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Mapping a Potential Location of Temporary Waste Storage Sites (TPS) in Sorong and East Sorong Districts using Geographic Information Systems (GIS)

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ABSTRACT: Garbage is the result of waste from the activities of living things that are often encountered and cause many problems. One way to overcome the waste problem is to provide TPS. One area in Indonesia that does not yet have TPS facilities is in East Sorong and Sorong Districts, West Papua. This study aims to 1) determine the location of TPS in East Sorong District and Sorong District using the Geographic Information System (GIS), 2) know the recommended TPS type based on the mapping of TPS locations using GIS, 3) know the amount of waste generation in Sorong District East and Sorong District. The research phase begins with determining the sample TPS locations by looking at the parameters of the distance to built-up land, the main road and the river. Mapping the suitability of TPSlocations using the GIS application. Determination of waste samples and waste collection to calculate the amount of waste generation. The recommended locations for TPS construction in East Sorong District and Sorong District based on the results of analysis using GIS and field surveys are: a) East Sorong District, which consists of the Klamana Village, the Klawuyuk Village, and the Klawalu Village. b) Sorong District, which consists of North Remu Village and Klademak Village. Waste generation in East Sorong Districtis 0.00816 kg/person/day and Sorong District is 0.0122 kg/person/day.

KEYWORDS: TPS, garbage, GIS, East Sorong District, Sorong District

I. INTRODUCTION

Waste is a by-product of human activities originating from household activities, markets, offices, hotels, restaurants, industry, material debris and scrap metal from used motor vehicles (Sucipto, 2012). The waste management is still often an urgent problem in big cities in Indonesia and if it is not handled well it will cause new problems to emerge which will have an impact on human life and will also cause changes in environmental balance. Waste management has an important role in urban development. One of them is the creation of a temporary disposal site (TPS), which is a facility used to temporarily store waste from waste sources before being transported to the final disposal site (TPA).

The population based on data from the Central Statistics Agency (Sorong in 2021 Figures) is 289,767 people. Sorong City has several sub-districts including Sorong District and East Sorong District. Based on the Sorong Central Statistics Agency, Sorong District in 2020 had a population of 19,083 people and decreased to 18,925 people in 2021. Meanwhile in East Sorong District the population in 2020 was 40,3374 people and increased to 41,9822 in 2021. The increase in population will cause an increase in the volume of waste and will have an impact on increasing the need for waste facilities, especially waste facilities. TPS. TPS plays an important role in dealing with waste problems, because the existence of TPS can reduce the generation of waste in various places that are prone to being used as illegal waste dumps and prevent residents from throwing rubbish carelessly because there are TPS as waste storage places.

The areas that require special attention to this problem are Sorong District and East Sorong District in Sorong City. As a result of the unavailability of TPS in the sub-district, people still often throw rubbish there along the roads in Sorong District, one of which is an arterial road where you often find a lot of rubbish still scattered around, covering part of the road. Based on a report from the head of the Sorong City Environmental Service, requests for the provision of container type TPS facilities have been very frequent but have not yet received an answer from the central government and to date these requests have not been realized.

Another impact that arises due to the unavailability of TPS is that the process of transporting waste carried out by cleaning staff is less effective. The process of transporting waste is carried out only by transporting rubbish that has been wrapped in sacks, otherwise if the rubbish is not wrapped in sacks or plastic then the rubbish is not transported and is just left there until it piles up. The waste transportation process only applies to people's homes located on large highways where only waste transportation routes pass (Karden, 2003).

Based on the background description above, the problem formulation is obtained as follows. How much waste is generated in Sorong and East Sorong Districts? What will be the population in Sorong and East Sorong Districts in the next 10 years? How to map the development of TPS locations and

appropriate types of TPS in Sorong and East Sorong Districts using the Geographic Information System (GIS) application. What is the projected waste generation in Sorong and East Sorong Districts for the next 10 years?

This research was carried out with a purpose to find out the amount of waste generation in Sorong and East Sorong Districts, the population in Sorong and East Sorong Districts in the next 10 years, and to find out the mapping of determining the location of TPS construction and appropriate types of TPS in Sorong and East Sorong Districts using the Geographic Information System application (SIG).

II. METHODOLOGY

In the present work, the tools used are digital camera for taking pictures, a set of laptops, GIS application (ArcGIS), gloves and masks, trash bags, scales, roll meter, waste volume measuring tool in the form of a tub measuring (1.0 m x 0.5 m x 1.0 m). The supporting data are digitized regional maps in East Sorong District and Sorong District, such as administrative maps, land use maps, road network maps and river network maps, and supporting data such as population data and data on the number of residential and non-residential facilities.

The first stage is to carry out a location survey to observe the surrounding environment that will be planned, then data collection is carried out. After obtaining the required data, data processing is then carried out. The projected population growth calculation was carried out to determine the population of Sorong and East Sorong Districts for the next 10 years. The calculation of projected population growth in this study uses three methods, namely the arithmetic method, geometric method and least squares method. Calculations is carried out for each method and a suitable method is determined to calculate the projected population growth for the next 10 years.

Determination of TPS locations is carried out to obtain recommendations for TPS locations that can be used for building a new TPS. To obtain field survey data, determining the research location was carried out by selecting suitable land conditions to be used as a TPS. In determining the location of the TPS, the purposive sampling method was used. According to Junianto, 2011, the criteria of this method are: 1) not too far and not too close from built-up land, (< 30 m, which is bad, 50-100 m, which is good, and > 100, which is fair); 2) the distance from the main road is not too close and not too far, (< 30 m which is bad, 50-100 m which is good and > 100 m which is fair); 3) Located far from the river, (< 30 m, which is poor, 60-100 m, which is average and > 100 m, which is very good). Once a value for each parameter is obtained, then scoring is carried out to determine the suitability of each sampling location point.

After knowing the suitability value of each sampling location point, mapping is then carried out to obtain recommendations for TPS location points using the GIS application. Measuring the amount of waste generation is carried out using a method based on the Indonesian National Standard (SNI) 19-3964-1994 concerning taking and measuring samples of urban waste generation and composition. The number of waste samples taken from residential and non-residential facilities was determined randomly and proportionally to the waste source for 8 consecutive days. Then, calculations were carried out to analyse waste density, waste volume and waste generation rate in Sorong and East Sorong Districts. Measurement of waste volume is done by measuring the height of the waste in the measuring box and then multiplying it by the length and width of the measuring box (0.5 m x 1.0 m x 1.0 m). This step was done for 8 consecutive days to represent the dynamic cycle of waste production. Eq. (1) is used to calculate waste volume

$$V = h\ x\ A \tag{1}$$

Where h is the height of waste in the test box, A is the cross-sectional area of the box

Meanwhile, waste density measurements are carried out by mixing thoroughly and putting the waste into the measuring city for 8 consecutive days. Waste density is calculated using Eq. (2)

$$\rho = \frac{m}{V} \tag{2}$$

Where m is the mass of the waste and V is the volume of the waste

III.RESULTS AND DISCUSSION

3.1. Projection of Population

Population projections are scientific calculations based on components of population growth rates such as births, deaths and migration (Central Statistics Agency, 2010). The method used to determine the projected population is based on the Backward projection method. Backward projection method is a backward calculation projection that functions to determine the type of method that will be used in projecting the future population the next few years (Central Statistics Agency, 2010). Each method used must first find the standard deviation value. The smallest standard deviation value in backward projection will then be used as a population projection method in forward projection. Eq. (3) is used to determine the standard deviation value.

$$STD = \sqrt{\frac{\sum(Y_i - Y_{mean})^2}{n}} \tag{3}$$

Based on the three methods (arithmetic, geometric and least square) which have been calculated using backward projection. The standard deviation values present in Table 1.

Table 1. Standard deviation of population projections

Method	STD
Arithmetic	346.134,91
Geometry	9.615,36
Least square	100.691,92

The results of calculating the standard deviation value obtained show that the standard deviation value is close to the smallest value using the geometric method. Thus, geometric method is used in determining population growth projections with the formula given in Eq. (4).

$$P_n = P_o(1 + r)^n \quad (4)$$

Where Pn is the number of populations in n year, Po is the number of reference population, r is the rate of population growth, and n is year interval.

Table 2. The projected population growth for 10 years

No	Year	Populations	
		Sorong	East Sorong
1	2021	18925	41982
2	2022	18787	42057
3	2023	18651	42132
4	2024	18515	42207
5	2025	18381	42282
6	2026	18247	42357
7	2027	18114	42432
8	2028	17983	42508
9	2029	17852	42584
10	2030	17772	42660

3.2. Mapping Locations and Suitability of TPS

Obtaining field survey data to determine the research location was carried out by selecting suitable land conditions to be used as a TPS. The method used is a purposive sampling method (Daruati, 2003). Purposive sampling is a technique of determining samples using certain criteria. In determining the location sample points, three important parameters have to be considered, i.e. 1) distance of TPS to roads, 2) distance of TPS to rivers, 3) distance of TPS to built-up land. The distance to the road is required to have a strategic location with adequate road facilities. A good road network requires considering the capacity and number of vehicles and anticipating the possibility of road damage early, which will be very useful when transporting waste, especially in order to facilitate mobility and achieve a good level of accessibility (accessibility) in transporting waste. The distance to the river is there a close relationship with the impact that will arise, namely pollution, so the distance between the TPS and the river must be considered to anticipate pollution in the river area.

The farther the TPS location is from the water source, the better it will be because it will have an impact on the leachate drainage process. The distance of TPS to settlements is closely related to the impact of pollution. Pollution caused by the proximity of TPS to settlements can cause unpleasant odors for people who live in residential areas close to TPS. Determining the suitability of TPS locations is carried out using the scoring method. The scoring or award approach is a weighted tiered award. Classification of the parameters produces a location suitability map for the TPS location after being multiplied by the weight for each parameter that has been determined. The results of the field survey to determine the location and suitability of the Sorong Subdistrict TPS sample points can be seen in Table 3 and for the location and suitability of the East Sorong District TPS sample points can be seen in Table 4

Based on the data obtained, a classification of the suitability of TPS locations for East Sorong District was figured out. The very suitable classification obtained 5 location points, the appropriate classification obtained 6 location points, the less suitable classification obtained 8 location points and the unsuitable classification obtained 2 location points. Those data were then processed using ArcGIS software to obtain a map of the suitability of TPS locations for Sorong District and East Sorong District which can be seen in Figure 1.

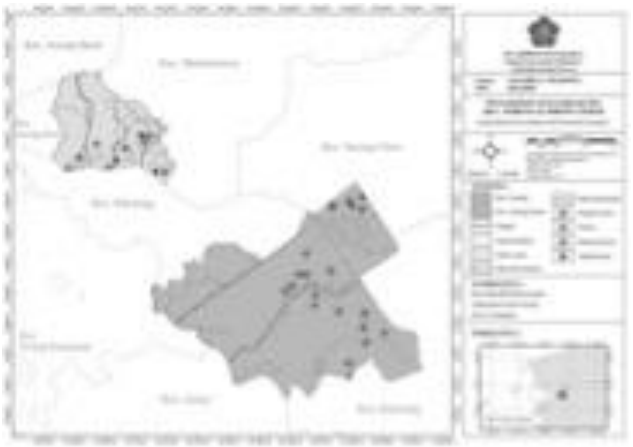

Fig. 1. Map of potential location for TPS Sorong District and East Sorong

the mapping location has a land area ranging between 10-50 m2, it is more appropriate to recommend it for the construction of type 3 TPS, whereas for mapping locations that have a land area between 60-200 m^2 it is more appropriate to recommend it for the construction of type 2 TPS and for mapping locations that have land area > 200 m^2 is recommended for construction of TPS type 1.

Based on the results of mapping TPS construction locations in Sorong District and East Sorong District using the GIS application, suitable locations for TPS construction according to type can be seen in Table 5.

3.4. Waste Generation

The waste that has been taken is waste that is in several residential and non-residential facilities which is obtained based on calculating the number of waste samples to be taken and measuring waste generation using a density box. Determining the amount of waste generation is aimed at: look for the results of waste volume and waste density to obtain waste generation results for Sorong District and East Sorong District. Measuring the volume of waste is done by measuring the height of the waste in the measuring box and then multiplying it by the length and width of the measuring box. Waste volume data collection was carried out for 8 consecutive days to represent the dynamic cycle of waste production for 1 week. The following is the volume of waste from residential and non-residential facilities for 8 consecutive days starting from waste sampling on February 27 - March 6, 2023 for East Sorong District and 13 – 20 March 2023 for Sorong District.

3.3. Recommendation of TPS Location

Based on the types of TPS according to SNI 19-2454-2002, recommendations for TPS that are suitable for mapping locations in East Sorong District and Sorong District are determined based on the land area of the mapping location. If

Table 3. Location points and classification of suitability of TPS locations in Sorong District

Coordinate			Location	Parameters				
No	X	Y		A (m)	B (m)	C (m)	Score	Classification
1	S 0˚52'57.5976"	E 131˚16'42.7188"	North Remu	45	450	55	20	Suitable
2	S 0˚52'53.364"	E 131˚16'47.7336"	North Remu	25	700	10	9	Not suitable
3	S 0˚52'44.7852"	E 131˚16'53.7636"	North Remu	95	500	20	15	Less suitable
4	S 0˚52'40.9404"	E 131˚17'06.0576"	North Remu	100	460	30	18	Suitable
5	S 0˚53'00.726"	E 131˚17'13.1172"	North Remu	70	730	15	9	Not suitable
6	S 0˚53'01.0392"	E 131˚17'19.1472"	North Remu	80	520	20	12	Less suitable
7	S 0˚53'01.0392"	E 131˚17'19.1472"	North Remu	20	290	30	12	Less suitable

8	S 0˚52'36.7752"	E 131˚17'04.2648"	North Remu	35	300	40	10	Not suitable
9	S 0˚52'58.6452"	E 131˚16'16.5"	Klademak	20	275	120	17	Suitable
10	S 0˚52'42.4812"	E 131˚16'35.0112"	Klademak	110	400	60	19	Suitable
11	S 0˚52'51.1176"	E 131˚16'23.5632"	Klademak	40	350	30	14	Less suitable

A= main road distance; B = river distance; C = building distance

Table 4. Location points and classification of suitability of TPS locations in East Sorong District

Coordinate			Location	Paremeters				
No	**X**	**Y**		**A (m)**	**B (m)**	**C (m)**	**Score**	**Classification**
1	S 0˚54'33.2964"	E 131˚19'29.0244"	Klamana	70	220	70	22	Very suitable
2	S 0˚54'32.2688"	E 131˚19'12.216"	Klamana	20	200	130	15	Less suitable
3	S 0˚55'05.9772"	E 131˚19'18.7608"	Klamana	100	110	110	21	Very suitable
4	S 0˚54'46.3788"	E 131˚19'41.8224"	Klamana	230	115	50	16	Suitable
5	S 0˚55'14.2644"	E 131˚19'19.9956"	Klamana	40	170	110	17	Suitable
6	S 0˚54'43.128"	E 131˚19'28.074"	Klamana	25	200	30	12	Less suitable
7	S 0˚54'52.9596"	E 131˚19'29.5788"	Klamana	70	97	25	12	Less suitable
8	S 0˚54'28.4184"	E 131˚18'56.1924"	Klamana	30	140	105	17	Suitable
9	S 0˚54'21.4096"	E 131˚18'57.0744"	Klamana	120	120	120	17	Suitable
10	S 0˚54'18.792"	E 131˚18'37.4076"	Klawalu	90	135	20	15	Less suitable
11	S 0˚54'05.724"	E 131˚19'07.1148"	Klawalu	50	270	30	14	Less suitable
12	S 0˚53'22.3908"	E 131˚19'08.4"	Klawuyuk	90	155	45	18	Suitable
13	S 0˚53'20.4468"	E 131˚19'18.9876"	Klawuyuk	30	90	40	13	Less suitable
14	S 0˚53'22.7076"	E 131˚19'20.5284"	Klawuyuk	60	160	100	24	Very suitable
15	S 0˚53'17.1852"	E 131˚19'27.7716"	Klawuyuk	20	100	10	8	Not suitable

A= main road distance; B = river distance; C = building distance

Table 5. Recommendations for TPS types

No	X-Coordinate	Y-Coordinate	District	Sub-district	TPS Type
1	S 0˚55'14.2644"	E 131˚19'19.9956		Klamana	
2	S 0˚54'28.4184"	E 131˚18'56.1924		Klamana	
3	S 0˚54'21.4096"	E 131˚18'57.0744"		Klamana	I
4	S 0˚53'22.3908"	E 131˚19'08.4"	North Sorong	Klawuyuk	
5	S 0˚53'54.0996"	E 131˚18'51.0552"		Klawalu	
6	S 0˚54'21.4096"	E 131˚18'57.0744"		Klamana	
7	S 0˚54'33.2964"	E 131˚19'29.0244"		Klamana	II
8	S 0˚55'05.9772"	E 131˚19'18.7608"		Klamana	

9	S 0˚54'46.3788"	E 131˚19'41.8224"		Klamana	III
10	S 0˚52'57.5976"	E 131˚16'42.7188"		North Remu	I
11	S 0˚52'58.6452"	E 131˚16'16.5"		Klademak	II
12	S 0˚52'42.4812"	E 131˚16'35.0112"	Sorong	Klademak	
13	S 0˚52'40.9404"	E 131˚17'06.0576"		North Remu	III

Table 6. Results of waste volume measurements

No	Sorong		North Sorong	
	Height (m)	Volume (m^3)	Height (m)	Volume (m^3)
1	3.52	1.76	2.55	1.275
2	3.41	1.705	2.45	1.225
3	3.6	1.8	2.52	1.26
4	3.29	1.645	2.33	1.165
5	3.67	1.835	2.35	1.175
6	3.17	1.585	2.2	1.05
7	3.63	1.815	2.38	1.19
8	3.45	1.725	2.3	1.15

Based on the Table 6, total volume of waste per day for 8 consecutive days, it can be seen that there is a difference in the amount of waste in East Sorong District and Sorong District. East Sorong District ranges 1.58 – 1.81 m^3/day. Meanwhile, Sorong District ranges from 2.29 – 2.89 m^3/day. The increase in the amount of waste in East Sorong District and Sorong District is caused by several factors, including the type and amount of waste produced by the community from both residential and non-residential activities.

3.5. Waste Density

Waste density measurements are carried out based on SNI 19-3964-1994 by mixing thoroughly and putting the waste in a wooden box measuring 0.5 m x 1.0 m x 1.0 m. Waste density measurements were carried out every day for 8 consecutive days. Density can be determined by dividing the weight of the waste in the box by the volume of the waste. The volume of waste is determined by measuring the height of the waste in a measuring box and then multiplying it by the length and width of the box. After carrying out calculations for 8 consecutive days, the results of the waste density are known

Table 7. Waste density

Based on the data above, the rate of waste generation can be calculated using the following formula

$$WGR = \frac{V x \rho}{n} \quad (5)$$

Where V is the waste average volume, ρ is the waste density, and n is the number of populations. The waste generation rate obtained for Sorong District were 0.012 kg/person/day and for East Sorong District it was 0.0081 kg/person/day.

3.6. Waste generation projections

According to SNI 19-3964-1995, the classification of cities based on the population of Sorong City is included in the category of small cities with a population of between 3,000 to 500,000 people so that the waste generation used based on SNI 19-3983-1995, waste generation in small cities is around 2, 75 litres/person/day. Calculation of the volume of waste generation can be done by multiplying the population from 2021 - 2030 by the waste generation standards in SNI 19-3983-1995. Based on the amount of waste generation that has been calculated, the projected waste generation can be calculated so that the results of the analysis of the projected waste generation for the year 2021 – 2030 can be seen in Table 8 and Table 9, respectively. Comparing Table 8 and Table 9 with field data, the results obtained for the projected volume of waste generation in Sorong District, the projected volume of waste generation obtained in 2021 is 227.1 m^3/day or 82,891 m^3/year and in 2030 amounting to 0.212664 m^3/day or 77,622 m^3/year. Meanwhile, for East Sorong District in 2021 is 0.3400 m^3/day or 124,119 m^3/year and in 2030 it will be 0.3455 m^3/day or 126,121 m^3/year.

IV. CONCLUSION

Mapping A Potential Location of Temporary Waste Storage Sites (TPS) in Sorong and East Sorong Districts Using Geographic Information Systems (GIS) has been done and analyses. It can be concluded that:

1. the calculation results of the projected population in East Sorong District for the next 10 years are 42,659 people and for Sorong District in 2030 it will be 17,593 people.
2. waste generation in East Sorong District and Sorong District is based on the results of calculations using a density box, the waste generation rate obtained for East Sorong District is 0.00816 kg/person/day and Sorong District is 0.0121 kg/person/day.

3. a map of the suitability of TPS locations in East Sorong District and Sorong District: a) Map of TPS locations in East Sorong District, there are 21 location points which are divided into 5 location points with a very suitable classification, 6 location points with a suitable classification, 8 location points with a less suitable classification and 2 location points with an inappropriate classification. b) The TPS location map in Sorong District contains 11 location points which are divided into 5 location points with appropriate classification, 4 location points with inappropriate classification and 4 location points with inappropriate classification.
4. The recommended TPS types based on TPS location mapping using GIS are: a) East Sorong District has 4 location points with TPS I type, 3 location points with TPS II type and 1 location point with TPS III type. b) Sorong District is there 1 location point is TPS I type, 2 locations are TPS II type and 1 location point is TPS III type.
5. The projected results of the amount of waste generation for the next 10 years: a) East Sorong District in 2030 is 0.3455 m3/day or 126,121 m3/year. b) Sorong District in 2030 amounting to 0.212664 m3/day or 77,622 m3/year.

Table 7. Results of waste density calculations

No	Height (m)	Volume (m^3)	Sorong		North Sorong			
			Weight (kg)	Density (kg/m^3)	Height (m)	Volume (m^3)	Weight (kg)	Density (kg/m^3)
1	2.55	1.275	241.4	241.4	3.52	1.76	348.8	198.18
2	2.45	1.225	231.2	231.2	3.41	1.705	335	196.48
3	2.52	1.26	235.7	235.7	3.6	1.8	346.3	192.39
4	2.33	1.165	226.5	226.5	3.29	1.645	323.4	196.60
5	2.35	1.175	228.8	228.8	3.67	1.835	348.6	189.97
6	2.1	1.05	219.9	219.9	3.17	1.585	316.9	199.94
7	2.38	1.19	229.5	229.5	3.63	1.815	347.2	191.29
8	2.3	1.15	221.6	221.6	3.45	1.725	338.3	196.12

Table 8. Projection of waste generation in Sorong District for the next 10 years

No	Year	Population Projection	Waste generation (l/day)	Projection of waste generation (l/day)	Projection of waste generation (m^3/day)	Projection of waste generation (m^3/year)
1	2021	18925	0.012	227,1	0,2271	82.891
2	2022	18787	0.012	225,444	0,225444	82.287
3	2023	18651	0.012	223,812	0,223812	81.691
4	2024	18515	0.012	222,18	0,22218	81.095
5	2025	18381	0.012	220,572	0,220572	80.508
6	2026	18247	0.012	218,964	0,218964	79.921
7	2027	18114	0.012	217,368	0,217368	79.339
8	2028	17983	0.012	215,796	0,215796	78.765
9	2029	17852	0.012	214,224	0,214224	78.191
10	2030	17722	0.012	212,664	0,212664	77.622

Table 8. Projection Of Waste Generation In North Sorong District For The Next 10 Year

No	Year	Population Projection	Waste generation (l/day)	Projection of waste generation (l/day)	Projection of waste generation (m^3/day)	Projection of waste generation (m^3/year)
1	2021	41982	0,0081	340,0542	0,3400	124.119
2	2022	42056	0,0081	340,6536	0,3406	124.338
3	2023	42131	0,0081	341,2611	0,3412	124.560
4	2024	42206	0,0081	341,8686	0,3418	124.782
5	2025	42281	0,0081	342,4761	0,3424	125.003

6	2026	42356	0,0081	343,0836	0,3430	125.225
7	2027	42432	0,0081	343,6992	0,3436	125.450
8	2028	42507	0,0081	344,3067	0,3443	125.671
9	2029	42583	0,0081	344,9223	0,3449	125.896
10	2030	42659	0,0081	345,5379	0,3455	126.121

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