Recent Trends in Civil Engineering and Built Environment Vol. 4 No. 2 (2023) 082-090

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

A Study of Managing Transportation Route in Food Waste Collection Using Mobile GPS and GIS

Anis Sakinah Ahmad Umar[1], Saifullizan Mohd Bukari[1]*

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

* Senior Lecturer, Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia

DOI: https://doi.org/10.30880/rtcebe.2023.04.02.010
Received 06 January 2022; Accepted 15 January 2023; Available online 20 July 2023

Abstract: Food waste has become an increasing problem in Malaysia. In 2017, Malaysians produce 38,000 tonnes of waste everyday where out of this, around 15,000 tonnes is food waste. Waste collection management that is systematic in the residential area are important because the use of diesel in waste collection trucks can cause greenhouse gases emission that contribute to global warming. The objectives of this study are to determine the route detection using Global Positioning System (GPS) for route mapping and to find out the shortest route for the food waste collection in Pura Kencana and Taman Universiti using Geographic Information System (GIS). The road network in Pura Kencana and Taman Universiti were used in this study. The Mapit GIS application was used for the data collection and shortest route for the food waste collection had been analyzed using Quantum GIS (QGIS). There were three scenarios for the shortest route such as current collection route (R0), different route with same collection point arrangement (R1) and different route with different collection point arrangement (R2). QGIS showed that scenario R2 provided the shortest route and collection time for the overall food waste collection compared to R0 and R1. This proved that QGIS provided the shortest distance and time taken for the food waste collection and at the same time assisted in making wise decision in planning.

Keywords: Food Waste, Shortest Route, QGIS

1. Introduction

Food waste is biodegradable and easy to recycle, but there is still little awareness in Malaysia about recycling and reducing food waste. Food waste reuse and recycling is found to be moderately low (5%) compared with paper (60%) and plastic (15%) [1]. The factors that contribute the increasing in food waste are the purchase of too much food, lack of control of the expiry date, lack of planning and shopping and lack of ideas for the use of food waste. Food waste is the most waste that generated by household [2]. Therefore, systematic solid waste management in the residentials area is necessary.

*Corresponding author: saifulz@uthm.edu.my

Waste collection is an essential activity in waste management systems. The activity relies on energy and fuels, primarily from fossil fuels [3]. The use of diesel in collection vehicles is undoubtedly the most important environmental burden of waste collection due to the emission of exhaust gases from the combustion process. This fuel consumption by the trucks can cause greenhouse gases emission that contribute to global warming [4].

The aim of this study is to determine the route detection using GPS for route mapping and to find out the shortest route for the food waste collection in Pura Kencana and Taman Universiti using GIS. GIS is one of the new technologies that has greatly contributed to the waste management society [5]. Mapit GIS application was used in this study to collect the data and the shortest route for food waste collection was analyzed using QGIS. The obtained shortest route will improve the waste collection efficiency by reduce the travel time and route length for waste collector. In addition, the benefits from this study is that it promotes the benefits of food waste recycling and also give awareness to the community. This can reduce the amount of food waste that generates in Malaysia.

2. Literature Review

Proper route planning for the waste collection truck is important. Planning can help to increase vehicle and labor efficiency while accelerating the collection process. Route planning is a complicated process that need detailed study of each collection area in order to take full advantage of vehicles's daily collection capacity [6]. Mapit GIS is used to provide work maps that support land data collection activities. This application may also be used to measure and calculate areas or distances easily. Mapit GIS allows to create map layers with objects described by different attributes directly in the mobile device. Spatial objects have assigned colours and descriptions but may not have specific symbols [7]. This application is convenient to use and it can export and import data. Data can be exported into common GIS formats such as Esri shapefiles, CSV, KML, DXF, GPX, Geojson and post process data using desktop GIS software like QGIS [8]. Next, GIS can be used to optimize routes because it allows to edit data in the computer to increase the options and make the best decisions possible. GIS is capable in storing, retrieving and analyzing a large amount of data and visualize outputs. In this study, QGIS is used because it is easy to access as it is free and it also has various toolset integrated from multiple programs that allows it to import, edit and save most spatial file formats. It is convenience to use and at the same time provide economy and environmental gains by reducing the distance from one place to another, travel time to complete the waste collection, the fuel consumption and vehicle emissions by the truck [9]. The benefits of using GIS are (1) improved decision making, (2) better communication, (3) maintaining better geographic information records, (4) issues related numerous map sets are resolved, (5) searching, analyzing and presenting map data is much easier and (6) cost savings resulting from greater efficiency [10].

3. Methodology

3.1 Attribute Data Using Mapit GIS

Attribute data is tabular information generally used to describe the feature that need to be map. It may include either text or numeric descriptors [11]. The attribute data is important and it need to be collected carefully. The data imported into Mapit GIS for food waste collection were:

- Location
- House number
- Type of waste
- Distance (km)
- Time

Once the required attribute data had been set up in Mapit GIS, field data collection was obtained by following the food waste collection truck from behind. The truck is part of the waste management service called SWM Environment Sdn. Bhd. The starting point was at Restoran Ikhwan, Pura Kencana and the end point at Solid Waste Research Center, a collection center at UTHM. When the food waste

collection was completed, Mapit GIS showed all the collection points in Pura Kencana and Taman Universiti.

Figure 1: Collection points at Pura Kencana in Mapit GIS

Figure 2: Collection points at Taman Universiti in Mapit GIS

3.2 Spatial Data Using QGIS

Spatial data represent features that have a known location on the earth. The spatial data can consist of points, lines and polygons [11]. The shapefile (SHP file) that exported from Mapit GIS was opened in QGIS and the use of QuickOSM plugin obtained the points, lines and polygons layers for this study. All layers from the field study using Mapit were displayed such as food waste collection point, road network, point of interest (POI) and land cover as shown in Figure 3.

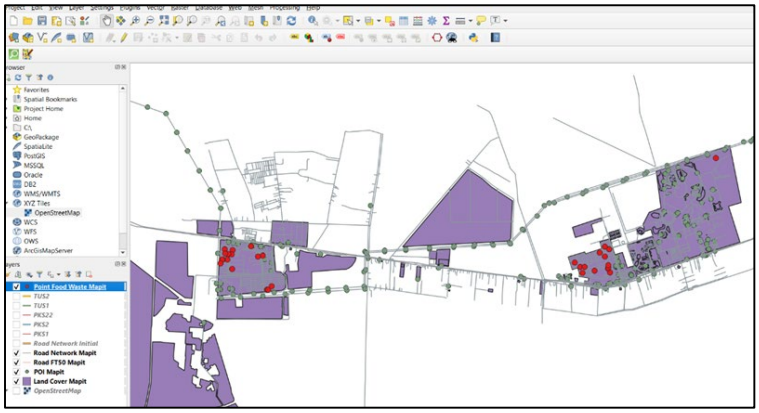

Figure 3: QuickOSM layers

3.3 Road Network Analysis

For the shortest route network analysis, ORS Tools plugin in QGIS was used. By selecting the collection points, the ORS Tools provided the shortest route for the food waste collection in Pura Kencana and Taman Universiti. There are three scenarios for the shortest route analysis:

- Current collection route (R0).
- Different route with same collection point arrangement (R1).
- Different route with different collection point arrangement (R2).

For R0 scenario, it was based on the current route used by the SWM workers to collect the waste. However, R1 had a different route from R0 but with the same collection point arrangement as used by SWM while R2 had a different route and different collection point arrangement. In R2, the start and end point for the food waste collection remained the same, only in between points changed.

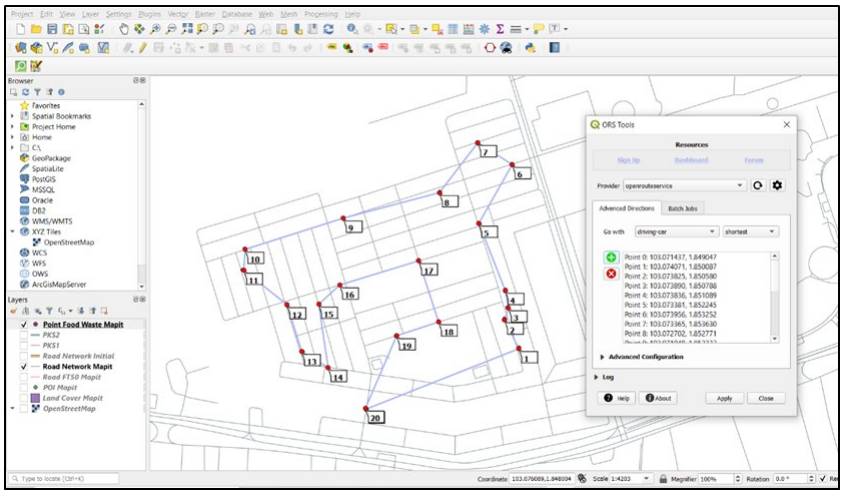

Figure 4: ORS Tools plugin

4. Results and Discussion

4.1 Taman Pura Kencana

- Scenario R0

In Pura Kencana, the truck started at Restoran Ikhwan at 9.44 a.m. The overall distance in kilometer (km) for the truck to collect the food waste was 5.91 km and the time required to collect the waste in Pura Kencana was 54 minutes. There were 16 stop points at Pura Kencana. Figure 5 showed the truck route during the food waste collection.

Figure 5: Scenario R0 in Pura Kencana

- Scenario R1

The overall distance given by QGIS was 4.6 km and the collection time was 14 minutes. The number of stops remained the same.

Figure 6: Scenario R1 in Pura Kencana

- Scenario R2

The distance for the collection using R2 was 3.53 km and the time taken to complete the collection at Pura Kencana was 10 minutes.

Figure 7: Scenario R2 in Pura Kencana

4.2 Taman Universiti

- Scenario R0

The truck started to collect food waste in Taman Universiti at 10.46 a.m. The overall distance for the truck to collect the waste in Taman Universiti using the current route was 3.14 km and the overall time required to collect the food waste was 29 minutes. There were 13 stop points at Taman Universiti.

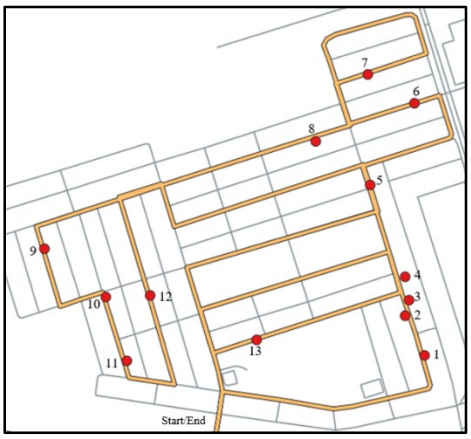

Figure 8: Scenario R0 in Taman Universiti

- Scenario R1

The overall distance using scenario R1 was 2.71 km and the collection time was 10 minutes. The number of stops remained the same.

Figure 9: Scenario R1 in Taman Universiti

- Scenario R2

The distance for food waste collection by using scenario R2 in Taman Universiti was 2.63 km and the time taken to complete the collection was 9 minutes.

Figure 10: Scenario R2 in Taman Universiti

4.3 Summary

In summary, for both road network in Pura Kencana and Taman Universiti, scenario R0 showed the longer distance (km) travelled by the truck than scenario R1 and R2. Scenario R0 was the current route used by SWM meanwhile scenario R1 and R2 were the route that obtained by using QGIS. QGIS was used to provide another route option that shorten the distance travelled and at the same time shorten the time to complete the food waste collection.

The time taken to complete the collection for scenario R0 was obtained by field study and it depends on the actual condition on site. The time taken in scenario R0 included the food waste handling process by the SWM workers such as unloading the container that full of food waste into the trucks. This explained why scenario R0 took longer time than R1 and R2 to complete the collection. Scenario R0 in Pura Kencana took 54 minutes because the number of stops in Pura Kencana is more than Taman Universiti. Other than that, the road in Pura Kencana also narrow so it took longer time for the trucks to complete the collection.

For scenario R1 and R2, both the distance travelled and time taken to complete the collection were analyzed by using QGIS. The result showed that scenario R2 has shorter distance than scenario R0 and R1. This proved that QGIS provided shortest distance and can be use in food waste management because it is easy to use and it helps to maximize the efficiency in making decision and planning to save time and cost.

Table 1: Summary for different route scenario

Road Network	Route Scenario	Distance (km)	Time taken to complete collection (min)
Pura Kencana	R0	5.91	54
	R1	4.6	14
	R2	3.53	10
Taman Universiti	R0	3.14	29
	R1	2.71	10
	R2	2.63	9

5. Conclusion

Route planning is a complicated operation that requires careful study of each collection area. In order to minimize the length of routes and speed up waste collection, it is important to properly plan the route for the waste collection vehicle. Reducing the distance between collection points could reduce the collection time, cost and greenhouse gases emissions caused by the trucks. The first objective to determine the route detection using GPS for route mapping had been achieved. Mapit GIS application

was used in this study to collect the data during field study. All the collection points in Taman Pura Kencana and Taman Universiti were shown in Mapit GIS and then exported into SHP file. By using QGIS, the SHP file that contained maps, point of collections, road networks for the study area and polygons can be obtained. Second objective that had been achieved is to find out the shortest route for the food waste collection in Pura Kencana and Taman Universiti using GIS. In this study, the shortest route was analyzed using QGIS. Three scenarios were analyzed for the shortest route, R0, R1 and R2. The result shown that scenario R2 provided the shortest route and collection time compared to scenario R0 and R1. This proved that QGIS provided the shortest distance and time taken for the food waste collection and at the same time assisted in making wise decisions in planning. To conclude, this study had achieved all of the objectives.

5.1 Recommendations

Based on the result, several suggestions were made to improve this study in order to achieve effective and appropriate planning in transportation management system.

- Additional info may be used such as total diesel consumption of the day and the amount of waste collected. This info helps planners to plan more accurately and gain more analysis regarding how much cost is being spend in waste collection process and the frequency to collect the waste.
- The results of this study are encouraged to expand the scope of the study to cover whole municipality for further study by using QGIS in waste management.
- Using GIS, efficiency may increase in transportation management system. This can be achieved if there is map route planning.

Acknowledgement

The authors would also like to thank the Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] W. J. Lim, N. L. Chin, A. Y. Yusof, A. Yahya and T. P. Tee, "Food waste handling in Malaysia and comparison with other Asian countries," Int. Food Res. J., vol. 23, pp. S1–S6, 2016.

[2] A. A. Kadir and M. S. A. M. Sani., Solid Waste Composition Study at Taman Universiti, Parit Raja, Batu Pahat: IOP Conf. Ser. Mater. Sci. Eng, vol. 136, pp. 1–6, 2016.

[3] R. Eisted, A. W. Larsen and T. H. Christensen, "Collection, transfer and transport of waste: Accounting of greenhouse gases and global warming contribution," Waste Manag. Res., vol. 27, pp. 738–745, 2009.

[4] A. W. Larsen, M. Vrgoc, T. H. Christensen and P. Lieberknecht, "Diesel consumption in waste collection and transport and its environmental significance," Waste Manag. Res., vol. 27, pp. 652–659, 2009.

[5] A. V. Bhambulkar, "Municipal Solid Waste Collection Routes Optimized With ARC GIS Network Analyst," Int. J. Adv. Eng. Sci. Technol., vol. 11, no. 1, pp. 202–207, 2011.

[6] M. Coffey and A. Coad, Collection of municipal solid waste in developing countries. 2010.

[7] I. Pisařovic, D. Procházka, J. Landa, J. Kolomazník, K. Zídek and L. Franěk, "Effective collaborative mapping based on mobile devices," Acta Univ. Agric. Silvic. Mendelianae Brun., vol. 65, no. 6, pp. 2067–2072, 2017.

[8] G. L. Mapit, "mapitGIS." Spatial Asset Collection, GPS Surveys and Data Management for Android, 2020. https://mapitgis.com/ (accessed Dec. 28, 2021).

[9] A. Kallel, M. M. Serbaji and M. Zairi, "Using GIS-Based Tools for the Optimization of Solid Waste Collection and Transport: Case Study of Sfax City, Tunisia," J. Eng., pp. 1–7, 2016.

[10] D. Pandey, A. K. Shukla, and A. Shukla, "GIS : Scope and Benefits," in Internatonal Conference on Advances in Engineering & Technology, 2013, pp. 60–65.

[11] R. Janipella, V. Gupta, and R. V. Moharir, "Application of Geographic Information System in Energy Utilization," Curr. Dev. Biotechnol. Bioeng. Waste Treat. Process. Energy Gener., pp. 143–161, 2019.