ECONOMIC ANALYSIS OF HANDLING, COLLECTION, TRANSPORTATION AND DISPOSAL OF MUNICIPAL SOLID WASTE OF RAWALPINDI CITY

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It is certified that the contents and form of the thesis entitled

"Economic Analysis of Handling, Collection, Transportation and Disposal of Municipal Solid Waste of Rawalpindi City"

Submitted by

Muhammad Tayyab Ishtiaq

Has been found satisfactory for the requirement of the degree of Masters of Science in Environmental Engineering

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To My Beloved Parents,

And Respectful Teachers

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

GHGs	Greenhouse Gases
SWM	Solid Waste Management
GIS	Geographic Information System
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
JICA	Japan International Cooperation Agency
RMC	Rawalpindi Municipal Corporation
EEA	European Economic Area
UV	Ultraviolet
US	United States (US)
TMA	Tehsil Municipal Administration
CDGR	City District Government Rawalpindi
HWMR	Hospital Waste Management Rules
RWMC	Rawalpindi Waste Management Company
UCs	Union Councils
C&D	Construction and Demolition
PHA	Punjab Horticulture Authority
WASA	Water and Sanitation Agency
$CAWH_c$	Commercial Area Waste Handling Cost.
$CAWC_c$	Commercial Area Waste Collection Operations Cost.

$CAWT_c$	Commercial Area Waste Transportation Cost.
$CAWD_c$	Commercial Area Waste Disposal Cost.
$RAWH_c$	Residential Area Waste Handling Cost.
$RAWC_c$	Residential Area Waste Collection Operations Cost.
$RAWT_c$	Residential Area Waste Transportation Cost.
$RAWD_c$	Residential Area Waste Disposal Cost.
$MAWH_c$	Municipal Are Waste Handling Cost.
$MAWC_c$	Municipal Area Waste Collection Cost.
$MAWT_c$	Municipal Area Waste Transportation Cost.
$MAWD_c$	Municipal Area Waste Disposal Cost.
CA_C	Commercial Area Cost
RA_C	Residential Area Cost
CA_E	Per Capita Commercial Area Expenses
RA_E	Per Capita Residential Area Expenses
WHC	Waste Handling Cost
EU_c	Equipment and Utilities Cost
C_C	Containers Cost
CR_C	Container Repair Cost
WCOC	Waste Collection Operation Cost
HD_C	Hauler Drivers Salaries Cost
TS_C	Transportation Staff Cost
UW_c	UC Workers’ Salaries Cost

SC_c	Operations Supervisors Salaries Cost
$CM\&R_C$	Collection, Maintenance, and Repair Costs
HD_C	Heavy Vehicles Driver Salaries Cost
LD_C	Light Vehicle Driver Salaries Cost
HO_c	Helper Operator Salaries Cost
CF_c	Fuel Consumption
OS_C	Operations Staff Salaries Cost
SI_C	Shift In-Charge Salaries Cost
M_C	Miscellaneous Expenses Cost
WTC	Waste transportation cost,.
$TM\&R_C$	Transport (Vehicles) Maintenance and Repair Cost
TF_C	Transport Fuel Cost
HD_C	Hauler Drivers Cost
TS_C	Transportation Staff Cost
WDC	Waste Disposal Cost
DS_C	Disposal Staff
DF_C	Disposal Fuel Cost
DU_C	Disposal Utility Cost
$DM\&R_C$	Disposal Maintenance and Repair Cost
DCM_C	Disposal Contractor Operators and Machinery Cost
DM_C	Miscellaneous Disposal Expenses
PKR	Pakistani Rupee

ABSTRACT

The appropriate estimation of the costs related to municipal waste management operations is crucial in planning and implementing the best cost-effective waste management system. In the presented study, the current municipal solid waste system was studied to evaluate the municipal waste (MW) types and their composition. The operational conditions were also considered to evaluate the current handling, collection, transportation, and disposal costs. Results suggest that the MW of Rawalpindi has a municipal waste with a varied composition containing 22% recyclable materials. As per the cost analysis based on the field data and departmental data, the current cost of municipal solid waste handling, collection, transportation, and disposal are 4.0%, 68.1%, 6.8%, and 21.1%, respectively of the total waste management cost . Moreover, the overall current per capita municipal solid waste operating cost of Rawalpindi city is 59.67 PKR/Capita and 0.39 $/capita. The recyclable content was considered an opportunity for the cost reduction. Its recovery can help to reduce the current transportation fuel cost & current disposal cost by 13.75% and 21.83% respectively. Additionally, it will add a recyclable cost-benefit and social carbon cost-benefit. The study is concluded by providing a cost-benefit of 8 PKR/capita or 0.05 $/ capita in the current per capita municipal waste operating cost by decreasing it to 52 PKR/Capita and 0.34 $/capita. Per capita cost saving of 13.23% has been achieved. This study puts into practice a method that utilized waste management data of a densely populated local city of Pakistan and highlighted the key areas, which can help in optimizing the cost of waste management. This approach can help local waste management companies to set a solid municipal tariff, in finding cost-effective and efficient solutions for waste management. Furthermore, the per capita cost of waste paid by the city residents can be economized.

CHAPTER 1. INTRODUCTION

1.1 Background of the Study

According to the world meter calculations, the current world population is 7.7 billion as of May 2020 and this population is growing at a rate of almost 1.05% per year (Khan et al.,2021). The increase in population is negatively impacting the carrying capacity and ecosystem functioning of the earth. However, it has been estimated that

> "It is increasing worldwide and the contributing factor towards the increase in volume and complexity of waste is the modern economy (Rodriguez et al., 2020). According to the World Bank. (2016), the worlds' cities generated 2.01 billion tonnes of solid waste, amounting to a footprint of 0.74 kilograms/ person/ day. Based on the current status, it is expected that there will be an increase of 70% from 2016 levels to 3.40 billion tonnes in 2050 (World Bank, 2020)."

For disposal of the waste different countries have different methods but in the case of developing or low-income countries, the most common method is unregulated dumps and open burning. This contributes to the emission of Greenhouse Gases (GHGs) in the atmosphere that adds to global climate change (World Bank, 2020). It is estimated that uncontrolled landfills are the world's third-biggest source of methane emissions (Azam et al., 2020). It contributes to about 5 percent of global GHGs emission (Shen et al., 2020). Therefore, to minimize the overall climate impact it is important to dispose of the waste properly which will contribute to sustainability also, but it remains a challenge for many developing countries as it demands 20–50% of municipal budgets. Unfortunately, in Pakistan like many other developing countries, it is the most neglected sector in overall environment planning. Due to this, the country is facing serious environmental problems (Exposito and velasco, 2018; Batool, 2017).

1.2 Introduction of Solid Waste Management

Over the years, globalization, population growth, economic changes, and lifestyles have increased the production of solid waste resulting in solid waste management (SWM). Waste is treated directly without proper inspection and supervision, which leads to serious environmental pollution and exacerbates health problems. Therefore, one of the biggest challenges facing urban areas around the world is SWM. The reason for this is the accumulation of human compositions, and these compounds are likely to produce many containers of waste, whether it is low or medium level. They cause environmental pollution and pose a long-term problem for humans (Das et al., 2019).

In 2000, solid waste production was estimated at more than one trillion metric tons per year and is expected to reach 5 billion by 2030. If this situation is not addressed in time, it will have serious consequences globally. In many countries, high importance is attached to SWM, and many new technologies have been developed to improve the waste management system (Nanda and Berruti, 2020) Geographic information system (GIS) transmits data to a computer to reinforce alternatives and make more efficient decisions (Singh, 2019). At present, the world's annual production of solid waste is around 1.6 billion tons, and a significant amount of the budget is used for SWM. In the 1990s, in waste management alone, Asian countries spent about 2.525 billion annually, and this number is expected to increase to 5.050 billion by 2025 (Aleluia and Ferrão, 2016)

Due to a lack of financial and technical resources; the developing countries have failed to properly dispose of solid waste. Despite the lack of funding and skills in the public sector, this raises an important question about how to provide quality services (Nanda and Berruti, 2020; Syeda Batool, 2017). Urban SWM relies on quantitative and reliable estimates. In urban areas, household waste is an important part of municipal solid waste, and as such, it directly affects the design of municipal SWM systems (Exposito and Velasco, 2018).

These statistics show that SWM has become a complex, large and costly service. In general, waste productivity is directly proportional to economic growth, population growth, and changes in people's lifestyles (Aleluia and Ferrão, 2016). As the world progresses and develops, so does the amount of waste, which has become a major issue of global concern. Engineers search for waste management solutions using an environmental protection map and study the effects of waste on public health and the environment, (Chang and Pires, 2015). Domestic, industrial, and other wastes also contribute to environmental pollution. Therefore, municipal solid waste management (MSWM) is essential for the sustainable development of developing countries (Azam et al., 2020).

Urban solid waste disposal sites are located in developed countries and have become a major source of pollution due to the spread of mosquito, fly, and poultry diseases affecting the health of residents (Bernhard et al., 2020). According to Marshall. (2020), dumping sites would lead to huge economic and social costs for public health services, and the management committee did not deal with them. The United Nations Environment Program (2006) has determined that people are at risk due to the free disposal of toxic substances and pollutants in open waste, especially children, litter boxes, health workers, workers, and people who live near the pond. The water supply is polluted (due to landfills or landmines) (Randhawa et al., 2020)

According to Rasheed et al. (2019), the amount of household waste in Pakistan is 0.5 to 1 kg per day, which is higher than the records of other developing countries. Even if the per capita head loss rate is low, waste management remains a major challenge for Pakistan. In Karachi, for example, which is the largest city in Pakistan; the municipality receives only 50 of the 7,000 tons of solid waste that is produced every day(Rasheed et al., 2019).

Traditionally, both the formal and informal sectors have been involved in the collection of solid waste in Pakistan. In the formal sector, the municipality is responsible for the collection of garbage or waste from the city and dumping it. The informal sector has two components: one is based on the small business owners, who buy formal items from homes and the other is based on street children. Other small efforts include creating a market for recycling, where households will sell their recyclable waste. Most solid wastes in Pakistan include vegetable and fruit wastes, dust, dirt, and construction wastes (Mahar et al., 2007).

These aspects may include the scale of urbanization, type and density of urban areas, the physical structure of waste, the density of waste, the performance of high temperature and rainfall and depth, capacity, and repeatable segregation (Withanage et al., 2020).

As the concerned municipalities have different styles of SWM, development authorities cannot provide the same SWM system to different communities, so non-standard SWM systems operate in Pakistan. Due to lack of storage tanks and poor management of waste, garbage collection efficiency is also very low. Open dumping, open burning, and centrifugal non-ferrous metal ground abrasives are some of the major waste disposal methods in Pakistan. Even for these cities, there are no solid waste estimates for different types of homes. For example, compared to low-income households, high-income households do not have disposable production and waste types, which creates a knowledge gap in Pakistan due to a lack of urban waste management policies. Despite its importance, the social and economic impact of solid waste in Pakistan is not well understood (Atta et al., 2020).

1.3 A Case Study of SWM in Rawalpindi

The city government of Rawalpindi collects waste from the city. The supervisory staffs of the Rawalpindi city committee consist of hygiene supervisors and senior sanitation inspectors, who monitor the collection and disposal of solid waste and provide guidance to these low-ranking employees. The area surrounding the public storage facility has been completely identified. People can throw garbage cans from a distance to a common spot showing the scenery where litter boxes could be. The number of compounds collected remains small and insufficient.

The average number of trips is 2 boxes per day, which is less than the number of ideal trips per day, i.e., 3 trips. The city government has installed 200 boxes in 57 points of Rawalpindi. From 100 boxes every day, the equivalent of this is about 128 tons per day (46,720 tons per year) (Akmal and Jamil, 2021).

The Japan International Cooperation Agency (J1CA) plan with the assistance of the Japanese government developed the municipal solid waste disposal system, providing 40 trucks and nearly 200 containers for garbage collection, including bulldozers and computers.

These projects have undoubtedly improved the solid waste collection and management component, but the final disposal of the collected waste remains a problem that needs to be solved through engineering. Presently, Rawalpindi Waste Management Company (RWMC) does not have a suitable landfill or disposal site. There is no separation of toxic and non-toxic waste. This can have serious health, safety, and environmental impacts.

1.4 Risks and Problems Associated with Solid Wastes in Study Area

Solid waste is not properly managed in Rawalpindi. Therefore, there can be many negative effects. Unselected garbage bins often enter the water, causing obstruction, flooding, and chaos in the city. Solid fruit flies reproduce in some parts of solid waste, and fruit flies are effective vectors for spreading disease. The mosquitoes are in water-filled drains and rainwater that is stored in canals, tires, and other objects. Diseases, including malaria and dengue fever, are rampant in mosquitoes. Waste disposal causes air pollution. Combustion products contain especially dangerous dioxins. Plastic bags have a special charm that eliminates edible pastures (Masood et al., 2014). Hazardous substances (such as broken glass, razors, hypodermic needles, other health wastes, aerosols, containers, and potentially explosive chemicals) can be a risk of injury or poisoning, especially of children and people with organized wastes (Altaf and Deshazo, 1996).

Waste trucks can cause serious damage to sidewalks that are not specifically designed for this type of load. Waste leachate to groundwater seriously contaminates the water supply. Chemical waste (especially persistent organic matter), if wet, gasped, or inhaled, can have fatal or harmful effects and can be a major cause of water pollution (Safar et al., 2021).

1.5 Problem Statement

The financial sustainability of solid waste management systems is one of the greatest challenges in low- and middle-income countries. This study summarizes the following:

- For sustainable waste management operations, the study of the waste composition is required
- The current per capita cost does not exist for waste management in Rawalpindi
- Cost benefit analysis for the running of waste management of Rawalpindi to be provided

1.6 Objectives

1.6.1 General Objective

The general objective of the study is to assess the economic efficiency of the existing and the old operational setup of SWM options in the Rawalpindi municipality.

1.6.2 Specific Objectives

1. To Assess the Composition of Municipal Waste (excluding hospital waste) in Rawalpindi
2. Calculating Current per Capita Cost of Handling, Collection, Transportation and Disposal of Commercial and Residential Waste
3. Conducting the Cost-Benefit Analysis to Reduce the Current Per Capita Municipal Waste Cost.

1.7 Significance & Justification of the Study

The study is significant because it has evaluated the economic aspects of different systems in Rawalpindi and found out comprehensive services, which will prove the ability to reduce costs; Operating costs usually account for 60-85% of total waste management costs.

The study generated empirical information on types of municipal solid waste generated in Rawalpindi Municipality, SWM, and the economic analysis of different alternative SW management options in Rawalpindi municipality. The study is going to analyse the cost-benefit analysis. Further, such information is useful as a tool in decision making, showing which option is cost-effective as well as showing cost centres that can be unnecessary and which can be reduced.

Moreover, it is a common practice that developed countries are disposing of their waste, while in developing countries like Pakistan it has become the favourite destination for this practice (Ilyas, 2018). This practice is severely affecting the health condition of the public and it has been estimated that approximately 5 million annual deaths alone are due to waste-related diseases in Pakistan (Ilyas, 2018).

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The SW literature not only questions household solid waste but also industrial and non-residential waste generated in cities. A review of the SWM literature reveals that much of the literature focuses on the delivery aspect of SWM, including topics such as garbage Handling, collection, transportation, and garbage disposal routes. Also, there is little literature on residential waste, with the main focus on recycling and filtration of solid waste and its determinants.

The adaption and implementation of other foreign strategies and policies become complicated due to variations in waste composition, which differ between geographical regions, from country to country, among nations, cities, and even within a city. Broadly saying in developing countries, it is mostly organic with high moisture content and low calorific value (Majeed et al., 2018). The absence of educational programs further adds to the problem of polices implementation because without a clear and proper understanding of policy it becomes difficult for states, provinces, and municipalities to determine the most appropriate solution for waste management (Majeed et al., 2018). Additionally, there is an absence of environmental legislation, a reliable framework as the limited investment is usually made in the SWM sector, and the weak government mostly controls it. The situation in developed countries is comparatively different, they are good at managing their waste and factors such as environment, climate change, resource scarcity, public health, awareness, and participation are acting as SWM drivers (Aleluia and Ferrão, 2016; Exposito and Velasco, 2018)

2.2 Waste Management

Waste management includes the proper handling, collection, transportation, and disposal of waste. More broadly, it includes all activity from generation until final treatment and disposal. Globally a lot of research is being conducted in waste management and to date, a wide range of waste management techniques are available such as landfills, incineration, recycling, composting, 8 waste collection, and energy recovery. Some of these techniques convert waste into energy and fuel and hence promote public health, environmental protection, and minimum GHGs emission (Gentil et al., 2009). Many European countries are following the waste management hierarchy, which encourages waste prevention as a top priority followed by reuse and recycling to avoid waste going to the landfill. By doing, they have minimized their waste products along with financial and environmental benefits. It has been estimated that in 2012 the total municipal waste generation in European Economic Area (EEA) countries declined by 2%, despite a 7% increase in real household expenditure (Rajaeifar et al., 2017)

2.3 Different Aspects Linked to Municipal Solid Waste

Unlike cities in developed countries, the amount of municipal solid waste in developing countries has not been extensively analysed, and the rate of waste production has not been estimated. The present literature presents only a few examples of research on the production of domestic waste, especially in developing countries (Iyamu et al., 2020). The waste disposal study in Kathmandu estimates that the per capita household solid waste production is 161.2 grams (g / day). Most of the collected waste is organic, but there is also some hazardous waste. The authors specify that, for a 95-confidence level, Kathmandu needs a sample size of 273 households to provide a reliable estimate of household solid waste production (Poudel et al., 2019).

2.3.1 Socio-Economics of Municipal Solid Waste

Domestic solid waste generation research generally involves income levels or fundamentals to differentiate a home sale price. A study of 125 Mexican families and separated them according to their structure. They were divided into dynamic fathers, extended fathers, and single fathers. Household garbage was collected from house samples for eight days. The results show that the family structure (nuclear, extended, and single parent) has a direct effect on the amount of waste produced. However, the structure of the house does not have a significant effect on the properties of the waste produced. Conversely, family life affects the type of waste produced (Ojeda et al., 2000).

Similar studies divided families among McCurdie, Nigeria into high, middle, and low-income groups. The study found that households generated 82% of municipal solid waste, and the rate of waste production was 540 g / c. The investigation lasted 11 days (Ogwueleka, 2013).

A study of about 160 households in a region of Nigeria found a significant correlation between household loss, household size, income, and education level. This study relied on a large sample of 648 households to collect social geomorphological data. However, the data was collected from one in every 648 households in the sample (Abel, 2007).

The solid waste produced in Indian cities is the same as mentioned in the literature. A survey of three neighbours with different incomes in New Delhi found that income has a significant impact on waste generation (Bhawal et al., 2016). Households in high-income residential areas generate more solid waste than middle-income and low-income residential areas. Data was collected from 500 to 700 households in the state. The study also found that the waste generated by each household increases with the size of the household. However, the density of heads decreases as the size of the family increases. The relationship between income, education, socioeconomic status, and the waste generated is not always a consequence. Although the above study reports that households with higher incomes and well-educated households produce more waste per capita.

Another study in Nigeria shows that with the improvement of education, income, and social status, household waste generated by households has decreased (Bhawal et al., 2016). Similarly, another study of 47 households in Garber, Botswana, found that there was no direct correlation between waste production and income (Mbongwe et al., 2008).

Another study of 113 households in six different communities in Beijing, China collected garbage for 10 days and found that each household generates 230 grams of waste per person per day (Du et al., 2018). However, the increase in household size or income is negatively proportional to the amount of waste generated every day. Likewise, most educated households seem to have low levels of trash cans.

The differences in the above results indicate that caution should be exercised when concluding the impact of socio-economic factors on households or singles in different parts of the world, and households living in different parts of cities. Temporary changes in household solid waste production were also reported. A Nigerian study shows that the number of trash bins in December has doubled compared with January (Olaseha et al., 2005). Another study in Nigeria found that the level of solid waste reported in October was higher, while the level of household waste observed in February was lower (Elemile et al., 2019). Every day, Saturday recorded the highest amount of waste generated, and Thursday recorded the lowest amount of waste generated.

2.3.2 Economics and Solid Waste Management

For example, Amino et al. (2021) found in Bangladesh, municipal officials failed to provide proper garbage collection services (Ananno et al., 2021). A study conducted by Sujauddin et al. (2008) cites the willingness of the private sector to pay for the collection and management of solid waste in Chittagong. The author found that 44% of households are willing to pay 0.3-0.4% of their garbage every month. They also discovered marginal price markets, because many garbage households are willing to pay for services and vice versa. The rate pricing system is believed to reduce household waste. The reason is that when households use the same pricing system, as the amount of waste generated increases, the cost increases, and the waste they generate decreases(Sujauddin et al., 2008).

Taiwan’s garbage disposal research shows that after implementing the same price, the number of garbage bins has decreased. On the other hand, the fact that households started throwing garbage in neighbouring areas led to a decrease in the garbage. Therefore, the effect of price recovery is minimal because it only transfers waste from one constituency to another which does not offset the costs of waste management. Each pricing program is based on internal payments for solid waste collection and management services. A Mexican household study in Mexico recorded the satisfaction of households paying for SWM services using a knife scale and showed that the socio-economic characteristics of a household directly affect home loss (Tsai, 2019).

Investment in MSW management involves establishment cost, operation cost, and maintenance cost. It requires good equipment and machinery to produce advanced and modern recycling products, pieces of land for composting, waste separation cost, and basic equipment for moisture control (Senzigeet et al., 2020). Dumping requires labour cost, transport cost, fuel, and maintenance of trucks. While composting, can serve as a source of organic fertilizer, which is cheap and environmentally sustainable. Recycling is a source of cheaper raw materials that can be used to create new products through which new jobs are created and resources are conserved. (Marshall, 2013).

In the United States, contracts for waste collection and management are usually awarded to private companies. Therefore, the cost of the same service requires an accurate estimation of solid waste production. In Broward County, Florida, household waste is estimated at 1837 kilograms per household per year. The revised estimate shows that the waste management rate is 18% lower than the site waste management rate with the waste management company. The revised estimates indicate that the contractor has incurred additional costs over the past few years, which could be avoided if appropriate waste production studies are carried out earlier (Feliciano and Prosperi, 2011).

A summary of waste production rates for 23 cities in India shows that GDP per capita (G) equals 743 grams. The amount of household waste generated ranges between 220 g / c / d as a minimum and 670 g/ c / d as a maximum.

2.3.3 Solid Waste Management in Pakistan

Other studies, particularly in Pakistan, have shown that families in Gujranwala not only care about improving SWM but are also willing to pay for better services (Altaf and Deshazo, 1996). The studies mentioned above were conducted in a low-income economy with a reported waste generation. A similar survey of 1500 households in Karachi showed that the level of garbage production per household was 1.1 kg. Larger homes have higher levels of household waste production, which also depends on the number of visitors to the home (Aslam et al.,2021).

The Quetta study also found that after a previous study in the mid-1990s, household waste production decreased by 20%. Although most household waste is produced in developed countries that include the use of vegetables and dust, some household solid waste is also dangerous (Korai et al., 2017).

A study in Lahore found that only 1.6 of household waste was hazardous. The author found that it happens every day in Lahore. Municipal solid waste in Pakistan has always been a source of pollution. Research conducted by Ravind in Punjab shows that municipal lands could seriously contaminate soil (Syeda Batool et al, 2009).

The literature examined to date shows that the level of solid waste production varies from sector to sector. Also, solid waste generation cannot be equated with followers of social planning. Note in the literature the increase in burnout and the decrease in family income.

Therefore, it is important to pay attention to the level of waste generation in cities. The MSWM provides similar waste rates to Pakistan.

2.4 Solid Waste Collection Systems

According to Korai et al. (2017) waste collection and disposal methods pose many problems with SWM in developing countries (Korai et al., 2017). Adeyemi and Adeyemo. (2007) said waste collection is one of the most serious operational problems in many Nigerian cities. The collection is done automatically, which will increase the cost of collecting heavy solid waste. The amount of static waste generated is growing rapidly which increases the ability of agencies to use the financial and technical resources required to rely on this capacity (Adeyemi and Adeyemo 2007).

Waste production is higher than the collection capacity, as shown by two-thirds of the solid waste generated in developed countries is not collected nor is it collected regularly. The system used by SWC depends on many factors. Different storage systems should be used to explain these factors in different regions. In general, these systems can be classified according to the operating condition, type of equipment, and type of debris collected (Chang and Pires, 2015).

2.5 Collection Based on Mode of Operation

Many factors affect the quality of operation, which are very important for waste collectors when choosing an operation collection method. These include the number of vehicles, vehicle maintenance, driving speed, vehicle capacity, assembly frequency, and the number and characteristics of employees (Oyekale and Oyekale, 2017)

Based on mode operation, the system of the collection can be by

a) Haul container system
b) Conventional model
c) Exchange model
d) Stationary container system

Since containers of different sizes and shapes can be used, the traditional utilization level (UL) model is very suitable for areas with high flexibility. It is also known for its low container usage. Container use is a fraction of the total volume of a container that is full of litter. Under this system, a dedicated truck is used to transport/lift the loaded/unloaded container to the terminal, and then return it to its original location.

The advantage of the exchange mode is the shipping container, which is used to collect the waste for transportation to the station or reduction site. These boxes will be cleaned up and replaced elsewhere in the exchange copy (Oyekale, 2017). The driver starts the journey from the residence station (warehouse) with the empty container and places it at the first assembly place. This system is useful when the boxes are the same size. Under this garbage collection system, some of the most used trucks are freight trucks, loaded containers, and garbage sellers.

2.6 Collection Based on Types of Waste

Based on the types of wastes collected waste has been categorized into two broad types of systems of collection. These are:

i. Collection of commingled (unseparated) and
ii. Segregated (sorted) wastes.

Previously, mergers could come from low-rise buildings, high-rise apartments, and commercial areas. The group of individual low-rise buildings includes roadside, street, and shingle combinations. To collect by the roadside, the owner (homeowner) places the container on the road. Where the witness is part of a master plan for a particular residential area, an oval storage container is commonly used. In the designated collection system, the container is removed from the residence, emptied by the collector, and returned. However, some low-lying and dilapidated apartments use the landing collection service and the maintenance staff's hiring service to bring containers to the streets.

Three methods of collecting commingled wastes from high-rise apartments

i. Pickup from various floors down to the basement
ii. Tenants take waste to the basement/service area and
iii. Use of waste chute system

High-rise apartments are more common in developing countries and this practice has given birth to modern pneumatic systems used to treat waste in central processing facilities through underground earthquakes. Commercial waste collection is usually affected by traffic congestion during the day, which forces it to collect during the rush hour (usually between night and morning). For safety reasons, the group usually includes more employees during this period. However, in places with heavy traffic and large container space, large mobile containers can be used for garbage collection. The classified waste must be collected separately for reuse or reuse. A road circuit system can be used to collect reusable items in residences. The system uses specially designed vehicles, such as repair flat box trucks, open box recycling trucks, body race trucks, etc. Contract private collectors also use classified litter bins in domestic and commercial units (George and Frank, 2002).

2.7 Solid Waste Collection Practices in Different Parts of the World

Generally, due to the concentration of garbage, it is necessary to remove waste or collect more valuable items, especially in big cities. In Asia, different countries have made great strides in waste management. However, so far, some countries are still working effectively on their collection and transportation plans ((Rajmohan et al., 2019).

In east Asia/Pacific, solid waste is being collected and transported. The cost of management is high. Similarly, many countries in South and West Asia are facing the problem of wasting measures to tackle unemployment. This can pose a health risk to employees in waste management. Public health problems may also be due to a lack of waste services for illegal immigrants in unfamiliar areas of Europe or a lack of waste management in Europe's most populous low-income areas (Zabaleta and Rodic, 2015)

The scope of activities for separate collection of municipal waste shows that the method of collection is almost complete. In general, they make different choices for different types of storage. For example, papers are often collected from an apartment to a football room or collection container, while a closed recycling container can be used to collect glass, sometimes with ice removal (Chiemchaisri et al., 2007).

In major Latin American and Caribbean cities, waste collection is performing well. In North America, four commonly selected methods of waste collection have been selected; the most commonly used is the method of collecting street waste. The back cover requires a lot of work and is, therefore, more expensive than the last. Collection point or mailbox collection point method is generally accepted in rural areas and is generally considered to be a cost-saving method. The fourth option is for waste generators to move the waste directly to the landfill site (Zabaleta and Rodic, 2015)

There are different levels of waste treatment in Antarctica. The potentially perishable trash can is burned at high temperatures in two stages and then returned to Australia. Separate metal, plastic, paper, cardboard, and glass and return to Australia for re-cooking. The appropriate waste will be disposed of properly in Australia. They use as much packaging material as possible. Biological wastewater treatment plants have also been set up in all of Australia's Antarctic plants. The packaging has been shipped from the factory to Australia, and the contaminated ultra violet (UV) rays are currently being tracked to ensure that harmful organisms are not transferred into the environment (Lingard et al., 2001)

In many African cities, poor vehicles, lack of operational budgets, usually cause the challenges of solid waste collection and a lack of public awareness of the risks associated with waste. However, due to the recent involvement of the private sector in waste management, progress has been made. In most African cities, solid waste disposal is close to the city centre, vehicles and waste collectors are very convenient (Zabaleta and Rodic, 2015). In Tanzania, before emergency city clean-up under the United States' permanent cities program, the proportion of litter decreased by 5 in 1992. In 1986, said that some of the challenges associated with land reclamation have been drastically reduced, usually due to lower maintenance rates and delays in returning vehicles to services. The author noted that as long as existing parts are available, minor repairs may take up to a week, and major repairs may take up to a month. It is not uncommon for cars to be closed for months to wait for funding to purchase other employees.

2.9 Waste Generation, handling, Collection, and Treatment Systems in Pakistan

From the local authorities' point of view, the waste management department has the function of collecting solid waste from the home, either by collecting at the door of the house or by collecting garbage and solid waste and processing solid waste (usually a landfill). In urban areas of Pakistan, the waste management department said that SWM is weak and the situation is deteriorating day by day. Factors included are the rate of urbanization, waste composition, and the role of sanitation workers in recycling and disposal, and the potential of current mitigation facilities for SWM (Mahar et al., 2007). In Pakistan, local governments are seen as major partners in solid waste collection and disposal. Since the amount of waste is constant daily, local authorities cannot deal with

SWM issues. The town's municipality assists the overall municipal government with waste management.

Several solutions have been proposed. Nevertheless, it appears that the cost of organizing a waste collection organization to be particularly appropriate for local conditions depends on a specific municipal budget or a small international cooperation project (Singh and Sushil, 2017)

In Pakistan, no city has a proper SWM system from solid waste collection to landfill. At present, regardless of the size of the city, Pakistan has no solid waste collection, transportation, and disposal plans. As a result, the environment and health of these cities become more dangerous every year. In Pakistan, urbanization and economic development have undergone major changes in the last few decades and more and more people have migrated to urban areas. Currently, urban population growth in cities is growing at a rate of 7.7, while Pakistan's population growth rate is 8% (Mohsin et al., 2019)

The amount of solid waste in urban areas in Pakistan is more than one thousand tons, which is more than one thousand tons in a day, and the amount of waste collected in the city is only £ 50 (PRB, 2012). Besides, there is no city in Punjab, Pakistan that manages land-appropriate land areas. The study examined only two cities, Lahore and Faisalabad, to determine where the land was destroyed. As we all know, unknown garbage will be placed in public places or on the streets. Due to the lack of landfills, the collected waste is mostly found in the land, open land, and rivers. In many of these areas, there is no formal or scientific basis for the safe disposal of solid waste. Additionally, the ground-paralyzed area was set on fire to reduce the amount of litter (Rehan et al., 2019)

According to a 2010 report by the Government of Pakistan, the report looks at energy permits, legal concessions, and financial mechanisms for the conversion of financial biomass / solid waste biomass in Pakistan. It was decided to establish a committee at the national level to oversee the waste management process. There is a need to establish regulatory mechanisms at the city, county, and county levels (converting waste biomass to energy waste). There are more than 10,000 Lagas in Lahore, with the help of intermediaries, who buy goods with small items without any commercial check from the Lahore City Government.

Only five years ago, Afghans outnumbered locals, so middlemen (Kaberia) are also happy with the increased number of employees. Usually, they never seek to improve their conditions and work. Not surprisingly, the country's unemployment rate is soaring. During the United States (US)-led invasion of Afghanistan, the influx of Afghans into Lahore increased. Generally, 2 to 3 rupees per kilogram of paper waste is paid to someone who drives a motor vehicle. There are reports that this has not changed in the last two years. Some well-organized collectors try to reach intermediaries and get supplies directly to the paper mill, but at the end of the day, they find their lives in danger.

The people of Kabul have become the mafia. No one dares to end the trade, and even the government does not dare to end this commercial role because the country is very poor and does not have clean drinking water due to the increase in industrial waste. It does not just pollute the environment. But waste management also brings various health problems to urban residents (Forouhar and Hristovski, 2012).

2.10 Social and Economic Constraints for Waste Management in Pakistan

The current state of waste management, water supply and sanitation, urban transport, and education shows that the government is incapable of dealing with urbanization. Due to financial, social, and economic factors, SWM is difficult. There is a need to develop new ways of SWM to meet the growing needs of urban dwellers

SWM is one of the most important barriers to environmental degradation. Waste collection systems are inadequate and only available in a few large cities, accounting for 51-69% of the collected waste. Waste collection is limited to high-income areas with high levels of corruption. Generally, discounted services are not fully established, and most discount sites do not have weighing facilities. Poor management of hazardous waste and proper treatment of existing waste does not use proper methods. Question marks from scholars in seven cities, including Karachi, Hyderabad, Lahore, Multan, Peshawar, and Quetta. Compared to Peshawar, the waste of Peshawar is much clearer than that of Lahore and Karachi. Cities with better socio-economic conditions perform better in waste management (Azam et al., 2020; Batool & Chaudary, 2009; Korai et al., 2017)

2.11 Current Laws and Regulation on SWM in Pakistan

The proper management of waste from generation to disposal is essential and requires awareness of the public and municipalities so that they become active in dealing with it. Although Pakistan has formulated various laws and regulations on SWM, it remained unsuccessful in overcoming the issue properly according to the EPD-Government of Punjab. While, at the local level Tehsil Municipal Administration (TMA) is looking after it which generally cannot manage the issues as per EPA-Pak

Many of these existing laws are outdated and inadequate to manage waste efficiently. Therefore, there is a need for detailed and more specific regulations dealing with SWM in the country

2.12 Rawalpindi City Waste Composition and Total Waste Generated

"The situation analysis study of SWM in the city has research-based data on different types of waste, i.e., municipal solid waste, and commercial waste generated. Although the Pakistan Environmental Protection Act defines four different waste categories, on the provincial level only municipal solid waste is referred to in rules on SWM. Therefore, a legal basis must be enacted to distinguish among:

- Municipal Solid Waste
- Construction Waste
- Slaughter Waste
- Hospital Waste

Reliable data on hospital waste generation is not available. It is mixed with municipal waste and collected and disposed of by the City District Government Rawalpindi (CDGR). Hospitals do not have a separate collection system. Hospital wastes include both risk and non-risk wastes.

Construction waste is generated at the construction sites located in and outside the residential areas. There is no data on the number and size of construction sites. Construction waste is mostly mixed with municipal waste or goes to open drains. Most of the building materials are locally produced and are based largely on natural resources. Common building construction waste and demolition materials are sand, bricks, tiles, building glass, cement, doors, windows, pipes, wood.

2.13 Economic and Environmental Perspectives of SWM

The collection, treatment, and disposal of municipal solid waste are usually carried out per the nature of the waste flow and the actual environmental and economic characteristics. The discovery of less efficient work in developing countries poses a serious threat to the quality of the local environment and public health. Although there is overwhelming evidence that waste generation and management are sensitive to changes in income and prices, the use of the natural public property and the presence of Internet strangers all show that individual economic behaviour has social benefits in this area and will not at all. Bring the result. Promoting community welfare may require community involvement as evidence is gathered to support arrangements that involve private companies (Batool et al., 2008)

Rehmani et al. (2020) also suggests that, at lower prices, the current advances in hazardous waste management will be much cheaper than reducing losses from current practices. From a rational social point of view, solutions to these problems will become necessary in the future, especially in developed countries. In developing countries, the author predicts that municipal solid waste treatment rates will rise to an annual rate of 2.7 in 2010 (Rehmani et al., 2020).

In a study by Chen and his coworkers, they proposed and integrated solid waste treatment method for MSW and sewage sludge (SS) (Chen et al., 2019). They analyzed four different scenarios in terms of energy, environment, and economic impact. In these, Case 1 was mono-incineration of MSW, case 2 was SS, case 3 was co-incineration of SS and MSW by traditional method while case 4 refers to the integrated ways of co-incineration of SS and MSW. Cost associated with multiple variables including chemical reagents, operation, maintenance, and SW treatment were considered for the estimation of approximate capital cost. In their work they provided a quantitative analysis to better understand the life cycle assessment (LCA) method. Results of their study supported case 4 as the best methods in terms of climate, economic and energy impact. Specifically, from the economic point of view, case 4 scenario was proposed as a potential method to reduce the cost of coal consumption up to 79.8% than all other cases. From the economic part, Case 4 is preferentially potential with the best profit, cutting down 79.08% of cost in coal than that in Case 3. They also showed that the coal consumption cost directly reduces the operation cost. They further emphasized that practice of case 4 although initial investment cost would be high, but it is an effective way to save climate, energy, environment, and budget (Chen et al., 2019).

In multiple cities of India, MSW management is a major problem. In a study by Mehta et al., 2018, they proposed a generic model to estimate the health and environment benefits and the relative cost associated to MSW management practices (Mehta et al., 2018). For the study, they considered the MSW management of Mumbai for over the next 20. The model developed in their study helped them to estimate the costs associated to waste dumping on open ground, sanitary landfilling with and without leachate treatment, and regional composting and landfilling. For the quantification of gaseous emission from the landfills, they have used LandGEM wherein the data of emission from leachate and composting was collected from previous studies. With OpenLCA software they developed life cycle impact model of 1 ton of MSW while for the impact assessment, they employed International Reference Life Cycle Data System (ILCD) 2011. Findings of this study suggested that the disposal cost for 1 ton of waste is US$5.17, US$11.13, and US$20.53 for first three scenarios proposed in their hypothesis. They further suggested that flaring of landfill gas reduces the global warming by 32% as compared to open dumping. Whereas, the leachate treatment effectively reduces the human toxicity and freshwater toxicity by 20% and 60% respectively. Additionally, this study suggests composting landfilling method as the most cost-effective methods as it incurs a cost of US US$7.97 with reduced global warming and freshwater Eco toxicity potential of approximately 79% and 64% respectively (Mehta et al., 2018).

In a study by Feo et al. (2017), a combinatorial approach including both the environmental and economic factors was used to determine the integrity and sustainability of a MSWM system. They evaluated multiple, waste segregation and waste management scenarios and proposed that this approach can be used to assess the margin of improvement of the SWM system. In terms of recovery of material during the waste collection procedure, they proposed a quantitative economic benefit for the area under study. They were of the view that the even if the cost of waste collection and waste transport increases, we can still compensate for this cost through generating more revenue from the recycling of the recyclable fraction (Sharma and Jain, 2019).

Another study work addresses the intrinsic association of various economic and environmental drivers to the SWM. In his work, he evaluated the bad practices responsible for the uncontrolled disposal in Lebanon and worked on the development of plan that would lead to more sustainable solid waste management in developing countries. In this study, 30 WM approaches were proposed, and each was assessed for its economic and environmental impact. Findings of this study suggests that the environmental impact and hazards can be reduced by coupling the recycling factor with the composting. Varied waste compositions play a crucial role in the environmental impact of any WM system, and it should be considered while devising plan for SWM. Waste with higher content of organic waste will be more hazardous and it will be challenging to generate recyclable content out of it. Study concludes that the SWM plan/strategy in any region/country should be customized according to the local conditions, and it should be tailored according to the environmental issues of specific region/country (Ikhlayel, 2018).

Singh and Basak conducted a study in 2018, applied industrial ecology strategy to Indian MSW and demonstrated the importance of some economic variables for the identification of sustainable SWM system. They conducted a comprehensive analysis of five then practiced technologies for SWM based on various environmental and economic parameters. Their findings suggests that acidification possesses maximum potential of reducing global warming by 123 tons CO_2 eq./day while generating an economic benefit 293 USD per day. They further suggested that the combined operation of acidification and gasification can yield maximum economic AD and gasification gives maximum economic interest of up to (1016 $/day) with a promise of minimum hazard/damage to the environment. They provided a useful insight into the ways /metrices to assess the MSWM system which will be helpful in future decision and policy making (Arashdeep et al., 2018).

Seng et al. (2018) conducted an analysis to assess the chemical and physical characteristics of MSW in the capital city of Cambodia namely Phnom Penh. The common practice in Cambodia to mix and dispose of all the waste into an open dump site without any waste segregation. Their study intends to evaluate the more suitable way of solid waste handling. Findings of the study suggests that waste was majorly composed of food (49.18%), plastic (21.13%), and recyclable items of approximately 17.28%. In the waste, moisture content was 60.92%, combustible material was 35.89% combustible. Whereas ash, carbon and nitrogen percentages were about 3.19%, 58.32% and 1.05%, respectively. High moisture content of the waste makes it challenging to recover energy after incineration. Poor waste collection and handling practices also made it impossible to recover recyclable content out of the total waste. The study suggests the digestion and co composting of wood, leaves and food waste. Study also emphasized the need of waste segregation during the waste collection period to complement the handling methods (Seng and Fujiwara, 2018) .

Sharma & Jain in 2019 discussed the current MSW management system of India and presented the situation and problems of MSW generation, composition, and its management in Indian cities. They statistically estimated that in 2015, urban areas of India were collectively generating approximately 62 Metric tons (Mt) of solid waste which corresponds to 450 g per capita per day. Out of this approximately, urban local bodies were able to collect only 82% while remaining 18% was litter. Of the total 82% of the collected waste, only 28% was treated and the remaining 72% was left untreated and dumped on open dump sites. In bigger cities, waste collection (WC) efficiency falls between 70% to 95%. Contrary to this, in various smaller cities waste collection (WC) efficiency was estimated to be below 50%. They discussed the financial constraints and scarce infrastructure as factors responsible for poor SWM. Multiple challenges associated to solid waste collection, handling, transport, and disposal were discussed in lieu of the currently implemented strategies and polices of government. They further compared the SWMS of India with various countries and suggested the plausible SWM approaches for specific cities of India (Sharma and Jain, 2019).

In a study by Palmer et.al. (1997), introduced three price-based policies for solid waste cost reduction. Analysis suggests that a modest reduction in municipal solid waste would be efficient if it could be accomplished without large administrative and transactions costs. Study considers the marginal social benefits of waste reduction to result from avoided disposal and transportation costs. These avoided social costs currently amount to approximately $33 per ton, although the costs vary substantially by region. This marginal benefit implies that a 7.5% reduction in the wastes if the reduction were accomplished by a deposit refund. Other wastes not included in the model might be reduced in the optimum as well, so the total percentage reduction in municipal solid waste remains to be determined (Palmer et al., 1997).

While De Jaeger and its coauthors studied the impact of some local policies aimed at municipal solid waste (MSW) reduction on the cost efficiency of MSW collection and disposal. Using data on 299 municipalities in Flanders, Belgium, for the year 2003, their results indicate that municipalities that are member of a waste collection joint venture, or that subscribe to a voluntary agreement to reduce MSW at the highest ambition level, collect and process MSW more efficiently than other municipalities. Weekly instead of two-weekly waste collection or using a weight-based pricing system appears to have no impact on efficiency. Our results show that aiming at MSW reduction does not lead to lower efficiency of public service provision, even on the contrary (Jaeger et al., 2011).

Another strand of literature focused on the cost reduction claimed by privatization. Bel and Warner. (2008) conducted a review of all published econometric studies of water and waste production since 1970. Little support is found for a link between privatization and cost savings. Cost savings are not found in water delivery and are not systematic in waste. Overall, the empirical results show the importance of market structure, industrial organization of the service sector, and government management, oversight, and regulation. Because there is no systematic optimal choice between public and private delivery, managers should approach the issue in a pragmatic way (Bel and Warner, 2008).

The role of municipalities and local authorities has always been very crucial for the reduction in SWM cost. Study conducted by Bel et al. (2012) examined whether small municipalities can reduce costs through cooperation and delegation. Study first examined factors explaining the decision of municipalities to cooperate and delegate service delivery responsibility, in this case residential solid waste services, to another government. Furthermore, study investigated the impact of cooperation on the costs of providing residential solid waste services. The empirical analysis is done using a sample of small Spanish municipalities. Results of the empirical analysis suggest that cooperation is a pragmatic choice for municipalities with a suboptimal size: municipalities that cooperate by delegating face lower costs for residential solid waste services than those that do not (Bel and Mur, 2014).

Study conducted by Pérez et al. (2016) highlights the existence of cost differences arising from different approaches to managing MSW services and from population size. As concerns the policy implications of the results obtained, study suggested that a key factor in determining how local public services, and particularly MSW collection and disposal, should be managed is the size of the municipality. In this regard, there has been a proliferation of formulas for joint provision in recent years, especially among smaller municipalities, with the idea of achieving cost savings by exploiting latent economies of scale. The results obtained in the study provided empirical evidence that smaller municipalities can indeed achieve better levels of cost efficiency when the service delivery form is shared, together with the resources and costs of the service. On the other hand, study pointed out that joint management formulas do not constitute an alternative to private management in larger municipalities, where outsourcing the MSW service clearly achieves greater cost savings (Pérez et al., 2016).

Another study by Goddard back in 1995, investigated that what are the appropriate types of public interventions in the economy to control this flow. Study argued that the source of the solid waste management problem in the United States is due to the 'short circuit' to the price mechanism for choices concerning materials use and reuse caused by local governments that provide waste management services at a zero price. It is 'government failure' not 'market failure' that is the source of the current problem. Study found that there is a widespread lack of recognition that the costs of source reduction will be lower than any other management option for initial levels of control, derivative of a lack of understanding of how consumer choice and willingness to pay for solid waste management services should fit into the overall solid waste management plan. Nonetheless, the rapidly growing use of variable rates or user charges around the country is a trend that should be the focus of federal legislation and regulation to promote it as soon as possible, as this use represents a flexible national solution to the solid waste management problem (Goddard, 1995).

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Conceptual Framework

The conceptual framework is a narrative outline or diagrammatic presentation of variables to be studied and hypothetical relationships between and among the variables. This study conducted a cost-benefit analysis of SW management options, whereby sources and types of SW were identified, cost and benefits of each management option was studied; capital, operation, and maintenance, collection, and disposal costs comprise the total costs associated with SW management options in Rawalpindi. These costs are the major costs that must be taken into consideration before embarking on such projects. Also, benefits obtained (outputs) should consider social benefits like avoidance of liabilities from MSW management options, economic benefits, and social benefits . Using specific criteria the best option scenarios were identified which is economic efficiency and which lead to environmental sustainability.

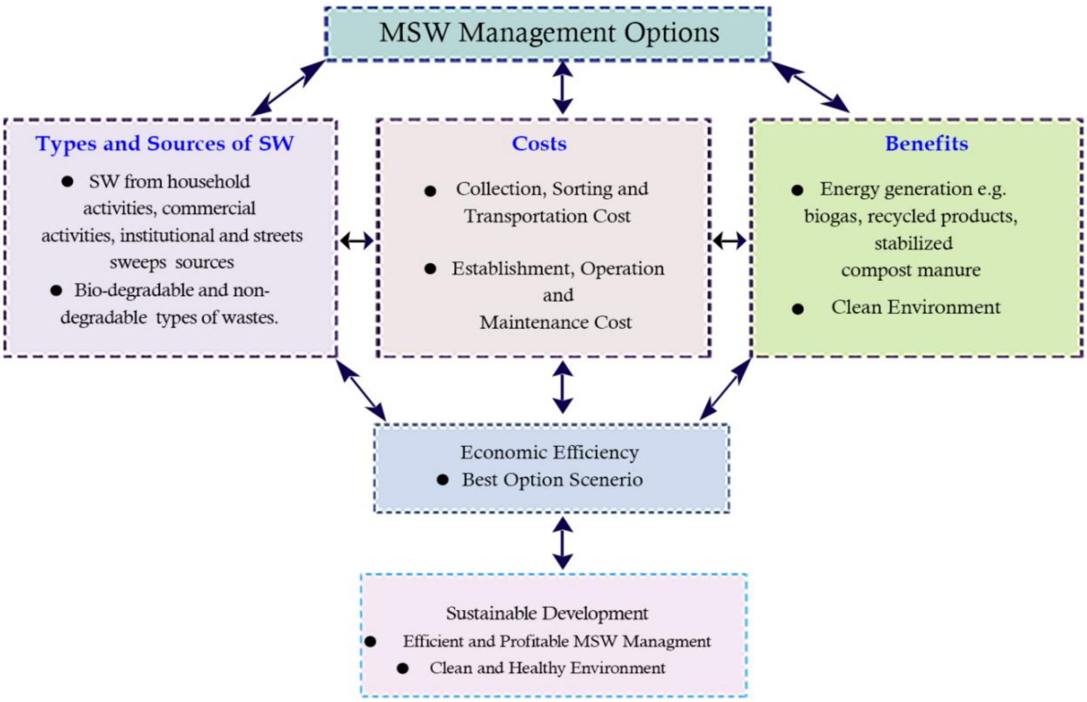


Figure 3. 1 Conceptual framework of the research study

3.2 Research Design

Research is concerned with the elements of human behaviour and thought, and in the sense of what is research in the social sciences, especially an activity that seeks to enhance the reality of existing knowledge and new knowledge. A research inquiry can usually change in a quantitative/qualitative manner. Research is generally seen as providing significant benefits to individuals as well as local, regional, national, and international communities (Smith, 1998). Research that increases control over factors that may interfere with the validity of results. Research design is a complete plan for collecting experimental research data. In this study, the mixed-mode method was adopted. The research tool is a survey method. Researchers use scientific planning methods to enable society to collect and analyse data in a planned manner, and thus to research society.

The research method is the method for solving a search problem. It covers all techniques used in research. There are two types of social sciences, qualitative research, and qualitative research. The researchers used mixed-mode research methods, which are used to describe the amount of data and summarize the results of a sample of the population.

3.3 Study Area

The definition of the universe is defined as a group or all of the individual members or things with specific properties. The study area is Rawalpindi, Pakistan. The target population of a survey is the complete set of units that use survey data to intervene. The target population determines which units will be explored through research.

3.3.1 Demographics of Study Area

Rawalpindi is a city in the Pothohar region of Pakistan near the country's capital city of Islamabad, in the province of Punjab. Rawalpindi is the fourth largest city in Pakistan after Karachi, Lahore, and Faisalabad. Rawalpindi city is located at 33° North and 73.08° East. Rawalpindi city has an area of 27.7 Km^2. Rawalpindi is situated in an arid region and has a relatively urbanized culture. In the 1950s, Rawalpindi was smaller than Hyderabad and Multan, but the development of Islamabad in the 1960s boosted the city's economy, resulting in a tenfold increase in population. Rawalpindi has located 275 km (171 miles) to the northwest of Lahore. Most of the population is engaged in salaried occupations including serving in the armed forces.

3.3.2 Sectorial and UCs Information

The estimated population of Rawalpindi city is 1.6 million in 2013, which has now exceeded 1.826 million in 2020. Until 2014, waste management in Rawalpindi was the responsibility of CDGR but from December 2014, onwards Rawalpindi Waste Management Company (RWMC) took over this responsibility. In total, 62 union councils (UCs) are covering the whole city as mentioned in the CDGR and RWMC. Rawalpindi is divided into two towns named Rawal Town and Pothohar Town. Rawal Town is further divided into four sectors that are A, B, C, and D. Each sector is further divided into multiple UCs. Each UC has a particular number. UCs included in each sector of Rawal Town by CDGR and RWMC are given in Table 3.1 whereas Pothohar Town isn't divided into sectors and the urban UCs of Pothohar Town are given in Table 3.1

Table 3.1 Sectorial and UCs information of Rawal Town and Pothohar Town of Rawalpindi City according to RWMC (2020) model and CDGR (2014) model.

Sector/Urban UCs	Union Councils Divisions
RWMC (2020)	
Rawal Town	
A	13,14,15,17,18,19,20,21,22,23,24,25,27,30
B	28,29,31,32,42,43,44,45,45 Civil Lines
C	33,34,35,36,37,38,39,40,41,46
D	1,2,3,4,5,6,7,8,9,10,11,12
Pothohar Town	
Urban UCs	74,75,76,77,78,79, 80, 81, 82, 84, 85, 86, 87
CDGR (2014)	
Rawal Town	
A	13,14,15,17,18,19,20,21,22,23,24,25,27,30
B	28,29,31,32,42,43,44,45,46
C	1,2,3,4,10,11,16,37,38,39
D	5,6,7,8,9,36,40,34,33,12,35,41
Pothohar Town	
Urban UCs	74,75,76,77,78,79,80,81,82,84,85,86,87

3.4 Sampling Design

A sample is a part or group of a population, and some observations summarize the entire population. Sampling involves selecting a subgroup of individuals in the community of interest to evaluate the characteristics of the entire community. In this study, non-probability samples were used. A non-probability sample is a sample in which member of the population is selected as the sample are not known.

3.4.1 Sampling Techniques

In sampling techniques, the researcher has used targeted sampling techniques. Objective sampling involves identifying and selecting people who are interested or experienced in this direction (Creswell & Clark, 2011).

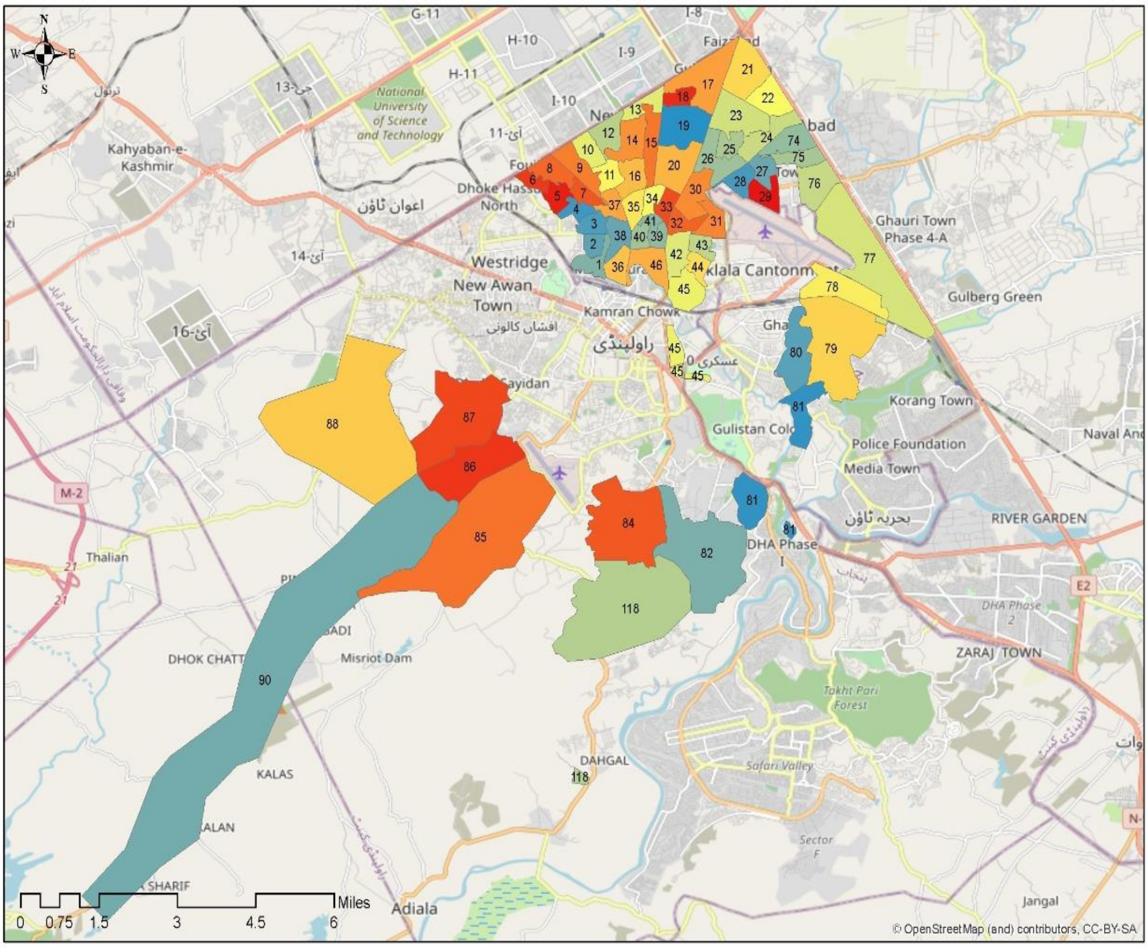


Figure 3.2 illustrating the map of Rawalpindi city in which multiple UCs are highlighted in different colours.

3.5 Municipal Waste Generation of Study Area

The waste generation rate for Rawalpindi city is approximately 0.6 kg/capita/day. The total waste generation of the city is 900-950 tons/day. This waste count accounts for the collected as well as uncollected waste. Quantities of collected and uncollected waste as per the estimations of RWMC and CDGR in 2020 and 2014 respectively are given in Table 3.2. The situation is becoming very complex in the city due to the economic and social uplift of urban areas, as these factors are the major cause of the drastic increase in the quantity and complexity of generated waste.

Table 3.2 Solid waste generation of Rawalpindi City as estimated by RWMC (2020) and CDGR (2014) models.

Description	Quantity
RWMC (2020)	
Generation Rate	0.6 kg/person/day
Total Waste	1000-1100 tons
Collected Waste	850-950 tons
Uncollected Waste	100-150 tons
CDGR (2014)	
Generation Rate	0.6 kg/person/day
Total Waste	900-950 tons
Collected Waste	600-700 tons
Un Collected Waste	300 tons

3.5.1 Categories and Composition of Waste in Rawalpindi

Waste generated in Rawalpindi city has been categorized into three types described below in detail

3.5.1.1 Residential Waste

Table 3.3 Describing the individual percentage of every component that makes up residential waste.

Residential Waste	
Items	**Percentages**
Organic Waste	50
Ash, Dirt, Bricks	1
Yard Waste	9
Plastic	3
Textile	3
Rubber	1
Paper & Cardboard	6
Glass	2
Metal	1
Shoppers	11
Hazardous waste	1
Pampers/diapers	12
Total	100

3.5.1.2 Commercial Waste

The commercial waste is comprised of all the garbage collected from the commercial areas of Rawalpindi city. The commercial market hires their staff for the collection of waste from the shops.

The fruit and vegetables markets have been shifted outside the city. Currently, the markets inside the city are of small scale. The magnitude of waste produced by them is being collected by CDGR. UC 38 has a sabzi mandi, grain mandi, ganj mandi, and other commercial areas. It is a very complex UC with 50 sanitary workers working in this particular UC. All markets have their sweepers who collect the waste from markets and shops and put the waste in municipal bins from where the CDGR transports all the waste.

Table 3.4 Describing the individual percentages of every component that make up commercial waste. The percentage of recyclable waste is also given and highlighted in bold.

Commercial Waste	
Items	**Percentage**
Organic Waste	30
Ash	1
Dirt ,Bricks	12
Plastic	11
Textile	2
Rubber	3
Paper & Cardboard	11
Glass	5
Metal	7
Shoppers	13
Hazardous waste	3
Pampers/diapers	2
Total	**100**

3.5.1.3 Institutional Waste

Table 3.5 Describing the individual percentages of every component that make up institutional waste. The percentage of recyclable waste is also given in the last row.

Institutional Waste	
Items	**Percentage**
Organic Waste	34
Green Waste	20
Ash, Dirt ,Bricks	1
Plastic	6
Textile	5
Rubber	1
Paper & Cardboard	7
Glass	1
Metal	1
Shoppers	12
Hazardous waste	3
Pampers/diapers	9
Total	**100**

3.5.1.4 Slaughterhouse Waste

There are two slaughterhouses in the city. CDGR containers have been placed in the slaughterhouse and approximately 3.5 tons of waste is being generated and cleaned out on daily basis.

3.5.1.5 Hospital Waste

Clinics and private hospitals dump their waste in municipal bins. Summary defining the quantity of the hospital waste collection in kilograms and number of hospitals and clinics entertained for daily waste collection by CDGR and RWMC in 2014 and 2020, respectively is given in Table 3.6. There is one incinerator at Holy Family Clinic Rawalpindi. Currently, it is not operational due to repair and maintenance. The capacity of the incinerator is 250 kg. So the hospital waste from Holy Family Clinic is being transported to the Attock Oil Refinery incinerator for its disposal. The hospital waste from clinics and other hospitals is being disposed of in the CDGR containers without segregation.

Table 3.6 Numeric data related to the hospital waste collection from the public and private hospitals and clinics as per CDGR (2014) and RWMC (2020) data.

Description	**Numeric Details**
RWMC (2020)	
Number of Hospital	5 major hospitals & 1000 clinics
No. of Beds	5000
The volume of Waste Production per day/ Average waste Generation per bed	10000 Kg/day, @ 2Kg/bed/day
Disposal Method in practice	Disposal of hazardous waste along with municipal waste
CDGR (2014)	
Number of Hospital	4 major hospitals & 800 clinics
No. of Beds	4500
Volume of Waste Production per day/ Average waste Generation per bed	9000 Kg/day, @ 2Kg/bed/day
Disposal Method in practice	Disposal of hazardous waste along with municipal waste

3.5.1.6 Construction and Demolition Waste

There is no specialized system for the collection of construction and demolition (C&D) waste in the city. The C&D is collected by CDGR vehicles and transported to the waste enclosure site and official dumpsite.

3.5.1.7 Garden Waste

The Punjab Horticulture Authority (PHA) staff are collecting the organic waste, which includes garden trimmings from the parks and green belts. They dump the waste in the depressions excavated inside the gardens and is being used as manure. The workers of PHA collect the municipal domestic waste, which includes empty bottles and wrappers from most parks. They dispose it of at the nearest container placed by CDGR.

3.5.1.8 Drainage Waste

The MSW department is also responsible for the collection of waste from the drains of the city. Only the cleaning of Nallah Lai is the responsibility of the Water and Sanitation Agency (WASA), all other nallahs are the responsibility of the SWM department CDGR. 20% of the total waste is estimated to be flushed in the nallahs. WASA regulates the maintenance of all nallahs. 35% of the city has a sewerage system in which all the sewerage lines/pipes are interconnected, and solid waste is always deposited in them, which makes them choked. The sewer workforce is too scarce. They are only 15 and due to work burden, they cannot clean all the drains in the city.

3.6 Waste Collection Procedure in Study Area

3.6.1 Primary Waste Collection

The primary collection in Rawal Town is conducted mainly through street sweeping and door-to-door collection done by the private companies in housing societies. Currently, door to a door collection facility is not being provided by CDGR. The sanitary workers after manual sweeping transfer the collected waste to secondary waste collection points by (two-wheeler and three-wheeler) handcarts. Manual sweeping is practiced six days per week except on Sundays.

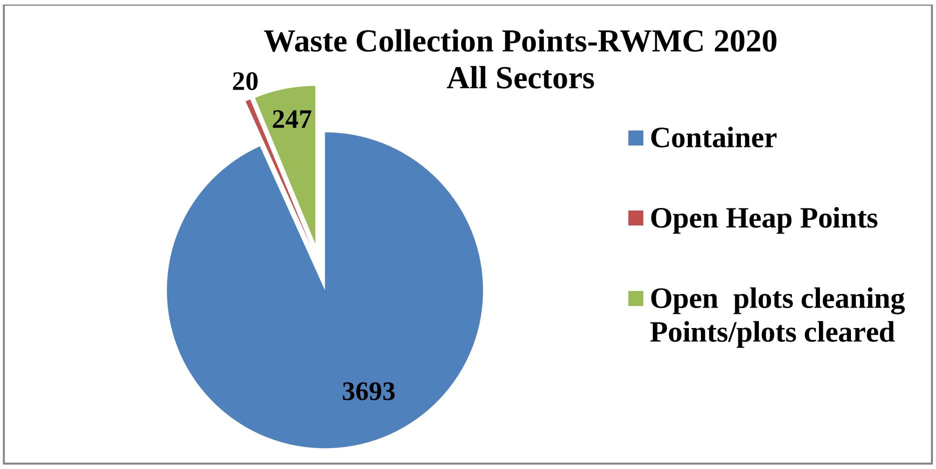


Figure 3. 3 Shows the total number of waste collection points in all sectors/areas of Rawalpindi city. These are currently being managed by RWMC.

3.6.1.1 Sweeping

Manual sweeping on the primary roads and in streets of Urban UCs are the responsibility of sanitary workers. Mechanical sweeping is being carried out on the major road

Table 3.7 Summary of solid waste collection points in Rawal Town as per RWMC 2020 data. Area-wise distribution of containers in each sector of Rawal Town is also given.

Sr. No	**Infrastructure**	**Sector A**		**Sector B**		**Sector C**		**Sector D**		**Sector E**		**Total**	
		0.8 m^3	**5 m^3**	**0.8 m^3**	**5 m^3**	**0.8 m^3**	**0.8 m^3**	**0.8 m^3**	**5 m^3**	**0.8 m^3**	**5 m^3**	**0.8 m^3**	**5m^3**
1	Container	876	22	944	28	993	16	309	17	484	4	3606	87
2	Open Heap Points Daily Cleared	4		3		3		4		6		20	
3	Plot (Cleared)	47		34		23		71		66		247	

Table 3.8 Summary of solid waste collection points at Rawal Town (sector-wise) and Pothohar Town taken from CDGR 2014 data

Sr. No	**Infrastructure**	**Rawal Town**					**Pothohar Town**	**Total**
		Sector A	**Sector B**	**Sector C**	**Sector D**	**Total** Rawal Town		
1	Container	16	8	3	6	33	0	33
2	Open Heap Points	47	67	52	31	197	81	278
3	Plot (One Time Cleaning Spots)	30	21	0	9	60	62	122

3.6.2 Secondary Collection (Transportation)

Waste is temporarily stored in open heaps and containers before transferring into the waste enclosure. The details of container open heaps and open dump plots in respective sectors of Rawal town and Pothohar town are mentioned in Table 3.7 and 3.8. Currently, most of the waste containers are not in good condition and not suitable for the storage of waste.

In Rawalpindi, a container system with arms and roll trucks is in use for part of the city. Collection vehicles complete approximately 130-140 trips a day. In the absence of door-to-door waste collection, the residents throw solid waste directly onto the streets and roads. CDGR staff collects this waste and transports it with the help of wheelbarrows to waste collection points established at various locations within city limits. For sweeping of main roads, five mechanical sweepers are used.

3.6.2.1 Operational Fleet Count of CDGR and RWMC

The sector-wise detail of vehicles used for waste collection in Rawal Town by CDGR and RWMP in 2014 and 2020, respectively are mentioned in Table 3.9 & 3.10, respectively

Table 3.9 Summary of vehicles used for transportation in Rawal Town (sector-wise) by CDGR in 2014

Sr. No	Vehicle Name	Sector A & B	Sector C & D
1	Detachable Container Truck	17	13
2	Front End Loader	2	3
3	Arm Roll	2	1
4	Dumper Truck	6	4
5	Tractor	1	1
6	Mechanical Sweeper	0	5
7	Water Tanker	0	1
Total		**56**	
* CDGR 2014 data			

Table 3.10 Summary of vehicles used for transportation in Rawal Town (sector-wise) by RWMC in 2020

Sr. No	Vehicle Name	Sector A, B, C,D & E
1	Minidumpers (Pickups)	138
2	Dumpers Hino 300	3
3	Dumpers Hino 500	3
4	Compactors Hino 8m^3	26
5	Compactors Hino 13m^3	18
6	Compactors Hino 25m^3	4
7	Armroll	4
8	JCB	2
9	Tractor Loaders	4
10	Tractor Trolley	2
11	Service Vehicles	4

12	Control Vehicles	16
13	Recovery Vehicles	1
14	Mechanical Sweeper	5
15	Tankers	2
16	Boozers	2
17	Container Washer	1
18	Prime Movers	9
19	Shovel	2
20	Excavator	2
Total		**248**

The number of vehicles used for the transportation of waste from temporary collection points to the waste enclosure site at Sowan Camp/Pothohar camp is mentioned in Table 3.11.

Table 3.11 Number of vehicles used for transportation of waste in Pothohar Town

Sr. No	Vehicles	Number
1	Heavy Tractor	2
2	Small Tractor	7

3.6.3 Waste Disposal in Study Area

In the collection and transport phase, vehicles start from a garage, move to multiple waste collection points, and drop the collected waste at the disposal facility. Waste collection and transport cycle include numerous back and forth movements of vehicles from the garage to temporary/initial waste collection point and then finally to the disposal facility.

Figure 3.4 Representing the procedure/workflow of the waste disposal operation

There is one waste enclosure present in the city, located at Sowan Camp. Solid waste collected from all over the city is temporarily stored here. The waste from the waste transfer station sites at Liaquat Bagh, Main Albayrak workshop is transported and disposed of at the official dumpsite located at Losar as shown in figure 3.4. The area of this dumpsite is 75 acres approximately. Currently, the waste collected is being dumped in cells. Furthermore, they are covered by soil after three days. The expected life span of the landfill is 15 to 17 years. There is a need to develop a proper sanitary landfill site in this area. Currently, no weighing system is being installed at the dumpsite to calculate the amount of waste received on daily basis. The authorities are planning to install the RDF plant.

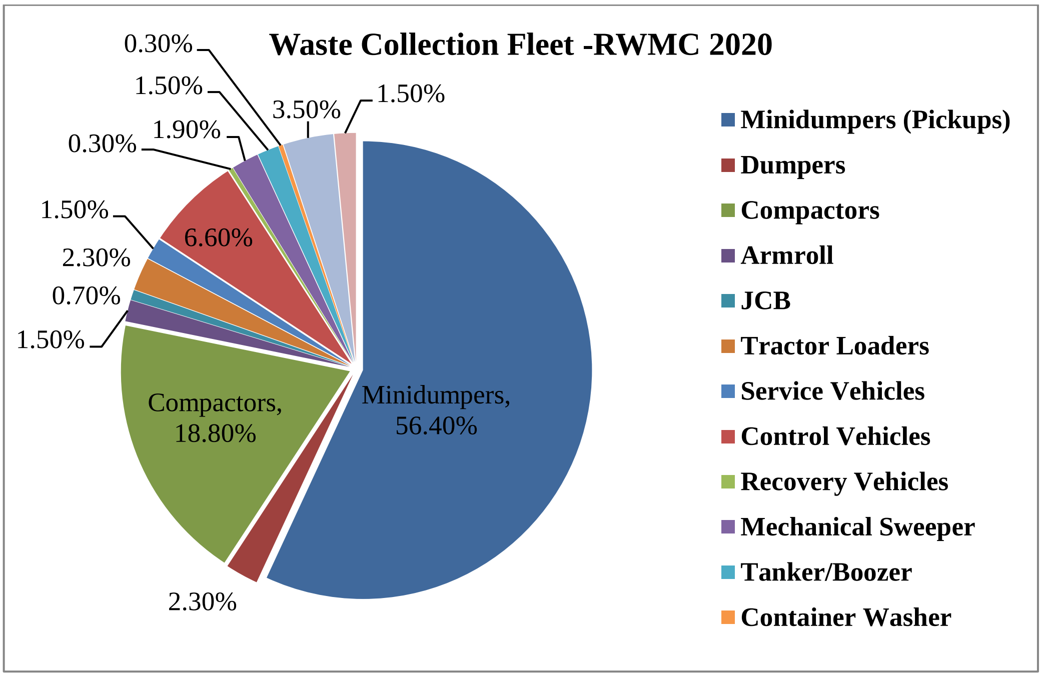


Figure 3.5 Represent the percentage summary of all vehicle types participating in the waste collection fleet of RWMC in 2020

3.7 Future Transportation Requirements for Waste Disposal

The following tables (Table 3.12 & 3.13) enlists the RWMC estimated requirements of vehicles for future system design of waste management in multiple sectors of Rawal Town, SWM department, Sawan Camp Transfer Station, and Losar dumpsite, respectively.

Table 3.12 Summary of the required number of vehicles in multiple sectors of Rawal Town for future system design

Sr. No	**Vehicle Name**	**Sector A, B, C, D & E**
1	Mini dumpers (Pickups)	144
2	Dumpers Hino 300	3
3	Dumpers Hino 500	3
4	Compactors Hino $8m^3$	26
5	Compactors Hino $13m^3$	18
6	Compactors Hino $25m^3$	4
7	Armroll	4
8	JCB	2
9	Tractor Loaders	4
10	Tractor Trolley	2
11	Service Vehicles	4
12	Control Vehicles	17
13	Recovery Vehicles	1
14	Mechanical Sweeper	5
15	Tankers	2
16	Boozers	2
17	Container Washer	1
18	Prime Movers (40m3)	9
19	Shovel	2
20	Excavator	2

Table 3.13 Enlisting the future requirements of vehicles for SWM Department, Sawan Camp transfer station, and Losar dumpsite

Sr. No.	**Type of Vehicle**	**Quantity**
	SWM Department	
1.	Arm Roll Truck	30
2.	Arm Loader Containers	100
3.	Containers of U.D Trucks	200
4.	Truck with front Bucket & Blade	8
5.	Suzuki Pick Up Emergency Services	4
	Sowan Camp Transfer Station	
1	Skip Lifting Truck (10 Tons)	3
2	Front End Wheel Loader	1
	Losar Dumpsite	
1	Bulldozer	2
2	Front End Wheel Loader	1
3	Excavator	1
4	Bull Dozer	1

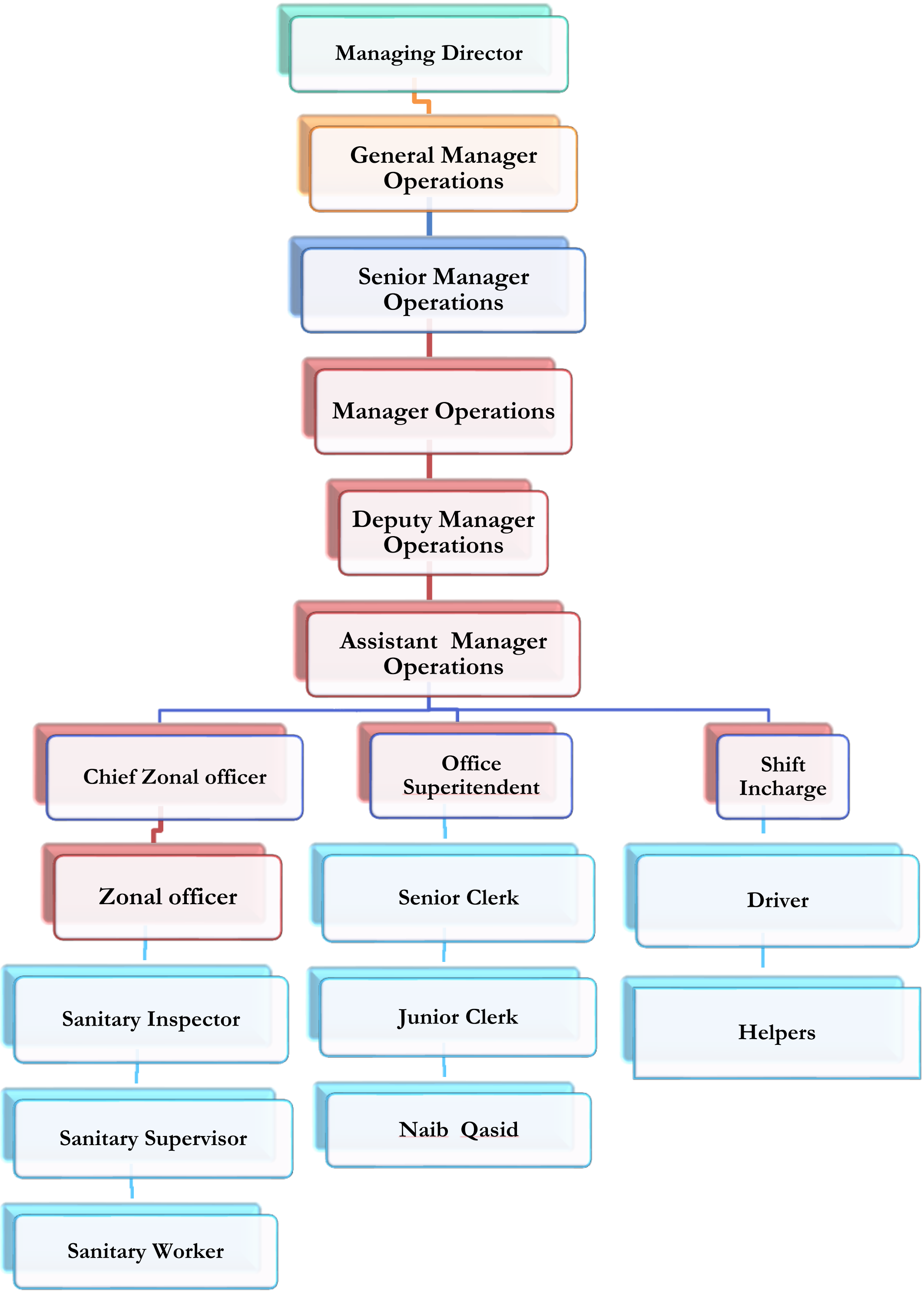


Figure 3. 6 Representing the human resource of RWMC.

3.8 Workforce Strategy of RWMC in Comparison with CDGR

As compared to CDGR, RWMC follows a sophisticated and well-planned labor division as shown in figure 3.6. Additionally, the number of employees working for SWM, maintenance, and repair of vehicles, helpers, office management, and garage management in Rawal Town are also given in Table 3.14

Table 3.14 Summary describing the number of employees for each designation in RWMC working for SWM in Rawal Town

Description	Sector A	Sector B	Sector C	Sector D	Sector E
Deputy Managers	1				1
Assistant Managers	4	2	2	2	4
Chief Zonal Officer	1	1	1	1	1
Zonal Officer	2	2	2	2	2
Chief Sanitary Inspector	1	1	1	1	1
Supervisors	23	18	17	18	26
Sanitary Workers	1970				
Sanitary Helpers	577				
Shift In-chagre	9				
Drivers	470				
Mechanic	32				
Welder	20				
Kamini Maker	3				
Black Smith	2				
Helpers	1				
Plumber	2				
Service Man	12				
Office Staff	12				
Electrician	6				
Painter	5				
Auto Denter	4				
Leaf Spring Maker	3				
Grease Man	2				
Tyreman	15				

In 2014, the workforce of CDGR was only mainly comprised of chief sanitary inspectors, sanitary workers, lorry inspectors, and drivers in multiple sectors of Rawal Town. Summary of the staff mainly dealing with waste collection and transport are given in Table 3.15. Furthermore, the workers concerned with the maintenance and repair of vehicles, helpers, office management, and garage management are also enlisted in Table 3.15

Table 3.15 Staff summary of Rawal Town (sector-wise) as provided in CDGR data in 2014.

Description	Sector A	Sector B	Sector C	Sector D
Chief sanitary inspector	1	1	1	1
Sanitary workers	2100			
Lorry inspector	2		1	
Drivers	28		29	
Mechanic	4			
Welder	2			
Kamini maker	1			
Garage superintendent	1			
Sub-engineer mechanic	1			
Blacksmith	2			
Helpers	1			
Serviceman	5			
Office staff	5			
Electrician	2			
Painter	2			

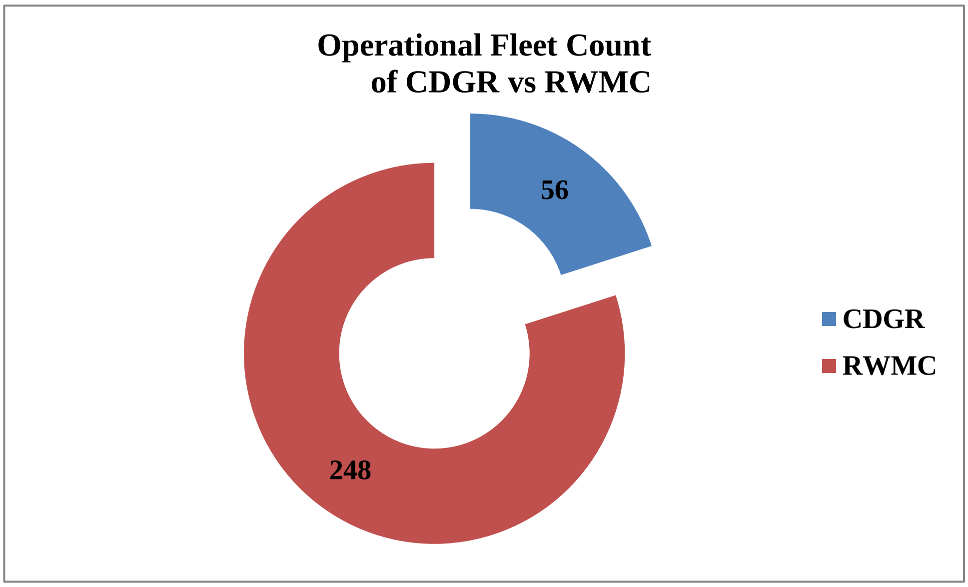


Figure 3.7 Operational fleet count of CDGR (blue) in 2014 as compared to RWMC (red) in 2020.

3.9 Empirical Methods for Data Analysis

Quantitative Methods for the analysis of this study are explained below. In quantitative analysis, tools of exploratory data analysis for finding the summary statistics. Input data variables related to waste handling, collection, transportation, and disposal were defined and calculated along with their respective dependent variables.

Input data for all the parameters including fuel cost, salaries details of staff members involved in SWM, maintenance, and repairs cost, etc. were taken from the utility company. From that data, monthly averages of each parameter were calculated and then added using the formula given below

$$\textbf{Total } MA_C \textbf{ in PKR} = MAWH_c + MAWC_c + MAWT_c + MAWD_c \quad (1)$$

$$\textbf{Per Capita } MA_E \text{ (PKR)} = [CA_C \text{ (PKR)} + RA_C \text{ (PKR)}] / \textbf{Total Municipal Area Population}$$

$$\textbf{Per Capita } MA_E (\$) = \textbf{Per Capita } MA_E \text{ (PKR)} / 153 \quad (2)$$

These variables are defined in detail below in table 3.17

3.9.1 Variable Measurement and Description

3.9.1.1 Measurement of Cost Variables in Per Capita

Per Capita cost for both the commercial and residential SWM was calculated using variable given in Table 3.16

Now the monthly cost of waste management in the commercial area represented as $\mathbf{CA_C}$ can be calculated by using:

$$CA_C \text{ (PKR)} = CAWH_c + CAWC_c + CAWT_c + CAWD_c \quad (3)$$

$$CA_C (\$) = CA_C \text{ (PKR)} / 153 \quad (4)$$

Similarly, the monthly cost of waste management in the residential area represented as $\mathbf{RA_C}$ can be calculated by using:

$$RA_C \text{ (PKR)} = RAWH_c + RAWC_c + RAWT_c + RAWD_c \quad (5)$$

$$RA_C (\$) = RA_C \text{ (PKR)} / 153 \quad (6)$$

In order to calculate the per capita commercial area expenses (CA_E) in PKR following formula can be used:

$$\textbf{Per Capita } CA_E \text{ (PKR)} = CA_C \text{ (PKR)} / \textbf{Total Commercial Area Population} \quad (7)$$

$$\textbf{Per Capita } CA_E (\$) = \textbf{Per Capita } CA_E \text{ (PKR)} / 153 \quad (8)$$

Likewise, to calculate the per capita residential area expenses (RA_E) in PKR following formula can be used:

$$\textbf{Per Capita } RA_E \text{ (PKR)} = RA_C \text{ (PKR)} / \textbf{Total Residential Area Population} \quad (9)$$

$$\textbf{Per Capita } RA_E (\$) = \textbf{Per Capita } RA_E \text{ (PKR)} / 153 \quad (10)$$

Table 3.16 Per Capita cost measurement variables of commercial and residential area and municipal waste collection.

Commercial Area Expenses (CA_E)	
Dependent Variables	
Variable Name (Unit)	**Description and Measurement: Definition of Variable**
$CAWH_c$ (PKR[1])	It represents monthly commercial area waste handling costs. It is the average of the Monthly handling costs
$CAWC_c$ (PKR[1])	It represents monthly commercial area waste collection operations cost. It is the average the monthly collection operations cost
$CAWT_c$ (PKR[1])	It represents monthly commercial area waste transportation costs. It is the average of the monthly transportation costs
$CAWD_c$ (PKR[1])	It represents monthly commercial area waste disposal costs. It is the average of the monthly disposal costs
Residential Area Expenses (RA_E)	
Dependent Variables	
$RAWH_c$ (PKR[1])	It represents monthly residential area waste handling costs. It is the average of the monthly handling costs
$RAWC_c$ (PKR[1])	It represents monthly residential area waste collection operations costs. It is the average the monthly collection operations cost
$RAWT_c$ (PKR[1])	It represents monthly residential area waste transportation costs. It is the average of the monthly transportation costs
$RAWD_c$ (PKR[1])	It represents monthly residential area waste disposal costs. It is the average of the monthly disposal costs
Municipal Waste Management Expenses (MA_E)	
$MAWH_c$ (PKR[1])	It represents monthly municipal area waste handling costs. It is calculated by adding up the averages of the monthly handling costs of both commercial and residential area (**$MAWH_c = CAWH_c + RAWH_c$**)
$MAWC_c$ (PKR[1])	It represents monthly municipal area waste collection costs. It is calculated by adding up the averages of the monthly waste collection costs of both commercial and residential area (**$MAWC_c = CAWC_c + RAWC_c$**)
$MAWT_c$ (PKR[1])	It represents monthly municipal area waste transportation costs. It is calculated by adding up the averages of the monthly waste transportation costs of both commercial and residential area (**$MAWT_c = CAWT_c + RAWT_c$**)
$MAWD_c$ (PKR[1])	It represents monthly municipal area waste disposal costs. It is calculated by adding up the averages of the monthly waste transportation costs of both commercial and residential area (**$MAWD_c = CAWD_c + RAWD_c$**)

3.9.1.2 Measurement of Overall Cost Variables

Waste Handling Cost (WHC)

In waste handling cost, the monthly cost incurred by the equipment and utilities (EU_c), in addition to the cost of the container (C_C) per project and the monthly container's repair cost (CR_C) will be considered.

So the waste handling cost (WHC) can be calculated by using:

$$\textbf{Waste Handling Cost (WHC)} = EU_c + C_C + CR_C \qquad \textbf{(11)}$$

Where **Equipment and Utilities (EU_c)** is the cost calculated from the monthly store equipment data, **Containers Cost (C_C)** is calculated by dividing the total cost of the containers with the duration (total number of months) of the project and **Container Repair Cost (CR_C)** is a monthly cost of container's repair taken from the store data.

Waste Collection Operation Cost (WCOC)

Waste collection operations cost **(WCOC)** depends on multiple parameters. It includes the cost imposed due to the monthly salaries UC workers (UW_c) and operations supervisors (SC_c). Additionally, collection, maintenance, and repair costs ($CM\&R_C$) of vehicles, cost due to the monthly salaries of heavy vehicles driver (HD_C), light vehicle driver (LD_C), and helper operator (HO_c) are also taken into consideration while calculating Waste Collection Operation Cost. Furthermore, the financial burden of fuel consumption (CF_c), operations staff cost (OS_C), the shift in-charge cost (SI_C), and Misc. cost (M_C) will also be considered.

So the waste collection operation cost (WCOC) can be calculated by using

$$\textbf{WCOC} = UW_C + OS_C + M\&R_C + HD_C + LDC + HO_C + CF_C + OS_C + SI_C + M_C \qquad \textbf{(12)}$$

Where UC workers cost **(UW_c)** and operations supervisor cost **(OS_C)** is taken from monthly wages of UC workers and supervisors. Monthly expenses of collection, maintenance, and repairs **($CM\&R_c$)** of vehicles are calculated from the store data, heavy driver cost **(HD_C),** light driver cost **(LD_C)** and helper operator cost **(HO_C)** can be estimated from the monthly wages of drivers of heavy, light vehicles and their helpers. Collection fuel cost **(CF_C)** represents the monthly fuel consumption cost during the waste collection operations phase. Operations staff cost **(OS_C)** and shift in-charge cost **(SI_C)** are the costs calculated from the monthly wages of field operations staff and shift in-charges. The last parameter implies the miscellaneous monthly expenses due to vehicle accidents, injuries to the staff, compensation in case of any unfortunate event, and cost of weekly social awareness campaigns.

Waste Transportation Cost (WTC)

In waste transportation cost **(WTC)**, maintenance and repair cost of the transport mediums used for the waste transfer ($TM\&R_C$), the fuel cost of the vehicles used for the transportation (TF_C), and the cost incurred due to the salaries of hauler drivers (HD_C), transportation staff cost (TS_C) will be considered. Waste transport cost (WT_C) can be calculated by using the formula given below

$$\mathbf{WTC = TM\&R_C + HD_C + TF_C + TS_C} \quad \mathbf{(13)}$$

Where **TM&Rc** is a parameter that is calculated on monthly basis from the store record related to the maintenance and repairs of the vehicles. Additionally, $\mathbf{TF_C}$ represents the cost of fuel generated by the vehicles used for the transportation of the waste from primary collection points to dumpsite is also considered while calculating transportation cost. ($\mathbf{HD_C}$) and **(**$\mathbf{TS_C}$**)** represent salaries of hauler drivers and transportation staff cost.

Procedure to Calculate Fuel Cost of Vehicles ($\mathbf{TF_C}$**)**

$\mathbf{TF_C}$ of Albayrak (Contractor) RWMC

TF_C of Albayrak (Contractor) RWMC**=** Total Trips = Total Tonnage/ per trip tonnage

$\mathbf{TF_C}$ = Monthly Diesel Rate * Total Numbers of trips * Per Trip Fuel $_{\text{Average}}$

$\mathbf{TF_C}$ of the Albayrak Sub-contractor

The Albayrak contractor of RWMC yearly decides this cost/ per ton basis. This cost was 560 PKR /ton in 2018, 580 PKR/ton in 2019 and 600 PKR /Ton in 2020.

The total tonnage of the sub-contractor is simply calculated by multiply the monthly tonnage with its total transported tonnage.

Transportation Cost of the Albayrak Sub-contractor = Monthly contractors Tonnage * rate for the transfer of the waste per ton

RWMC Waste Transportation Cost = TF_C of Albayrak (Contractor) RWMC + TF_C of the Albayrak Sub-contractor (14)

HD_C and TS_C represent the amount/cost based on the monthly wages of the hauler drivers and transportation staff, respectively. Monthly transportation staff expenses are calculated from HR and store data.

Waste Disposal Cost (WDC)

In disposal cost, parameters like disposal staff cost (DS_C), disposal fuel cost (DF_C), disposal utility cost (DU_C), disposal maintenance and repair cost ($DM\&R_C$), disposal contractor operators, and machinery cost (DCM_C) as well as miscellaneous disposal expenses (DM_C) will be considered. Waste disposal cost (WDC) can be calculated by using the formula given below

$$WDC = DS_C + DF_C + DU_C + DM\&R_C + DCM_C + DM_C \quad (15)$$

Where disposal staff cost **(DS_C)** represents the monthly disposal staff wages, disposal fuel cost **(DF_C)** represents the monthly disposal fuel expenses (given in table 3.16), disposal utility cost (**DU_C**) can be calculated from the monthly utility expenses. This data can be taken from store data, disposal maintenance and repair cost **($DM\&R_c$)** can be calculated from the monthly disposal machinery and equipment maintenance and repair cost. In the equation, 4 disposal contractor operators & machinery cost **(DCM_C)** represents the monthly pavements to the contractor for machinery support and disposal miscellaneous expenses **(DMC)** includes all the monthly expenses of tools at weighing stations, accidental recovery cost or legal fees, etc.

Per Ton Disposal Cost = Monthly disposal cost / total monthly tonnage **(16)**

The result value PKR/ton disposal value is used to calculate the disposal monthly cost of all other month's costs.

Monthly Per Capita Disposal Cost= (Average of all monthly tonnages *per ton disposal cost**)** / Total population **(17)**

Monthly Per Capita Disposal Cost of Recyclable items = (Total recyclable tonnage *per ton disposal cost)/ Total population **(18)**

3.10 Recyclable Cost Benefit

Recyclable Cost-Benefit of Item= % of the item in the MW waste * MW monthly tonnage * Per Ton Cost **(19)**

Recyclable Cost-Benefit of Item= % of the item in the MW waste * MW monthly Tonnage * Per Ton Cost **(20)**

Monthly Recyclable Cost-Benefit = Cost-benefit of Paper & Cardboard + Cost-benefit of rubber + Cost-benefit of Glass+ Cost-benefit of Metal + Cost benefit of plastic **(21)**

Per Capita Monthly Recyclable Benefit (PKR,$) = Monthly Recyclable Benefit / Total Population **(22)**

3.10.1 Carbon Social Cost-Benefit

3.10.1.1 Current Per Capita Carbon Social Cost-Benefit

Monthly Transportation Trips = Total waste Tonnage / per trip tonnage **(23)**

Monthly Transportation Fuel of Waste = Transportation trips* Per Trip Fuel in liters **(24)**

Total Monthly Carbon Emissions= Transportation fuel * Per Liter Carbon emissions (Per kg/Liter) **(25)**

Total Monthly Carbon Benefit in $ = (Total Monthly Carbon emissions /1000)* per ton Carbon Social Cost in $ **(26)**

Per Capita Carbon Benefit = Total Monthly Carbon Benefit in $ /Total Population **(27)**

3.10.1.2 Reduced Per Capita Carbon Social Cost-Benefit

Similarly, the carbon social cost saved due to saved transportation fuel by the recovery of recyclables is calculated.

Monthly Transportation of Recyclable Waste Trips = Total recyclable waste Tonnage / per trip tonnage **(28)**

Monthly Transportation Fuel of Recyclable Waste = Transportation trips* Per Trip Fuel in liters **(29)**

Total Monthly Carbon Emissions Reduced = Transportation fuel reduced * Per Liter Carbon emissions (Per kg/Liter) **(30)**

Total Monthly Carbon Benefit by Recyclable Waste Recovery ($) = (Total Monthly Carbon emissions reduced /1000)* per ton Carbon Social Cost ($) **(31)**

Per Capita Carbon Benefit by Recyclable Waste Recovery= Total Monthly carbon Benefit by the recyclable waste recovery ($) /Total Population **(32)**

3.11 Economic Analysis Summary

The Overall Municipal Waste Expenses per capita = MW handling Cost/ Capita + MW Collection Cost/Capita + MW transportation Cost /Capita + MW Disposal Cost/ Capita

The equation (1) for this has been given above in section 3.9

Reduced Municipal Waste Expenses (MAE_r) per capita Cost= The overall municipal waste expenses per capita Cost-Fuel Transportation Cost-benefit - Disposal Cost-Benefit - Recyclable Material Cost Saved -Carbon Social Cost Saved **(33)**

3.12 Ethical Consideration

For research work, ethical issues have a prime role in research activities. It is very important to handle carefully in any research activity. Data was collected only for research activities, which was the body of knowledge and need to be kept confidential. Research work was carried out with the informed consent of the respondents, which has not violated research ethics. So, the confidentiality and privacy of the respondents and/or can be safeguarded.

CHAPTER 4. RESULTS AND DISCUSSION

In the study, the current solid waste situation of Rawalpindi was studied and evaluated to check the real composition of the waste types, its composition, and its different sources. To assess the current cost of the handling collection transportation disposal of municipal waste are calculated based on field data analysis and departmental data analysis. All the costs are separately calculated for the compressive analysis and data study to calculate the current per capita cost of commercial areas and residential areas to justify and get an accurate value. After this, the current per capita municipal waste expenses are calculated and validated with the original RWMC payment invoices to get the accuracy.

4.1 Types and Classification of Waste

4.1.1 Waste Generation Rate

The waste generation rate is an important factor to be considered in SWM operations. It defines all the basic calculations ranging from workforce requirements to fleets requirements and all the costing and financial aspects also in the waste management system. The given table is the waste generation and population increment of different years taken from the CDGR report and data of 2014 submitted with the post clerical 1(PC1) for RWMC and Albayrak contract. Year-wise population and different phases of waste generation rate are calculated and attached in Appendix 1. The percentage increment in the rate of waste generation (Kg/c/day) is given in the following Table 4.1

Table 4.1 Year-wise distribution of the rate of waste generation in different phases (kg/c/day)

Waste Generation Rate (kg/c/day)						
Phase	**Incremental Increase in Waste Generation**					
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
A	0.57	0.58	0.58	0.59	0.60	0.61
B	0.57	0.58	0.58	0.59	0.60	0.61
C	0.57	0.58	0.58	0.59	0.60	0.61
D	0.57	0.58	0.58	0.59	0.60	0.61

4.1.2 Sources of Waste Collection

For waste collection calculations, UCs Area, population, classification, phase, workers, and waste tonnage details of the CDGR (2014) model & RWMC (2015-2021) model all are important factors in defining and calculating the cost and financial aspects for the better municipal waste collection system. All the data is taken from the CDGR and RWMC officially. The workforce is the crucial aspect of municipal waste management cost. Following are the workforce details compiled after extensive data analysis of HR records of RWMC & Albayrak (Table 4.2)

Table 4.2 Summary highlighting the comparison of workers of CDGR in 2014 and RWMC in 2020

Workforce Details 2014 & 2020					
Workers	**CDGR 2014**	**RWMC 2020**	**Worker**	**CDGR 2014**	**RWMC 2020**
Regular UC SWs	984	1441	Regular Drivers	82	32
Contract	316	118	Contract	24	37
Daily Wages SWs	415	589	Daily Wages Drivers	52	300
Helpers	184	610	OPS Staff Driver	28	44
Vacant	35	52	Vacant	6	5
Total SWs	1934	2810	Total Drivers	192	418

Waste collection from the UCs waste was also calculated based upon the available tonnage data and after analysis; Table 4.3 shows the waste collection percentages and daily waste collection in both CDGR and RWMC waste management models. In the RWMC waste management system, the percentage of the daily collection is almost double as compared to CDGR waste collection. RWMC is collecting 875 tons of waste on daily basis from 62 UCs of the study area (Table 4.3). According to the CDGR data, waste tonnage collection was only 40% in 2014. It was mainly due to the limited resources and mismanagement of collection operations. Whereas the RMWC model, waste tonnage collection is between 80-85 %. Rest 10 % of the uncollected waste is being illegally dumped e.g., in Nala Lai and few areas coinciding with Capital Development Authority (CDA), Rawalpindi Cantonment Board (RCB), and Railway colonies. Scavengers are also taking out the recyclable items from some of the percentage of this uncollected waste away.

Table 4.3 Comparison of daily waste collection percentages and tonnage in both CDGR and RWMC waste management models

Rawalpindi City Models	**No of UC**	**Estimated Tonnage (tons)**	**Daily Collection (%)**	**Collected Tonnage Daily (tons)**
RWP CDGR Model (2014)	62	781	0.4	312
RWMC Model (2015- 2021)	62	1092	0.8	874

4.1.3 Classification and Composition of Waste

As part of the study analysis, waste classification was also done to find out the percentages and tonnage of different types of waste being collected by RWMC. Field sorting of waste was carried out for 3 months to find out the correct percentages of different types of wastes. Sorting is split into commercial waste sorting, residential waste sorting, and institutional waste sorting. The composition of waste, their percentages, and percentage/yield of recyclable waste in commercial, residential, and institutional waste is given in table 4.4

Table 4.4 Classification and Composition of waste in commercial, residential, and institutional waste. Percentage of recyclable waste in each category is also given

Composition of waste in RWP					
Residential Waste		**Commercial Waste**		**Institutional Waste**	
Items	**Percentages**	**Items**	**Percentage**	**Items**	**Percentage**
Organic Waste	50%	Organic Waste	30%	Organic Waste	34%
Ash ,Dirt ,Bricks	1%	Ash	1%	Green Waste	20%
Yard Waste	9%	Dirt ,Bricks	12%	Ash,Dirt ,Bricks	1%
Palstic	3%	Palstic	11%	Palstic	6%
Textile	3%	Textile	4%	Textile	5%
Rubber	1%	Rubber	3%	Rubber	1%
Paper & Cardboard	6%	Paper & Cardboard	11%	Paper & Cardboard	7%
Glass	2%	Glass	5%	Glass	1%
Metal	1%	Metal	5%	Metal	1%
Shoppers	11%	Shoppers	13%	Shoppers	12%
Hazardeous waste	1%	Hazardeous waste	3%	Hazardeous waste	3%
Pampers/diapers	12%	Pampers/diapers	2%	Pampers/diapers	9%
Total	**100%**	**Total**	**100%**	**Total**	**100%**
Recyclable Material	**27%**	**Recyclable Material**	**52%**	**Recyclable Material**	**33%**

Furthermore, the percentage of each recyclable item was calculated from three types of wastes and given in Table 4.5. The recyclable materials in the municipal waste are the average values taken from the above table of the items in residential waste, commercial waste, and institutional waste which were taken from the field survey and collected data. In the municipal waste, paper and cardboard are present in the highest percentage followed by plastic (7%), glass (3%), rubber (2%), and metal (2%) in Table 4.5.

Table 4.5 Percentage of multiple components of recyclable items in municipal waste.

Recyclables Materials in MW	
Recyclables	**Percentage in MW**
Plastic	7%
Rubber	2%
Paper & Cardboard	8%
Glass	3%
Metal	2%

RWMC is operating with its contractor, which is responsible for the waste collection of 62 Union Councils of Rawalpindi. (Figure 4.1). Albayrak is collecting the MW through different means and equipment is ranging from sanitary workers collection at house level to waste collection through a variety of machinery with a total fleet of 270 vehicles.

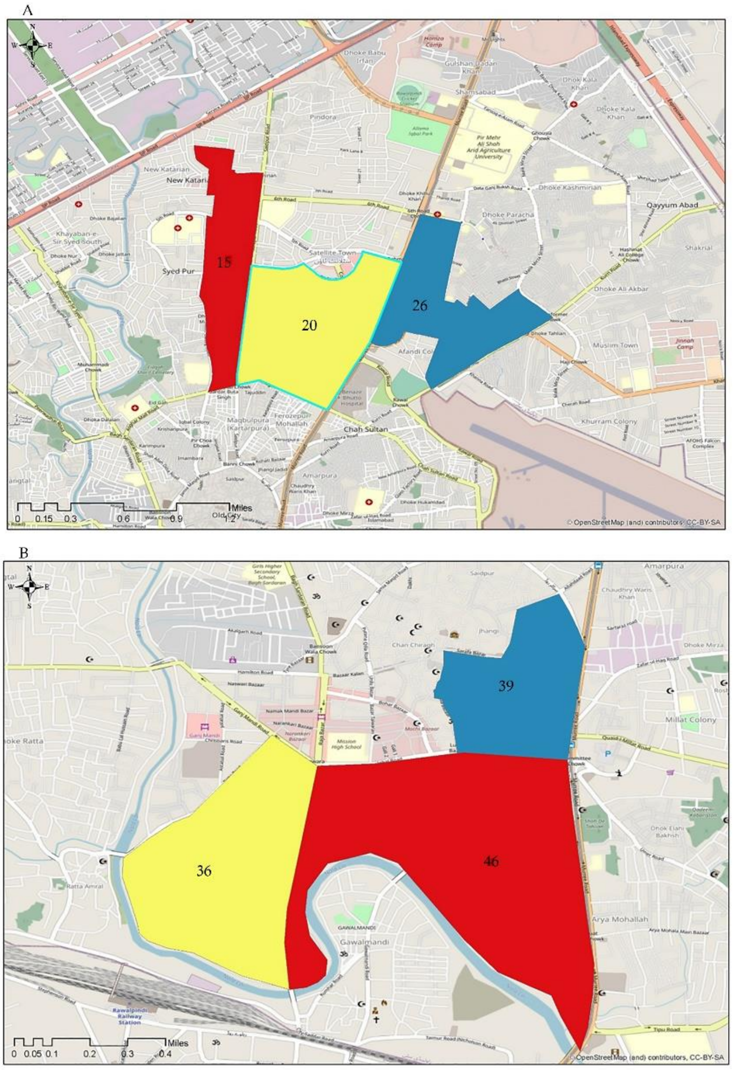


Figure 4.1 Map of multiple UCs of Rawalpindi from where RWMC is collecting waste

4.1.4 Tonnage Collection

Tonnage collection along with different types of waste collection tonnage is calculated from the filed data. Albayrak tonnage, contractor tonnage, municipal tonnage, C & D, and Recyclable waste are the parameters involve in calculating tonnage collection. Here Albayrak tonnage is the hauler-transported tonnage to the dumpsite. Contractor tonnage is the tonnage transported by the contractor to the dumpsite. Municipal waste is the waste collected from residential, commercial, and institutional areas, which is around 85%. C& D waste is the waste collected from construction and demolition activities in the city and RWMC is separately paying for it, which is almost 15 %, and only 22 % of the collected waste is of recyclable materials from the MW. Year-wise tonnage collection of RWMC for 2018, 2019, and 2020 is given in Table 4.6

Table 4.6 Summary of year-wise RWMC collected tonnage

RWMC Collected Tonnage (Year-wise)				
Yearly Tonnage	**Daily Average in Tons**	**Total C& D Tonnage Collected In Tons**	**Total Recyclable Waste Tonnage Collected In Tons**	**Total RWMC Tonnage Collected In Tons**
2018	882	48,233.2	6,013.06616	341,081.9
2019	857	37,508.6	5,845.08368	312,571.32
2020	808	44,323.3	5,525.63757	295,488.64

4.2 Analysis of Per Capita Cost of Handling, Collection, Transportation and Disposal of Municipal Waste

4.2.1 Commercial Area Waste Management Cost (CAC)

The monthly analysis of commercial waste collections shows that the waste handling cost (CAWHc) is almost 4.2% of the total expenses. In the case of commercial waste, the collection cost (CAWCc) showed the highest percentage of 68.7%. Transportations waste cost (CAWTc) and disposal waste cost (CAWDc) in the commercial area are 7.1% and 20%, respectively (Table 4.7).

Table 4.7 Commercial area waste cost analysis in PKR. The contribution of each variable to the total cost is calculated in PKR and percentages are given

Commercial Area Waste Cost (CA_C)		
Costs (PKR)		**Percentage (%)**
Commercial Area Handling Cost **($CAWH_c$)**	258,919.5134	4.2
Commercial Area Collection Operations cost **($CAWC_c$)**	4,402,738.63	68.7
Commercial Area Transportation cost **($CAWT_c$)**	441,267.779	7.1
Commercial Area Disposal cost **($CAWD_c$)**	1,365,886	20.0
Total	**6,468,811.9224**	**100**

Characterization of commercial area waste in terms of percentage is also given in figure 4.2. Percentage of food/domestic, bulky & C&D waste is 54.5%, 20% and 25.5 % respectively.

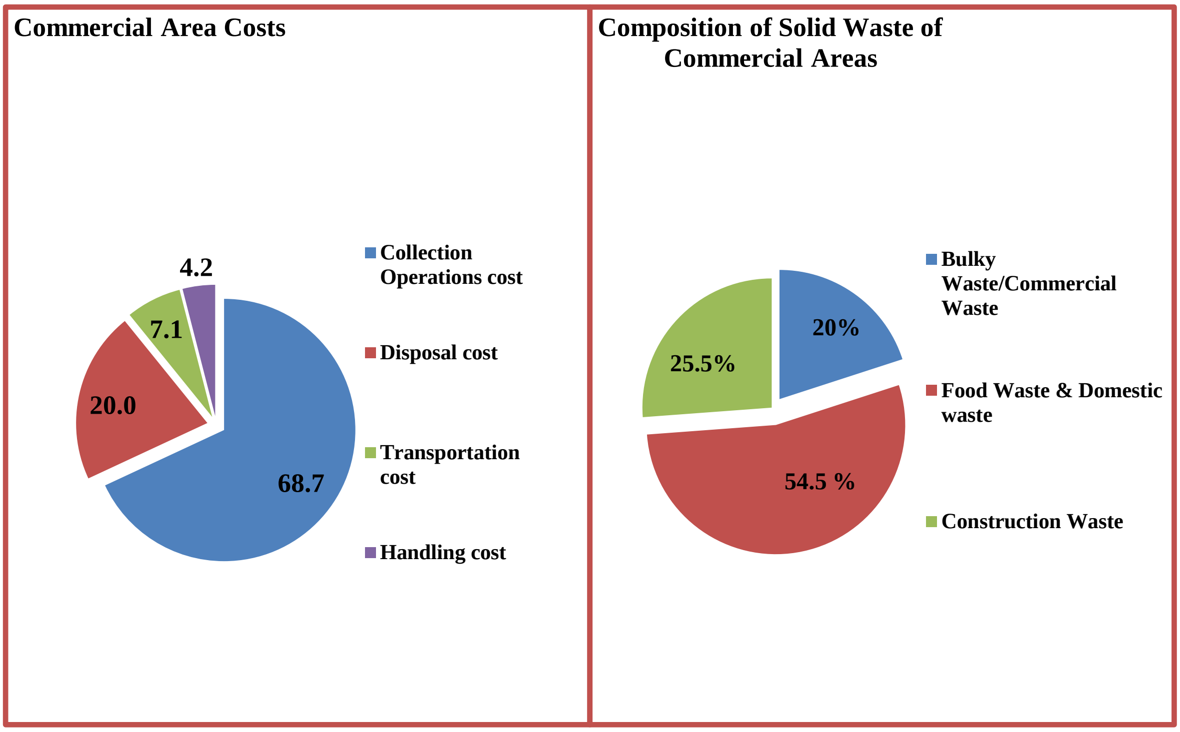


Figure 4.2 (left) Pie chart representing the percentage contribution of each variable of Commercial area waste cost analysis. (Right) Pie chart representing the percentages of multiple categories of commercial waste.

4.2.2 Residential Area Waste Cost (RA_C)

The monthly analysis of residential area waste collection cost **(RA_C)** shows that the waste handling cost (**$RAWH_c$)** is almost 3.8 % of the total expenses. Whereas waste collection cost (**$RAWC_c$)** in the case of residential areas is 62.3%. Moreover, the waste transportations cost (**$RAWT_c$)** and disposal waste cost (**$RAWD_c$)** in of residential area is 8.3 % and 25.6% (Table 4.8)

Furthermore, the characterization of the residential waste in terms of food/domestic, bulky & C&D waste yielded 54.5%, 20%, and 25.5 %, respectively (Figure 4.3).

Table 4.8 Residential area waste cost analysis in PKR. The contribution of each variable to the total cost is calculated in PKR and percentages are given.

Residential Area Waste Cost (RA_C)		
Cost (PKR)		**Percentage (%)**
Residential Area Waste Handling Cost (**$RAWH_c$**)	204,456.13	3.8
Residential Area Waste Collection Operations Cost (**$RAWC_c$**)	3,320,608.6	62.3
Residential Area Waste Transportation Cost (**$RAWT_c$**)	441,267.78	8.3
Residential Area Waste Disposal Cost (**$RAWD_c$**)	1,365,886	25.6
Total	**5,332,218.51**	**100**

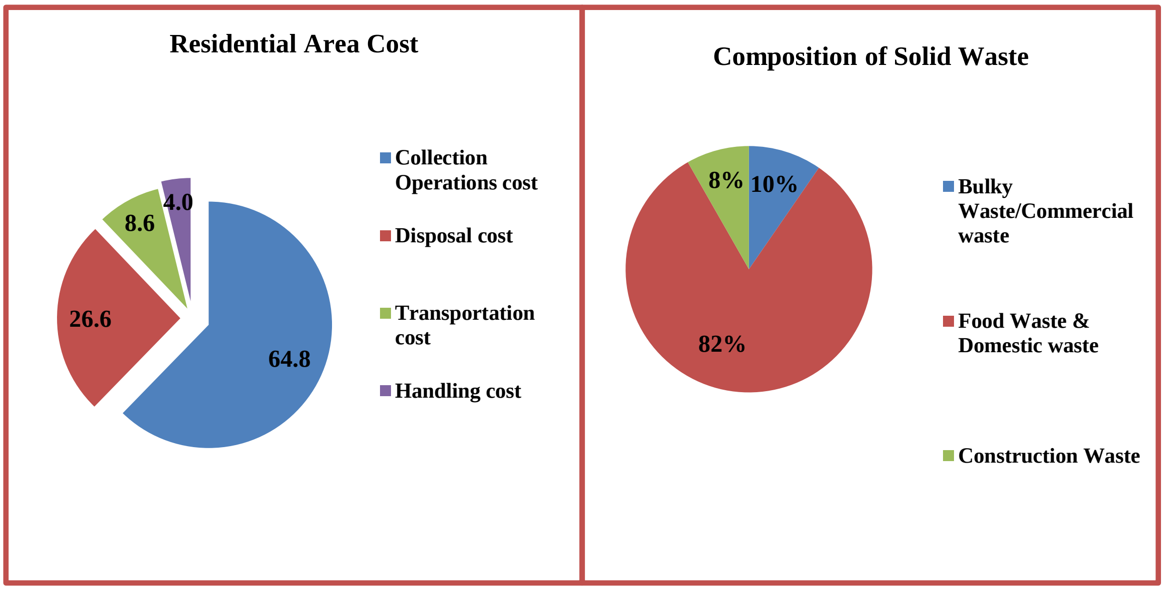


Figure 4.3 (left) Pie chart representing the percentage contribution of each variable of residential area waste cost analysis. (Right) Pie chart representing the percentages of multiple categories of residential waste.

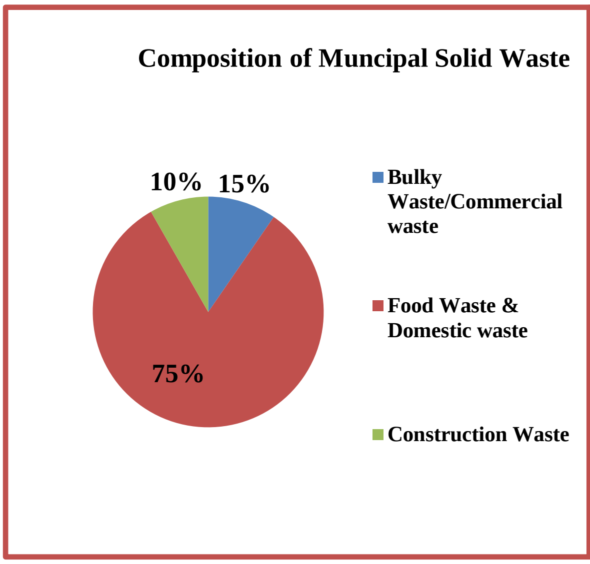
4.2.3 Municipal Waste Management Cost

In overall municipal cost analysis, municipal area waste handling cost (**$MAWH_c$**) was calculated from the average monthly values of commercial and residential areas analysis the handling cost accounts for 4.0%, municipal area waste collection operations cost (**$MAWC_c$**) accounts for 68.1%, municipal area waste transportation cost (**$MAWT_c$**) was 6.8 % while the municipal waste disposal cost (**$MAWD_c$**) was 21.1% shown in Table 4.9

Table 4.9 Municipal waste management cost analysis in PKR. The contribution of each variable to the total cost is calculated in PKR and percentages are given.

Municipal Waste Management Cost & Percentage		
Cost (PKR)		Percentage (%)
Municipal Area Waste Handling Cost (**$MAWH_c$**)	258,919.5134	4.0
Municipal Area Waste Collection Operations Cost (**$MAWC_c$**)	4,402,738.63	68.1
Municipal Area Transportation cost (**$MAWT_c$**)	438,767.779	6.8
Municipal Area Disposal cost (**$MAWD_c$**)	1,365,886	21.1
Total	**6,466,311.923**	**100**

Percentages appeared after municipal waste characterization into food/domestic, bulky & C&D waste are 75%, 10%, and 15 %, respectively (Figure 4.4)



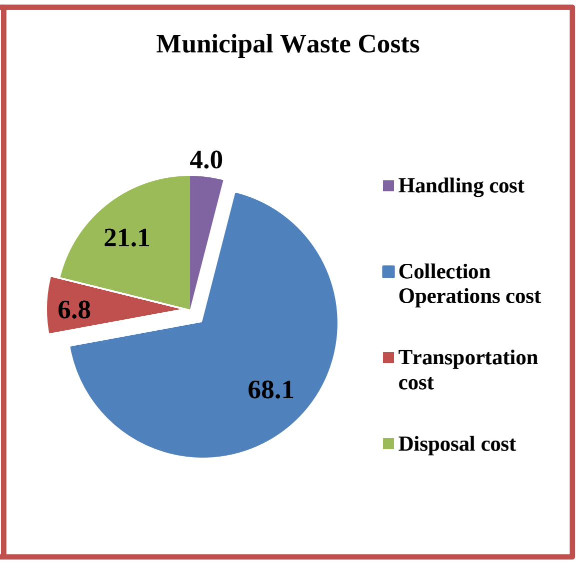


Figure 4.4 (left) Pie chart representing the percentages of multiple categories of residential waste. (Right). Pie chart representing the percentage contribution of each variable of municipal area waste cost analysis.

4.3 Per Capita Municipal Waste Cost (MA_E)

Per capita cost of municipal waste can be drawn out by considering the average cost of the per capita cost of commercial area expenses **(CA_E)** and per capita Residential Area expenses (**RA_E**).

4.3.1 Per Capita Commercial Area Expenses (CA_E)

Per capita commercial area expenses (**CA_E**) are depending on the cost associated with the commercial area waste management **(CA_C**) given in Table 4.7 and the number of people in the commercial area (Table 4.10). According to this analysis, the per capita cost of waste management in the commercial area is 67.69 PKR and 0.44 $ (Table 4.10)

Table 4. 10 Analysis of per capita commercial area expenses.

Per Capita Commercial Area Expenses (CA_E)	
Monthly Expenses (PKR)	6,468,811.9224
Total Population (count)	95,560.90165
Per Capita Cost (PKR)	67.6930817
Per Capita Cost ($)	0.44

4.3.2 Per Capita Residential Area Expenses (RA_E)

Per capita residential area expenses (**RA_E**) is depending on the cost associated with the residential area waste management (**RA_C**) given in Table 4.8 and the number of people in the commercial area (Table 4.11). According to this analysis, the per capita cost of waste management in the commercial area is 55.50 PKR and 0.36 $ (Table 4.11)

Table 4. 11 Analysis of per capita commercial area expenses

Per Capita Residential Area Expenses (RA_E)	
Monthly Expenses (PKR)	5,33,2218.51
Total Population	96,058
Per Capita Cost (PKR)	55.51040527
Per Capita Cost ($)	0.36

Comparison of per capita cost of commercial area expenses (CA_E) and residential area expenses (RA_E) are given in Figure 4.5

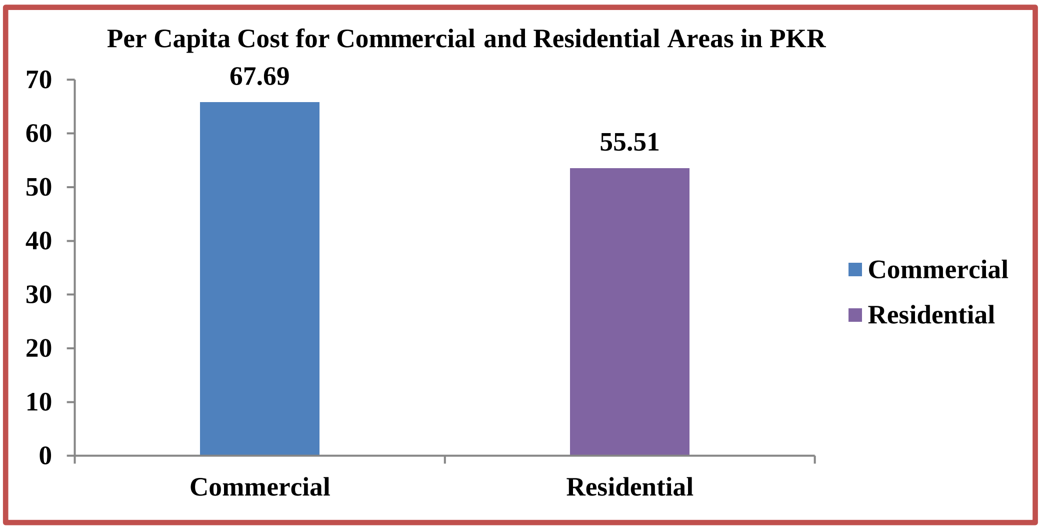


Figure 4.5 Bar plot comparing the per capita cost of commercial and residential area waste management in PKR.

After calculating commercial area expenses **(CA_E)** and residential area expenses **(RA_E),** per-capita municipal waste management expenses **(MA_E)** were calculated according to the formula given in Section 3.9. The analysis is given below

4.3.3 Per Capita Municipal Waste Cost Summary

The per capita cost for the municipal waste handling collection transportation and disposal comes out to be 0.39 $ per capita or 59.67 PKR per capita in Rawalpindi city given in Table 4.12.

Table 4.12 Per capita municipal waste cost analysis

Per Capita Municipal Waste Cost Summary	
Monthly Expenses (PKR)	11,747,270.19
Current Population of 62 UCs	1,826,019
Current Per Capita Cost (PKR)	59.67
Current Per Capita Cost ($)	0.39

Summary of the commercial area expenses **(CA_E)** and residential area expenses **(RA_E)** and final per capita cost for the Municipal waste handling collection transportation and disposal is given in Table 4.13.

Table 4.13 Summary of expenses, percentage expense. Per capita cost in PKR and $ for commercial, residential, and municipal area

Area	**Expense**	**Percentage Expense**	**Per Capita Cost ($)**	**Per Capita Cost (PKR)**
Commercial	6,468,811.923	54.60587863	0.44	67.6930817
Residential	5,332,218.527	45.39412137	0.36	55.51040527
Municipal waste	11,747,270.19	100	0.39	59.67

4.4 Data Validation

Per capita cost analysis values were further validated with the actual RWMC/Albayrak invoices for the month of July-2019 and August-2019. Their data showed 59.86 PKR (0.39$) per capita cost in July 2019 and 60.98 PKR (0.39$) in August 2019 (Table 4.14). Analysis of the proposed study showed 59.67 PKR (0.39$) per capita municipal cost (Table 4.12 & 4.13). Analysis done in the proposed study is similar to the per capita cost that RWMC is paying to its contractor monthly on a tonnage basis.

Table 4.14 Summary of the per capita cost being paid by RWMC to its contractor monthly on a tonnage basis

Data Validation Validating Against the Amount Paid as Per Invoice by RWMC to Albayrak			
July-2019			
Population of RWP		1,826,019	Per Capita Cost ($)
Paid ($)	Manual Sweeping	146,138.7	0.080031324
Paid in ($)	Per ton	611,648	0.334962753
Paid ($)		757,787.2	0.414994077
Per Capita Cost ($)			0.391290128
Per Capita Cost (PKR)			59.86738958
August-2019			
Population of RWP		1,826,019.3	Per Capita Cost ($)
Paid ($)	Manual Sweeping	15,9181.22	0.087173898
Paid ($)	Per ton	660,725	0.361839008
Paid ($)		819,906.22	0.44
Per Capita Cost in $ after Analysis			0.398569136
Per Capita Cost in PKR after Analysis			60.9810778

All the variables calculated for this analysis are given in Appendix 4 and 5.

4.5 Analysis of Overall Cost Variables

4.5.1 Per Capita Waste Transportation Cost (WTC)

RWMC is currently operating with one contractor (Albayarak) which has two means of transporting the collected waste from the city to its dumpsite in Losar (22 Km round trip distance). Albayrak is using its haulers to transfer the collected waste using sub-contractors' machinery at different yearly per ton rates. The Hauler truck is of 40 cubic meter capacity. However, due to the unavailability of an unloading platform at the dumpsite, it takes a reduced weight of 25 tons per trip to avoid toppling and accidents. The average fuel for each hauler round trip to the dumpsite is 30 liters. The cost of all the variables associated with the WTC is 162,658,316.3 PKR as given in Table 4.15

Table 4.15 Cost of all the variables associated with the waste transport (WTC)

Waste Transportation Cost per Month	
Variables	**Cost (PKR)**
Shift In-charge (**TS_C**)	150,000
Operators/Drivers **(HD_C)**	405,000
Transportation Fuel **(TF_C)**	161,656,316.3
Helpers **(TS_C)**	351,000
Maint. and repair **($TM\&R_C$)**	96,000
Total (PKR)	**162,658,316.3**

Per capita transportation cost used for transporting the collected waste to dump at Losar dumpsite is 89.078 PKR or 0.582$ per year. Monthly per capita WTC is also given in Table 4.16.

Table 4.16 Monthly and yearly summary of per capita waste transport cost (WTC) of all the collected waste

Summary Per Capita Transportation Cost (Fuel Used for Transporting All the Collected Waste)	
Total 3 Year Transportation Expenses (PKR)	487,974,948.9
Total 3 Year Transportation Expenses ($)	3189378.751
Total Yearly Transportation Expenses (PKR)	162658316.3
Total Yearly Transportation Expenses ($)	1063126.25
Total Population (count)	1826019
Yearly per capita Transportation Cost (PKR)	89.07810724
Yearly per capita Transportation Cost ($)	0.582209851
Monthly per capita Transportation Cost (PKR)	7.423175603
Monthly per capita Transportation Cost ($)	0.048517488

4.5.1.1 Reduced Per Capita Waste Transportation Cost (WTC_r)

The analysis given in Table 4.17 describes the reduced per capita waste transportation (WTC_r) due to fuel used for transporting only the non-recyclable waste. This will help to reduce the transportation fuel cost **(TF_C)** from not transporting the recyclable cost waste. Reduced **(TF_C)** was calculated and a cost-benefit value was termed.

The recyclable waste percentage was taken from the analysis above which is 22% of the 85% municipal waste extracted from the total collected waste in Table 4.7. Fuel cost saved for not transporting the recyclable waste and fuel cost for only transporting the non-recyclable waste was calculated separately. Table 4.17 displays the reduced cost as well as the extent of reduction in four dependent variables.

Table 4.17 Reduced cost of all the variables associated with the waste transport cost (WTCr)

Reduced Waste Transportation Cost per Month (WTCr)			
Variables	**Cost**	**Reduction**	**Reduced Cost (Non-recyclable waste transport only)**
Shift In-charge (**TS_C**)	150,000	33,000	117,000
Operators/Drivers **(HD_C)**	405,000	89,100	315,900
Transportation Fuel **(TF_C)**	161,656,316.3	22,154154,304.9	139,502,011.4
Helpers **(TS_C)**	351,000	77,220	273,780
Maint. and repair **($TM\&R_C$)**	96,000	21,120	74,880
Total Reduction (PKR)			140,283,571.4
Total Reduction ($)			9,1961,67.524

The summary of reduced per capita waste transportation cost (WTC_r) for not transporting the recyclable waste and only transporting the non-recyclable waste is given below in Table 4.18. Results revealed that by not transporting the recyclable waste RWMC can save 12.25 PKR per capita every year. While the month-wise detail of each parameter is in Appendix 6

Table 4.18 Summary of reduced per capita waste transportation cost (WTC_r) for not transporting the recyclable waste

Transportation Cost Reduced for Not Transporting the Recyclable Waste	
Total 3-year transportation fuel expenses saved for not transporting recyclable waste (PKR)	67,124,234.64
Total 3-year transportation fuel expenses saved for not transporting recyclable waste ($)	438,720.4878
Total yearly transportation fuel expenses saved for not transporting recyclable waste (PKR)	22,374,744.88
Total yearly transportation fuel expenses saved for not transporting recyclable waste ($)	146,240.1626
Total population (count)	1,826,019
Yearly per capita transportation cost saved for not transporting recyclable waste (PKR)	12.25329248

Yearly per capita transportation cost saved for not transporting recyclable waste ($)	0.080086879
Monthly per capita transportation cost saved for not transporting recyclable waste (PKR)	1.021107707
Monthly per capita transportation cost saved for not transporting recyclable waste ($)	0.006673907
Transportation Cost for Only transporting the non-recyclable waste	
Total 3-year transportation fuel expenses saved for only transporting the non-recyclable waste (PKR)	420,850,714.3
Total 3-year transportation fuel expenses saved for only transporting the non-recyclable waste ($)	2,750,658.263
Total yearly transportation fuel expenses saved for only transporting the non-recyclable waste (PKR)	140,283,571.4
Total yearly transportation fuel expenses saved for only transporting the non-recyclable waste ($)	916,886.0877
Total Population	1,826,019
Yearly per capita transportation cost saved for only transporting the non-recyclable waste (PKR)	76.82481476
Yearly per capita transportation cost saved for only transporting the non-recyclable waste ($)	0.502122972
Monthly per capita transportation cost saved for only transporting the non-recyclable waste (PKR)	6.402067896
Monthly per capita transportation cost saved for only transporting the non-recyclable waste ($)	0.041843581
Monthly percentage of transportation per capita cost saved ($)	13.75567225

4.5.2 Waste Disposal Cost (WDC)

Disposal cost is the last cost that represents the cost of the dumping process of the collected waste. It includes four different parameters such as $\mathbf{DS_C}$, $\mathbf{DF_C}$, $\mathbf{DU_C}$, $\mathbf{DM\&R_C}$, $\mathbf{DCM_C}$, $\mathbf{DM_C}$ to conclude the total cost of waste disposal. The cost of all these four parameters is given in Table 4.19

Table 4.19 Cost of all the variables associated with the waste disposal (WDC)

Waste Disposal Cost per Month	
Variables	**Price (PKR)**
Staff ($\mathbf{DS_C}$)	931,500
Fuel ($\mathbf{DF_C}$)	134,704.9
Utilities ($\mathbf{DU_C}$)	24,000
Maint. & Repair ($\mathbf{DM\&R_C}$)	150,000
Cont-Machinery & Operators ($\mathbf{DCM_C}$)	105,000
Misc. ($\mathbf{DM_C}$)	195,000
Per Month Disposal Cost (PKR)	**1,54,0205**

All the expenditures of monthly WDC (**1,54,0205** PKR) given in Table 4.19 were divide by total monthly tonnage **(22859.23 tons).** The monthly per ton disposal cost after analysis was 68 PKR. This value can be reduced by reducing the tonnage through the removal of recyclable items. Monthly per capita disposal cost and monthly reduced per capita disposal cost are given in Table 4.20. To reduce this per capita disposal cost from 0.96 $ to 0.001$ given in Table 4.20, the recyclable tonnage disposal cost per capita was also calculated with the process cost.

Table 4.20 Monthly per capita waste disposal cost (WDC) and reduced waste disposal cost (WDC_r) analysis

Monthly Per Capita Waste Disposal Cost (WDC) and Reduced Waste Disposal Cost (WDCr) Analysis	
Total Population	1826019
Per capita waste disposal cost **(WDC)** (PKR)	0.0062851
Per capita waste disposal cost **(WDC) (**$)	0.96162095
Per capita reduced waste disposal cost (**WDC_r)** (PKR)	0.21
Per capita reduced waste disposal cost **(WDC_r)** ($)	0.001

Now the reduced disposal cost waste disposal cost **(WDC_r)** values come up which can be considered as the new disposal cost waste disposal cost **(WDC)** (Table 4.21). In this table, it has been shown that it has saved 21% of the current per capita disposal cost.

Table 4.21 Per month per capita Waste Disposal Cost (WDC) saving

Per Month Per Capita Waste Disposal Cost (WDC) Saving	
Current per capita cost ($)	0.006285
Current per capita cost (PKR)	0.961621
Per capita cost saving through recyclable material ($)	0.001373
Per capita cost saving through recyclable material (PKR)	0.21
New waste disposal cost **(WDC) (**$)	0.004913
New waste disposal cost **(WDC)** (PKR)	0.751621
Percentage Per Capita waste disposal cost **(WDC)** Saving	21.83813

4.6 Cost-Benefit Analysis

The current global scenario is changing from landfilling and dumping of waste. This way of waste dumping has many financial implications. Besides, there are various environmental issues linked to it such as degradation of land, air, and groundwater. One way of reducing these hazardous impacts on the environment, recyclable material composed of plastic rubber can be sorted and segregated from the collected waste. The retaining of the recyclable waste from total waste will have manifold positive impacts and would be beneficial for cost reduction, generate revenue, and save the environment. While performing the cost-benefit analysis, benefits obtained (outputs) should consider social benefits like avoidance of liabilities from MSW management options, economic benefits, and social benefits (Mollel, 2016). Using NPV criteria the best option scenarios were identified which is economic efficiency and which lead to environmental sustainability (Kathryn, 2001)

With the composition of waste already calculated above, the recyclable material benefit is quite clear. The current global market prices of recyclables are considered to calculate the recyclable benefits and given in Table 4.22 (WV Solid Waste Management Board and North Carolina Market Prices for recyclables.

Table 4.22 Prices of recyclable waste in USD

Price of recyclables waste $	
Plastic	88.16
Rubber	92
Paper & Cardboard	95.5
Glass	33
Metal	40

4.6.1 Recyclable Cost Benefit

This recyclable cost-benefit can also reduce the overall per capita cost of handling, collection, transportation, and disposal of MW. The recyclable items in the municipal waste are the average values of those items in residential waste, commercial waste, and institutional waste. These individual values were taken from the field survey and collected data.

By using the recyclable items' percentages and their prices, the overall cost saved as recyclable benefit has been calculated and summarized in Table 4.23.

Table 4.23 Per capita cost (benefit) saved in case of recyclable waste retention.

Items	**Waste %**	**Price/ton ($)**	**Population**	**Per Capita Cost Saved monthly ($)**	**Per Capita Cost Saved monthly (PKR)**
Paper & Cardboard	8	95.5	1826019	0.0185377	2.8548061
Rubber	2	92	1826019	0.0045793	0.7052173
Glass	3	33	1826019	0.0024021	0.3699291
Metal	2	40	1826019	0.0022323	0.3437725
Plastic	7	88	1826019	0.0149466	2.3017808
Total Per Capita Cost-Benefit by Recovering the Recyclable Material from the Municipal Waste ($)					0.0426981
Total Per Capita Cost-Benefit by recovering the Recyclable Material from the Municipal Waste (PKR)					6.5755057

4.6.2 Carbon Social Cost-Benefit

Another challenge to consider is environmental pollutions. The burning of fuel is producing carbon emissions which have a severe social impact on the environment and society. Carbon social cost is related to the cost of damages caused by carbon emissions to the environment, society, and climate. It is the external cost-benefit. According to US-EPA and environmental defense fund (EDF), social carbon values account for the climatic damages that also include net agricultural yield, human health, property loss, food risks, and energy system changes costs. The global value of social carbon per ton is 51 $.

Current per capita cost due to transportation fuel in terms of CO_2 emission implications currently are following tables (Table 4.24 & 4.25). In case of high transport fuel cost consumption for whole collected waste transfer, monthly per capita CO_2 emission cost is 0.328 PKR (Table 4.24). It can be reduced to 0.123 PKR if the recyclable items are not transported along with non-recyclable items in Table 4.25.

Table 4.24 Carbon social cost analysis for CO_2 emission estimation

Carbon Social Cost due to Transportation Fuel in terms of CO_2 Emission	
Total Population	1826019
Yearly Social Carbon Cost/Capita ($)	0.025756055
Monthly Social Carbon Cost/Capita ($)	0.002146338
Monthly Social Carbon Cost/Capita (PKR)	0.328389707

Table 4.25 Reduced carbon social cost analysis for CO_2 emission estimation

Carbon Social Cost Saved due to Transportation Fuel for not Transporting Recyclable Waste in terms of CO_2 Emission	
Total Population	1826019
Yearly Social Carbon Cost/Capita ($)	0.00968089
Monthly Social Carbon Cost/Capita ($)	0.000806741
Monthly Social Carbon Cost/Capita (PKR)	0.123431341

Table 4.26 Carbon Social Cost Reduction Analysis

Carbon Social Cost Reduction in terms of CO2 Emissions from Transportation Fuel by Recyclable Waste Recovery			
Scenario	**Per Capita Social Carbon Cost due to transporting total Waste**	**Per Capita Social Carbon Cost Saved due to Recyclable Waste Recovery**	**Per Capita Social Carbon Cost Remaining due to not Transporting Non-recyclable Waste only**
Yearly Social Carbon Cost/Capita ($)	0.025756055	0.00968089	0.016075166
Monthly Social Carbon Cost/Capita ($)	0.002146338	0.000806741	0.001339597
Monthly Social Carbon Cost/Capita (PKR)	0.328389707	0.123431341	0.204958366
Percentage Reduction in Per Capita Carbon Social Cost in terms of Reduced CO^2 Emissions			37.58684841

In the analysis given in Table 4.26, it has been revealed that the carbon social cost reduction in terms of CO_2 emissions from transportation fuel by recyclable waste recovery is calculated which is 37.5% lesser as compared to the current value **(**Table 4.24**)**

Table 4.27 Per Capita Cost Benefit Analysis

Per Capita Cost Benefits					
Cost terms	**Fuel Transportation Cost Saved**	**Disposal Cost Benefit**	**Carbon Social Cost Saved**	**Recyclable Material Cost Saved**	**Total Cost Saving per Capita**
US-Dollars	0.006	0.001	0.001	0.042	0.051
PKR	0.96	0.28	0.2	6.57	8.05

All the four cost benefits described above are now compiled in table 4.27 and the total per capita cost saving has been calculated

4.7 Summary of Overall Municipal Waste Expenses Per Capita Economic Analysis

4.7.1 Current Municipal Waste Expenses Per Capita

The overall municipal waste expenses per capita were calculated by considering the municipal waste handling cost and its per capita value, municipal waste collection operation cost, and its per capita value, municipal waste transport cost, and its per capita value and municipal waste disposal cost, and its per capita value. All these parameters have been calculated above in Table 4.12 and its final per capita municipal waste expenses are given in Table 4.28. The formula used for calculation is given in the Methods section.

4.7.2 Reduced Municipal Waste Expenses Per Capita Cost

The overall reduced municipal waste expenses were calculated considered following parameters; overall municipal waste expenses per capita, cost-benefit transportation, cost-benefit disposal, cost-benefit recyclable material cost saved, and carbon social cost saved

Reduced MW Cost PKR/capita = 60 - 0.96 – 0.28 – 6.57 – 0.2 = 51.95= 51.99= 52 PKR/Capita

Reduced MW Cost $/capita = 0.39 – 0.006 – 0.002 – 0.042 – 0.001 = 0.34 $/Capita

The cost reduction per capita is 13% shown in Table 4.28 and compared in Figure 4.6

Table 4.28 Summary of overall economic analysis

Economic Analysis Summary	
Current Per Capita Cost after Analysis ($)	0.39492963
Current Per Capita Cost after Analysis (PKR)	60.4242337
Reduced from the Current Per Capita Cost Value ($)	0.051
Reduced from the Current Per Capita Cost Value (PKR)	8.05
Proposed Per Capita Cost ($)	0.34392963
Proposed Per Capita Cost (PKR)	52.3742337
Percentage Per Capita Cost Reduction	13.3224693

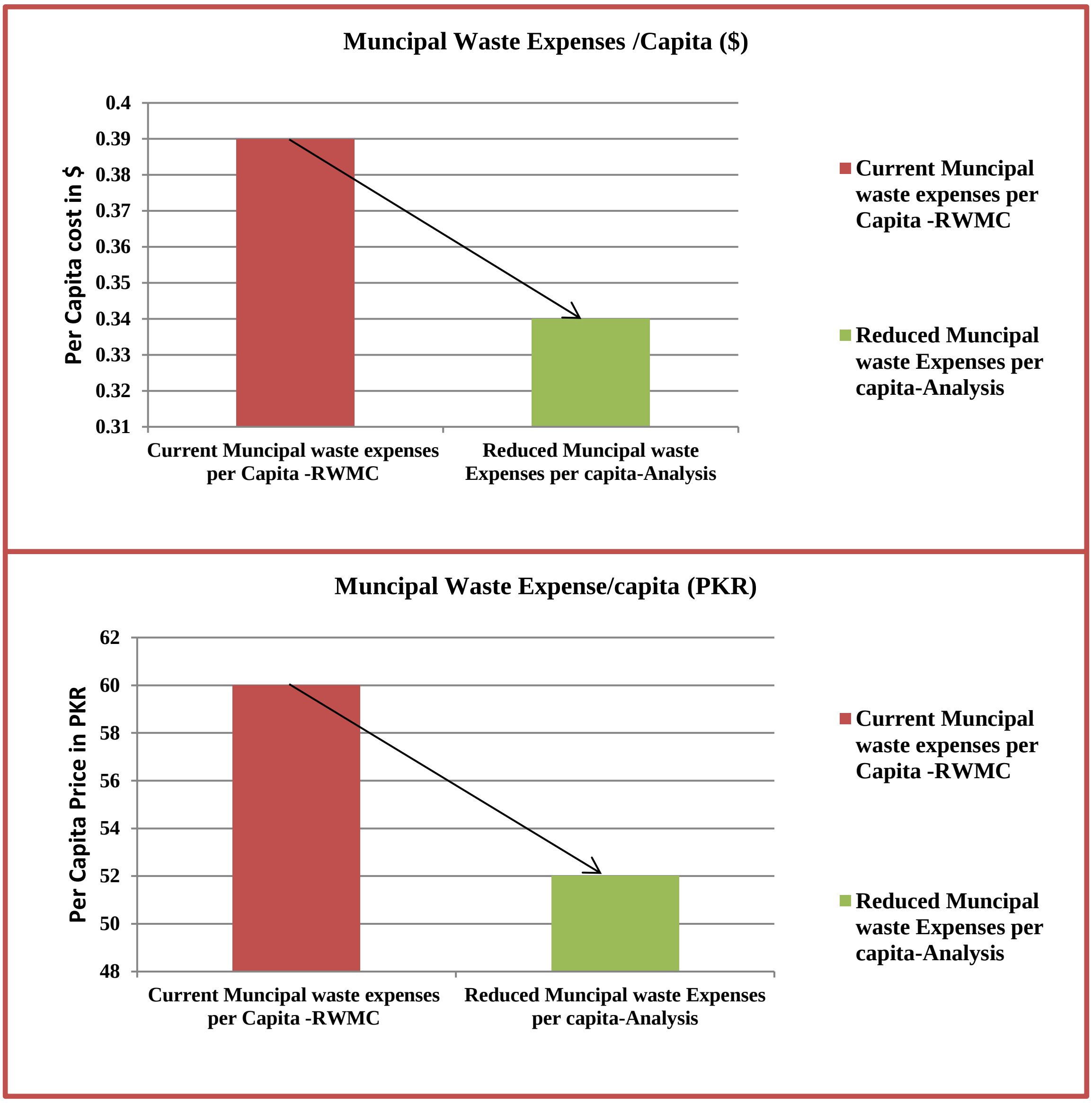


Figure 4.6 The current monthly per capita MW expenses and the reduced monthly per capita MW

All these four factors have reduced the overall per capita operating cost of municipal waste. The reduction was calculated significant as the reduction in expenses was 13 % which reduces the 60 PKR/capita to 52 PKR/capita. The new per capita operating cost of municipal waste is optimized, and it provides room for the waste recovery option and also facilitates the environmentally friendly policy to be adopted by the RWMC. The waste recovery and its price benefit can be a source of revenue for the company, and it will reduce the environmental & health damages to society.

Chapter 5 Conclusions & Recommendations

5.1 Conclusions

Municipal solid waste collection covers approximately 70% of the entire costs of the solid waste management system. The appropriate estimation of the costs related to municipal waste collection procedure is crucial to plan, define and implement the best cost-effective waste management system. In the present study, the cost-benefit analysis was done to reduce the current cost potentials and improve the efficiency of the system. Current global environmental and local conditions are considered so the composition of waste data helped gives the alternative system of recyclable content recovery which environmentally important and reduced the cost of the transportation fuel and the disposal cost. This recyclable content has added a benefit in terms of its value which is calculated based on the global available prices. The transportation fuel was also reduced due to the waste recovery which also reduces the waste tonnage. Reduced Fuel consumption can reduce the carbon emissions and providing a saved social cost benefit.

The study shows that the municipal waste of Rawalpindi constitutes of domestic waste and C&D waste containing 22% recyclable waste items. It will not only reduce the transportation fuel cost and disposal cost but would also save and provide recyclable material revenue to the RWMC. The current monthly cost of handling, collection, transportation and disposal of municipal waste of Rawalpindi is 60 rupees/capita or 0.39 $/capita. By saving transportation fuel, the environmental benefit can be achieved which will include the reduction of social carbon emission reduction. All these costs-benefits have reduced the per capita cost of handling, collection, transportation, and disposal cost. Recyclable waste recovery can provide a economic benefit by reducing current transportation fuel and disposal cost, a recyclable recovery benefit, social and environmental benefit and also can reduce the current per capita cost of handling, collection, transportation and disposal cost to 52 rupees per capita or 0.35 $ per capita.

5.2 Recommendations

The present study shows the potential contribution of recyclable waste for cost reduction and revenue generation. Additionally, it has also estimated environment-related parameters such as carbon social cost-benefit to provide an option that is considerable and environmentally acceptable. Separating the recyclables items and their implication on cost reduction and cost associated with the sale of recycled waste have been analyzed. The results of this study emphasize the country's need for the implementation of persistent recycling planning in solid waste management companies.

In the current scenario, the need is to reduce this per capita cost and by reducing the costs like handling, collection, transportation, and disposal costs. Field and area analysis suggests that keeping in mind the current situation of urban planning and the rise in the city population, the congestion of the areas, RWMC & Albayrak had optimized the waste handling, and waste collection costs quite well. However, there is no revenue for RWMC and its policy implemented by RWMC Producer Encouraging Policy (PEP). By keeping the waste composition of Rawalpindi in mind, evaluating the transportation and disposal costs is necessary. If the recyclable waste is segregated at the RWMC transfer station by simple conveyor belt segregation, waste transportation, and waste disposal costs will be the overall per capita cost.

The present study had a detailed methodological plan for estimating the costs associated to waste handling, collection operation, transport, and disposal and applied this methodology to the varied composition of waste collected from multiple sectors of the city (commercial, residential). This study puts into practice a method that utilized waste management data of a densely populated local/national city of Pakistan and highlighted the key areas which can help in reducing the cost of waste management. This approach can help local waste management companies to set a solid municipal waste tariff, in finding cost-effective and efficient solutions for waste management. By planning the waste collection procedure in the right direction will in turn increase the productivity of the company. Furthermore, the per capita cost of waste paid by the city residents can be reduced.

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APPENDICES

Appendix 1 : Population and Tonnage Estimation

UC No.	Town	PHASE: A									
		Population									Classification
		Year 2012	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	
44	Rawal Town	30336	31307	32309	33342	34409	35511	36647	37820	39030	Planned
43		26086	26921	27782	28671	29589	30536	31513	32521	33562	Planned
32		26622	27474	28353	29260	30197	31163	32160	33189	34251	planned
31		28558	29472	30415	31388	32393	33429	34499	35603	36742	Unplanned
30		28129	29029	29958	30917	31906	32927	33981	35068	36190	Unplanned
34		23516	24269	25045	25847	26674	27527	28408	29317	30255	Planned
33		23238	23982	24749	25541	26358	27202	28072	28971	29898	Planned
39		20651	21312	21994	22698	23424	24174	24947	25745	26569	Planned
35		24734	25525	26342	27185	28055	28953	29879	30836	31822	planned
38		23468	24219	24994	25794	26619	27471	28350	29257	30194	planned
42		25387	26199	27038	27903	28796	29717	30668	31650	32662	Planned
41		20143	20788	21453	22139	22848	23579	24333	25112	25916	Planned
40		21024	21697	22391	23108	23847	24610	25398	26210	27049	Planned
46		28030	28927	29853	30808	31794	32811	33861	34945	36063	Planned
45		30774	31759	32775	33824	34906	36023	37176	38366	39593	Unplanned
36		25594	26413	27258	28130	29031	29960	30918	31908	32929	Planned
Waste Generation (Tons per Day)											
Waste G.R (kg/c/day)		**0.55**	**0.56**	**0.57**	**0.58**	**0.58**	**0.59**	**0.60**	**0.61**	**0.62**	**Classification**
44	Rawal Town	16.68	17.48	18.31	19.18	20.09	21.04	22.04	23.09	**23.43**	Planned
43		14.35	15.03	15.74	16.49	17.27	18.09	18.95	19.85	**20.15**	Planned
32		14.64	15.34	16.07	16.83	17.63	18.46	19.34	20.26	**20.56**	planned
31		15.71	16.45	17.23	18.05	18.91	19.81	20.75	21.73	**22.06**	Unplanned
30		15.47	16.21	16.97	17.78	18.63	19.51	20.44	21.41	**21.73**	Unplanned
34		12.93	13.55	14.19	14.86	15.57	16.31	17.08	17.90	**18.16**	Planned
33		12.78	13.39	14.02	14.69	15.39	16.12	16.88	17.68	**17.95**	Planned
39		11.36	11.90	12.46	13.05	13.67	14.32	15.00	15.72	**15.95**	Planned
35		13.60	14.25	14.93	15.63	16.38	17.15	17.97	18.82	**19.10**	planned
38		12.91	13.52	14.16	14.83	15.54	16.28	17.05	17.86	**18.13**	planned
42		13.96	14.63	15.32	16.05	16.81	17.61	18.44	19.32	**19.61**	Planned
41		11.08	11.60	12.16	12.73	13.34	13.97	14.63	15.33	**15.56**	Planned
40		11.56	12.11	12.69	13.29	13.92	14.58	15.27	16.00	**16.24**	Planned
46		15.42	16.15	16.92	17.72	18.56	19.44	20.36	21.33	**21.65**	Planned
45		16.93	17.73	18.57	19.45	20.38	21.34	22.36	23.42	**23.77**	Unplanned
36		14.08	14.75	15.45	16.18	16.95	17.75	18.59	19.48	**19.77**	Planned
WGR (Tons /day)		**223**	**234**	**245**	**257**	**269**	**282**	**295**	**309**	**314**	

UC No.	Town	PHASE: B									
		Population									Classification
		Year 2012	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	
18	Rawal Town	26909	27770	28659	29576	30522	31499	32507	33547	34621	UnPlanned
17		28043	28940	29866	30822	31809	32826	33877	34961	36080	Unplanned
13		24648	25437	26251	27091	27958	28852	29776	30728	31712	planned
14		22825	23555	24309	25087	25890	26718	27573	28456	29366	Planned
15		24220	24995	25795	26620	27472	28351	29259	30195	31161	planned
20		28654	29571	30517	31494	32502	33542	34615	35723	36866	Planned
19		26559	27409	28286	29191	30125	31089	32084	33111	34170	Planned
12		25936	26766	27622	28506	29419	30360	31331	32334	33369	Unplanned
11		23240	23984	24751	25543	26361	27204	28075	28973	29900	Planned
10		21047	21721	22416	23133	23873	24637	25425	26239	27079	Planned
16		21194	21872	22572	23294	24040	24809	25603	26422	27268	planned
9		27372	28248	29152	30085	31047	32041	33066	34124	35216	planned
8		26433	27279	28152	29053	29982	30942	31932	32954	34008	Unplanned
7		25179	25985	26816	27674	28560	29474	30417	31390	32395	Unplanned
5		18927	19533	20158	20803	21468	22155	22864	23596	24351	Unplanned
6		18407	18996	19604	20231	20879	21547	22236	22948	23682	Unplanned
4		30763	31747	32763	33812	34894	36010	37163	38352	39579	Unplanned
37		22397	23114	23853	24617	25404	26217	27056	27922	28816	UnPlanned
3		20294	20943	21614	22305	23019	23756	24516	25300	26110	UnPlanned
2		26610	27462	28340	29247	30183	31149	32146	33174	34236	Unplanned
1		26855	27714	28601	29516	30461	31436	32442	33480	34551	planned
Waste Generation (Tons per Day)											
Waste G.R (kg/c/day)		0.55	0.56	0.57	0.58	0.58	0.59	0.60	0.61	0.62	Classification
18	Rawal Town	14.80	15.50	16.24	17.01	17.82	18.66	19.55	20.48	**20.78**	UnPlanned
17		15.42	16.16	16.92	17.73	18.57	19.45	20.37	21.34	**21.66**	Unplanned
13		13.56	14.20	14.87	15.58	16.32	17.10	17.91	18.76	**19.04**	planned
14		12.55	13.15	13.77	14.43	15.11	15.83	16.58	17.37	**17.63**	Planned
15		13.32	13.95	14.62	15.31	16.04	16.80	17.60	18.43	**18.71**	planned
20		15.76	16.51	17.29	18.11	18.97	19.87	20.82	21.81	**22.13**	Planned
19		14.61	15.30	16.03	16.79	17.59	18.42	19.30	20.21	**20.51**	Planned
12		14.26	14.94	15.65	16.39	17.17	17.99	18.84	19.74	**20.03**	Unplanned
11		12.78	13.39	14.02	14.69	15.39	16.12	16.88	17.69	**17.95**	Planned
10		11.58	12.13	12.70	13.30	13.94	14.60	15.29	16.02	**16.26**	Planned
16		11.66	12.21	12.79	13.40	14.03	14.70	15.40	16.13	**16.37**	planned
9		15.05	15.77	16.52	17.30	18.12	18.98	19.89	20.83	**21.14**	planned
8		14.54	15.23	15.95	16.71	17.50	18.33	19.20	20.12	**20.42**	Unplanned
7		13.85	14.51	15.19	15.92	16.67	17.46	18.29	19.16	**19.45**	Unplanned
5		10.41	10.90	11.42	11.96	12.53	13.13	13.75	14.40	**14.62**	Unplanned
6		10.12	10.60	11.11	11.64	12.19	12.77	13.37	14.01	**14.22**	Unplanned
4		16.92	17.72	18.56	19.45	20.37	21.34	22.35	23.41	**23.76**	Unplanned
37		12.32	12.90	13.52	14.16	14.83	15.53	16.27	17.04	**17.30**	UnPlanned
3		11.16	11.69	12.25	12.83	13.44	14.08	14.74	15.44	**15.68**	UnPlanned
2		14.64	15.33	16.06	16.82	17.62	18.46	19.33	20.25	**20.55**	Unplanned
1		14.77	15.47	16.21	16.98	17.78	18.63	19.51	20.44	**20.74**	planned
W G R(Tons /day)		284.08	297.57	311.70	326.50	342.00	358.24	375.25	393.06	398.96	

UC No.	Town	PHASE: C									
		Population									Classification
		Year 2012	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	
26	Rawal Town	21787	22484	23204	23946	24712	25503	26319	27162	28031	Planned
29		25020	25821	26647	27500	28380	29288	30225	31192	32190	Unplanned
25		24651	25440	26254	27094	27961	28856	29779	30732	31716	Unplanned
24		23875	24639	25427	26241	27081	27947	28842	29765	30717	Unplanned
22		23758	24518	25303	26113	26948	27810	28700	29619	30567	Unplanned
23		25032	25833	26660	27513	28393	29302	30239	31207	32206	planned
21		24067	24837	25632	26452	27299	28172	29074	30004	30964	Unplanned
27		21252	21932	22634	23358	24106	24877	25673	26495	27342	Planned
28		26197	27035	27900	28793	29715	30665	31647	32659	33705	Planned
79	Potohar Town	17453	18011	18588	19183	19797	20430	21084	21758	22455	Planned
74		22122	22830	23560	24314	25092	25895	26724	27579	28462	Unplanned
75		16928	17470	18029	18606	19201	19815	20450	21104	21779	Unplanned
77		17020	17565	18127	18707	19305	19923	20561	21219	21898	Unplanned
78		21079	21754	22450	23168	23909	24675	25464	26279	27120	Planned
76		24575	25361	26173	27010	27875	28767	29687	30637	31618	Unplanned
81		24289	25066	25868	26696	27550	28432	29342	30281	31250	Planned
80		18935	19541	20166	20812	21478	22165	22874	23606	24361	Unplanned
Waste Generation (Tons per Day)											
Waste G.R (kg/c/day)		**0.55**	**0.56**	**0.57**	**0.58**	**0.58**	**0.59**	**0.60**	**0.61**	**0.62**	Classification
26	Rawal Town	11.98	12.55	13.15	13.77	14.43	15.11	15.83	16.58	**16.83**	Planned
29		13.76	14.41	15.10	15.82	16.57	17.35	18.18	19.04	**19.33**	Unplanned
25		13.56	14.20	14.88	15.58	16.32	17.10	17.91	18.76	**19.04**	Unplanned
24		13.13	13.75	14.41	15.09	15.81	16.56	17.35	18.17	**18.44**	Unplanned
22		13.07	13.69	14.34	15.02	15.73	16.48	17.26	18.08	**18.35**	Unplanned
23		13.77	14.42	15.11	15.82	16.57	17.36	18.19	19.05	**19.34**	planned
21		13.24	13.87	14.52	15.21	15.94	16.69	17.48	18.31	**18.59**	Unplanned
27		11.69	12.24	12.82	13.43	14.07	14.74	15.44	16.17	**16.42**	Planned
28		14.41	15.09	15.81	16.56	17.35	18.17	19.03	19.94	**20.23**	Planned
79	Potohar Town	9.60	10.05	10.53	11.03	11.56	12.10	12.68	13.28	**13.48**	Planned
74		12.17	12.74	13.35	13.98	14.65	15.34	16.07	16.83	**17.09**	Unplanned
75		9.31	9.75	10.22	10.70	11.21	11.74	12.30	12.88	**13.08**	Unplanned
77		9.36	9.81	10.27	10.76	11.27	11.80	12.37	12.95	**13.15**	Unplanned
78		11.59	12.14	12.72	13.32	13.96	14.62	15.31	16.04	**16.28**	Planned
76		13.52	14.16	14.83	15.53	16.27	17.04	17.85	18.70	**18.98**	Unplanned
81		13.36	13.99	14.66	15.35	16.08	16.85	17.65	18.48	**18.76**	Planned
80		10.41	10.91	11.43	11.97	12.54	13.13	13.76	14.41	**14.63**	Unplanned
WGR. (Tons /day)		**207.92**	**217.79**	**228.14**	**238.97**	**250.31**	**262.20**	**274.65**	**287.69**	**292.00**	

UC No.	Town	PHASE: D									
		Population									Classification
		Year 2012	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020	
88	Potohar Town	10608	10947	11298	11659	12032	12417	12815	13225	13648	Unplanned
87		20225	20872	21540	22229	22941	23675	24432	25214	26021	Unplanned
85		22288	23001	23737	24497	25281	26090	26925	27786	28675	Unplanned
90		13160	13581	14016	14464	14927	15405	15898	16406	16931	Unplanned
86		13874	14318	14776	15249	15737	16241	16760	17297	17850	Unplanned
118		5822	6008	6201	6399	6604	6815	7033	7258	7490	Unplanned
84		14101	14552	15018	15498	15994	16506	17034	17580	18142	Unplanned
82		18359	18946	19553	20178	20824	21491	22178	22888	23620	Unplanned
Waste Generation (Tons per Day)											
Waste G.R (kg/c/day)		**0.55**	**0.56**	**0.57**	**0.58**	**0.58**	**0.59**	**0.60**	**0.61**	**0.62**	**Classification**
88	Potohar Town	5.83	6.11	6.40	6.71	7.02	7.36	7.71	8.07	**8.19**	Unplanned
87		11.12	11.65	12.21	12.78	13.39	14.03	14.69	15.39	**15.62**	Unplanned
85		12.26	12.84	13.45	14.09	14.76	15.46	16.19	16.96	**17.22**	Unplanned
90		7.24	7.58	7.94	8.32	8.71	9.13	9.56	10.01	**10.16**	Unplanned
86		7.63	7.99	8.37	8.77	9.19	9.62	10.08	10.56	**10.72**	Unplanned
118		3.20	3.35	3.51	3.68	3.85	4.04	4.23	4.43	**4.50**	Unplanned
84		7.76	8.12	8.51	8.91	9.34	9.78	10.24	10.73	**10.89**	Unplanned
82		10.10	10.58	11.08	11.61	12.16	12.73	13.34	13.97	**14.18**	Unplanned
WGR (Tons per Day)		**65.14**	**68.23**	**71.47**	**74.87**	**78.42**	**82.14**	**86.04**	**90.13**	**91.48**	

Appendix 2: Union Councils Area , Population , Classification, Phase , Workers , Waste Tonnage Details of CDGR (2014) Model & RWMC (2015-2021) Model

Union Councils Area , Population , Classifcation, Phase , Workers , Waste Tonnage Details of CDGR (2014) Model & RWMC (2015-2021) Model																
Sr.No.	District	Town	UC No.	UC Name	Area (sq.m)	Population 2014	Population 2020	UC Classification	Phase (2014)	Total Workers 2014	Total Workers 2020	Estimated Tonnage 2014	Collected Average daily-2014	Estimated tonnage 2020	Collected Average daily
1			44	Dhoke Farman Ali	54699	30336	39,030	Planned	Phase A	32	32	16.6848	6.67392	23.43188484	18.745508
2			43	Dhoke Khabba	53360	26086	33,562	Planned	Phase A	32	43	14.3473	5.73892	20.14913462	16.119308
3			32	Amar pura	39860	26622	34,251	planned	Phase A	37	36	14.6421	5.85684	20.56314735	16.450518
4			31	Dhoke Hukam dad	31389	28558	36,742	Unplanned	Phase A	36	39	15.7069	6.28276	22.05853663	17.646829
5			30	Chaha Sultan	73503	28129	36,190	Unplanned	Phase A	44	46	15.47095	6.18838	21.72717196	17.381738
6			34	Banni	34258	23516	30,255	Planned	Phase A	35	23	12.9338	5.17352	18.16403625	14.531229
7			33	Kartar Pura	32857	23238	29,898	Planned	Phase A	32	41	12.7809	5.11236	17.94930577	14.359445
8			39	Waris Khan	26735	20651	26,569	Planned	Phase A	35	32	11.35805	4.54322	15.9510764	12.760861
9			35	Mohallah Imam Bargah	34804	24734	31,822	planned	Phase A	40	21	13.6037	5.44148	19.10483385	15.283867
10			38	Ganjmandi	56215	23468	30,194	planned	Phase A	37	31	12.9074	5.16296	18.12696049	14.501568
11			42	Millat Colony	64781	25387	32,662	Planned	Phase A	46	32	13.96285	5.58514	19.60921876	15.687375
12			41	Shan Chan Chiragh	16632	20143	25,916	Planned	Phase A	33	35	11.07865	4.43146	15.5586912	12.446953
13			40	Purana Qilla	24586	21024	27,049	Planned	Phase A	38	36	11.5632	4.62528	16.23918601	12.991349
14			46	City(Urban)	72372	28030	36,063	Planned	Phase A	50	50	15.4165	6.1666	21.65070319	17.320563
15			45	Chamanzar Colony + Civil lines	73920	30774	39,593	Unplanned	Phase A	36	71	16.9257	6.77028	23.77020121	19.016161
16			36	Mohan Pura	37872	25594	32,929	Planned	Phase A	41	36	14.0767	5.63068	19.76910801	15.815286
17			18	Pindora	45030	26909	34,621	UnPlanned	Phase B	24	21	14.79995	5.91998	20.78482954	16.627864
18			17	Dhoke Babu Irfan	179561	28043	36,080	Unplanned	Phase B	25	20	15.42365	6.16946	21.66074454	17.328596
19			13	New Katarian	47998	24648	31,712	planned	Phase B	27	21	13.5564	5.42256	19.03840643	15.230725
20			14	F-Block Satellite Town	86475	22825	29,366	Planned	Phase B	26	23	12.55375	5.0215	17.63029969	14.10424
21			15	Saidpur Scheme	61593	24220	31,161	planned	Phase B	28	21	13.321	5.3284	18.70781417	14.966251
22			20	Asghar Mall Scheme	108276	28654	36,866	Planned	Phase B	54	33	15.7597	6.30388	22.13268816	17.706151
23			19	Satellite Town	65438	26559	34,170	Planned	Phase B	45	29	14.60745	5.84298	20.51448541	16.411588
24		Rawal	12	Dhoke Najjo	53366	25936	33,369	Unplanned	Phase B	25	24	14.2648	5.70592	20.03327285	16.026618
25			11	Khayban-e-Sir Syed(South) (S)	55941	23240	29,900	Planned	Phase B	24	23	12.782	5.1128	17.95085059	14.36068
26			10	Khayban-e-Sir Syed(North) (N)	34063	21047	27,079	Planned	Phase B	25	21	11.57585	4.63034	16.25695148	13.005561
27			16	Mohallah Eidgah	45546	21194	27,268	planned	Phase B	22	25	11.6567	4.66268	16.37049602	13.096397
28			9	Bangish Colony + GBS	69008	27372	35,216	planned	Phase B	34	62	15.0546	6.02184	21.14245621	16.913965
29			8	Fauji Colony	55294	26433	34,008	Unplanned	Phase B	27	24	14.53815	5.81526	20.41716152	16.333729
30			7	Pir Wadhahi	30040	25179	32,395	Unplanned	Phase B	27	26	13.84845	5.53938	19.4485571	15.558846
31	RAWALPINDI		5	Dhoke Hassu(North)	30681	18927	24,351	Unplanned	Phase B	27	21	10.40985	4.16394	14.61943843	11.695551
32			6	Dhoke Hassu(South)	26374	18407	23,682	Unplanned	Phase B	27	22	10.12385	4.04954	14.21778429	11.374227
33			4	Dhoke Mangtal	29608	30763	39,579	Unplanned	Phase B	27	26	16.91965	6.76786	23.76170468	19.009364
34			37	Dhoke Dalal	32077	22397	28,816	UnPlanned	Phase B	34	36	12.31835	4.92734	17.29970743	13.839766
35			3	Hazara Colony	33761	20294	26,110	UnPlanned	Phase B	26	21	11.1617	4.46468	15.67532538	12.54026
36			2	Dhoke Ratta	28184	26610	34,236	Unplanned	Phase B	35	22	14.6355	5.8542	20.55387841	16.443103
37			1	Ratta Amral	47517	26855	34,551	planned	Phase B	28	27	14.77025	5.9081	20.74311931	16.594495
38			26	Afandi Colony	94394	21787	28,031	Planned	Phase C	28	23	11.98285	4.79314	16.57983865	13.263871
39			29	Khurram Colony	40801	25020	32,190	Unplanned	Phase C	24	31	13.761	5.5044	19.0401415	15.232113
40			25	Sadiq Abad	54023	24651	31,716	Unplanned	Phase C	26	24	13.55805	5.42322	18.75933366	15.007467
41			24	Dhoke Ali Akbar	62884	23875	30,717	Unplanned	Phase C	26	28	13.13125	5.2525	18.16880009	14.53504
42			22	Qayyum Abad	103620	23758	30,567	Unplanned	Phase C	26	22	13.0669	5.22676	18.07976346	14.463811
43			23	Dhoke Kashmirian	88044	25032	32,206	planned	Phase C	27	28	13.7676	5.50704	19.04927346	15.239419
44			21	Dhoke Kala Khan	155158	24067	30,964	Unplanned	Phase C	26	24	13.23685	5.29474	18.31491149	14.651929
45			27	Muslim Town(East)	82124	21252	27,342	Planned	Phase C	30	27	11.6886	4.67544	16.17270532	12.938164
46			28	Muslim Town(West)	41188	26197	33,705	Planned	Phase C	30	31	14.40835	5.76334	19.93583481	15.948668
47			79	Dhok Munshi Khan	2285594	17453	22,455	Planned	Phase C	11	34	9.59915	3.83966	13.28167824	10.625343
48			74	Shakrail (Shamali)	148786	22122	28,462	Unplanned	Phase C	11	30	12.1671	4.86684	16.83477259	13.467818
49			75	Shakrial (Janubi)	133805	16928	21,779	Unplanned	Phase C	11	31	9.3104	3.72416	12.88215489	10.305724
50			77	Gangal	627920	17020	21,898	Unplanned	Phase C	11	38	9.361	3.7444	12.9521666	10.361733
51			78	Chaklala	146649	21079	27,120	Planned	Phase C	11	39	11.59345	4.63738	16.04105287	12.832842
52			76	Khanna Dak	127365	24575	31,618	Unplanned	Phase C	11	36	13.51625	5.4065	18.7014979	14.961198
53			81	Kotha Kalan	2591760	24289	31,250	Planned	Phase C	11	26	13.35895	5.34358	18.4838528	14.787082
54		Pothohar	80	Rehmat Abad	95986	18935	24,361	Unplanned	Phase C	11	29	10.41425	4.1657	14.40947559	11.52758
55			88	Garja	2450823	10608	13,648	Unplanned	Phase D	0	13	5.8344	0	8.193744539	6.5549956
56			87	Chak Jalal Din	1454392	20225	26,021	Unplanned	Phase D	11	41	11.12375	4.4495	15.62202897	12.497623
57			85	Dhamial	1097898	22288	28,675	Unplanned	Phase D	10	15	12.2584	4.90336	17.21551454	13.772412
58			90	Ranial	5233901	13160	16,931	Unplanned	Phase D	0	9	7.238	0	10.16493949	8.1319516
59			86	Lakhan	1802981	13874	17,850	Unplanned	Phase D	11	19	7.6307	3.05228	10.71644153	8.5731532
60			118	Kalial	1947765	5822	7,490	Unplanned	Phase D	0	13	3.2021	0	4.49698159	3.5975853
61			84	Dhamian Syedan	2578958	14101	18,142	Unplanned	Phase D	11	18	7.75555	3.10222	10.89177901	8.7134232
62			82	Morgha	1509995	18359	23,620	Unplanned	Phase D	11	24	10.09745	4.03898	14.18070852	11.344567

Appendix 3 : Collected Tonnage and Categorization

Collected Tonnage and Categatization 2018								
Year	Month	Albayrak	Contractor	Tonnage				
		Tons	Tons	Daily Avg	C&D	Muncipal waste	Recyclable waste	Total Tonnage
2018	Jan	1745.56	21113.67	737.39452	3428.8845	19430.35	427.4676	22859.2
	FEB	517.11	26411.85	961.74857	4039.344	22889.62	503.57155	26929
	March	1349.71	27746.54	938.58871	4364.4375	24731.81	544.09988	29096.3
	April	1881.33	29709.12	1053.015	4738.5675	26851.88	590.74142	31590.5
	May	3156.24	25939.02	938.55677	4364.289	24730.97	544.08136	29095.3
	June	3306.38	20809.45	803.861	3617.3745	20498.46	450.96602	24115.8
	July	1729.34	21867.3	761.18194	3539.496	20057.14	441.25717	23596.6
	August	2839.32	26670.28	951.92258	4426.44	25083.16	551.82952	29509.6
	Sept	1634.46	20181.01	727.18233	3272.3205	18543.15	407.94929	21815.5
	October	2708.92	26791.78	951.63548	4425.105	25075.6	551.66309	29500.7
	Nov	1928.38	25116.19	901.48567	4056.6855	22987.88	505.73346	27044.6
	Dec	1937.13	24464.25	851.65742	3960.207	22441.17	493.70581	26401.4
	Total	**24667.51**	**316414.39**	**881.51917**	**48233.151**	**273321.2**	**6013.0662**	**341082**

Collected Tonnage and Categatization 2019								
Year	Month	Albayrak	Contractor	Tonnage				
		Ton	Ton	Daily Avg	C&D	Muncipal waste	Recyclable waste	Tonnage
2019	Jan	1686.18	24342.18	839.6245161	3123.403	22124.11	486.73033	26028.36
	Feb	1579.13	26641.81	1007.890714	3386.513	23987.8	527.73158	28220.94
	Mar	1575.56	26108.67	893.0396774	3322.108	23531.6	517.6951	27684.23
	April	1668.07	25128.72	893.2263333	3215.615	22777.27	501.09997	26796.79
	May	2285.84	24891.11	876.6758065	3261.234	23100.41	508.20897	27176.95
	June	2020.7	25638.24	921.9646667	3319.073	23510.1	517.22218	27658.94
	July	975.58	24040.07	806.9564516	3001.878	21263.3	467.79266	25015.65
	Aug	1323.93	25520.22	865.9403226	3221.298	22817.53	501.98561	26844.15
	Sept	1470.54	22618.45	802.9663333	2890.679	20475.64	450.46411	24088.99
	Oct	1630.23	22738.67	786.0935484	2924.268	20713.57	455.69843	24368.9
	Nov	1520.9	21670.5	773.0466667	2782.968	19712.69	433.67918	23191.4
	Dec	1625.78	23870.24	822.4522581	3059.522	21671.62	476.77557	25496.02
	Total	**18962.44**	**293208.9**	**857.4897746**	**37508.56**	**265685.6**	**5845.0837**	**312571.3**

Collected Tonnage and Categatization 2020								
Year	Days	Albayrak	Contractor	Tonnage				
		Ton	Ton	Daily Avg	C&D	Muncipal waste	Recyclable waste	Tonnag
2020	**31**	1860.2	25342.18	877.49548	4080.4	23122.006	508.68413	27202.3
	28	8641.8	16760	598.57143	2514	14246	313.412	16760
	31	6108.7	15802	706.79581	3286.6	18624.07	409.72953	21910.6
	30	5128.7	12268.07	579.893	2609.5	14787.272	325.31997	17396.7
	31	9891.1	17285.84	876.67581	4076.5	23100.408	508.20897	27176.9
	30	5638.2	23618.45	975.223	4388.5	24868.187	547.1001	29256.6
	31	18109	9040.07	875.76581	4072.3	23076.429	507.68144	27148.7
	31	19129	5520.22	795.1271	3697.3	20951.599	460.93518	24648.9
	30	20891	4618.45	850.31867	3826.4	21683.126	477.02877	25509.5
	31	19638	6738.67	850.86806	3956.5	22420.374	493.24822	26376.9
	30	17040	8670.5	857.019	3856.6	21853.985	480.78766	25710.5
	31	19520	6870.24	851.30516	3958.6	22431.891	493.5016	26390.4
	365	**151596**	**100208.88**	**807.92153**	**44323**	**251165.34**	**5525.6376**	**295488.**

Appendix 4a: Monthly WM Analysis of Commercial Area month July-2019

DETAIL AREA SOLID WASTE ANALYSIS

Food Waste & Domestic Waste

Date	Commercial %age	transfer/Big Compactor 1.1 m^3 (lift's)	Fuel	Trips	Tons	Suzuki Pickups Pickup 1 Trips	Fuel	Pickup 2 Trips	Fuel/litres	Total Fuel	Total Trips	Tons	Small Compactor 1.1 m^3(lifts)	Fuel	Trips	Tons	Total tonage/Fuel Total Fuel	Weight (Ton)	%age
1-Jan	20.50	65.00	24.54	1.00	6.11	4.00	9.49	5.00	11.11	20.60	9.00	5.01	136.00	82.11	4.00	14.50	127.25	25.62	57.91
2-Jan	15.10	67.00	27.10	1.00	6.24	5.00	12.39	6.00	14.21	26.60	11.00	5.60	140.00	85.23	4.00	15.84	138.93	27.68	49.69
3-Jan	22.66	72.00	25.60	1.00	6.12	4.00	9.13	4.00	10.15	19.28	8.00	4.60	88.00	81.11	4.00	13.38	125.99	24.10	55.31
4-Jan	32.60	62.00	24.10	1.00	6.45	6.00	13.66	5.00	11.34	25.00	11.00	5.52	125.00	92.10	4.00	13.11	141.20	18.63	44.37
5-Jan	21.47	74.00	24.60	1.00	6.29	5.00	14.50	6.00	13.89	28.39	11.00	4.80	129.00	93.00	4.00	16.88	145.99	27.97	58.93
6-Jan	27.69	68.00	23.20	1.00	5.23	4.00	10.67	5.00	13.22	23.89	9.00	4.60	124.00	96.19	4.00	13.93	143.28	23.76	50.22
7-Jan	19.27	67.00	24.40	1.00	6.41	5.00	12.50	6.00	14.55	27.05	11.00	4.70	129.00	101.13	4.00	15.46	152.58	26.57	55.73
8-Jan	23.21	59.00	25.60	1.00	5.11	4.00	10.12	5.00	12.02	22.14	9.00	5.20	133.00	99.87	4.00	14.11	147.61	24.42	55.41
9-Jan	22.73	80.00	24.67	1.00	5.11	5.00	12.11	5.00	12.36	24.47	10.00	4.11	138.00	92.45	4.00	16.78	141.59	26.00	54.78
10-Jan	23.27	70.00	17.78	1.00	4.74	4.00	9.23	4.00	9.88	19.11	8.00	4.15	111.00	84.34	4.00	14.76	121.23	23.65	54.66
11-Jan	22.50	63.00	26.54	1.00	5.25	5.00	11.34	6.00	13.44	24.78	11.00	4.38	135.00	100.11	4.00	18.12	151.43	27.75	55.03
12-Jan	25.15	65.00	23.24	1.00	5.90	5.00	12.07	5.00	12.02	24.09	10.00	4.20	130.00	96.23	4.00	17.34	143.56	27.44	55.51
13-Jan	23.95	69.00	24.12	1.00	5.95	6.00	14.33	5.00	11.89	26.22	11.00	4.80	143.00	93.89	4.00	16.12	144.23	26.87	55.23
14-Jan	21.34	77.00	25.11	1.00	5.19	4.00	8.90	6.00	13.56	22.46	10.00	4.58	137.00	92.11	4.00	14.32	139.68	24.09	53.81
15-Jan	22.85	0.00	23.12	1.00	5.64	4.00	9.18	5.00	11.67	20.85	9.00	4.90	138.00	94.56	4.00	16.23	138.53	26.77	56.54
16-Jan	23.65	64.00	22.78	1.00	7.13	5.00	11.13	6.00	13.25	24.38	11.00	5.12	140.00	98,71	4.00	14.46	47.16	26.71	51.11
17-Jan	18.46	81.00	19.83	1.00	4.43	4.00	7.98	3.00	6.54	14.52	7.00	5.12	105.00	87.11	4.00	15.90	121.46	25.45	61.83
18-Jan	20.24	73.00	24.11	1.00	5.27	6.00	12.86	5.00	11.68	24.54	11.00	5.18	140.00	95.22	4.00	13.12	143.87	23.57	35.58
19-Jan	13.32	69.00	23.67	1.00	5.62	6.00	13.04	5.00	12.09	25.13	11.00	4.80	133.00	92.11	4.00	14.43	140.91	24.85	46.89
20-Jan	12.41	67.00	22.38	1.00	5.18	5.00	11.33	5.00	11.98	23.31	10.00	5.28	130.00	94.32	4.00	14.72	140.01	25.18	60.21
21-Jan	15.29	70.00	24.57	1.00	5.29	5.00	12.33	6.00	13.54	25.87	11.00	5.80	134.00	96.76	4.00	15.11	147.20	26.20	58.13
22-Jan	17.04	60.00	21.87	1.00	4.69	4.00	9.67	4.00	10.12	19.79	8.00	5.19	139.00	93.44	4.00	15.12	135.10	25.00	55.56
23-Jan	14.63	62.00	22.82	1.00	5.39	5.00	12.03	6.00	13.22	25.25	11.00	4.80	137.00	99.12	4.00	16.92	147.19	27.11	59.45
24-Jan	16.03	79.00	21.96	1.00	5.44	4.00	9.45	4.00	8.87	18.32	8.00	5.20	114.00	86.78	4.00	12.22	127.06	22.86	58.83
25-Jan	14.97	69.00	22.43	1.00	5.74	5.00	12.02	5.00	11.59	23.61	10.00	5.80	135.00	97.51	4.00	15.34	143.55	26.88	59.09
26-Jan	13.99	66.00	23.68	1.00	5.28	5.00	11.77	5.00	12.05	23.82	10.00	4.43	141.00	95.22	4.00	17.34	142.72	27.05	60.15
27-Jan	20.22	59.00	23.82	1.00	6.07	5.00	11.34	5.00	11.07	22.41	10.00	4.20	119.00	98.13	4.00	15.68	144.36	25.95	56.92
28-Jan	15.51	65.00	24.29	1.00	5.89	6.00	13.89	5.00	12.33	26.22	11.00	5.38	132.00	102.13	4.00	16.45	152.64	27.72	60.13
29-Jan	15.48	71.00	22.61	1.00	5.43	4.00	8.90	5.00	11.68	20.58	9.00	5.29	139.00	97.66	4.00	16.76	140.85	27.48	57.95
30-Jan	16.14	66.00	25.11	1.00	4.80	5.00	11.89	5.00	12.30	24.19	10.00	5.18	137.00	94.79	4.00	15.22	144.09	25.20	58.96
31-Jan	20.89	58.00	18.13	1.00	4.57	4.00	9.67	3.00	7.12	16.79	7.00	5.46	113.00	88.24	4.00	14.45	123.16	24.48	58.31
Total	19.77	2037.00	727.78	31.00	165.51	148.00	348.91	155.00	364.74	713.65	303.00	153.38	4024.00	2802.97	124.00	474.12	4244.40	793.01	54.8

Construction Waste

Date	Small Dumpers Trips	Fuel	Tons	Big Dumpers Trips	Fuel	Tons	Total tonage/fuel Fuel	Weight (Ton)	%age	Total Fuel	Total Waste /Day tons
1-Jan	3.00	27.18	9.55	0.00	0.00	0.00	27.18	9.55	21.59	221.75	44.2
2-Jan	3.00	23.90	10.20	2.00	19.11	9.42	43.01	19.62	35.22	257.47	55.7
3-Jan	2.00	17.88	9.60	0.00	0.00	0.00	17.88	9.60	22.03	207.56	43.5
4-Jan	3.00	25.85	9.67	0.00	0.00	0.00	25.85	9.67	23.03	251.13	41.9
5-Jan	3.00	27.18	9.30	0.00	0.00	0.00	27.18	9.30	19.60	254.16	47.4
6-Jan	3.00	22.31	10.45	0.00	0.00	0.00	22.31	10.45	22.09	248.89	47.3
7-Jan	3.00	21.90	11.92	0.00	0.00	0.00	21.90	11.92	25.00	247.70	47.6
8-Jan	3.00	25.17	9.42	0.00	0.00	0.00	25.17	9.42	21.37	234.23	44.0
9-Jan	3.00	27.31	10.67	0.00	0.00	0.00	27.31	10.67	22.48	247.48	47.4
10-Jan	2.00	15.78	9.55	0.00	0.00	0.00	15.78	9.55	22.07	195.64	43.2
11-Jan	3.00	22.67	11.33	0.00	0.00	0.00	22.67	11.33	22.47	258.46	50.4
12-Jan	3.00	25.31	9.56	0.00	0.00	0.00	25.31	9.56	19.34	246.66	49.4
13-Jan	3.00	26.42	10.13	0.00	0.00	0.00	26.42	10.13	20.82	250.10	48.6
14-Jan	4.00	32.17	11.12	0.00	0.00	0.00	32.17	11.12	24.85	242.00	44.7
15-Jan	3.00	27.13	9.76	0.00	0.00	0.00	27.13	9.76	20.61	231.59	47.3
16-Jan	3.00	28.42	13.19	0.00	0.00	0.00	28.42	13.19	25.24	147.91	52.2
17-Jan	2.00	19.11	8.11	0.00	0.00	0.00	19.11	8.11	19.70	201.56	41.1
18-Jan	4.00	24.17	11.72	3.00	26.23	17.55	50.40	29.27	44.18	271.32	66.2
19-Jan	3.00	26.52	10.17	2.00	17.66	10.92	44.18	21.09	39.79	255.21	53.0
20-Jan	3.00	27.21	11.45	0.00	0.00	0.00	27.21	11.45	27.38	240.06	41.8
21-Jan	4.00	31.76	11.98	0.00	0.00	0.00	31.76	11.98	26.58	261.02	45.0
22-Jan	3.00	27.95	12.33	0.00	0.00	0.00	27.95	12.33	27.40	224.80	45.0
23-Jan	3.00	25.29	11.82	0.00	0.00	0.00	25.29	11.82	25.92	246.92	45.6
24-Jan	2.00	18.21	9.77	0.00	0.00	0.00	18.21	9.77	25.14	204.72	38.8
25-Jan	3.00	28.90	11.80	0.00	0.00	0.00	28.90	11.80	25.94	258.44	45.4
26-Jan	3.00	27.16	11.63	0.00	0.00	0.00	27.16	11.63	25.86	238.50	44.9
27-Jan	3.00	23.67	10.42	0.00	0.00	0.00	23.67	10.42	22.86	251.31	45.5
28-Jan	3.00	26.32	11.23	0.00	0.00	0.00	26.32	11.23	24.36	260.81	46.1
29-Jan	4.00	26.35	12.60	0.00	0.00	0.00	26.35	12.60	26.57	240.53	47.4
30-Jan	3.00	23.39	10.64	0.00	0.00	0.00	23.39	10.64	24.89	245.72	42.7
31-Jan	2.00	15.42	8.73	0.00	0.00	0.00	15.42	8.73	20.80	193.55	41.9
Total	92.00	768.01	329.82	7.00	63.00	37.89	831.01	367.71	25.42	7337.19	1446.

Appendix 4b: Monthly WM Analysis of Commercial Area month August-2019

STATISTICAL ANALYSIS REPORT OF SOLID WASTE MANAGEMENT

Zone: C
Area of Work: UC 36,46,38 (SWM)
Doted: 1 t0 31 August 2019
Report type: Engr Tayyab

AREA WORK SUMMARY

Weight Summary	
Weight characterization of waste	
Total weight Ton/Month	1473 t
Toatal weight kg/Month	1469026 kg
Total weight Ton/Quarter	737 t
Total weight Kg/Quarter	734513 Kg
Total weight Ton/Week	368 t
Total weight Kg/Week	367256 kg
Total weight Ton/Day	48 t
Total weight Kg/day	47388 kg
Total Fuel Used /month (litres)	7373.03

High Vs Low Tonnage	
Highest waste generated day in a month	68 t
Lowest waste generated day in a month	39 t

Composition of Solid Waste	
Bulky Waste/Commercial Waste	20 %
Food Waste & Domestic waste	54 %
Construction Waste	26 %

Vehicles Trips & Weight Summary

Vehicle type	Tons	Waste type	Fuel	Trips/Month
Skip Loader	159.50	B.Waste/C.Waste	757.46	153.00
Pick up 1	36.11	B.Waste/C.Waste	351.23	136.00
Pick up 2	36.11	B.Waste/C.Waste	348.55	133.00
Pick up 3	31.50	B.Waste/C.Waste	336.15	108.00
Pick up 4	31.50	B.Waste/C.Waste	376.60	140.00
Pick up 5	76.69	Food/Domestic waste	348.9123	148.00
Pick up 6	76.69	Food/Domestic waste	364.74	155.00
Small Compactor	474.12	Food/Domestic waste	2802.97	124.00
Big Compactor	165.51	Food/Domestic waste	734.4592	31.00
Small Dumper	347.82	Construction	768.01	92.00
Big Dumper	37.89	Construction	63.00	7.00

Working Hours Summary

Manpower		Equipments	
Supervisor	816 hrs	Tractor	248 hrs
Heavy Driver	1016 hrs	Back Hoe JCB	0 hrs
Light Driver	1488 hrs	Loader/Shovel	0 hrs
Helper	2976 hrs	Total	248 hrs
UC workers	24496 hrs		
Operator	248 hrs		

Bins Collection Summary

Bins type	No. of Bins
1.1 m^3	6061.00
5 m^3	153.00

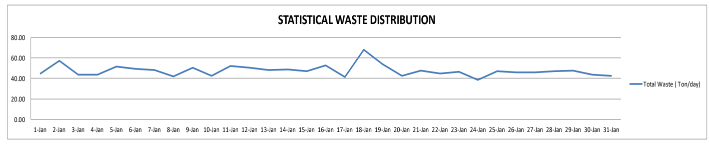
Bin Washing Summary

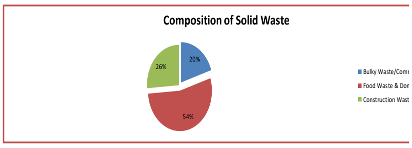
Bins type	No. of Bins
360 litre wheelebins	0.00
1.1 m^3	66.00
Koragan Bins	8.00
5 m^3	0.00

Type	Fuel used in Litres	Price/litre	Cost
Pertol	2126.19	100.11	212852.6
Diesel	6004.30	101.46	609196.1
Total Fuel Cost			822048.7

Description of abbrevations, term used in the report

Terms	Description	Collection Modes
Bulky Waste/Commercial waste	Furnitures,trees,wood,Garden, Ceramic etc.	Pickups,minidumpers, Skip Loaders, 6-wl
Food Waste	General food waste, canes,plastic bags,tetra pack,bottles etc	Compactors
Construction Waste	blocks, concerete,demolition,stones etc	DUMPERS
UC workers	Labour in Union Council for Roads , Streets cleaning, Parks & Open Grounds Paper Collecting	
Composition of solid waste	Components , ingredients of waste mixture	
H.D	Heavy Driver	
L.D	Light Driver	
Supr.	Supervisor	
Helper	Vehicle loader	
Optr.	Operator	





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DETAIL AREA SOLID WASTE ANALYSIS

Commercial Waste/BULKY WASTE

Date	Day	Suzuki Pickups: Pickup 1 trip	Fuel	Pickup 2 trip	Fuel	Total Fuel	Tons	Skip Loader: 5 CBM Trips	Fuel	Tons	FAW Pickups: Pickup 1 Trips	Fuel	Pickup 2 Trips	Fuel	Total Fuel	Tons	Total tonage/Fuel: Total Fuel	Weight (Ton)	%age
23-Jan	Saturday	4.00	10.87	5.00	12.41	23.28	2.65	4.00	23.14	4.66	4.00	13.14	5.00	14.19	27.33	0.00	50.61	7.31	15.81
24-Jan	Sunday	2.00	5.44	3.00	9.72	15.16	1.04	5.00	24.83	4.93	3.00	11.10	3.00	7.81	18.91	0.00	34.07	5.97	15.47
25-Jan	Monday	5.00	12.46	6.00	13.82	26.28	3.47	5.00	23.23	4.94	4.00	13.44	5.00	14.36	27.80	0.00	54.08	8.41	17.86
26-Jan	Tuesday	4.00	11.32	4.00	10.79	22.11	2.70	5.00	24.13	4.49	4.00	12.57	6.00	13.93	26.50	0.00	48.61	7.19	15.67
27-Jan	Wednesday	5.00	12.15	5.00	12.69	24.84	2.37	6.00	27.05	7.31	3.00	9.41	5.00	14.19	23.60	0.00	48.44	9.68	21.02
28-Jan	Thursday	5.00	13.11	5.00	12.17	25.28	2.40	5.00	24.64	5.45	4.00	12.47	5.00	12.36	24.83	0.00	50.11	7.85	16.77
29-Jan	Friday	3.00	8.32	3.00	9.65	17.97	0.71	4.00	22.05	5.51	2.00	9.14	4.00	11.14	20.28	0.00	38.25	6.22	13.15
30-Jan	Saturday	5.00	13.06	4.00	10.33	23.39	2.92	5.00	25.56	4.88	5.00	13.75	4.00	11.47	25.22	0.00	48.61	7.80	17.87
31-Jan	Sunday	4.00	10.52	2.00	9.46	19.98	1.34	3.00	18.36	5.19	3.00	9.37	3.00	7.37	16.74	2.70	36.72	9.23	21.75
Total		136.00	351.23	133.00	348.55	699.79	72.22	153.00	757.46	159.50	108.00	336.15	140.00	376.60	712.75	63.00	1412.54	294.72	20.00

Food Waste & Domestic Waste

Date	Big Compactor uc 26: 1.1 m^3 (Bin's)	Fuel	Trips	Tons	Suzuki Pickups: Pickup 1 Trips	Fuel	Pickup 2 Trips	Fuel/litres	Total Fuel	Total Trips	Tons	Big Compactor: 1.1 m^3 (Bins)	Fuel	Trips	Tons	Total tonage/Fuel: Total Fuel	Weight (Ton)	%age
23-Jan	62.00	23.14	1.00	5.39	5.00	12.03	6.00	13.22	25.25	11.00	4.80	137.00	99.12	4.00	16.92	147.51	27.11	58.63
24-Jan	79.00	21.83	1.00	5.44	4.00	9.45	4.00	8.87	18.32	8.00	5.20	114.00	86.78	4.00	12.22	126.93	22.86	59.22
25-Jan	69.00	23.23	1.00	5.74	5.00	12.02	5.00	11.59	23.61	10.00	5.80	135.00	97.51	4.00	15.34	144.35	26.88	57.08
26-Jan	66.00	24.13	1.00	5.28	5.00	11.77	5.00	12.05	23.82	10.00	4.43	141.00	95.22	4.00	17.34	143.17	27.05	58.97
27-Jan	59.00	24.05	1.00	6.07	5.00	11.34	5.00	11.07	22.41	10.00	4.20	119.00	98.13	4.00	15.68	144.59	25.95	56.35
28-Jan	65.00	24.64	1.00	5.89	6.00	13.89	5.00	12.33	26.22	11.00	5.38	132.00	102.13	4.00	16.45	152.99	27.72	59.23
29-Jan	71.00	22.05	1.00	5.43	4.00	8.90	5.00	11.68	20.58	9.00	5.29	139.00	97.66	4.00	16.76	140.29	27.48	58.10
30-Jan	66.00	25.56	1.00	4.80	5.00	11.89	5.00	12.30	24.19	10.00	5.18	137.00	94.79	4.00	15.22	144.54	25.20	57.75
31-Jan	58.00	18.36	1.00	4.57	4.00	9.67	3.00	7.12	16.79	7.00	5.46	113.00	88.24	4.00	14.45	123.39	24.48	57.68
Total	2037.00	734.46	31.00	165.51	148.00	348.91	155.00	364.74	713.65	303.00	153.38	4024.00	2802.97	124.00	474.12	4251.08	793.01	53.8

Construction Waste

Date	Small Dumpers: Trips	Fuel	Tons	Big Dumpers: Trips	Fuel	Tons	Total tonage/fuel: Fuel	Weight (Ton)	%age
1-Jan	3.00	27.18	11.55	0.00	0.00	0.00	27.18	11.55	25.83
2-Jan	3.00	23.90	12.20	2.00	19.11	9.42	43.01	21.62	37.79
3-Jan	2.00	17.88	9.60	0.00	0.00	0.00	17.88	9.60	21.93
4-Jan	3.00	25.85	9.67	0.00	0.00	0.00	25.85	9.67	22.23
5-Jan	3.00	27.18	12.30	0.00	0.00	0.00	27.18	12.30	23.97
6-Jan	3.00	22.31	11.45	0.00	0.00	0.00	22.31	11.45	23.27
7-Jan	3.00	21.90	11.92	0.00	0.00	0.00	21.90	11.92	24.65
8-Jan	3.00	25.17	9.42	0.00	0.00	0.00	25.17	9.42	22.63
9-Jan	3.00	27.31	12.67	0.00	0.00	0.00	27.31	12.67	25.29
10-Jan	2.00	15.78	9.55	0.00	0.00	0.00	15.78	9.55	22.39
11-Jan	3.00	22.67	11.33	0.00	0.00	0.00	22.67	11.33	21.77
12-Jan	3.00	25.31	9.56	0.00	0.00	0.00	25.31	9.56	18.99
13-Jan	3.00	26.42	10.13	0.00	0.00	0.00	26.42	10.13	21.02
14-Jan	4.00	32.17	14.12	0.00	0.00	0.00	32.17	14.12	29.10
15-Jan	3.00	27.13	9.76	0.00	0.00	0.00	27.13	9.76	20.80
16-Jan	3.00	28.42	13.19	0.00	0.00	0.00	28.42	13.19	24.94
17-Jan	2.00	19.11	8.11	0.00	0.00	0.00	19.11	8.11	19.60
18-Jan	4.00	24.17	13.72	3.00	26.23	17.55	50.40	31.27	46.15
19-Jan	3.00	26.52	10.17	2.00	17.66	10.92	44.18	21.09	39.16
20-Jan	3.00	27.21	11.45	0.00	0.00	0.00	27.21	11.45	26.80
21-Jan	4.00	31.76	13.98	0.00	0.00	0.00	31.76	13.98	29.28
22-Jan	3.00	27.95	12.33	0.00	0.00	0.00	27.95	12.33	27.67
23-Jan	3.00	25.29	11.82	0.00	0.00	0.00	25.29	11.82	25.56
24-Jan	2.00	18.21	9.77	0.00	0.00	0.00	18.21	9.77	25.31
25-Jan	3.00	28.90	11.80	0.00	0.00	0.00	28.90	11.80	25.06
26-Jan	3.00	27.16	11.63	0.00	0.00	0.00	27.16	11.63	25.35
27-Jan	3.00	23.67	10.42	0.00	0.00	0.00	23.67	10.42	22.63
28-Jan	3.00	26.32	11.23	0.00	0.00	0.00	26.32	11.23	24.00
29-Jan	4.00	26.35	13.60	0.00	0.00	0.00	26.35	13.60	28.75
30-Jan	3.00	23.39	10.64	0.00	0.00	0.00	23.39	10.64	24.38
31-Jan	2.00	15.42	8.73	0.00	0.00	0.00	15.42	8.73	20.57
Total	92.00	768.01	347.82	7.00	63.00	37.89	831.01	385.71	26.18

Zone Head Count

Date	Supr.	H.D	L.D	Helpr	UC Workers	Optr.
1-Jan	4	4	6	12	112	1
2-Jan	2	5	6	12	86	1
3-Jan	2	4	6	12	31	1
4-Jan	4	4	6	12	117	1
5-Jan	4	4	6	12	116	1
6-Jan	4	4	6	12	119	1
7-Jan	4	4	6	12	115	1
8-Jan	4	4	6	12	114	1
9-Jan	2	4	6	12	88	1
10-Jan	2	4	6	12	32	1
11-Jan	4	4	6	12	120	1
12-Jan	3	4	6	12	112	1
13-Jan	4	4	6	12	114	1
14-Jan	4	4	6	12	117	1
15-Jan	4	4	6	12	118	1
16-Jan	2	4	6	12	87	1
17-Jan	2	4	6	12	118	1
18-Jan	4	5	6	12	35	1
19-Jan	4	5	6	12	117	1
20-Jan	4	4	6	12	118	1
21-Jan	4	4	6	12	114	1
22-Jan	4	4	6	12	33	1
23-Jan	2	4	6	12	89	1
24-Jan	2	4	6	12	116	1
25-Jan	4	4	6	12	117	1
26-Jan	4	4	6	12	121	1
27-Jan	4	4	6	12	122	1
28-Jan	3	4	6	12	120	1
29-Jan	4	4	6	12	122	1
30-Jan	2	4	6	12	91	1
31-Jan	2	4	6	12	31	1

Zone Head Count - working hours

Date	Supr. (hrs)	H.D (hrs)	L.D (hrs)	Helper (hrs)	UC Workers	Optr. (hrs)	Total hrs
1-Jan	32	32	48	96	896	8	1112
2-Jan	16	40	48	96	688	8	896
3-Jan	16	32	48	96	248	8	448
4-Jan	32	32	48	96	936	8	1152
5-Jan	32	32	48	96	928	8	1144
6-Jan	32	32	48	96	952	8	1168
7-Jan	32	32	48	96	920	8	1136
8-Jan	32	32	48	96	912	8	1128
9-Jan	16	32	48	96	704	8	904
10-Jan	16	32	48	96	256	8	456
11-Jan	32	32	48	96	960	8	1176
12-Jan	24	32	48	96	896	8	1104
13-Jan	32	32	48	96	912	8	1128
14-Jan	32	32	48	96	936	8	1152
15-Jan	32	32	48	96	944	8	1160
16-Jan	16	32	48	96	696	8	896
17-Jan	16	32	48	96	944	8	1144
18-Jan	32	40	48	96	280	8	504
19-Jan	32	40	48	96	936	8	1160
20-Jan	32	32	48	96	944	8	1160
21-Jan	32	32	48	96	912	8	1128
22-Jan	32	32	48	96	264	8	480
23-Jan	16	32	48	96	712	8	912
24-Jan	16	32	48	96	928	8	1128
25-Jan	32	32	48	96	936	8	1152
26-Jan	32	32	48	96	968	8	1184
27-Jan	32	32	48	96	976	8	1192
28-Jan	24	32	48	96	960	8	1168
29-Jan	32	32	48	96	976	8	1192
30-Jan	16	32	48	96	728	8	928
31-Jan	16	32	48	96	248	8	448
Total	816	1016	1488	2976	24496	248	31040

Washing , Sweeping & Special cleaning tasks

Date	Bins Washing: 1.1 m^3	360 Litre wheelibins	Koragan Dustbins	5 m^3 (N.W)	Total No. of washing Bins	Equipment Working Hours: Tractor (hrs)	Fuel Used	JCB (hrs)	Fuel Used	Loader/Shovel(hrs)	Fuel Used	Total working hrs	Tot
1-Jan	0	0	0	0	0	8	31.24	0	0	0	0	8	
2-Jan	0	0	0	0	0	8	27.73	0	0	0	0	8	
3-Jan	0	0	0	0	0	8	27.22	0	0	0	0	8	
4-Jan	0	0	0	0	0	8	29.33	0	0	0	0	8	
5-Jan	0	0	0	0	0	8	28.25	0	0	0	0	8	
6-Jan	0	0	0	0	0	8	27.76	0	0	0	0	8	
7-Jan	34	0	0	0	34	8	28.38	0	0	0	0	8	
8-Jan	0	0	0	0	0	8	25.66	0	0	0	0	8	
9-Jan	0	0	0	0	0	8	31.25	0	0	0	0	8	
10-Jan	0	0	4	0	4	8	23.99	0	0	0	0	8	
11-Jan	0	0	0	0	0	8	29.31	0	0	0	0	8	
12-Jan	0	0	0	0	0	8	31.28	0	0	0	0	8	
13-Jan	0	0	0	0	0	8	28.28	0	0	0	0	8	
14-Jan	0	0	0	0	0	8	26.51	0	0	0	0	8	
15-Jan	0	0	0	0	0	8	27.78	0	0	0	0	8	
16-Jan	0	0	0	0	0	8	32.66	0	0	0	0	8	
17-Jan	0	0	0	0	0	8	23.77	0	0	0	0	8	
18-Jan	0	0	0	0	0	8	27.88	0	0	0	0	8	
19-Jan	0	0	0	0	0	8	29.83	0	0	0	0	8	
20-Jan	32	0	0	0	32	8	27.66	0	0	0	0	8	
21-Jan	0	0	0	0	0	8	28.88	0	0	0	0	8	
22-Jan	0	0	0	0	0	8	32.12	0	0	0	0	8	
23-Jan	0	0	0	0	0	8	28.66	0	0	0	0	8	
24-Jan	0	0	4	0	4	8	26.56	0	0	0	0	8	
25-Jan	0	0	0	0	0	8	29.81	0	0	0	0	8	
26-Jan	0	0	0	0	0	8	28.73	0	0	0	0	8	
27-Jan	0	0	0	0	0	8	28.87	0	0	0	0	8	
28-Jan	0	0	0	0	0	8	28.81	0	0	0	0	8	
29-Jan	0	0	0	0	0	8	27.54	0	0	0	0	8	
30-Jan	0	0	0	0	0	8	30.32	0	0	0	0	8	
31-Jan	0	0	0	0	0	8	22.33	0	0	0	0	8	
Total	66	0	8	0	74	248	878.4	0	0	0	0	248	

Appendix 5a: Monthly WM Analysis of Residential Area month July-2019

STATISTICAL ANALYSIS REPORT OF SOLID WASTE MANAGEMENT

Zone: A
Area of Work: UC 15,20,26 (SWM)
Dated: 1 t0 31 July 2019
Report type: Engr Tayyab

AREA WORK SUMMARY

Weight Summary

Weight characterziation of waste	
Total weight Ton/Month	1149 t
Toatal weight kg/Month	1145139 kg
Total weight Ton/Quarter	574 t
Total weight Kg/Quarter	572569 Kg
Total weight Ton/Week	287 t
Total weight Kg/Week	286285 kg
Total weight Ton/Day	37 t
Total weight Kg/day	36940 kg
Total Fuel Used /month (litres)	5891.31

High Vs Low Tonnage

Highest waste generated day in a month	54 t
Lowest waste generated day in a month	30 t

Composition of Solid Waste

Bulky Waste/Commercial Waste	10 %
Food Waste & Domestic waste	82 %
Construction Waste	8 %

Vehicles Trips & Weight Summary

Vehicle type	Tons	Waste type	Fuel	Trips/Month
Pickup 1	147.00	Food/Domestic waste	441.15	130.00
Pick up 2	55.16	B.Waste/C. Waste	481.23	131.00
Pick up 3	55.56	B.Waste/C. Waste	466.55	132.00
Pick up 4	147.00	Food/Domestic waste	570.05	138.00
Pick up 5	147.00	Food/Domestic waste	590.60	150.00
Pick up 6	81.23	Food/Domestic waste	446.9123	137.00
Pick up 7	81.23	Food/Domestic waste	454.20	139.00
Big Compactor	410.89	Food/Domestic waste	1450.72	62.00
Big Compactor	365.30	Food/Domestic waste	1489.65	62.00
Small Dumper	29.95	Construction	62.27	7.00
Big Dumper	64.80	Construction	89.69	12.00

Working Hours Summary

Manpower		Equipments	
Supervisor	1024 hrs	Tractor	48 hrs
Heavy Driver	560 hrs	Back Hoe JCB	18 hrs
Light Driver	1736 hrs	Loader/Shovel	0 hrs
Helper	2728 hrs	Total	66 hrs
UC workers	14392 hrs		
Operator	80 hrs		

Bins Collection Summary

Bins type	No. of Bins
1.1 m^3	10141.00
5 m^3	947.79

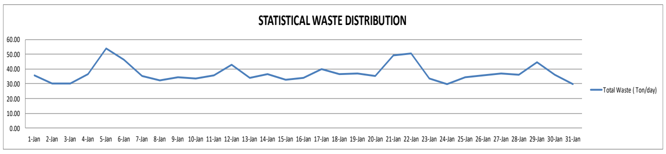
Bin Washing Summary

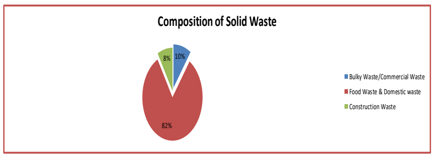
Bins type	No. of Bins
360 litre wheeliebins	0.00
1.1 m^3	66.00
Koragan Bins	7.00
5 m^3	0.00

Type	Fuel used in Litres	Price/litre	Cost
Pertol	3450.70	103.97	358768.9
Diesel	3388.40	62.86	212994.6
Total Fuel Cost			571763.5

Description of abbrevations, term used in the report

Terms	Description	Collection Modes
Bulky Waste/Commercial waste	Furnitures,trees,wood,Garden, Ceramic etc.	Pckups,minidumpers, Skip Loaders, 6-wheel
Food Waste	General food waste, canes,plastic bags,tetra pack,bottles etc	Compactors
Construction Waste	blocks, concerete,demolition,stones etc	DUMPERS
UC workers	Labour in Union Council for Roads , Streets cleaning, Parks & Open Grounds Paper Collecting	
Composition of solid waste	Components , ingredients of waste mixture	
H.D	Heavy Driver	
L.D	Light Driver	
Supr.	Supervisor	
Clnr.	Vehicle loader	
Optr.	Operator	





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DETAIL AREA SOLID WASTE ANALYSIS

Commercial Waste/Residential Waste and **Food Waste & Domestic Waste** (part 1)

Date	Day	Suzuki Pickups (uc-26,20,15) Pickup 1 trip	Fuel	Pickup 2 trip	Fuel	Total Fuel	Tons	Total: Total Fuel	Weight (Ton)	%age	FAW Pickups (uc 20) Pickup 1 Trips	Fuel	Pickup 2 Trips	Fuel	FAW Pickups (uc 15) Pickup 3 Trips	Fuel	Total Fuel: Total Fuel	Total trips	Tons
1-Jan	Friday	3.00	14.32	4.00	13.12	27.44	2.18	27.44	2.18	6.095	3.00	11.64	4.00	15.87	3.00	11.22	38.73	10.00	4.87
2-Jan	Saturday	4.00	17.05	5.00	16.88	33.93	3.84	33.93	3.84	12.69	4.00	14.38	5.00	19.42	4.00	13.74	47.54	13.00	7.37
3-Jan	Sunday	3.00	14.11	3.00	12.45	26.56	2.86	26.56	2.86	9.492	3.00	15.16	4.00	15.02	3.00	10.04	40.22	10.00	3.76
4-Jan	Monday	4.00	18.71	5.00	16.72	35.43	3.21	35.43	3.21	8.787	5.00	21.08	6.00	24.12	5.00	18.58	63.78	16.00	5.11
5-Jan	Tuesday	5.00	18.17	4.00	14.84	33.01	3.32	33.01	3.32	6.137	5.00	20.70	5.00	24.88	5.00	16.84	62.42	15.00	6.44
6-Jan	Wednesday	6.00	20.92	4.00	15.13	36.05	4.68	36.05	4.68	10.09	5.00	21.40	5.00	18.68	5.00	17.50	57.58	15.00	6.89
7-Jan	Thursday	5.00	15.994	5.00	17.24	33.23	5.44	33.23	5.44	15.44	4.00	15.12	5.00	18.70	5.00	16.44	50.26	14.00	7.15
8-Jan	Friday	3.00	14.1	5.00	18.32	32.42	2.60	32.42	2.60	8.091	4.00	17.34	5.00	19.52	3.00	10.90	47.76	12.00	5.67
9-Jan	Saturday	4.00	16.75	4.00	14.60	31.35	2.86	31.35	2.86	8.348	5.00	20.44	6.00	22.50	5.00	16.80	59.74	16.00	6.82
10-Jan	Sunday	3.00	13.11	3.00	12.56	25.67	2.69	25.67	2.69	7.973	4.00	17.18	5.00	17.18	3.00	10.92	45.28	12.00	4.98
11-Jan	Monday	5.00	17.42	5.00	16.26	33.68	3.35	33.68	3.35	9.444	5.00	21.82	4.00	16.30	5.00	18.22	56.34	14.00	8.16
12-Jan	Tuesday	5.00	17.02	6.00	19.68	36.70	3.66	36.70	3.66	8.559	5.00	20.70	5.00	18.67	4.00	13.80	53.17	14.00	5.67
13-Jan	Wednesday	4.00	13.96	5.00	15.43	29.39	3.66	29.39	3.66	10.81	4.00	15.22	5.00	19.64	3.00	11.76	46.62	12.00	6.68
14-Jan	Thursday	5.00	18.01	5.00	17.13	35.14	4.13	35.14	4.13	11.29	5.00	18.04	5.00	18.84	4.00	12.26	49.14	14.00	6.89
15-Jan	Friday	4.00	15.02	3.00	10.56	25.58	2.25	25.58	2.25	6.862	3.00	13.88	5.00	18.42	3.00	9.46	41.76	11.00	5.94
16-Jan	Saturday	4.00	14.83	4.00	14.52	29.35	3.89	29.35	3.89	11.5	5.00	21.44	6.00	24.68	4.00	12.80	58.92	15.00	6.32
17-Jan	Sunday	3.00	12.1	3.00	12.43	24.53	2.32	24.53	2.32	5.817	4.00	17.88	3.00	12.08	3.00	11.66	41.62	10.00	5.72
18-Jan	Monday	6.00	18.56	5.00	17.04	35.60	4.70	35.60	4.70	12.88	5.00	20.92	5.00	19.42	5.00	15.42	55.76	15.00	6.23
19-Jan	Tuesday	5.00	15.44	5.00	16.53	31.97	4.22	31.97	4.22	11.47	5.00	19.78	5.00	18.30	5.00	17.92	56.00	15.00	7.12
20-Jan	Wednesday	4.00	13.77	5.00	16.13	29.90	3.86	29.90	3.86	10.93	5.00	20.82	4.00	16.18	5.00	15.92	52.92	14.00	6.11
21-Jan	Thursday	5.00	16.75	4.00	14.55	31.30	3.20	31.30	3.20	6.511	5.00	19.76	5.00	20.46	4.00	13.08	53.30	14.00	5.89
22-Jan	Friday	4.00	14.35	3.00	12.87	27.22	2.87	27.22	2.87	5.687	5.00	18.40	4.00	18.34	4.00	12.96	49.70	13.00	5.23
23-Jan	Saturday	4.00	14.19	5.00	15.73	29.92	3.63	29.92	3.63	10.83	4.00	16.10	6.00	24.15	5.00	16.46	56.71	15.00	5.98
24-Jan	Sunday	3.00	11.57	2.00	7.85	19.42	2.42	19.42	2.42	8.148	5.00	20.49	4.00	15.20	4.00	14.23	49.92	13.00	5.12
25-Jan	Monday	5.00	16.26	6.00	20.62	36.88	5.42	36.88	5.42	15.85	4.00	19.84	5.00	19.76	5.00	17.24	56.84	14.00	6.67
26-Jan	Tuesday	4.00	14.77	4.00	14.24	29.01	3.74	29.01	3.74	10.52	5.00	22.92	5.00	18.28	5.00	16.02	57.22	15.00	5.12
27-Jan	Wednesday	5.00	17.38	5.00	15.92	33.30	4.84	33.30	4.84	13.1	5.00	19.10	6.00	23.88	4.00	12.64	55.62	15.00	5.72
28-Jan	Thursday	5.00	16.46	5.00	15.52	31.98	4.24	31.98	4.24	11.76	5.00	20.52	5.00	18.41	5.00	15.82	54.75	15.00	6.54
29-Jan	Friday	3.00	11.88	3.00	13.21	25.09	2.91	25.09	2.91	6.532	5.00	19.82	4.00	17.82	4.00	12.70	50.34	13.00	6.23
30-Jan	Saturday	4.00	14.51	4.00	15.78	30.29	3.69	30.29	3.69	10.17	4.00	16.10	5.00	18.82	5.00	17.20	52.12	14.00	7.34
31-Jan	Sunday	4.00	13.75	3.00	12.69	26.44	3.63	26.44	3.63	12.2	3.00	12.06	4.00	17.06	3.00	10.60	39.72	10.00	4.76
Total		131.00	481.23	132.00	466.55	947.79	110.31	947.79	110.31	9.60	138.00	570.05	150.00	590.60	130.00	441.15	1601.80	418.00	188.49

Food Waste & Domestic Waste (part 2)

Date	Big Compactor (UC-20-15) 1.1 m^3 (lift's)	Fuel	Trips	Tons	Suzuki Pickups (UC-26) Pickup 1 Trips	Fuel	Pickup 2 Trips	Fuel/litres	Total Fuel	Total Trips	Tons	Big Compactor (Uc 26) 1.1 m^3 (lift's)	Fuel	Trips	Tons	Total tonage/Fuel: Total Fuel	Weight (Ton)	%age
1-Jan	110.00	51.30	2.00	11.31	4.00	12.70	4.00	13.51	26.21	8.00	5.21	103.00	41.06	2.00	12.20	118.57	33.59	93.90
2-Jan	112.00	47.48	2.00	10.24	5.00	16.71	4.00	13.31	30.02	9.00	5.66	105.00	42.62	2.00	10.50	120.12	26.40	87.31
3-Jan	117.00	43.07	2.00	10.31	3.00	11.24	3.00	10.32	21.56	6.00	4.16	110.00	40.56	2.00	12.80	105.18	27.27	90.51
4-Jan	107.00	52.45	2.00	13.45	5.00	16.41	5.00	16.34	32.75	10.00	6.20	100.00	46.05	2.00	13.67	131.25	33.32	91.21
5-Jan	119.00	48.15	2.00	12.29	5.00	15.93	5.00	17.89	33.82	10.00	5.38	112.00	46.50	2.00	13.69	128.47	31.36	57.97
6-Jan	113.00	50.63	2.00	13.23	4.00	14.12	4.00	13.42	27.54	8.00	4.88	106.00	48.10	2.00	11.19	126.27	29.30	63.15
7-Jan	112.00	48.48	2.00	12.41	5.00	15.84	5.00	16.36	32.20	10.00	5.23	105.00	50.57	2.00	12.15	131.24	29.79	84.56
8-Jan	104.00	53.64	2.00	11.78	5.00	13.34	5.00	15.02	28.36	10.00	5.44	97.00	49.94	2.00	12.31	131.94	29.53	91.91
9-Jan	125.00	50.62	2.00	12.11	4.00	15.43	5.00	15.36	30.79	9.00	5.61	118.00	46.23	2.00	13.68	127.64	31.40	91.65
10-Jan	115.00	51.23	2.00	13.74	3.00	10.36	5.00	16.39	26.75	8.00	4.55	108.00	42.17	2.00	12.76	120.15	31.05	92.03
11-Jan	108.00	49.32	2.00	13.11	5.00	15.14	4.00	13.54	28.68	9.00	4.80	101.00	50.06	2.00	14.21	128.06	32.12	90.56
12-Jan	110.00	45.92	2.00	10.89	5.00	15.52	5.00	16.92	32.44	10.00	5.42	103.00	48.12	2.00	13.43	126.48	29.74	69.56
13-Jan	114.00	45.63	2.00	11.70	4.00	13.56	4.00	12.90	26.46	8.00	5.18	107.00	46.95	2.00	13.31	119.03	30.19	89.19
14-Jan	122.00	49.49	2.00	12.86	4.00	12.29	5.00	16.26	28.54	9.00	5.26	115.00	46.06	2.00	14.33	124.09	32.45	88.71
15-Jan	107.00	41.09	2.00	10.64	5.00	12.39	5.00	17.17	29.55	10.00	5.59	38.00	47.28	2.00	14.32	117.92	30.55	93.14
16-Jan	109.00	52.80	2.00	13.13	4.00	14.45	5.00	16.23	30.67	9.00	5.36	102.00	49.24	2.00	11.46	132.71	29.95	88.50
17-Jan	126.00	44.85	2.00	10.54	4.00	11.09	3.00	8.15	19.24	7.00	4.32	119.00	43.56	2.00	12.39	107.65	27.25	68.33
18-Jan	118.00	50.09	2.00	14.27	5.00	16.11	5.00	15.80	31.91	10.00	5.28	111.00	47.61	2.00	12.22	129.61	31.77	87.12
19-Jan	114.00	48.65	2.00	13.44	5.00	17.47	5.00	16.90	34.37	10.00	5.28	107.00	46.06	2.00	13.84	129.08	32.56	88.53
20-Jan	112.00	49.55	2.00	12.67	4.00	14.78	4.00	13.80	28.58	8.00	5.08	105.00	47.16	2.00	13.67	125.29	31.42	89.07
21-Jan	115.00	47.88	2.00	11.29	4.00	13.67	5.00	16.40	30.07	9.00	5.38	108.00	48.38	2.00	14.71	126.33	31.38	63.76
22-Jan	105.00	46.52	2.00	9.69	5.00	16.89	3.00	10.21	27.10	8.00	4.82	98.00	46.72	2.00	14.82	120.34	29.33	58.04
23-Jan	107.00	46.93	2.00	10.39	5.00	15.35	6.00	19.22	34.57	11.00	5.78	100.00	49.56	2.00	13.69	131.06	29.86	89.17
24-Jan	124.00	44.56	2.00	9.34	5.00	16.58	4.00	12.39	28.97	9.00	5.52	117.00	43.39	2.00	12.42	116.92	27.28	91.85
25-Jan	114.00	43.80	2.00	9.67	5.00	15.82	5.00	15.90	31.72	10.00	5.98	107.00	48.76	2.00	13.14	124.28	28.79	84.15
26-Jan	111.00	48.75	2.00	12.33	4.00	12.22	5.00	16.11	28.33	9.00	5.24	104.00	47.61	2.00	14.23	124.69	31.81	89.48
27-Jan	104.00	49.75	2.00	13.11	5.00	15.57	4.00	12.70	28.27	9.00	4.82	97.00	49.07	2.00	14.17	127.09	32.10	86.90
28-Jan	110.00	47.58	2.00	11.89	5.00	17.24	5.00	16.50	33.74	10.00	5.44	103.00	51.07	2.00	14.50	132.39	31.83	88.24
29-Jan	116.00	48.08	2.00	12.43	4.00	12.46	4.00	12.68	25.14	8.00	5.33	109.00	48.83	2.00	13.60	122.05	31.36	70.39
30-Jan	111.00	48.47	2.00	11.68	4.00	14.34	5.00	17.30	31.64	9.00	5.80	104.00	47.40	2.00	15.12	127.51	32.60	89.83
31-Jan	103.00	42.89	2.00	9.36	3.00	11.90	3.00	9.22	21.12	6.00	4.46	96.00	44.12	2.00	12.35	108.13	26.16	87.80
Total	6926.00	1489.65	62.00	365.30	137.00	446.91	139.00	454.20	901.11	276.00	162.46	3215.00	1450.72	62.00	410.89	3841.48	943.52	82.1

Construction Waste (part 3)

Date	Small Dumpers Trips	Fuel	Tons	Big Dumpers Trips	Fuel	Tons	Total tonage/fuel: Fuel	Weight (Ton)	%age	Total Fuel	Total Waste /Day tons
1-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	157.30	35.77
2-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	167.66	30.24
3-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	145.40	30.13
4-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	195.03	36.53
5-Jan	0.00	0.00	0.00	3.00	26.17	19.42	26.17	19.42	35.90	217.06	54.10
6-Jan	0.00	0.00	0.00	2.00	18.81	12.42	18.81	12.42	26.77	202.66	46.40
7-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	181.50	35.23
8-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	179.70	32.13
9-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	187.38	34.26
10-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	165.43	33.74
11-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	184.40	35.47
12-Jan	2.00	17.69	9.36	0.00	0.00	0.00	17.69	9.36	21.89	197.34	42.76
13-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	165.65	33.85
14-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	173.23	36.58
15-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	159.68	32.80
16-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	191.63	33.84
17-Jan	2.00	18.35	10.31	0.00	0.00	0.00	18.35	10.31	25.86	167.61	39.89
18-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.37	36.47
19-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.08	36.78
20-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	178.21	35.28
21-Jan	0.00	0.00	0.00	3.00	24.90	14.63	24.90	14.63	29.73	204.53	49.21
22-Jan	0.00	0.00	0.00	4.00	19.81	18.33	19.81	18.33	36.27	189.85	50.53
23-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	187.77	33.49
24-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	166.84	29.70
25-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	181.12	34.22
26-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	181.91	35.55
27-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	182.71	36.93
28-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	187.14	36.07
29-Jan	3.00	26.23	10.28	0.00	0.00	0.00	26.23	10.28	23.08	198.62	44.55
30-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	179.63	36.29
31-Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	147.85	29.80
Total	7.00	62.27	29.95	12.00	89.69	64.80	151.96	94.75	8.25	5595.24	1148.58

Zone Head Count

Date	Supr.	H.D	LD	Helpr	UC Workers	Optr.
1-Jan	5	2	7	11	70	0
2-Jan	2	2	7	11	68	0
3-Jan	3	3	7	11	69	1
4-Jan	5	2	7	11	65	0
5-Jan	5	2	7	11	68	0
6-Jan	5	3	7	11	68	1
7-Jan	5	3	7	11	69	2
8-Jan	5	3	7	11	66	1
9-Jan	3	2	7	11	32	0
10-Jan	2	2	7	11	30	0
11-Jan	5	2	7	11	68	0
12-Jan	4	2	7	11	65	0
13-Jan	5	3	7	11	67	1
14-Jan	5	2	7	11	67	0
15-Jan	5	2	7	11	68	0
16-Jan	2	2	7	11	37	0
17-Jan	3	3	7	11	25	1
18-Jan	4	2	7	11	67	0
19-Jan	5	2	7	11	67	0
20-Jan	5	2	7	11	66	1
21-Jan	5	2	7	11	68	0
22-Jan	5	2	7	11	36	0
23-Jan	3	3	7	11	26	1
24-Jan	2	2	7	11	68	0
25-Jan	5	3	7	11	66	1
26-Jan	5	2	7	11	68	0
27-Jan	5	2	7	11	69	0
28-Jan	5	2	7	11	66	0
29-Jan	5	2	7	11	67	0
30-Jan	3	2	7	11	35	0
31-Jan	2	2	7	11	28	0

Zone Head Count - working hours

Date	Supr. (hrs)	H.D (hrs)	LD (hrs)	Helper (hrs)	UC Workers	Optr. (hrs)	Total hrs
1-Jan	40	16	56	88	560	0	760
2-Jan	16	16	56	88	544	0	720
3-Jan	24	24	56	88	552	8	752
4-Jan	40	16	56	88	520	0	720
5-Jan	40	16	56	88	544	0	744
6-Jan	40	24	56	88	544	8	760
7-Jan	40	24	56	88	552	16	776
8-Jan	40	24	56	88	528	8	744
9-Jan	24	16	56	88	256	0	440
10-Jan	16	16	56	88	240	0	416
11-Jan	40	16	56	88	544	0	744
12-Jan	32	16	56	88	520	0	712
13-Jan	40	24	56	88	536	8	752
14-Jan	40	16	56	88	536	0	736
15-Jan	40	16	56	88	544	0	744
16-Jan	16	16	56	88	296	0	472
17-Jan	24	24	56	88	200	8	400
18-Jan	32	16	56	88	536	0	728
19-Jan	40	16	56	88	536	0	736
20-Jan	40	16	56	88	528	8	736
21-Jan	40	16	56	88	544	0	744
22-Jan	40	16	56	88	288	0	488
23-Jan	24	24	56	88	208	8	408
24-Jan	16	16	56	88	544	0	720
25-Jan	40	24	56	88	528	8	744
26-Jan	40	16	56	88	544	0	744
27-Jan	40	16	56	88	552	0	752
28-Jan	40	16	56	88	528	0	728
29-Jan	40	16	56	88	536	0	736
30-Jan	24	16	56	88	280	0	464
31-Jan	16	16	56	88	224	0	400

Washing , Sweeping & Special cleaning tasks

Date	Bins Washing: 1.1 m^3	360 Litre wheelbins	Koragan Dustbin	5 m^3 (K.W)	Total No. of washing Bins	Equipment Working Hours: Tractor (hrs)	Fuel Used	JCB (hrs)	Fuel Used	Loader/Shovel(hrs)	Fuel Used	Total working hrs	Total Fuel used
1-Jan	0	0	0	0	0			0	0	0	0	0	0
2-Jan	0	0	0	0	0			0	0	0	0	0	0
3-Jan	0	0	0	0	0		27.22	6	28.29	0	0	6	55.51
4-Jan	0	0	0	0	0		0	0	0	0	0	0	0
5-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
6-Jan	0	0	0	0	0	8	25.67	0	0	0	0	8	25.67
7-Jan	34	0	3	0	37	8	29.82	0	0	0	0	8	29.82
8-Jan	0	0	0	0	0	8	29.86	0	0	0	0	8	29.86
9-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
12-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
13-Jan	0	0	0	0	0	8	32.38	0	0	0	0	8	32.38
14-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
16-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Jan	0	0	0	0	0	0	0	5	25.61	0	0	5	25.61
18-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Jan	32	0	0	0	32	8	29.76	0	0	0	0	8	29.76
21-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Jan	0	0	0	0	0	0	0	7	34.65	0	0	7	34.65
24-Jan	0	0	4	0	4	0	0	0	0	0	0	0	0
25-Jan	0	0	0	0	0	8	32.81	0	0	0	0	8	32.81
26-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
30-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 5b: Monthly WM Analysis of Residential Area month August-2019

STATISTICAL ANALYSIS REPORT OF SOLID WASTE MANAGEMENT

Zone: A
Area of Work: UC 15,20,26 (SWM)
Dated: 1 t0 31 August 2019
Report type: Engr Tayyab

AREA WORK SUMMARY

Weight Summary	
Weight characterziation of waste	
Total weight Ton/Month	1120 t
Toatal weight kg/Month	1116376 kg
Total weight Ton/Quarter	560 t
Total weight Kg/Quarter	558188 Kg
Total weight Ton/Week	280 t
Total weight Kg/Week	279094 kg
Total weight Ton/Day	36 t
Total weight Kg/day	36012 kg
Total Fuel Used /month (litres)	5784.02

High Vs Low Tonnage	
Highest waste generated day in a month	49 t
Lowest waste generated day in a month	29 t

Composition of Solid Waste	
Bulky Waste/Commercial waste	10 %
Food Waste & Domestic waste	85 %
Construction Waste	5 %

Vehicles Trips & Weight Summary

Vehicle type	Tons	Waste type	Fuel	Trips/Month
Pick up 1	150.00	Food/Domestic waste	451.27	124.00
Pick up 2	55.07	B.Waste/C. Waste	490.35	136.00
Pick up 3	55.00	B.Waste/C. Waste	480.67	135.00
Pick up 4	150.42	Food/Domestic waste	539.05	146.00
Pick up 5	150.42	Food/Domestic waste	541.60	143.00
Pick up 6	69.04	Food/Domestic waste	459.4423	133.00
Pick up 7	69.04	Food/Domestic waste	501.23	141.00
Big Compactor	420.42	Food/Domestic waste	1485.25	62.00
Big Compactor	385.72	Food/Domestic waste	1505.46	62.00
Small Dumper	22.63	Construction	47.73	5.00
Big Dumper	38.87	Construction	69.72	8.00

Working Hours Summary

Manpower		Equipments	
Supervisor	1008 hrs	Tractor	15 hrs
Heavy Driver	560 hrs	Back Hoe JCB	33 hrs
Light Driver	1736 hrs	Loader/Shovel	0 hrs
Helper	2728 hrs	Total	48 hrs
UC workers	14216 hrs		
Operator	72 hrs		

Bins Collection Summary

Bins type	No. of Bins
1.1 m^3	9991.00
5 m^3	971.03

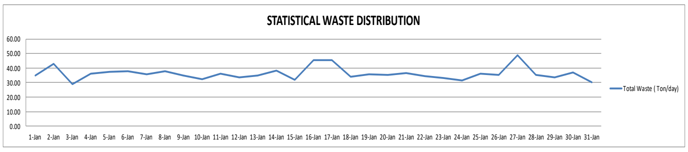
Bin Washing Summary

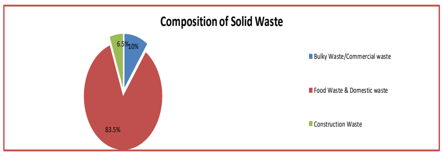
Bins type	No. of Bins
360 litre wheeliebins	0.00
1.1 m^3	106.00
Koragan Bins	11.00
5 m^3	0.00

Type	Fuel used in Litres	Price/litre	Cost
Pertol	3463.62	100.11	346742.9
Diesel	3291.42	101.46	333947.9
Total Fuel Cost			680690.9

Description of abbrevations, term used in the report

Terms	Description	Collection Modes
Bulky Waste/Commercial waste	Furnitures,trees,wood,Garden, Ceramic etc.	Pckups,minidumpers, Skip Loaders, 6-wheel
Food Waste	General food waste, canes,plastic bags,tetra pack,bottles etc	Compactors
Construction Waste	blocks, concerete,demolition,stones etc	DUMPERS
UC workers	Labour in Union Council for Roads , Streets cleaning, Parks & Open Grounds Paper Collecting	
Composition of solid waste	Components , ingredients of waste mixture	
H.D	Heavy Driver	
LD	Light Driver	
Supr.	Supervisor	
Clnr.	Vehicle loader	
Optr.	Operator	





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DETAIL AREA SOLID WASTE ANALYSIS

Column groups: Commercial Waste/Residential Waste – Suzuki Pickups (uc-26,20,15) (cols 3–8), Total (cols 9–11); Food Waste & Domestic Waste – FAW Pickups (uc 20) (cols 12–15), FAW Pickups (uc 15) (cols 16–17), Total Fuel (cols 18–20), Big Compactor (UC-20-15) (cols 21–24), Suzuki Pickups (UC-26) (cols 25–31), Big Compactor (Uc 26) (cols 32–35), Total tonage/Fuel (cols 36–38); Construction Waste – Small Dumpers (cols 39–41), Big Dumpers (cols 42–44), Total tonage/fuel (cols 45–47); Total Fuel (col 48).

Date	Day	Pickup 1 trip	Fuel	Pickup 2 trip	Fuel	Total Fuel	Tons	Total Fuel	Weigh t(Ton)	%age	Pickup 3 Trips	Fuel	Pickup 4 Trips	Fuel	Pickup 5 Trips	Fuel	Total Fuel	Total trips	Tons	1.1 m^3 (Mt's)	Fuel	Trips	Tons	Pickup 6 Trips	Fuel	Pickup 7 Trips	Fuel/litres	Total Fuel	Total Trips	Tons	1.1 m^3 (lift)	Fuel	Trips	Tons	Total Fuel	Weight (Ton)	%age	Trips	Fuel	Tons	Trips	Fuel	Tons	Fuel	Weight (Ton)	%age	Total Fuel
1-Jan	Friday	[illegible]	12.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2-Jan	Saturday	[illegible]	17.37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3-Jan	Sunday	[illegible]	13.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4-Jan	Monday	[illegible]	19.46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5-Jan	Tuesday	[illegible]	18.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6-Jan	Wednesday	[illegible]	19.37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-Jan	Thursday	[illegible]	16.334	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8-Jan	Friday	[illegible]	14.32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9-Jan	Saturday	[illegible]	17.43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10-Jan	Sunday	[illegible]	13.24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11-Jan	Monday	[illegible]	18.22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12-Jan	Tuesday	[illegible]	17.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13-Jan	Wednesday	[illegible]	17.19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14-Jan	Thursday	[illegible]	18.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15-Jan	Friday	[illegible]	15.23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16-Jan	Saturday	[illegible]	15.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17-Jan	Sunday	[illegible]	12.21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18-Jan	Monday	[illegible]	18.81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19-Jan	Tuesday	[illegible]	15.87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20-Jan	Wednesday	[illegible]	14.22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21-Jan	Thursday	[illegible]	17.09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22-Jan	Friday	[illegible]	14.57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23-Jan	Saturday	4.00	14.51	5.00	16.05	30.56	3.95	30.56	3.95	11.98	4.00	14.78	5.00	20.83	5.00	16.78	52.39	14.00	5.98	116.00	49.25	2.00	10.71	4.00	13.67	5.00	17.82	31.49	9.00	4.28	95.00	51.88	2.00	14.01	132.62	29.00	88.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.01
24-Jan	Sunday	3.00	11.7	3.00	11.98	23.68	2.55	23.68	2.55	8.141	5.00	17.36	4.00	14.07	4.00	14.36	45.79	13.00	5.12	112.00	48.69	2.00	11.47	5.00	16.71	5.00	17.87	34.58	10.00	4.75	112.00	48.52	2.00	12.55	131.79	28.78	91.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	177.58
25-Jan	Monday	5.00	17.06	6.00	18.42	35.48	4.82	35.48	4.82	13.43	6.00	21.04	5.00	19.96	5.00	18.04	59.04	16.00	7.77	103.00	49.60	2.00	10.47	5.00	16.62	5.00	15.90	32.52	10.00	6.70	102.00	50.56	2.00	13.94	132.68	31.11	86.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	191.72
26-Jan	Tuesday	4.00	15.22	4.00	14.69	29.91	4.19	29.91	4.19	11.94	5.00	19.47	4.00	14.83	4.00	16.47	50.77	13.00	6.21	121.00	46.20	2.00	12.78	4.00	12.67	4.00	15.05	27.72	8.00	3.43	100.00	49.06	2.00	14.68	122.98	30.89	88.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	173.75
27-Jan	Wednesday	5.00	17.61	5.00	17.15	34.76	4.07	34.76	4.07	8.337	4.00	15.87	5.00	20.65	3.00	11.87	48.39	12.00	4.67	115.00	51.98	2.00	13.34	5.00	15.80	5.00	17.80	33.60	10.00	4.18	92.00	51.30	2.00	14.40	136.88	31.92	65.43	0.00	0.00	0.00	2.00	20.31	12.80	20.31	12.80	26.24	205.58
28-Jan	Thursday	5.00	16.81	5.00	16.87	33.68	3.59	33.68	3.59	10.24	5.00	19.17	5.00	19.06	4.00	16.17	54.40	14.00	7.15	124.00	48.93	2.00	12.24	5.00	17.59	5.00	17.95	35.54	10.00	4.38	98.00	52.42	2.00	14.85	136.89	31.47	89.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	191.29
29-Jan	Friday	3.00	12.44	4.00	13.77	26.21	3.47	26.21	3.47	10.37	4.00	16.26	5.00	18.26	4.00	13.26	47.78	13.00	6.82	109.00	43.64	2.00	12.99	4.00	13.02	3.00	10.68	23.70	7.00	2.83	105.00	49.39	2.00	14.16	116.73	29.98	89.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	164.51
30-Jan	Saturday	4.00	14.96	5.00	17.23	32.19	4.14	32.19	4.14	11.19	6.00	20.65	5.00	18.37	5.00	17.65	56.67	16.00	7.83	118.00	49.92	2.00	13.13	5.00	18.79	4.00	15.43	34.22	9.00	4.18	100.00	49.85	2.00	15.57	133.99	32.88	88.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	190.66
31-Jan	Sunday	4.00	13.98	3.00	12.92	26.90	3.86	26.90	3.86	12.76	4.00	15.83	4.00	13.83	3.00	10.83	40.49	11.00	4.48	107.00	41.12	2.00	10.59	3.00	12.13	4.00	14.52	26.65	7.00	3.26	93.00	42.35	2.00	12.58	110.12	26.42	87.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	150.61
Total		136.00	490.35	135.00	480.67	971.03	110.15	971.03	110.15	9.84	146.00	539.05	143.00	541.60	124.00	451.27	1531.92	413.00	189.93	6913.00	1505.46	62.00	385.72	133.00	459.44	141.00	501.23	960.67	274.00	138.08	3078.00	1485.25	62.00	420.42	3951.38	948.09	84.7	5.00	47.73	22.63	8.00	69.72	38.87	117.45	61.50	5.49	5600.76

Zone Head Count

Date	Supr.	H.D	L.D	Helpr	UC Workers	Optr.
1-Jan	4	2	7	11	66	0
2-Jan	2	2	7	11	67	1
3-Jan	3	3	7	11	69	0
4-Jan	5	2	7	11	66	0
5-Jan	5	2	7	11	68	0
6-Jan	5	3	7	11	65	1
7-Jan	4	3	7	11	69	0
8-Jan	5	3	7	11	62	1
9-Jan	3	2	7	11	35	0
10-Jan	2	2	7	11	30	1
11-Jan	5	2	7	11	68	0
12-Jan	5	2	7	11	65	0
13-Jan	5	3	7	11	68	1
14-Jan	5	2	7	11	67	0
15-Jan	4	2	7	11	68	0
16-Jan	2	2	7	11	35	1
17-Jan	3	3	7	11	24	1
18-Jan	5	2	7	11	68	0
19-Jan	5	2	7	11	66	0
20-Jan	5	2	7	11	66	0
21-Jan	5	2	7	11	66	0
22-Jan	5	2	7	11	32	0
23-Jan	3	3	7	11	27	1
24-Jan	2	2	7	11	68	0
25-Jan	5	3	7	11	68	0
26-Jan	5	2	7	11	66	0
27-Jan	4	2	7	11	66	1
28-Jan	5	2	7	11	65	0
29-Jan	5	2	7	11	65	0
30-Jan	3	2	7	11	34	0
31-Jan	2	2	7	11	28	0

Zone Head Count - working hours

Date	Supr. (hrs)	H.D (hrs)	L.D (hrs)	Helper (hrs)	UC Workers	Optr. (hrs)	Total hrs
1-Jan	32	16	56	88	528	0	720
2-Jan	16	16	56	88	536	8	720
3-Jan	24	24	56	88	552	0	744
4-Jan	40	16	56	88	528	0	728
5-Jan	40	16	56	88	544	0	744
6-Jan	40	24	56	88	520	8	736
7-Jan	32	24	56	88	552	0	752
8-Jan	40	24	56	88	496	8	712
9-Jan	24	16	56	88	280	0	464
10-Jan	16	16	56	88	240	8	424
11-Jan	40	16	56	88	544	0	744
12-Jan	40	16	56	88	520	0	720
13-Jan	40	24	56	88	544	8	760
14-Jan	40	16	56	88	536	0	736
15-Jan	32	16	56	88	544	0	736
16-Jan	16	16	56	88	280	8	464
17-Jan	24	24	56	88	192	8	392
18-Jan	40	16	56	88	544	0	744
19-Jan	40	16	56	88	528	0	728
20-Jan	40	16	56	88	528	0	728
21-Jan	40	16	56	88	528	0	728
22-Jan	40	16	56	88	256	0	456
23-Jan	24	24	56	88	216	8	416
24-Jan	16	16	56	88	544	0	720
25-Jan	40	24	56	88	544	0	752
26-Jan	40	16	56	88	528	0	728
27-Jan	32	16	56	88	528	8	728
28-Jan	40	16	56	88	520	0	720
29-Jan	40	16	56	88	520	0	720
30-Jan	24	16	56	88	272	0	456
31-Jan	16	16	56	88	224	0	400
Total	1008	560	1736	2728	14216	72	20320

Washing , Sweeping & Special cleaning tasks

Date	Bins Washing: 1.1 m^3	360 Litre wheelibins	Koragan Dustbins	5 m^3 (N.W)	Total No. of washing Bins	Equipment Working Hours: Tractor (hrs)	Fuel Used	JCB (hrs)	Fuel Used	Loader/Shovel(hrs)	Fuel Used	Total working hrs	Total Fuel
1-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
2-Jan	0	0	0	0	0	0	0	7	31.9	0	0	7	31.9
3-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
4-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
5-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
6-Jan	0	0	0	0	0	0	0	8	32.33	0	0	8	32.33
7-Jan		0	0	0	0	0	0	0	0	0	0	0	0
8-Jan	0	0	0	0	0	0	0	6	28.77	0	0	6	28.77
9-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Jan	34	0	4	0	38	0	0	0	0	0	0	0	0
11-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
12-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
13-Jan	37	0	4	0	41	0	0	0	0	0	0	0	0
14-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
16-Jan	0	0	0	0	0	8	0	6	32.38	0	0	14	32.38
17-Jan	0	0	0	0	0	0	0	6	28.1	0	0	6	28.1
18-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Jan		0	0	0	0	0	0	0	0	0	0	0	0
21-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Jan	35	0	3	0	38	0	0	0	0	0	0	0	0
24-Jan	0	0		0	0	0	0	0	0	0	0	0	0
25-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
26-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Jan	0	0	0	0	0	7	29.78	0	0	0	0	7	29.78
28-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
30-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	106	0	11	0	117	15	29.78	33	153.48	0	0	48	183.26

Appendix 6a: Monthly Cost Analysis for Different costs for Commercial Area & Residential Area

Per Capita Cost Analysis (July-Anugust-2019)

Cost Analysis - JULY 2019 (UC 36,39,46)

Costing Summary

Vehicle type	Tons	Waste type	Fuel	Trips/Month	Fuel Cost	Collection Cost	Transportation Cost
Skip Loader	159.5022	Bulky Waste	757.4592	153	101.46	76851.81043	16332.38727
Pick up 1	36.112	Bulky Waste	351.234	136	100.11	35162.03574	3697.724352
Pick up 2	36.11	Bulky Waste	348.551	133	100.11	34893.44061	3697.51956
Pick up 3	31.498	Bulky Waste	336.15	108	100.11	33651.9765	3225.269208
Pick up 4	31.498	Bulky Waste	376.6	140	100.11	37701.426	3225.269208
Pick up 5	76.688	Food Waste	348.9123	148	100.11	34929.61035	7852.544448
Pick up 6	76.688	Food Waste	364.74	155	100.11	36514.1214	7852.544448
Small Compactor	474.124	Food Waste	2802.97	124	101.46	284389.3362	48548.4011
Big Compactor	165.51	Food Waste	734.4592	31	101.46	74518.23043	16947.56196
Small Dumper	347.824	Construction	768.01	92	101.46	77922.2946	35615.7863
Big Dumper	37.89	Construction	63	7	101.46	6391.98	3879.78444
JCB /Tractor/Shovel	-		878.4		101.46	89122.464	0
TS Shovel/Dozer	-		1388		101.46	0	140826.48
						822048.7263	**291701.2723**

Working Hours/Cost Summary		
Manpower		
Supervisor	816	100038.46
Heavy Driver	1016	124557.69
Light Driver	1488	168115.38
Helper	2976	293307.69
UC workers	24496	2296500
Operator	248	32788.462
Total		**3015307.7**
Other Expenses		
Operations Staff		**110000**
Disposal Staff		**20596.774**
Equipment and Utilities		**139400.51**

Cost Analysis - JULY 2019 (UC 15,20,26)

Costing Summary

Vehicle type	Tons	Waste type	Fuel	Trips/Month	Fuel Cost	Collection Cost	Transportation Cost
Pick up 1	150	Bulky Waste	451.27	124	100.11	45176.6397	18262.8
Pick up 2	55.0732	Bulky Waste	490.354	136	100.11	49089.33894	6705.272246
Pick up 3	49.56	Bulky Waste	480.5	135	100.11	48102.855	6034.02912
Pick up 4	150.423333	Bulky Waste	539	146	100.11	53959.29	18314.34168
Pick up 5	150.423333	Bulky Waste	541.6	143	100.11	54219.576	18314.34168
Pick up 6	69.04105	Food Waste	459.4	133	100.11	45990.534	8405.88592
Pick up 7	69.04105	Food Waste	501.2	141	100.11	50175.132	8405.88592
Big Compactor	420.4224	Food Waste	1485.2	62	101.46	150688.392	51187.26804
Big Compactor	385.7174	Food Waste	1505.46	62	101.46	152743.9716	46961.86488
Small Dumper	22.625	Construction	47.733	5	101.46	4842.99018	2754.639
Big Dumper	38.872	Construction	69.721	8	101.46	7073.89266	4732.743744
JCB /Tractor/Shovel			183.6		101.46	18628.056	0
TS Shovel/Dozer			846			0	85835.16
						680690.6681	**275914.2322**

Working Hours/Cost Summary		
Manpower		
Supervisor	1008	123576.92
Heavy Driver	560	68653.846
Light Driver	1736	196134.62
Helper	2728	268865.38
UC workers	14216	1332750
Operator	72	9519.2308
Total Fuel Cost		**1999500**
Other Expenses		
Operations Staff		**110000**
Disposal Staff		**20596.774**
Equipment and Utilities		**139400.51**

Cost Analysis - AUGUST 2019 (UC 36,39,46)

Costing Summary

Vehicle type	Tons	Waste type	Fuel	Trips/Month	fuel Cost	Collection Cost	Transportation Cost
Skip Loader	157.1822	Bulky Waste	879.502	149	106.46	93631.78292	20080.34041
Pick up 1	32.9	Bulky Waste	342.85	136	103.97	36499.811	4203.0408
Pick up 2	32.9	Bulky Waste	351.54	133	103.97	36549.6138	4203.0408
Pick up 3	31.498	Bulky Waste	321.17	101	103.97	33392.0449	4023.932496
Pick up 4	31.498	Bulky Waste	366.72	124	103.97	38127.8784	4023.932496
Pick up 5	76.688	Food Waste	348.9123	148	103.97	36276.41183	9797.045376
Pick up 6	76.688	Food Waste	364.74	155	103.97	37922.0178	9797.045376
Small Compactor	474.124	Food Waste	2802.97	124	106.46	298404.1862	60570.28925
Big Compactor	165.51	Food Waste	727.7792	31	106.46	77479.37363	21144.23352
Small Dumper	329.824	Construction	768.01	92	106.46	81762.3446	42135.67565
Big Dumper	37.89	Construction	63	7	106.46	6706.98	4840.52328
JCB /Tractor/Shovel			935		106.46	99540.1	0
TS Shovel/Dozer			1237		106.46	0	131691.02
						876292.5451	**296429.779**

Working Hours/Cost Summary		
Manpower		
Supervisor	808	24764.423
Heavy Driver	1016	124557.69
Light Driver	1488	168115.38
Helper	2976	293307.69
UC workers	24440	2291250
Operator	288	38076.923
Total		**2940072.1**
Other Expenses		
Operations Staff		**110000**
Disposal Staff		**20596.774**
Equipment and Utilities		**139400.51**

Cost Analysis - AUGUST 2019 (UC 15,20,26)

Costing Summary

Vehicle type	Tons	Waste type	Fuel	Trips/Month	Fuel Cost	Collection Cost	Transportation Cost
Pickup 1	147	Bulky Waste	441.14	0	103.97	45865.3258	18779.544
Pick up 2	55.1562	Bulky Waste	481.24	131	103.97	50034.5228	7046.314862
Pick up 3	49.56	Bulky Waste	466.55	132	103.97	48507.2035	6331.38912
Pick up 4	147	Bulky Waste	570.25	138	103.97	59288.8925	18779.544
Pick up 5	147	Bulky Waste	590.64	150	103.97	61408.8408	18779.544
Pick up 6	81.23	Food Waste	446.98	137	103.97	46472.5106	10377.29496
Pick up 7	81.23	Food Waste	454.15	139	103.97	47217.9755	10377.29496
Big Compactor	410.8924	Food Waste	1450.75	62	106.46	154446.845	52492.32588
Big Compactor	365.2974	Food Waste	1489.64	62	106.46	158587.0744	46667.47344
Small Dumper	29.9522	Construction	62.2	7	106.46	6621.812	3826.453454
Big Dumper	64.8	Construction	89.65	12	106.46	9544.139	8278.3296
JCB /Tractor/Shovel			296		106.46	31512.16	0
TS Shovel/Dozer			788			0	83890.48
						719507.3019	**285625.9883**

Working Hours/Cost Summary		
Manpower		
Supervisor	1024	125538.46
Heavy Driver	560	68653.846
Light Driver	1736	196134.62
Helper	2728	268865.38
UC workers	14392	1349250
Operator	80	10576.923
Total		**2019019.2**
Other Expenses		
Operations Staff		**110000**
Disposal Staff		**20596.774**
Equipment and Utilities		**139400.51**

Commercial Area

July		August	
Handling cost		**Handling cost**	
Equipment and Utilities	139400.5134	Equipment and Utilities	139400.5134
Containers Cost	92261	Containers Cost	92261
Container Repair Cost	27258	Container Repair Cost	27258
Total	**258919.5134**	Total	258919.5134
Percentage	**4.0**	Percentage	4.02
Collection Operations cost		**Collection Operations cost**	
UC workers	2296500	UC workers	**2291250**
Supervisor	100038.4615	Supervisor	24764.42308
Maintaince and repair	140000	Maintaince and repair	120000
Heavy Driver	124557.6923	Heavy Driver	124557.6923
Light Driver	168115.3846	Light Driver	168115.3846
Helper	293307.6923	Helper	293307.6923
Operator	32788.46154	Operator	38076.92308
Collection Fuel cost	822048.7263	Collection Fuel cost	822048.7263
Operations Staff	110000	Operations Staff	110000
Shift Incharge	200000	Shift Incharge	200000
Minc.	156000	Minc.	170000
Total	4443356.419	Total	**4362120.842**
Percentage	68.36	Percentage	67.76
Transportation cost		**Transportation cost**	
Maintaince and repair	106000	Maintaince and repair	96000
Hauler Operater	19596	Hauler Operater	19596
Fuel Cost	296429.779	Fuel Cost	296429.779
Staff	24242	Staff	24242
Total	446267.779	Total	436267.779
Percentage	6.87	Percentage	9.46
Disposal cost		**Disposal cost**	
Staff	1081500	Staff	1081500
Fuel	206	Fuel	216
Utilities	22000	Utilities	24000
Maint. & Repair	123000	Maint. & Repair	135000
Contractor Operators & machinery	44675	Contractor Operators & machinery	44675
Minc.	80000	Minc.	95000
Total	1351381	Total	1380391
Percentage	20.8	Percentage	27.20
Grand Total	6499924.711	Grand Total	**6437699.134**
Per Capita Expenditures		**Per Capita Expenditures**	
Monthly Expenses	6499924.711	Monthly Expenses	6437699.134
Total Population	95560.90165	Total Population	95560.90165
Per Capita Cost(PKR)	68.01866243	**Per Capita Cost(PKR)**	**67.36750097**
Per Capita Cost(USD)	0.430497864	**Per Capita Cost(USD)**	**0.437451305**

Residental

July		August	
Handling cost		**Handling cost**	
Equipment and Utilities	139400.513	Equipment and Utilities	139400.5
Containers Cost	37797.619	Containers Cost	37797.62
Container Repair Cost	27258	Container Repair Cost	27258
Total	204456.132	Total	204456.1
Percentage	3.83	**Percentage**	3.84
Collection Operations cost		**Collection Operations cost**	
UC workers	**1349250**	UC workers	1349250
Supervisor	123576.923	Supervisor	125538.5
Maintaince and repair	140000	Maintaince and repair	120000
Heavy Driver	68653.8462	Heavy Driver	68653.85
Light Driver	196134.615	Light Driver	196134.6
Helper	268865.385	Helper	268865.4
Operator	9519.23077	Operator	10576.92
Collection Fuel cost	719507.3	Collection Fuel cost	680690.7
Operations Staff	110000	Operations Staff	110000
Shift Incharge	200000	Shift Incharge	200000
Minc.	156000	Minc.	170000
Total	**3341507.3**	Total	3299710
Percentage	62.5	**Percentage**	62.0
Transportation cost		**Transportation cost**	
Maintaince and repair	106000	Maintaince and repair	96000
Hauler Operater	19596	Hauler Operater	19596
Fuel Cost	296429.779	Fuel Cost	296429.8
Staff	24242	Staff	24242
Total	446267.779	Total	436267.8
Percentage	8.35	**Percentage**	8.20
Disposal cost		**Disposal cost**	
Staff	1081500	**Staff**	1081500
Fuel	206	**Fuel**	216
Utilities	22000	**Utilities**	24000
Maint. & Repair	123000	**Maint. & Repair**	135000
ontractor Operators & machine	44675	**ontractor Operators & machiner**	44675
Minc.	80000	**Minc.**	95000
Total	1351381	Total	1380391
Percentage	25.29	**Percentage**	25.9
Grand Total	**5343612.21**	**Grand Total**	5320825
Per Capita Expenditures		**Per Capita Expenditures**	
Monthly Expenses	5343612.21	Monthly Expenses	5320825
Total Population	96058	Total Population	96058
Per Capita Cost(PKR)	**55.629018**	**Per Capita Cost(PKR)**	**55.39179**
Per Capita Cost(USD)	**0.35208239**	**Per Capita Cost(USD)**	**0.359687**

Appendix 6b: Per Capita Transportation Cost due to Fuel used for transporting all the collected waste

Transporatation Fuel Cost albayrak-Contractor RWMC

Albayrak & Sub contractor Transportation Tonnage &Expense 2018

Year	Month	Days	Contractor		Albayrak Cost	
			Tons	560 pkr/ton	Tons	Cost
	Jan	31	21113.67	11823655	1745.56	188331.9595
	FEB	28	26411.85	14790636	517.11	52441.15932
	March	31	27746.54	15538062	1349.71	142642.7516
	April	30	29709.12	16637107	1881.33	217745.1342
	May	31	25939.02	14525851	3156.24	332162.6976
2018	June	30	20809.45	11653292	3306.38	417833.8534
	July	31	21867.3	12245688	1729.34	192641.5586
	August	31	26670.28	14935357	2839.32	324500.2042
	Sept	30	20181.01	11301366	1634.46	182072.3062
	Octobe	31	26791.78	15003397	2708.92	346427.5253
	Nov	30	25116.19	14065066	1928.38	261349.4846
	Dec	31	24464.25	13699980	1937.13	257886.2426
	Total	365	316414.39	166219458	316414	2916034.877

Albayrak & Sub contractor Transportation Tonnage &Expense 2019

Year	Month	Days	Contractor		Albayrak Cost	
			Ton	580 pkr/ton	Tons	Cost
	Jan	31	**24342.18**	14118464.4	1686.18	215858.02
	Feb	28	**26641.81**	15452249.8	1579.13	202153.91
	Mar	31	**26108.67**	15143028.6	1575.56	219544.83
	April	30	**25128.72**	14574657.6	1668.07	235057.75
	May	31	**24891.11**	14436843.8	2285.84	335524.74
2019	June	30	**25638.24**	14870179.2	2020.7	307518.21
	July	31	**24040.07**	13943240.6	975.58	148467.67
	Aug	31	**25520.22**	14801727.6	1323.93	210457.21
	Sept	30	**22618.45**	13118701	1470.54	224357.35
	Oct	31	**22738.67**	13188428.6	1630.23	194786.4
	Nov	30	**21670.5**	12568890	1520.9	177361.27
	Dec	31	**23870.24**	13844739.2	1625.78	243886.51
	Total	365	293208.88	170061150.4	293208.9	2714973.9

Albayrak & Sub contractor Transportation Tonnage &Expense 2019

Year	Month	Days	Contractor		Albayrak Cost	
			Ton	600pkr/ton	Ton	Cost
	Jan	31	25342.18	15205308	1860.18	284071.8
	Feb	28	16760	10056000	8641.81	1319708
	Mar	31	15802	9481200	6108.67	896215.2
	April	30	12268.07	7360842	5128.72	660066.3
	May	31	17285.84	10371504	9891.11	950733.5
2020	June	30	23618.45	14171070	5638.24	504194
	July	31	9040.07	5424042	18108.67	2204767
	Aug	31	5520.22	3312132	19128.72	2443732
	Sept	30	4618.45	2771070	20891.11	2668881
	Oct	31	6738.67	4043202	19638.24	2010877
	Nov	30	8670.5	5202300	17040.07	1987145
	Dec	31	6870.24	4122144	19520.22	2540127
	Total	365	100208.9	91520814	100208.88	18470518

Appendix 7a: Current Disposal costs

Disposal Cost Currently																	
Disposal Cost 2018						Disposal Cost 2019						Disposal Cost 2020					
Year	Month	Days	Tonnage	Per ton Disposal Cost	Disposal Cost	Year	Month	Days	Tonnage	Per ton Disposal Cost	Disposal Cost	Year	Month	Days	Tonnage	Per ton Disposal Cost	Disposal Cost
	Jan	31	22859.23	68	1554427.6		Jan	31	26028.36	68	1769928		Jan	31	27202.36	68	1849760
	FEB	28	26928.96	68	1831169.3		Feb	28	28220.94	68	1919024		Feb	28	16760	68	1139680
	March	31	29096.25	68	1978545		Mar	31	27684.23	68	1882528		Mar	31	21910.67	68	1489926
	April	30	31590.45	68	2148150.6		April	30	26796.79	68	1822182		April	30	17396.79	68	1182982
	May	31	29095.26	68	1978477.7		May	31	27176.95	68	1848033		May	31	27176.95	68	1848033
2018	June	30	24115.83	68	1639876.4	2019	June	30	27658.94	68	1880808	2020	June	30	29256.69	68	1989455
	July	31	23596.64	68	1604571.5		July	31	25015.65	68	1701064		July	31	27148.74	68	1846114
	August	31	29509.6	68	2006652.8		Aug	31	26844.15	68	1825402		Aug	31	24648.94	68	1676128
	Sept	30	21815.47	68	1483452		Sept	30	24088.99	68	1638051		Sept	30	25509.56	68	1734650
	October	31	29500.7	68	2006047.6		Oct	31	24368.9	68	1657085		Oct	31	26376.91	68	1793630
	Nov	30	27044.57	68	1839030.8		Nov	30	23191.4	68	1577015		Nov	30	25710.57	68	1748319
	Dec	31	26401.38	68	1795293.8		Dec	31	25496.02	68	1733729		Dec	31	26390.46	68	1794551
	Total	365	341081.9		21865695		Total	365	312571.3		21254850		Total	365	295488.6		20093228

Appendix 7 (b): Disposal Cost Saved by Recyclable Material Recover

Disposal Cost Saved by recovery of recyclable waste																			
Tonnage & Fuel 2018								Disposal Cost saved 2019						Disposal Cost saved2020					
Year	Month	Days	Tonnage	Recyclea ble %	Recycleabl e Material	Per ton Disposal Cost	Disposal Cost Saved	Year	Month	Days	Recyclea ble Material	Per ton Disposal Cost	Disposal Cost Saved	Year	Month	Days	Recyclea ble Material	Per ton Disposal Cost	Disposal Cost Saved
	Jan	31	22859.23	0.21	4800.4383	68	326429.8		Jan	31	5465.956	68	371685		Jan	31	5712.496	68	388449.7
	FEB	28	26928.96	0.21	5655.0816	68	384545.5		Feb	28	5926.397	68	402995		Feb	28	3519.6	68	239332.8
	March	31	29096.25	0.21	6110.2125	68	415494.5		Mar	31	5813.688	68	395330.8		Mar	31	4601.241	68	312884.4
	April	30	31590.45	0.21	6633.9945	68	451111.6		April	30	5627.326	68	382658.2		April	30	3653.326	68	248426.2
	May	31	29095.26	0.21	6110.0046	68	415480.3		May	31	5707.16	68	388086.8		May	31	5707.16	68	388086.8
2018	June	30	24115.83	0.21	5064.3243	68	344374.1	2019	June	30	5808.377	68	394969.7	2020	June	30	6143.905	68	417785.5
	July	31	23596.64	0.21	4955.2944	68	336960		July	31	5253.287	68	357223.5		July	31	5701.235	68	387684
	August	31	29509.6	0.21	6197.016	68	421397.1		Aug	31	5637.272	68	383334.5		Aug	31	5176.277	68	351986.9
	Sept	30	21815.47	0.21	4581.2487	68	311524.9		Sept	30	5058.688	68	343990.8		Sept	30	5357.008	68	364276.5
	October	31	29500.7	0.21	6195.147	68	421270		Oct	31	5117.469	68	347987.9		Oct	31	5539.151	68	376662.3
	Nov	30	27044.57	0.21	5679.3597	68	386196.5		Nov	30	4870.194	68	331173.2		Nov	30	5399.22	68	367146.9
	Dec	31	26401.38	0.21	5544.2898	68	377011.7		Dec	31	5354.164	68	364083.2		Dec	31	5541.997	68	376855.8
	Total	365	**341081.9**		**67526.411**		**4591796**		Total	365	**65639.98**		**4463518**		Total	365	**62052.61**		**4219578**

Appendix 8a: Recyclable Cost Benefit for year 2018, 2019, 2202

Recycleable Tonnage Cost Benefit 2018

Year	Month	Days	Tonnage: Recycleable Tonnage	% of Paper & Card Board	Quantity of Paper & Card Board in tons	Price /ton in $	Price Saved by Paper and Cardboard in $	% of Rubber	Quantity of Rubber in tons	Price/ ton in $	Price Saved by rubber in $	% of Glass	Quantity of Glass in tons	Price /ton in $	Price Saved by Glass in $	% of Metal	Quantity of Metal in tons	Price /ton in $	Price Saved by Metal in $	% of Plastic	Quantity of Plastic in tons	Price/ ton in $	Price Saved by Plastic in $
2018	Jan	31	3886.0691	0.08	310.88553	95.5	29689.568	0.0215	83.55	92	7686.645	0.03	116.58207	33	3847.2	0.023	89.379589	40	3575.2	0.07	272.0248	88	23938
	FEB	28	4577.9232	0.08	366.23386	95.5	34975.333	0.0215	98.425	92	9055.132	0.03	137.3377	33	4532.1	0.023	105.29223	40	4211.7	0.07	320.4546	88	28200
	March	31	4946.3625	0.08	395.709	95.5	37790.21	0.0215	106.35	92	9783.905	0.03	148.39088	33	4896.9	0.023	113.76634	40	4550.7	0.07	346.2454	88	30470
	April	30	5370.3765	0.08	429.63012	95.5	41029.676	0.0215	115.46	92	10622.6	0.03	161.1113	33	5316.7	0.023	123.51866	40	4940.7	0.07	375.9264	88	33082
	May	31	4946.1942	0.08	395.69554	95.5	37788.924	0.0215	106.34	92	9783.572	0.03	148.38583	33	4896.7	0.023	113.76247	40	4550.5	0.07	346.2336	88	30469
	June	30	4099.6911	0.08	327.97529	95.5	31321.64	0.0215	88.143	92	8109.189	0.03	122.99073	33	4058.7	0.023	94.292895	40	3771.7	0.07	286.9784	88	25254
	July	31	4011.4288	0.08	320.9143	95.5	30647.316	0.0215	86.246	92	7934.606	0.03	120.34286	33	3971.3	0.023	92.262862	40	3690.5	0.07	280.8	88	24710
	August	31	5016.632	0.08	401.33056	95.5	38327.068	0.0215	107.86	92	9922.898	0.03	150.49896	33	4966.5	0.023	115.38254	40	4615.3	0.07	351.1642	88	30902
	Sept	30	3708.6299	0.08	296.69039	95.5	28333.932	0.0215	79.736	92	7335.67	0.03	111.2589	33	3671.5	0.023	85.298488	40	3411.9	0.07	259.6041	88	22845
	October	31	5015.119	0.08	401.20952	95.5	38315.509	0.0215	107.83	92	9919.905	0.03	150.45357	33	4965	0.023	115.34774	40	4613.9	0.07	351.0583	88	30893
	Nov	30	4597.5769	0.08	367.80615	95.5	35125.488	0.0215	98.848	92	9094.007	0.03	137.92731	33	4551.6	0.023	105.74427	40	4229.8	0.07	321.8304	88	28321
	Dec	31	4488.2346	0.08	359.05877	95.5	34290.112	0.0215	96.497	92	8877.728	0.03	134.64704	33	4443.4	0.023	103.2294	40	4129.2	0.07	314.1764	88	27648
	Total	365	**341081.9**		**4373.139**		**417634.78**		**1175.3**		**108125.9**		**1639.9271**		**54118**		**1257.2775**		**50291**		**3826.497**		**336732**

Recycleable Tonnage Cost benefit 2019

Year	Month	Days	Tonnage: Recycleable Tonnage	% of Paper & Card Board	Quantity of Paper & Card Board in tons	Price /ton in $	Price Saved by Paper and Cardboard in $	% of Rubber	Quantity of Rubber in tons	Price/ton in $	Price Saved by rubber in $	% of Glass	Quantity of Glass in tons	Price /ton in $	Price Saved by Glass in $	% of Metal	Quantity of Metal in tons	Price /ton in $	Price Saved by Metal in $	% of Plastic	Quantity of Plastic in tons	Price /ton in $	Price Saved by Plastic in $
2019	Jan	31	4424.8212	0.08	353.9857	95.5	33805.63	0.02	88.49642	92	8141.671	0.03	132.7446	33	4380.573	0.023	101.7709	40	4070.836	0.07	309.7375	88	27257
	Feb	28	4797.5598	0.08	383.8048	95.5	36653.36	0.02	95.9512	92	8827.51	0.03	143.9268	33	4749.584	0.023	110.3439	40	4413.755	0.07	335.8292	88	29553
	Mar	31	4706.3191	0.08	376.5055	95.5	35956.28	0.02	94.12638	92	8659.627	0.03	141.1896	33	4659.256	0.023	108.2453	40	4329.814	0.07	329.4423	88	28991
	April	30	4555.4543	0.08	364.4363	95.5	34803.67	0.02	91.10909	92	8382.036	0.03	136.6636	33	4509.9	0.023	104.7754	40	4191.018	0.07	318.8818	88	28062
	May	31	4620.0815	0.08	369.6065	95.5	35297.42	0.02	92.40163	92	8500.95	0.03	138.6024	33	4573.881	0.023	106.2619	40	4250.475	0.07	323.4057	88	28460
	June	30	4702.0198	0.08	376.1616	95.5	35923.43	0.02	94.0404	92	8651.716	0.03	141.0606	33	4655	0.023	108.1465	40	4325.858	0.07	329.1414	88	28964
	July	31	4252.6605	0.08	340.2128	95.5	32490.33	0.02	85.05321	92	7824.895	0.03	127.5798	33	4210.134	0.023	97.81119	40	3912.448	0.07	297.6862	88	26196
	Aug	31	4563.5055	0.08	365.0804	95.5	34865.18	0.02	91.27011	92	8396.85	0.03	136.9052	33	4517.87	0.023	104.9606	40	4198.425	0.07	319.4454	88	28111
	Sept	30	4095.1283	0.08	327.6103	95.5	31286.78	0.02	81.90257	92	7535.036	0.03	122.8538	33	4054.177	0.023	94.18795	40	3767.518	0.07	286.659	88	25226
	Oct	31	4142.713	0.08	331.417	95.5	31650.33	0.02	82.85426	92	7622.592	0.03	124.2814	33	4101.286	0.023	95.2824	40	3811.296	0.07	289.9899	88	25519
	Nov	30	3942.538	0.08	315.403	95.5	30120.99	0.02	78.85076	92	7254.27	0.03	118.2761	33	3903.113	0.023	90.67837	40	3627.135	0.07	275.9777	88	24286
	Dec	31	4334.3234	0.08	346.7459	95.5	33114.23	0.02	86.68647	92	7975.155	0.03	130.0297	33	4290.98	0.023	99.68944	40	3987.578	0.07	303.4026	88	26699
	Total	365	**53137.1244**		**4250.97**		**405967.6**		**1062.742**		**97772.31**		**1594.114**		**52605.75**		**1222.154**		**48886.15**		**3719.599**		**327325**

Recycleable Tonnage Cost Benefit2020

Year	Month	Days	Tonnage: Recycleable Tonnage	% of Paper & Card Board	Quantity of Paper & Card Board in tons	Price/ton in $	Price Saved by Paper and Cardboard in $	% of Rubber	Quantity of Rubber in tons	Price /ton in $	Price Saved by rubber in $	% of Glass	Quantity of Glass in tons	Price/ ton in $	Price Saved by Glass in $	% of Metal	Quantity of Metal in tons	Price/ton in $	Price Saved by Metal in $	% of Plastic	Quantity of Plastic in tons	Price/ton in $	Price Saved by Plastic in $
2020	Jan	31	4624.4012	0.08	369.9521	95.5	35330.43	0.02	92.48802	92	8508.898	0.03	138.732	33	4578.157	0.023	106.3612	40	4254.449	0.07	323.7081	88	28486.31
	Feb	28	4318.3077	0.08	345.4646	95.5	32991.87	0.02	86.36615	92	7945.686	0.03	129.5492	33	4275.125	0.023	99.32108	40	3972.843	0.07	302.2815	88	26600.78
	Mar	31	3724.8139	0.08	297.9851	95.5	28457.58	0.02	74.49628	92	6853.658	0.03	111.7444	33	3687.566	0.023	85.67072	40	3426.829	0.07	260.737	88	22944.85
	April	30	2957.4543	0.08	236.5963	95.5	22594.95	0.02	59.14909	92	5441.716	0.03	88.72363	33	2927.88	0.023	68.02145	40	2720.858	0.07	207.0218	88	18217.92
	May	31	4620.0815	0.08	369.6065	95.5	35297.42	0.02	92.40163	92	8500.95	0.03	138.6024	33	4573.881	0.023	106.2619	40	4250.475	0.07	323.4057	88	28459.7
	June	30	4973.6373	0.08	397.891	95.5	37998.59	0.02	99.47275	92	9151.493	0.03	149.2091	33	4923.901	0.023	114.3937	40	4575.746	0.07	348.1546	88	30637.61
	July	31	4615.2858	0.08	369.2229	95.5	35260.78	0.02	92.30572	92	8492.126	0.03	138.4586	33	4569.133	0.023	106.1516	40	4246.063	0.07	323.07	88	28430.16
	Aug	31	4190.3198	0.08	335.2256	95.5	32014.04	0.02	83.8064	92	7710.188	0.03	125.7096	33	4148.417	0.023	96.37736	40	3855.094	0.07	293.3224	88	25812.37
	Sept	30	4336.6252	0.08	346.93	95.5	33131.82	0.02	86.7325	92	7979.39	0.03	130.0988	33	4293.259	0.023	99.74238	40	3989.695	0.07	303.5638	88	26713.61
	Oct	31	4484.0747	0.08	358.726	95.5	34258.33	0.02	89.68149	92	8250.697	0.03	134.5222	33	4439.234	0.023	103.1337	40	4125.349	0.07	313.8852	88	27621.9
	Nov	30	4370.7969	0.08	349.6638	95.5	33392.89	0.02	87.41594	92	8042.266	0.03	131.1239	33	4327.089	0.023	100.5283	40	4021.133	0.07	305.9558	88	26924.11
	Dec	31	4486.3782	0.08	358.9103	95.5	34275.93	0.02	89.72756	92	8254.936	0.03	134.5913	33	4441.514	0.023	103.1867	40	4127.468	0.07	314.0465	88	27636.09
	Total	365	**51702.177**		**4136.174**		**395004.6**		**1034.044**		**95132**		**1551.065**		**51185.15**		**1189.15**		**47566**		**3619.152**		**318485.4**

Appendix 8b: Current Carbon Social Cost & Reduced Carbon Social Cost of transportation fuel due to recyclable waste recovery.

Carbon Social Cost due Transportation Fuel

Carbon Social Cost due Transportation Fuel 2018							
Year	Month	Days	Tonnage	Fuel (litres)	per Litre CO2 Emission (Kg)	CO2 Emissions reduced (kg)	Social Cost at the Rate of 51$ per ton of CO2
2018	Jan	31	22859.23	27431.076	2.48	68029.1	3469.482492
	FEB	28	26928.96	32314.752	2.48	80140.6	4087.169833
	Mar	31	29096.25	34915.5	2.48	86590.4	4416.11244
	April	30	31590.45	37908.54	2.48	94013.2	4794.672139
	May	31	29095.26	34914.312	2.48	86587.5	4415.962182
	June	30	24115.83	28938.996	2.48	71768.7	3660.204214
	July	31	23596.64	28315.968	2.48	70223.6	3581.403633
	Aug	31	29509.6	35411.52	2.48	87820.6	4478.84905
	Sept	30	21815.47	26178.564	2.48	64922.8	3311.064775
	Oct	31	29500.7	35400.84	2.48	87794.1	4477.498243
	Nov	30	27044.57	32453.484	2.48	80484.6	4104.716656
	Dec	31	26401.38	31681.656	2.48	78570.5	4007.095851
	Total	**365**	**341081.9**	**385865.208**		**956946**	**48804.23151**

Carbon Social Cost due Transportation Fuel 2018							
Year	Month	Days	Tonnage	Fuel (litres)	per Litre CO2 Emission (Kg)	CO2 Emissions reduced (kg)	Social Cost at the Rate of 51$ per ton of CO2
2019	Jan	31	26028.36	31234.03	2.48	77460.399	3950.48037
	Feb	28	28220.94	33865.13	2.48	83985.517	4283.26139
	Mar	31	27684.23	33221.08	2.48	82388.268	4201.80169
	April	30	26796.79	32156.15	2.48	79747.247	4067.1096
	May	31	27176.95	32612.34	2.48	80878.603	4124.80876
	June	30	27658.94	33190.73	2.48	82313.005	4197.96328
	July	31	25015.65	30018.78	2.48	74446.574	3796.77529
	Aug	31	26844.15	32212.98	2.48	79888.19	4074.29771
	Sept	30	24088.99	28906.79	2.48	71688.834	3656.13055
	Oct	31	24368.9	29242.68	2.48	72521.846	3698.61417
	Nov	30	23191.4	27829.68	2.48	69017.606	3519.89793
	Dec	31	25496.02	30595.22	2.48	75876.156	3869.68393
	Total	**365**	**312571.3**	**375085.6**		**930212.25**	**47440.8247**

Carbon Social Cost due Transportation Fuel 2018							
Year	Month	Days	Tonnage	Fuel (litres)	per Litre CO2 Emission (Kg)	CO2 Emissions reduced (kg)	Social Cost at the Rate of 51$ per ton of CO2
2020	Jan	31	27202.36	32642.83	2.48	80954.22	4128.665
	Feb	28	16760	20112	2.48	49877.76	2543.766
	Mar	31	21910.67	26292.8	2.48	65206.15	3325.514
	April	30	17396.79	20876.15	2.48	51772.85	2640.415
	May	31	27176.95	32612.34	2.48	80878.6	4124.809
	June	30	29256.69	35108.03	2.48	87067.91	4440.463
	July	31	27148.74	32578.49	2.48	80794.65	4120.527
	Aug	31	24648.94	29578.73	2.48	73355.25	3741.118
	Sept	30	25509.56	30611.47	2.48	75916.45	3871.739
	Oct	31	26376.91	31652.29	2.48	78497.68	4003.382
	Nov	30	25710.57	30852.68	2.48	76514.66	3902.247
	Dec	31	26390.46	31668.55	2.48	78538.01	4005.438
	Total	**365**	**295488.6**	**354586.4**		**879374.2**	**44848.08**

Reduced Carbon Social Cost of transportation fuel due to recyclable waste recovery

Reduced Carbon Cost -2018

Year	Month	Days	Recyclable material Benefit	Carbon Social Cost			
			Recycleable waste	litre of Dieasl Saved	per Litre CO_2 Emission (Kg)	CO_2 Emissions reduced (kg)	Cost Saved at the Rate of 51$ per ton of CO_2 by saving the Disposal Feul cost
2018	Jan	31	8000.7305	9600.877	2.68	25730.349	1312.247814
	FEB	28	9425.136	11310.16	2.68	30311.237	1545.873106
	Mar	31	10183.6875	12220.43	2.68	32750.739	1670.287689
	April	30	11056.6575	13267.99	2.68	35558.211	1813.468737
	May	31	10183.341	12220.01	2.68	32749.625	1670.230857
	Jun	30	8440.5405	10128.65	2.68	27144.778	1384.383691
	July	31	8258.824	9910.589	2.68	26560.378	1354.579277
	Aug	31	10328.36	12394.03	2.68	33216.006	1694.016294
	Sept	30	7635.4145	9162.497	2.68	24555.493	1252.330145
	Oct	31	10325.245	12390.29	2.68	33205.988	1693.505384
	Nov	30	9465.5995	11358.72	2.68	30441.368	1552.509768
	Dec	31	9240.483	11088.58	2.68	29717.393	1515.58706
	Total	365	112544.019	**135052.8**		361941.57	**18459.01982**

Reduced Carbon Cost -2019

Year	Month	Days	Contractor's Payment breakdown	Recyclable material Benefit	Carbon Social Cost			
			Muncipal waste	Recycleabl e waste	litre of Dieasl Saved	per Litre CO_2 Emission(Kg)	CO_2 Emissions reduced (kg)	Cost Saved at the Rate of 51$ per ton of CO_2 by saving the Disposal Feul cost
2019	Jan	31	11853997.08	9109.926	10931.91	2.68	29297.52202	1494.173623
	FEB	28	12997028.02	9877.329	11852.79	2.68	31765.49006	1620.039993
	Mar	31	12734500.59	9689.4805	11627.38	2.68	31161.36929	1589.229834
	April	30	12243336.87	9378.8765	11254.65	2.68	30162.46682	1538.285808
	May	31	12072449.15	9511.9325	11414.32	2.68	30590.37492	1560.109121
	Jun	30	12463851.42	9680.629	11616.75	2.68	31132.90286	1587.778046
	July	31	11766879.05	8755.4775	10506.57	2.68	28157.61564	1436.038398
	Aug	31	12466286.55	9395.4525	11274.54	2.68	30215.77524	1541.004537
	Sept	30	11022958.87	8431.1465	10117.38	2.68	27114.56714	1382.842924
	Oct	31	11068334.3	8529.115	10234.94	2.68	27429.63384	1398.911326
	Nov	30	10551238.2	8116.99	9740.388	2.68	26104.23984	1331.316232
	Dec	31	11626585.46	8923.607	10708.33	2.68	28698.32011	1463.614326
	Total	365	142867445.6	109399.962	**131280**		351830.2778	**17943.34417**

Reduced Carbon Cost -2020

Year	Month	Days	Recyclable material Benefit	Carbon Social Cost			
			Recycleable waste	litre of Dieasl Saved	per Litre CO_2 Emission (Kg)	CO_2 Emission s reduced (kg)	Cost Saved at the Rate of 51$ per ton of CO_2 by saving the Disposal Feul cost
2020	Jan	31	9520.826	11424.99	2.68	30618.98	1530.948821
	FEB	28	5866	7039.2	2.68	18865.06	943.2528
	Mar	31	7668.7345	9202.481	2.68	24662.65	1233.132508
	April	30	6088.8765	7306.652	2.68	19581.83	979.0913412
	May	31	9511.9325	11414.32	2.68	30590.37	1529.518746
	Jun	30	10239.8415	12287.81	2.68	32931.33	1646.566513
	July	31	9502.059	11402.47	2.68	30558.62	1527.931087
	Aug	31	8627.129	10352.55	2.68	27744.85	1387.242343
	Sept	30	8928.346	10714.02	2.68	28713.56	1435.678037
	Oct	31	9231.9185	11078.3	2.68	29689.85	1484.492495
	Nov	30	8998.6995	10798.44	2.68	28939.82	1446.99088
	Dec	31	9236.661	11083.99	2.68	29705.1	1485.255089
	Total	365	103421.024	**124105.2**		332602	**16630.10066**