. The bags were then stacked on the queue in order of the delivery to the location.

A simultaneous verification process was in place to ensure that the samples are received from each designated source by cross checking the designated sample location numbers within the respective zone covered by the vehicle that delivered the bags. When an issue like absence of bags from a sample was noted, the WACS team members in charge at Heenpendala (CACG staff member and the university personnel) discussed with the team member of the respective Vehicle to resolve the issue.

Figure 8: Waste Bags Unloading

• Weighing unloaded waste bags

The bags on the queue were then weight using the electronic scale (Figure 09) by two team members (one to keep on the scale while other read out the weight) and the weight was recorded on respective data sheet (Annex 03) by the designated member for the respective sector. Simultaneously, all the records were entered into the excel sheet according to the numbers assigned to each sample unit. This recorded the Wet and Dry weight of waste by each sector.

Figure 9: Weighing of unloaded waste bags

• Mixing and Measuring Volume of Waste

This process was followed separately for both the Wet and Dry wastes.

Example: Process of measuring the volume of 'wet' portion of the wastes

First the designated location at the site was prepared by laying the polythene sheet on the floor and then the "wet waste" collected from all the sectors were disposed on the tarpaulin sheet. Then the heap of wet waste was mixed well by assigned workers with the support of other team members to get a homogenous mixture of the wet waste collection of the day as shown in Figure 09 above. Simultaneously the dry waste materials that were mistakenly added to the wet waste (e.g. plastic, metal, etc.) were also removed. Loads were contaminated with a negligible amount of dry materials.

Figure 10: Mixing of waste collection of the day

As per the standard approach to measure the volume, it was planned to prepare a collection of 50 kg of waste portion and to measure the volume of the same. The following steps were followed to get a homogeneous wet waste mixture of 50 kg.

The well mixed, flattened waste heap was divided into four (04) quadrants and then the two (2) of the crossing quadrants were removed and the other two were mixed again and measured the weight. If the weight was 50 kg it was used for the volume measurements. If weight exceeded 50 kg, the same process was repeated until a portion of 50 Kg of waste is separated from the total collection as shown in Figure 11.

Figure 11: Mixing the waste and getting 50kg portion by separating wet waste into quadrants

Example:

Total weight of the received waste - 400 kg
First separation into quadrants - 400 /4 = 100 kg
Second separation into quadrants by taking the crossing quadrants - 100/4 = 25 kg
Mix crossing quadrants to get 50 kg as the final portion for measuring the volume

- **Measuring of Waste Volume**

To measure the waste volume, three (3) wooden containers of 50cm x 50cm x 50cm were made as shown in Figure 12.

Figure 12: Wooden Box for taking the volume of the waste

The weighted portion of 50 Kg of wet waste was loosely put into the box and the volume is recorded on the respective data sheet.

The similar procedure was followed in all seven (7) days, except the day 1, to record the daily volume of the wet portion of the waste.

• Calculating the Waste Density

After completing the above-mentioned steps, the density of the wet waste was calculated using the below equation.

$$\text{Density} = \frac{\text{(Weight (50kg))}}{\text{(Volume (m3))}}$$

Note: The same sequential steps discussed above were repeated to measure the volume and to calculate the density of the dry waste taking the dry waste collected from the sources.

• Segregation and sorting the 'Dry' Waste into Categories

The measured portion of 50 kg of the dry waste was then manually sorted into the following categories by dispersing on the same tarpaulin sheet by team members and then the weight of each category was measured and recorded on the respective data sheet.

Table 3: Categories considered in sorting the dry waste

No	Waste Category		Description/ examples
1	Biodegradable	Kitchen Waste	Liquid food waste, Fruit and Vegetable Scraps, Spoiled Foods
2		Garden Waste	Grass, Bushes, Plants
3	Recyclables	Paper	White Paper, Cardboards, Cartons, Newspaper, Textbooks, Magazine, Pamphlets, Mixed paper
4		PET	PET bottles
5		HDPE	HDPE plastics, detergent containers, shampoo containers, bottle caps
6		LDPE	LDPE plastics, plastic bags
7		PVC	PVC plastics, water pipes
6		PP	PP plastics (yogurt boxes, straws, spoons, cups)
8		PS	PS plastics (Styrofoam box, plastic coffee cup)
8		Others	Synthetic plastic items, snack packaging, instant noodle
9		Glass	All kinds of glass (except for medicine bottles)
10		Metals	Tin cans, Aluminum cans & Trays, Copper tubes and Wires, Steels
11	Residual	Flexible Plastics	Packaging Papers, Wrappers
12		Leather	Leather Products
13		Rubber	Slippers, Mats
14		Textile	Cloths and Clothes
15		Sanitary Composites	Napkins, Dippers, Soiled Tissue Papers
16		Soiled Paper	Coated Papers, Food contaminated papers
17		Soiled Plastics	Lab
18		others	Asbestos
19	Special Waste	Hazardous waste	Pesticides, WEE, Cleaning Containers, Paint, and Chemical Containers
20		Health care waste	Grouses, Masks, Expired medicine
21		Bulky Waste	Bulky Yard waste
22		e-waste	Computer monitors, Printers, Scanners, Keyboards, Mice
23		Ceramic	Wall and floor tiles, Bricks and Roof tiles, Household ceramics,

The steps followed in dry waste sorting (after measuring the initial weight of delivered dry waste bags) are as follows.

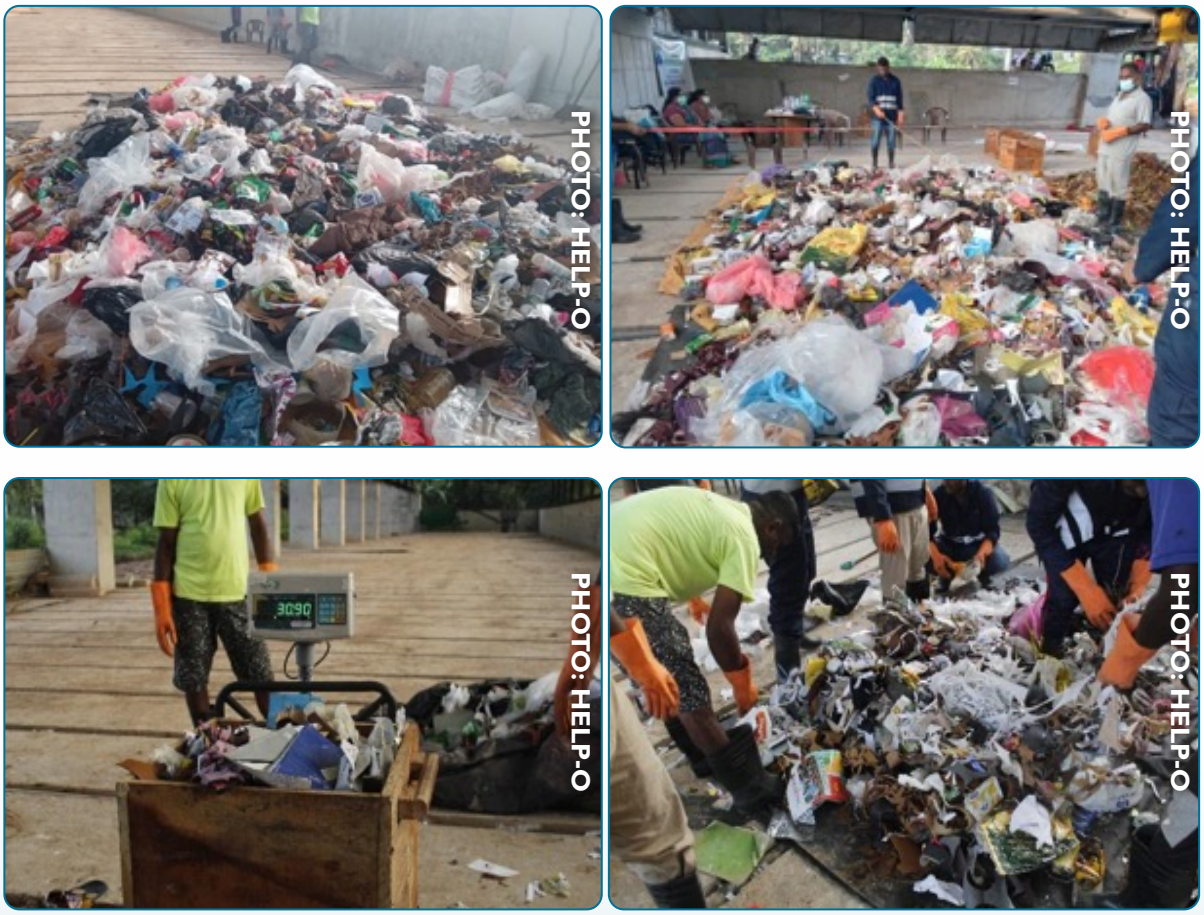


Figure 13: The entire process of dry waste characterization

3.3.2. Waste Quantification Study

As the second stage of the Waste Audit, weighing the daily waste collection fleets of the GMC was conducted at the Heenpandala site. Under this process, the collection vehicle fleet of the GMC were weighted using a vehicle measurement scale and recorded collection details by two university students. A standard data entry format was used to enter measurements. 23 vehicles are used in the waste collection of the GMC daily. Below were the sequential steps followed in this process.

- **Preparation**

The project team had a discussion with the transport unit and waste management unit of the GMC on this waste collection audit. Coded stickers were attached to the collection vehicles to identify the vehicles. The above activities were done on the first day.

Figure 14: Preparation for the Waste Audit

• Weighing the loaded vehicles

The loaded vehicle was weighed and recorded in the given data entry sheet by university graduates. Also, they recorded the collected waste type in that sheet.

Figure 15: Weighing the loaded vehicles

• Weighing the unloaded vehicles

After measuring the loaded vehicle, the unloaded measurement of the same vehicle was taken. Weight of unloaded vehicles were recorded daily as there could be some changes mainly due to the available quantity of fuel or changes in the trailers and so forth.

Figure 16: Weighing the unloaded vehicle

• Calculating the net weight of the waste

After recording the unloaded weight of vehicles, the net weight of the waste was calculated using the below equation. All the records were entered into an MS Excel database.

Waste Weight = Weight of the Loaded vehicle – Weight of the Unloaded Vehicle

CHAPTER 4

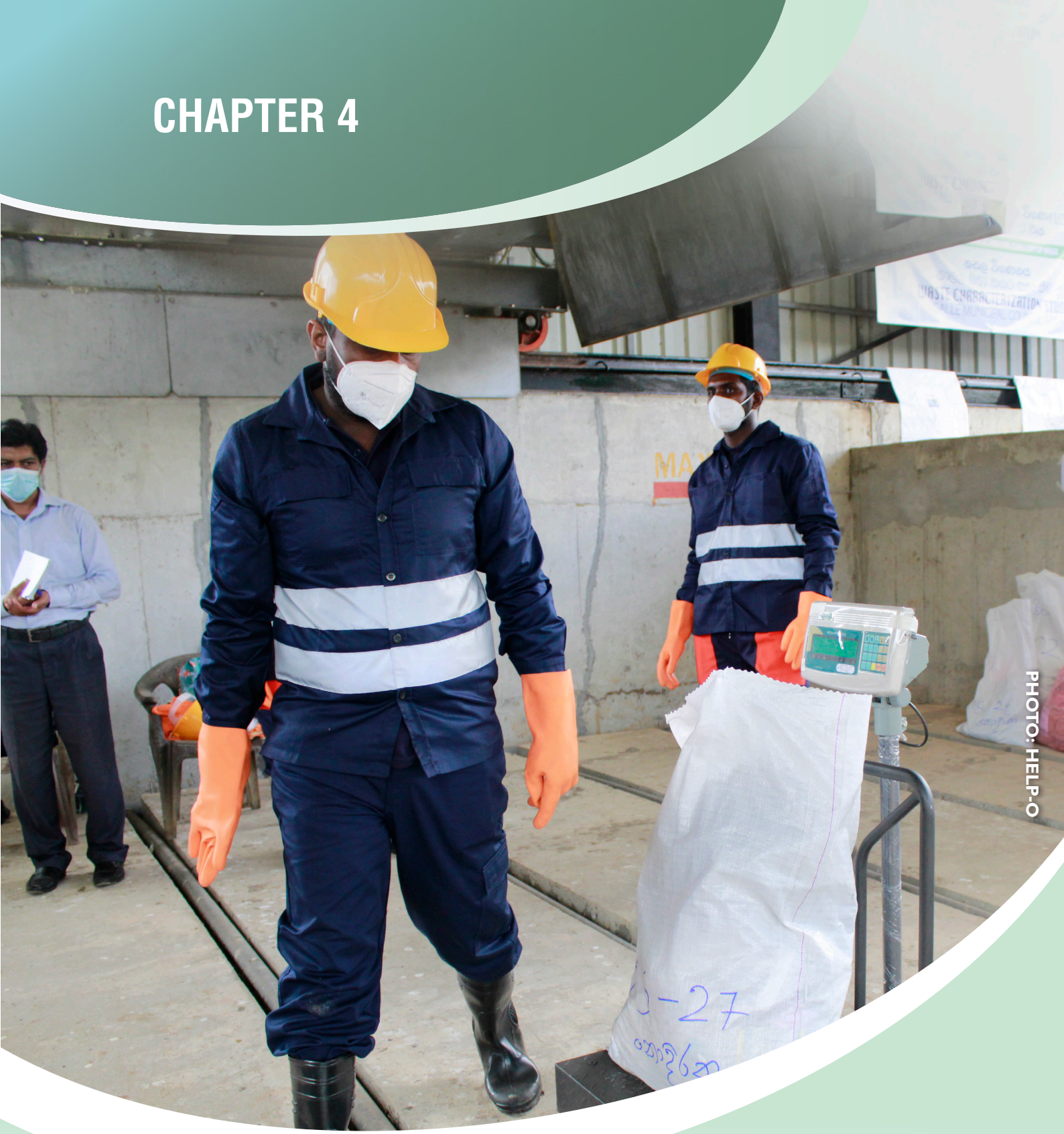


PHOTO: HELP-O

RESULTS AND DISCUSSION: WASTE CHARACTERIZATION STUDY

4.1. Waste Generation of Key Sectors in the GMC Area

In the first stage of the WACS, the WACS team recorded the waste generation of the GMC area using a scientific approach. Accordingly, the amount waste generated by residential, commercial, industrial, and service sectors were measured by taking a sample of 251 units (including 101 houses, 70 commercial units, 50 industrial units, and 30 service sector establishments).

4.1.1. Residential Sector: Key Findings

Figure 16 below illustrates the collected waste quantities within the eight (08) days of the Waste Audit in the residential sector. The GMC collects waste as wet and dry and the same procedure was applied for the Waste Audit.

According to the literature, handbooks and toolkits that provide guidelines for conducting a Waste Audit, the first day of the audit provides space for the audit team to get familiar with the process. Also, since the audit team does not know for how many days the waste has been accumulated, the data collected during the day one will be exempted from calculations (Rothenberger, 2006, pg 26). With that basis, the first day of the Waste Audit in Galle was considered a trial day. Therefore, the collection of waste was comparatively lower in the first day. It can be observed a regular waste collection pattern from the second day onwards.

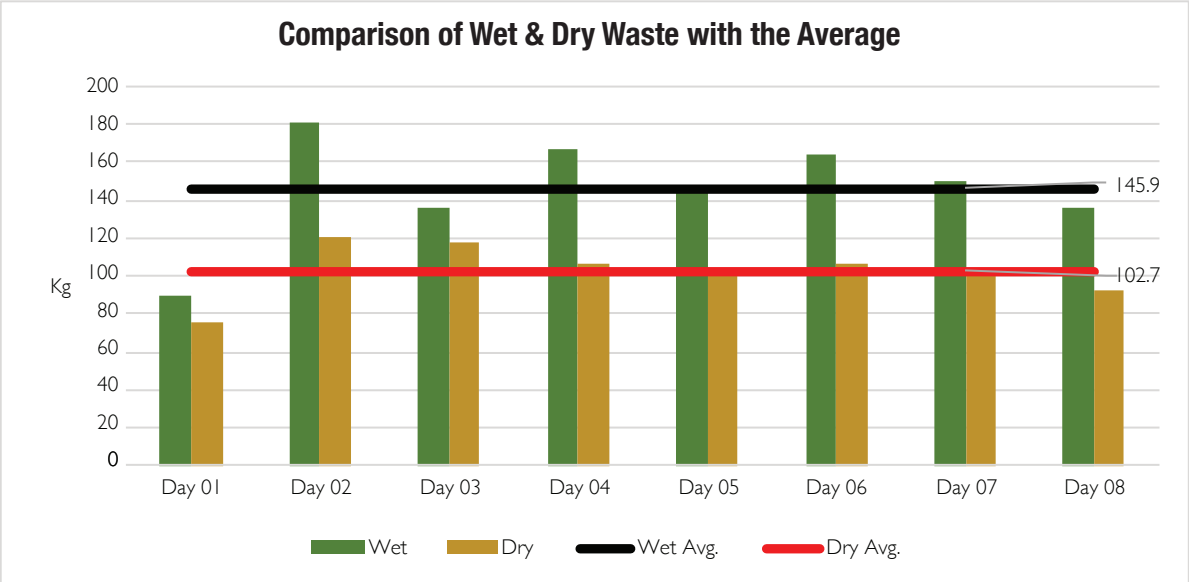


Figure 17: Comparison of the daily wet & dry waste generation with the average: Residential sector

As per the figure, per-day average weight of wet waste collected from the household sample is recorded as 145.9 kg, whereas per-day average weight of dry waste collection is 102.7 kg. Using this information, quantities can be estimated for how much residential waste is generated on a daily basis in the GMC and by each household per day (on average.) According to that data, average wet and dry waste generation can be calculated as follows,

Quantities Generated Per HH per Day

Daily per-HH 'wet' waste generation

= Average weight of wet waste generation sampled from HHs per day / Sample size

= 145.9 kg per day/ 101 HHs

= 1.44 kg/ HH/ day

Daily per-HH 'dry' waste generation

= Average weight of wet waste generation sampled from HHs per day / Sample size

= 102.7 kg per day / 101 HHs

= 1.02 kg/ HH/ day

Total Quantities of HH Waste Generated in GMC per Day

According to the above calculations, average wet waste generation of a unit is 1.44 kg and Average dry waste generation is 1.02 kg. Using the average wet and dry waste generation of a unit, total wet waste generation of GMC area and total dry waste generation in GMC area were calculated.

Daily total of 'wet' HH waste generated in the GMC area

= Kg of wet waste Per-day x Total HHs in GMC

= 1.44 kg/day x 21,291 HH

= 30,659 kg/day of Residential Wet Waste

Daily total of 'dry' HH waste generated in the GMC area

=Kg of dry waste per HH per day x Total HHs in GMC

= 1.02 kg/ day x 21,291HH

= 21,717 kg/day of Residential Dry Waste

Daily total of waste generated in the GMC area

= Total kg of 'wet' waste/day + Total kg of 'dry' waste/day

= 30,659 kg/day + 21,717 kg/day

= 52,376 kg/day of Residential Waste

GMC Residential Waste	Kg/ Household/ Day	Total Kg/ Day
Wet Waste	1.44	30,659
Dry Waste	1.02	21,717
Total Waste	2.46	52,376

4.1.2. Commercial Sector: Key Findings

Figure 18 demonstrates the collected waste quantities from commercial establishments within the 08 days span of the Waste Audit. It can be identified that there is a high waste quantity collected from the second day to the fourth day compared to other days and a gradual decrease from the fifth day to the eighth day. Also, a regular collection can be seen in dry waste compared to the wet waste throughout the audit.

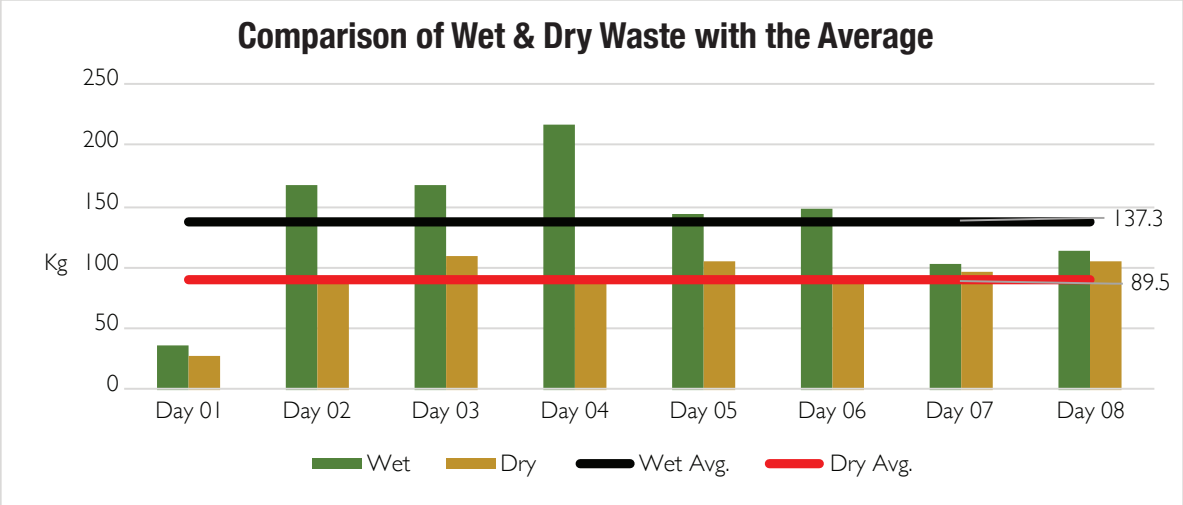


Figure 18: Comparison of the daily wet & dry waste generation with the average: Commercial sector

As per the figure, per-day average of wet waste collection in the commercial sector is recorded as 137.3 kg, whereas per-day average of dry waste collection is recorded as 89.5 kg /day. Using this information, quantities can be estimated for how much waste is generated by commercial units on a daily basis in the GMC and by each commercial unit per day (on average.)

Quantities of Waste Generated Per Commercial Unit per Day

Daily per-unit 'wet' commercial waste generation

=Average weight of commercial wet waste sampled per day / Sample size

= 137.3 kg per day/ 70 commercial units

= 1.96 kg/ commercial unit/ day

Daily per-unit 'dry' Commercial waste generation

= Average weight of Commercial dry waste sampled per day / Sample size

= 89.5 kg per day/ 70 commercial units

= 1.28 kg/ commercial unit/ day

Total Quantities of Commercial Waste Generated in GMC per Day

Daily total of 'wet' Commercial waste generated in the GMC area

= Per-unit Commercial wet waste generation per day x Total no. of units

= 1.96 kg/ per day x 3,440 units

= 6,742 kg/ day

Daily total of 'dry' Commercial waste generated in the GMC area

= Per-unit Commercial dry waste generation per day x Total no. of units

= 1.28 kg/ per day x 3,440 units

= 4,403 kg/ day

Daily total of Commercial waste generated in the GMC area

=Total Commercial 'wet' waste + Total Commercial 'dry' waste

= (6,742 kg + 4,403kg)/ day

= 11,145 Kg/ day Commercial Waste

GMC Commercial Waste	Kg/ Unit/ Day	Total Kg/ Day
Wet Waste	1.96	6,742
Dry Waste	1.28	4,403
Total Waste	3.24	11,145

4.1.3. Industrial Sector: Key Findings

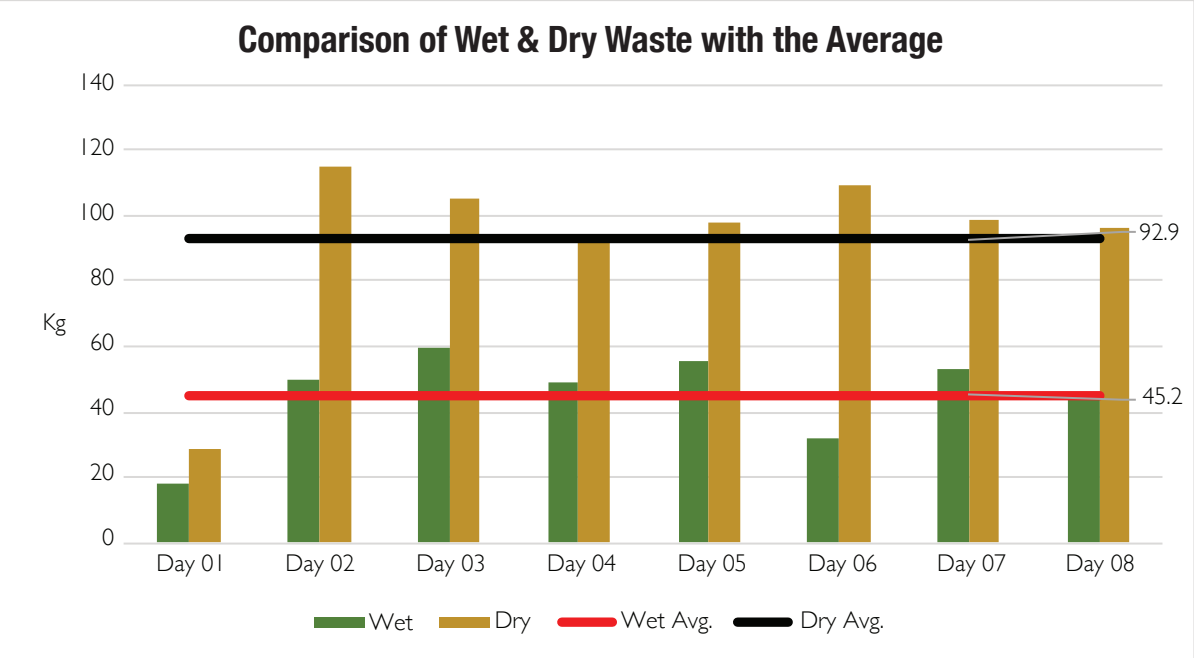


Figure 19: Comparison of the daily wet & dry waste generation with the average: Industrial sector

As in the residential and commercial sectors, Figure 19 above shows a similar variation in the wet and dry waste generation in the industrial sector during the period of waste audit. As per the figure, there is a higher but more or less a regular waste generation from the second day onwards. As per the results of the Waste Audit, per-day average of wet waste collection in the industrial sector is recorded as 45.2 kg, whereas per-day average of dry waste collection is recorded as 92.9 kg/day. Using this information, quantities can be estimated for how much waste is generated by industrial units on a daily basis in the GMC and by each industrial unit per day (on average.)

Quantities Generated Per Industrial Unit per Day

Daily per-unit Industrial 'wet' waste generation

= Average weight of Industrial wet waste sampled per day / Sample size

= 45.2 kg per day/ 50 units

= 0.90 kg/ Industrial Unit/ day

Daily per-unit Industrial 'dry' waste generation

= Average weight of Industrial dry waste sampled per day / Sample size

= 92.9 kg per day/ 50 units

= 1.86 kg/ Industrial Unit/ day

Total Quantities of Industrial Waste Generated in GMC per Day

Daily total of 'wet' Industrial waste generated in the GMC area

= Per-unit Industrial wet waste per day x Total no. of Industrial units

= 0.90 kg per day x 942 units

= 848 kg/ day of Industrial Wet Waste

Daily total of 'dry' Industrial waste generated in the GMC area

= Per-unit Industrial dry waste per day x Total no. of Industrial units

= 1.86 kg per day x 942 units

= 1,752/ day of Industrial Dry Waste

Daily total of Industrial waste generated in the GMC area

= Total 'wet' Industrial waste + Total 'dry' Industrial waste

=(848 kg + 1,752kg)/ day

= 2,600 kg/ day of Industrial Waste

GMC Industrial Waste	Kg/ Unit/ Day	Total Kg/ Day
Wet Waste	.09	848
Dry Waste	1.86	1,752
Total Waste	1.95	2,600

4.1.4. Service Sector: Key Findings

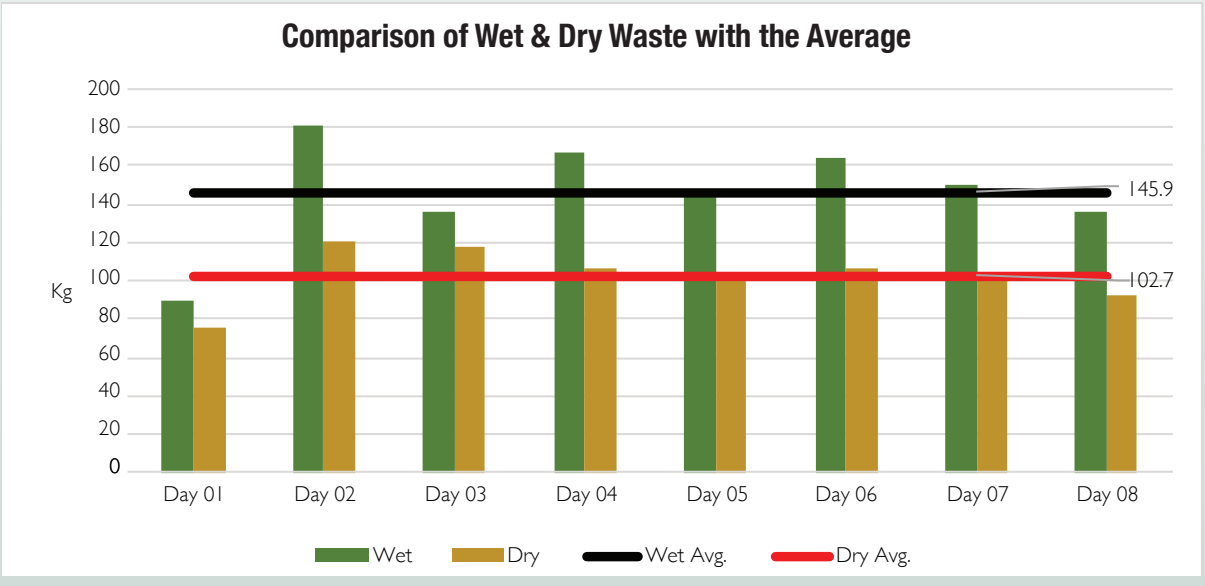


Figure 20: Comparison of the daily wet & dry waste generation with the average: Service sector

Figure 20 below illustrates the wet and dry waste generation in the service sector during the waste audit. As per the analysis, it is possible to observe an irregular pattern of waste generation throughout. However, per-day average of wet waste collection in the service sector is recorded as 61.2 kg/day, whereas per-day average of dry waste collection is recorded as 43.4 kg/day. Using this information, quantities can be estimated for how much waste is generated by service sector units on a daily basis in the GMC and by each service sector unit per day (on average.).

Quantities Generated Per Service Unit per Day

Daily per-unit 'wet' Service waste generation

= Average weight of Service wet waste sampled per day / Sample size

= 61.2 kg per day/ 30 units

= 2.04 kg/ Service Unit/ day

Daily per-unit 'dry' Service waste generation

= Average weight of Service dry waste sampled per day / Sample size

= 43.4 kg per day/ 30 units

= 1.45 kg/ Service Unit/ day

Total Quantities of Service Waste Generated in GMC per Day

Daily total of 'wet' Service waste generated in the GMC area

= Per-unit Service wet waste per day x Total no. of Service units

= 2.04 kg per day x 646 units

= 1,318 kg/ day of Service Wet Waste

Daily total of 'dry' Service waste generated in the GMC area

= Per-unit Service dry waste per day x Total no. of Service units

= 1.45 kg per day x 646 units

= 938 kg/ day of Service Dry Waste

Daily total of Service waste generated in the GMC area

= Total 'wet' Service waste + Total 'dry' Service waste

= (1,318kg + 938kg)/ day

= 2,256 kg/ day of Service Waste

GMC Service Waste	Kg/ Unit/ Day	Day
Wet Waste	2.04	1,318
Dry Waste	1.45	938
Total Waste	3.49	2,256

4.1.5. Total GMC Waste: Key Findings

From the information provided in 4.1.1 - 4.1.4, an estimation of the daily totals of waste generated in the GMC can be calculated.

Daily total of sectoral waste generation in GMC area

= HH + Commercial + Industrial + Service

= 52,376 kg/ Day +11,145 kg/ Day +2,600 kg/ Day +2,256 kg/ Day

= 68,377 kg/ Day (68.34 MT/ Day)

GMC Waste	Kg/ Unit/ Day	Total Kg/ Day
Total Household Waste	2.46	52,376
Total Commercial Waste	3.24	11,145
Total Industrial Waste	1.95	2,600
Total Service Waste	3.49	2,256
Total GMC Waste	11.14	68,377

Based on the above, per capita waste generation in the GMC area can be calculated as below. The population size of the GMC area is taken as 103, 600 (GMC Resource Profile, 2021) for this purpose.

Daily Per Capita Waste Generation = Waste Generation/ Total Population of the GMC Area

= 68,377/ 103,600

= 0.66 kg/ Day

The Waste Audit was conducted in a challenging time where people and businesses were going through many hardships due to high inflation and subsequent increase of cost of living. Accordingly, the above Per Capita Waste Generation (0.66 Kg/ Day) may reflect the reduced waste generation due to the reduced consumption patterns of people and decreased sales and production of goods of commercial and industrial establishments.

4.2. Findings Related to Different Waste Components

4.2.1. Composition of the total waste components

Below figure 21 illustrates the composition of the total waste components considered in the waste audit. Accordingly, 54% of the MSW is wet (biodegradable, e.g. garden waste and kitchen waste) and 27% consists of dry recyclables (e.g. types of Plastic, metal and glass). Residual waste (e.g. leather, textile) and special waste (e.g. hazardous waste, healthcare and bulky waste) compositions are 17% and 2%, respectively.

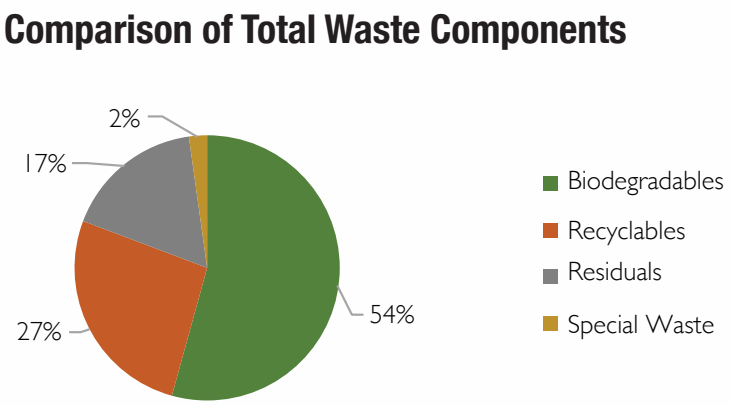


Figure 21:Composition of Total Waste Components

4.2.2. Composition of Biodegradable Waste

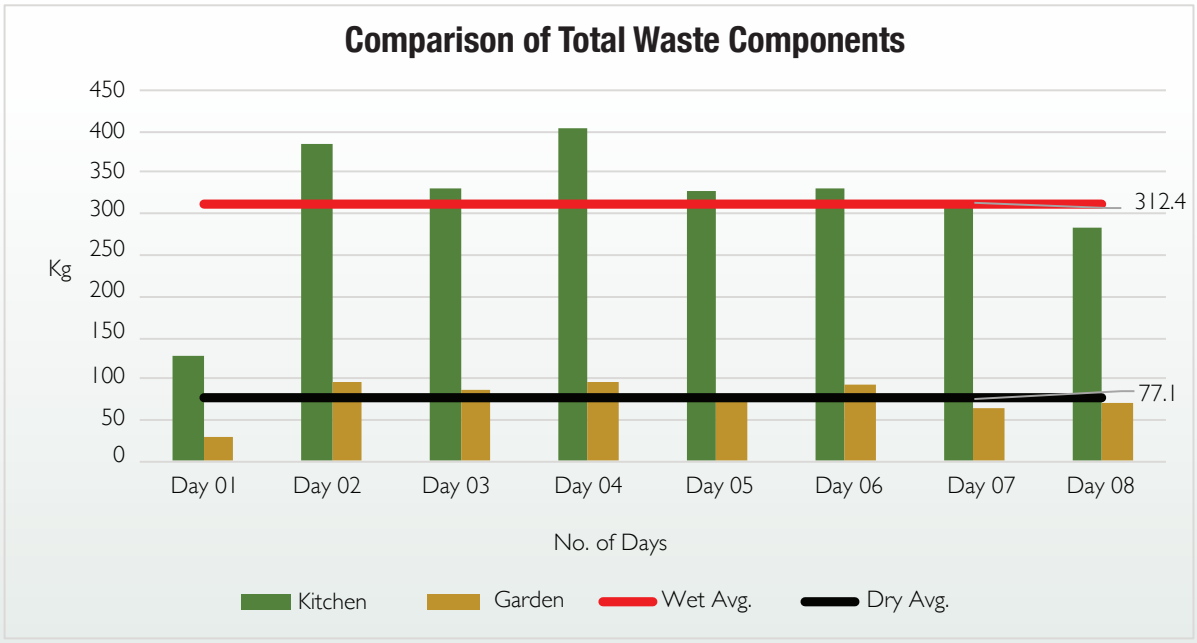


Figure 22: Composition of Biodegradables Waste

Above figure 22 is an illustration of the composition of the biodegradable waste generated by the samples selected from the four (04) key sectors. As per the figure, it is observed that there is a high amount of kitchen waste compared to the garden waste.

4.2.3. Composition of Non-Degradable Waste

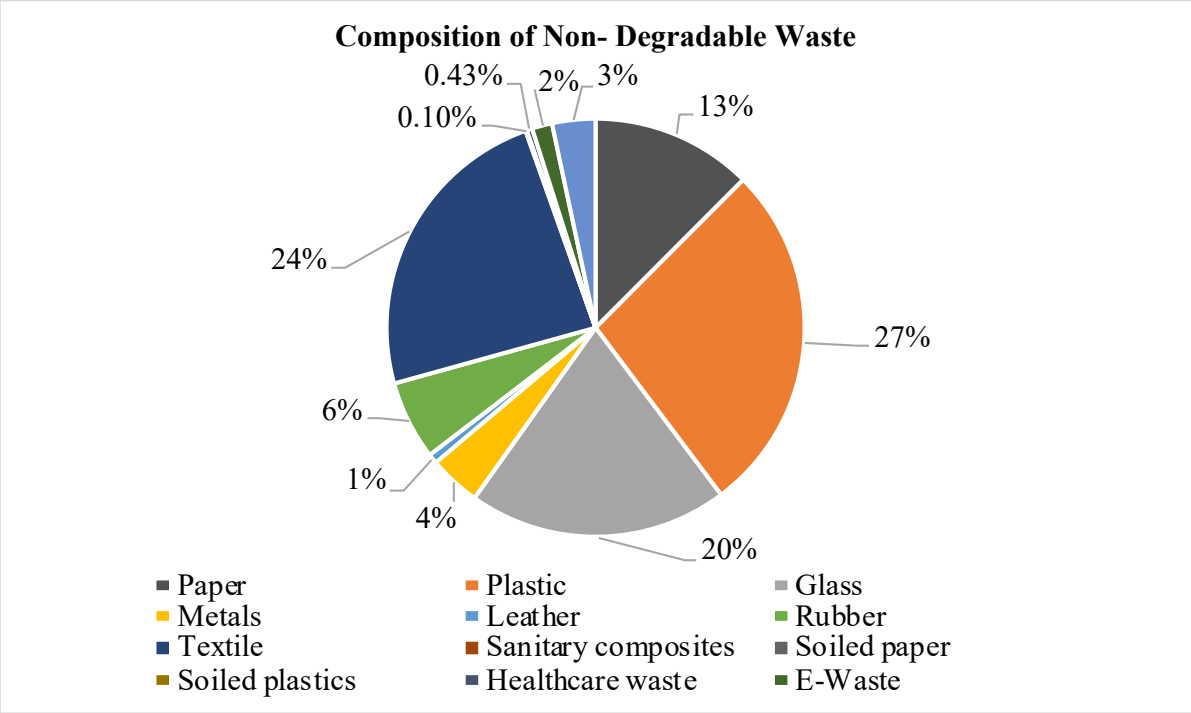


Figure 23:Composition of non-degradable waste

When the compositional data of non-degradable waste is considered (Figure 23), the highest amounts come from plastic, textile, and glass. In addition, paper also composes a significantly large amount (13%) of the total non-degradable waste.

4.2.4. Composition of Plastic Waste

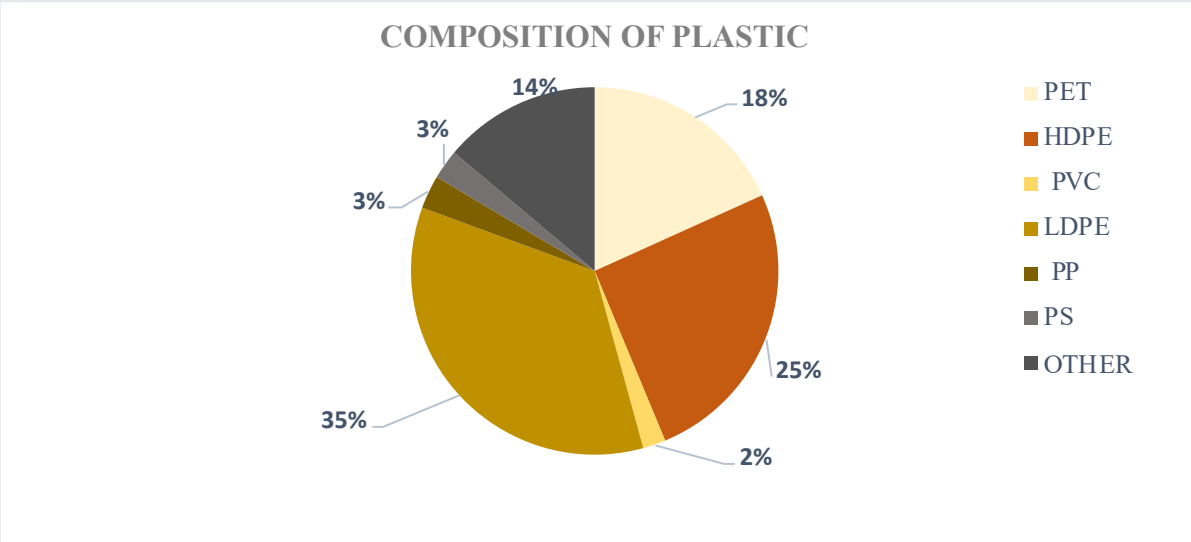


Figure 24: Composition of plastic waste

As in the figure 24, when analyzing the composition of types of plastic waste, LDPE constitutes the highest proportion at 35%. Second highest quantity was HDPE (25%) and constitute 18%, 25%, and 14% respectively. PVC, PP, and PS types of plastic constitute in small amounts.

4.3. Calculation of Waste Density

The following figure 25 presents the volume of 50 kg of wet and dry waste in m3. This figure can be used in calculating the density of wet and dry waste separately.

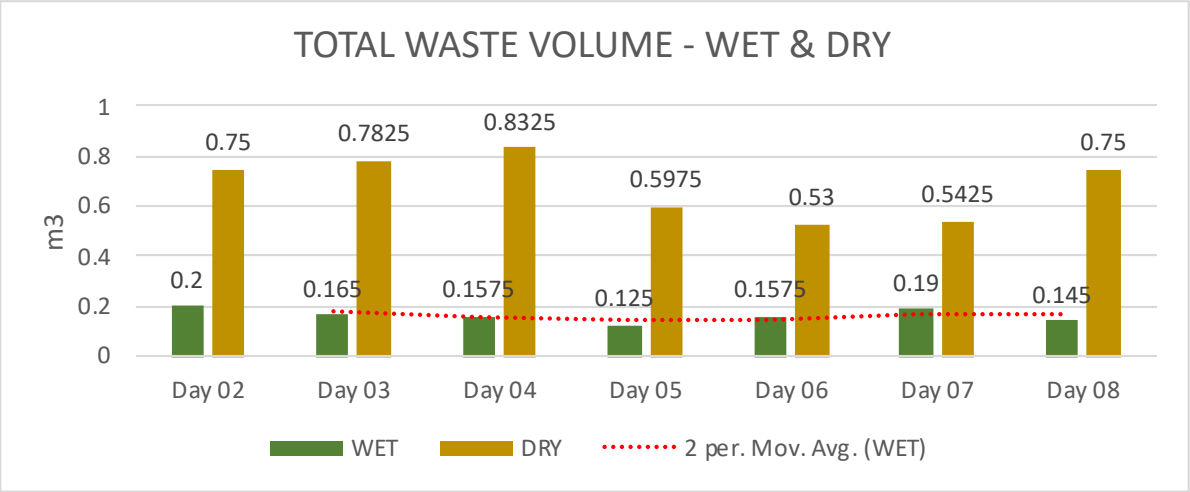


Figure 25: Total Waste Volume - Wet & Dry

As per the above information, the density of wet and dry waste collected daily was calculated and presented in the following figure 26.

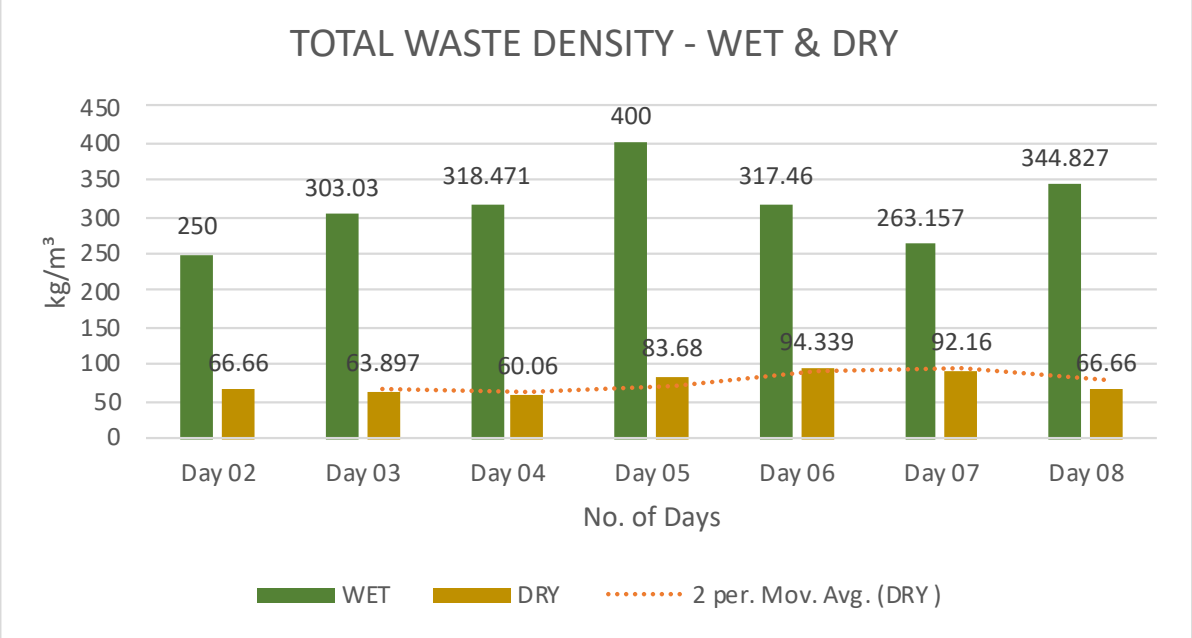


Figure 26: Density of wet and dry waste

CHAPTER 5

PHOTO: HELP-O

RESULTS AND DISCUSSION: WASTE QUANTIFICATION STUDY

5.1. Results

The weighing of the GMC vehicle fleet that collect and transport solid waste from all residential, commercia, industrial, and service sector units was conducted for eight (8) days from 1st February to7th February 2023. The GMC collects solid waste from 54 different locations. The 'Wet' and' Dry' waste is often collected and transported separately, and in some instances, mix waste is collected. Following table (table 5) illustrates the collection of the sector-wise solid waste by the GMC during the week of the waste quantification study.

Table 4: Net weight of sector-wise waste collected by the GMC vehicle fleet

Day	Wet (Degradable) Waste Collection (kg)	Dry (Non-Degradable) Waste Collection (kg)	Mixed (Wet and Dry) Waste Collection (kg)	Total Waste Collection (kg)
Day 1	15,627	4,634	2,787	23,048
Day 2	11,056	1,518	1183	13,757
Day 3	23,179	683	721	24,583
Day 4	11,285	10,886	1,059	23,230
Day 5	8,789	6,017	1,027	15,833
Day 6	21,509	2,849	2,505	26,863
Day 7	15,461	3,035	4,549	23,045
Total	106,906	29,622	13,831	150,359

According to the collected data,

Daily average collection of the 'Wet' waste = 106,906 kg / 7

= 15,272.3 kg (15.3t/d)

Daily average collection of the 'Dry' waste = 29,622 kg / 7

= 4,231.7 kg (4.2t/d)

Daily average collection of the 'Mix' waste = 13,831 kg / 7

= 1,975.8 kg (2 t/d)

Daily average collection of the total waste = 150,359 kg / 7

= 21,479.9 kg (21.5 t/d)

Accordingly,

Rate of collection of waste by GMC = (Average daily collection/ Total waste generation) x 100

(By Weight) = (21,479.9kg /68,377 kg) x 100

= 31.43 %

Note: Daily Weighing Data base – Vehicle attached as an attachment

5.2 Discussion

The rate of collection of waste by the GMC, which is 31.43% of the total waste generation, is in par with the national average solid waste collection rate for Local Authorities in Sri Lanka (Kaza et. al., 2018). As Kaza et. al. state, the Local Authorities in Sri Lanka have the capacity to collect only one-third of municipal solid waste, which is estimated to be around 7,110 MT/Day from a generation of 21,331 MT/D. Accordingly, the accuracy and acceptability of the results of this WACS can be justified.

Results also indicate that 68.57% (by weight) of solid wastes generated in the GMC area is not handed over to the GMC. However, survey observations indicate that most of the streets and open areas of the GMC are clean and no visible signs of haphazard waste dumping. This leads to the question 'how the rest of the waste that is not collected by the GMC is being disposed or managed?'

The findings of the Baseline Waste Assessment, which was conducted as a sample study from November 2022 to January 2023 illustrate to what extent the residential, commercial, industrial, and service sectors are served by the GMC. Accordingly, 81% of residential units, 84% of small-scale commercial establishments, 86% of large-scale commercial establishments, 64% of industrial establishments, and 79% of service sector establishments are served by the GMC Waste Collection Service. This indicates that 19% of residential units, 16% of small-scale commercial establishments, 14% of large-scale commercial establishments, 36% of industrial establishments, and 21% of service sector establishments manage their own waste without handing over to the GMC.

In addition to the above, the findings of the Baseline Waste Assessment indicates that some of the waste types under residential, commercial, industrial, and service sectors are not handed over to the GMC and managed at the source. Since the waste audit focused on the weight-based calculations, the baseline survey findings related to the waste disposal methods of some of the heavy weight waste types such as degradable wastes, iron/ scrap metal, glass, ceramic waste, etc. are presented below as evidence to the above claim.

For example, in addition to handing over to the GMC, rice waste of all four sectors is disposed using the following methods.

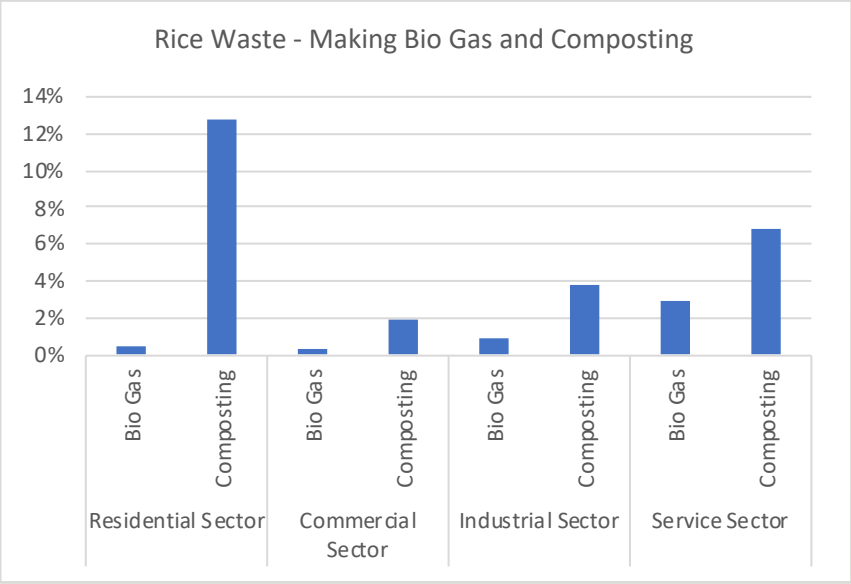


Figure 27: Rice Waste- Making compost and biogas

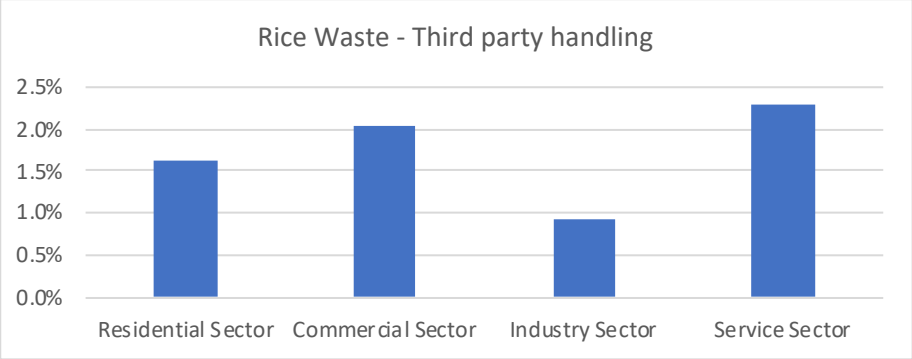


Figure 28: Rice Waste - Handing over to third-party

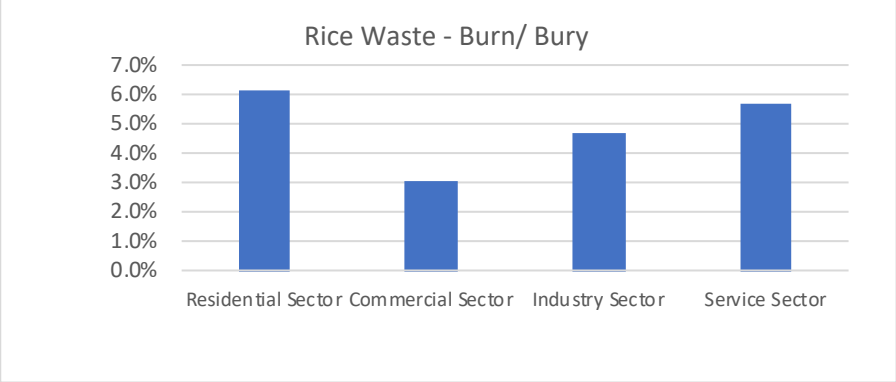


Figure 29: Rice Waste - Burning or Burying practic

According to the above figures, while handing over to the GMC, some parts of the rice waste generated in all four sectors have been disposed by using other methods, such as composting, making biogas, handing over to a third-party, burning and burying. This is a significant amount of the rice waste generated in the GMC area.

Also, based on the results of the Baseline Waste Assessment, it has been found that 08 out of 1840 housing units have biogas units established in their premises, resulting an estimated number of 92 biogas units (8/1840 x 21,291) in the entire GMC area. Accordingly, these units seemingly use 128.8 kg of degradable waste every day to produce biogas, which is again a significant amount of waste that is not handed over to the GMC. Similarly, 10 religious places and 09 service establishments that were surveyed have their own biogas units and use degradable waste to generate biogas. Commercial and industrial sectors have less number of biogas units (02 units in each sector), perhaps due to the fact that they do not generate large quantities of degradable waste.

Moreover, according to the GMC Community Development Unit, 350 compost bins have been donated to residential units in the GMC area under their supervision. Also, according to a survey conducted by the GMC Community Development Unit, 100 more compost generation units (other than the ones they have distributed) have been identified. Accordingly, it can be estimated that approximately 450 households are using compost bins to produce compost. Accordingly, the daily total wet waste used to produce compost is 630 kg. (1.4 kg x 450).

Another important kitchen waste disposal method is using them to feed animals. Most kitchen waste generated in service stations, hotels, and restaurants are collected daily by farmhouses to feed animals. For example, the amounts of kitchen waste collected by 03 major piggery farms in the GMC area and surrounding, namely Sukara Farmhouse, Boossa Farmhouse and Bope Farmhouse are 350 kg, 200 kg, and 450 kg, respectively. In addition, small farmhouses also collect kitchen waste from residential and other commercial, religious, and service establishments to feed animals.

Similar situation can be observed with regard to garden waste as well. For example, based on the survey results, over 35% of residential garden waste is either burnt or buried.

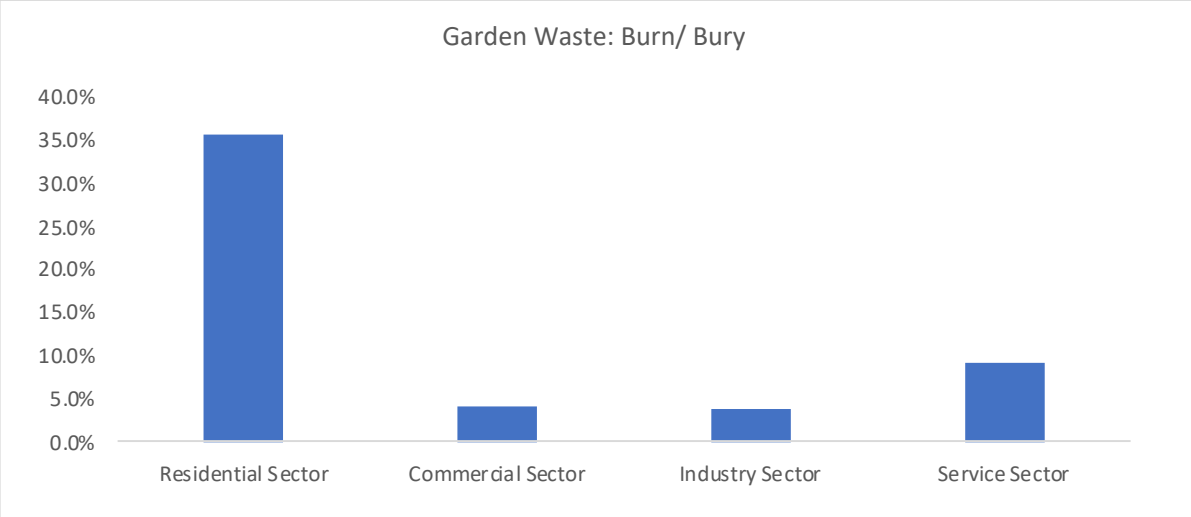


Figure 30: Garden Waste – Burning or Burying practice

According to the baseline assessment results, similar situation can be seen with regard to non-degradable waste as well. For example, following charts (Figure 31) illustrate the % of different waste types (e.g. Cardboards, clothes, glass and metal) handed over to a third party under four key sectors.

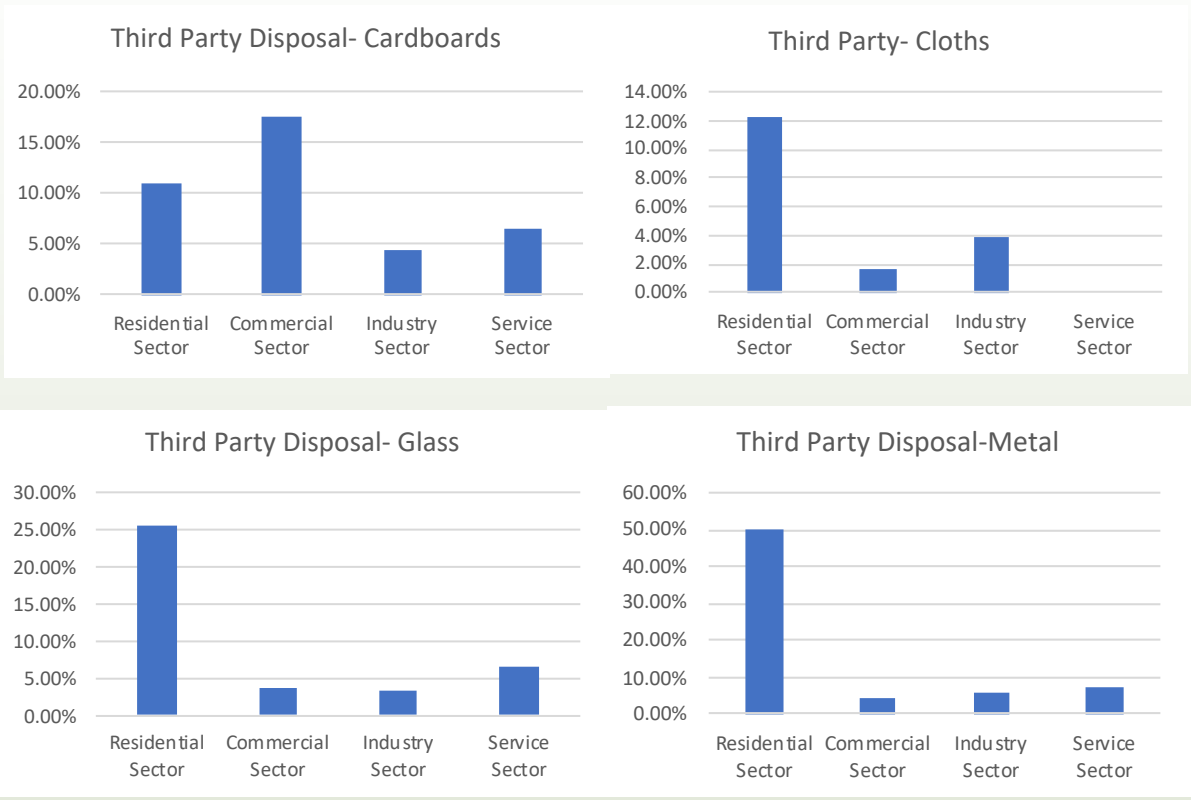


Figure 31: Percentage of different types of waste handled by a third party under the four key sectors

Accordingly, significant percentage of household units, ranging from 10% (cardboard) to 50% (metal), hand over non-degradable waste to the third-party collectors. A similar, perhaps with different waste amounts, can be observed in other types of non-degradable waste.

As in the degradable waste, burning and burying is another major waste disposal practice in relation to nondegradable waste.

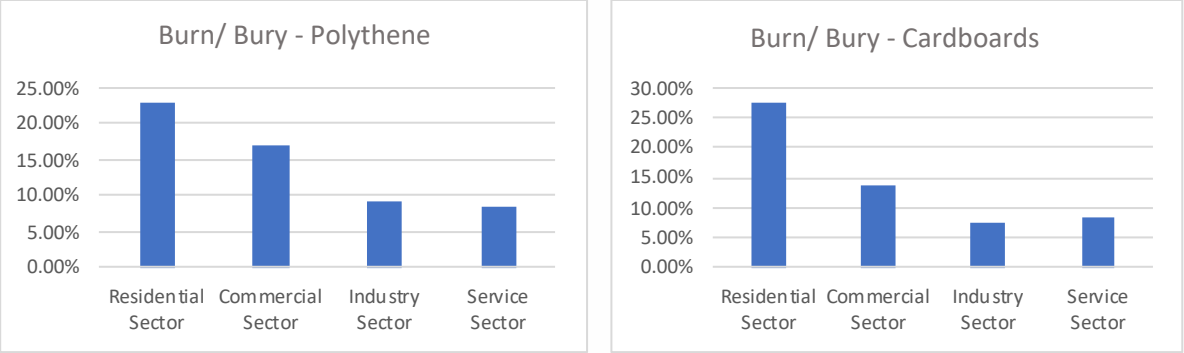


Figure 32: Percentage of different types of waste disposed by burning or burying

Furthermore, field observations focus group discussion with the GMC and Environment Police officials confirmed illegal waste dumping has been a regular practice within the GMC area. The interview with illegal waste dumpers indicated absence of access road for waste collection and irregularities or mismatching of waste collection schedule with their presence at residence as reason for adopting illegal disposal.

For example, HELP-O has identified several large-scale waste generators in the GMC area, which manage waste on their own. These waste generators include Navy Camp, Army Camp, Galle Prison, Karapitiya Teaching Hospital, Mahamodara Hospital, Galle Commercial Harbor, Fishery Harbor, and Galle Railway Station. The waste generated by these generators were not included in the WACS. The following table illustrates the amount of waste generated by these large-scale establishments that were not included in the GMC waste collection data.

Table 5: Amount of Waste Generated by Large-scale Waste Generators

Institution	Wet Waste Weight	Dry Waste Weight
Army Camp	650 kg	60 kg
Navy Camp	1100 kg	90 kg
Mahamodara Hospital	4500 kg	1100 kg
Karapitiya Hospital	9500 kg	2500 kg
Fishery Harbor	50 kg	1500 kg
Galle Railway Station	500 kg	3500 kg
Galle prison	6000 kg	500 kg

Similarly, based on the Rapid Assessment conducted for Waste Aggregators with the Guidance of CCBO, other than the GMC, waste aggregators also contribute to the waste collection and management. Aggregators collect waste materials such as metal, PET bottles, HDPE and Cardboard, etc. with some value for them. As per the results of the Rapid Assessment, aggregators collect 27.6 T of metal, 7.8 T of PET bottles, 4.7 T of HDPE, 9T of Coconut Shells and 12.8 T of Cardboards within the GMC area per month.

As a summary, the waste that is not handed over to the GMC is being subjected to acceptable 3R practices (prominently composting or giving to a third party for recycling) or unacceptable practices like burning, burying, or dumping in the open environment. Thus, a considerable portion of comparatively heavy weight materials are not being handed over to GMC but being deposed as described above. The weights of the waste disposed using some of these alternative methods are not available. Hence, the percentage of waste managed by using these alternative methods (other than handing over to the GMC) cannot be calculated. However, it is clear with evidence that even though the GMC waste collection rate is found to be 31.43%, which is close to the average waste collection rate by local authorities in Sri Lanka (Kaza et. al., 2018), the rest of the waste is disposed either through acceptable or unacceptable means, as discussed above.

CHAPTER 6

CONCLUSION

The Waste Audit and Characterization Study for Galle Municipal Council Area was carried out under the "Collaborative Action for Clean City of Galle" project implemented by HELP-O in collaboration with the Galle Municipal Council for an efficient SWM system via reducing the generation of plastic waste and promoting a city-wide waste management system. The CCBO flagship programme of the USAID implemented by TetraTech provides the financial and technical support for the said project.

The Waste Audit and Characterization Study (WACS) is a key requirement for the development of the Integrated Solid Waste Management Action Plan (ISWMAP) to be prepared under the project. Under the WACS, waste generation and collection pattern of the GMC area was analyzed by employing a comprehensive methodology developed through a thorough literature review. The ASTM standard method and Rothernberg method were used as the key guides to develop the methodology. The WACS covered the entire GMC area, including Mahamodara Zone, Richmond Hill Zone, Karapitiya Zone, Moragoda Zone, and Galle Bazar Zone.

A comprehensive training sessions and awareness programs were conducted prior to the commencement of the WACS. Appropriate Health and Safety Protocols, as per the USAID guidelines, to be followed during the WACS were included in these training and awareness sessions. During the first stage of the WACS, waste generation quantities, composition of the generated waste, volume and density of the waste were measured. The second stage of the WACS focused on weighing the GMC waste collection vehicle fleet.

According to the findings of the two stages of the WACS, several important measures with regard to the municipal waste generation and collection were calculated. Following is a summary of those measures under key sectors of residential, commercial, industrial, and service.

Residential Sector:

- Daily total of 'wet' waste generation in the GMC area is about 30.7 MT.
- Daily total of 'dry' waste generation in the GMC area is about 21.7 MT.
- Daily total of waste generation in the GMC area is about 52.4 MT.

Commercial Sector:

- Daily total of 'wet' waste generation in the GMC area is about 6.7 MT.
- Daily total of 'dry' waste generation in the GMC area is about 4.4 MT.
- Daily total of waste generation in the GMC area is about 11.1 MT.

Industrial Sector:

- Daily total of 'wet' waste generation in the GMC area is about 0.85 MT.
- Daily total of 'dry' waste generation in the GMC area is about 1.75 MT.
- Daily total of waste generation in the GMC area is about 2.6 MT.

Service Sector:

- Daily total of 'wet' waste generation in the GMC area is about 1.32 MT.
- Daily total of 'dry' waste generation in the GMC area is about 0.94 MT.
- Daily total of waste generation in the GMC area is about 2.56 MT.

In addition to sectoral measures, the following important measures were derived in relation to the GMC waste generation and collection.

- Daily total waste generation in the GMC area is about 68.34 MT.
- Per capita waste generation in the GMC area is about 0.66 Kg/ Day

When compared the waste generation data with collection data, the following important measures were derived.

- Daily average collection of the waste by GMC is about 21.5 MT.

Accordingly,

- The rate of collection of waste by GMC is approximately 31.43%

This leads to the question that if the GMC collects 31.43% waste from the whole GMC area, how the rest of the waste is being disposed or managed? As per the results of the Baselines Waste Assessment, it has been found that a significant amount of waste, particularly heavy waste such as degradable waste, glass, metals, clothes, etc. are managed by using alternative disposal methods, which can be both acceptable and unacceptable practices. Also, illegal waste dumping has been a practice within the GMC area. That way, GMC waste collection rate, which is close to the average waste collection rate by Sri Lankan local authorities, is justifiable.

The above measures derived from the data collected from the WACS paint a reasonable picture of the waste generation and collection within the GMC area. These findings, however, may not reflect the accurate picture of the waste generation due to several reasons. These include,

- Some commercial establishments and industries may have temporary stopped operating due to Covid19 pandemic and subsequent economic downturn in the country during the last 2-3 years.
- High inflation rate during the time of the WACS may have influenced HHs and commercial and industrial establishments to have reduced consumption levels and reduced waste generation rates, compared to other times of the year.
- Some large commercial establishments and industries manage waste on their own so the impact of those waste generators may have a considerable impact on the measures derived. Due to resource limitations, large industries and commercial establishments were not taken for the WACS.

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ANNEXURES

Annexure 01:

No		Activity	December 2022		January 2023				February 2023	
1		Preparatory work -Discussions with the CCBO and GMC -Purchasing equipment and tools -Identifying the sample -Recruiting field staff for the WACS -Training the field staff								
2		WACS -Make aware the sample -Distribution of empty waste bags -Preparation of the sorting area -Commencement of the WACS								
3		Data analysis and reporting								

Annexure 02:

Leaflets distributed among the participants of the waste audit during the awareness.

Collaborative Action for Clean City of Galle (CACG) Project

Waste Characterization Study (WACS) - 2023

Galle Municipal Council Area

Waste Bags Receipt Format - *Commercial Sector*

✓ - Received X - Not Received

Commercial Ref.No	Day		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7		Day 8	
	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY
C001																
C002																
C003																
C004																
C005																
C006																
C007																
C008																

Annexure 04:

Format used to record the collection of waste from HHs and other establishments

Collaborative Action for Clean City of Galle (CACG) Project

Waste Characterization Study (WACS) - 2023

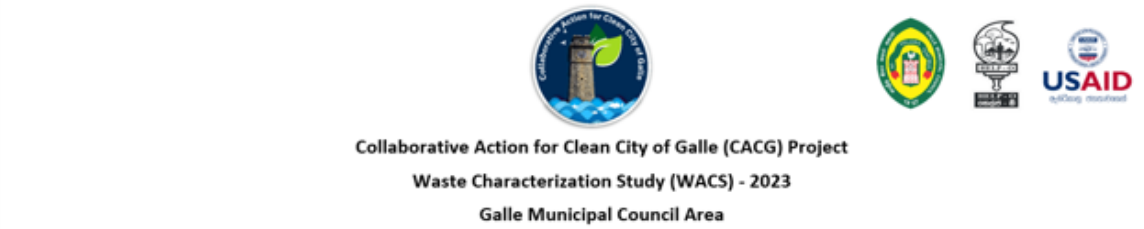
Galle Municipal Council Area

Record of Total Waste Received - *Residential Sector*

HH Ref.No	Family Size	Day 1(kg)		Day 2(kg)		Day 3(kg)		Day 4(kg)		Day 5(kg)		Day 6(kg)		Day 7(kg)		Day 8(kg)		*Total (kg)*	
		WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	*WET*	*DRY*
H001																			
H002																			
H003																			
H004																			
H005																			
H006																			

Annexure 05:

Format used to record the waste components commercial sector and other establishments



Collaborative Action for Clean City of Galle (CACG) Project

Waste Characterization Study (WACS) - 2023

Galle Municipal Council Area

WASTE COMPONENTS DATA FORM									
WASTE GENERATOR:	Commercial Sector								
Date									
The person filling out the form:									
Temperature (C)									
Rainfall (mm)									
Waste Category	Subcategory	Weight (kg)							
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
day of the week (Mon, Sun, etc.)									
BIODEGRADABLES	Long term biodegradables								
	Short term biodegradables								
	SUB-TOTAL								

Annexure 06:

Format used to record the waste density calculation in all sectors

Collaborative Action for Clean City of Galle (CACG) Project

Waste Characterization Study (WACS) - 2023

Galle Municipal Council Area

Form for Waste Density Calculation

Day	Residential Sector			Commercial Sector			Industrial Sector			Service Sector		
	Weight of the container	Weight With waste	Net Weight of waste	Weight of the container	Weight With waste	Net Weight of waste	Weight of the container	Weight With waste	Net Weight of waste	Weight of the container	Weight With waste	Net Weight of waste
Day 1 (23/01/23)												
Day 2 (24/01/23)												
Day 3 (25/01/23)												
Day 4 (26/01/23)												
Day 5 (27/01/23)												
Day 6 (28/01/23)												
Day 7 (29/01/23)												
Day 8 (30/01/23)												
Total												

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