Doi http://doi.org/md.v13i2.701

Planning Of 3r Integrated Waste Processing Site In Klawuyuk Village, East Sorong, West Papua

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ABSTRACT

Sorong City is one of the areas in West Papua Province that has a fairly fast economic growth rate. It is due to its strategic position in inter-regional transportation routes in West Papua Province, which furthermore triggers the acceleration of regional development as reflected in the HDI and the level of community welfare. However, this condition at the same time also raises a number of problems related to environmental problems, particularly waste problem in Klawuyuk village, East Sorong. The generation waste produced tends to increase along with the population growth. Therefore, an alternative processing is necessary to cope the issue. The construction 3R Integrated Waste Processing Site is considered as an alternative to reduce the rate of waste disposal as well as to manage waste generation in final disposal site (landfill), which can directly extend the existence of it. The objective of this study was to plan an integrated waste management site in Klawuyuk village, East Sorong. The method used was descriptive method with observation technique. The result revealed that the average volume of waste generation in Klawuyuk village was 1.95 liters/person/day with the average generation weight was 0.42 kg/person/day. The total area of the 3R Integrated Waste Processing Site is 415,609 m^2.

Keywords : *Planning, 3R Integrated Waste Processing Site, Waste Management, TOWS Analysis, East Sorong*

INTRODUCTION

West Papua Province has several regencies and cities, which one of them is Sorong City. Sorong City is a very strategic city due to its position as a transit gate for exit and entry port of West Papua Province. Sorong City is located between 131° 17' East Longitude and 0° 5' South Latitude and is traversed by the equator. Sorong City consists of 10 districts, one of which is East Sorong District with total area of 69.39 Km^2. Klawuyuk is one of villages in East Sorong District. In 2015, total population was reaching 10.326 people and kept increasing 10.589 people in 2016. The population continue to increase by 11.582 people in 2018 and at the end of 2019, the population increase to be as many as 11.777 people, with 2.974 heads of families.

The increased number of population is directly related to the problem of waste generation. The problem includes the imbalance of waste generation with the number of available temporary shelters. It is due to they have not been able to accommodate the increasing rate of waste generation in this region. If this condition is not accompanied by efforts to improve and enhance the performance of the waste management system, then

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it will impact the environment. Waste problems must be handled properly, not only its process but also its management efforts. The management efforts carried out are starting from the source of waste generation, storage, collection, transfer, transportation to the final disposal site (landfill). In addition, the effort to reuse waste that can still be recycled must be done in order to reduce waste quantitatively. Thus far, based on the reality, people's habit to throw garbage in the provided containers is still very low. This is due to lack of public awareness about the importance of maintaining cleanliness and assuming that waste management is the responsibility of the district or city government, particularly the city cleansing departments or other bureaus that handle waste management.

Integrated solid waste management based on the 3R approach (reduce, reuse, recycle) is an approach that can be used as a solution to properly manage or solve the solid waste problems. Integrated solid waste management based on the 3R approach involves activities in reducing, sorting, collecting, utilizing, transporting, and processing from the source on a communal level. The main concept of waste management based on 3R approach is to minimize the amount waste and to fix the characteristics of the waste, which will be further processed at the waste final processing site (TPA). Moreover, the Integrated Waste Management System is addressed to manage waste more effectively in order to answer the waste management problem that has not yet been completely resolved. To cope the issue, an alternative management needed is waste management planning, especially Integrated Waste Processing Site (TPST) based on the 3R approach. Planning for the Integrated Waste Management Site is specifically allocated to manage both organic and inorganic waste, generated from the community residential area in Klawuyuk Village, East Sorong District.

METHODS

The planning of integrated waste processing site 3R is located in Klawuyuk Village on Basuki Rahmat street, East Sorong District, West Papua with total area of 69.39 km^2. The village is dominated by residential areas and shops with paved and wide road condition which makes it easy to access. In this research, quantitative method with observation and interview techniques have been used to planning the Integrated Waste Processing Site based on 3R approach in Klawuyuk Village. In addition, sampling was carried out randomly using research instrument to perform statistical data analysis. The selection of the methods is related to the research data performed by numbers as well as the analysis using statistics (Sugiyono, 2012:7).

Before conducting the research regarding the weight of waste or waste generation, it is necessary to calculate the number of samples of waste to determine the number of housings, which is using the formula (SNI 19-3964-1994). The method of collecting waste samples is carried out directly at the waste source of each housing. The total sample of waste generation from the housing is calculated based on the formula below:

$S = Cd \sqrt{Ps}$

Description:

S = Total number of sample (people)

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Cd = Housing Coefficient
Cd = 1 (Big city/metropolitan)
Cd = 0,5 (Middle or small city)
Ps = Population (people)

Number of head of household observed:

$$K=\frac{S}{N}$$

Description:
K = Total of sample (head of household)
N = Average number of people per family
S = Number of sample people

The rate of waste generation is also determined by the classification of community settlements. Based on SNI 19-3964-1994 regarding Methods of Collection and Measurement of Sample Generation and Composition of Urban Waste, settlements are classified into permanent, non-permanent and semi-permanent settlements. The number of examples of waste generation from housing is listed as follows:

Example of permanent housing = (S1 x F) family
Example of semi-permanent housing = (S2 x F) family
Example of non-permanent housing = (S3 x F) family

Where :
S1 = Proportion of total household head in permanent housing (25%)
S2 = Proportion of total household head in semi-permanent housing (30%)
S3 = Proportion of total household head in non-permanent housing (45%)

The number of samples to answer the questionnaires was determined using the probability sampling technique, namely proportionate stratified random sampling by using the Slovin formula. For proportionate stratified random sampling, the samples are calculated based on comparison. In addition to that, this technique is used when the members of population are not homogeneous and stratified proportionally. Through this proportionate stratified random sampling, the samples selected in this research are the number of families whom live in PAM Resident located in Klawuyuk Village, East Sorong. This method was chosen due to the population has been identified, thus to get the samples, the following equation is used:

$$n= N/Nd2 + 1$$

Where :
n = sample size (total number of responden)
N = total of head of household
d = degree of confidence of the study

After collecting primary as well as secondary data, we therefore run an analysis of problem that emerges in the planning stage of Integrated Waste Management Site.
Several analyzed data discussed include:

1. Analyze the prediction of population growth
2. Analyze the projection of heap trash

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3. Analyze the projection of trash composition
4. Analyze the Mass Balance
5. Analyze the material loading rate
6. Analyze the land requirement
7. TWOS Analyze

According to Kertajaya, et al (2005:72), the reason to use TOWS analysis instead of SWOT analysis is due to this analysis begins with identifying the external factors by conducting an analysis of threats and opportunities, then followed by the identification of internal factors by analyzing the strengths and weaknesses. This sequence of the analysis is based on the fact that in the 1990s, the change and turbulence of external environment became more and more important far beyond changes in the internal environment. Therefore, in this study we start analyzing the external factors firstly and continue analyzing the internal factors (*outside-inside approach*), thus examining how they link up, impact and influence each other.

RESULTS AND DISCUSSIONS

The Analysis of Population Growth

Population projection is a scientific estimation based on assumption of the tree components of population change which are Fertility, Mortality and Migration. Population growth is a major factor in various planning of an area. Therefore, projection of population growth is extremely needed to calculate or determine the amount of waste generated in a planning area. The population projection of Klawuyuk Village has been carried out for the next 10 years or until 2029. According to the Central Bureau of Statistics of Sorong Municipality, the population in Klawuyuk Sorong Timur Village at the end of 2019 is reaching 11,777 people, as shown in the following Table 1.

Table 1. Total Population of Klawuyuk Village, East Sorong for the Last 8 Years

Year	Total Population (people)
2012	9.695
2013	9.874
2014	10.128
2015	10.326
2016	10.589
2017	11.232
2018	11.582
2019	11.777

Geometric Method

One example calculation of the Geometric Method in 2013:

Yi = Po + (1+r).(dn)
= 9.695 + (1+2,47%) x (2013-2012)
= 9.935

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Xi - $\overline{Xi}$` = 9.874 – 10.650
= - 776
Yi - $\overline{Yi}$` = 9.935 – 10.606
= - 643
X^2 = (-776)
= 602.758
Y^2 = (-643)
= 412.819
X.Y = (-776). (-643)
= 498.829

Result of calculation is thus presented in Table 2.

Table 2. Calculation of Correlation Coefficient of Population with Geometric Method

Year	Total Population	Geometric Method	XI - XI	YI - YI	X2	Y2	X.Y
	xi	Yi	X	Y			
2012	9.695	9.695	- 955	- 882	912.741	778.583	842.998
2013	9.874	9.935	- 776	- 643	602.758	412.819	498.829
2014	10.128	10.181	- 522	- 397	272.876	157.381	207.233
2015	10.326	10.433	- 324	- 145	105.219	20.977	46.980
2016	10.589	10.691	- 61	113	3.767	12.832	-6.952
2017	11.232	10.955	582	378	338.288	142.714	219.723
2018	11.582	11.226	932	649	867.925	420.961	604.452
2019	11.777	11.504	1.127	927	1.269.284	858.517	1.043.888
Total	85.203	84.619	0	0	4.372.858	2.804.783	3.457.150
Average	10.650	10.577			Correlation coefficient		0,99

Description to find the correlation value on the Geometric Method is described as follows:

$$r = \frac{n(\sum X.Y) - (\sum Y).(\sum X)}{\sqrt{[n.(\sum Y2) - (\sum Y)2].[(n.(\sum X2) - (\sum X)2]}}$$

$$r = \frac{8.(3.457.150) - (0).(0)}{\sqrt{[8.(2.804.783) - (0)2].[8.(4.372.858) - (0)2]}} = 0{,}98715$$

Based on the calculation of the value of the correlation coefficient, it was found that for the arithmetic method, r = 0.98467, for the geometric method, r = 0.98715 and for the Least square method, r = 0.98467. Therefore, the method that can be applied based on the value of the correlation coefficient is the geometric method. It is due to the method has a final result close to one (1) compared to both the arithmetic and least square methods. Hence, the result of projected population of Klawuyuk Village from 2019 to 2029 is presented in Table 3.

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Table 3. The Projection Result of Total Population from 2019 to 2029

Projection Year	Geometric Method (people)
2019	11.504
2020	11.788
2021	12.080
2022	12.379
2023	12.685
2024	12.999
2025	12.999
2026	13.320
2027	13.650
2028	13.988
2029	14.334

The Analysis of Waste Density

Table 4. Waste Density of Klawuyuk Village, East Sorong

Day to-	Trash Weight (Kg)	Trash Volume (m3)	Density (Kg/m3)
1	2,0556	0,0101	203,30
2	1,9222	0,0095	203,05
3	1,7333	0,0089	195,49
4	1,8725	0,0085	220,01
5	1,9889	0,0088	224,87
6	2,2833	0,0092	248,79
7	1,9000	0,0089	212,69
8	1,9056	0,0087	218,75
Average			215,868

The Analysis of Waste Generation

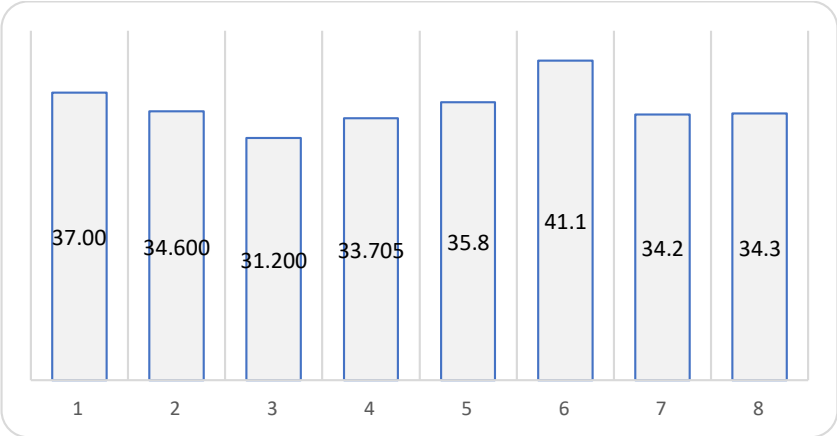

Figure 1. Total of Trash per day in Klawuyuk Village, East Sorong

Based on our observation in the site during 8 consecutive days, we found that the average value of total waste generation was 0.5005 kg/person/day. Furthermore, the

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projection of waste generation for 10 years is predicted to be 70,933 tons/day. The projection of waste generation for the next 10 years is shown in Table 5.

Table 5. The Projection of Waste Generation

Year	Total Population (people)	Waste Generation (kg/person/day)	Total Amount of Waste (ton/day)
2019	11.504	0,5005	5.758
2020	11.788	0,5005	5.900
2021	12.080	0,5005	6.046
2022	12.379	0,5005	6.196
2023	12.685	0,5005	6.349
2024	12.999	0,5005	6.506
2025	12.999	0,5005	6.506
2026	13.320	0,5005	6.667
2027	13.650	0,5005	6.832
2028	13.988	0,5005	7.001
2029	14.334	0,5005	7.174
Total			70.933

Analysis of Waste Composition

Table 6. The Result of Measuring Average Composition of Waste Generation

No	Waste Components	Percentage (%)
1	Organic (leftover food + twigs + leaves)	70,61
2	Plastic	16,46
3	Metal	0,58
4	Glass	0,57
5	Paper and Cardboard	8,22
6	Rubber and Leather	1,71
7	Cloth	1,60
8	Etc (others)	0,24
Total		100

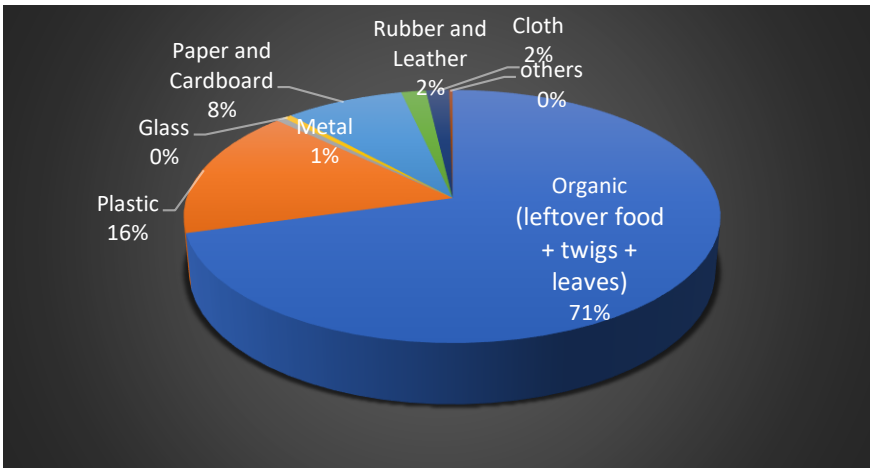

Figure 2. Percentage of Waste Composition

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Mass Scale and Recovery Factor

Table 7. The Result of Measuring Waste Recovery Factor

No	Waste Components	Weight Recovery (kg)	Recovery Factor (%)	Volume Recovery (liter)
1	Organic (leftover food + twigs + leaves)	2.796,63	58,71	10.895,94
2	Plastic	732,12	65,95	2.852,43
3	Metal	3,24	8,25	12,64
4	Glass	3,66	9,52	14,25
5	Paper and Cardboard	334,44	60,28	1.303,00
6	Rubber and Leather	33,57	29,06	130,80
7	Cloth	52,74	48,96	205,49
8	Etc (others)	0,00	0,00	0,00

Tabel 8. The Result of Mass Scale of Integrated Waste Processing Site

Waste Component	Component Weight (ton)	Component Volume (m)	Weight Recovery (ton)	Volume Recovery (m^3)	Weight Residue (ton)	Volume Residue (m^3)
Composted Waste	4,763	18,557	2,797	10,896	1,966	7,661
Selected Waste to be reuse	1,982	7,722	1,159	4,519	822,30	3,204
Total	6,745	26,280	3,956	15,415	2,789	10,865

Table 9. Total Residue of Waste at Integrated Waste Processing Site in Klawuyuk Village, East Sorong

Waste Components	Component Weight (ton)	Component Volume (m^3)
Total waste come in	6,745	26,280
Managed waste	3,956	15,415
Initial residue	0,130	0,652
Total Residue	2,919	10,867

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The Layout of the Integrated Waste Management Site

Figure 3. The Layout of the Integrated Waste Management Site of Klawuyuk Village, East Sorong

The Description of Pictures :

1. Office
2. Post
3. Entrepot
4. Toilet
5. Container parking area
6. Reception and selection area
7. Organic waste
8. Inorganic waste
9. Compost and counting area
10. Compost maturation and sifting area
11. Compost and goods storage areas

The Budget Plan for Integrated Waste Processing Site Development

Table 10. Recapitulation of Budget Plan for Integrated Waste Processing Site Development

No.	Works	Total (Rp)
1	Preparatory Work	333.879
2	Building Foundation Work	313.365
3	Building Structure Work	950.746
4	Brick and Plaster Installation Work	065.974
5	Flooring Work	202.518
6	Roofing and Ceiling Work	667.902
7	Door and Window Works	6.100.525
8	Painting Work	759.206
9	Electrical Installation Work	101.900
10	Sanitation and Installation Work	937.945
11	Steel and Steel Structure Work	673.227
	Total	684.107.186

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TWOS Analysis

Table 11. Evaluation Matric for External and Internal Factors

Key External Factors
Opportunities: 1. The Availability of the land for Construction of Integrated Waste Processing Site development based on 3R in Klawuyuk Village, East Sorong (land area is 890,228 m^2). 2. The Population of Klawuyuk village is larger than other villages in East Sorong District (11.777 people). 3. There is no strict local policy/regulation concerning waste management.
Threats: 1. Lack of human resources for operating 3R Integrated Waste Processing Site. 2. Complaint from local community against 3R Integrated Waste Processing Site. 3. Standard operating procedure and standard management of technical criteria for infrastructure and facilities. 4. Operational funding and maintenance for Integrated Waste Processing Site planning. 5. Plan for future facility development related to funding and operation. 6. Waste management at 3R Integrated Waste Processing Site. 7. Status of land ownership (property right) on the planning of 3R Integrated Waste Processing Site.
Key Internal Factors
Strengths: 1. Reduce quantity/enhance waste character. 2. A pattern of approach of waste management on a communal or regional scale. 3. Protect air quality from burning waste pollution. 4. Improve environmental cleanliness. 5. Protect soil quality from pollution caused by landfill activities. 6. Protect river water quality from trash dump. 7. Expand the technical life of the landfill. 8. The construction of 3R Integrated Waste Processing Site is conducted in the legal land.
Weaknesses: 1. Odor disturbance due to waste managed at 3R Integrated Waste Processing Site in residential area. 2. Long term maintenance of facilities and infrastructure of 3R Integrated Waste Processing Site. 3. Lack of public knowledge about the function of 3R Integrated Waste Processing Site. 4. Inappropriate selection of technology (causing pollution).

CONCLUSION

The amount of waste generated in Klawuyuk village, East Sorong was 0.5005 kg/person/day or 1.95 liters/person/day with the projected waste generation was of 70.933

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tons/day for 10 years. The composition of the generated waste covered 70.61% of organic waste, 16.46% plastic, 0.58% metal, 0.57% glass, 8.22% paper and cardboard, 1.71% rubber and leather, 1.60% cloth, and the others 0.24%. The planning area for Integrated Waste Processing Site (TPST) based on the 3R approach was 415,609 m^2, divided into 28 m^2 for receiving and sorting area, 290,25 m^2 for composting area, 29,609 m^2 for storage of compost and goods, 25 m^2 for office space, 14 m^2 for container parking area, 12.30 m^2 for building equipment area and 16.45 m^2 for toilet area.

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