Optimization of waste transport routes in Pati Regency using ArcGIS

A Rahman1, and Maryono Maryono1

1 Department Urban and Regional Planning, Faculty of Engineering, University of Diponegoro, Semarang, Central Java, Indonesia

e-mail : andyr4004@gmail.com

Abstract. Based on the Recapitulation Data of the 2017 Pati District Waste from the Sanitation and Gardening Sector of the DPUTR Pati Regency shows that the amount of waste in Pati Regency is 3,082 tons / day. Meanwhile, the amount of waste transport to sanitary landfill only reaches 320 tons/day. Based on data from the Sanitation Strategy in Pati Regency 2015, Pati Regency Government was able to generate waste transportation service in urban areas by 7.17% and rural areas by 0.87%. This issue not comparable to the area of 1.580,37 km² with a population density of 785 people/km². The purpose of this study is to find the optimal value of waste transportation from the existing TTS point and New TTS points to the sanitary landfill by considering the distance and travel time with ArcGIS to improve waste transportation services in Pati Regency. Data collection methods in this study are: first, primary survey with direct interviews with Public Works Agency and Environmental Agency in Pati Regency about waste transportation systems at the polling station point. Second, the secondary surveys related to waste transportation system data namely density points for waste generation, number of garbage trucks and other data related to waste transportation systems. The results show that ArcGIS can help Optimize Travel Time by 39,04% and Optimization of Mileage by 37,38% and the volume of waste transported to reach 2.19% from Temporary Trash Shelter to Landfill.

1. Introduction

Waste problems faced by every country in the world. They are often related to transportation costs, disposal, and problems arisen from the management of solid waste. The main problems are inadequate, inefficient and expensive, thus affecting public health and the environment [1]. The amount of waste generated increases with population increasing and consumption patterns[2]. This causes greater costs incurred to process its waste by a country. Almost all countries in the world spend US $ 410 billion annually to process waste. Meanwhile, developed countries spend 50% of the waste management funds for transportation of waste, where developing countries are even bigger, which is 85% of the cost of waste management. This situation encouraged various countries to reduce the cost of transporting waste[3].

Pati Regency, which is located in Central Java Province, also has similar problems in waste management, especially in waste transportation services. In 2017, it shows that the amount of waste generated is 3,082 tons / day in Pati Regency. The amount of waste transported to landfill only reaches 320 tons / day. Based on document (Pati Regency Sanitation Strategy) data, in 2015 waste transportation in Pati Regency was only able to serving garbage transport in urban areas by 7.17% and rural areas by 0.87%. This is not comparable to the area of Pati Regency amounting to 1,580.37 km² consisting of 21 sub-district and with a population density of 785 people / km². The area handling waste transportation will be more extensive along with the rate of population growth and economic growth.

Pati City is the center of the Pati Regency administration as well as the Regency Capital City. The city of Pati has a fairly high level of consumption of goods. With this activity, the production of waste in Pati Regency increases every year. Sukoharjo Landfill (Waste Final Disposal Site) which uses controlled landfill technology has developed into an alternative local tourist spot for residents of Pati.
City and its surroundings. Landfill located in Village Sukoharjo sub-district Margorejo Pati Regency, was originally like various other Waste Disposal Sites which were identical to rubbish mounds and foul odors. In addition to the Sukoharjo landfill, Pati Regency also has two other landfill units that are still using open dumping processing namely Sampok landfill and Plosojenar landfill. In addition, the new landfill serves 13 sub-district or (62%) of the 21 sub-district.

Garbage collection is a handling activity that not only collects waste from individual containers and or from communal containers but also transports them to certain terminals, both directly and indirectly[4]. Waste disposal is an activity to transfer collected waste into transporters to be taken to a landfill (TPA). Meanwhile, the transportation of garbage is an activity of carrying waste from the location of the transfer or directly from the source of garbage to the final disposal site [5].

From the stages of waste transportation process, one way that can be done to reduce costs is to minimize the cost of waste transportation by optimized waste transportation route [6]. This operational cost is one of the driving forces so that the wheels of waste management, especially the transportation of garbage, can move smoothly. The waste management system in Indonesia related to the financing system is generally more directed to the self-financing system as well as regional-owned companies.

With increasing the percentage of services in the field of waste transportation in Pati Regency, this research is expected to be able to contribute to optimizing the existing garbage transportation system. By using the spatial data of the locations of existing waste generation points in Pati Regency, which are then processed in ArcGIS, it will be clearly seen the level of capability of existing TTS service coverage that is then required the location of new TTS points to accommodate waste services that are not well accommodated in TTS existing. This optimization is adjusted to the facilities and infrastructure that are already owned by the local regional government. The waste transportation route must be made effective and efficient so that it gets the most optimum route [7]. The waste transportation routes studied are existing and new routes planned as a result of the addition of TTS. The existence of this new TTS will add to the existing garbage transportation services. The tools for optimizing existing and new waste transportation routes are using the help of the Network Analyst ArcGIS.

2. Methods

The study was conducted at polling stations located in Pati Regency. The research area can be seen in Figure 1. Samples of the Temporary Trash Shelter (TTS) points in this study was 39 polling station points that were transported using Arm Roll Truck Fleet managed by the Public Works and Spatial Planning Office of Pati Regency.

The TTS points are 1) TTS Porda Juwana Market, 2) TTS Juwana Baru Market, 3) TTS SMAN 1 Jakenan, 4) TTS Juwana Bus Station, 5) TTS LP Office, 6) TTS RSI Pati, 7) TTS Bulumanis Market, 8) TTS Pakis Market, 9) TTS Dororejo, 10) TTS Tayu Market, 11) TTS Puncel Market, 12) TTS in Pecangaan Fish Market, 13) TTS Mitra Bangsa Hospital, 14) TTS3R Desa Winong, 15) TTS3R Ketanggan, 16) TTS Gembong Market, 17) TTS PSAA Margorejo, 18) TTS Blaru, 19) TTS3R Panjunan, 20) TTS SMPN 2 Gabus, 21) TTS Gabus Market, 22) TTS Kayen Market, 23) TTS Kayen Government Hospital, 24) TTS Winong Market, 25) TTS3R Larangan, 26) TTS RSUD RAA Soewondo Pati, 27) TTS Parkiran RSUD RAA Soewondo, 28) TTS Trangkil Market, 29) TTS Runting Market, 30) TTS Pati Police Department, 31) TTS Karanganyar – Guyangan Road, 32) TTS Puri, 33). TTS CV. Kecap Lele, 34) TTS Garuda Food, 35) TTS SlekoMarket, 36) TTS PuriMarket, 37) TTS Joyokusumo Stadium Pati, 38) TTS BTN Kembleb, 39) TTS Regency Government and PKK Pati. The scope of this study is about the process of optimizing the transportation of waste from Temporary Trash Shelterpoints to landfill. The scope of the study can be seen in Figure 2.
The ArcGIS tools used to proximity analysts with buffering, overlay, and network analyst, which serve as the optimum pathfinder using the transport time and mileage parameters [8]. To optimize the waste transportation route in Pati Regency, detailed spatial information needed. This information closely related to geographical data of the study area, including also spatial data related to the transport of waste from Temporary Trash Shelter to the landfill. The analysis technique used in this study is the spatial analysis technique using Network Analyst Methods in ArcGIS 10.

Observations to optimize the garbage transportation route in Pati Regency were carried out directly in the field by taking spatial data from GPS (Global Positioning System) in the form of existing garbage transportation routes, pool locations, Temporary Trash Shelter and landfill [9, 10]. Whereas non-spatial data consist of the name of the road, type of road, the average speed of transportation of garbage, travel time, number of Temporary Trash Shelter, capacity of Temporary Trash Shelter, and transportation time of Temporary Trash Shelter and operational costs of garbage transportation carried out by direct observation in the field. This observation looks Temporary Trash Shelter location, the condition of other equipment and facilities for transporting garbage and the road conditions that are traversed by garbage carriers’ fleet. To find out the existing route by followed the garbage transport fleet from Temporary Trash Shelter one to the other Temporary Trash Shelter until it reaches the landfill. In addition, the observation also measured the speed of the fleet transporting waste from Temporary Trash Shelter to the landfill; this is in line with previous studies using vehicle speed variables for several days [11].

Network Analyst methods can spatially connect the movement of a resource from one location to another location through human elements (human-made) that form networks (arcs and nodes) that are interconnected with each other [12]. The several sub-analyzes that are in it are:
1. Network modeling (traffic rules consisting of: directional/two-way roads, may turn left-right-hold, dead-end roads, roads that are not opened or cannot be used, under / overpass);
2. Determination of the shortest path (shortest path / distance);
3. Determination of the best optimal path (distance traveled with the least cost and obstacles);
4. Determination of alternative routes along with travel times.

This study aims to find out the route with the optimal travel time and distance from the Temporary Trash Shelter point to the landfill in Pati Regency. The first step is to determine the location of the waste generation points in the residentsials, offices, schools, markets, shops and industries. Then rasterization of waste generation points to carry out to get the centroid location at a fairly high density, and this can
be used as a candidate for the construction of a new Temporary Trash Shelter location. Furthermore, the location of the existing Temporary Trash Shelter was carried out with GPS assistance in several locations on Pati Regency. Then, location of existing Temporary Trash Shelter and location of new Temporary Trash Shelter matched by linking several variables. This variables related to environmental impacts, including Temporary Trash Shelter location with Landuse, Temporary Trash Shelter location by the river, the Temporary Trash Shelter distance to the network route transportation, the location of the Temporary Trash Shelter with the service area overlap Temporary Trash Shelter. After obtaining the optimal Temporary Trash Shelter location, then fill in the road attributes of road speed, road length, road status, and road conditions. For the average road speed calculated after the inclusion of the road speed attribute on each road segment. The length of the road can be obtained from the SHP file in Pati regency road. With the availability of road network-based spatial data, it will help the process of determining the shortest route, direction of travel, direction of the nearest facility and service area. And then, using existing road network modeling, ArcGIS will help create dynamic and realistic network models, including boundaries in turn, speed, altitude, and traffic flow conditions [13].

3. Results and Discussion

3.1. Identification of Waste generation

This analysis begins by entering data to ArcGIS application. The observation data, as attribute data from the distribution layer of the garbage source. The secondary data consists of the rate of waste generation, the population growth rate of each kecamatan, the number of economic activities in each kecamatan. Primary data consists of the number of people in a building or building area. After input data, then a spatial analysis carried out to produce a scattered map of waste generation and as an ingredient to determine the location of the best new Temporary Trash Shelter. The partial map of Pati Regency can be seen in Figure 3 and Map of Economic Activities in Pati Regency can be seen in Figure 4. Whereas for identification of types of buildings can be seen in table 1.
Table 1. Identify Building Types

| No | Sub-district   | amount | Residential | Offices | School | Shops | Market | Industry |
|----|----------------|--------|-------------|---------|--------|-------|--------|----------|
| 1  | Sukolilo       | 275    | 6,29        | 1       | 17     | 73    | 168    | 11       | 5        |
| 2  | Kayen          | 352    | 8,05        | 1       | 18     | 83    | 244    | 6        | -        |
| 3  | Tambakromo     | 138    | 3,16        | 2       | 19     | 44    | 70     | 3        | -        |
| 4  | Winong         | 236    | 5,40        | 1       | 31     | 63    | 136    | 4        | 1        |
| 5  | Pucakwangi     | 159    | 3,64        | 1       | 21     | 55    | 78     | 4        | -        |
| 6  | Jaken          | 185    | 4,23        | 1       | 22     | 36    | 123    | 3        | -        |
| 7  | Batangan       | 100    | 2,29        | 1       | 19     | 36    | 23     | 4        | 17       |
| 8  | Juwana         | 189    | 4,32        | 1       | 31     | 65    | 35     | 3        | 54       |
| 9  | Jakenan        | 295    | 6,75        | 1       | 24     | 41    | 223    | 6        | -        |
| 10 | Pati           | 286    | 6,54        | 35      | 49     | 104   | 75     | 9        | 14       |
| 11 | Gabus          | 337    | 7,71        | 3       | 25     | 53    | 238    | 3        | 15       |
| 12 | Margorejo      | 107    | 2,45        | 16      | 19     | 47    | 12     | 2        | 11       |
| 13 | Gembong        | 107    | 2,45        | 3       | 12     | 62    | 27     | 2        | 1        |
| 14 | Tlogowungu     | 118    | 2,70        | 6       | 16     | 62    | 30     | 2        | 2        |
| 15 | Wedarijaksa    | 131    | 3,00        | 1       | 19     | 48    | 50     | 5        | 8        |
| 16 | Trangkil       | 165    | 3,78        | 1       | 17     | 55    | 70     | 3        | 19       |
| 17 | Margoyoso      | 438    | 10,02       | 1       | 23     | 88    | 290    | 3        | 33       |
| 18 | Gunung-wungkal | 85     | 1,95        | 1       | 16     | 40    | 26     | 1        | 1        |
| 19 | Cluwak         | 103    | 2,36        | 1       | 14     | 53    | 34     | 1        | -        |
| 20 | Tayu           | 315    | 7,21        | 3       | 22     | 75    | 203    | 3        | 9        |
| 21 | Dukuhseti      | 249    | 5,70        | 1       | 13     | 68    | 163    | 2        | 2        |
|    | TOTAL          | 4,370  | 100         | 82      | 447    | 1,251 | 2,318  | 80       | 192      |

Source: Analysis Results, 2018.

Based on Statistical Bureau of Pati, the population in Pati City was 107,028 people in 2016. Based on total population, Pati City categorized as a medium type city. According to SNI 19-3983-1995 about the specifications of waste generation for Small Cities and Medium Cities in Indonesia, the amount of waste generated for medium cities about 2.75-3.25 liters/person/day. From the results of sampling for 8 days in Pati City, domestic waste generation was obtained at 2.169 liters/person/day. From these results, it can be seen that the volume of waste generated in Pati City still under the SNI provisions for medium cities, but these results indicate that the generation of waste produced by the City of Pati is included in the classification of small cities.

Then secondary data and sample survey data are included as attributes at each garbage point. The use of the calculator field is used to estimate waste generation by multiplying the unit field with the rate of waste generation and shown in Figure 5. The recapitulation of waste generation based on the source of waste can be seen in Table 2.
Table 2. Waste generation, according to the source of waste

| No | Source of Trash | Unit | Waste generation rate | Waste generation (liter/day) |
|----|-----------------|------|-----------------------|------------------------------|
| 1  | Residential     | Person| 2.169                 | 2,689,536.14                 |
| 2  | Office          | Person| 0.351                 | 5,719.42                     |
| 3  | Shops           | Person| 2.554                 | 31,475.58                    |
| 4  | School          | Person| 0.150                 | 24,765.75                    |
| 5  | Market          | m²    | 0.543                 | 316,255.61                   |
|    | TOTAL           |       |                       | 3,067,752.50                 |

Source: Analysis Results, 2018.

Table 2 shows that the total waste source generation in Pati Regency is 3,067,752.50 liters/day, the residential sector being the main contributor to waste generation in Pati Regency is 87.67%. The second place is the market sector as the biggest trade center, which is 10.31%, then third place is shopping, which is 1.03%, then the fourth rank is office buildings which are 0.19% and fifth place is school, which is 0.81%.

3.2. **TTS Optimal Location Analysis**

Based on the waste generation point, rasterization is carried out on the waste source point layer using ArcGIS 10 to determine the location of the new TTS. The tool used is ArcToolbox-Conversion Tools - To Raster - Point to Raster, as input is the Timbulan_Sampah layer with the generation value field, cell assignment type "sum", and cellsize 150. After rasterization, solid waste density can be calculated by dividing the value raster with its area. Then identify areas with high density by giving centroids using the ArcToolbox-Conversion Tools - From Raster - Raster to Point, as input is the dense layer. The results of the centroid identification at a fairly high density are as many as 80 points as in Figure 6.
3.3. Location Suitability Analysis of Temporary Trash Shelter (TTS)

The analysis of TTS suitability location reviewed by from the closest distance from the use of certain lands, such as school buildings, hospitals, offices, shops and other public facilities, then carried out by providing a 75 meter buffer divided into three 25 meters each, as in picture 7.

Overall, out of the 102 existing TTS pieces, 100 TTS enter the zone close to the settlement where there are school facilities, hospitals and other public facilities as well as industry. So that for the convenience and health of the community users of the facility, the TTS should be moved out of the zone,
but it all depends on the level of vacant land available. Furthermore, these criteria will still be used to assess the suitability of the new optimizations TTS.

3.4. Proximity to Sensitive Environment Areas

This analysis for checks proximity to sensitive environments such as river flow. This is because if the location of the TTS is very close to the river flow, it will have an impact on environmental pollution, such as leachate waste or the remnants of garbage entering the river if carried by rain. The buffer used is 15 meters on both sides of the river flow.

After analyzing the results of which we can see in Figure 8, none of the existing TTS included in the 15 meter buffer zone of the river flow, so that the existing "TTS" is not prone to river pollution.

![Figure 8. SensitifMap of Proximity Analysis with Sensitive Environmental Areas](image)

3.5. Access to Garbage Transport Routes

The travel time of the garbage transport route will be influenced by the suitability of the location of TTS with the accessibility of garbage transportation, because the more difficult the location of TTS access, the travel time will increase. This is due to the increase in time needed for loading and unloading garbage and maneuvering garbage transport vehicles.

Accessibility assessment of the location of TTS in the waste transportation route is to provide a 180 meter buffer against the existing garbage transport route. The results of the analysis can be seen in Figure 9, 99 TTSs are in the 180 meter zone of the existing garbage transport route, while 3 TTS are outside the 180 meter zone namely TTS in Pecangaan Fish Market, TTS Puncel Market and TTS3R Larangan.
3.6. **Ideal Distance to Remove Trash to TTS**

The existence of TTS is said to be effective if it can really be used by the community to the fullest so that it indirectly requires the ideal distance. So the following analysis will pay more attention to the community as the user of TTS itself.

In this analysis using a service area of 150 meters at the existing TTS location. The results can be seen in Figure 10, where there are about 13 existing TTS that service areas overlap with each other, namely TTS Tayu Market, TTS Dororejo, TTS Juwana Baru Market, TTS Porda Juwana Market, TTS Juwana Terminal, TTS Puri Market, TTS Puri, TTS LP Office, TTS Parking of RAA Soewondo Hospital, TTS Pati Police Station, TTS RSUD RAA Soewondo Pati, TTS CV. Soy Sauce, TTS Garuda Food.

The new TTS also uses a service area of 150 meters, and the results can be seen in figure 11, of which 80 TTS have been analyzed after producing 34 new TTS that are optimal and do not overlap with the existing TTS location.
3.7. Analysis of Existing Waste Transport Routes

Determination of the optimal existing garbage transportation route is done by ArcGIS 10 for Desktop software using the Network Analyst Route. The analysis was carried out on the existing waste transport route for eight units of Arm Roll Truck (K9584SA, K9563SA, K9564SA, K9587H, K9598ZA, K9599ZA, K9588H, K9531AA) for transporting waste. As a stop point uses the garbage transport pool - TTS - Landfill. Figure 12 is the existing route of garbage transportation with an Arm Roll Truck fleet.

After optimization by using the Network Analyst Route, the results of the analysis on the eight existing routes using two optimization indicators which are valued, namely the distance and travel time values are shown in Figure 13 and Table 3.
3.8. Analysis of Optimal Waste Transport Routes

However, the optimal TTS route analysis uses a Vehicle Routing Problem (VRP), which is a combination of several TTS where a set of requests needs to be served by a set of routes or vehicles so that the overall cost can be reduced. Besides those things that need to be considered include the capacity of the garbage transport fleet, the distance of waste transportation time and related to the driver's special expertise in maneuvering to take the garbage at the TTS and emptying the garbage at the Landfill.

In Figure 14, it will be seen the distribution of 73 points TTS which will become orders in the process of analyzing vehicle routing problems. The route of the arms roll truck garbage transport fleet will carry out the process of transporting waste at the other points until the process of transporting garbage is transported all. The results of the analysis obtained between the existing route and the route that has been optimized with the addition of the new TTS service can be seen in Figure 15 and Table 4.

Table 3. Evaluation of Existing Waste Transport Routes

| No | Trash Transport Route | Traveling time | Mileage | | |
|----|-----------------------|----------------|---------|---|---|
|    |                       | Existing | Optimal | Existing | Optimal |
| 1  | K-9531-AA             | 670 min  | 567 min  | 313.300 meter | 266.029 meter |
| 2  | K-9563-SA             | 308 min  | 267 min  | 161.400 meter | 148.979 meter |
| 3  | K-9564-SA             | 1450 min | 967 min  | 625.600 meter | 428.293 meter |
| 4  | K-9584-SA             | 240 min  | 228 min  | 118.200 meter | 112.019 meter |
| 5  | K-9587-H              | 779 min  | 612 min  | 328.100 meter | 270.087 meter |
| 6  | K-9588-H              | 384 min  | 337 min  | 142.900 meter | 132.100 meter |
| 7  | K-9598-ZA             | 416 min  | 364 min  | 180.100 meter | 162.631 meter |
| 8  | K-9599-ZA             | 274 min  | 264 min  | 104.500 meter | 98.743 meter |
|    | Total                 | 4.521 min | 3.605 min | 1.974.100 meter | 1.618.880 meter |

| Percentage of Optimization of Existing Route | 20.25% | 17.99% |

*Source: Analysis Results, 2018.*
Figure 14. Map of Analysis of Vehicle Routing Armada Problem Arm Roll Truck

Figure 15. Map of Waste Transport Optimization Routes with Arm Fleet Roll Truck

Table 4. Optimization of Waste Transport

| No | Route    | Travel Time (Minutes) | Mileage (Meters) | Garbage Transported (liter) |
|----|----------|-----------------------|------------------|-----------------------------|
|    |          | Existing              | Model            | Optimat. (%) | Existing | Model | Optimat. (%) | Existing | Model | Optimat. (%) |
| 1  | K-9531-AA | 670                   | 893              | -33,24%     | 313.300  | 422.511| -34,86%     | 46.764   | 74.147| 37,00%    |
| 2  | K-9563-SA | 308                   | 263              | 14,70%      | 161.400  | 125.489| 22,25%      | 39.312   | 38.285| -3,00%    |
| 3  | K-9564-SA | 1.450                 | 413              | 71,48%      | 625.600  | 178.230| 71,51%      | 55.957   | 31.905| -75,00%   |
| 4  | K-9584-SA | 240                   | 324              | -35,41%     | 118.200  | 151.915| 22,25%      | 39.312   | 38.285| -3,00%    |
| 5  | K-9587-H  | 779                   | 255              | 67,23%      | 328.100  | 108.928| 71,51%      | 55.957   | 31.905| -75,00%   |
| 6  | K-9588-H  | 384                   | 127              | 66,84%      | 142.900  | 151.915| 22,25%      | 39.312   | 38.285| -3,00%    |
| 7  | K-9598-ZA | 416                   | 252              | 39,41%      | 180.100  | 103.604| 42,47%      | 53.316   | 47.583| -12,00%   |
| 8  | K-9599-ZA | 274                   | 228              | 16,80%      | 104.500  | 92.395 | 11,58%      | 34.398   | 39.991| 14,00%    |
|    | Total     | 4.521                 | 2.756            | 39,04%      | 1.974.100| 1.236.239| 37,38%     | 332.572  | 340.022| 2,19%     |

The optimization results that the longer distance traveled on the model, it can be reached with a shorter time. These can occur because the route analysis is based on a faster time. The travel time itself was influenced by the maximum speed of each road segment, so the route will choose a road with a higher speed even though the distance becomes further. Therefore, the optimization results that the obtained an optimal travel time was reached 39.04%, the distance reached 37.38% and the volume of waste transported rose to 2.19%.

These will be different if the route analysis is based on the closest distance (shorter distance), then the route to be chosen is one which has a closer distance by ignoring the maximum speed of each road segment [14]. In the short distance-based analysis (shorter distance) also still uses a geographic
developed datas such as road networks, various zone boundaries, center-centroid locations, location of moving stations, etc.

The result of this study has a value close to the results of previous studies related to the optimization of the transportation distance of waste from the TTS to the landfill which is saving of range from 20% to 40% [15,16,17,18,19,20,21].

Optimization of mileage by calculating the maximum speed of each section, it should affect the amount of travel time and the amount of waste transported. In previous studies showed an increasing the amount of waste transported from 43 to 75 kg by considering the demographic conditions, commercial activities and the capacity of the fleet used [22]. It is in line that the study shows the volume of transported waste also increased by 2.19% or 7,450 liters / day with different demographic conditions such as the location of Existing TTS, New TTS, fleet capacities, operational costs and the determination of the waste transportation routes.

4. Conclusions
Optimizing waste transportation in Pati Regency can be done using the software; one of the software that can be used is ArcGIS software. ArcGis software provides tools that can help analyze a transportation network from TTS to Landfilling spatial analysis, namely Network Analyst. With ArcGis Network Analyst users can dynamically model networks that connect TTS with Landfill in a more realistic manner with predetermined speed limits and traffic conditions.

After identify existing conditions and the location of the existing TTS and Landfill, then several stages of analysis are carried out starting from the identification of waste generation, assessing the suitability of the existing TTS and TTS locations, and then optimizing the garbage transport route. The model built with ArcGis can be used as a material for consideration in policy making in integrated and sustainable waste management.

Based on the identification of the composition of waste generated in Pati Regency, most of the waste sources come from the household sector, which is 87.67%. This can be used as a basis for waste management strategies related to garbage collection and transportation so that it is expected that there will be no garbage disposal of the community in an empty land, roadside, riverbanks and places that disrupt environmental pollution and can disrupt public health. Optimization causes a reduction in travel time of up to 39.04% and travel distance of up to 37.38% and the volume of waste transported to reach 2.19% or 425,421 liters/day.

Based on the analysis results and conclusions in this study, the things that need to be discussed further are as follows:

1. To improve the accuracy of the data related to waste generation and its spatial distribution, more specific measurements need to be taken of various sources of waste, including hospitals, hotels, tourist attractions, terminals, ports and restaurants that have not been accommodated in SNI 19-3983-1995 about specifications Waste generation for Small Cities and Medium Cities in Indonesia.
2. To increase the coverage of TTS services for the community, the addition of TTS and the addition of the existing garbage truck at the TTS location needs to be provided regularly. This should also be accompanied by the expansion of the location of TTS, which is easily accessible to the public.
3. Further research is needed regarding all components of waste transportation by linking the data on the number of garbage collectors who dispose garbage to TTS, the volume of rubbish waste used, the number of people served and those that have not been served spatially, the number of 3-wheeled vehicles, garbage numbers Roll Truck that has been provided by the Public Works and Spatial Planning Office of Pati Regency.
4. Local governments are expected to be able to provide regular socialization regarding waste disposal, good and correct waste management and provide public complaints services related to the transportation of existing waste so that it can be a material consideration for improving services to the community.
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