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Analysis of solid waste risk areas in Cimahi City using the 2018 district/city sanitation strategy guidelines

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ABSTRACT

Introduction: 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. **Method:** 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. **Findings:** 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. **Conclusion:** Cimahi City is dealing with serious solid waste issues, and to tackle them effectively (especially to meet the national goal of reducing waste by 30%), it's crucial to identify which areas are at the highest risk. The study highlights where the biggest problems are and gives a practical solution—add more treatment facilities to manage waste better and reduce risk. **Novelty/Originality of this article:** The novelty of this research lies in its spatially-targeted risk assessment approach to solid waste management at the village level in Cimahi City, which is rarely addressed in existing studies on urban waste issues in Indonesia.

KEYWORDS: solid waste risk; Cimahi City; sanitation strategy guidelines.

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 other technical aspects, such as inadequate capacity of garbage containers in several source

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locations, limited application of waste sorting activities, limited collection fleet, waste handling by open burning and stockpiling, and others (KLHK, 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 (Perpres No. 97 Tahun 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 (Haryanto, 2018) Calculating the score of the risk areas in Cimahi City; (KLHK, 2019) Mapping out risky waste areas in all villages in Cimahi City; and (Perpres No. 97 Tahun 2017) Developing solid waste reduction strategies based on the risk areas of solid waste in Cimahi City.

2. Methods

2.1 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 (Kusnuri, 2007). The first step in determining priorities is assessing pair comparisons for each Impact and Exposure parameter. Pairwise comparison assessments are carried out based on the justification given by the author.

For Impact parameters, the pairwise comparison assessments are as follows: Population density is moderately more important than the population. The poverty rate is strongly more important than the population. The population is moderately more important than the urban/rural function. Poverty is very strongly more important than population density. Population density is strongly more important than the urban/rural functions. The poverty rate is very strongly more important than the urban/rural function.

For Exposure parameters, the pairwise comparison assessments are as follows: Secondary data is moderately more important than the SRI. Secondary data is strongly more important than the perception of RGA. The SRI is moderately more important than the perception of RGA.

2.2 Determination of impact score

Impact is a strong influence that brings consequences, both negative and positive (Kemdikbud, 2016). Impact parameters consist of population, population density, poverty rate, and classification of urban/rural areas (BPS Cimahi, 2018; BPS Cimahi, 2018; BPS Cimahi, 2018). The following is the calculation step for the Impact score determination parameter (Kementerian PUPR, 2018):

$$Population = \frac{Population\ per\ Village}{Population\ per\ City} \times 100\%$$

Eq. 1

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

Eq. 2

$$Poverty\ Rate = \frac{Householder}{Householder\ per\ Village} \times 100\%$$

Eq. 3

The classification of regions is determined by assigning a score of 1 for urban areas and a score of 2 for rural areas. Once the four parameter values are obtained, the next step is to normalize the scores using the following equation as outlined by the Ministry of Public Works and Public Housing (Kementerian PUPR, 2028).

$$X > [X_{min} + 75\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 4}$$
Eq. 4
$$X > [X_{min} + 50\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 3}$$
Eq. 5
$$X > [X_{min} + 25\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 2}$$
Eq. 6
$$X > [X_{min} + 0\% \cdot (X_{max} - X_{min})] \rightarrow \text{Score 1}$$
Eq. 7

The variables used for normalization include the value of a specific parameter (X), the minimum value of that parameter across all villages in Cimahi City (Xmin), and the maximum value (Xmax). Using these values, the normalization process is carried out to standardize the data.

2.3 Determination of exposure score

Exposure is a state of experiencing something or being under the influence of something in a particular situation/place. 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.

Then, 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 in equation 8.

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

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

2.4 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 (Kemenkes, 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 in

$$EHRI = \frac{Source\ of\ hazards}{\sum Population\ each\ village}$$

Eq. 13

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.

2.5. 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 (PP RI No.41 Tahun 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 (Kementerian PUPR, 2018). Risk areas for solid waste were calculated by multiplying the Impact parameters and Exposure parameters.

3. Results and Discussion

3.1 Priority for impact and exposure parameters

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 parameters

Impact Parameter	Priority
Population	16%
Population density	23%
Poverty rate	52%
Area classification	9%

Table 2. Priority of exposure parameters

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

3.2 Determination of impact score

Impact parameters include population, population density, poverty rate, and the classification of urban and rural areas.The step taken after obtaining the four values of each parameter is to normalize the score. 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 3.

Table 3. Determination of impact scores.

No.	Village	Population	Population Density	Poverty Rate	Area Classification	Impact	Impact Score
		16%	23%	52%	9%		
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

No.	Village	Population	Population Density	Poverty Rate	Area Classification	Impact	Impact Score
		16%	23%	52%	9%		
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	3	1	1	1.8	2
14	Citeureup	2	2	1	1	1.4	1
15	Cipageran	2	1	1	1	1.2	1

3.3 Determination of exposure score

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 4.

Table 4. Normalization of Exposure Parameter Score.

No.	Village	Secondary Data	SRI	RGA	Exposure	Exposure Score
		54%	30%	16%		
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	2
9	Setiamanah	4	3	2	3,4	4
10	Padasuka	4	3	2	3,4	4
11	Cimahi	1	3	2	1,8	1
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 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 m^2 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 (Permen PUPR No. 03/PRT/M/2013 Tahun 2013).

Table 5. Recommendation for waste reduction strategies in Cimahi City

No.	Village	Processing Unit		Waste Reduction	
		Existing	Strategy	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 transfer stations with 3R methods	9%	28%
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%

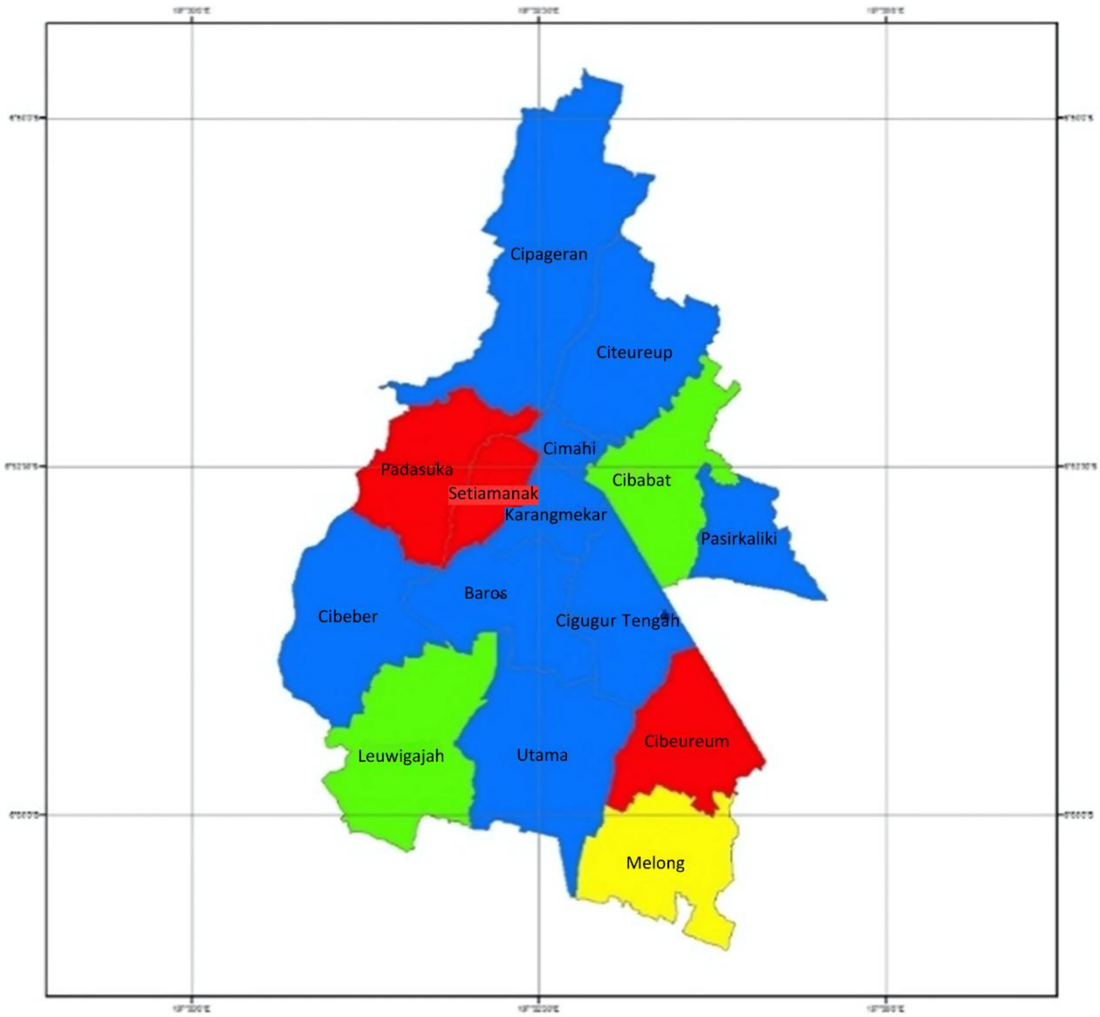
Table 5 shows the waste reduction strategy in Cimahi City. With the addition and/or reactivation of the waste treatment facility in Cimahi City, an Exposure score change can occur which in turn affects the changes in the Area Score at Risk of Waste. The results of the calculation of the Waste Risk Area score after the waste reduction strategy can be seen in Table 6. The changes of the solid waste risk area in Cimahi City can be seen in Figure 1.

Table 6. The solid waste risk area score of Cimahi City with strategies

No	Village	Existing Conditions				With Strategies			
		I	E	Score	Score (Normal)	I	E	Score	Score (Normal)
1	Melong	2	4	8	3	2	3	6	2
2	Cibeureum	4	3	12	4	4	1	4	1
3	Utama	1	2	2	1	1	2	2	1
4	Leuwigajah	2	3	6	2	2	3	6	2
5	Cibeber	1	4	4	1	1	3	3	1
6	Baros	1	3	3	1	1	3	3	1

7	Cigugur Tengah	4	1	4	1	4	1	4	1
8	Karangmekar	2	2	4	1	2	3	6	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	3	1
12	Pasirkaliki	1	4	4	1	1	3	3	1
13	Cibabat	2	4	8	3	2	3	6	2
14	Citeureup	1	3	3	1	1	3	3	1
Minimum Score				2					
Maximum Score				12					
Interval				10					

The figures below show the spatial distribution of solid waste risk levels across Cimahi City. In the first map, different colors represent varying levels of risk: red indicates areas with a "Very High Risk," yellow shows areas with a "High Risk," green highlights regions with a "Low Risk," and blue signifies areas categorized as "Very Low Risk." From this visualization, it is clear that the majority of Cimahi City falls within the "Very Low Risk" category, with only a few regions facing higher risk levels. Meanwhile, the second map illustrates the solid waste risk areas after implementing specific strategies to mitigate risks. In this adjusted map, green areas represent "Low Risk" zones, while blue continues to represent "Very Low Risk" zones. It is evident that, following strategic interventions, risk levels across Cimahi City have significantly improved, with a wider spread of low-risk areas compared to the initial conditions.



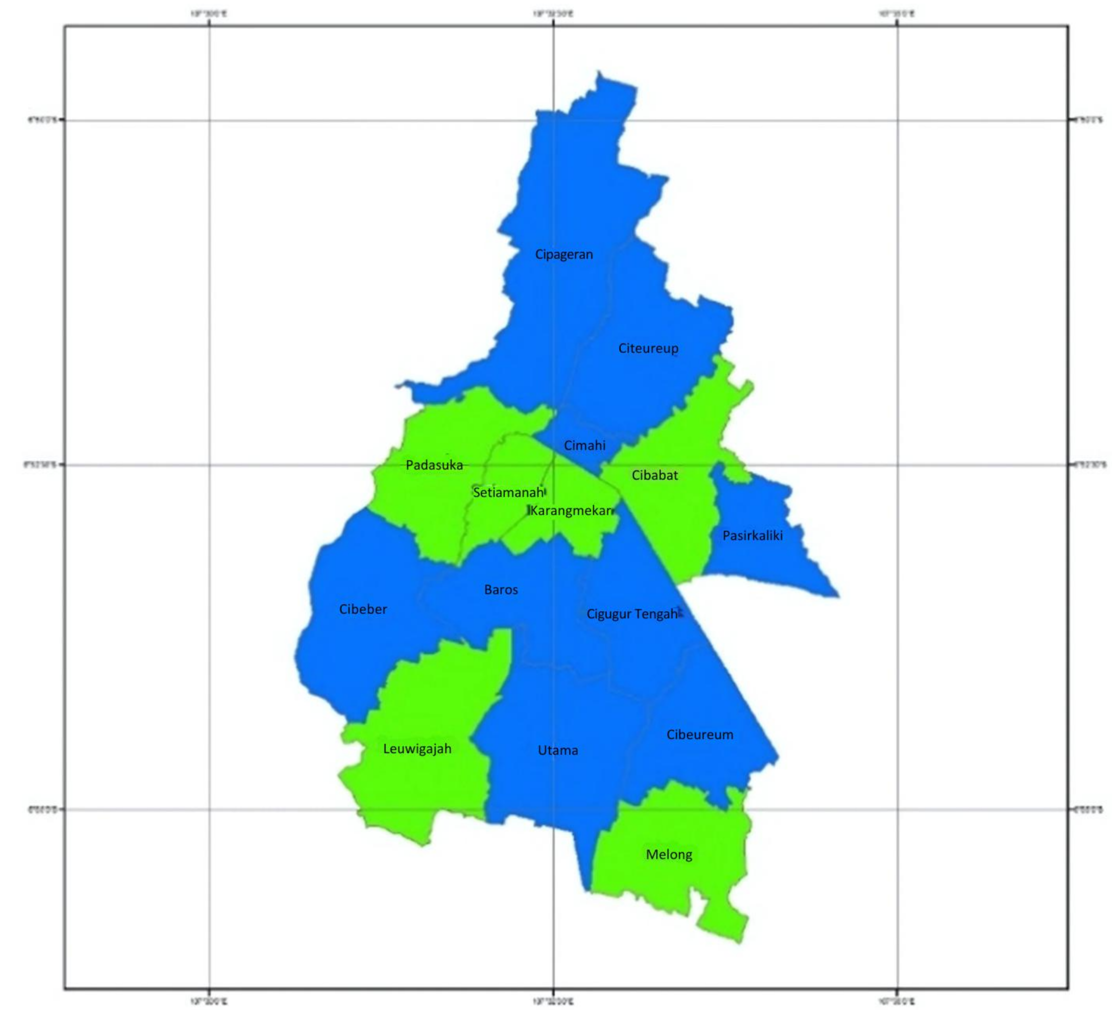


Fig 1. Map of the solid waste risk area in Cimahi City

4. Conclusions

Based on the results of the 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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