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Operational Factors Affecting Municipal Solid Waste Collection Cost in Horizontal Building Cities: A Case Study of Al-Diwaniyah, Iraq

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ABSTRACT

Municipal waste collection is a critical process due to its high operational costs. This study aimed to identify the key operational factors affecting total collection costs in horizontally structured cities and to determine optimal ranges for three key operational variables. The study was conducted in three stages: spatial data collection using GIS, field surveys, and model building via Excel-based calculations across 45 scenarios. The three variables identified as most influential were collection frequency, compactor truck capacity, and crew size. The results indicate that collection frequency is the dominant factor in reducing costs, followed by compactor truck capacity and then workforce allocation. Collection frequency was limited to once every three days to prevent the degradation of organic waste. A 4-ton compactor truck was found to be the most suitable option for the street widths in the study area, while an optimal crew size of three workers per truck (excluding the driver) provided the best balance between labor efficiency and operational cost. The regression model achieved a high explanatory power ($R^2 = 0.888$), demonstrating that nearly 89% of the cost variability is explained by these parameters.

Keywords: Compactor truck, Crew size, Frequency, Cost, Collection, Waste.

INTRODUCTION

Solid waste management poses significant environmental and economic challenges for local governments, especially in medium and large cities experiencing rapid population growth and uncontrolled urban expansion. Waste collection and transportation costs constitute approximately 70% of the total waste management budget(Mazloomi et al., 2015). Waste collection process is generally carried out through three main methods: door to door collection, curbside containers and street bins (Guerrini et al., 2015). Although curbside collection is more costly, it offers enhanced control and preserves the integrity of the waste composition until it reaches the recycling facility, largely due to the reduced interference from informal pickers (Reis-Filho et al., 2025). Waste collection costs are influenced by several factors, including the type of collection vehicle, route design, bin distribution, crew size, collection point locations, and the quantity and composition of the generated waste (Bošković et al., 2016). However, the factors that have the most direct and significant impact on costs are the frequency of collection, the capacity of the compactor truck, and the number of workers assigned to each truck. These parameters are therefore critical in assessing and optimizing waste collection systems. The management of waste collection differs from one city to another according to urban characteristics and population patterns. Street width, building structure, housing size, infrastructure availability, *per capita* income, socio-cultural aspect, waste generation rate, and climatic conditions are among the key factors that determine the efficiency of waste collection systems.

In the context of Iraq, particularly Al-Diwaniyah, located in central Iraq as in (Figure 1), exhibits predominantly horizontal urban development, resulting in a low population density relative to the built-up area compared to rapidly developing cities. From a municipal solid waste management perspective, this spatial configuration leads to relatively low waste generation per unit area, extended collection routes for compactor trucks, and consequently, increased operational time and resource requirements for waste collection. The waste collection system in Al-Diwaniyah operates in an irregular and uncoordinated manner, primarily relying on a street-bin collection approach. These practices result in significant environmental impacts and public health risks due to the inefficiency of the system and the persistent accumulation of waste in urban areas. Therefore, a tailored collection plan that aligns with the city's urban characteristics and population patterns is required to enhance operational efficiency and minimize the associated environmental and health risks.

Numerous studies have explored various management aspects of the waste collection process Shatnawi (2018) showed that poor waste classification and unstructured collection approaches increase operational inefficiencies and environmental impacts. Teixeira et al. (2014) used statistical analyses based on key variables, such as collection distance, time, and fuel consumption. Gallardo et al. (2010) studied the efficiency of the collection systems by comparing between the curbside bins and drop-off points as well as the role the citizens in waste component separation in the source. Nguyen and Wilson (2010) estimated the fuel consumption associated with the kerbside waste collection system and reported that fuel usage in rural areas was two to five times greater than in urban settings. Similarly, Rattanawai et al. (2024) examined the influence of road conditions on fuel consumption and the time required for municipal waste collection operations. In addition, Carlos-Alberola et al. (2021) investigated operational factors, such as collection frequency and bin size, highlighting their significant impact on collection efficiency and overall waste management costs in cities with limited economic resources.

This study differs from earlier research by examining the cost of the waste collection process in horizontally expanding urban development, like Al-Diwaniyah city, explicitly considering operational variables and constraints. The significant variables identified are collection frequency, crew size, and compactor truck capacity, whereas the restrictive factors involve climate conditions (temperature), street width, and task overlaps between collection crews. This study presents an original framework for estimating municipal solid waste collection costs in horizontally expanding cities, such as Al-Diwaniyah. Unlike previous studies that focused on dense urban areas, it adapts established cost equations using local spatial and operational data, rather than relying on pre-existing models, to account for low population density, extended collection routes, and dispersed waste generation. This approach offers a practical, data-driven, and transferable tool for optimizing waste collection efficiency in similar urban contexts.

The methodology of this study included a spatial survey and subsequent data analysis conducted with GIS software and Excel spreadsheets, which enabled the transformation of results into equations and tabulated formats to enhance usability and application. Accordingly, this study aims to systematically analyze spatial and field data in order to estimate municipal waste collection costs through mathematical equations and Excel-based tables. In addition, it seeks to highlight the relative contribution of key operational variables, thereby providing a practical framework for evaluating and optimizing collection efficiency in cities with horizontal urban expansion, such as Al-Diwaniyah.

MATERIALS AND METHODS

Spatial Data Collection

Spatial data for Al-Diwaniyah city was collected using satellite imagery (2024) and analyzed with a GIS program to determine the city's total area, neighborhood boundaries, housing unit density per neighborhood, and route length per hectare, as summarized in Table 1. The survey included ten residential neighborhoods representing diverse socio-economic levels, accounting for approximately 20% of the city's total area.

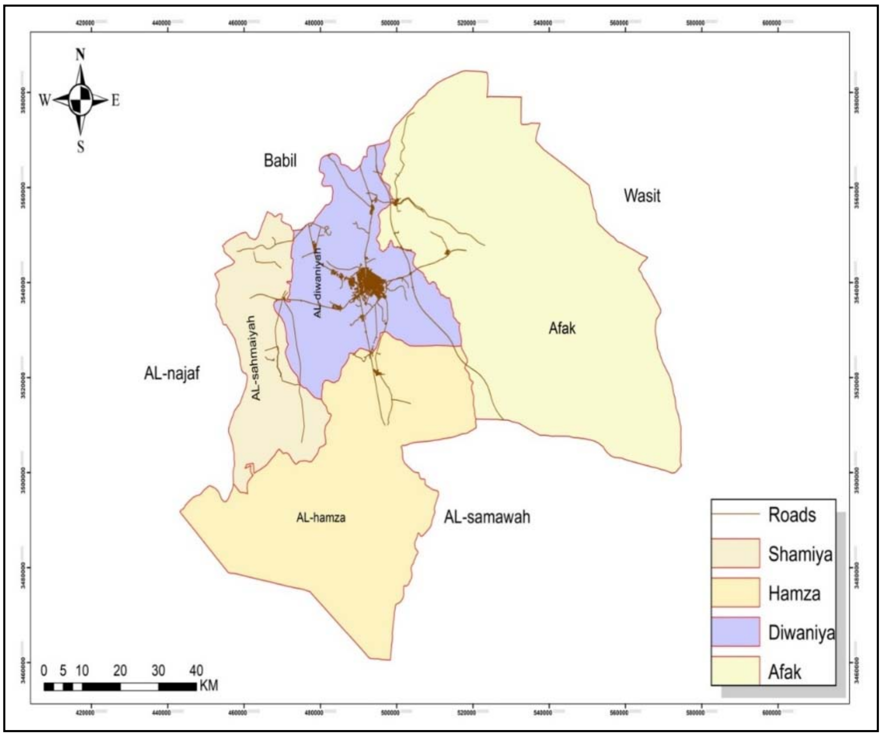

Figure 1. Location of Al-Diwaniyah city

As a result, the total urban area was determined to be 48 km^2 (19,200 Dunums, where (1 Dunum = 2500m^2)), with a total of 116,000 housing units. The average route length was 54 ± 7 m, and the housing unit density was 6 ± 1.6 units per Dunum. The distance between the city center and the selected transfer station was 8 km; for this study, only one transfer station was considered, located in the direction of the landfill to minimize travel time. These spatial and operational data was essential for accurately evaluating and managing the waste collection process in a horizontally developed urban area.

Table 1. The spatial data of Al-Diwaniyah city

Neighborhood	No. of Residential Units	Area (m^2)	Area (Dunum)	Housing Density (Residential Units/ Dunum)	Total Route Length (km)	Route Length (m/ Dunum)
1	1154	786000	314.4	3.67	15.5	49.36
2	1264	444000	177.6	7.12	12	67.42
3	1320	656000	262.4	5.03	15	57.25
4	1392	663000	265.2	5.25	13	49.06
5	2200	590000	236.0	9.32	15	63.56
6	2504	1381000	552.4	4.53	27	48.82
7	2694	1106000	442.4	6.09	25	56.56
8	2840	1119000	447.6	6.34	23	51.34
9	3128	1262000	504.8	6.20	24	47.52
10	3880	1438000	575.2	6.75	28	48.70
Average	----	----	----	6.03	----	53.96
STDEV				1.57		6.98
Utilized				7.6 ≈ 8		61

Field Survey Data

The fieldwork was conducted to identify key factors essential for defining the waste collection system, including crew size, the number and capacity of compactor trucks, collection frequency, and the overall operational cost. From Table 2, household containers had a capacity of 90 liters, sufficient for one household for three days, with an average waste bulk density of 0.15 kg/L (Przewoźna et al., 2020). These containers were also readily available locally. According to the Environmental Directorate, the waste generation rate was 0.55 kg *per capita*. To validate this value, a continuous one-month field survey was carried out across numerous households in different neighborhoods, confirming compatibility with official data and alignment with previous studies.

Based on field observations, the time required to transfer a household container to the compactor truck, empty it, and return it to the household was equal to or less than 80 seconds. This duration represents a crucial parameter influenced by both worker activity and the distance between the household and the compactor truck. In support of the field survey and GIS analysis, the selection of the transfer station complied with environmental regulations; it was located 8 km from the city center in the direction of the landfill site. Furthermore, the 2025 Population Census indicated that the average number of persons per household was six (6 persons), which is an essential factor for estimating the quantity of waste generated per household.

Table 2. Field survey data

Characteristics	Symbol	Value	Unit
Size of waste housing container	---	90	L
Waste generation rate *per capita*	GR	0.55	kg
The time for lifting and emptying of the household container	t1	80 (1.3 min)	sec
Distance to the waste transfer station	DTs	8	km
Number of persons per household	PPH	6	persons
Average transfer station - city center time	t2	48	min
Total number of households in the city	TH	116000	houses
Household per Dunum	HPDu	8	houses
Distance or (route length) per Dunum	DPDu	61	m
Work time per day	T	12	hrs
Worker salary per month	WrS	800	$
Monthly maintenance cost per compactor truck	MC	400	$

Model Parameters and Scenario Ranges

After determining the spatial and field data, it was necessary to develop a strategy to account for human resources and vehicle requirements in order to estimate the total operational cost. This procedure depends on both constant and variable parameters. In this study, the spatial and field data was treated as constant parameters, while the variable parameters included the capacity of the garbage compactor truck, crew size, and the frequency of collection, as summarized in Table 3.

Table 3. Model parameters and scenario ranges

Parameter	Value	Range
Collection frequency "number of collection cycles"	X1	(1, 2, and 3) days
Capacity of garbage compactor truck	X2	(2, 3, 4, 5, and 6) tons
Crew size "number of workers per compactor truck	X3	(2, 3, and 4) workers except driver

These variable parameters had a crucial impact on the overall cost due to their influence on collection times. Collection frequency also plays a significant role in estimating total operational cost, ranging from once per day to once every three days. While increasing collection frequency raises the overall cost, decreasing it can create social challenges due to the accumulation of waste. Increasing the size or capacity of compactor truck allows more households to be serviced per trip, thereby reducing the number of trips and associated lost time. The selection of an appropriate compactor truck capacity depends on several factors, including street width, compactor cost, and distance to the transfer station.

For city planning purposes, the acceptable compactor sizes range from 4 to 12 m³ in volume, corresponding to a capacity of 2 to 6 tons. The number of workers assigned to lift household containers ranged from 2 to 4. Increasing the number of workers reduces the overall collection time per trip, which consequently increases the number of trips that can be completed per day.

Estimation Procedures and Mathematical Modeling

To estimate the operational efficiency and cost performance of the waste collection process, a structured sequence of analytical procedures was developed. These procedures rely on mathematical equations that relate key input parameters—such as collection frequency (X_1), compactor truck capacity (X_2), and crew size per compactor truck (X_3)- to operational outcomes including the number of required trips, compactor trucks, total manpower, total monthly costs, and expected profits.

Each computational step was formulated as an individual equation to ensure clarity and ease of replication, allowing municipal planners to apply the methodology to different scenarios and urban contexts. These equations are fully presented in Table 4.

Table 4. Mathematical equations for estimating operational efficiency and cost of waste collection

No.	Equation	Remark
1	$\mathrm{TWG} = \mathrm{TH} \times \mathrm{PPH} \times \mathrm{GR}$	Total waste generation (ton)
2	$WHCy = PPH \times GR \times X1$	Waste per household per cycle (kg)
3	$\mathrm{HPTr} = \mathrm{X2} * 1000/ \mathrm{WHCy}$	Number of households per trip
4	$TTr = TWG / (X2 * 1000)$	The total number of trips required per day
5	$timeoftrip = HPTr * (\frac{t_1}{X3}) + t_2$	The total time required for each trip
6	$TrPCt = \frac{\mathrm{T}}{timeoftrip}$	Number of trips per compactor truck
7	$TCt = \frac{TTr}{TrPCt}$	Required number of compactor trucks
8	$\mathrm{DPTr} = \left(\frac{\mathrm{HPTr}}{\mathrm{HPDu}}\right) * (\frac{\mathrm{DPDu}}{1000})$	Collection distance per trip
9	$TD\mathrm{PTr} = \mathrm{DTs} * 2 + \mathrm{DPTr}$	Total distance per trip
10	$FC = (TD\mathrm{PTr} * TTr)$*0.25(liter/km)*0.31($)*30 (days)	Monthly fuel cost ($)
11	$\mathrm{manpower} = TCt \times (X3 + 1)$	The required manpower for the system
12	$TMC = TCt * \mathrm{MC}$	Monthly maintenance cost ($)
13	$Cost = (TCt \times FC) + (\mathrm{manpower} \times WrS) + TMC$	The total monthly cost ($)
14	$Revenue = TH \times Fee$	The expected monthly revenue ($)
15	$Profit = Revenue - Cost$	The monthly net profit ($)

These equations were developed based on established operational principles in municipal solid waste management. They represent standard relationships between key service parameters—such as garbage compactor size, workers per compactor, and collection frequency—and system performance metrics, like cost, manpower, and profitability. These equations are employed to simulate the behavior of the waste collection process in cities characterized by horizontal building patterns and provide the structural foundation for a predictive regression model, utilizing field data obtained from 45 trials. Previous studies have modeled the waste collection process using mathematical equations, including those conducted by (Akbarpour Shirazi et al., 2016), (Giel et al., 2021), and (Lin, 2024).

RESULTS AND DISCUSSION

The data analysis indicated that the overall cost of the waste collection process is influenced by three key variables, each exerting a distinct impact. The effects of these variables were examined both individually and collectively to assess their relative significance and contribution to the total cost. Overall, these variables influence several key operational factors, including the number of households served per trip, the service area, travel distance, crew size, and the number of trips per compactor truck, all of which collectively affect system efficiency and cost performance.

Collection Frequency "Number of Collection Cycles" (X_1)

This variable is one of the most significant factors in Huencing the overall cost of the waste collection process through its effect on key operational factors. An increase in collection frequency tends to reduce the number of trips per route while simultaneously increasing the number of households served per trip, the total number of compactor trucks required, the overall crew size, and consequently, all categories of operational costs. Daily collection operations resulted in the highest costs, whereas reducing the frequency to once every two days led to a reduction of approximately (43±2) % in overall cost. Moreover, performing collection once every three days decreased costs by nearly (68±2) % depending on the values of the other operational variables (X_2 and X_3). From Table 5 and Figure 2, it is apparent that the maximum and minimum overall cost when ($X_2 = 2$, $X_3 = 2$) and ($X_2 = 6$, $X_3 = 4$), respectively.

This observation aligns with operational logic, as a lower collection frequency directly reduces fuel consumption, labor hours, and vehicle utilization. However, excessively extending the collection interval beyond socially acceptable limits can result in waste accumulation, unpleasant odors, and public dissatisfaction.

Therefore, it is essential to establish an optimal balance between economic efficiency and the broader environmental and social considerations. The results of this study are in close agreement with those of (Neto et al., 2024), who evidenced that strategic optimization of collection routes combined with an appropriately determined weekly collection frequency can achieve up to a 66% reduction in total operational costs. Fontaine et al. (2024) observed that higher collection frequency not only lowers the total collection cost, but also enhances public participation in waste management activities.

The primary limitations associated with this variable are the capacity of household containers and the rapid degradation of organic waste, particularly during the summer months when temperatures can exceed 50°C. Such degradation not only causes public dissatisfaction, but also reduces the market value of recyclable materials, thereby complicating waste segregation. Consequently, the maximum collection frequency in this study was limited to once every three days. These limitations were addressed in relevant studies, such as that of Ampong et al. (2024), who reported that increasing the collection frequency can result in container overflow and the improper disposal of waste in open areas, thereby raising public health and environmental pollution concerns.

Table 5. Collection costs under different collection frequencies (X_1)

Collection Frequency (X_1) (Day^{-1})	**Compactor Truck Capacity(X_2) (ton)**														
	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6
	Number of Workers Per Compactor Truck (X_3)														
	2	3	4	2	3	4	2	3	4	2	3	4	2	3	4
	Collection Cost (Y) (Thousand ($))														
1	358	325	314	343	307	293	336	298	282	332	293	276	329	290	271
2	206	195	194	192	177	173	185	168	163	181	163	156	178	160	152
3	156	152	155	141	134	134	134	125	123	130	120	117	127	116	113

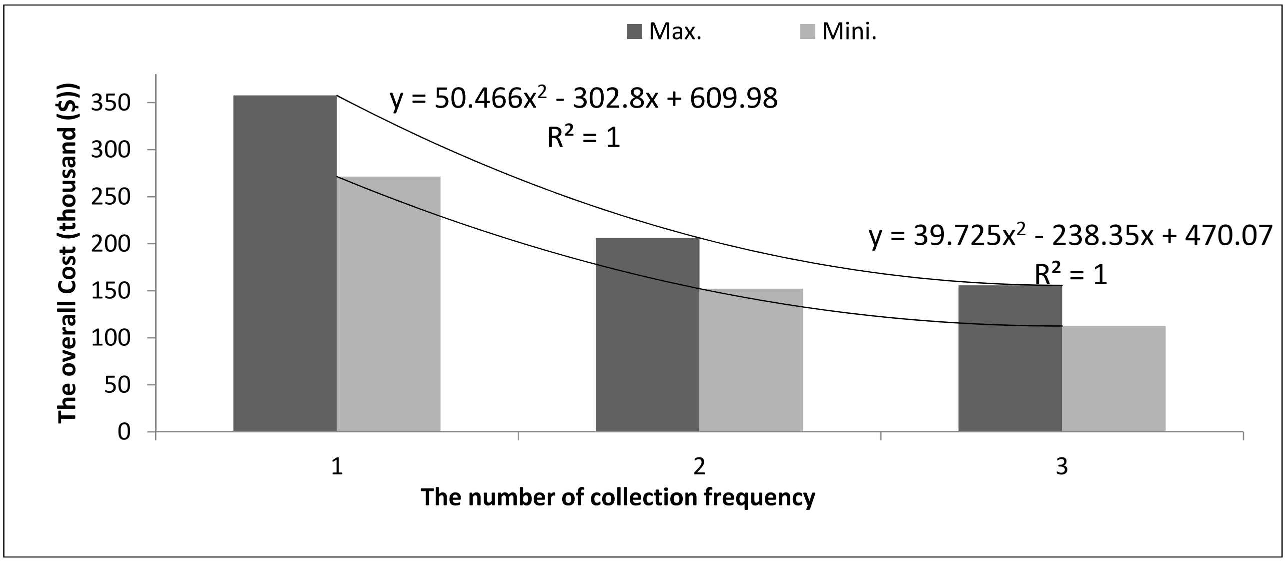

Figure 2. Effect of collection frequency on total costs

Capacity of Compactor Truck (X_2)

The capacity of garbage compactor trucks had the least influence on overall collection cost among the studied variables. Increasing the capacity of compactor trucks allows a greater number of households to be served per trip, thereby reducing the total number of trips, compactor trucks, total crew size, and associated fuel and maintenance expenses. As presented in Table 6, increasing the capacity of compactor trucks from 2 to 6 tons generally decreases collection costs by approximately (8 to 30) %, depending on the values of the other operational variables. In the maximum-cost scenario (X_1 = 1 and X_3 = 2), the cost reduction achieved by increasing the capacity from 2 to 6 tons was about 8%. Conversely, in the minimum-cost scenario (X_1 = 3 and X_3 = 4), the same increase in truck capacity resulted in a 30% cost reduction. Figure 3 illustrates the variation in overall collection cost under both maximum and minimum cost scenarios as the compactor truck capacity increases. The figure clearly demonstrates a downward trend, indicating that larger truck capacities are associated with lower total collection costs due to the reduction in the number of required trips and overall fuel consumption.

The main limitations associated with this variable are the high purchase cost of compactor trucks and their corresponding fuel consumption, both of which directly affect the overall operational expenses. In addition, the physical characteristics of the service area, particularly street width, play a crucial role in determining the feasible truck capacity. Narrow or congested streets often restrict the use of high-capacity compactors, requiring smaller vehicles that can maneuver efficiently within urban areas, even though they may increase the total number of trips and operational costs.

Several studies have investigated the influence of truck capacity on waste collection costs. Bošković et al. (2016) analyzed several operational factors influencing the waste collection process, one of which was truck capacity. The authors confirmed that truck capacity has a measurable effect on the overall collection cost. Vu et al. (2020) reported that increasing the capacity of compactor trucks expands the service area coverage and reduces the number of required trips and total travel distance, consequently lowering fuel consumption and overall operational costs. Their findings indicated that a 25% increase in truck capacity could reduce travel distances by approximately 4.1%-24.4%.

Table 6. Effect of garbage compactor capacity on collection costs

Capacity (ton)	Number of collection frequency (day) (x_1)								
(x_2)	1	2	3	1	2	3	1	2	3
	Number of workers per garbage compactor (x_3)								
	2	2	2	3	3	3	4	4	4
	Collection cost (Thousand ($))								
2	358	206	156	325	195	152	314	194	155
3	343	192	141	307	177	134	293	173	134
4	336	185	134	298	168	125	282	163	123
5	332	181	130	293	163	120	276	156	117
6	329	178	127	290	160	116	271	152	113

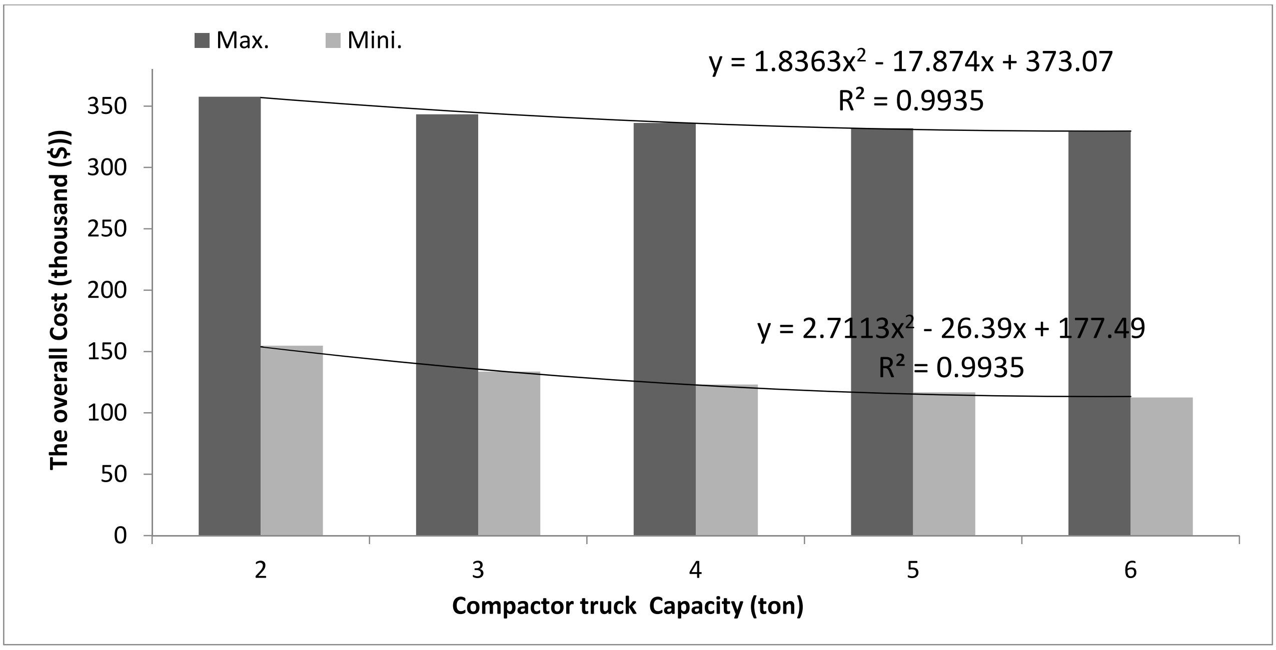

Figure 3. Effect of garbage compactor truck capacity on total costs

Crew Size per Garbage Compactor Truck (X3)

This variable is denoted as (X_3) and has a significant impact on the overall cost of the waste collection process through its effect on some key operational factors; theoretically, its values were arranged from 1 to 5 for model building, and particularly, (2 to 4). Essentially, increasing the crew size reduces the time required for container lifting, as well as the total number of compactor trucks and maintenance costs. However, a larger crew size also increases the number of trips per compactor. It does not significantly affect fuel consumption, since the reduction in the total number of compactors is offset by an increase in the number of trips per vehicle.

Based on the cost analysis, the optimal crew size was three workers per compactor truck. This configuration resulted in the lowest total manpower cost due to the balance achieved between crew size and the number of required compactor trucks. In Table 7, the maximum and minimum overall costs when (X_1 = 2, X_2 = 2) and (X_1 = 3, X_2 =6) are shown respectively. Figure 4 illustrates the change in overall cost under maximum and minimum scenarios as crew size increases. The study revealed that increasing the number of crew size from 2 to 3 significantly reduced collection costs by accelerating the loading and unloading process. However, further increasing the crew size to 4 or 5 produced diminishing returns and, in some cases, even increased costs.

Several previous studies have acknowledged the influence of crew size on the overall cost and efficiency of municipal solid waste collection; however, they have not provided a detailed quantitative assessment comparable to the present study. Neto et al. (2024) identified crew size as one of the critical operational parameters affecting waste collection performance, while Ahsan et al. (2014) analyzed the functional roles and responsibilities of collection workers within the broader context of municipal waste management systems.

Table 7. Collection costs under varying crew size

Number of workers per compactor (x_3)	Collection frequency (day-1) (x_1)														
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	Garbage compactor capacity (ton)(x_2)														
	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6
	Collection cost (Thousand ($))														
1	476	260	189	465	250	178	460	244	172	457	241	169	455	239	167
2	358	206	156	343	192	141	336	185	134	332	181	130	329	178	127
3	325	195	152	307	177	134	298	168	125	293	163	120	290	160	116
4	314	194	155	293	173	134	282	163	123	276	156	117	271	152	113
5	311	198	161	286	174	136	274	161	124	267	154	117	262	149	112

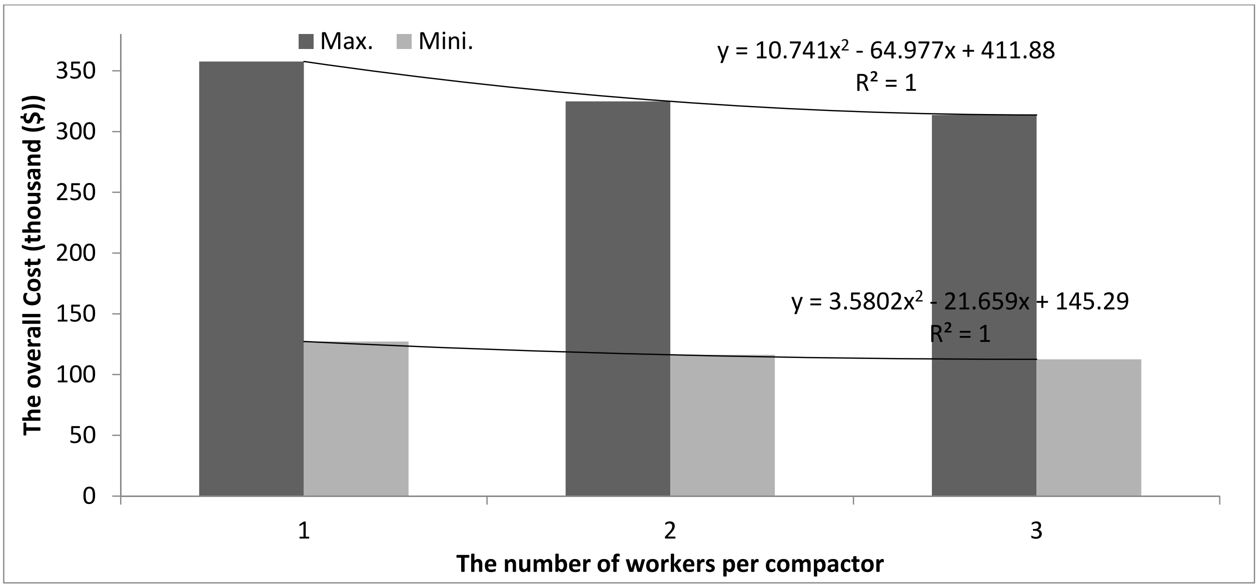

Figure 4. Effect of crew size on total costs

Based on the coefficient values of the equations presented in Figures 2, 3, and 4, the operational variables exhibit a clear hierarchy of influence on the overall cost of the waste collection process. Collection frequency emerges as the most critical factor, followed by crew size, and finally, compactor truck capacity. This ranking is consistently supported by the data presented in the Tables, which reveal that the magnitude of impact varies considerably between variables. The results indicate that even small adjustments in collection frequency can produce substantial cost savings, whereas modifications in crew size and truck capacity lead to moderate, but significant, effects. These findings underscore the importance of prioritizing operational parameters in strategic planning and provide a quantitative basis for optimizing municipal waste collection systems.

Regression Analysis

To statistically validate the operational relationships, a multiple linear regression model was applied using 45 field observations. The dependent variable was the total monthly collection cost (Y), while the independent variables were collection frequency (X_1), garbage compactor weight (X_2), and the number of workers (X_3).

The model achieved a strong explanatory power ($R^2 = 0.888$), indicating that nearly 89% of the cost variability can be explained by these three factors. All coefficients were statistically significant ($p < 0.05$). The resulting predictive equation is:

$$Cost\ (Y) = 752.22 - 141.03X_1 - 9.97X_2 - 49.1X_3$$

From a practical standpoint, the relationship between dependent and independent parameters represents a key indicator. Practically, it was evident that collection frequency exerted the most significant influence on collection cost, while the capacity of the compactor truck had the least effect. The negative coefficients clearly indicate that increases in any of the independent variables lead to a reduction in total collection costs, albeit with varying degrees of influence. Among these variables, collection frequency (X_1) exhibited the strongest impact, followed by compactor truck capacity (X_2) and crew size (X_3). These statistical findings are in full agreement with the parametric equations developed earlier and strongly support the conclusion that the operational efficiency and overall cost of waste collection can be accurately predicted through regression modeling, as illustrated in Figure 5.

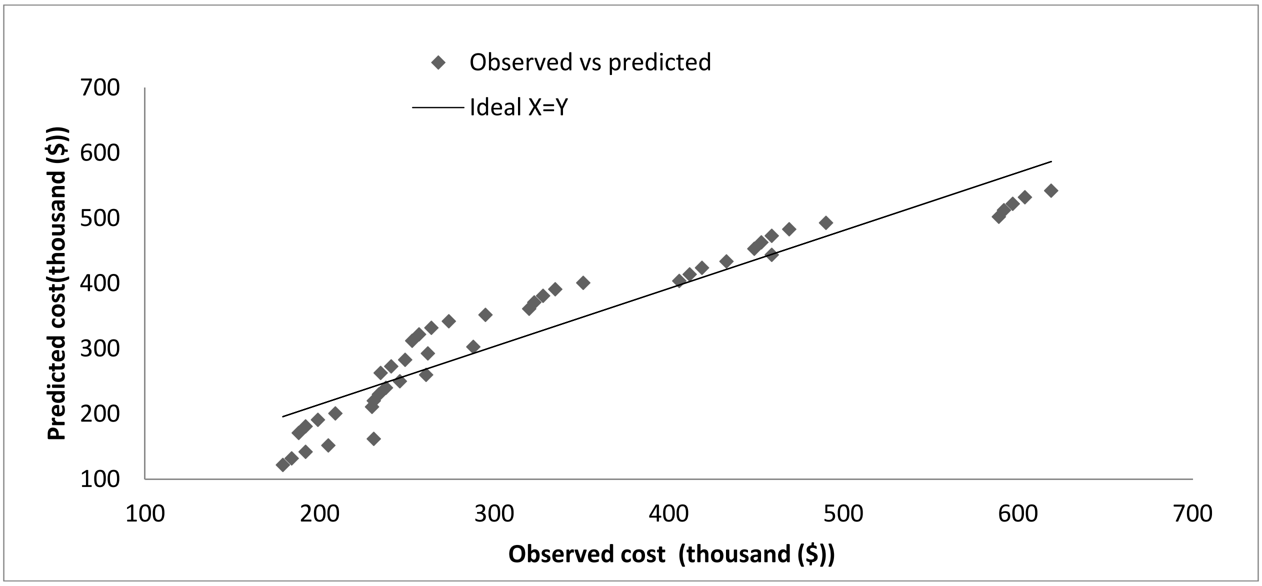

Figure 5. Comparison of predicted versus observed costs

The findings of this study are based on the spatial, operational, and climatic characteristics of Al-Diwaniyah city, which represents a horizontally expanding urban form with relatively low population density. Accordingly, the proposed cost estimation framework may require recalibration when applied to cities with different urban structures, higher density levels, or alternative waste collection practices. Factors, such as variations in labor costs, vehicle types, regulatory conditions, and climatic extremes, may influence the applicability of the model parameters. Nevertheless, the methodological approach and the structure of the developed equations are transferable and can be adapted to other urban contexts by adjusting the input variables to reflect local conditions. This flexibility allows the framework to serve as a practical decision-support tool for a wide range of cities facing similar operational challenges.

CONCLUSIONS

This research identified the most influential operational variables that determine the overall cost of the municipal solid waste collection process in horizontally structured cities, with Al-Diwaniyah city - Iraq selected as the case study. The findings revealed that the total collection cost is affected by several factors at varying magnitudes, as summarized below:

1- Waste collection frequency plays a decisive role in driving fluctuations in overall costs. However, environmental and practical limitations, particularly high ambient temperatures exceeding 50 °C during the summer, impose restrictions on increasing collection frequency beyond once every three days. These extreme conditions accelerate the degradation of organic waste, leading to odor problems, reduced recyclables quality, and public dissatisfaction, which collectively constrain operational flexibility.

2- The capacity of garbage compactor trucks had the least influence on overall collection cost among the studied variables. Increasing truck capacity reduced the total number of trips, the number of required compactors, and the total crew size, while increasing the number of households served per trip. However, street width proved to be the most restrictive factor in selecting larger trucks. Under field conditions, a 4-ton compactor truck was identified as the most suitable and operationally feasible option.

3- Crew size was found to be a significant factor influencing key operational parameters. Increasing the number of workers per compactor truck increased the number of trips due to faster container handling, while reducing the total compactors required and maintenance costs. Fuel consumption remained nearly unchanged due to the balance between trip frequency and truck number. The optimal crew size was determined to be three workers per truck, excluding the driver, providing the best balance between labor efficiency and operational cost.

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