Western Cape Government
Environmental Affairs & Development Planning

WASTE COLLECTION AND TRANSPORTATION

Status Quo Report 2021

Table of Contents

Executive summary 1

1 Introduction 3

1.1 Background 3

1.2 Data collection 4

1.3 Report structure 5

2 The Solid Waste Collection System 6

2.1 Process overview 6

2.2 Benefits of an efficient waste collection system 7

2.3 Challenges to the provision of effective and efficient waste collection services 8

2.3.1 Lack of Political Commitment 8

2.3.2 Financial constraints 8

2.3.3 Fleet age 8

2.3.4 Poor vehicle routing and operational scheduling 9

2.3.5 Poor road networks 9

2.3.6 Haul distances to landfill/ transfer station 9

2.3.7 Staff challenges 9

2.3.8 Organisational challenges 9

2.3.9 Challenges with waste collection in informal settlements and rural areas .. 10

3 Western Cape Overview 11

3.1 Overview of waste collection vehicle fleet 13

3.1.1 Survey findings 14

3.2 Vehicle maintenance and replacement 20

3.2.1 Survey findings 21

3.3 Collection route design 25

3.3.1 Survey findings 26

3.4 Waste collection operations 28

3.4.1 Survey findings: 28

3.5 Summary of waste collection 31

4 Conclusion and recommendations 33

5 Sign-off 35

6 References 36

List of Figures

Figure 1: Two triangles approach for the Integrated Sustainable Waste Managment Framework (Source: Wilson et al., 2010 in Wilson et al., 2013) 3

Figure 2: Waste collection and transportation process (Source: Sulemana, et al., 2018) 6

Figure 3: Stages of the waste collection and transportation process (Source: Boskovic et al., 2013) 7

Figure 4: Questionnaire response rate per district 11

Figure 5: Waste collection vehicle types 15

Figure 6: Average age of waste collection vehicle fleet (years) 16

Figure 7: Number of waste collection vehicles and percentage of vehicles that are 8 years and older 17

Figure 8: Condition of vehicles as indicated by the municipalities 18

Figure 9: Percentage of municipalities that have vehicle maintenance and replacement plans 21

Figure 10: Average age (years) of vehicles in municipalities with vs without vehicle replacement plans 22

Figure 11: Pecentage of municipalities who undertake fleet maintenance externally vs both internally and externally 22

Figure 12: Percentage of municpalities with a dedicated fleet manager 23

Figure 13: Total annual fuel expenditure (R) for 2019 29

Figure 14: Fuel expenditure (R/km) 29

Figure 15: Average days per week and hours per day vehicles are in use 30

Figure 16: Average number of staff per vehicle (excluding driver) 31

Executive summary

Municipalities are responsible for providing waste services in South Africa. Waste service delivery is especially challenging because of factors such as limited municipal finances, staff shortages, ageing vehicle fleet, long distances associated with providing services in rural areas, rampant illegal dumping, rapid urbanization and the growth of informal areas and backyard dwellings, which places pressure on waste collection services.

Waste collection and transportation is an integral component of waste management service provision. A significant portion of waste management costs is associated with the provision of waste collection and transport services. The high cost of waste collection coupled with limited financial resources available to many municipalities, require municipalities to operate efficiently. Efficiency refers to internal operations and involves maximizing the outputs i.e. waste collection services, with the available resources e.g. time, vehicles, staff, financial resources. It must be noted that although many municipalities in the province provide an effective waste collection service in terms of service levels, they may not be doing so efficiently.

This Status Quo Report provides an overview of waste collection and transportation services in the Western Cape by narrowing the focus on the waste collection vehicle fleet and internal operations. Local municipalities were requested to provide the aforementioned information. An overall response rate from municipalities of 76% was obtained.

Based on the information provided, the key findings and recommendations include:

- Municipalities are providing waste collection services with an ageing vehicle fleet. The use of older vehicles may increase fuel consumption and maintenance costs. Using the information provided by municipalities, the average age of waste collection vehicles in the province is 10.5 years, which is higher than the standard replacement age of 8 years. In the case of Knysna, Cederberg and Swellendam Municipalities, all vehicles in the waste collection fleet are either 8 years or older. These municipalities have indicated that vehicle breakdowns and subsequent repairs are a challenge for them. In addition, municipalities often rely on external service providers to repair their vehicles. To reduce repair turnaround times, approximately a third of municipalities undertake internal maintenance as well. To ensure that maintenance and vehicle replacement is undertaken proactively, most municipalities have vehicle maintenance plans (83%) and vehicle replacement plans (61%).

  It would thus be beneficial for municipalities to investigate alternative options that may suit them such as leasing vehicles with maintenance included as part of the agreement, and the possibility of doing in-house maintenance for smaller repairs. In addition, all municipalities should prioritise having vehicle maintenance plans and vehicle replacement plans to ensure a proactive approach is undertaken.

- Most municipalities that responded to the survey, do not use route optimisation software to plan their waste collection routes, which is often guided by practical experience instead. It is important for municipalities to plan their waste collection routes optimally to reduce costs and to ensure that everyone receives adequate services. If routes are not planned optimally it could lead to collection beats not being evenly distributed among vehicles, overlapping collection points and time wasting.

- In terms of collection operations, the cost of providing waste collection services varies from R2.08/km to R11.16/km, the cost could be dependent on various factors such as distance between collection points, topography, vehicle type, condition of vehicles and driver behaviour. On average, waste collection vehicles in the province are utilised for 5.1 days per week and 6.9 hours per week. Excluding the driver, municipalities make use of between 3-5 staff per trip.

- Municipalities can improve efficiency by assessing their current operations to determine levels of efficiency and by identifying and responding to any gaps. Studies would however require the availability of good data. To improve data that could assist with efficiency/optimisation studies, municipalities must ensure that vehicles are fitted with GPS tracking devices and that logbooks are completed after each trip. Ensure that proper staff records and fuel usage records are kept and maintained.

- In addition to the above, municipalities should identify gaps in training amongst waste collection staff e.g. driver behaviour training to reduce fuel costs and breakdowns. This includes current staff as well as new staff.

1 Introduction

1.1 Background

Waste collection and transportation is considered an integral component of the waste management system and is driven by environmental and public health concerns (Figure 1). Waste collection is the use of waste collection vehicles to load waste from waste collection points and waste transportation is the activity of taking the collected waste to its destination (Yaman et al., 2019 in Wu et al., 2020).

Municipalities often struggle to deliver an effective and efficient waste collection service because of insufficient funds and other factors e.g. lack of political will, priority, technical expertise and commitment (Sulemana et al., 2018). Effective waste collection can be considered as the level or standard of waste collection services provided to residents. Whereas efficiency refers to internal operations and involves maximizing the outputs i.e. waste collection services, with the available resources i.e. time, vehicles, staff, financial resources etc. It is important to note that municipalities can be effective at delivering waste collection services, but this does not necessarily imply that they are efficient at doing so. It has been found that internal efficiency impacts on waste collection costs, therefore poor operational activity may lead to unnecessary spending (Greco et al. 2015 in Sulemana et al., 2018). This is especially relevant since waste collection is considered the biggest cost driver in waste management, accounting for approximately 60-80 percent of the total cost (Sulemana et. al., 2018.).

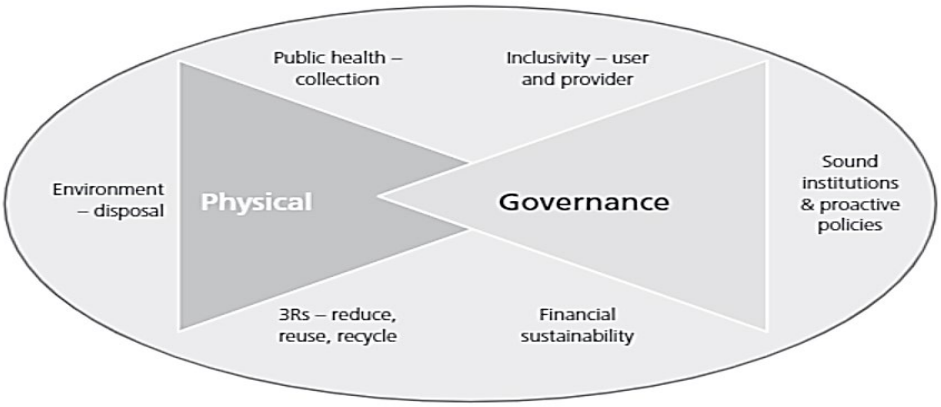


Figure 1: Two triangles approach for the Integrated Sustainable Waste Managment Framework (Source: Wilson et al., 2010 in Wilson et al., 2013)

During 2018, approximately 2.4 million tonnes of municipal solid waste was generated in the Western Cape (DEA&DP, 2019). This waste is required to be collected and transported for the purposes of recovery, beneficiation, treatment or disposal to landfill. Local municipalities are responsible for ensuring that a refuse removal service is provided to the communities they serve as specified in Schedule 5, part B of the Constitution. The Municipal Systems Act, 2000, Section 4(2)(e)(ii), requires that these services be equitable, accessible and be provided in an efficient and effective way as well as show improvement over time. In terms of Section 94(1)(k)(i), it is important that an effective and efficient waste collection system is in place to ensure communities are being adequately serviced and to reduce unnecessary municipal spending.

Based on the municipal Annual Reports for 2018/19, basic refuse removal service levels in the province range between 41.4% to 100%. Domestic waste collection services are generally provided to households and businesses in urban areas. Informal waste pickers also form part of the waste collection system in South Africa, and play an integral role in the collection and sorting of recyclables. In most instances, households in rural areas and farms can take their waste to a waste drop-off or waste disposal facility. Hazardous waste generated by industry and healthcare waste is collected by private waste collection companies.

Municipalities in the province are currently providing waste management services with limited funds. Some municipalities are operating waste management services at a loss (DEA&DP, 2020). It is therefore necessary for municipalities to improve waste collection and transportation operations to increase efficiency, enhance cost savings and to ensure financially sustainable solid waste management. Waste collection vehicles are a core component of the waste collection system. Ensuring that there are sufficient vehicles available and that they are well maintained and reliable is essential for providing an effective waste collection service. In terms of efficiency, it is important for waste collection routes to be optimized to reduce travelling time, distance and costs. Vehicle route optimisation may be achieved using scientific means and technology e.g. mathematical modelling or Geographic Information System (GIS)-based approaches. Operating an efficient waste collection system also ensures that the appropriate number of staff is assigned to waste collection services. Too few staff may result in inadequate collections being undertaken and overworked staff. Whereas too many staff may result in the inefficient use of time; excess staff may be used in other areas of waste management e.g. collection of recyclables and waste awareness initiatives.

The purpose of this status quo report is to obtain understanding of waste collection and transportation practices being undertaken by municipalities in the Western Cape. The aim is to identify areas in waste collection and transportation where efficiency and effectiveness can be improved. The study aligns with the provincial integrated Waste Management Plan 2017-2022, specifically Goal 2 i.e. "Promote the establishment of integrated waste management infrastructure and services". A key activity under Goal 2 is to monitor the provision of municipal waste removal services.

Since the report only provides a broad overview of waste collection and transportation services in the province, municipalities are encouraged to undertake more detailed studies of their waste collection activities to obtain a clearer understanding of their operations and identify possible areas of improvement.

1.2 Data collection

In addition to reviewing local and international literature, primary data collection was also undertaken through questionnaires. A questionnaire was designed to obtain information about the waste collection fleet as well as waste collection and transportation practices. Waste Management Officers at each municipality were given an opportunity to provide input into the questionnaire design. Once finalized, the questionnaire was distributed to all

municipalities (24 local municipalities and the City of Cape Town). The completed questionnaires were analysed using MS Excel.

The main themes of the questionnaire are indicated below:

Theme	Requested information
Vehicle fleet	Vehicle types Vehicle age Vehicle condition
Vehicle maintenance and replacement	Maintenance Plan Vehicle Replacement Plan Internal vs external maintenance Dedicated fleet manager
Collection route design	Use of software Methods used for route design
Fuel costs	Annual fuel cost Fuel cost per km
Collection operations	Days and hours vehicles are in use Number of staff per vehicle

1.3 Report structure

Section 2: Provides an overview of the solid waste collection system in terms of processes as well as the benefits and challenges associated with an efficient and effective waste collection system

Section 3: Provides an overview of the waste collection fleet and collection operations in the province based on the questionnaire responses received from municipalities

Section 4: Concludes this report and provides a list of possible recommendations based on the findings of the report

Section 5: Director: Waste Management sign-off

Section 6: Provides a list of references utilised

2 The Solid Waste Collection System

2.1 Process overview

Waste management systems consists of various inputs, outputs and actions (Department of Human Settlements (DoHS), 2019). Once waste is generated, it follows different processes depending on the nature of the waste and type of infrastructure and systems in place in the municipality (DoHS, 2019).

Figure 2 depicts the processes involved in solid waste collection. The stages of solid waste collection are outlined in Figure 3 and can be summarized as provided by Boskovic et al. (2013):

- Stage 1- Waste collection truck leaves the depot (or "garage" as indicated in Figure 3) and travels to the collection area.
- Stage 2- Once at the collection area, the vehicle stops along collection points and unloads waste from bins into the vehicle. This is done along a predetermined route.
- Stage 3- Once the vehicle has been fully loaded, it travels to a treatment or disposal facility.
- Stage 4- The vehicle is then unloaded at a recovery, beneficiation, treatment or disposal facility and travels back to restart the process along a different collection route.

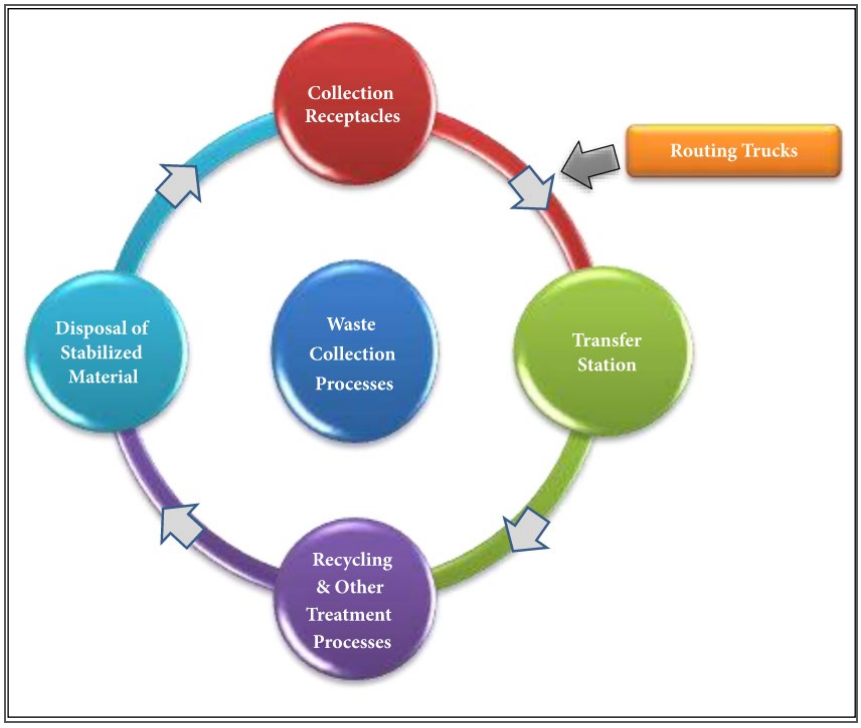


Figure 2: Waste collection and transportation process (Source: Sulemana, et al., 2018)

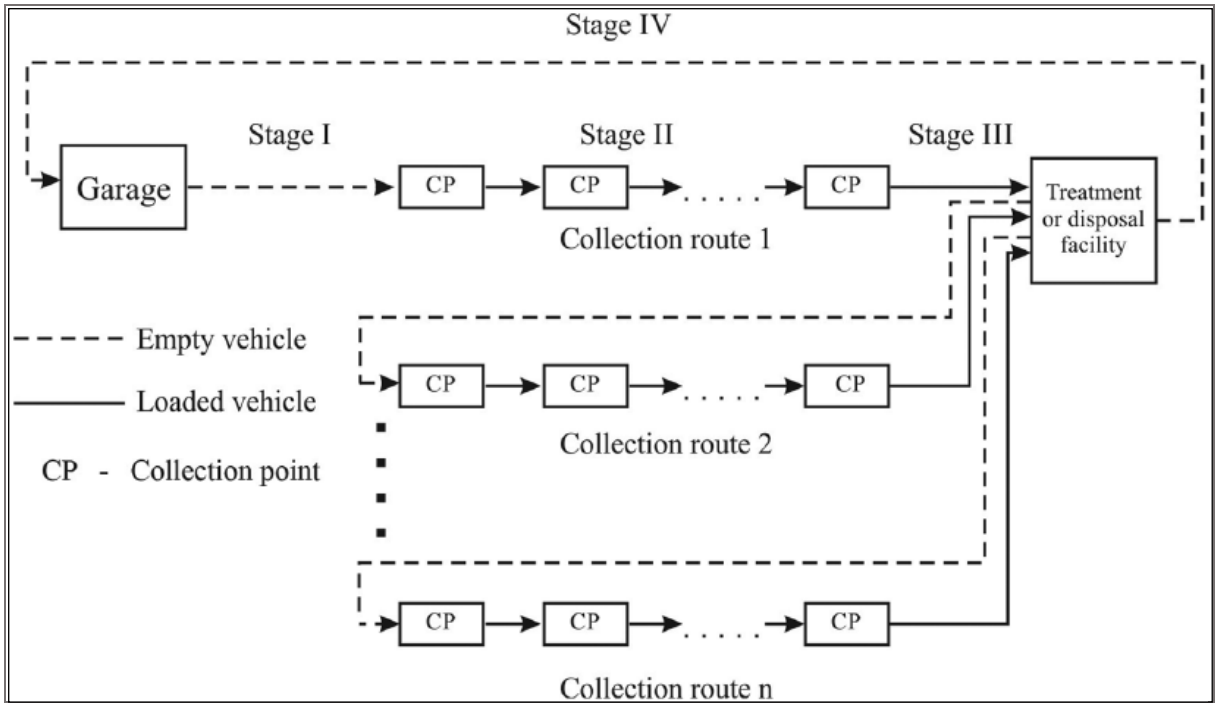


Figure 3: Stages of the waste collection and transportation process (Source: Boskovic et al., 2013)

2.2 Benefits of an efficient waste collection system

An efficient waste collection system may reduce illegal dumping and/or burning practices thus preventing air, soil and water pollution as well as protecting human health. Optimising routes and possibly having fewer trucks on the roads also reduces emissions and noise pollution as well as improve road safety for pedestrians and drivers of the vehicles (Sahoo et al, 2005). Fewer trucks on the roads would also reduce the cost of road maintenance as a result of heavy loading of waste vehicles. Service to the public can also improve with more consistent and reliable services and improve client satisfaction and buy-in to sustainable waste management practices (Sahoo et al, 2005). Since collection and transportation accounts for approximately 60 to 80% of the total cost for solid waste management, an efficient waste collection system can also reduce operational costs (Sulemana et al., 2018) and free up money for other waste management priorities or perhaps transferring the benefit to the public with reduced tariffs. An integrated waste collection approach, taking into consideration layout, length, width of streets and load-bearing of roads would also lead to a more cost-effective waste service (DOHS, 2019).

2.3 Challenges to the provision of effective and efficient waste collection services

The most common challenges for solid waste collection systems include financial constraints, age of fleet, poor vehicle routing, poor road networks, staff challenges and organisational challenges. Rapid urbanisation, informal areas and rural areas also provide waste collection challenges.

2.3.1 Lack of Political Commitment

Politicians generally do not prioritise waste management compared to e.g. healthcare, housing, electricity and water services, which tend to be of greater interest to the electorate (UN-Habitat, 2010). This in turn affects the budget allocation for waste management issues such as waste collection systems; politicians need to support waste management by making adequate resources available (DEAT, 2001).

2.3.2 Financial constraints

Waste management generally receives a small percentage of the municipal budget and income is generated through waste tariffs. However, if the tariffs are set inadequately and users do not pay for waste services then waste management operations cannot be performed. Adequate funding is crucial for e.g. the employment of skilled and unskilled staff, for purchasing of waste collection equipment and vehicles, for maintenance and fuel for collection vehicles (UN-Habitat, 2010) as well as maintenance of waste management infrastructure. Waste collection has been reported to be a fuel-intensive process in waste management systems and contributes significantly to the total cost of municipal waste management (Jaunich et al., 2016). According to the UN-Habitat (2010), a waste collection system can only be sustainable if there is a long-term funding base to support day-to-day operating and long-term financial costs. Often municipalities do not have accurate knowledge of the operating and financial costs and this information is crucial for long-term financial planning and the sustainability of the waste service (UN-Habitat, 2010).

2.3.3 Fleet age

The replacement of old vehicles and equipment for waste collection is affected by limited funding. Municipalities are forced to use old, unreliable and inefficient vehicles and equipment leading to higher operational costs (UN-Habitat, 2010). New vehicles and equipment have low maintenance costs but as they get old, the maintenance costs increase and operating efficiency decreases leading to delays in service provision (UN-Habitat, 2010). Continuing repairing old vehicles and equipment in this case is not effective or efficient and it is more cost-effective to replace the old fleet for a waste collection system to operate sustainably (UN-Habitat, 2010). Municipalities may consider hiring private contractors or trucks to carry out waste collection, but this can be costly and may not be feasible for small municipalities.

2.3.4 Poor vehicle routing and operational scheduling

Waste collection vehicle drivers cannot be expected to determine routes as vehicle routing needs to be determined through effective route planning in order to minimise operating costs, reduce the municipality's carbon footprint and increase time efficiency (Sulemana et al., 2018). According to Sulemana et al. (2018), an effective waste collection system requires good collection schedules that consider cost reduction and environmental conservation. The best vehicle route must consider the distance to the disposal site and time taken to get there (UN-Habitat, 2010).

2.3.5 Poor road networks

Road surfaces in poor conditions increase vehicle operating costs as vehicle speeds need to be slower, increasing journey times (UN-Habitat, 2010). Inadequate road networks and congested roads have a negative impact on waste collection as some waste vehicles may not be able to access suburbs or areas with narrow roads (Sulemana et al., 2018). This usually takes place when waste collection vehicles are donated or purchased without consideration of existing road networks in service areas.

2.3.6 Haul distances to landfill/ transfer station

The long travel distances and associated transportation costs to provide waste collection services in rural areas is a challenge (CSIR, 2011). In municipalities, where it is not feasible to provide a weekly waste collection service to rural areas, residents are able to take their waste to waste drop-off facilities.

The vehicle type is also determined by how far and how often waste must be transported to the disposal site, where some may be unsuitable for frequent, long trips to a disposal site (DEAT, 2001).

2.3.7 Staff challenges

The misuse of waste collection vehicles and equipment by staff leads to high operating costs and according to the UN-Habitat (2010). Drivers also need to be held accountable for any reckless driving that results in traffic fines. The staff complement is negatively affected by lack of funding as municipalities tend to have inadequate technical expertise. Sulemana et al. (2018) emphasises the importance of technical competence for operational staff and how critical this is for optimal performance in terms of waste collection systems. According to Mahmuda et al. (2015), developed countries have capital-intensive waste management systems that require expensive, skilled labour, while developing countries have inexpensive, labour-intensive systems intended for the creation of unskilled jobs to reduce unemployment.

2.3.8 Organisational challenges

Institutional factors can influence the design and management of waste collection systems (UN-Habitat, 2010). Public cleansing and collection services generally account for the largest proportion of solid waste management expenditure, but these services are often managed

by personnel with minimal training in this field (UN-Habitat, 2010). Some municipalities employ community members for public cleansing, which includes the clearing of illegal dumping and street sweeping as well as a waste collection service (CSIR, 2011). A municipality may perform the waste collection service but outsource the clearing of illegal dumping to a contractor (CSIR, 2011). An integrated waste collection system is crucial for the provision of a sustainable waste management service. Waste that is not collected due to delays or breakdown of vehicles becomes a public cleansing issue and often street sweeping, the clearing of illegal dumping and waste collection fall under different sections within the Solid Waste Department.

2.3.9 Challenges with waste collection in informal settlements

An increasing number of people in the Western Cape are unable to access formal housing and live in informal settlements and/or informal housing arrangements (Western Cape Government (WCG, 2016). Informal settlements provide challenges for planning, land use management and the provision of public services and infrastructure (WCG, 2016). One of the biggest challenges in collecting waste in informal settlements is related to limited road access and infrastructure. Limited road infrastructure impacts on the ability of waste collection vehicles to reach households (CSIR, 2011). Narrow roads and steep topography associated with some informal settlements, make these areas inaccessible to waste collection vehicles (CSIR, 2011). Municipalities have had to adopt alternative solutions, such as providing skips where residents can drop off their waste. These skips are then emptied by the municipality. However, illegal dumping of waste outside of these skips and within communities remains a concern.

3 Western Cape Overview

This section provides an overview of the survey results. Nineteen out of the 25 municipalities responded, i.e. a 76% response rate. Figure 4 provides an overview of the response rate per district. Response rates do, however, vary per section, as some of the municipalities provided incomplete information and not all questions were responded to.

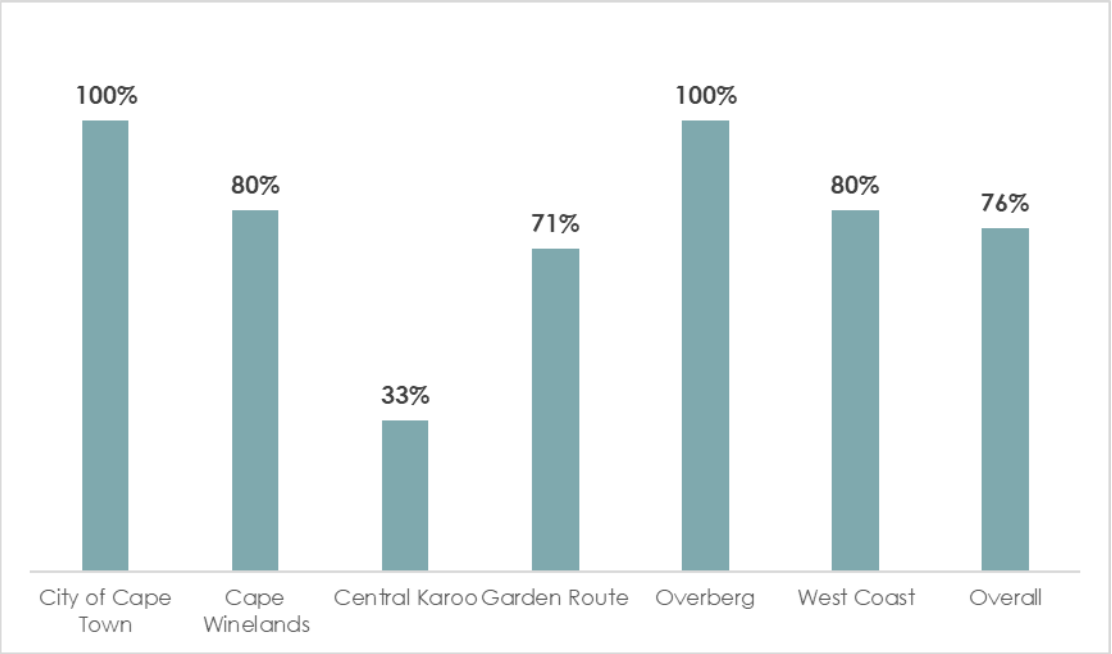


Figure 4: Questionnaire response rate per district

Vehicle fleet overview

This section provides an overview of the waste collection fleet i.e. number and type of vehicles, age and condition of fleet.

Source: Feni,2017

Source: Waste Today, 2019

3.1 Overview of waste collection vehicle fleet

Collection vehicles form a core component of the waste collection system and are used for collecting domestic waste from households and businesses, the collection of recyclables, garden waste and street cleaning waste. Several options for vehicle types are available for collecting and transporting waste. It is necessary that waste vehicles are suitable for the conditions in which they are intended to be used (Table 1). There are various factors that need to be considered when selecting vehicles e.g. local road conditions, accessibility and topography, waste generation, waste density, loading height, number of staff in collection team, method of collection and local manufacture and sustainability (CSIR, 2000, CSIR, 2011, UN-HABITAT, 2010). In the case of compactors, these vehicles are not suited for the transportation of very dense waste with a high ash content; a non-compaction vehicle should instead be used (DEAT, 2001). Using vehicles that are not suited to their working conditions may cause them to become unreliable, thereby negatively impacting waste collection service provision (UN-HABITAT, 2010).

Table 1: Overview of waste collection vehicle types

Vehicle type	Suitable use	Considerations
Roll-on roll-off	Transportation of large capacity open or closed compacted containers ranging from 18 m^3 to 30 m^3.	
Flat-bed truck	Use in developing areas where the high ash content of the collected waste results in increased mass of the container.	High loading height.
Tractor and trailer	Useful where road conditions are not suitable for trucks.	Limited to a maximum 10-kilometre distance to the disposal facility.
Rear-end loaders (compactor)	High compaction ratio and carrying capacity, capable of handling containers up to 6 m^3. Useful for high volumes and where distances to disposal facilities are in excess of 10 km.	Relatively high maintenance costs. Can only be effectively used where good road infrastructure is in place. Legal payloads must be monitored if transporting high-density waste, to prevent a negative impact on the road infrastructure.

Source: information taken from CSIR (2000)

3.1.1 Survey findings

Vehicle types

Most municipalities make use of compactor trucks to undertake waste collection and transportation (Figure 5). These are advantageous in that they have a high compaction ratio and can handle large volumes of waste (CSIR, 2010). Drawbacks include that they are reliant on good road infrastructure and usually have relatively high maintenance costs (CSIR, 2000). The City of Cape Town's vehicle fleet consists of 226 compactor trucks (not shown in the Figure 5). There are however a few exceptions e.g. Cape Agulhas Municipality, mostly makes use of tipper trucks and Cederberg Municipality has a fleet consisting of three small (15m^3 capacity) trucks. Most of the municipalities reported that road conditions along waste collection routes are good, which implies that poor road conditions may not be a major factor during vehicle selection.

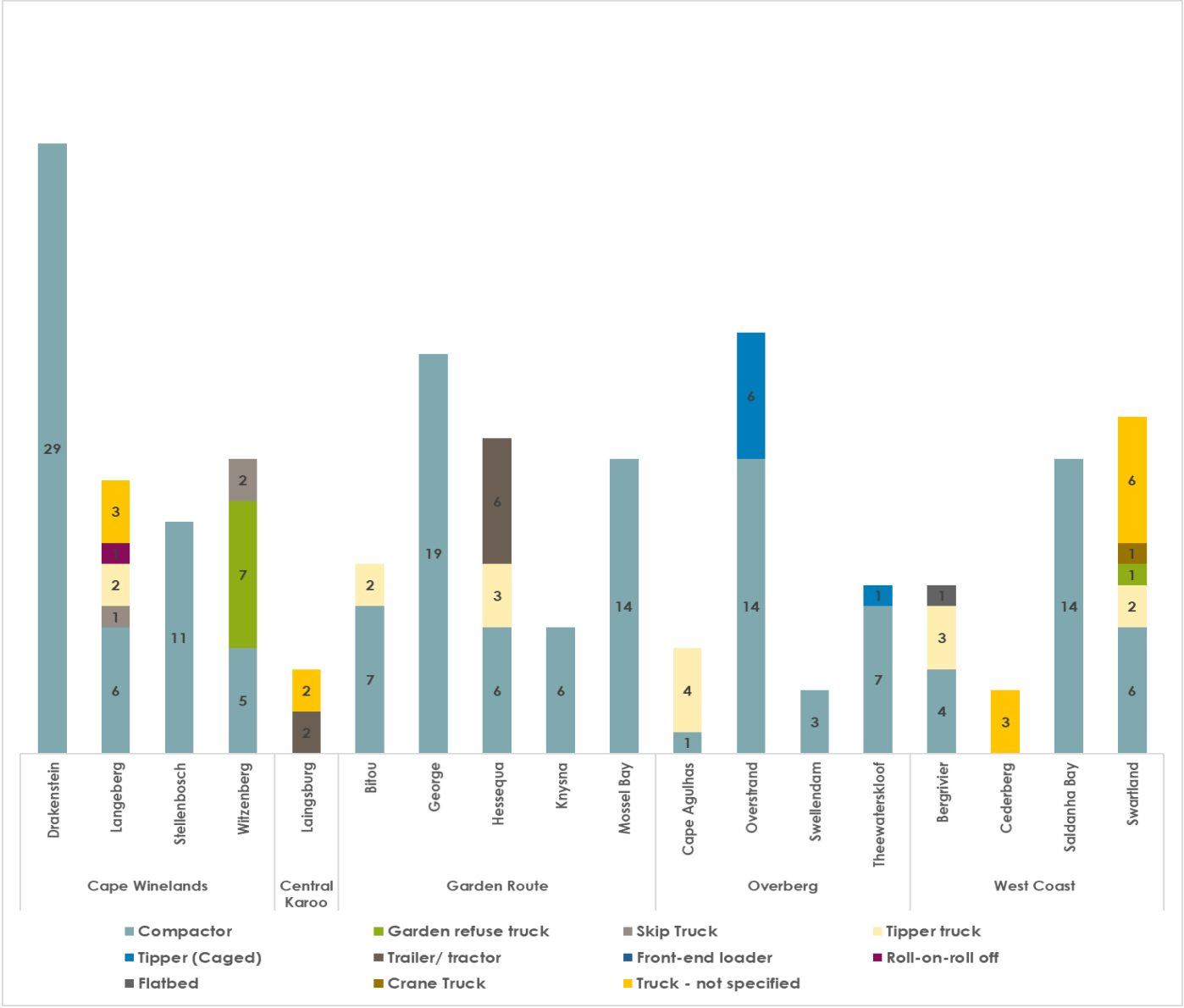


Figure 5: Waste collection vehicle types

Age of solid waste collection fleet

The average fleet age was calculated for each municipality (Figure 6). Municipalities with the oldest waste collection fleet include Hessequa (16.8 years), Langeberg (15.5 years), Overstrand (14.3 years) and Swellendam (14.3 years). Bitou (4.8 years) and Stellenbosch (5.6 years) Municipalities have the youngest fleet. The average vehicle age for the Western Cape is 10.5 years. Figure 6 indicates that when using a vehicle replacement age of 8 years[1], the average age of vehicle fleet per municipality is below this value in only four out of the 18 municipalities that responded.

Figure 7 indicates the percentage of vehicles per municipality that meets the threshold of being 8 years or older. All the vehicles in Knysna, Swellendam and Cederberg Municipalities are 8 years or older. These municipalities have indicated that breakdowns and repairs are a

[1] A replacement age of 8 years was used as this is the general replacement age indicated by municipalities in their IWMPs

challenge for them. Meanwhile Bitou and Saldanha Bay Municipalities have the smallest number of vehicles that are 8 years or older, at 11% and 29%, respectively.

In Cederberg Municipality, where all three of their collection vehicles are 8 years or older, breakdowns were noted as a regular occurrence. Theewaterskloof and Overstrand Municipalities highlighted that when a breakdown occurs, vehicle repairs take a long time. Long vehicle repair times reduces the number of vehicles available for undertaking waste collection, thereby placing pressure on the rest of the fleet.

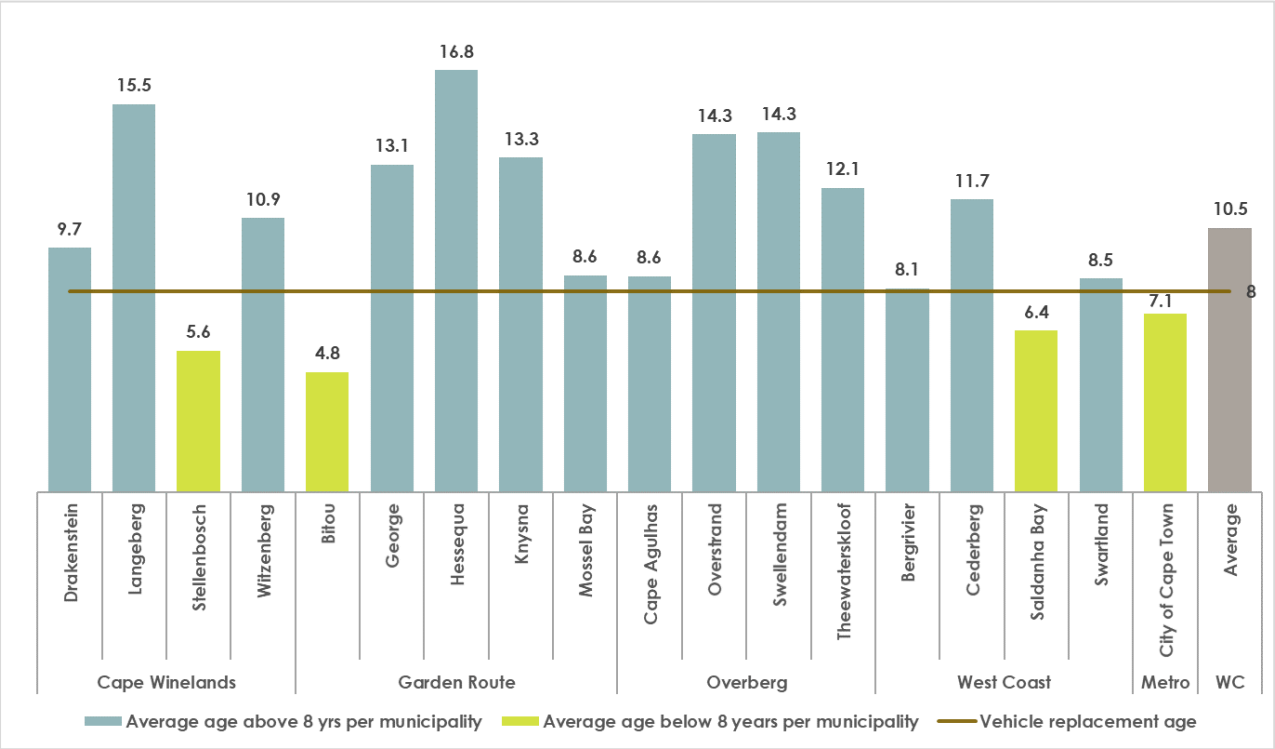


Figure 6: Average age of waste collection vehicle fleet (years)

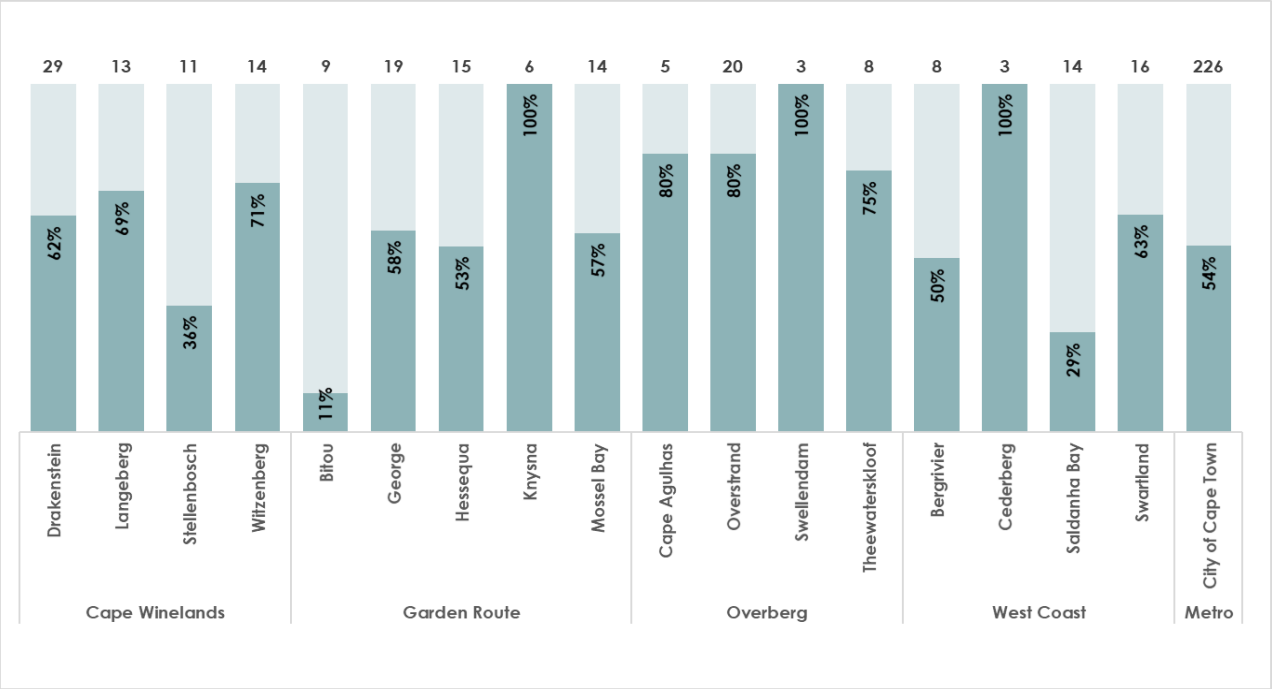


Figure 7: Number of waste collection vehicles and percentage of vehicles that are 8 years and older

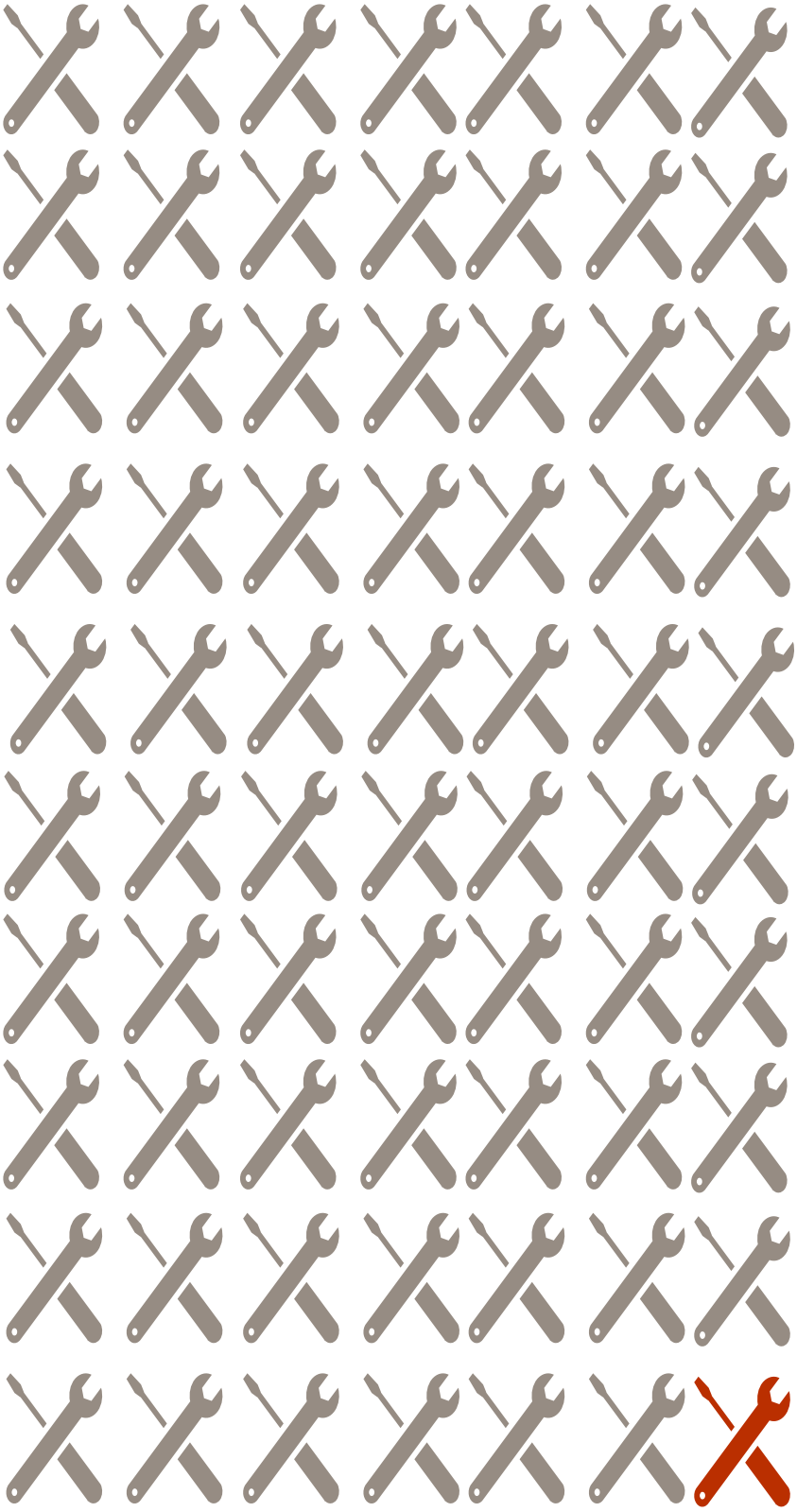
Condition of vehicle fleet

Municipalities were asked to provide information on the current condition of their vehicles. Figure 8 provides the percent of vehicles that were considered to be in "new", "good/fair" and "poor" condition by municipalities. Most municipalities considered their waste collection vehicles to be in good /fair condition. Cederberg Municipality indicated that two of the three vehicles in their fleet were in poor condition. Meanwhile half of Knysna Municipality's fleet is considered to be in poor condition. These municipalities are therefore at risk of having their waste collection services interrupted should they experience breakdowns and not have sufficient available vehicles to undertake the collection.

Figure 8: Condition of vehicles as indicated by the municipalities

Vehicle maintenance and replacement

This section provides insights into whether municipalities have maintenance plans and vehicle replacement plans, internal versus external maintenance and whether municipalities have a dedicated fleet manager to oversee the waste collection fleet.



3.2 Vehicle maintenance and replacement

Municipalities were requested to provide information regarding whether they have plans in place for the maintenance and replacement of their waste collection vehicles. Having these plans in place will assist municipalities in ensuring that there are sufficient vehicles and that vehicles are adequately maintained at all times. This will assist in ensuring that effective services are carried out and that vehicles are not overloaded. It will also reduce unnecessary pressure on other vehicles in the fleet that may need to perform additional rounds. An overview of vehicle maintenance and replacement plans is provided below:

Vehicle maintenance plan

A vehicle maintenance plan is a document that outlines the proactive work that must be done to a vehicle to keep it functioning well. With waste collection vehicles operating frequently and, in some instances, covering great distances, the importance of a maintenance plan cannot be overstated. Refuse truck preventative maintenance is key to minimising costs while maximising uptime (Cottom, 2019). According to Lovely (2018), the lifespan of a truck can be 10 to 15 years with proper maintenance.

These plans typically include the following (Segzdaite, 2019):

- What work must be done, the priority and sequence of the work to be done;
- clear and detailed instructions to conduct the maintenance;
- scheduling of the work to be done;
- stipulate which staff members will conduct which activities, based on their specific skills set;
- spare parts, in this phase the spare parts consumption is predicted. This is generally shared with a store manager, who ensures the relevant spares are in stock; and
- contractors, here the plan specifies work which will require outside contractors.

Vehicle replacement plan

The purpose of a vehicle replacement plan is to decide strategically and plan practically, which vehicles of a fleet would need to be replaced and when. In order to do this, there must be sufficient data/history on the vehicles in the fleet. Parameters such as the age of vehicle, distance covered, maintenance and breakdown history would all have to be considered when planning for replacements. Optimising fleet vehicle replacement allows you to keep costs low, use vehicles through their most useful life, control vehicle safety and more. Effective replacement plans, however, are easier said than done as there is no one size fits all strategy (Robinson, 2018).

3.2.1 Survey findings

Vehicle maintenance and replacement plans

Most municipalities indicated that they have vehicle maintenance plans in place (83%) (Figure 9). Fewer municipalities indicated that they have Vehicle Replacement Plans (61%) (Figure 9). Vehicle Replacement Plans could assist municipalities in being proactive in ensuring that vehicles are replaced timeously. It is expected that those municipalities who have vehicle replacement plans in place would replace vehicles more regularly, thus resulting in a younger fleet. It was found that the average age of vehicles was slightly higher where no plans were in place at 11.6 years compared to 10 years in municipalities that indicated that they had plans in place (Figure 10). It should be noted that there are other factors also influencing how often vehicles are replaced e.g. vehicle replacement cost, condition of vehicles and allocated/available budget.

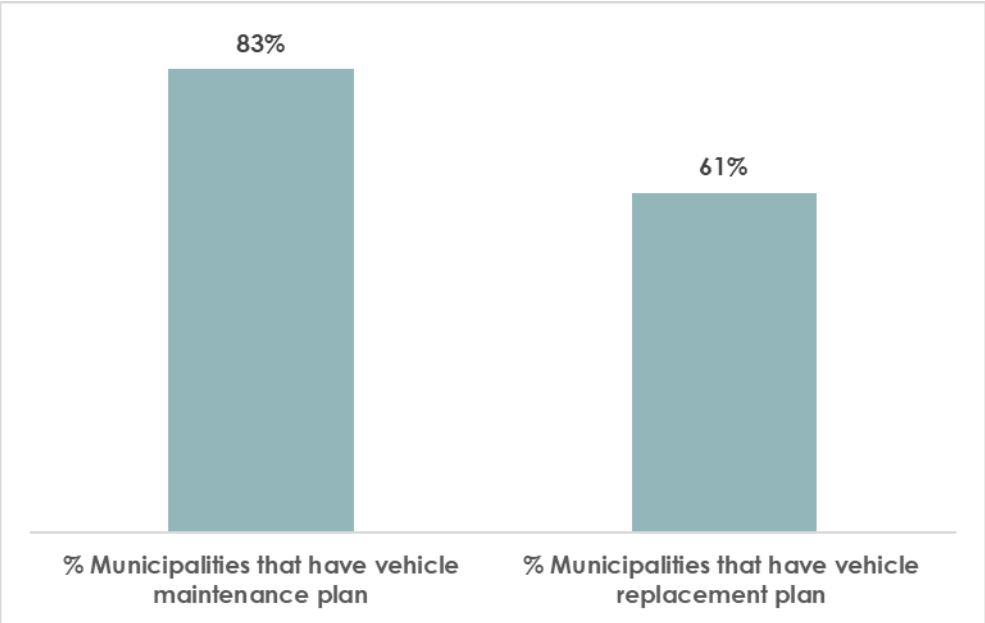


Figure 9: Percentage of municipalities that have vehicle maintenance and replacement plans

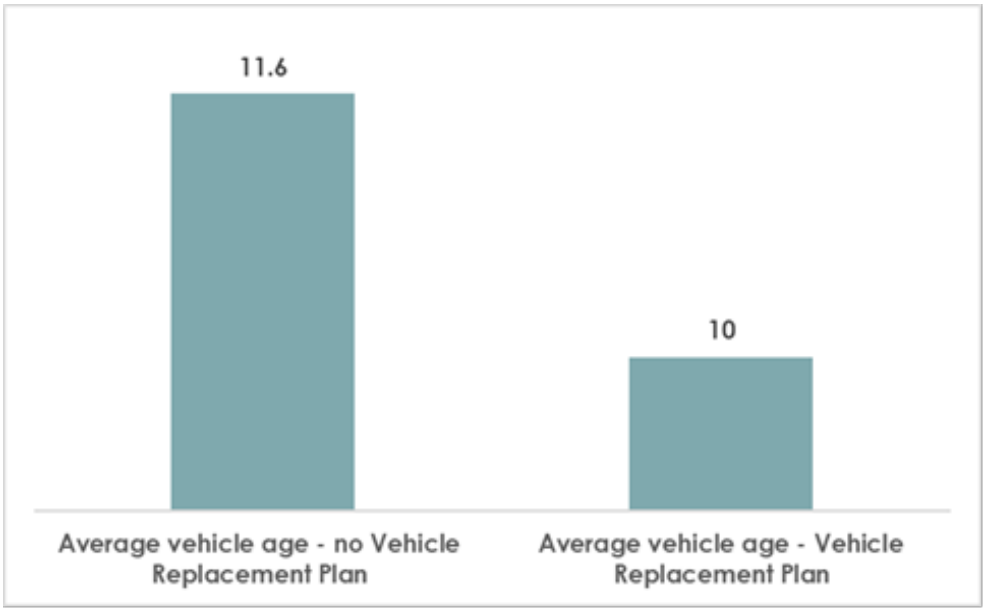


Figure 10: Average age (years) of vehicles in municipalities with vs without vehicle replacement plans

Vehicle maintenance and repair

To ensure that vehicle maintenance is streamlined by reducing vehicle downtime, some municipalities (33%) have their own dedicated workshops and staff to deal with breakdowns and maintenance (Figure 11). Municipalities with dedicated workshops also rely on external service providers when needed. It can be an added challenge when external service providers are situated a distance away. In the case of Knysna Municipality, this challenge was highlighted since their servicing is done in George Municipality and not locally.

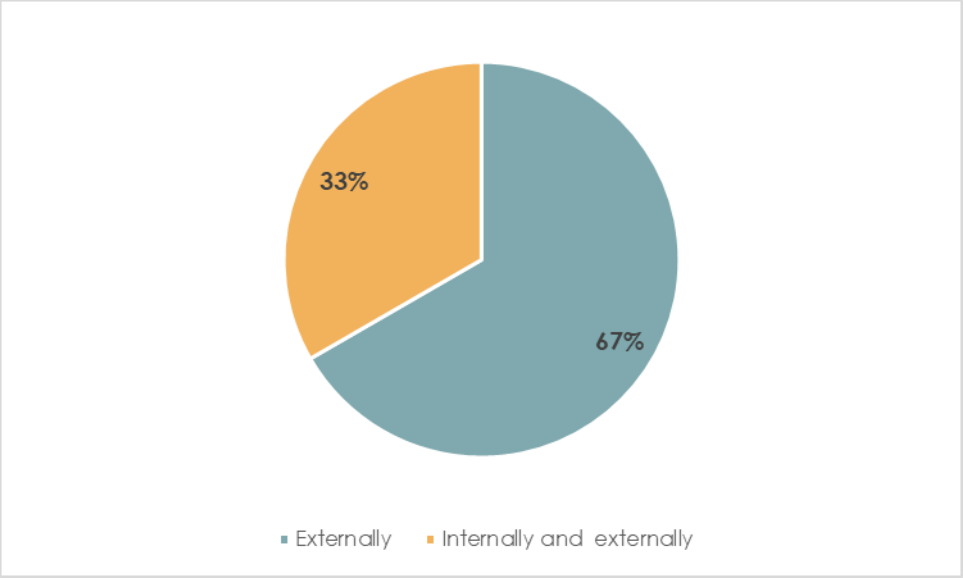


Figure 11: Pecentage of municipalities who undertake fleet maintenance externally vs both internally and externally

Most municipalities (67%) also indicated that they have a dedicated fleet manager to oversee the vehicle fleet and to ensure that vehicles are properly maintained. Vehicle fleet managers are often responsible for overseeing the entire municipal vehicle fleet, of which waste collection vehicles form a part of.

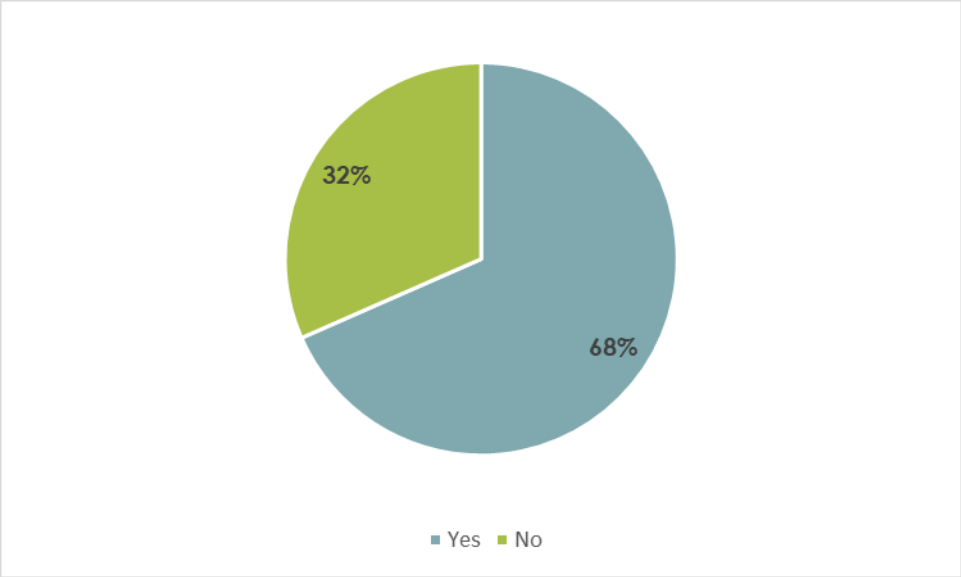
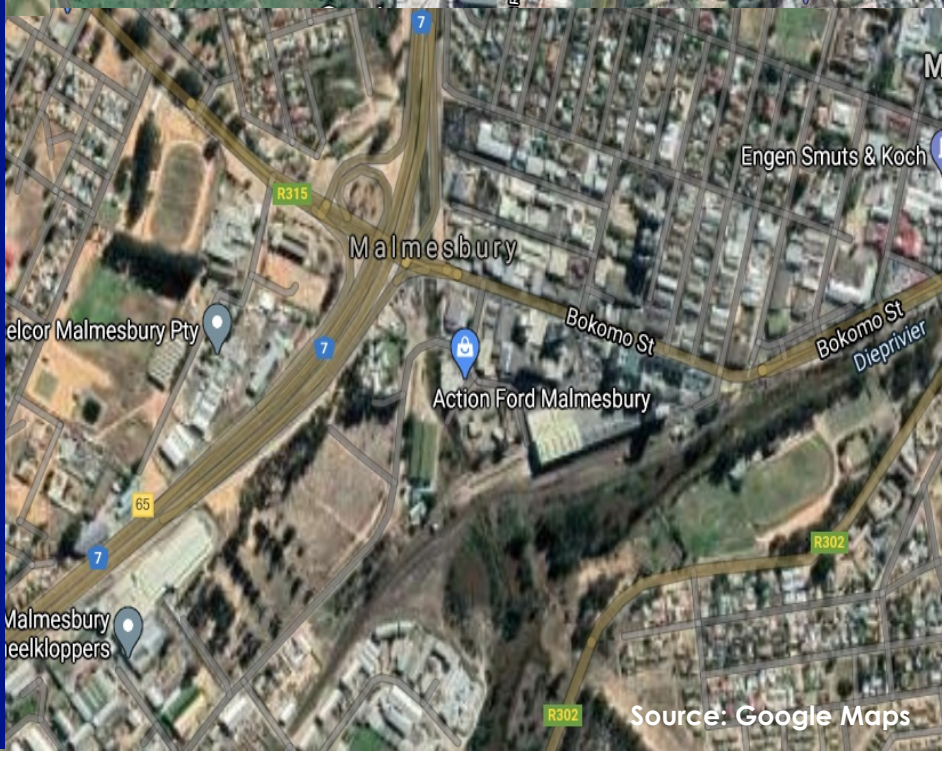


Figure 12: Percentage of municpalities with a dedicated fleet manager

Collection route design

An overview of how municipalities plan their waste collection routes is provided.



3.3 Collection route design

Routing of vehicles is an essential part of waste collection. Routing includes the scheduling and defining of routes trucks will make use of during waste collection (Sulemana et al., 2018). It is important for municipalities to plan their waste collection routes to reduce costs and to ensure that everyone receives adequate services.

Key steps in route planning consists of:

- Identifying the pickup points and the likely amounts of waste to be collected from each point.
- Grouping pickup points to form 'collection rounds' that can be served by a single collection vehicle.
- Planning the route of each collection round taking account of the distance travelled, traffic levels and safety to the public and the waste collectors.

(The Open University, 2017)

In developing countries, there is generally no systematic scheduling of vehicles. Scheduling is thus often based on practical experience, which could result in inefficient and expensive practices (Arribas et al., 2009; Sulemana, 2018, Viotti et al., 2003). Optimal routing of vehicles may be achieved via the application of optimal system designs using mathematical programming, specialised software and the incorporation of Geographic Information Systems (GIS) (Sulemana et al., 2018).

Optimal routing

Route optimisation of waste collection vehicles encompasses the scheduling of collection trucks so that all waste collection points are visited in a defined path to reduce fuel consumption and operating time (Chalkias and Lasaridi, 2009). Route optimisation studies may be used to determine the most cost-effective route a vehicle can use to deliver an efficient service. There has been increasing attention to use innovative approaches to waste collection that simulate waste collections systems (Viotti et al., 2003). Various mathematical methods are used to determine the shortest path in waste collection; some of these are theoretical whereas other use real-time data (Cavdar et al., 2016). Other areas of optimisation focus on a reduction of collection cost or minimising the number of collection vehicles (Sulemana et al., 2018).

GIS can be used for the improvement of productivity and operational efficiency in solid waste collection (Sanjeevi & Shahabudeen 2015 in Sulemana et al., 2018). It has been successfully used in a wide variety of applications, such as environmental modelling and engineering. Optimising waste collection and transportation has been a preferential field of GIS applications, from the early onset of the technology (Chandrakant & Patel, 2015). The technology integrates statistical analysis and geographical analysis from maps.

3.3.1 Survey findings

Except for the City of Cape Town and Mossel Bay Municipality, all municipalities that responded indicated that they did not use any route planning or GIS software when planning their routes. Stellenbosch is currently undertaking a Route Mapping and Vehicle Optimisation study, which will provide inputs into the mapping, analysing and optimising of waste collection operations.

Since most municipalities are not using software to plan their routes, various methods are in place to plan collection routes and schedules. Overstrand Municipality has indicated that their collection routes were planned by their operations teams. Clients/areas are divided into specific collection days. Knysna Municipality indicated that when planning their routes, factors that are considered include population size per ward and the number of available waste compactors. In the case of Stellenbosch Municipality, there are no formal collection routes available. Since truck drivers are familiar with the area, they create and follow their own routes. Some of the waste collection scheduling challenges highlighted by Stellenbosch Municipality include that their waste collection beats are not evenly distributed among vehicles, some of the collection points overlap and that trucks stop at too many collection points, thereby wasting time.

Collection operations

An overview of fuel expenditure, time that vehicles are in use and the number of staff involved in waste collection is provided.

3.4 Waste collection operations

Waste collection costs contribute a significant portion of a municipality's waste management budget. This includes expenditure on e.g. staff salaries, vehicle insurance, cost of purchasing collection vehicles, vehicle maintenance and fuel costs. These costs depend on various factors e.g. size of staff complement, number of households that must be serviced, distance required to travel, size of vehicle fleet, collection frequency and weight and number of bins.

Municipalities must therefore ensure that when scheduling vehicles and planning collection routes, that there are sufficient vehicles and staff available. Another consideration for waste collection is whether the workload is evenly spread amongst vehicles.

3.4.1 Survey findings:

Fuel cost

Municipalities were requested to provide information about their monthly waste collection fuel expenditure for the 2019 period. The annual total waste collection fuel expenditure is presented in Figure 13 per municipality. As expected, the cost of fuel varies greatly across municipalities since fuel usage is dependent on many factors e.g. vehicle type and condition, traffic conditions, topography, number of collection points, distance travelled and driver behaviour. As indicated in Figure 13, Swartland Municipality had highest fuel spend during 2019 compared to other municipalities, whereas Laingsburg Municipality had the lowest.

The total distance covered during 2019 was used to calculate the fuel cost per kilometer (km) Figure 14). This provides a more useful comparison across municipalities. Figure 14 shows that Laingsburg, Overstrand and Bergrivier Municipalities spent the lowest per km for waste collection during 2019. Swellendam, Knysna and Saldanha Bay Municipalities spent more on fuel per km compared to the other municipalities during 2019.

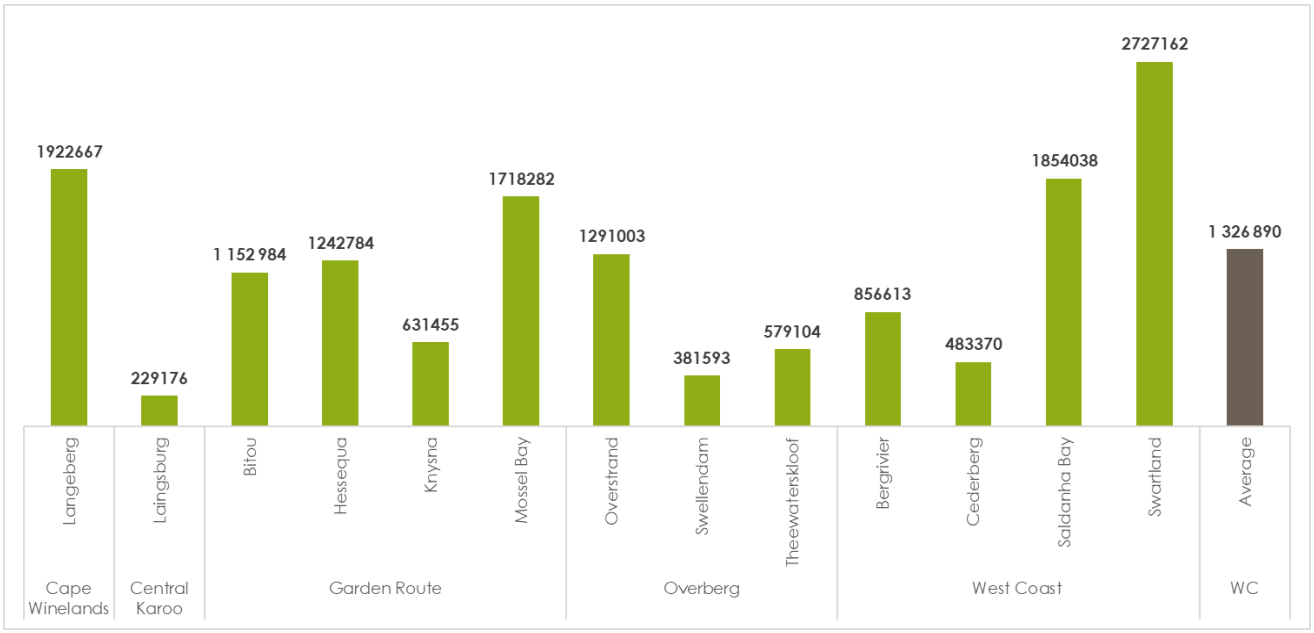


Figure 13: Total annual fuel expenditure (R) for 2019 [2]

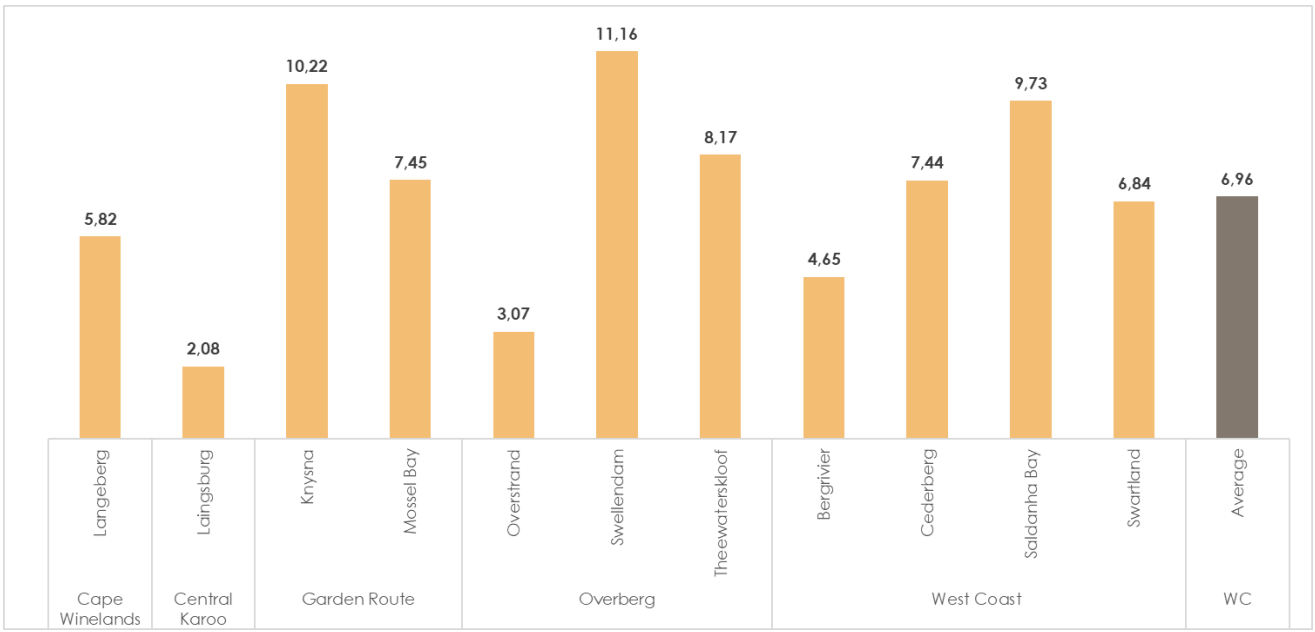


Figure 14: Fuel expenditure (R/km)

[2] Data for Laingsburg and Bitou Municipalities based on approximations and not actual figures

Collection time

On average, most collection vehicles were used 5 days a week, as expected (Figure 15). In the case of Cederberg Municipality, which only has 3 vehicles, vehicles have to be used more frequently i.e. on average 6 days a week to service 6200 collection points. Cape Agulhas and Bergrivier Municipalities use each vehicle on average only 4.6 days and 4.4 days a week, respectively. Cape Agulhas Municipality has 5 vehicles, 4 of which are being used 5 days per week. The remaining vehicle is used to collect recyclables only 3 days a week. In the case of Bergrivier Municipality, although half of their vehicles are used 5-6 times per week, the other half is only used 2-4 times a week, which indicates an uneven spread of vehicle usage. In the Overstrand Municipality, 2 of their vehicles covering the Stanford area, are only used 3 times per week, whereas the rest of the fleet covering other areas, are used either 5-6 days per week. All other municipalities that responded indicated that they have a relatively even spread of vehicle usage.

Vehicles are used 6.9 hours a day on average (Figure 15). The number of hours per day was calculated for each municipality by dividing the total hours per week by the number of days the vehicle was in use. Hessequa, Knysna, Swellendam, Saldanha Bay and the City of Cape Town Municipalities indicated that their vehicles were used on average 8 hours per day. Municipalities such as Laingsburg and Mossel Bay only used their vehicles 5 hours per day. The difference in vehicle usage amongst municipalities could be as a result of distances needed to travel from collection points to the landfill.

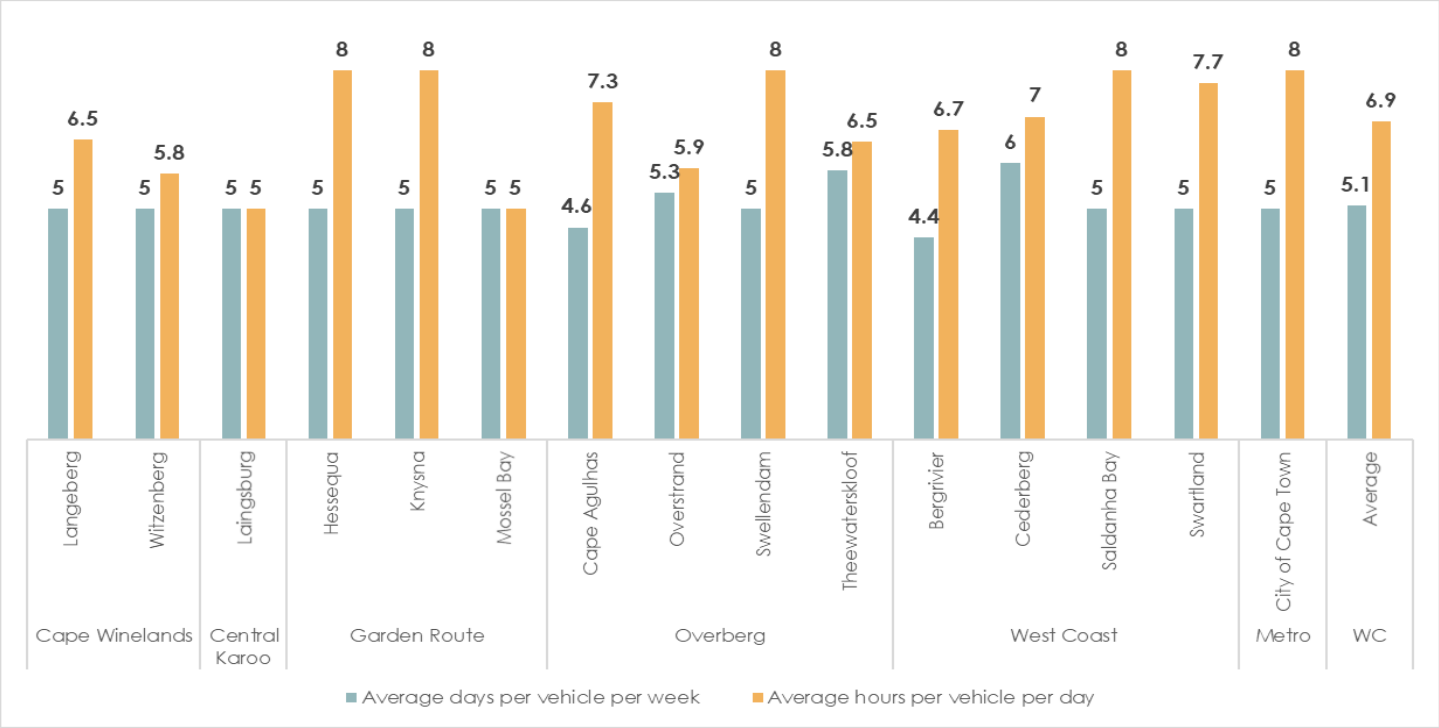


Figure 15: Average days per week and hours per day vehicles are in use [3]

[3] Most values provided are estimations, due to lack of actual trip time data

Collection staff

The number of staff utilised during collection would depend on a number of factors, e.g. type of vehicle and size of collection area. The number of staff utilised could also be dependent on the availability of staff. Many municipalities indicated that there are staff shortages and a lack of finances to fund vacant posts. On average, 4 staff (excluding the driver) are assigned to a truck during collection (Figure 16). Stellenbosch, Mossel Bay and Overstrand Municipalities make use approximately five staff on average. Whereas Laingsburg, Hessequa and Bergrivier on average use fewer staff, approximately 3 on average.

Figure 16: Average number of staff per vehicle (excluding driver)

3.5 Summary of waste collection

An overview of waste collection is provided for each municipality in Table 2.

Table 2:Summary of waste collection

District	Municipality	Refuse removal % (18/19 Annual reports)	Average age of fleet (yrs)	% of vehicles 8 years and older	% of vehicles in poor condition	Vehicle maintenance plan	Vehicle replacement plan	Internal and external maintenance	Route design software	Fuel cost (R/km) (WC average = R6.96 /km)	Days vehicle in use per week (WC average = 5.1 days)	Hours vehicle in use per day (WC average = 6.9 hours)
ODM	Cape Agulhas	100	8.6	80%	0%	Y	N	Internally & externally	N	-	4.6	7.3
	Overstrand	100	14.3	80%	15%	Y	Y	Internally and externally	N	3.07	5.3	5.9
	Swellendam	51.9	14.3	100%	33.3%	-	N	Externally	N	11.16	5	8
	Theewaterskloof	100	12.1	75%	12.5%	Y	Y	Externally	N	8.17	5.8	6.5
GRDM	Bitou	41.4	4.8	11%	0%	Y	Y	Externally	N	-	-	-
	George	100	13.1	58%	42.1%	Y	Y	Externally	N	-	-	
	Hessequa	100	16.8	53%	0%	Y	Y	Externally	N	-	5	8
	Kannaland	64.5	-	-	-	-	-	-	-	-	-	-
	Knysna	96.6	13.3	100%	50%	Y	N	Externally	N	10.22	5	8
	Mossel Bay	98.2	8.6	57%	7.1%	Y	Y	Externally	Y	7.45	5	5
	Oudtshoorn	100	-	-	-	-	-	-	-	-	-	-
CWDM	Breede Valley	100	-	-	-	-	-	-	-	-	-	-
	Drakenstein	100	9.7	62%	0%	Y	Y	Externally	N	-	-	-
	Langeberg	100	15.5	69%	23.1%	Y	N	Internally & externally	N	5.82	5	6.5
	Stellenbosch	93.5	5.6	36%	-	N	-	-	N	-	-	-
	Witzenberg	100	10.9	71%	0%	Y	Y	Internally & externally	N	-	5	5.8
WCDM	Bergrivier	100	8.1	50%	12.5%	Y	Y	Externally	N	4.65	4.4	6.7
	Cederberg	100	11.7	100%	66.7%	N	N	Externally	N	7.44	6	7
	Matzikama	100	-	-	-	-	-	-	-	-	-	-
	Saldanha Bay	83	6.4	29%	0%	Y	N	Internally & externally	N	9.73	5	8
	Swartland	83.5	8.5	63%	0%	Y	Y	Externally	N	6.84	5	7.7
CKDM	Beaufort West	-			-	-	-	-	-	-	-	-
	Laingsburg	100	-	-	0%	N	N	Externally	N	2.08	5	5
	Prince Albert	100	-	-	-	-	-	-	-	-	-	-
Cape Metro	City of Cape Town	98.4	7.1	54%	-	Y	Y	Internally & externally	Y	-	5	8

Acceptable/good		Requires improvement	
Higher than average		Lower than average	

4 Conclusion and recommendations

Although most municipalities across the province offer a good level of service, improvements can be made to improve operational efficiency, thereby reducing costs. A notable issue is that some municipalities are operating with aged vehicles. Breakdowns along with long turnaround times for repairs are also often a challenge. In terms of vehicle routing and scheduling, this is often done using practical experience rather than using mathematical modelling or route planning software, which may lead to inefficiencies. Recommendations for consideration:

- When budgeting and planning, ensure that necessary budgets are set aside to purchase new vehicles when required. The Municipal Infrastructure Grant may be applied for to purchase vehicles in instances where the service will be expanded to poor / previously unserviced areas. The leasing of vehicles or purchasing of second-hand vehicles should also be investigated. The benefits of leasing a vehicle is that upfront capital costs are avoided. Additionally, if vehicle maintenance is included as part of the lease agreement, this could result in a decrease in vehicle downtime (CSIR, 2010). It would thus be beneficial for municipalities to undertake a comparative assessment of the various vehicle procurement options e.g. full purchase vs full maintenance leasing.

- Ensure a proactive approach to vehicle maintenance and replacement. Developing vehicle replacement and maintenance plans can assist in ensuring a well-maintained fleet with sufficient vehicles to provide collection services.

- Investigate the possibility of providing in-house services for smaller repairs, where possible to reduce turnaround times and possibly save costs. Municipalities should compare the cost of setting up and providing in-house vehicle repair services vs the cost of outsourcing all maintenance. The potential higher cost of outsourcing repairs may result in municipalities replacing vehicles more frequently to avoid such costs.

- Several options are available for municipalities to identify and improve operation efficiencies such as high fuel costs, uneven spread of vehicle usage, too many/few staff used during waste collection.

    — Time and Motion studies are defined as, "systematic observation, analysis, and measurement of the separate steps in the performance of a specific job for the purpose of establishing a standard time for each performance, improving procedures, and increasing productivity" (Merriam-Webster, 2020). The data and learnings from Time and Motions studies can be used to formulate waste collection simulation models which calculate the time required to accomplish a solid waste collection trip. Options for economy of time and improvement in the efficiency of collection operation can

best be evaluated by conducting a time and motion study on an existing system (Aremu, et al., 2011).

— Route optimisation studies may be used to determine the most cost-effective route a vehicle can use to deliver an efficient service.

— Route optimisation using software e.g. GIS and mathematical modelling.

- To improve data and to assist with efficiency/optimisation studies, ensure the availability of good data collection and record-keeping practices e.g. vehicles are fitted with GPS tracking devices and logbooks are completed after each trip, maintain accurate staff records and fuel usage records.

- Municipalities should identify gaps in training amongst waste collection staff e.g. driver behaviour training to reduce fuel costs and breakdowns. This includes current staff as well as new staff.

5 Sign-off

I, hereby approve the Waste Collection and Transportation Status Quo Report.

Signature

Eddie Hanekom
Director: Waste Management

Date: 8 March 2021

6 References

Aremu, A. S., Mihelcic, J. R. and Sule, B. F. 2011. 'Trip time model for municipal solid waste collection applicable to developing countries'. *Environmental Technology*, vol. 32, no. 15, pp. 1749-1754.

Arrabis, C. A., Blazquez, C. A. and Lamas, A. N. 2009.' Urban solid waste collection system using mathematical modelling and tools of geographic information systems'. '*Waste Management & Research'*, vol. 0, pp. 1-9

Boskovic, G., Jovicic, N.; Milasinovic, M., Jovicic, G. and Milavanovic, D. 2013. 'Methodology for reduction of GHG emissions from municipal solid waste collection and transport'. *International Journal for Quality Research,* vol. 7, no.4, pp. 641–652.

Cavdar, K. 2016. Design and implementation of a smart solid waste collection system. '*International Journal of Environmental Science and Technology*', vol. 13, pp.1553-1562.

Chandrakant, K. P. and Patel, H. 2015. 'Optimization of solid waste management using Geographic Information System (GIS) for Zone A under Pimpri Chinchwad Municipal Corporation (PCMC)'. *International Journal of Science and Research*), vol. 4, no. 6, pp. 1576-1582.

Council for Scientific and Industrial Research. 2000. Guidelines for Human Settlement Planning and Design. Volume 2. CSIR Pretoria https://www.csir.co.za/sites/default/files/Documents/Chapter_011_Vol_IIsolid_waste.pdf.

Council for Scientific and Industrial Research. 2010. Toolkit: South Africa's good waste management practises – lessons learned.

Council for Scientific and Industrial Research. 2011. Municipal waste management - good practices. Edition 1. CSIR, Pretoria.

Cottom, T. 2019. The importance of preventative maintenance for haulers. [online] Available: https://www.wastetodaymagazine.com/article/nonferrous-copper-aluminum-market-recycling/
[Accessed 3 August 2020].

Department of Environmental Affairs (DEA). 2008. National Environmental Management: Waste Act (NEMWA) (Act No. 59 of 2008). DEA: Pretoria.

Department of Environmental Affairs and Development Planning (DEA&DP). 2017. Western Cape Integrated Waste Management Plan. DEA&DP: Cape Town.

Department of Environmental Affairs and Development Planning. 2020. State of Waste Management Report 2019. DEA&DP: Cape Town.

Department of Human Settlements (DoHS). 2019. The Neighbourhood Planning and Design Guide. Section M, Solid Waste Management. DoHS: Pretoria.

Department of Environmental Affairs and Tourism (DEAT). 2001. Working with Waste: Guideline on Waste Collection in High Density and Un-Serviced Areas. DEAT: Pretoria.

Feni, 2017. Trucks wait at the Muizenberg landfill to drop off the garbage they have collected during the day. GroundUp. 2017. Meet the people who collect our garbage. Available at: https://www.groundup.org.za/article/meet-people-who-collect-our-garbage/ [Accessed 15 February 2021]

Lovely, L. 2018. Waste collection vehicle maintenance. [online]
Available at: https://www.mswmanagement.com/collection/collection-vehicles/article/13034702/waste-collection-vehicle-maintenance
[Accessed 5 August 2020].

Mahmuda, A., Hannan, M. A., Basri, H. and Scavino, E. 2015. 'Solid waste generation and collection efficiencies: issues and challenges'. *Jurnal Teknologi (Sciences & Engineering),* vol. 75, no., pp 41–49.

Merriam-Webster. 2020. Time and motion study. [online]
Available: https://www.merriam-webster.com/dictionary/time%20and%20motion%20study.
[Accessed 20 July 2020].

Robinson, J. 2018. *How to Approach Vehicle Replacement Strategically*. [online]
Available: https://www.fleetio.com/blog/how-to-approach-vehicle-replacement-strategically.
[Accessed 5 August 2020].

Sahoo, S., Kim, S. Kim, B., Kraas, B and Popov Jr., A. 2005. 'Routing optimization for waste management'. *Interfaces*, vol. 35, no.1, pp. 24-36.

Segzdaite, E., 2019. Creating an effective maintenance plan: what should you include?. [online]. Available: https://www.dynaway.com/blog/creating-an-effective-maintenance-plan-what-should-you-include. [Accessed 4 August 2020].

Sulemana, A., Donkor, E. A., Forkuo, E. K. and Oduro-Kwarteng, S. 2018. 'Optimal routing of solid waste collection trucks: A review of methods'. *Journal of Engineering,* vol. 2018, pp:1-12.

The Open University, 2017. Urban sanitation and solid waste management: planning the route for waste collection services [online]. Available: https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=80575&section=7. [Accessed 4 August 2020].

United Nations Centre for Human Settlements (UN-HABITAT), 2010. Collection of municipal solid waste in developing countries. UN-HABITAT. Nairobi. ISBN Number (Volume): 978-92-1-132254-5.

Viotti, P., Polettini, A. and Pomi, R. 2003. Genetic algorithms as a promising tool for optimisation of the MSW collection routes. Waste Management Research, 21: 292-298https://www.researchgate.net/publication/9060508_Genetic_algorithms_as_a_promising_tool_for_optimisation_of_the_MSW_collection_routes.

Waste Today. 2019. The importance of preventative maintenance for haulers. Available at : https://www.wastetodaymagazine.com/article/waste-truck-preventative-maintenance-best-practices/ [Accesses 21 December 2020]

Western Cape Government. 2016. Western Cape informal settlement strategic framework. From precarious settlements to dignified communities. Available: https://www.westerncape.gov.za/assets/departments/human-settlements/docs/issp/western_cape_issp_strategic_framework_2016.pdf. [Accessed 17 December 2020].

Wilson, D. C., Velis, C. and Rodic-Wiersma, L. 2013. 'Integrated sustainable waste management in developing countries'. *Waste and Resource Management*, vol.166, pp.52-68 https://www.researchgate.net/publication/237076750_Integrated_sustainable_waste_management_in_developing_countries.

Wu, H., Tao, F. and Yang, B. 2020. 'Optimization of vehicle routing for waste collection and transport'. *International Journal of Environmental Research and Public Health,* vol. 17, no. 14, pp. 1-26.

Chief Directorate: Environmental Quality
Directorate: Waste Management
Western Cape Department of Environmental Affairs and Development Planning
Private Bag X9086
Cape Town, 8000
Tel: +27 21 483 2712 **Fax:** +27 21 483 3200
Website: www.westerncape.gov.za/eadp

Email: August.Hoon@westerncape.gov.za

Western Cape Government
Environmental Affairs and Development Planning

PR65/2021
ISBN: 978-0-621-49249-1