# Analysis of Urban Waste Management Transportation Networks

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**Abstract.** Municipal waste management is an important aspect in maintaining the cleanliness of the urban environment and reducing negative impacts on human health and the ecosystem. Transport network analysis in the context of municipal waste management is a critical step to improve operational efficiency and reduce the environmental impact of these activities. This research aims to examine transportation network analysis in municipal waste management with a focus on several aspects, namely Identification of Collection Routes, Assessment of Road Infrastructure, Optimization of Transport Schedules and Evaluation of Environmental Impacts. Transportation network analysis will later use QGis tools to map all aspects for the purpose of this research. The research object was carried out at the Madiun City TPA and the location of the community around the nearest TPA by taking the coordinates of each object to produce a digital map image output. This research hoped that the results of this research will provide valuable insight to the Madiun city government, waste management companies and other related parties in efforts to increase the efficiency and sustainability of municipal waste management. In addition, this research can make a positive contribution in reducing the environmental impact of urban waste management activities.

**Keywords:** Transport Network, Waste Management, QGis

## 1 Introduction

Based on Law no. 18 of 2018 concerning Waste Management [1]–[3], basically waste is the remainder of daily human activities or natural processes in solid form. People can produce approximately 3 kg of waste per household per day and the waste categories include inorganic and organic. Waste treatment itself varies according to residential location, usually in residential area, people usually use complex cleaning/garbage collection services [4] whereas in rural areas, because they have a large area, at least each house has own waste disposal location and the processing reduces the accumulation by burning. . From these two scopes, not many people have the awareness to use waste into something of value, where especially in the city of


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Madiun, in several region/districts, waste bank activities have been implemented [5]. This process involves community around settlement and initiator of the activity. To minimize accumulation of waste, the types of waste will be sold to the waste bank manager and generate money in the form of waste cash [6]. This activity is very good for reducing amount of waste that will be thrown away by categorizing waste so can be reused and has value for sale [7]. The most important point of this activity is the awareness of each community to care more about the waste produced and how to process it.

Many ideas for waste processing have been implemented but waste is still a serious problem especially in Madiun City where inefficient waste processing will cause problems including waste accumulation in temporary shelters (TPS) or final processing sites (TPA) which can disrupt environmental comfort due to piles overloaded waste at each landfill. It is very important to implement management system to create healthy, beautiful and conducive environment for waste.

The technical implementation of waste scheduling in Madiun city area covers three region, namely Taman, Kartoharjo and Mangunharjo. For the Taman Region, there are 9 districts where there are several polling stations totaling 8 points. The Kartoharjo Region area with 9 districts has 9 TPS points around it, then the Mangunharjo Region area with 9 districts has 6 TPS area points. From all the TPS points, the Madiun City DLH made a schedule for transporting waste at each TPS point in the district out of a total of 23 TPS for Madiun City and later the waste will be moved from the TPS to the central TPS, namely TPA Precet Winongo. In the waste collection process at each TPS there are waste boxes where the amount is different in several temporary shelters (TPS). From data obtained, in order to avoid the accumulation of waste in temporary storage areas, a network transportation scheme is needed to simulate the scheduling of waste transportation cycles in accordance with regulations (Permenpu No. 13 of 2013). Where the minimum waste transportation rotation is 5 cycles per day. As a form of service from DLH, in order to evenly distribute transportation cycles, needs to optimize the transportation frequency by looking at simulations including routes, routes and working times as scheduling data which will be optimized both in terms of actions and looking at the capacity of districts which have a large waste ratio so that they require intense rotations to reduce accumulation in the TPS area [8]–[10].

There are several past results regarding waste management as part of supply chain management and green logistics. The following are the results of research [11], with the theme of proposed waste management logistics policies in the city of Padang, discussing determining waste transportation routes using VRP, resulting in policy analysis based on two levels of policy, namely tactical policy used to determine the need for designated trucks and strategic policy as mapping. TPS locations with service area cluster stages. The results of similar research were also carried out by [12], with the theme Mapping Bus Transportation Routes using *QGIS* and *Geoserver* in the design and coding stage for searching for bus stops, routes and destinations. From these two studies, it can be concluded that the process of mapping an object which aims to facilitate transportation access can use several shortest path tools according to the needs and expected results. Based on past research, the massive aim of this research is to create a transportation network design for waste management, especially Madiun City, using *QGIS* which focuses on how the transportation network design based on digitally managed data will later be able to generate the location of the surrounding TPS and

create a schedule to reduce accumulation. waste at the TPA and a solution was obtained at each TPS to carry out independent waste management.

## 2 Materials and Methods

### 2.1. Materials

Based on the problems in this research, produce a framework of thinking and assumptions for management, handling, control and evaluation related to waste. The following stages in the resulting framework of thinking can be seen in Figure 1 below:

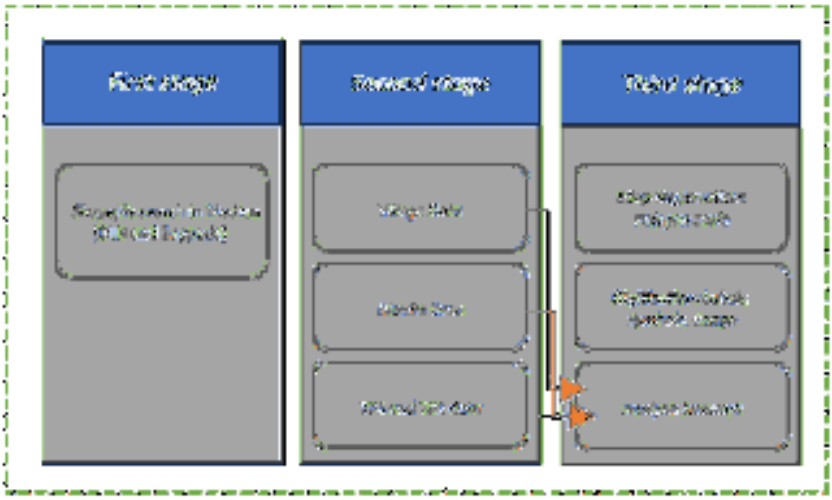

**Fig. 1.** frame of mind

Information:

1. Search for the SHP *(shapefile)* map of Madiun city
2. Data recapitulation of Madiun city which consists of 3 namely Taman, Kartoharjo and Mangunharjo
3. Recapitulation of 24 district data
4. Recapitulation of TPS data for 24 locations
5. In the third stage, namely map registration, digitization and network analysis using *QGIS.*

#### 2.1.1. Data Collection

Based on geographical location, the city of Madiun is a lowland with a total of 33.23 $km^2$ and belongs the western of East Java. Geographic coordinates at 111° East Longitude – 112° East Longitude. The data in this research was obtained at the Environmental Service due to discussions regarding municipal waste management, so that several observation data were obtained as follows in table 1.

**Table 1.** City Area

| ID | Region Name | Area |
|---|---|---|
| 1 | Taman | 1072,724 |
| 2 | Kartoharjo | 1124,463 |
| 3 | Mangunharjo | 1155,534 |

The data that will be processed for research can be seen in table 2, which is detailed data on districts, districts and TPS/TPA. This data will later be used to design maps in the form of polygons, digitalization and network analysis to optimize city waste management.

**Table 2.** Urban Region, District and TPS/TPA Data

| Region | District | TPS/TPA |
|---|---|---|
| **Kartoharjo** | Kanigoro | TPS Kampir Kanigoro |
| -7.625662763189852, | Kelun | TPS Kelun |
| 111.52447069277738 | Kartoharjo | TPS Kresno Kartoharjo |
| | Klegen | TPS Nusa Penida Klegen |
| | | TPS Slamet Riyadi |
| | Oro-Oro Ombo | TPS Pudak |
| | Pilangbango | TPS Pilangraya |
| | Rejomulyo | |
| | Sukosari | TPS INKA |
| | Tawangrejo | TPS Tawangrejo |
| **Mangunharjo** | Madiun Lor | |
| -7.611272909225155, | Mangunharjo | |
| 111.51634192883024 | Nambangan Kidul | TPS Merak |
| | Nambangan Lor | |
| | Ngegong | |
| | Pangongangan | TPS Pandan Pangongangan |
| | Patihan | TPS Kalasan Patihan |
| | | TPS Terminal |
| | Sogaten | TPS Gambir Sawit |
| | Winongo | TPA Precet Winongo |
| **Taman** | Banjarejo | PG Kanigoro Stasiun |
| -7.648938258380444, | | Penimbangan Tebu |
| 111.52034771716926 | Demangan | TPS Sedoro Banjarejo |
| | Josenan | TPS Jati mas |
| | Kejuron | TPS Tilam Upih Josenan |
| | Kuncen | TPS Kapten Saputro |
| | Mojorejo | Kejuron |
| | Manisrejo | TPS Kuncen |
| | Pandean | |
| | Taman | TPS Pucangsari |
| | | TPS Pandean |

## 2.2. Methods

### 2.2.1. Geographic Information Systems

GIS is an organized collection of computer hardware, software, geographic data and personnel designed to efficiently obtain, store, update, manipulate, analyze and display all forms of geographically referenced information [13], [14]. QGIS is able to help in solving problems by displaying data in a way that is easy to understand and the results are easy to disseminate. Geographically oriented data, has a certain coordinate system as a reference basis consisting of [15]:

1) Spatial information in the form of a data layer that displays latitude and longitude information, including datum and projection information.
2) Descriptive information or non-spatial information, a location that has several attributes or properties related to it; for example vegetation type, population, area and so on.

Spatial data is represented in two formats, namely vector data and raster data. Vector data is a representation of the earth into a collection of points, lines, areas and nodes. Raster data is data resulting from a remote sensing system. In raster data, geographic objects are represented as a structure of grid cells called pixels [16].

### 2.2.2. Network Transport Analysis

A network is usually thought of as a flow access, where many realities on earth can logically only move or flow through that network [17], [18]. For example, road traffic, where four-wheeled vehicles can only access the road, because in many cases, even though physically the location with a straight distance is closer (can be used with a buffer/range model) it turns out they have to go through a certain route which may require time or distance [9]. longer or further away. Network analysis utilizes line segments or features as a way for this analysis. By using Network analysis, users have the ability to:

1) Find an efficient travel route.
2) Determine the closest distance based on facilities or vehicles.
3) Generates the direction of travel.
4) Find the nearest service area around the location.

Almost all types of networks have several similar characteristics, including [19], [20]:

1) Has a phenomenon where there are objects or resources that move within the network in question.
2) Has a phenomenon where moving from the initial location to the destination location of an object or resource in the network requires a connection (connected path) between the initial location and the destination [21]–[23].

## 3 Result and Discussion

A descriptive approach method was used in this research as mapping TPS/TPA clusters based on district data to describe the area of the TPS/TPA. Creating a network analysis for municipal waste management, especially Madiun City, can be carried out in several stages, including:

a. Create a Madiun city *shapefile*

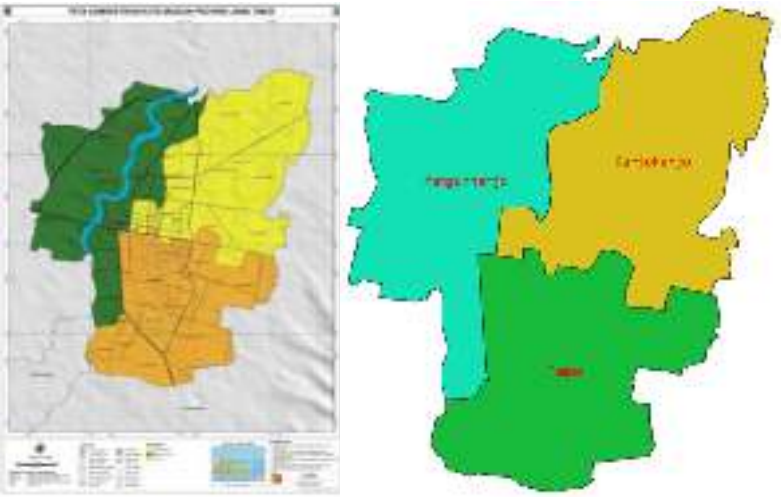

**Fig. 2.** Madiun city shapefile into a polygon map

On the SHP map (figure 2) of Madiun city registration mapping is carried out into a polygon map (figure 2) which aims to detail the floor plan, roads and make it easier to label/give symbols on the map, where an analysis of the waste management network for each region/district is then carried out.

After the registration map is generated, the next stage is digitization. In this digitization, the previous polygon map will be given a cable as a description of the name and symbol to differentiate region, district and TPS/TPA data. The following results of the digitization stages are in Figure 3 below:

**Fig. 3.** Labelling and Symbolling

### 3.1. Network Transport Analysis

Geographically, a map is described using coordinate points. The coordinate point functions as an address identity in indicating the actual point to be implemented in *QGIS.* Waste management is studied in this analysis by means of short path service. This service area search aims to provide area network analysis data on *.shp shapefile data which displays region, district and TPS/TPA data. The following area network analysis will be discussed as follows:

**1) Service Area (from layer)**

This waste management transportation network analysis activity aims to design and simulate the conditions of the waste transportation cycle in the Madiun city area which can be mapped in each district which has a TPS at each particular point. Based on the results of the service area with a coverage of 500 m, data can be obtained on the TPS in each subdistrict which can be used by the community as a waste disposal container. The reach scale of 500 m can still be reached by the community and may be used by the community as a place to dispose of family waste to avoid the accumulation of family waste in each household. This has an impact on the health situation of the surrounding environment from waste and can create a clean and beautiful city. In Figure 4, data on the use of the closest polling stations around the district/district can be obtained which can be used by the surrounding community. The following TPS data with a range of 500 m are obtained.

**Taman Region**

| | |
|---|---|
| Kejuron | TPS Kapten Saputro Kejuron |
| | TPS Salak Taman |
| Mojorejo | TPS Kapten Saputro Kejuron |
| | TPS Salak Taman |
| Manisrejo | TPS Pucangsari |
| Pandean | TPS Pandean |
| Banjarejo | *null* |
| Josenan | *null* |
| Kuncen | TPS Kuncen |
| Demangan | TPS Jati Mas |
| Taman | TPS Taman |
| | TPS Sedoro Banjarejo |

**Kartoharjo Region**

| | |
|---|---|
| Kanigoro | TPS Kampir Kanigoro |
| Klegen | TPS Kresno Kartoharjo |
| | TPS Nusa Penida Klegen |
| | TPS Slamet Riyadi |
| Oro-oro Ombo | TPS Pudak |
| Kartoharjo | *null* |
| Pilangbango | *null* |
| Sukosari | TPS INKA |
| Rejomulyo | *null* |
| Tawangrejo | TPS Tawangrejo |
| Kelun | *null* |

**Mangunharjo Region**

| | |
|---|---|
| Nambangan Kidul | null |
| Nambangan Lor | null |
| Pangongangan | TPS Pandan Pangongangan |
| Madiun Lor | null |
| Winongo | TPA Precet Winongo |
| Ngegong | null |
| Patihan | TPS Kalasan Patihan |
| | TPS Gambit Sawit |
| Sogaten | *null* |

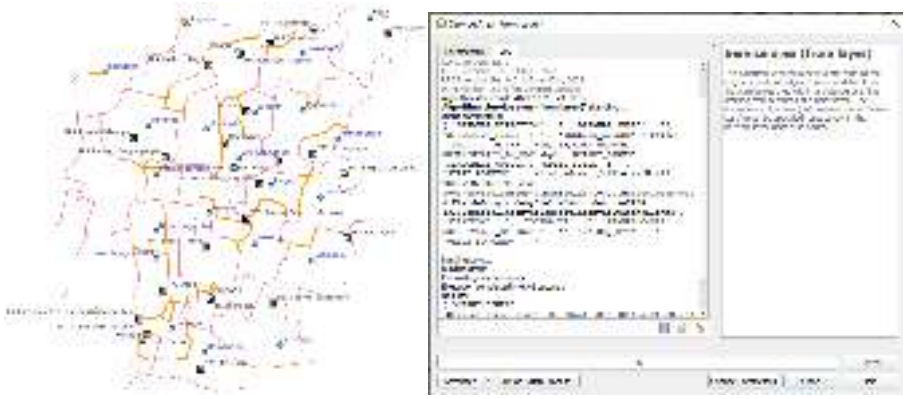

**Fig. 4.** Service Area (500 m)

Based on the analysis of the service area in Figure 4 and the recapitulation of the service area route, several null data were obtained because in the 500 m radius test results there were no TPS/TPA to carry out daily waste management/recycling. Based on the results of a survey of the needs of households who do not have access to TPS/TPA, there is a solution by employing waste processing workers with an agenda once a week 3 days. Data with null values include Banjarejo and Josenan in Taman region, in Kartoharajo region there are 4 districts with null values including Kartoharjo, Pilangbango, Rejomulyo and Kelun. Meanwhile, for Magunharjo region, there are 5 districts, namely Nambangan Kidul, Nambangan Lor, Madiun Lor, Ngegong and Sogaten.

For 1 km service area data, the following discussion are obtained:

**Taman Region**

| | |
|---|---|
| Kejuron | TPS Kapten Saputro Kejuron |
| | TPS Salak Taman |
| | TPS Nusa Penida Klegen |
| | TPS Kresno Kartoharjo |
| Mojorejo | TPS Kapten Saputro Kejuron |
| | TPS Salak Taman |
| | TPS Nusa Penida Klegen |
| Manisrejo | TPS Pucangsari |
| Pandean | TPS Pandean |
| Banjarejo | *null* |
| Josenan | TPS Tilam Upih Josenan |
| | PG Kanigoro Stasiun Penimbangan Tebu |
| | TPS Merak |
| Kuncen | TPS Kuncen |
| Demangan | TPS Jati Mas |
| Taman | TPS Taman |

| | |
|---|---|
| | TPS Sedoro Banjarejo |
| | TPS Pandean |
| **Kartoharjo Region** | |
| Kanigoro | TPS Kampir Kanigoro |
| Klegen | TPS Kresno Kartoharjo |
| | TPS Nusa Penida Klegen |
| | TPS Slamet Riyadi |
| Oro-oro Ombo | TPS Pudak |
| | TPS Slamet Riyadi |
| Kartoharjo | TPS Slamet Riyadi |
| Pilangbango | TPS Pilangraya |
| | TPS Slamet Riyadi |
| Sukosari | TPS INKA |
| | TPS Terminal |
| Rejomulyo | *null* |
| Tawangrejo | TPS Tawangrejo |
| Kelun | *null* |
| **Mangunharjo Region** | |
| Nambangan Kidul | TPS Merak |
| Nambangan Lor | *null* |
| Pangongangan | TPS Pandan Pangongangan |
| Madiun Lor | TPS Pandan Pangongangan |
| Winongo | TPA Precet Winongo |
| | TPS Pandan Pangongangan |
| Mangunharjo | TPA Precet Winongo |
| | TPS Pandan Pangongangan |
| Ngegong | *null* |
| Patihan | TPS Kalasan Patihan |
| | TPS Gambit Sawit |
| | TPS Terminal |
| Sogaten | *null* |

There is a change to the 1 km range data, in this range the public can access waste recycling in each district with more than 1 TPS that can be reached. At a range of 500 m, the community's reach to search for TPS is very limited, then in the service area analysis the range was increased to 1 km and data was obtained on several TPS locations in each district that could be reached. However, there are several districts within a reach of 1 km that have not found a TPS location, including: in Taman region, only Banjarejo, within a reach of 1 km, has not found a TPS. Kartoharjo region, from the 500 m range data, there are 4 districts that have a null value, within a radius of 1 km there are only 2 districts that have a null value, namely Rejomulyo and Kelun. Meanwhile, in Mangunharjo region district within a radius of 1 km, data on the use of rubbish waste is the same as in several surrounding areas, it is possible that there are

only a few TPS/TPS registered in the Mangunharjo zone data. More detailed data can be seen in Figure 5 as below with a range of 1 km:

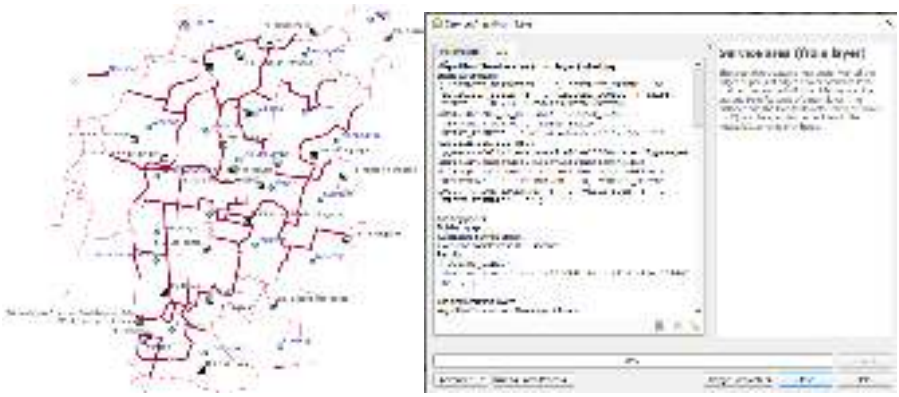

**Fig. 5.** Service Area (1 km)

**2) Shortest Path (layer to point)**

**Fig. 6.** Shortest Path from TPS to TPA

The analysis stage in this research is network transportation design using the shortest path with *QGIS*. From the total data set of region, districts and TPS/TPA data, the results in Figure 6 are obtained. The routes for scheduling waste management activities in Madiun City can be mapped as follows:

1) Taman Region

Route 1 Kuncen - TPS Tilah Upih Josenan - PG Kanigoro Stasiun Penimbangan Tebu - TPA Precet Winongo

Route 2 TPS Pandean - TPS Salak Taman - TPA Precet Winongo
Route 3 Sedoro Banjarejo - TPS Kapten Saputro Kejuron - TPA Precet Winongo
Route 4 Pucangsari - TPA Precet Winongo

2) Kartoharjo Region
Route 1 Slamet Riyadi - TPS Nusa Penida Klegen - TPS Kresno Kartoharjo - TPS Pudak - TPA Precet Winongo
Route 2 TPS Pilangraya – TPS INKA – TPS Terminal – TPA Precet Winongo

3) Mangunharjo Region
Route 1 TPS Merak - TPS Pandan Pangongangan - TPA Precet Winongo
Route 2 TPS Kalasan Patihan - TPS Gambir Sawit - TPA Precet Winongo

## 4 Conclusion

At the network transportation analysis stage for waste management Traffict in Madiun city using *QGIS* based on the region, district and TPS/TPA data sets, it produces an overview of transportation routes by service area which is used to determine TPS access around the subdistrict within a sampling range of 500 m and 1 km. And, the shortest path analysis produces scheduling routes for waste management routines in each region zone with route descriptions in each district. The results of the network transportation analysis in this research are used as a mapping of overall waste data from each district TPS which will later be carried out in further research by implementing SiMASKOT based on the Forecasting system which aims to minimize the hassle of managing waste to the TPA and create an independent waste management system for each district in Madiun City.

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