

# Deciding Parameters for Waste Collection System and Waste Collection Vehicle for Gram Panchayats

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## 1. Background

The clarion call of Swachh Bharat made by Prime Minister Narendra Modi, 68 years after India's independence in 2014, has sparked significant activity across the country. Largely focusing on sanitation and ending the age-old practice of open defecation in India, Swachh Bharat Mission (SBM) is termed as the largest behaviour change program globally<sup>1</sup>. Proceeded by Swachh Survekshan, the world's largest urban sanitation survey, numerous local bodies have initiated sanitation and waste management programs particularly after phase 2 of Swachh Bharat Mission (Urban) that brought the vision of 'Garbage Free Cities' under its ambit<sup>2</sup>.

SBM Gramin that initially targeted Open Defecation Free (ODF) status for all villages eventually incorporated solid waste management (SWM) in its second phase<sup>3</sup> considering the growing quantum of dry waste that rural areas had started generating. Funding is provided under 15<sup>th</sup> Finance Commission to build infrastructure and promote behaviour change for solid waste management in villages. The biggest operational expenditure is the waste collection cost and one of the biggest capital expenditures is the waste collection vehicles (WCV) for most Gram Panchayats (GPs). Hence finalising the Waste Collection System and Waste Collection Vehicle are the two most critical decisions for a GP. While there are multiple decisions points under each, the most important questions are:

1. **Waste Collection System:** Should all waste categories be collected daily or there should be different collection days for wet and dry fractions?
2. **Waste Collection Vehicle:** Should the GP deploy compartmentalized vehicles or create compartments by using bins, bags in a non-partitioned vehicle?

This analysis will focus on these two critical decisions.

## 2. Waste Collection System and Waste Collection Vehicle

**Waste Collection Systems** in the context of GPs primarily defines how frequently each category of waste is to be collected. Often Wet and Sanitary waste require daily or alternate day collection while Dry waste and Domestic Hazardous waste can be collected once or twice a week. This has also been recommended under Swachh Survekshan. Daily collection of all streams reduces waste dumping but will increase collection cost (diesel and man power). Separate day collection brings in more efficiency with respect to transporting the waste to separate destinations however, balancing out vehicle **carrying capacity** for wet and dry waste

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<sup>1</sup> Swachh Bharat Mission-Urban 2.0 launches National Behaviour Change Communication Framework for Garbage Free Cities, Ministry of Housing & Urban Affairs 2022

<sup>2</sup> MoHUA launches roadmap to make Urban India 'Garbage Free', Ministry of Housing & Urban Affairs 2023

<sup>3</sup> <https://swachhbharatmission.gov.in/sbmcms/index.htm>

is a challenge. Dry waste being voluminous and wet being heavy, for same tonnage, the size of the vehicle will vary. This capacity optimisation to ensure that the vehicle is suitable for managing both dry and wet waste is a challenge especially in rural areas.

Based on the waste collection system, suitable **Waste Collection Vehicle (WCV)** has to be deployed. Daily collection of all streams will require compartmentalisation whether inbuilt or created by using bins/bags. Different collection days for wet and dry will not require compartmentalisation. Compartmentalisation is likely to reduce carrying capacity but it is claimed to improve **waste segregation**<sup>4</sup>. It must be noted that dry waste packs better in bags as it can be pressed in bags, storing it without bags in compartmentalised vehicles is less efficient. On the other hand, wet waste packs better if placed directly in the body than storing it in bins. However, placing waste directly on the body especially wet waste, will soil the vehicle and will entail frequent cleaning. It will also corrode the body and other parts, increasing annual **maintenance cost** and also shortening the **vehicle life** eventually. Both these factors, are very critical in successful SWM operations in the long run. This is because the maintenance and vehicle replacement cost will need to be absorbed by the GP while the initial funding is coming from SWM /15th Finance Commission. If WCV is not available, the SWM system will not work as vehicles are the most essential component of the system.

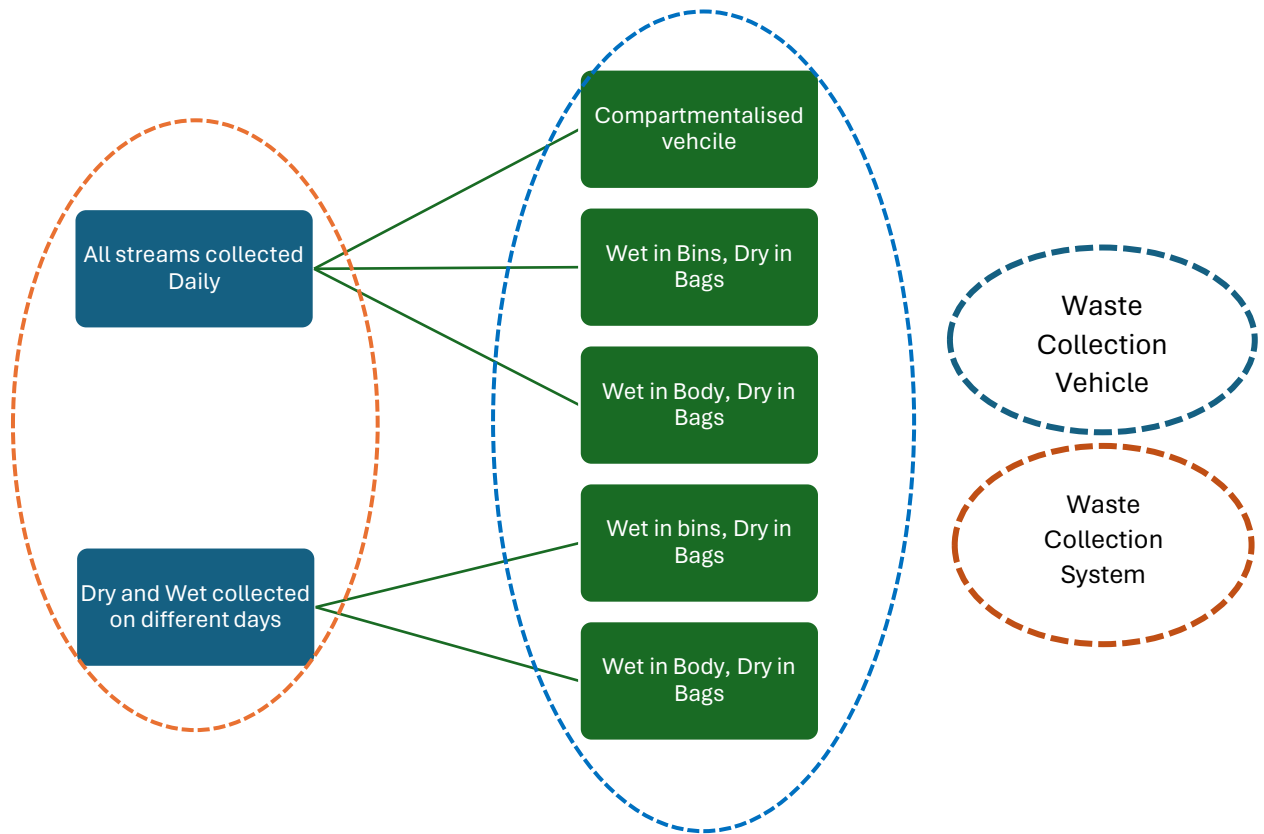
Decision on the type of compartmentalisation also impacts the overall **material handling effort**. The material handling effort required for moving around waste at the time of waste collection comprises of three stages - effort in putting waste into the vehicle, effort in emptying the vehicle, effort in shifting the waste to the processing area from the unloading point. Storing wet waste in bins is not a favourable option from the material handling point of view. While collecting waste, dumping it in the compartment directly is quicker than transferring waste into bins. When emptying out the vehicle, lifting bins is laborious while using a tipper and inverting the whole trailer is quite convenient. If the vehicle can tip the waste directly into composting tanks, the shifting effort is also minimised. Dry waste on the other hand is easier to handle if stored in bags. It packs better in bags; the bags are also used to do basic sorting at the time of collection by keeping higher value recyclables separately. While emptying the vehicle, removing dry waste in bags is much more convenient as it can be easily chucked out and then the bags can be stored in the dry waste collection centers for further sorting and transportation. If Dry waste is stored without bags and wet waste is stored without bins, the dry waste can get soiled by the leachate from the wet waste, thus bringing down the value potential of recyclables that the collectors sell to make extra income. Hence, often Dry Waste is stored in bags even if wet is stored directly on the vehicle body.

Summarising the above, the Waste Collection System and Waste Collection Vehicle will impact the following parameters:

1. Carrying Capacity
2. Segregation
3. Maintenance Cost
4. Vehicle Life or replacement cost
5. Material Handling effort

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<sup>4</sup> <https://www.sciencedirect.com/science/article/abs/pii/S1364032123003830>



### 3. The project “Parivataneya Hejje”

Saahas, an NGO implementing sustainable waste management solutions for more than two decades, started working with the Marenahalli GP in Bangalore Urban district in the year 2022 under the project ‘Parivataneya Hejje’ supported by Shell CSR.

The team had to guide the GP in deciding the suitable Waste Collection system and Waste Collection vehicle configuration. Saahas has been working in a few other GPs around Bangalore and did an analysis of the systems in those GPs and came up with a decision matrix to arrive at a suitable Waste Collection system and Waste Collection Vehicle for the Marenahalli GP. The following sections compare the Waste Collection System and Waste Collection Vehicle in Marenahalli GP with 3 other GPs:

- Chikkajaala from Bangalore urban district
- Doddajaala from Bangalore urban district, and
- Kudluru from Chamarajanagar District of Karnataka

The impact of the collection system and vehicle compartmentalisation was analysed on the Carrying Capacity, Segregation, Maintenance Cost, Vehicle Life or replacement cost and Material Handling effort as explained in the earlier. These GPs were chosen for the analysis so as to be able to cover different configurations of waste collection system and vehicle compartmentalisation. In these 3 GPs, Saahas had got involved with the SWM program after

the vehicle had been procured hence we could not guide the GP in appropriate vehicle selection and waste collection system.

#### 4. Key Observation

##### 4.1 Waste Collection Vehicle

As per the SBM Manual, the choice of primary collection vehicle for door-to-door waste collection should consider factors such as the terrain, availability of repair and maintenance facilities, and waste generation projections for the city. These vehicles may include handcarts, tricycles, light commercial vehicles with tippers, and mini-trucks (Figure 1). In regions with challenging terrain, such as hilly areas with limited accessibility, the use of backpacks equipped with leak-proof containers is also suggested.<sup>5</sup>



For rural areas, the Manual for the utilization of 15<sup>th</sup> Finance Commission, released in 2021, mandated purchase of tricycles and battery-operated vehicles for solid waste collection<sup>6</sup>. However, this guideline was revoked in 2022, after many states objected to the mandate stating difficulties in transporting waste due to high waste quantities and difficult terrains where only the heavy-duty diesel/petrol/CNG vehicles could operate<sup>7</sup>.

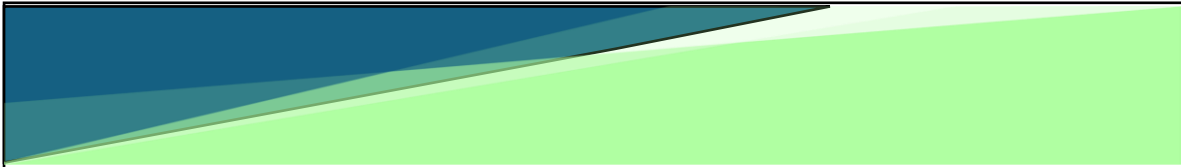
In all 3 GPs covered under this study, non-electric WCVs were deployed. Chikkajaala and Kudluru each had one WCV, Marenahalli had 2 WCVs and Doddajaala had 3 WCVs. The make, model etc. of different WCVc are detailed in Table 1.

Name of the GP	Marenahalli		Kudluru	Doddajaala			Chikkajaala
Parameters	Vehicle 1	Vehicle 2	Vehicle	Vehicle 1	Vehicle 2	Vehicle 3	Vehicle 1
Type of vehicles used for waste collection; Brand and Model Number	Maruthi Suzuki Super Carry STD CNG	Maruthi Suzuki Super Carry STD CNG	Three Wheeler, Bajaj RE Maxima Cargo BS-IV	TATA Lamisafe-LT Diesel vehicle 4-wheeler	Piaggio Ape Xtra LD Diesel vehicle 3-wheeler	Piaggio Ape Xtra LD Diesel vehicle 3-wheeler	Massey Ferguson Tractor MF 1035 DI Mahashakthi
Usage start date for waste collection	2023	2024	2018	2016	2017	2018	2017
Stated Carrying Capacity	2000 Kg	2000 Kg	471 Kg	2000 Kg	800 Kg	800 Kg	3000 Kg
Current Vehicle Mileage (Km/Ltr)	21	21	32	15	16	17	8

<sup>5</sup> Swachh Bharat Mission, Municipal Solid Waste Management Manual, Ministry of Urban Development, 2016

<sup>6</sup> Manual for the utilization of 15th Finance Commission tied grants to Rural Local Bodies/PRI for Water & Sanitation (2021-22 to 2025-26), Ministry of Jal Shakti, Department of Drinking Water & Sanitation, 2021

<sup>7</sup> Clarification for purchase of motorized vehicles dt 22-12-2022, Ministry of Jal Shakti, 2022



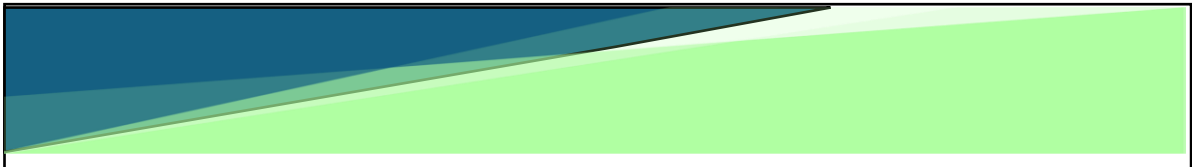
For Marenahalli, non-electric vehicles were chosen because electric vehicles when deployed for waste collection, frequently breakdown. The stated capacity was 2000 Kg because these villages are urbanising fast and they are likely to generate more dry waste in near future which requires more volume in the vehicle.

## 4.2 Waste Collection System

The frequency of collection of dry, wet and domestic hazardous waste categories primarily depends on the quantity and composition of waste and the budget available for waste collection. The wet waste that comprises of kitchen waste, crop residue, plant trimmings, animal waste etc. typically constitutes 60-80% of the total waste in villages<sup>8</sup>. The remaining 30-40% is dry waste consisting of paper, plastic, textile, glass, metal etc. and domestic hazardous waste. The proportion of dry waste and plastic in specific has been growing in urban as well as rural areas due to increased access and purchasing power, supported by small format packaging<sup>9</sup>. However, owing to the local lifestyle, occupation and practices, the waste generated can differ in quantity and composition. Assessing the quantity of waste generated and the typical wet/dry composition is important in deciding the collection system. The waste collection system followed in each of the GPs is summarised in Table 2.

Parameters	Marenahalli		Kudluru	Doddajaala			Chikkajaala
Waste Collection System	Both waste collected on all days except Sundays	Both waste collected on all days except Sundays	Both waste collected 2 Days Per week	Tuesday for dry waste and Wet waste on other days	Wednesday for dry waste and Wet waste on other days	Thursday for dry waste and Wet waste on other days	Wednesday, Thursday for dry waste and on remaining days Wet waste is collected
Average daily quantity of waste collected in one run (Wet & Dry)	Wet - 250 Kg & Dry - 170 Kg	Wet - 220 Kg & Dry - 140 Kg	Wet - 30 Kg Dry - 40 Kg	Wet - 100 Kg Dry - 65 Kg	Wet - 75 Kg Dry - 40 Kg	Wet - 75 Kg Dry - 55 Kg	Wet - 450 Kg Dry - 140 Kg

The wet waste collected is often less than what is estimated as many of the household use it for feeding the livestock or they compost it. In Kudluru, dry waste quantity exceeds wet waste.



For Marenahalli, the dry waste proportion was already high and was expected to go up compared to other GPs hence the GP wanted to collect dry waste regularly else waste dumping could happen. Hence GP decided to collect both wet and dry daily.

<sup>8</sup> Manual- Biodegradable Waste Management, Ministry of Jal Shakti, Government of India, 2021

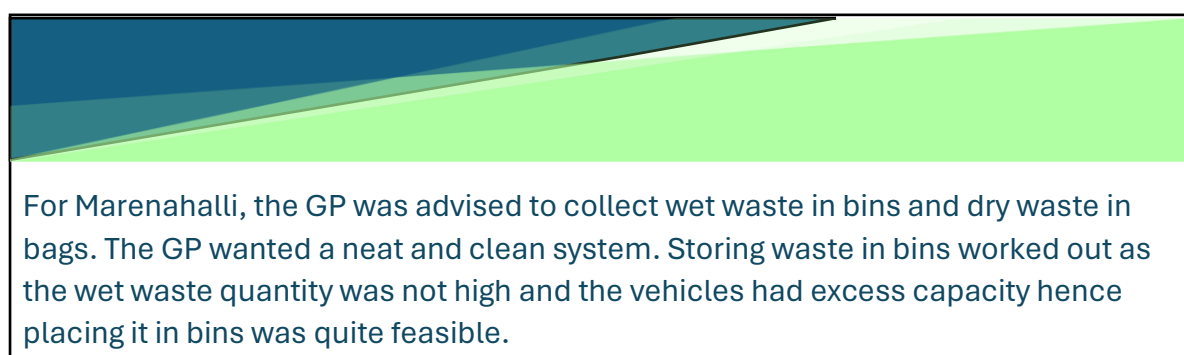
<sup>9</sup> India Plastics Pact Insights report - Small formats and Sachets, Confederation of Indian Industry, WWF India, DSS, 2022

### 4.3 Vehicle Compartmentalisation

The GPs follow different ways of storing/placing waste in the WCV, this is summarised in Table 3.

Parameters	Marenahalli		Kudluru	Doddajaala			Chikkajaala
Waste Placement/Storage	Blue Bins for Wet waste white bags for Dry waste	Blue Bins for Wet waste white bags for Dry waste	Wet waste directly in the compartment. Dry waste in gunny bags in the dry waste compartment	Wet and Dry waste both stored in white bags	Wet and Dry waste both stored in white bags	Wet and Dry waste both stored in white bags	Wet waste directly in the vehicle, Dry waste in white bags

All 3 GPs were collecting dry waste in bags while wet waste was directly stored in Kudluru (in compartmentalised vehicle) and in Chikkajaala it was placed directly on the body. Doddajaala was keeping wet waste in bags.



## 5. Impact of Waste Collection System and WCV

### 5.1 On the Maintenance Cost

The expenditure associated with collecting, transporting and processing Municipal Solid Waste (MSW) typically ranges from 15% to 45% of the total municipal revenue<sup>10</sup>. The percentage pertaining to SWM in rural areas would be even higher as the transportation cost would be high due to dispersed houses<sup>11</sup>. Hence any savings in SWM are critical. Table 4 shows the annual maintenance expenditure for each of the Panchayats. The maintenance cost was highest for Kudluru and Chikkalaja where waste was stores directly on the body. An additional expenditure of Rs. 150,000/- was incurred towards major repairs in the vehicle body in Chikkajaala as that was also the oldest vehicle.

Parameters	Marenahalli		Kudluru	Doddajaala			Chikkajaala
Waste Placement/Storage	Blue Bins for Wet waste white bags for Dry waste	Blue Bins for Wet waste white bags for Dry waste	Wet waste collected directly in the compartment. Dry waste collected in gunny bags kept in dry compartment	Wet and Dry waste both collected in white bags	Wet and Dry waste both collected in white bags	Wet and Dry waste both collected in white bags	Wet waste directly in the vehicle and Dry waste in white bags
Average repair and maintenance cost per year	Rs. 8000/-	Rs. 8000/-	Rs.13500/-	Rs. 12000/-	Rs. 8000/-	Rs. 7000/-	Rs. 35000/-

Wet waste, characterized by high density and moisture content, contrasts with the voluminous and low-density nature of dry waste. Thus, even though the carrying capacity by collecting

<sup>10</sup> The Business of Waste, Swati Singh Sambyal, CSE

<sup>11</sup> Plastic STORI: Study of Rural India, Pratham Education Foundation, 2022.

both these fractions in one vehicle may be better, it affects the vehicle adversely when they are stored in separate compartments. In case of partitioned WCVs, balancing both compartments in a single vehicle can present challenges, as one compartment becomes heavier while the other fills up by volume.



Fig 2: Damaged WCV body in Chikkajaala

For Marenhalli, the GP was advised to place the wet waste in bins and dry waste in bags to minimise the maintenance cost and keep the vehicles on good shape.

## 5.2 On the Vehicle condition (Replacement Cost Factor)

The physical condition of a WCV depends on many factors such as cleaning, maintenance, utilization and type of road infrastructure, to list a few. But the method of waste placement also has a direct impact as leachate generated by wet waste is acidic in nature and corrodes parts of the WCVs. Therefore, vehicles, in Chikkajaala and Kudluru, where wet waste is directly put on the body, faced significant corrosion, as summarised in Table 5.

Parameters	Table 5 - Physical condition of the WCV						
	Marenahalli		Kudluru	Doddajaala			Chikkajaala
Waste Placement/Storage	Blue Bins for Wet waste white bags for Dry waste	Blue Bins for Wet waste white bags for Dry waste	Wet waste collected directly in the compartment. Dry waste collected in gunny bags kept in dry compartment	Wet and Dry waste both collected in white bags	Wet and Dry waste both collected in white bags	Wet and Dry waste both collected in white bags	Wet waste directly in the vehicle and Dry waste in white bags
Current vehicle condition	Vehicle paint is peeling off	Vehicle paint is peeling off	Rusting and breakage of the floor/base of the vehicle	Vehicle paint is peeling off	Vehicle paint is peeling off	Vehicle paint is peeling off	Vehicle paint peeling off, Rusting
Corrosion issues	No Corrosion	No Corrosion	Wet waste compartment corroded and broken	Some corrosion at the back door and edges	Some corrosion at the back door and edges	Some corrosion at the back door and edges	Corrosion of the body, back door and base

The worst impact was found on the partitioned vehicle in Kudluru, where the vehicle compartment has suffered major damage. (Fig 3)

Fig 3: Broken WCV in Kudluru



For Marenhalli, looking at the poor conditions of the vehicles where wet waste was stored on the body, it was decided to place wet waste in Bins and Dry waste in bags.

### **5.3 On the Material Handling Effort:**

All 3 GPs were collecting Dry Waste in bags as that is most effective both from the carrying capacity as well as material handling perspective. 2 GPs were using tipper for transferring wet waste while Doddajaala was collecting wet waste in bags which still led to some leachate leaking out.

For Marenhalli, dry waste was collected in bags & wet waste in bins. This increased the material handling effort but it was decided that the gains in terms of longer vehicle life & a lower maintenance cost were more important than the additional effort. As wet waste quantity is not high, it does not entail handling too many bins.



## 5.4 On the Carrying Capacity

The carrying capacity of the WCV is defined as the amount of waste collected compared to the stated carrying capacity. Dry waste is lighter but occupies more space, while the wet waste is heavier and occupies less space.

Parameters	Marenahalli		Kudluru	Doddajaala			Chikkajaala
Average daily quantity of waste collected in one run (Wet & Dry)	Wet - 250 Kg & Dry - 170 Kg	Wet - 220 Kg & Dry - 140 Kg	Wet - 30 Kg & Dry - 40 Kg	Wet - 100 Kg & Dry - 65 Kg	Wet - 75 Kg & Dry - 40 Kg	Wet - 75 Kg & Dry - 55 Kg	Wet - 450 Kg & Dry - 140 Kg
Stated Carrying Capacity	2000 Kg	2000 Kg	471 Kg	2000 Kg	800 Kg	800 Kg	3000 Kg
Capacity utilization % (total weight carried in one run/ stated carrying capacity)	21.00	18.00	14.86	Wet: 5.00 Dry: 3.25	Wet: 9.38 Dry: 5.00	Wet: 9.38 Dry: 6.88	Wet: 15.00 Dry: 4.67

Collection of wet and dry waste in the same vehicle achieves highest capacity utilization. Also higher the proportion of wet waste, better is the utilisation as we are only assessing the capacity utilisation on the basis of weight and not volume (this is a limitation of this analysis).

For Marenahalli, because of daily collection of dry and wet waste, the capacity utilisation was one of the highest.

## 5.5 On Segregation

Unexpectedly, the segregation percentage was not significantly influenced by the Waste collection system.

Parameters	Marenahalli		Kudluru	Doddajaala			Chikkajaala
Frequency of waste collection (days per week) in the vehicle	Both waste collected on all days except Sundays	Both waste collected on all days except Sundays	Both waste collected 2 Days Per week	Tuesday for dry waste and Wet waste on other days	Wednesday for dry waste and Wet waste on other days	Thursday for dry waste and Wet waste on other days	Wednesday, Thursday for dry waste and on remaining days Wet waste is collected
Waste Segregation %	71%		90%	90%			75%

Both Kudluru (where wet and dry waste was collected together on two days) and Doddajaala (where dry and wet waste was collected on separate days) had high segregation levels. While Chikkajala, with separate days for wet and dry waste collection had a lower segregation level. The segregation was high in Kudluru and Doddajaala because of better governance in both the GPs, the panchayat members closely monitored waste management in the GPs.

For Marenahalli, the GP decided to collect wet and dry on both days primarily because Panchayat thought that waste dumping would be high if waste is not collected daily. In future, as segregation levels improve, the GP may consider reducing the frequency.

## Conclusion

Every GP has unique considerations with respect to arriving at a suitable waste collection system and waste collection vehicle. The decision has important implications on the capacity utilization, physical condition of the vehicles, cost of maintenance, material handling effort and even segregation. While some rural local bodies have been putting the waste directly in partitioned vehicles, it is not a recommended collection method owing to its impact on vehicle body and the associated maintenance costs, as observed in Kudluru. And although collecting wet waste on a daily basis in bins/bags, and dry waste on scheduled days is likely to work out well, but in rural areas where the proportion of wet waste may be much less than that in urban areas, it will turn out to be expensive. Thus, where wet waste generation is limited but GP must organize collection of wet waste, collecting both wet and dry streams of waste in bags/bins in the same vehicle is a more optimal solution. The summary of decision criteria and their impact on various parameters is summarised below.

