8. WASTE TRANSPORTATION ROUTE IN MALANG USING NETWORK ANALYSIS

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WASTE TRANSPORTATION ROUTE IN MALANG USING NETWORK ANALYSIS

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Summary. Malang has a projection population of 861.414 people in 2018[1]. This big population have causes waste generation that is increasing every day. Waste generation recorded that amount to 646,07 tons/day waste just from Malang in 2018. However, the waste that transported to landfill only 516,84 tons/day. It means that the load factor only comes to 84,73%. Waste transportation problems come from various factor. Malang has only just 68 temporary waste storage (TPS) that spread in the city. The number of TPS does not commensurate with waste generation that comes everyday. The limited number of trucks has become other issues considering Malang only have 35 truck that capable make three trips per day. Limited number from trucks and TPS lead to bad situation for transporting waste. As a result, many wastes were left behind in TPS. Therefore, it is necessary to analyze the best route for the truck thus the waste route can be optimized using network analysis in ArcGIS. This study assessed one route from truck which had longest distance (TPS Tunggul wulung) through a total of 60,2 km with a time and it reached for 113,8 minutes. The result of the network analysis method by ArcGIS shown that total distance decline to 36,2 km. This indicates that the alternative route shows by shortest distance method able to reduce existing distance for waste transportation route until 24 km. This certainly affect on the decline in travel time for ± 39 minutes/day. This indicates that the existing routes can be optimized by alternative route network analysis in ArcGIS

Keywords: Waste Transportation, Network Analysis, GIS

Introduction

The environment currently has potential risk due to the management and unsustainable of waste disposal. Sustainable waste disposal is a sensitive issue that concerns about environmental problems in the world. The disposal of waste without treatment such as proper separation can lead to serious consequences for the environmental pollution [2]. The problem of the waste management is commonly found in large cities, one of the cities is Malang. Malang is a city located in the province of East Java, with a population of 861.414 in 2015 [1].

Material and Methods

2.1 Waste Transportation routes and patterns

A transporting waste is activity to bring garbage that has accumulated at a certain point heading to landfill (TPST). Transportation stages is a stage which requires the cost of most high costs compared to other stages, this is because the cost of investment, operation and maintenance required. Therefore, it is very important to determine an alternative route for the waste transport to be shorter distances. Shorter distance will affect on the decrease in time and fuel consumption. Transporting pattern for waste transportation divided by two type, direct transport and indirect transport[8].

2.2 TPS Types

According to ISO 3242-2008, TPS is a place for transferring waste from garbage collector to landfill. TPS classification is divided into 3 types[9], with a characteristic as shown Table 1.

Table 1. TPS Characteristic

Type	Characteristic
Type 1	· Sorting room · Warehouse · Grounding for waste removal container · Total area ± 10 - 50 m^2
Type 2	· Sorting room (10 m^2) · Room for organic waste composting (200 m^2) · Warehouse (50 m^2) · Grounding for waste removal container · Total area ± 60 - 200 m^2
Type 3	· Sorting room (30 m^2) · Room for organic waste composting (800 m^2) · Warehouse (100 m^2) · Grounding for waste removal container · (60 m^2) · Total area > 200 m^2

2.3 Descriptive Analysis of Waste Management

Descriptive analysis of waste management explains both non technical, operational and technical operations. Operational non-technical aspects to be discussed in this research which is included of retribution and financing [3], accountable institutions in waste management and regulation [4] as well as community participation [6]. As for the technical aspects of operational waste that will be focused and discussed is about the source, collection and TPS [9] as well as the route of the existing solid waste.

2.3 Network Analysis (Shortest Distance)

The study was conducted in Malang which has five districts and 68 TPS. The study was use one sample the number of garbage trucks in Malang that has the longest distance driving for waste transportation. Network analysis method is used to determine the alternative route for the waste transportation in Malang to run an efficient, effective and environmentally friendly route. The key point of this network analysis technology is using Geographic Information System (GIS). The execution of the three stages of gathering data on geo-spatial database development and analysis of the current condition of the garbage collection needs to to determine the alternative route [7]. In addition to the general criteria used in this study were include two main criteria, distance and time [2].

2.4 GIS Analysis and Constrain

GIS software has advantages compared to other software because it can provide a barrier so that vehicles are not recommended to use routes that have been marked with a barrier. This study will provide a barrier to the waste transportation route if the route has the following road criteria (Chalkias, 2009):

a. The road that is traversed is a one-way type of road.
b. The type of road is narrow and dense so it is difficult to pass by garbage trucks (assuming the width of the road cannot be passed by 2 garbage trucks simultaneously).
c. Small type of road (village road that can only be passed by a medium-sized car, or motorcycle).
d. U-turn access, GIS cannot calculate roads that have a U-turn access because all roads are connected.
e. Residential road, a special road for residents who live in residential so that the access road is closed to the public.
f. Public Road, access road that cannot be passed by garbage trucks (schools, military roads, education, public facilities, government, hospitals).

To do a network analysis, it takes the right route selection so that the results released can be read and easily understood.

Results and Conclusions

3.1 Waste Management System

Waste management includes two aspect, both in terms of operational technical and non- operational. Non technical aspects will address regulatory, institutional, retributions and community participation. Waste management regulations in Malang stated in its Regional Regulation No. 10 year 2010 on Waste Management, the institutional aspects of waste management, which is responsible about trash in Malang is the Malang Environmental Services.Table 2 shows each district have waste point (TPS) to accommodate waste management in Malang.

Table 2. TPS in Malang

No	District	TPS Total
1	Klojen	3 unit type II and 11 unit type I
2	Blimbing	1 unit type II and 20 unit type I
3	Kedungkandang	11 unit type I
4	Sukun	12 unit type I
5	Lowokwaru	17 unit type I

Table 2 shows that Blimbing have the most TPA in Malang while Kedungkandang is the very least to have with total 21 and 11 unit respectively. There are some problems in the waste management system in Malang . This problem can be caused by several things, among others in terms of hardware (infrastructure), lack of waste containers as well as a growing number of illegal TPS uncontrolled and inefficient patterns of transporting waste and mileage of these trucks either from the pool to get to waste containers and landfill.

3.2 Existing Waste Transportation Route

Transporting waste vehicle from TPS to landfill in Malang consist of 35 unit. The number vehicle divided by 17-unit arm roll trucks and 18-unit dump trucks. Transportation facilities carried out the waste transport operations for 365 days a year which is the operation began from 04.00 am until 07.00 am.

Table 3. Existing waste transport in Malang

Trips (time)	Total trucks (Unit)	Total Distance (km)	Average Distance Trips (km/trips/truck)
2	3	125,2	20,86
3	32	1.971,95	20,54

Table 3 shows that the traveling truck with three times trips have shorter distance to travel compared to trucks that travel as much as 2 trips. This shows that the existing transport conditions in Malang can be maximized by adding the number of trips so that the vehicle can carry more waste and make the waste service increased.

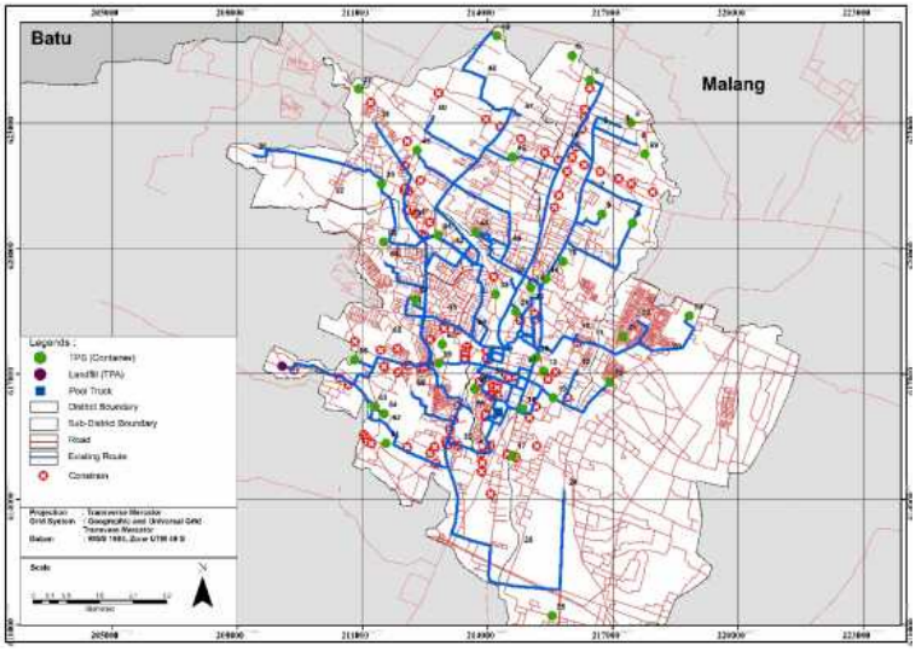

Figure 1. Existing Route Waste Transportation in Malang

3.3 Alternative waste transportation

Alternative waste transportation with shortest distance method is an analysis to predict the route that can be taken by trucks so the truck can travel with shorter distance, time and lower fuel consumption. Alternative routes not only taking into the financial aspects such as the distance, time, and fuel consumption, but also take into public facility aspect. Table 3 shows the comparison sample of one dump truck in Malang between existing routes and alternative routes based on network analysis.

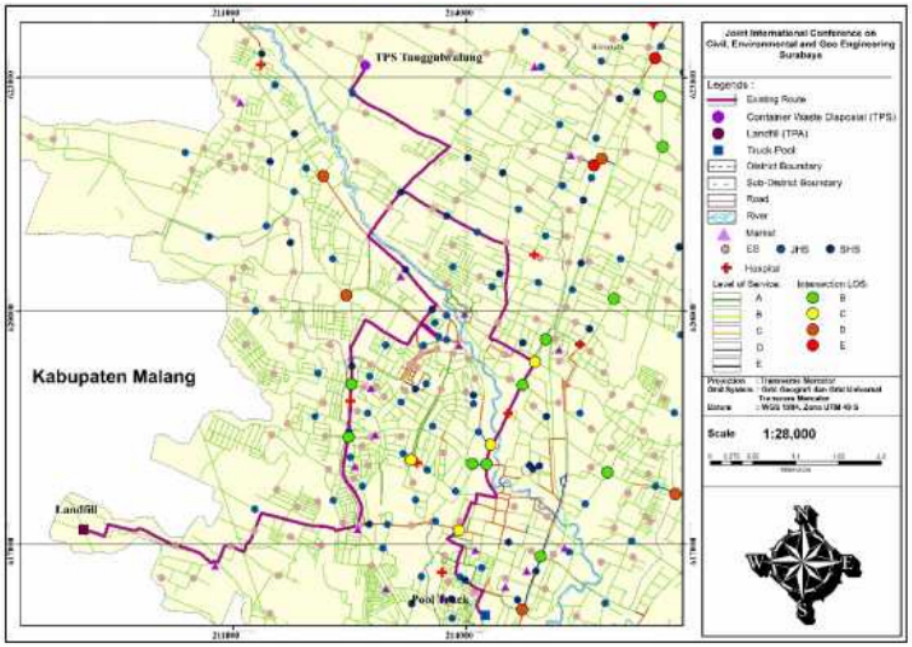

Figure 2. Existing Route Waste Transportation Pool-TPS Tunggulwulung-Landfill

Based on Figure 2, the dump truck route started from the truck pool to Tunggulwulung TPS then to Landfill. The existing condition represented the route crosses several barriers of infrastructure such as schools and hospitals. Moreover, the existing route also passes the road with an average service level B and C and the level of service of intersections B and C. This route took a distance of 60.20 km in 1 trip, with a travel time of 113.48 minutes with gasoline consumption reaching 7.89 liters per trip.

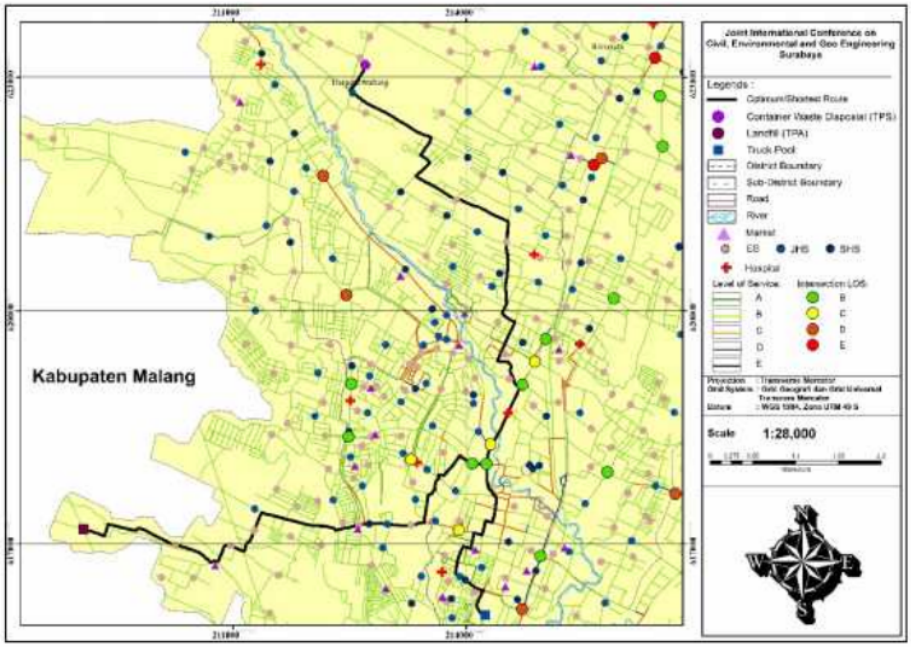

Figure 3. Optimal/Shortest Route Waste Transportation Pool-TPS Tunggulwulung-Landfill

According to Figure 3, there are different routes taken using network analysis from GIS by considering to obstacle such as the form of road service levels, intersections and infrastructure. In Figure 3, the majority of the routes passed are minimal in contact with infrastructure and only through roads with service level B. The intersection majority is crossed with service level C, so that this is able to shorten the distance in one trip. The comparison of distance, time and fuel consumption between the existing route and the optimum route, can be seen in table 3.

Table 3. Comparison existing route and alternative route

Information	Distance (km)	Time (minute)	Fuel (lt/day)
Existing Route	60,20	113,48	7,89
Shortest Route	36,27	74,28	4,59
Difference	23,93	39,2	3,3

As shown in table 2, distance between existing route and alternative route was significantly decreased (±40%), this affects the distance of travel time and total fuel consumption. The sample showed that using network analysis which is considering the alternative routes based on the shortest route and the level of service affects the travel time of garbage trucks in the same origin.

4 Conclusion

The conclusion obtained from this study is that the method of determining network analysis through GIS can help waste management, especially in the field of transportation so that route selection is effective. The shorter route will have an impact on travel time and also fuel consumption. Determining the route must also consider obstacles along the way including the presence of urban infrastructure, the level of road services and the level of intersection services.

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