

Determining the Number of Effective and Efficient Transport Fleets Based on Waste Generation Projections in Cakranegara District.

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ABSTRACT: *The increase in population is accompanied by an increase in the amount of waste disposed of, which is the cause of increased environmental pollution, exacerbated by proper and inadequate landfill locations. If not accompanied by good waste management, the waste problem will have a negative impact on the environment. As much as 2,695 tons or 80 percent of the total waste in West Nusa Tenggara (NTB) is not managed properly. With so much waste that has not been taken care of, the thought arises, whether waste in Cakranegara District, especially household waste, can all be transported to the TPS. The purpose of this study is to determine the amount of household waste generation in each neighborhood in Cakranegara District, determine the number of efficient fleets to transport household waste to TPS, project an increase in population to predict the number of effective and efficient transportation fleets until 2027. The research method used in this study is a research method through direct observation and measurement, which includes observation and interviews with the community in the environment in Cakranegara District. The result of this study is the projected amount of waste generation in 2027 as much as 217.97 m³ / day, the number of transportation fleets needed is 118 units of motor carts, but by adding rhythm can be reduced to 56 units of motor carts. The efficiency that was previously 62.86% can be increased to 100.23% which makes the transportation of waste quite effective.*

Keywords: *Waste, Management, Infrastructure, Effective, Efficient*

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I.INTRODUCTION

Increasing environmental pollution is caused by various things, such as the increase in human population which results in an increase in the amount of waste thrown away. This is exacerbated by the lack of adequate places and locations for waste disposal, lack of awareness and willingness of the community to manage and dispose of waste. Because rubbish is considered something dirty and must be thrown away. These various things cause a decline in environmental quality which has a negative impact on society [1].

Therefore, waste causes social problems in the community. One of the social problems that usually arises in developing areas is the problem of waste. Amount Waste continues to increase every year along with the increase in population and the quality of people's lives, and accompanied by people's lifestyles which are influenced by advances in science and technology technology so it still tends to be consumerist [2].

The number of landfills continues to increase, where the increase in the amount of landfills must be followed by optimal management so that the waste problem does not cause environmental damage and a decrease in the quality of public health [3].

Indonesia's population growth is growing at a faster rate than ASIAN countries other. The urban population increased by an average of 4.1% annually between 2000 to 2010, compared to 3.8% in China, 3.1% in India, and 2.8% in Thailand [4]

World Bank 2014, In 2012 the urban population reached more than 52% of the population in Indonesia and by 2025, it is estimated that 68% of Indonesia's population will live in urban areas [4]. The population in NTB as of January 2020 was 5.1 million people, of which the population in the capital city, Mataram city, was 498,681 people. Produces 1080 m³ of waste per day. Coupled with the consumerist nature of modern society, waste matters in NTB need good management so that waste does not cause social problems.

A total of 2,695 tons or 80 percent of the total waste in West Nusa Tenggara (NTB) is not managed properly, referring to the Adipura assessment which requires a minimum of 60% of the total waste overall can be managed. So we can be sure that waste management in NTB still needs study.

Secretary of the NTB Environment and Forestry Service (LHK), Syamsudin, admitted that the volume of waste in 10 districts/cities in NTB reached 3,388 tons and the waste thrown away per day reached 76 tons. Meanwhile,

641.92 tonnes of waste enters the final disposal site (TPA) and only 51.21 tonnes of waste is recycled per day [5].

Infrastructure systems are defined as basic facilities or structures, equipment, installations that are built and needed for the functioning of the social system and economic system of society [4]. In terms of waste management, the fleet in question is a facility for transporting waste from the waste source to the TPS (Temporary Disposal Place) or from the TPS to the TPA (Final Disposal Place) before it is managed further.

There are several landfills in NTB, including the Kebon Kongok landfill 8.41 hectares for Mataram City and West Lombok Regency. Pengengat landfill covers an area of 10 hectares in Central Lombok, Ijo Balit TPA with an area of eight hectares in East Lombok, Jugil TPA covering eight hectares in North Lombok and Oi Mbo TPA covering an area of seven hectares in Bima City [5].

In Cakranegara District, there is waste infrastructure in the form of 74 transport fleets tasked with serving 10 sub-districts consisting of 74 neighborhoods and 293 neighborhood units (RT), where each neighborhood has 1 waste transport fleet in the form of a motorbike trash cart, each The motorbike cart is operated by one person with the waste transportation routine once a day. Other infrastructure such as TPS is also available, with an area of 15×20 m. And this fleet functions to transport waste from waste sources to TPS in the area.

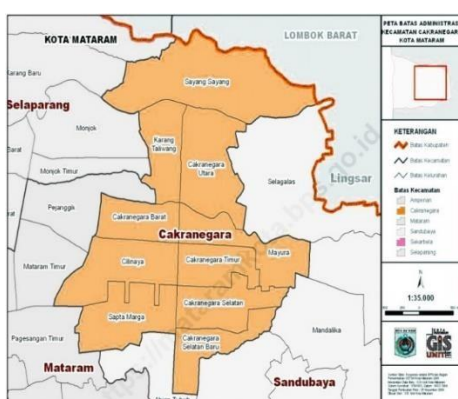


Figure 1. Map of the Cakranegara area

Cakranegara District is 1 (one) of 6 (six) Districts within the administrative area of Mataram City, West Nusa Tenggara Province. This subdistrict, which is located in the heart of Mataram City, has an area of 9.67 km², with a population in 2020 of 67,826 people with a population density of 14,122 people/km². In terms of government administration and social systems, Cakranegara sub-district is divided into 10 sub-districts and 74 neighborhoods. The problem is that there are 74 waste transport fleets from the origin of the waste to the TPS which are still unable to transport all the existing waste, whether this is due to a lack of transport fleets or because of the lack of effective and efficient use of transport fleets to deal with waste in Cakranegara District.

It is important to assess the number of fleets so that all of the trash piles in Cakranegara District can be transported. Because, if proper waste management is not carried out, the waste problem will become a serious problem that causes other problems in society, such as the spread of disease and foul odor pollution. This prompted the author to conduct further research with the title: Determining the Number of Effective and Efficient Transport Fleets Based on Waste Generation Projections in Cakranegara District.

II. STUDIES OF METHOD

The data required for this research is primary data and secondary data. Primary data is data obtained through field surveys using a sampling method in the form of the amount of daily waste generated by each household in Cakranegara District. Meanwhile, secondary data was obtained from the relevant agency, namely the Central Statistics Agency (BPS) for the city of Mataram in the form of data on population, number of families based on welfare level, and number of fleets available. After the data is collected, the population growth ratio will be calculated to find out the predicted population each year for the next 5 years, and also to find out the predicted amount of waste generation and the number of fleets needed according to current conditions. After this process is carried out, the effectiveness and efficiency of the use of the transport fleet in the existing position using 1 rotation (currently) and the modified position in the use of the transport fleet using 2 cycles will be carried out. From these calculations, whether the current transport fleet needs to be increased or not.

Scope of Study

This research was conducted in Cakranegara District, Mataram City to obtain related data; (1) daily waste generation rate, (2) capacity and number of transport fleets (3) efficiency and effectiveness of transport equipment.

Tools used in research

The tools used to obtain data in this research are transport fleets, stopwatches to measure time, meters to measure waste volume, and writing instruments.

Determining the Number of Effective and Efficient Transport Fleets

The study of Determining the Number of Effective and Efficient Transport Fleets was carried out based on SNI 19-3964-1994 concerning "Methods for Processing, Collecting and Measuring Samples of Waste Generation", the capacity and number of transport fleets as well as the efficiency and effectiveness of transport equipment. The stages are as follows:[1]

Daily waste generation rate (Qd)

$$Qd = \text{units of waste generation (qd)} \times \text{number of population(pd)} = qd \times pd \quad (1)$$

$$\text{Number of fleet} = \frac{\text{Waste generation}}{\text{Transport fleet capacity} \times Fp \times Rt} \quad (2)$$

Fp = a compaction factor (1.2)

Rt = a rotation of waste transported

$$\text{Waste capacity carried} = \text{Transport fleet capacity} \times Fp \times Rt \times \text{number of fleet} \quad (3)$$

$$\text{Effectiveness} = \frac{\text{Amount of waste}}{\text{Waste capacity carried}} \leq 1 \text{ (all the rubbish was picked up)} \quad (4)$$

$$\text{Efficiency} = \frac{\text{Transport fleet capacity} \times Fp \times Rt \times \text{number of fleet}}{\text{amount of waste}} \times 100 \% \leq 100\% \quad (5)$$

(all the rubbish is not picked up)

III. RESULTS AND DISCUSSION

Data on population numbers and population growth ratios are needed to calculate projections of future population numbers and are used to calculate the volume of waste generation and the need for waste transport fleets. Population data in Cakranegara District in 2016 – 2021 can be seen in table 1:

Table 1. Total population of Cakranegara District

No.	Year	Number of Population (People)	Ratio (r) (%)
1	2016	67.395	-
2	2017	67.791	0,59
3	2018	68.119	0,48
4	2019	68.455	0,49
5	2020	68.719	0,39
6	2021	67.826	-1,31
Average			0,13

Based on the analysis results in table 1, the average population growth ratio in the subdistrict is known Cakranegara was 0.13%. Once the average population ratio is known, the next stage is to find population growth projections from 2022 - 2027 using the exponential method. Results of calculations of population projections from 2022 to 2027 shown in the following 2 images:

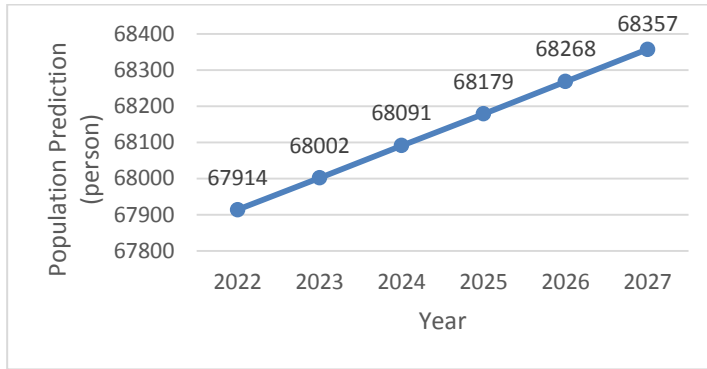


Figure 2. Projection of population from 2022 to 2027

After knowing the projected population in 2022-2027, then use the calculation results. This is continued to determine the projected amount of waste generation in 2022-2027, the calculation results of which are shown in table 2 below:

Table 2. Projection of the amount of waste generation from 2022 to 2027

No	Year	Number of Population (People)	Projection of the amount of waste generation (m ³ /day)
1	2022	68.234	210,53
2	2023	68.644	210,81
3	2024	69.057	211,08
4	2025	69.473	211,35
5	2026	69.891	211,63
6	2027	70.312	211,90

Based on the data that has been obtained, the rate can be determined daily waste generation in Cakranegara District, using equation 2.1, with the known waste generation unit (*qd*) from field observations of 0.0031m³/org/day and the total population (*pd*) in 2021 of 67,826 people, as follows the calculation:

$$Qd = \text{units of waste generation (qd)} \times \text{number of population(pd)} = qd \times pd$$

$$Qd = qd \times pd = \frac{0,0031 \text{m}^3}{\text{person day}} \times 68,234 \text{ people} = 210.53 \text{ m}^3/\text{day}$$

So the total waste in 2022 in Cakranegara District is = 210.53 m³/day, and the number of fleets needed is as follows:

$$\text{Number of fleet} = \frac{\text{Waste generation}}{\text{Transport fleet capacity} \times FpxRt} = \frac{210.53}{1.5 \times 1.2 \times 1} = 116.96 = 117 \text{ Unit}$$

By using the same calculation method, we can find out predictions of waste generation and predictions of the need for transport fleets or motorized rickshaws from 2022 to 2027, as can be seen in table 3 below.

Table 3. Projection of waste generation and need for motorized carts from 2022 to 2027

No	Year	Waste generation projections (m ³ /day)	Projected Quantity Requirements Motorcycle Cart (units)
1	2022	210,53	117
2	2023	210,81	118
3	2024	211,08	118
4	2025	211,35	118

5	2026	211,63	118
6	2027	211,90	118

From the calculation results, the amount of waste generated is at least 211.90 m³/day requires 118 motorized carts to transport household waste in the District Cakranegara. However, in Cakranegara District, it is recorded that there are 74 waste transport fleets spread across 10 sub-districts and 74 neighborhoods, which means that each neighborhood has 1 motorized rickshaw transporting rubbish.

The current fleet size means that not all of the waste generated can be transported. By taking the highest projected amount of waste generation in 2027, which is 211.90 m³/day, the following alternatives can be implemented to optimize the existing transport fleet:

By changing the transportation rite, from the results of the experiment to optimize the available fleet, the rite was taken 2 times, here are the calculations:

$$\text{Number of fleet 1 ritation} = \frac{\text{Waste generation}}{\text{Transport fleet capacity} \times F \times R \times t} = \frac{211.90}{1.5 \times 1.2 \times 1} = 117.72 = 118 \text{ unit}$$

$$\text{Number of fleet 2 ritation} = \frac{\text{Waste generation}}{\text{Transport fleet capacity} \times F \times R \times t} = \frac{211.90}{1.5 \times 1.2 \times 2} = 58.86 = 59 \text{ unit}$$

By changing the transportation frequency to 2 times, the currently available fleet can be optimized until 2027.

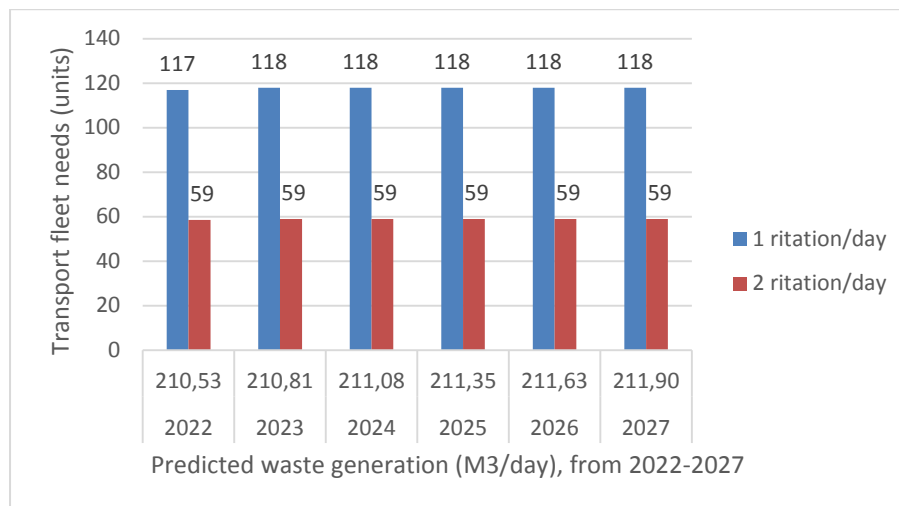


Figure 3. The relationship between the need for transportation equipment, predictions of waste generation in 1-time and 1-time ritation , from 2022-2027

Effectiveness is a method used to achieve a goal, in this case the goal is to move household waste to the TPS. Moving waste to the TPS can be done by transporting the waste using a transport fleet. The projected waste generation in 2027 is used as a reference for calculations with waste generation of 211.90 m³. Cakranegara District currently has 74 motorbike carts as a waste transport fleet, here are the calculations with 74 motorbike carts with a capacity of 1.5 m³, a compaction factor of 1.2, and a ritation of 1 times the amount of waste transported:

$$\begin{aligned} \text{Waste capacity carried} &= \text{Transport fleet capacity} \times F \times R \times t \times \text{number of fleet} \\ &= 1.5 \times 1.2 \times 1 \times 1 \times 74 = 133.20 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Effectiveness} &= \frac{\text{Amount of waste}}{\text{Waste capacity carried}} \leq 1 \text{ (all the rubbish was picked up)} \\ \text{Effectiveness} &= \frac{\text{Amount of waste}}{\text{Waste capacity carried}} = \frac{211.90}{133.20} = 1.64 \text{ (all the rubbish is not picked up)} \end{aligned}$$

The calculation results show that the effectiveness value is still more than one, which means that waste transportation is not effective enough. To compare whether adjusting the ritation 2 times can achieve the desired effectiveness value, here are the calculations:

$$\begin{aligned} \text{Waste capacity carried} &= \text{Transport fleet capacity } F_{pxRt} \times \text{number of fleet} \\ &= 1.5 \times 1.2 \times 2 \times 59 = 212.40 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Effectiveness} &= \frac{\text{Amount of waste}}{\text{Waste capacity carried}} \leq 1 \text{ (all the rubbish was picked up)} \\ \text{Effectiveness} &= \frac{\text{Amount of waste}}{\text{Waste capacity carried}} = \frac{211.90}{212.4} = 0.99 \text{ (all the rubbish is picked up)} \end{aligned}$$

From the calculation results, the capacity of waste that can be transported is 212.40 m³ from the total existing waste of 211.90 m³, this shows that by changing the ritation to 2 times, the effectiveness value can be changed to 0.99. Which means that waste transportation with 59 fleets and 2 routes has been effective.

Efficiency is defined as doing something to achieve a goal with fewer resources. Waste transportation is said to be efficient if waste transportation can maximize the existing transportation fleet without the need to add motorized cart units. To calculate efficiency, a sample of the largest projected waste generation was taken, namely in 2027, which was 211.90 m³/day, with 1 ritation, 74 motorized carts with a capacity of 1.5 m³, and a compaction factor of 1.2. Here's the calculation:

$$\begin{aligned} \text{Waste capacity carried} &= \text{Transport fleet capacity } F_{pxRt} \times \text{number of fleet} \\ &= 1.5 \times 1.2 \times 1 \times 74 = 133.20 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Efficiency} &= \frac{\text{Transport fleet capacity } \times F_{pxRt} \times \text{number of fleet}}{\text{amount of waste}} \times 100 \% \leq 100 \% \\ &\text{(all the rubbish is not picked up)} \end{aligned}$$

$$\begin{aligned} \text{Efficiency} &= \frac{\text{Transport fleet capacity } \times F_{pxRt} \times \text{number of fleet}}{\text{amount of waste}} \times 100 \% = \frac{133.20}{211.90} \times 100 \% \\ &= 62.86 \text{ (all the rubbish is not picked up)} \end{aligned}$$

From the calculation results with 1 ritation, the efficiency obtained is 62.86% compared to changing the ritation to 2 times, the following is the calculation:

$$\begin{aligned} \text{Waste capacity carried} &= \text{Transport fleet capacity } F_{pxRt} \times \text{number of fleet} \\ &= 1.5 \times 1.2 \times 2 \times 59 = 212.40 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Efficiency} &= \frac{\text{Transport fleet capacity } \times F_{pxRt} \times \text{number of fleet}}{\text{amount of waste}} \times 100 \% \leq 100 \% \\ &\text{(all the rubbish is not picked up)} \end{aligned}$$

$$\begin{aligned} \text{Efficiency} &= \frac{\text{Transport fleet capacity } \times F_{pxRt} \times \text{number of fleet}}{\text{amount of waste}} \times 100 \% = \frac{212.40}{211.90} \times 100 \% \\ &= 100.23 \% \text{ (all the rubbish is not picked up)} \end{aligned}$$

From the calculation results, the efficiency was successfully increased to 100.23% by changing the ritation to 2 times, making it possible for all household waste in the Cakranegara sub-district to be transported to the TPS, by maximizing the number of available fleets.

IV. CONCLUSION

The population in Cakranegara District has increased every year with an increase in the amount of waste generated per day, where the projected population in 2027 will reach 68,357 people with daily waste generation of 211.90 m³/day, requiring 118 transport fleets. By changing the 1-time ritation to 2-times, we can optimize the fleet currently available in Cakranegara District, namely 74 units. Where in the calculation to transport a waste volume of 211.90 m³/day with 1 ritation, 118 motorized carts are needed, and with 2 ritations, only 59 motorized carts are needed, so there is no need to procure a fleet. With a motorized cart capacity of 1.5 m³ and 1 transportation cycle, the waste transportation efficiency level achieved was only 62.86% and an

effectiveness value of 1.64, which means not effective enough. However, with the ritation changed to 2 times, with the same motor rickshaw capacity, the efficiency level can reach 100.23% and the effectiveness value is 0.99 which is shows that all waste will be transported and by changing the waste transportation routine it will be effective and efficient.

REFERENCE

- [1]. Agustina, E., Gewe,S.R., dan Widyarsana, I.M.W. 2019. Evaluasi Sistem Pengelolaan Sampah di Kawasan Kota Bandung. Jurnal Teknik Lingkungan Volume 26 Nomor 2
- [2]. Anggraini, dan Elka. 2019. Manajemen Pengolahan Sampah di Kota Semarang
- [3]. Dzakiyati, T.N., dan Rahmadyanti, E. 2020. Kajian Infrastruktur Pengelolaan Sampah Kota Sedang .jurnal Rekayasa Teknik Sipil 2.
- [4]. Ikhsandr. 2020. Kajian Infrastruktur Pengolahan Sampah di Kawasan Berkembang Jakabaring Kelurahan 15 Ulu Kota Palembang. Jurnal Teknik Sipil dan Lingkungan
- [5]. Itah, I. 2019. 2.695 sampah di NTB tak terurus, 28 juni 2019, tersedia di nasional.republika.co.id, diakses 07-12-2020 .