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# Utilizing Geographical Information in Solid Waste Management Transportation Systems: A Case Study at Jordan

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**Abstract:**

Collecting and transporting of SW became worldwide problem, because it affects direct human life. This process starts from placing the waste in containers to reach the disposal place. The system used to collect and transport solid waste in the study area (Tabarbour and Alkhazneh) is depending only on the experiences of truck drivers. GIS was used to organize this process in the best, most accurate way and at the lowest possible economic cost. The improved scenarios were developed using Arc GIS Network analyst tool, to improve the efficiency of waste collection. GIS was established in the study area, which linked with the GAM, the data was entered (streets network layer, vehicle traffic paths, container locations layer) in addition to other information (collection times, number of trucks and their types, number of workers, the volume of waste collection containers), these data were analyzed through the program and the ideal collection paths and time were obtained, so the economic cost was reduced by reducing time and fuel.

**Keywords:** Waste Collection, Route Planning, Network Analysis, GIS, Greater Amman Municipality.

## 1. INTRODUCTION

With an ever-increasing global population, Municipal waste creation has grown as a result of rapid economic expansion and rising living standards, making its management a major worldwide challenge (Hassen et al., 2024). The situation is significantly more acute in cities, where poor management results in contamination of the soil, water, and environment posing public health problems (Sikder et al., 2024; Nimer et at., 2024; Ismail et al, 2021). Traditional methods, which need a lot of data were used to evaluate these waste disposal and management problems. Recent advancements in new software technologies and the Internet, as well as the advent of increasingly compact and reliable hardware devices, have made it possible to correctly handle these operations without the need for costly and time-consuming field tests (Singh, 2019). However, only around 20% of waste is recycled each year, with vast amounts ending up in landfills. Waste is frequently dumped at dangerous open dump sites, particularly in poor countries. Richer countries generate more trash than poorer countries, but they usually have superior waste management to address these challenges.
Every year Jordan produces millions of metric tons of solid waste from municipal, agricultural and industrial sources. The majority of solid waste is disposed of at one of Jordan's 24 waste disposal sites. Around 80% of municipal solid waste comes from home and commercial sources, while 20% comes from industrial activity (Aldayyat et al, 2019). Truck lane planning plays an important role in solid waste collection. Trucks must pass through all boxes to reduce cost, time, effort and mileage. (Nagrale et al, 2018). The choice of methods will help to improve the efficiency of the group as well as reduce the cost. Bins are placed in the exact location of the waste generated and sufficient storage

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space within the area, this leads to optimization of routes and time analysis gives the best truck routes with the lowest fuel consumption (Awasare & Sutar, 2015). GIS and network analysis require precise spatial data, including the location of waste containers, and transportation network information (street directions, turns, and truck lanes). This study was conducted on Tabarbour, which is part of the Greater Amman Municipality, the waste collection system depends on the experience of truck drivers without any kind of planning or operation (Bhambulkar, 2011). The aim of this research was to conduct an experimental study to evaluate the methods of collecting and transporting waste in a new way, developing and facilitating its task based on geospatial data, which in turn helps to improve the efficiency of the process. Collection this study was based on the distance between the waste bins and how they are collected and transported to the truck (Hatameleh et al, 2020).

## 2. PROBLEM AND QUESTIONS

The current research problem is the process of collecting and transporting waste on the truck, and the distance between the waste bins. The issue of the study lies in asking the following questions:

1- Does reducing truck lanes in the waste collection process affect solid waste management (cost, effort)?

2- Do the distances between waste bins affect reducing the amount of scattered waste that affects the environment?

## 3. STUDY AREA

Jordan is a developing country with an area of 90,000 $km^2$, its climate is dry to desert. the government of Jordan considered the management of municipal solid waste within the country among the pillars for achieving sustainable development. The municipal solid waste production in Jordan is 2,077,215 tons / year, and the per capita waste is 0.9 kg / day, Tabarbour area is one of the areas of the Greater Amman Municipality that make up the Marka Brigade of the Capital Governorate in the Hashemite Kingdom of Jordan. It is located in the northeastern part of the Jordanian capital, Amman. It has an area of (26 km / $m^2$) and a population of (75,000 people), and there are many residential neighborhoods that are characterized by calm, beautiful urbanization and sophistication. Figure (1) shows the map of the Amman, Tabarbour area, Global municipal solid trash output is anticipated to have grown by 70% to 3.4 billion metric tons by 2050 (World Bank,2018). This is attributable to a variety of factors, including population increase, urbanization, economic growth, and customer shopping habits. With such massive amounts of trash being generated, the necessity for authorities to offer proper waste treatment and disposal services has never been greater (United Nations, 2017).
Every year Jordan produces millions of metric tons of solid waste from municipal, agricultural and industrial sources. The increased manufacturing and rapid expansion of the population, along with the Syrian forced migration, as their number in 2021 million and three hundred thousand people became, have resulted in a significant increase in solid waste production in Jordan, putting further strain on the current waste management system. The majority of solid waste is disposed of at one of Jordan's 24 waste disposal sites. Around 80% of municipal solid waste comes from home and commercial sources, while 20% comes from industrial activity (Aldayyat et al ,2019).

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**Figure (1): Map of the Jordan, Tabarbour Study Area.**

## 4. WASTE COLLECTION

As mentioned previously Tabarbour area is a service area of the Greater Amman Municipality, which collects and transports the waste generated there and sends it to the area of barley station. This station has hydraulic presses, and there is a private contractor who loads the waste and sends it with him. Ghabawi landfill of the Greater Amman Municipality is being treated in a sanitary landfill. The amount of waste per day from the study area is 125 tons / day. Waste is collected by trucks carrying weights 8 and 10 tons. There are hundreds baskets distributed in the area as shown in figure (2). The entire assembly process depends on the driver, except in some cases when inquiring about such services in some areas due to the natural situation or events (the express bus project that crosses the study area), so the choice of truck routes is the responsibility of the drivers and / or waste collectors. It is supposed to take into account the distribution and schedule of trucks serving the area, the routes tracked by the GIS team, and the time required to unload each container was calculated then the average time required to empty the containers ranged about two minutes.

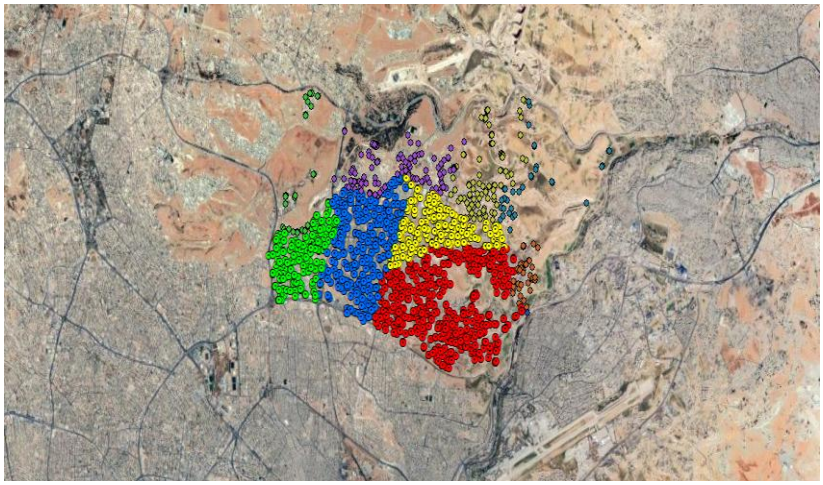

**Figure (2): Existing roads in Tabarbour and the location of abandoned containers (blue dots).**

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## 5. DATA COLLECTION

To analyze this data and obtaining a result from the GIS program, it requires the collection of modern and reliable geographical data. In this section, data will be analyzed for Tabarbour area, as well as field visits to the neighborhoods of the study area, and a visit Greater Amman Municipality and taking all the data related to the problem of the study, where there will be coordinates for the locations of the waste containers, in addition to the coordinates of the route of the road, and aerial photographs of the study area were obtained from the Greater Amman Municipality. The path was determined in terms of the shortest distance and time.

## 6. METHODOLOGY AND TOOLS

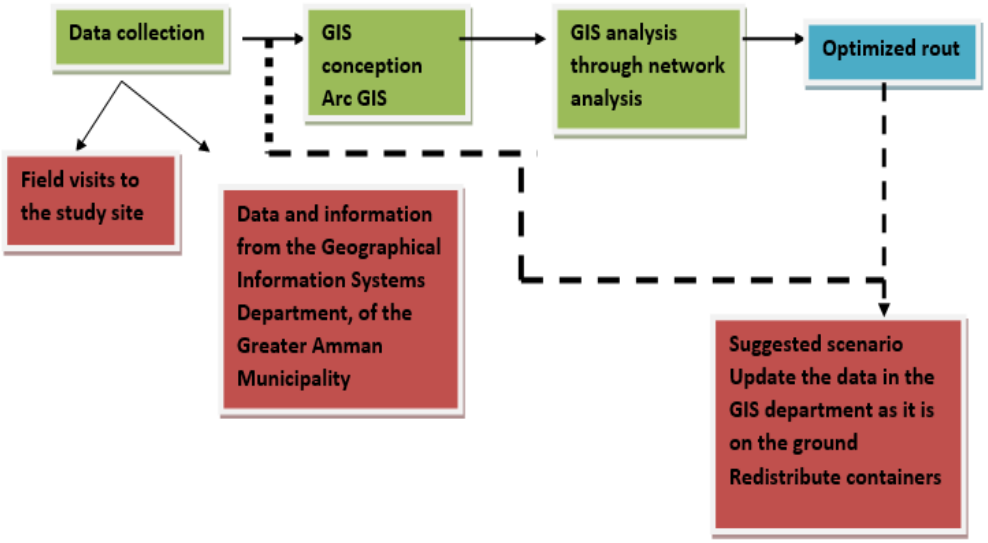


**Figure (3): Methodology and analysis steps.**

It includes solving the problem of collecting and transporting waste time to obtain the shortest path that the truck takes. Figure (3) shows how the process of designing the geographical database and analyzing the results. Data were collected from two types (field visits to the study site, the Geographical Indications Systems Department of the Greater Amman Municipality, the geographical database was prepared through the ESRI Arc GIS geographic information system through maps, municipal and statistical services data for the study area, data were obtained (vectors), road network, container sites aerial photos ), The assembly tracks were tracked through field visits, the tracking section of the Greater Amman Municipality, to take the location of the starting point, the route of the trucks, and the time of arrival at the transfer station. Once this data and information was taken, our database was created. To be executed using Network Analyzer in Arc GIS Administration, Arc GIS software is easy to use and provides efficient route solutions to find the best route (Amjad Kallel et al 2016). The Arc GIS Network Analyst extension enables the effective movement of goods, efficient organization and coordination of vehicles, and intelligent transport network analysis. Make smarter decisions by developing strategic routing plans. Save time and money by creating and implementing daily route plans to solve vehicle routing problems and perform post -route spatial network analysis for greater insight. Integrate with existing workflows and business systems for increased

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organizational efficiency, this analysis aims to direct advanced vehicles to achieve maximum transportation efficiency (Hatameleh R.I et al 2020). The following figure (4) shows how the road network is analyzed, by entering the data obtained into the program to perform a network analysis of these data.

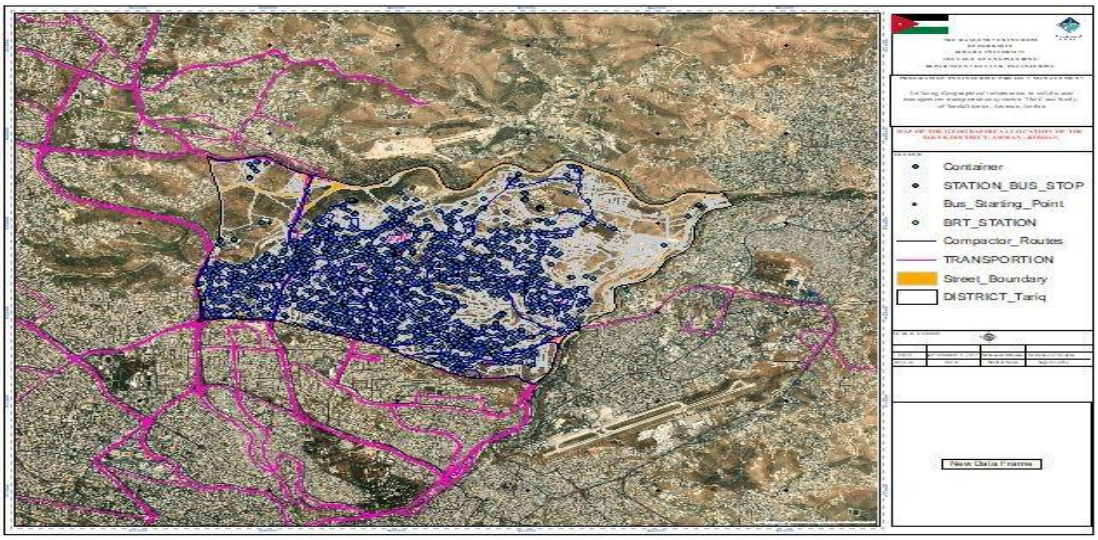


**Figure (4): Shows how the road network is analyzed.**

## 7. RESULT AND DISCUSSION

The Tabarbour study area was analyzed using geographic information provided by the Greater Amman Municipality and processed through the ArcGIS software environment. Table 1 presents a detailed summary of the key operational parameters used in the analysis, including the number and distribution of waste containers, truck capacities, collection times, travel distances, and routing scenarios. These data were systematically evaluated using the ArcGIS Network Analyst tool to assess the performance of the existing waste collection system and to develop optimized routing alternatives. The results summarized in Table 1 highlight the differences between the current and optimized scenarios, demonstrating how improved route planning can significantly reduce travel time and operational inefficiencies while maintaining full service coverage across the study area.

**Table 1: Results for analyzed scenarios.**

| Scenarios | Transport equipment | work | number of tracks | Path Containers | Full Containers | Traveled Distance | time taken |
|---|---|---|---|---|---|---|---|
| *S* | *10 ton , 8 ton* | *2* | *1* | *141* | *35* | *8856.2* | *86 min* |
| | | | *1* | *103* | *30* | *11959.2* | *79 min* |
| | | | *1* | *82* | *28* | *19396.2* | *85 min* |
| | | | *1* | *66* | *23* | *9674.9* | *50 min* |
| | | | *1* | *32* | *15* | *7275.8* | *44 min* |
| | | | *1* | *15* | *8* | *6900.2* | *26 min* |

Figure (5) illustrates the optimized waste collection network for the Tabarbour area after applying the GIS-based network analysis. The figure clearly shows the improved routing of waste collection trucks, where container locations are efficiently connected through the road network using the

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shortest and most time-effective paths. Compared to the existing collection practice, the optimized routes reduce unnecessary overlaps and backtracking, resulting in smoother and more organized truck movement across the study area. This optimized network contributes directly to reducing collection time, travel distance, and fuel consumption, thereby improving the overall operational efficiency of the municipal solid waste collection system.

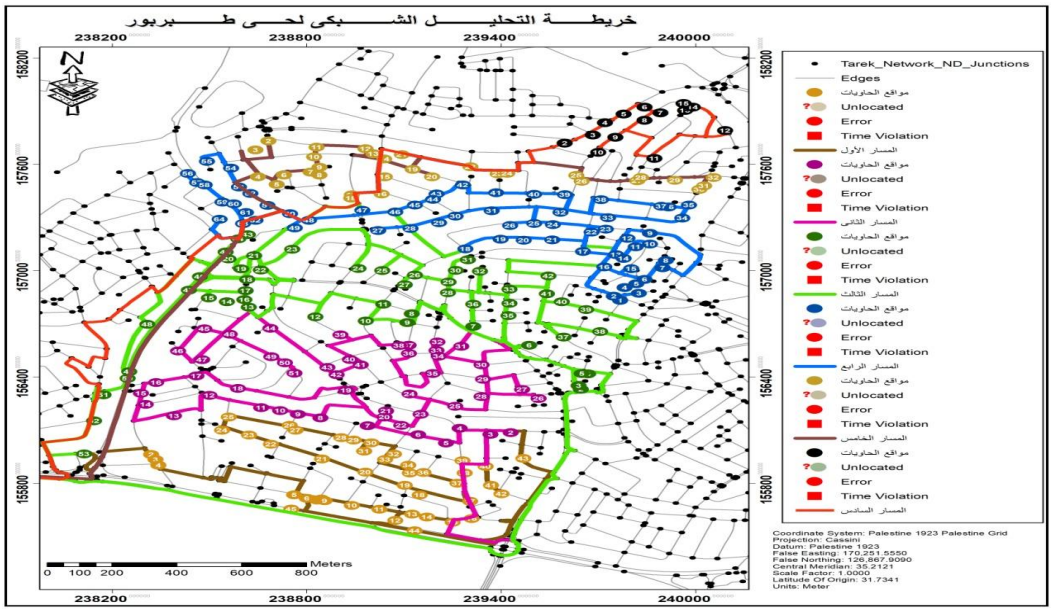


**Figure (5): The analysis of the Tabarbour network.**

## 8. CONCLUSION

In this study, a system of the waste collection and transportation was developed for the study area (Tabarbour) through the analysis of the Arc GIS network, scenario was developed to calculate the time spent in the collection and transportation process of solid waste management using artificial intelligence, it is seemed that the time spent in the collection and transfer process was reduced by nearly an hour for all tracks. In addition to other benefits related to reduce also $CO_2$ emissions, working hours, number of workers, fuel consumption, and vehicle maintenance.

Overall, the findings of this study confirm that integrating GIS-based network analysis into municipal solid waste collection planning can substantially enhance operational performance and decision-making processes. By replacing experience-based routing with data-driven optimization, municipalities can achieve more reliable service coverage, reduce unnecessary travel, and improve resource utilization. The proposed approach demonstrates strong potential for scalability and can be adapted to other urban areas with similar characteristics, provided that accurate spatial and operational data are available. This research highlights the practical role of geospatial technologies as effective decision-support tools for sustainable urban waste management and offers a valuable framework for future improvements in municipal service planning.

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## REFERENCE

1. Al-Rifai, J., & Amoudi, O. (2018). An Exploratory Study on Waste Management in Micro-Enterprises in Jordan. The Journal of Solid Waste Technology and Management, 44(3), 214-222.
2. Amjad Kallel, Mohamed Moncef Serbaji, Moncef Zairi, (2016) "Using GIS-Based Tools for the Optimization of Solid Waste Collection and Transport: Case Study of Sfax City, Tunisia", Journal of Engineering, vol. 2016, Article ID 4596849, 7 pages, 2016.
3. Awasare, S., and Sutar, A. (2015). Review Article: Solid Waste Management & GIS. International Journal of Research in Environmental Science and Technology. 5(1), 22-28
4. Bhambulkar, A. (2011). Municipal solid waste collection routes optimized with ArcGIS Network Analyst. International journal of advanced engineering sciences and technologies. 11(1), 202-207.
5. European Parliament, (2015). Briefing - Understanding waste management: policy challenges and opportunities).
6. Greater Amman Municipality / processing Department / Al-Sha'eer Station.
7. Hassen, W., Hassen, B., El Ouaer, M., Kouki, S., & Hassen, A. (2024). State-of-the-Art and Current Status of Municipal Solid Waste Management on a Global Scale. In Technical Landfills and Waste Management: Volume 2: Municipal Solid Waste Management (pp. 87-114). Cham: Springer Nature Switzerland.
8. Hatamleh, Jamhawi, AL-Kofahi, Hijazi, (2020). The Use of a GIS System as a Decision Support Tool for Municipal Solid Waste Management Planning: The Case Study of Al Nuzha District, Irbid, Jordan, Procedia Manufacturing, Volume 44, 2020, Pages 189-196, ISSN 2351-9789.
9. Ismail, R., Dahim, M., Jaradat, A., Hatamleh, R., Telfah, D., Abuaddous, M., & Al-Mattarneh, H. (2021, June). Field Dielectric Sensor for Soil Pollution Application. In IOP Conference Series: Earth and Environmental Science (Vol. 801, No. 1, p. 012003). IOP Publishing.
10. Jordanian Geographical Center / Geographical Information Department GIS.
11. Kallel, A., Serbaji, M. M., & Zairi, M. (2016). Using GIS-Based Tools for the Optimization of Solid Waste Collection and Transport: Case Study of Sfax City, Tunisia. Journal of Engineering, 2016, 1–7.
12. Nagrale et al. (2018). Route Optimization of Solid Waste by using ArcGIS Application in Pune, India, International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue VI, June 2018.
13. Nimer, H., Ismail, R., Rawashdeh, A., Al-Mattarneh, H., Khodier, M., Hatamleh, H., & Abuaddous, M. (2024). Artificial intelligence using FFNN models for computing soil complex permittivity and diesel pollution content. Civ. Eng. J.(Iran), 10(9), 3053-3069.
14. Sikder, S., Toha, M., & Mostafizur Rahman, M. (2024). An overview on municipal solid waste characteristics and its impacts on environment and human health. Technical Landfills and Waste Management: Volume 1: Landfill Impacts, Characterization and Valorisation, 135-155.
15. Singh, A. (2019). Solid waste management through the applications of mathematical models. Resources, Conservation and Recycling, 151, 104503.

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