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Solid waste management strategies planning of Cimahi City based on 2018 district/city sanitation strategy guideline

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ABSTRACT
Background: Cimahi City is one of the cities in West Java facing solid waste problems, such as the limited implementation of waste sorting activities, the limited number of transfer stations, the indiscriminate waste disposal on river, open burning of solid waste, etc. In overcoming these various waste problems and achieving the target of 30% waste reduction determined by the National Strategic Policy, an instrument is needed to analyze risk areas based on the level of risk of solid waste per village in Cimahi City. **Findings:** These risk areas are depicted in the form of maps by referring to the 2018 District/City Sanitation Strategy Guidelines. Risk areas are assessed through a score of 1 until 4 for very low, low, high and very high risks. The score is obtained by multiplying the Impact parameters and Exposure parameters. **Methods:** This study uses a quantitative approach. The object of this research is the amount of flow discharge in the five river sections, while the subject of this research is the observation. **Conclusion:** The results of this study indicate that there are three villages with very high risk of solid waste, namely Village Cibeureum, Setiamanah, and Padasuka and one village with high risk of solid waste, namely Village Melong. The addition of the number of treatment units was recommended in several villages so that changes in the score of risk areas occurred.

KEYWORDS: guideline; management; sanitation; strategy; waste.

1. Introduction

In 2018, there were still people in Cimahi City who indiscriminate waste disposal on river (Juwana et al., 2014; Hikmat & Juwana, 2019). One of the rivers that became the disposal site is Sungai Curug, which is located in Village Utama, Sub-district Cimahi Selatan, Cimahi City. The types of waste contained in the river are household waste such as used plastic, food and beverage waste, styrofoam, and others. A total of 1.5 tons of garbage originating from the northern and central parts of Cimahi City are carried by the flow of rain water so that it accumulates in the southern part of the city (Haryanto, 2018). The limitation of the number of transfer station as a waste transfer facility is one of the factors that causes the waste disposal into the river. The difficulty of obtaining permits from the community and the limited land area caused the minimum number of transfer station in Cimahi City. In addition to the limited garbage transfer facilities, there are several solid waste problems in

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other technical aspects, such as inadequate capacity of garbage containers in several source locations, limited application of waste sorting activities, limited collection fleet, waste handling by open burning and stockpiling, and others (Ministry of Environment and Forestry Republic of Indonesia, 2019; Pranaditya & Juwana, 2019; Juwana & Albar, 2019; Farida & Juwana, 2016).

Referring to Presidential Regulation No. 97 In 2017, solid waste management directions and policies consist of reduction and handling. National strategic policy (Jakstranas) targets waste reduction by 30% and waste management by 70% of the waste generation rate (Presidential Regulation of the Republic of Indonesia, 2017). In following up on various waste problems that occurred in Cimahi City and achieving the targets set by Jakstranas, an instrument is needed to analyze risk areas based on the level of risk of solid waste per village in Cimahi City. The instrument is 2018 District/City Sanitation Strategy Guideline which can then be used in this solid waste management strategies planning in Cimahi City.

The objectives of the implementation of this study are (1) Calculating the score of the risk areas in Cimahi City; (2) Mapping out risky waste areas in all villages in Cimahi City; and (3) Developing solid waste reduction strategies based on the risk areas of solid waste in Cimahi City.

2. Methods

2.1 Flow Rate Measurement

The data used in this research comes from primary data and secondary data. Primary data was obtained by observation including direct flow discharge measurements in the field in the upstream, middle and downstream parts of the river as well as in the water catchment area around residential areas and mixed gardens using the float method by dividing it into several segments. Secondary data was obtained from aerial photography of the 2020 Bompon watershed to determine the location of each section. The population of this study is the Bompon sub-watershed river flow in the upstream, middle and downstream parts as well as river flow in residential catchment areas and mixed gardens. Meanwhile, the research samples were water points in each sub-watershed that entered the three canals in the Bompon Sub-watershed as well as river flows in residential catchment areas and mixed gardens.

2.2 Measurement of Catchment Area

The tool used to measure the catchment area is ArcGis software. Measurements of the size of the catchment area were carried out in the water catchment area around settlements, mixed gardens, as well as in the three river sections based on plotting the measurement coordinate points which act as an outline. This measurement is used to obtain data on area area as one of the factors that influences the magnitude of surface flow discharge to a greater or lesser extent.

2.3 Data Analysis Technique

Data analysis was carried out using qualitative and quantitative descriptive methods. Quantitative descriptive analysis describes the calculation of surface flow discharge in each section using the formula:

Discharge (Q) = K x A x V

Where :

- Q = discharge (m3/sec)
- V = average flow speed (m/sec)
- A = wet cross-sectional area (m2)
- K = Float coefficient

Meanwhile, the qualitative descriptive analysis used aims to describe the results of field observations in the form of factors that influence the size of the flow discharge in each upstream, middle, downstream section, as well as water catchment areas in residential areas and mixed gardens. AThis kind of analysis is needed to find out what factors influence the flow rate based on data obtained in the field.

3. Result and Discussion

3.1 Determination of Priority for Impact and Exposure Parameters

Determination of score priority for Impact and Exposure parameters is carried out through the Analytical Hierarchy Process (AHP) method (Syaifullah, 2010; Kusnuri, 2007). The first step in priorities determination is assessing pair comparisons for each Impact and Exposure parameters. Pairwise comparison assessments are carried out based on the justification given by the author. The following are the pairwise comparison assessments for Impact parameters: [a] population density is moderate important than the population, [b] the poverty rate is strong important than the population, [c] the population is moderate important than the urban / rural function, [d] poverty is very strong important than the population density, [e] population density is strong important than the urban / rural functions, [f] The poverty rate is very strong than the urban / rural function.

The following are the pairwise comparison assessments for Impact parameters: [a] secondary data is moderate important than the SRI, [b] secondary data is strong important than the perception of RGA, [c] the SRI is moderate important than the perception of RGA.

The results of priorities determination for Impact parameters are displayed in Table 1 and priorities determination for Exposure parameters are displayed in Table 2.

Table 1. Priority of impact parameter

Impact Parameter	Priority
Population	16%
Population Density	23%
Poverty Rate	52%
Area Classification	9%

Table 2. Priority of exposure parameter

Exposure Parameter	Priority
Secondary data	54%
Sanitation Risk Index (SRI)	30%
Perception of Regional	16%
Government Agency (RGA)	-

3.2 Determination of Impact Score

Impact is a strong influence that brings consequences, both negative and positive (Ministry of Education and Culture of the Republic on Indonesia, 2016). Impact parameters consist of population, population density, poverty rate, and classification of urban/rural areas (Cimahi City Central Bureau of Statistics, 2018). The following is the calculation step for the Impact score determination parameter (Ministry of Public Works and Public Housing of the Republic of Indonesia, 2018):

$$\text{Population} = \frac{\text{Population per Village}}{\text{Population per City}} \times 100\% \quad (1)$$

$$\text{Population Density} = \frac{\text{Population per Village (people)}}{\text{Area of Built-in Areas (ha)}} \quad (2)$$

$$\text{Poverty Rate} = \frac{\text{Householder}}{\text{Householder per Village}} \times 100\% \quad (3)$$

Region classification = Score 1 for urban areas and score 2 for rural areas

The step taken after obtaining the four values of each parameter is to normalize the score with the following equation (Ministry of Public Works and Public Housing of the Republic of Indonesia, 2018):

$$X > [X_{min} + 75\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 4} \quad (4)$$

$$X > [X_{min} + 50\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 3} \quad (5)$$

$$X > [X_{min} + 25\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 2} \quad (6)$$

$$X > [X_{min} + 0\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 1} \quad (7)$$

Where:

X = value of a parameter

X_{min} = the smallest value of parameters for all villages in Cimahi City

X_{max} = the biggest parameter value of all villages in Cimahi City

The normalized value for Impact parameters each village is displayed in Table 3.

Table 3. Normalization of impact parameter score

No	Village	People	%	N	People/H	N	%	N	Value (N)
1.	Melong	72.120	12,3%	4	432	4	4,1%	1	2 (1)
2.	Cibeureum	69.116	11,8%	4	472	4	9,3%	4	2 (1)
3.	Utama	38.863	6,6%	2	192	1	7,0%	2	2 (1)
4.	Leuwigajah	48,195	8,2%	3	230	2	6,2%	2	2 (1)
5.	Cibeber	29.355	5,0%	2	165	1	5,7%	2	2 (1)
6.	Baros	23.840	4,1%	1	199	1	5,0%	1	2 (1)
7.	Cigugur Tengah	52.439	9,0%	3	418	4	9,3%	4	2 (1)
8.	Karangmekar	18.195	3,1%	1	260	2	6,9%	2	2 (1)
9.	Setiamanah	24.763	4,2%	1	337	3	7,6%	3	2 (1)
10.	Padasuka	42.481	7,3%	3	402	4	7,0%	2	2 (1)
11.	Cimahi	12.048	2,1%	1	268	2	10,4%	4	2 (1)
12.	Pasirkaliki	17.786	3,0%	1	262	2	5,0%	1	2 (1)
13.	Cibabat	56.407	9,6%	3	368	3	4,8%	1	2 (1)
14.	Citeureup	39.046	6,7%	2	226	2	4,7%	1	2 (1)
15.	Cipageran	40.966	7,0%	2	129	1	5,2%	1	2 (1)

After normalization, each Impact parameter per village is multiplied by the percentage of priorities, and the result is called the Impact score. Impact scores that are converted by normalizing into scores 1 to 4 are shown in Table 4.

Table 4. Determination of impact scores

No	Village	Population (16%)	Population Density (23%)	Poverty Rate (52%)	Area Classification (1)	Impact	Impact Score
1.	Melong	4	4	1	1	2,2	2
2.	Cibeureum	4	4	4	1	3,7	4
3.	Utama	2	1	2	1	1,7	1
4.	Leuwigajah	3	2	2	1	2,1	2
5.	Cibeber	2	1	2	1	1,7	1
6.	Baros	1	1	1	1	1,0	1
7.	Cigugur Tengah	3	4	4	1	3,6	4
8.	Karangmekar	1	2	2	1	1,8	2
9.	Setiamanah	1	3	3	1	2,5	3
10.	Padasuka	3	4	2	1	2,5	3
11.	Cimahi	1	2	4	1	2,8	3
12.	Pasirkaliki	1	2	1	1	1,2	1
13.	Cibabat	3	2	1	1	1,8	2
14.	Citeureup	2	3	1	1	1,4	1
15.	Cipageran	2	1	1	1	1,2	1

3.3 Determination of Exposure Score

Exposure is a state of experiencing something or being under the influence of something in a particular situation/place (Cambridge University Press, 2019). Exposure parameters consist of secondary data, Sanitation Risk Index (SRI), and perceptions of Regional Government Agency (RGA). After the priority determination through the AHP Method, calculations for each parameter are carried out and the scores are normalized. The following is the calculation step for the parameter for determining the Exposure score.

3.3.1 Secondary Data

The value of secondary data in this study is the percentage of reduction in solid waste in a district/city. The equation used to calculate the percentage of reduction in solid waste is as follows:

$$\%\text{Reduction} = \frac{\sum(\text{The amount of waste treatment units} \times \text{Processing capacity})}{\text{The amount of waste each village}} \times 100\% \quad (8)$$

The lower the percentage of waste reduction, the higher the waste risk score so that there are exceptions to the normalization of secondary data scores. Normalization for secondary data scores follows Equation 15 until 18. Exposure scores that are converted by normalizing into scores 1 to 4 are shown in Table 6.

$$X > [X_{min} + 75\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 1} \quad (9)$$
$$X > [X_{min} + 50\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 2} \quad (10)$$
$$X > [X_{min} + 25\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 3} \quad (11)$$
$$X > [X_{min} + 0\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 4} \quad (12)$$

Table 5. Determination of secondary data score

No	Village	The Number of Waste Generation (tons/day)	The Number of Reduced Waste (tons/day)	Waste Reduction (%)	Secondary Data Score
1.	Melong	33,09	2,31	7%	4
2.	Cibeureum	31,71	0,66	2%	4
3.	Utama	17,83	2,33	13%	3
4.	Leuwigajah	22,11	4,55	21%	3
5.	Cibeber	13,47	0,62	5%	4
6.	Baros	10,94	1,86	17%	3
7.	Cigugur Tengah	24,06	2,95	12%	3
8.	Karangmekar	8,35	1,77	21%	2
9.	Setiamanah	11,36	0,07	1%	4
10	Padasuka	19,49	1,69	9%	4
11.	Cimahi	5,53	2,29	41%	1
12.	Pasirkaliki	8,16	0,02	0%	4
13.	Cibabat	25,88	5,31	21%	3
14.	Citeureup	17,92	0,75	4%	4
15.	Cipageran	18,80	2,27	12%	3

3.3.2 Sanitation Risk Index (SRI)

The SRI value is obtained from the results of the processing of the primary data based on 2014 Environmental Health Risk Assessment (EHRA) Guidelines (Ministry of Health of the Republic of Indonesia, 2014). The processing of primary data is carried out through these following steps (Azhar, 2015).

The first step in getting the SRI value is through calculating the environmental health risk index (EHRI) by dividing the source of hazards, the chances of hazard exposure, and the components in it in the form of percentages for each particular study area. The equations used to determine the EHRI are as follows:

$$\text{EHRI} = \frac{\text{Source of hazards}}{\sum \text{Population each village}} \quad (12)$$

The second step is to give weight to each component of the source of the hazard and the opportunity for hazard exposure. Then, the 100% weight is divided according to the number of components present in the hazard variable and the chance of hazard exposure. The third step is to determine the cumulative EHRI by summing the health risk index calculated from the weighting results in the second step. The sum of the risk index is hereinafter referred to as the SRI value.

The sanitation risk index (SRI) value is determined according to the classification of each village. Class 2 has a SRI value of 17, class 3 has a SRI value of 15, and class 4 has a SRI value of 9. The results of determining the SRI score for each village converted by normalization to scores 1 to 4 are displayed in Table 6.

3.3.3 Perceptions of Regional Government Agency (RGA)

The RGA perception is a risk assessment that is made based on government agencies' experience or expertise on the solid waste component in a district/city (Government Regulation of the Republic of Indonesia, 2007). In this case, the number of RGAs involved is a minimum of 5 (five) and a maximum of 9 (nine) RGAs. The score for the perception of RGA is obtained from a value that is most often chosen by all RGAs involved (Ministry of Public Works and Public Housing of the Republic of Indonesia, 2018).

After the Exposure total score was obtained, the Exposure score normalization was carried out. Normalization of the Exposure score is calculated by Equation 6 until 9. Each Exposure parameter is multiplied by the percentage of priority that has been calculated using the AHP Method, then summed per village, and the result is referred as the Exposure score. Exposure scores that are converted by normalization into scores 1 to 4 are displayed in Table 6.

Table 6. Normalization of exposure parameter score

No	Village	Secondary Data (54%)	SRI (30%)	RGA (16%)	Exposure	Exposure Score
1.	Melong	4	3	3	3,5	4
2.	Cibeureum	4	1	3	2,9	3
3.	Utama	3	1	3	2,4	2
4.	Leuwigajah	3	4	3	3,3	3
5.	Cibeber	4	4	3	3,8	4
6.	Baros	3	4	2	3,1	3
7.	Cigugur Tengah	3	1	2	2,2	1
8.	Karangmekar	2	3	2	2,3	4
9.	Setiamanah	4	3	2	3,4	4
10.	Padasuka	4	3	2	3,4	1
11.	Cimahi	1	3	2	1,8	4
12.	Pasirkaliki	4	4	1	3,5	4
13.	Cibabat	4	3	2	3,4	4
14.	Citeureup	3	4	2	3,1	3
15.	Cipageran	3	4	2	3,1	3

3.4 Determination of Waste Risk Area Score

Risk areas for solid waste were calculated by multiplying the Impact parameters and Exposure parameters. The results of the calculation and normalization of risk area scores for each village in Cimahi City are shown in Table 10. The map of the solid waste risk area in Cimahi City is shown in Figure 1.

3.5 Waste Reduction Strategies in Cimahi City

The strategy planned in this study focuses on the technical aspects of waste reduction in Cimahi City. The scenario contained in the strategy below is to plan the addition of waste processing units, in the form of composting plants, compost reactors, and transfer stations with 3R method. The capacity of the composting plant, compost reactor and transfer stations with 3R method processing units are 0.615; 0.034; and 1,601 in tons/units/day. The three processing units have greater processing capacity compared to the capacity of other waste treatment units that have been implemented in Cimahi City, such as the composter unit (0.01 tons/unit/day), biodigester (0.021 tons/unit/day), and waste bank (0.022 tons/unit/day). Thus, the addition of the three processing units takes precedence.

The addition of compost reactor units is planned because there are integrated transfer stations or in several villages in Cimahi City which have the potential to be the storage and operation of compost reactors. The addition of a composting plant unit is planned because it is capable of reducing waste which is quite large at 0.601 tons/day. Composting plants can be applied using the open windrow method or mini bioreactor. The open windrow method can be carried out if there is extensive land available so that it is able to place composting material with a width of 1.8 - 3.5 meters, height 1.2 - 2.5 meters, and length that is adjusted and there are workers for operational activities (Bachert et al., 2008). Mini bioreactors can be operated on a narrow area and community participation is needed. The addition of the transfer stations with 3R method was planned because of the processing capacity of transfer stations with 3R method, which is 1.601 tons/unit/day, potentially the most in increasing the percentage of waste reduction compared to other types of processing in Cimahi City. Addition of this unit can be done by transferring some existing transfer stations into transfer stations with 3R method if there is waste sorting activity in the service area, there are operational workers, and the area is greater than 200 m2 or carried out through the construction of transfer stations with 3R method in accordance with Regulation of the Minister of Public Works of the Republic of Indonesia 3 of 2013 (Regulation of the Minister of Public Works of the Republic of Indonesia, 2013).

Table 7. Recommendation for waste reduction strategies in Cimahi City

No	Village	Processing Unit (Existing & Strategy)	Waste Reduction (Existing & Strategy)
1.	Melong	1 transfer stations with 3R methods & 2 transfer stations with 3R methods	7% & 12%
2.	Cibeureum	No transfer stations with 3R methods & 4 transfer stations with 3R methods	2% & 22%
3.	Cibeber	No transfer stations with 3R methods & 1 transfer stations with 3R methods	5% & 16%
4.	Setiamanah	No composting plants and transfer stations with 3R methods & 2 composting plants; 1 transfer stations with 3R methods	1% & 26%
5.	Padasuka	1 composting plant; No transfer stations with 3R methods & 2 composting plant; 2	9% & 28%

		transfer stations with 3R methods	
6.	Pasirkaliki	No transfer stations with 3R methods & 1 transfer stations with 3R methods	0,3% & 20%
7.	Citeureup	No transfer stations with 3R methods & 1 transfer stations with 3R methods	4% & 13%

Table 7 shows the waste reduction strategy in Cimahi City. With the addition and/or reactivation of the waste treatment facility in Cimahi City, an Exposure score change can occur which in turn affects the changes in the Area Score at Risk of Waste. The results of the calculation of the Waste Risk Area score after the waste reduction strategy can be seen in Table 8. The changes of the solid waste risk area in Cimahi City can be seen in Figure 2.

Table 8. The solid waste risk area score of Cimahi City with strategies

No	Village	I	E	Score	Score (Normal)	I	E	Score	Score (Normal)
1.	Melong	2	4	8	3	2	3	6	3
2.	Cibeureum	4	3	12	4	4	1	6	1
3.	Utama	1	2	2	1	1	2	4	1
4.	Leuwigajah	2	3	6	2	2	3	2	2
5.	Cibeber	1	4	4	1	1	3	6	1
6.	Baros	1	3	3	1	1	3	3	1
7.	Cigugur Tengah	4	1	4	1	4	1	3	1
8.	Karangmekar	2	2	4	1	2	3	4	2
9.	Setiamanah	3	4	12	4	3	2	6	2
10.	Padasuka	3	4	12	4	3	2	6	2
11.	Cimahi	3	1	3	1	3	1	6	1
12.	Pasirkaliki	1	4	4	1	1	3	3	1
13.	Cibabat	2	4	8	3	2	3	3	2
14.	Citeureup	1	3	3	1	1	3	6	1
15.	Cipangeran	1	3	3	1	1	3	3	1

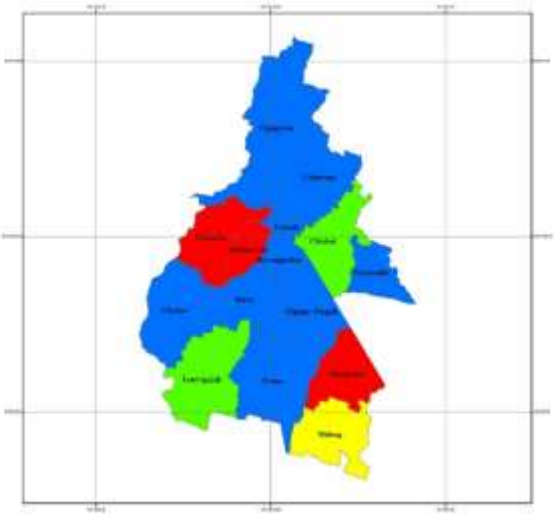

Figure 1. Map of the solid waste risk area in Cimahi City

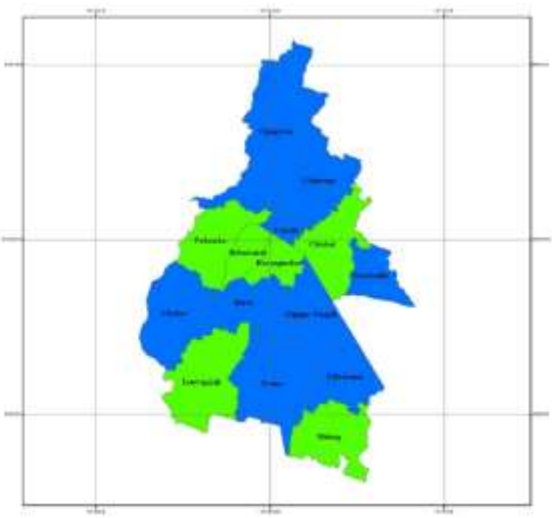

Figure 2. Map of the solid waste risk area with strategies in Cimahi City

4. Conclusion

Based on the results of determination of the risk areas that have been carried out, there are 3 indicated villages with a very high risk of solid waste, 1 indicated village with a high risk of solid waste, 2 indicated villages with a low risk of solid waste, and 9 indicated villages with a very low risk of solid waste. Villages which need to be prioritized in providing solid waste management strategies are very high-risk urban villages, namely Cibeureum, Setiamanah, and Padasuka and high-risk villages, namely Melong. The recommended strategy is by adding and/or reactivating waste processing facilities in the form of transfer station with 3R method and/or composting plants in several villages in Cimahi, namely Melong, Cibeureum, Cibeber, Setiamanah, Padasuka, Pasirkaliki and Citeureup.

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The author declare no conflict of interest.

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